2. Electrification R&D

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

The VTO Electrification Technologies subprogram supports the decarbonization of transportation across all modes, serves to increase American advancement/manufacturing of battery technology, and creates good paying jobs with the free and fair chance to join a union and bargain collectively. The subprogram supports research with partners in academia, national laboratories, and industry covered under the Energy Storage Grand Challenge key priority and distinct crosscuts. The Energy Storage Grand Challenge encompasses research and development (R&D) across electrification including electric vehicle charging infrastructure. The Critical Minerals crosscut aims to realize electric drive motor innovations through high energy product magnet R&D to reduce or eliminate heavy rare earth (HRE) magnet materials. Grid Modernization continues to develop Smart Charge Management technologies for fleets, including medium and heavy vehicles to provide more advanced grid services such as resilience of the charging network and continuity of grid and emergency services operations during disruptive events.

The Electric Drive R&D activity supports early-stage R&D for extreme high-power density motors that have the potential to enable radical new vehicle architectures by dramatic volume/space reductions and increased durability and reliability. Reduce the cost of electric traction drive through core research of motors, high-density integration technologies, leveraging high performance computing for modeling and optimization, and utilizing new materials for high-density electric motors. Approaches will include novel circuit topologies and new materials for high-density electric motors. Electric traction drive system integration based on electric motor innovations will also be a priority.

The Electrification R&D activity supports early-stage R&D to understand the potential impacts on, and benefits of, plug-in electric vehicle (PEV) charging to the Nation's electric grid. This research will inform the development of communication and cybersecurity protocols; enable industry to enhance the interoperability between charging equipment, the on-board vehicle charger, and charging networks; and foster technology innovations to improve PEV refueling through extreme fast charging. Core research focuses on developing smart charging, extreme fast charging, and wireless charging technologies for reliable and cost-effective charging of light-, medium-, and heavy-duty electric vehicles. This includes the research of technologies related to cybersecurity of electric vehicle charging/supply equipment, and integration with the electric grid.

Project Feedback

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

Table 2-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT179	Low Cost High-Performance Heavy Rare-Earth-Free 3-In-1 Electric Drive Unit	David Crecelius (American Axle & Manufacturing)	2-7	3.33	3.50	3.17	3.25	3.41
ELT209	High-Voltage High-Power Density Traction-Drive Inverter	Gui-Jia Su (Oak Ridge National Laboratory)	2-10	3.67	3.67	3.67	3.17	3.60
ELT210	Development of Next-Generation Vertical Gallium-Nitride Devices for High-Power Density Electric Drivetrain	Andrew Binder (Sandia National Laboratories)	2-13	3.33	3.33	3.67	3.33	3.38
ELT212	Non-Heavy Rare-Earth High-Speed Motors	Vandana P Rallabandi (Oak Ridge National Laboratory)	2-16	3.00	3.00	3.25	3.25	3.06
ELT215	Develop fine-grain RE permanent magnet with high coercivity at high temperature AND cost-effective manufacturing process for high performance soft magnetic materials in thin sheet form	Iver Anderson (Ames Laboratory)	2-18	3.50	3.50	3.17	3.50	3.46

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT216	Isotropic Bottom-Up Soft Magnetic Composites for Rotating Machines	Todd Monson (Sandia National Laboratories)	2-21	3.33	3.33	3.50	3.33	3.35
ELT217	Integrated/ Traction Drive Thermal Management	Bidzina Kekelia (National Renewable Energy Laboratory)	2-24	3.33	3.17	3.17	3.00	3.19
ELT218	Advanced Power Electronics Packages	Douglas DeVoto (National Renewable Energy Laboratory)	2-27	3.83	3.83	3.67	3.50	3.77
ELT221	Integrated Electric Drive System	Shajjad Chowdhury (Oak Ridge National Laboratory)	2-30	3.67	3.67	3.50	3.83	3.67
ELT236	Direct-Current Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture	Watson Collins (EPRI)	2-33	3.33	3.50	3.17	3.67	3.44
ELT238	Intelligent Grid-Friendly Modular Extreme Fast Charging System with Solid-State Direct-Current Protection	Srdjan Lukic (North Carolina State University)	2-36	3.00	3.00	3.38	2.00	3.02

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT262	Long-Range Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging	Ryan Reed (Kenworth)	2-40	3.33	3.33	3.50	3.50	3.38
ELT264	Demonstration of Utility Managed Smart Charging For Multiple Benefit Streams	Stephanie Leach (Exelon/Pepco Holdings Inc.)	2-43	3.25	3.00	3.25	3.00	3.09
ELT265	A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicle's-At-Scale	Duncan Woodbury (Liberas)	2-46	3.75	3.75	3.75	3.25	3.69
ELT274	eMosaic Electrification Mosaic Platform for Grid-Informed Smart Charging Management	James Stoupis (ABB)	2-49	3.25	3.25	3.25	2.75	3.19
ELT275	Low-Cost Rare-Earth Free Electric Drivetrain Enabled by Novel Permanent Magnets Inverter Integrated Design and Advanced Thermal Management	Ayman El-Refaie (Marquette University)	2-52	3.38	2.75	3.50	3.00	3.03
ELT282	Technology & Design Innovations to Maximize the Reduction Effect on DCFC Unit Cost Economics (Max-REDUCE)	Robert Keefover (BorgWarner)	2-55	3.00	3.17	3.00	2.83	3.06

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT283	A Solid State Technology Enabled Compact Modular Design to Reduce DC Fast Charging Cost and Footprint	Bogdan Borowy (Eaton)	2-58	3.25	3.00	3.13	2.88	3.06
ELT285	Development and Demonstration of Zero-Emission Technologies for Commercial Fleets (SuperTruck 3)	Maarten Meijer (PACCAR)	2-62	3.38	3.63	3.63	3.38	3.53
ELT286	A Zero Emission Freight Future (SuperTruck 3)	Eric Bond (Volvo)	2-67	3.92	3.42	3.42	3.42	3.54
ELT287	Cummins High Power Density Inverter	Santhosh Krishnamoorthi (Cummins)	2-73	3.40	3.20	3.30	3.30	3.28
ELT288	Scalable Ultra Power-Dense Extended Range (SUPER) Inverter	Harsha Nanjundaswamy (BorgWarner)	2-78	3.58	3.33	3.33	3.42	3.41
ELT290	Behind-the-Meter-Storage	Anthony Burrell (National Renewable Energy Laboratory)	2-83	3.00	3.50	2.50	2.75	3.16
ELT293	Ruggedized Mobile Fast Charger for Off-Road Vehicles	Brij Singh (John Deere)	2-86	2.50	2.83	3.17	3.00	2.81
ELT294	Modular Direct Current (DC) Back Bone Recharging System for Non-Road Vehicles in Austere Environments	Leandro Della Flora (Beta Technologies)	2-89	2.67	2.67	2.83	2.83	2.71
ELT295	EVs@Scale VGI & SCM	Jesse Bennett (National Renewable Energy Laboratory)	2-92	3.13	3.13	3.38	3.13	3.16

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT296	Charging Infrastructure Interconnection Simplification Resource CIISR	Watson Collins (EPRI)	2-96	2.83	3.00	3.33	3.17	3.02
ELT297	Electric Vehicle Smart Program Management Supporting Local Governments to Achieve Equitable Access to Electric Mobility	Ed Gilliland (IREC)	2-99	3.50	3.33	3.33	3.00	3.33
ELT298	Bidirectional Power Flow for Medium-duty Vehicle-to-Grid Connectivity	Steven Sokolsky (CALSTART)	2-101	3.75	4.00	3.50	3.75	3.84
ELT299	EVs@Scale High Power Charging Pillar	John Kisacikoglu (National Renewable Energy Laboratory)	2-104	3.33	3.33	3.17	3.17	3.29
ELT300	EVs@Scale Codes and Standards Pillar	Ted Bohn (Argonne National Laboratory)	2-108	3.50	3.50	3.33	3.33	3.46
ELT301	EVs@Scale Cyber-Physical Security Pillar	Richard Carlson (Idaho National Laboratory)	2-112	3.50	3.75	3.75	3.00	3.59
ELT302	EVs@Scale EV Modeling Toolkit	Andrew Satchwell (Lawrence Berkeley National Laboratory)	2-115	3.33	3.33	3.17	3.17	3.29
Overall Average				3.33	3.32	3.33	3.18	3.31

Presentation Number: ELT179
Presentation Title: Low Cost High-Performance Heavy Rare-Earth-Free 3-In-1 Electric Drive Unit
Principal Investigator: David Crecelius, American Axle & Manufacturing

Presenter

David Crecelius, American Axle & Manufacturing

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

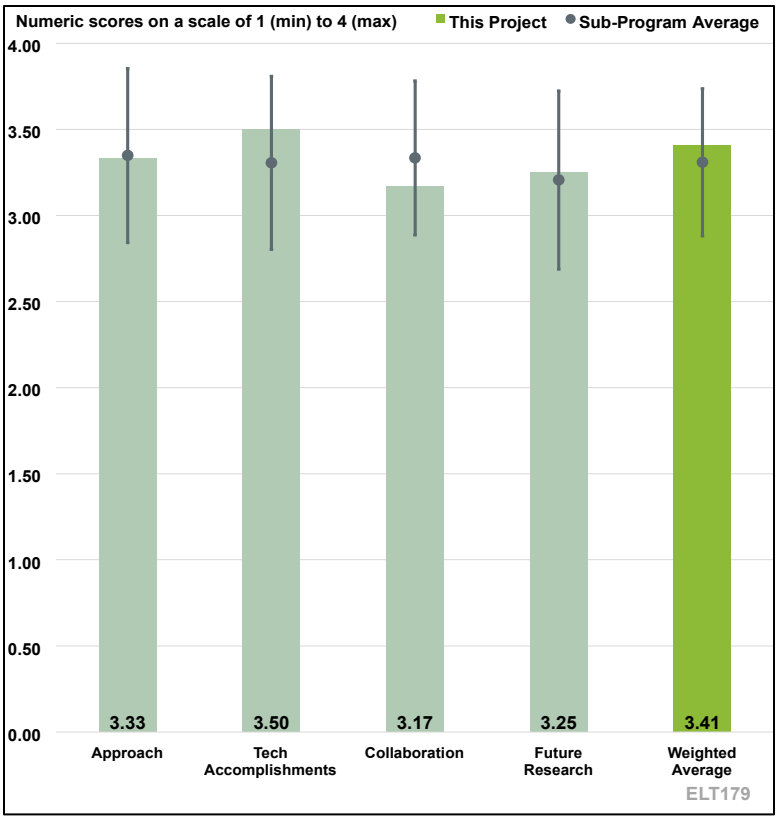

Figure 2-1. Presentation Number: ELT179 Presentation Title: Low Cost High-Performance Heavy Rare-Earth-Free 3-In-1 Electric Drive Unit Principal Investigator: David Crecelius, American Axle & Manufacturing

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

Reviewer 1

The reviewer noted American Axle & Manufacturing (AAM) used Arnon7 thin laminate to reduce the loss and achieved low core at high speed, solving the materials problem. The reviewer further noted AAM used the new insulated copper bar to reduce rotor losses and the high-speed approach to improve the motor power density. AAM used winding encapsulation to improve motor thermal management and designed a new inverter to run at 650V to improve system cost and power density. The reviewer concluded the combination of these five approaches resulted in highly efficient non-rare earth (RE) permanent magnet (PM) motor.

Reviewer 2

The reviewer observed the choice of very high-speed induction machine is challenging and noted it will be interesting to see the full test results all the way up to 30,000 rpm.

Reviewer 3

The reviewer said this is an exciting project in which all the technical barriers are addressed, and the timelines are reasonably planned. One doubt this reviewer had is in terms of the targets that the project is addressing. At a traction drive system level, these targets appear to not be either the 2020

or 2025 targets from the roadmap nor from the VTO solicitation out of which this project award came about. The reviewer requested the principal investigator (PI) and project team to look closely at some of the targets they listed in the table in their presentation and clarify what and why they were targeting certain numbers for cost and power density.

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

Reviewer 1

The reviewer remarked it was impressive to see the team completed the majority of the milestones and demonstrated a motor at 30,000 rpm and met or exceeded all three objectives ($7/kW, greater than 12 kW/L, and greater than 600VDC).

Reviewer 2

The reviewer concluded the project seems to meet all the milestones so far and is on track to conclude by end of 2024.

Reviewer 3

The reviewer affirmed there was great technical progress made in the project. The reviewer also cautioned that more information about the flow configurations in the heat exchangers, as well as the specifics of the reliability characterization of the bonded interfaces would have been helpful.

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

Reviewer 1

The reviewer noted there was good collaboration across multiple organizations.

Reviewer 2

The reviewer observed most of the work is being done in-house within AAM, which is okay.

Reviewer 3

The reviewer observed the team worked with Electricore as a partner and with Encap Tech, MacDermid Alpha, and Munro as suppliers, but there is no national laboratory involvement. It is 100% industry.

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

Reviewer 1

The reviewer affirmed that a good future research and demonstration plan is laid out. The person added that the project is moving closer towards the end.

Reviewer 2

The reviewer observed the project is 90% complete at the time of review, is scheduled to end on Oct. 31, 2024, and the team did not request any no-cost extension.

Reviewer 3

The reviewer commented that testing of the full system will be the ultimate verification step.

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

Reviewer 1

The reviewer expressed that by pushing an induction motor to 92% efficient at 16,000 rpm, AAM provided an alternative solution and a backup plan for the EV industry in case of any RE crisis. It directly supports the overall VTO objectives in the Electrification Technologies (ELT) subprogram.

Reviewer 2

The reviewer emphasized the project is very relevant for vehicle electrification—specifically, on power electronics, electric machines, and the electric traction drive system for vehicles.

Reviewer 3

The reviewer mentioned the project addresses DOE power density and cost targets as well as the elimination of rare-earth materials.

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

Reviewer 1

The reviewer noted, with $7.8 million, the company has received sufficient funds to develop this impressive motor.

Reviewer 2

The reviewer observed the resources appear adequate.

Reviewer 3

The reviewer said the project is nearing its end and seems to be on track to meet its milestones within the allocated resources.

Presentation Number: ELT209
Presentation Title: High-Voltage High-Power Density Traction-Drive Inverter
Principal Investigator: Gui-Jia Su, Oak Ridge National Laboratory

Presenter

Gui-Jia Su, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

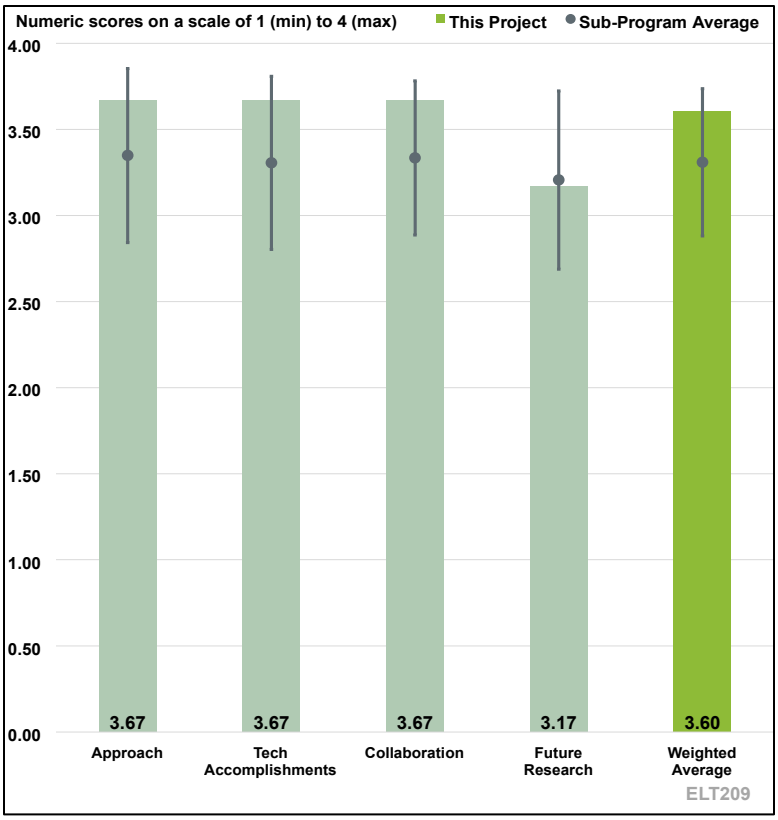

Figure 2-2. Presentation Number: ELT209 Presentation Title: High-Voltage High-Power Density Traction-Drive Inverter Principal Investigator: Gui-Jia Su, Oak Ridge National Laboratory

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

Reviewer 1

The reviewer observed that this project focuses on high energy density traction inverter design for 100 kW and 200 kW size inverters. A new design was implemented to achieve high energy density in a 200 kW inverter by switching the design to a segmented inverter type. The project timeline was designed to achieve this in sequence where understanding from 100 kW is applied to optimized for the 200 kW design. The reviewer concluded the timeline is reasonably planned.

Reviewer 2

The reviewer noted this is one of the keystone projects with aggressive targets on power density (100 kW/L), cost ($2.70/kW), peak efficiency (greater than 97%) and reliability (300,000 miles or 15 years). Performance of this project and approaches taken in packaging and thermal management have met power density and efficiency targets. It is not obvious from the report and presentation if cost and reliability targets are met. The heat sink is optimized using genetic algorithm method. Phase-shifted control of dual winding electric motor driven by the six-phase inverter has resulted in a more than 50% reduction in capacitor size, which has helped to meet the power-density target; however, the reviewer sought clarity in how to meet the target costs of the capacitor and SiC

devices, bus bar, heat sink, etc. The reviewer concluded the PI is executing this project quite well and doing a commendable job.

Reviewer 3

The reviewer asserted that the segmented inverter concept is an innovative approach for increasing the power density of the inverter. Simulation results support the approach, and experimental results are proving the feasibility.

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

Reviewer 1

The reviewer commented that the design phase and evaluation part has been successfully completed and the testing is on track for the project.

Reviewer 2

The reviewer observed the power module with integrated cooling has been fabricated, which is an enabling component in this project. This module is characterized and integrated in the power-dense inverter. Flow rate versus pressure drop evaluation has been carried out. A photo of the 200 kW Gen-1 SiC is included in the report. A mini-channel-based heat sink is also included in the project report. Efficiency characterization has been only carried out at 640 watts power and is quite high, greater than 97.5% when Gen-1 to Gen-2 power modules are compared. Tunnel magnetoresistance (TMR) based current sensor has been tried; however, the TMR sensor did not track the current signature measured by a current probe. There are additional efforts needed before the TMR-based sensor could be used in the power-dense SiC inverter. The reviewer concluded the project has adequately progressed in all aspects as needed to overcome barriers outlined in the overview slide of the project report.

Reviewer 3

The reviewer expressed there was great work on simulation and experimental validation.

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

Reviewer 1

The reviewer remarked that the project is a collaboration between Virginia Tech, University of Arkansas, Oak Ridge National Laboratory (ORNL), National Renewable Energy Laboratory (NREL) and Stony Brook University and has been carried out in an effective manner by leveraging design and evaluation capabilities of various laboratories.

Reviewer 2

The reviewer observed the project team includes the following entities and members with their key and impactful contributions: Virginia Tech, with a power module for a 100 kW inverter; the University of Arkansas, with requirements for the inverter power modules including development of power modules for the 200 kW inverter; Stony Brook University, with support for the inverter power module; and NREL, with thermal management and expert feedback on thermal management.

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

Reviewer 1

The reviewer observed that testing of the 100 kW inverter using a power module from Virginia Tech is outlined as a task for future research, along with research activities related to a 200 kW inverter.

Reviewer 2

The reviewer noted the project has a few months left, and the proposed future plan is sound.

Reviewer 3

The reviewer stated future research is outlined in terms of some of the remaining challenges of supporting component development, such as a bus bar for high voltage and thermal design. It is not clear whether these can be achieved in the remaining timeline of the project.

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

Reviewer 1

The reviewer asserted the project is fully aligned with the ELT subprogram objectives of achieving a lightweight and high powder density traction inverter.

Reviewer 2

The reviewer concluded the project activities do address VTO targets for inverter power-density, reliability, efficiency and cost.

Reviewer 3

The reviewer expressed that the project supports the overall ELT objectives.

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

Reviewer 1

The reviewer asserted the resources are sufficient and include expertise from national laboratories.

Reviewer 2

The reviewer observed the project is well staffed and supported by its collaborators, and has necessary funding, concluding ORNL has excellent facilities to execute a project like ELT209.

Reviewer 3

The reviewer cautioned that more resources would be helpful.

Presentation Number: ELT210
Presentation Title: Development of Next-Generation Vertical Gallium-Nitride Devices for High-Power Density Electric Drivetrain
Principal Investigator: Andrew Binder, Sandia National Laboratories

Presenter

Andrew Binder, Sandia National Laboratories

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

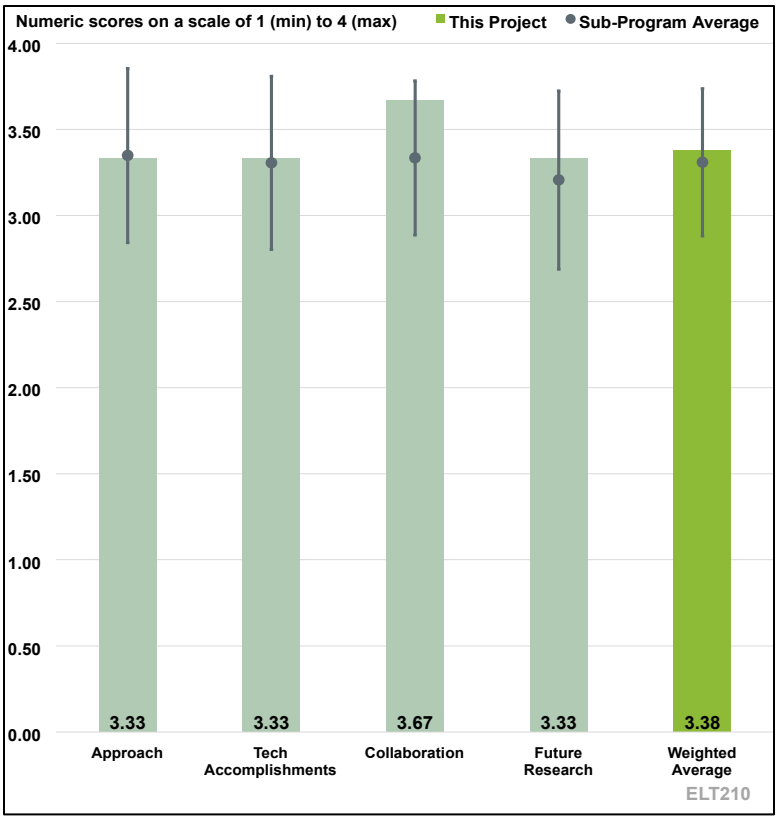

Figure 2-3. Presentation Number: ELT210 Presentation Title: Development of Next-Generation Vertical Gallium-Nitride Devices for High-Power Density Electric Drivetrain Principal Investigator: Andrew Binder, Sandia National Laboratories

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

Reviewer 1

The reviewer noted this project focuses on developing GaN based devices for high power density applications and uses vertical GaN design to achieve higher power density. The project is focused on the biggest technical challenges of power chip design.

Reviewer 2

The reviewer observed the project team is using stage approach from SiC metal-oxide-semiconductor field-effect transistor (MOSFET) plus SiC diode (stage 1) to SiC MOSFET plus GaN diode (stage 2) to GaN MOSFET plus GaN diode (stage 3). Each stage includes characterization and evaluation of device technology in the test bed. This approach will allow the project team to develop/evolve deep insight on various wide bandgap (WBG) devices, including their performance.

Reviewer 3

The reviewer cautioned that the goal of this project is high risk and ambitious. It focuses on addressing multiple challenging problems with fabricating vertical GaN devices with kilovolt blocking voltage.

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

Reviewer 1

The reviewer found the project had achieved a significant breakthrough in technology; however, there still remains many challenges before the technology can be practically employed to achieve targets of power density for the program.

Reviewer 2

The reviewer commented that the various processes needed to fabricate the devices are covered in the report, including passivation, edge termination, metal contact, etc. The project team has used a cycle of learning method until the appropriate device is achieved. Vertical GaN was compared with SiC MOSFET, and if the switching performance and dynamic Ron is accounted, the advantage of better FoM (figure of merit) offered by GaN is not as pronounced as claimed in the literature. Vertical GaN shows a marginal advantage. This is really great insight provided by the project team.

Reviewer 3

The reviewer praised the reported achievements of a kilovolt vertical GaN diode, adding that this is a big deal.

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

Reviewer 1

The reviewer observed the project is a collaboration among Ohio State University (OSU), ORNL, NREL, State University of New York Polytechnic Institute (SUNY Poly) and Sonrisa Research, Inc. These institutes together cover all aspects of development.

Reviewer 2

The reviewer noted ORNL, NREL, SUNY Poly and the OSU are collaborating with the team at Sandia National Laboratories (SNL).

Reviewer 3

The reviewer concluded there is great collaboration with university partners.

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

Reviewer 1

The reviewer noted future research efforts proposed are logical next steps in the development of GaN devices. The project develops new technology that is still in an immature stage and requires further development before commercialization.

Reviewer 2

The reviewer noted documentation on the project findings (including a research paper and patent disclosures) is one of the future works proposed. This is extremely valuable to researchers involved in the WBG device discovery and their applications to power electronic systems. High current devices will be realized, and the application of high voltage and lifetime analysis may be covered in future research.

Reviewer 3

The reviewer answered yes.

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

Reviewer 1

The reviewer affirmed the project is in alignment with ELT subprogram objectives.

Reviewer 2

The reviewer acknowledged the project activities are tied to 2025 VTO targets for power-density (100kW/L inverter) and concluded industry will greatly benefit from knowledge evolved through this project.

Reviewer 3

The reviewer stated the project supports the overall VTO ELT objectives.

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

Reviewer 1

The reviewer affirmed the project has sufficient resources.

Reviewer 2

The reviewer expressed the project has the necessary resources; SNL has a world class research facility, and collaborators (ORNL, NREL, SUNY Poly and the OSU) seem to be providing support in execution of project activities.

Reviewer 3

The reviewer pointed out that more support would help speed up the progress.

Presentation Number: ELT212
Presentation Title: Non-Heavy Rare-Earth High-Speed Motors
Principal Investigator: Vandana Rallabandi, Oak Ridge National Laboratory

Presenter

Vandana P Rallabandi, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

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

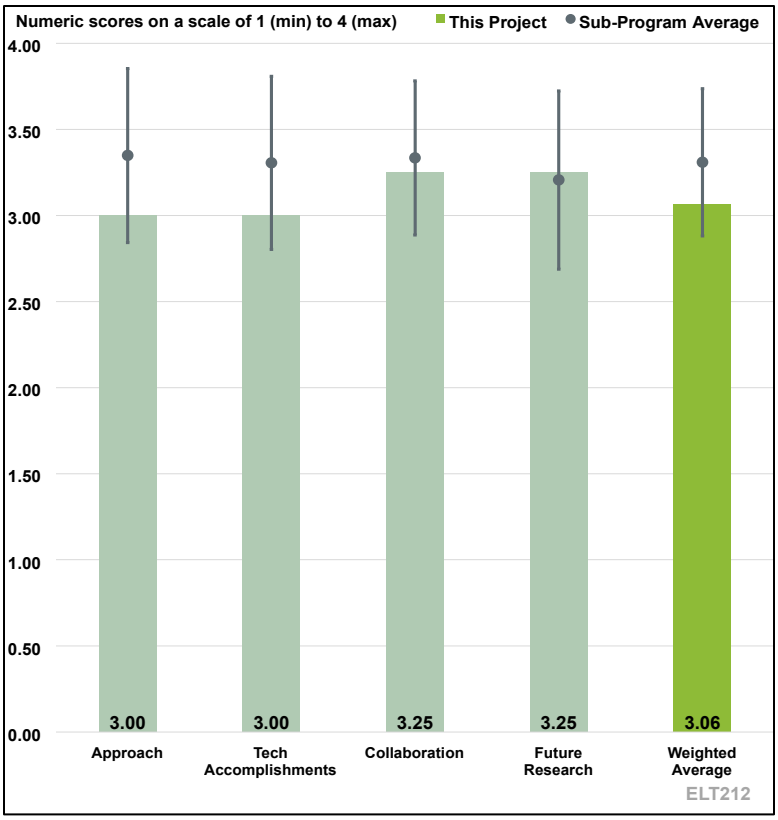

Figure 2-4. Presentation Number: ELT212 Presentation Title: Non-Heavy Rare-Earth High-Speed Motors Principal Investigator: Vandana Rallabandi, Oak Ridge National Laboratory

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

Reviewer 1

The reviewer asserted the approach for replacing rare heavy earth metals is rightly designed.

Reviewer 2

The reviewer noted the proposed design is very high risk and fairly complicated.

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

Reviewer 1

The reviewer noted communication of the results was very effective.

Reviewer 2

The reviewer cautioned rotor dynamics is a big risk that needs to be addressed. In addition, the very high fundamental frequency adds a lot of complications in terms of using Litz wire and very high level of magnet segmentation. The choice of a Halbach array also adds complications. Even though the focus is on improving the power density, the proposed design seems to be fairly complicated and expensive for traction applications, even though the integration concept of the motor and inverter has merit.

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

Reviewer 1

The reviewer remarked there was excellent collaboration.

Reviewer 2

The reviewer noted there seems to be a good collaboration among multiple organizations.

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

Reviewer 1

The reviewer observed the future work is clearly defined.

Reviewer 2

The reviewer noted a rotor spin test is planned, the project is near its end, and testing the prototype will be valuable.

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

Reviewer 1

The reviewer stated the project is relevant for VTO ELT technologies.

Reviewer 2

The reviewer asserted improving the system power density is important, but it comes at the expense of efficiency and the level of complication and cost.

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

Reviewer 1

The reviewer noted the project is sufficiently resourced.

Reviewer 2

The reviewer observed the project started in 2019 and is close to coming to an end.

Presentation Number: ELT215
Presentation Title: Develop fine-grain RE permanent magnet with high coercivity at high temperature AND cost-effective manufacturing process for high performance soft magnetic materials in thin sheet form
Principal Investigator: Iver Anderson, Ames Laboratory

Presenter

Iver Anderson, Ames Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

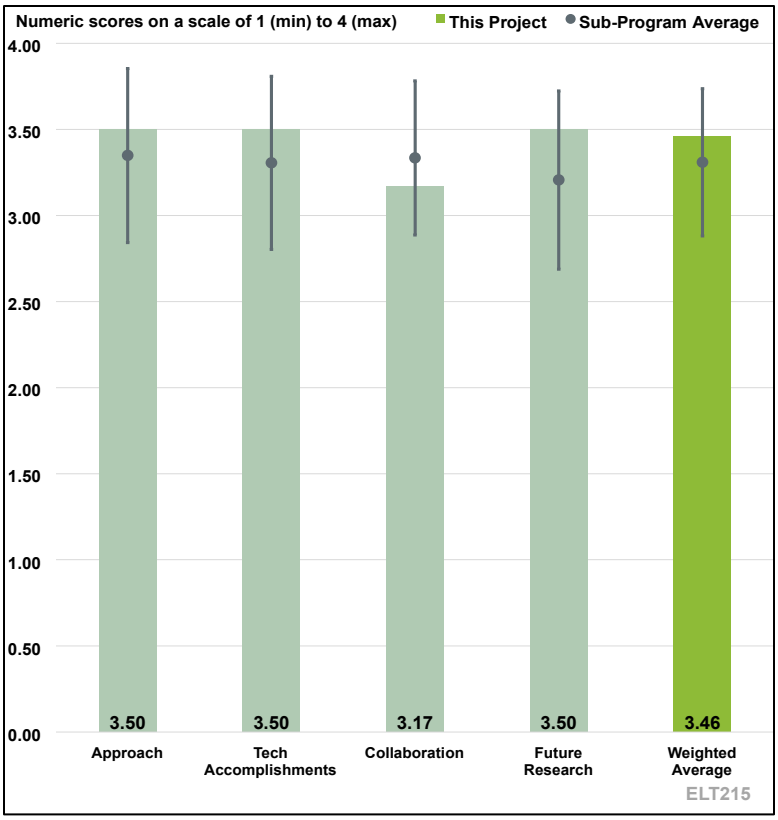

Figure 2-5. Presentation Number: ELT215 Presentation Title: Develop fine-grain RE permanent magnet with high coercivity at high temperature AND cost-effective manufacturing process for high performance soft magnetic materials in thin sheet form Principal Investigator: Iver Anderson, Ames Laboratory

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

Reviewer 1

The reviewer commented that goal is to develop high-energy-density PMs without expensive and scarce HRE elements. The project aims to develop ultrafine grain magnets that reduce PM motor eddy current losses at high speeds, which helps reduce the motor's cooling needs. The second part of the project develops soft magnetic materials using 6.5% Si content.

Reviewer 2

The reviewer observed the presentation covers two projects. The first project (Sustainable High Performance Magnetic Materials for Exceptional Power Density Electric Drive Motors) is focused on developing high performance motor materials and designs that can be locally sourced (from the U.S.) for energy security and to become a global supplier. The project leverages the expertise and facilities of Ames National Laboratory (Ames), NREL, ORNL, and SNL to do the work. The ultrafine grain HRE-free materials are a unique approach that can eliminate (or significantly reduce HRE use). The second project (Soft Magnets to Achieve High-Efficiency Electric Drive Motors of

Exceptional Power Density) is focused on developing a process to manufacture 6.5% Si steel (which improves motor performance) that can be mass produced.

Reviewer 3

The reviewer stated the goal of having HRE free magnets as well as thin laminations of 6.5% Si is an important one.

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

Reviewer 1

The reviewer observed the project processed commercial (HRE-free) powders (4 to 2.5 µm, 1-5 runs) with a new jet mill placed in a glove box. The project found that ultrafine powders (2.5 µm) resulted in more uniform size (improved coercivity) and rounded edges (better aligned). The project developed a modified jet milling system to passivate powder immediately post-milling.

Reviewer 2

The reviewer noted the first project's powder particle size processing/refinement and passivation process, and grain boundary engineering are impressive. The reviewer further noted the second project modified an existing melt-spinner to produce a low volume sample spool of the 6.5% Si steel showing the potential. The reviewer observed the project evaluated several alloying additions to improve performance, with the boron addition found to be beneficial and feasible.

Reviewer 3

The reviewer mentioned it is not clear how the expected properties and cost compare to what is commercially available.

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

Reviewer 1

The reviewer noted the project collaborates with: ORNL for motor design, NREL for mechanical modeling, and SNL.

Reviewer 2

The reviewer noted Ames is the lead, with ORNL, NREL, and SNL adding to the team with unique expertise and facilities. There appears to be good collaboration, with each laboratory contributing.

Reviewer 3

The reviewer observed there seems to be reasonable collaboration among multiple organizations.

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

Reviewer 1

The reviewer pointed out the project identified future research, remaining challenges, and opportunities. It appears that there are many important scientific observations and knowledge generation happened from this project. It appears that there is more research to be done in this area by solving the remaining challenges. For example, it is mentioned that there is more work to do to obtain ultrafine grain HRE-free PMs.

Reviewer 2

The reviewer noted the project is 94% complete. The presenter highlighted the remaining uncertainties in the findings that need to be better understood and then integrated into material supply and manufacturing processes to have a pathway to commercialization.

Reviewer 3

The reviewer noted it is important to be clear about the expected properties and how the result will be better than what is commercially available.

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

Reviewer 1

The reviewer noted the project is important because the proposed solution attempts to eliminate HRE elements, such as dysprosium, from PMs currently used in many electric vehicle (EV) traction motors.

Reviewer 2

The reviewer asserted the project is directly relevant to removing critical materials and HRE materials from magnets for improved cost and energy security. The reviewer mentioned soft motor material research is relevant to improving motor cost and performance. Both are critical (if successful and transitioned to industry to commercialize) for decreasing PEV costs.

Reviewer 3

The reviewer noted eliminating HRE material as well as having very low loss lamination have the potential of significantly improving the performance of high-speed motors.

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

Reviewer 1

The reviewer noted from the project presentation that multi-jet milling can produce ultrafine powders from commercial strip cast/heavy duty particles but handling the fine powder without the loss of properties to native oxidation remains difficult. The reviewer raised the question of whether additional investment can help to solve this issue.

Reviewer 2

The reviewer commented that the project includes very technical work, with unique facilities, labs, and staff, and the budget appears to be in line.

Reviewer 3

The reviewer noted resources seem to be sufficient.

Presentation Number: ELT216
Presentation Title: Isotropic Bottom-Up Soft Magnetic Composites for Rotating Machines
Principal Investigator: Todd Monson, Sandia National Laboratories

Presenter

Todd Monson, Sandia National Laboratories

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

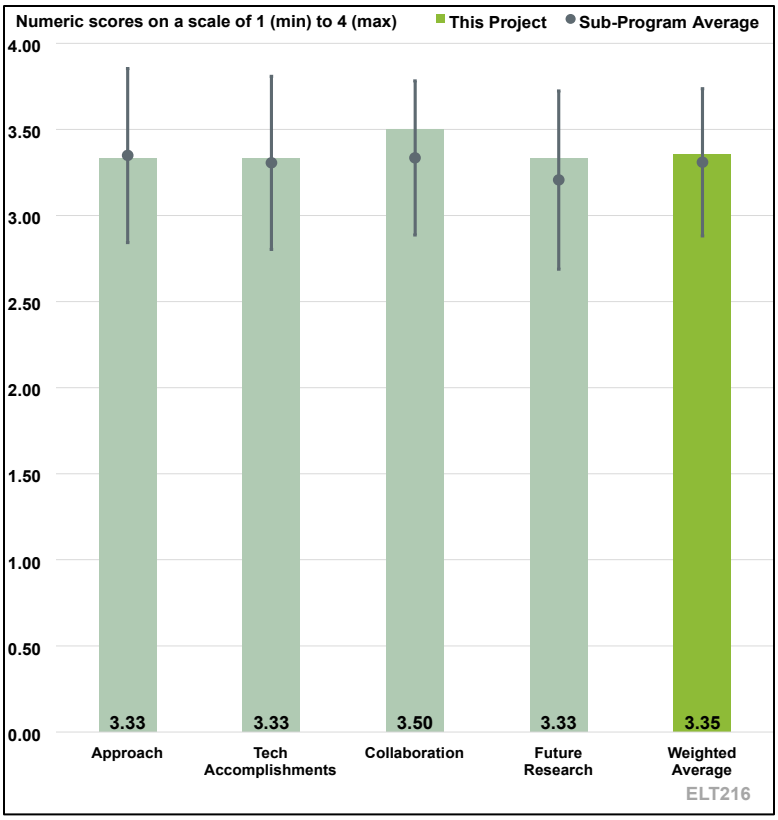

Figure 2-6. Presentation Number: ELT216 Presentation Title: Isotropic Bottom-Up Soft Magnetic Composites for Rotating Machines Principal Investigator: Todd Monson, Sandia National Laboratories

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

Reviewer 1

The reviewer noted the project aims to develop soft magnetic materials, which are timely subjects for electric machine design. The goal is to design machines without RE element materials, so it is important to design machines with soft magnetic materials. Dual homopolar machines without using PMs are proposed. A demonstration of net-shaped bulk iron nitride soft magnetic part consolidated using spark plasma sintering (SPS) and evaluation of saturation magnetic polarization is aimed.

Reviewer 2

The reviewer affirmed the approach of using low-cost materials (Fe, N) and composite (epoxy) to provide strength and durability to meet DOE targets and targeting near net shape to simplify manufacturing is good.

Reviewer 3

The reviewer remarked it was hard to tell if the proposed approach will lead to better properties compared to other available sheet molding compound (SMC) materials.

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

Reviewer 1

The reviewer observed the project received and installed SPS and received an initial Fe_4N sample fabricated using SPS. The project also worked with Ames to investigate SPS protocols for ultrafine-grained NdFeB.

Reviewer 2

The reviewer noted an example of the Fe_4N composite near net shape rotor was produced. Design improvements were identified to remove stress cracks.

Reviewer 3

The reviewer noted the saturation level of 1.18 T seems low and needs to be improved. Specific core loss data and mechanical properties are needed.

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

Reviewer 1

The reviewer expressed the project worked closely with Purdue University on machine design. It is nice to see that the development of new materials does not stay at the level of the material, but actual implementations of electric machines happen. This increases the impact of the project with the final product in mind. The project's collaboration with Purdue and other national laboratories is well described.

Reviewer 2

The reviewer expressed the team contributions were not described in detail but are described in the presentation. The project team seems to be a good combination of expertise, staff, facilities, which complement each other and do not duplicate.

Reviewer 3

The reviewer praised the good collaboration among multiple organizations.

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

Reviewer 1

The reviewer observed the project clearly defined the future work, including: the evaluation of SPS Fe_4N soft magnetic parts and the completion of fabrication and evaluation of ultrafine-grained HRE-free PMs. The reviewer further noted if the soft magnetic is implemented in the motor design by the end of this project, this will be a great accomplishment.

Reviewer 2

The reviewer noted the project was 94% done at the Annual Merit Review (AMR), so the final remaining items (Slide 17) are all that remain.

Reviewer 3

The reviewer said the specific core losses and mechanical properties are needed.

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

Reviewer 1

The reviewer noted the project is relevant as it tries to eliminate HRE materials from motor design, particularly PMs. Developing this soft magnetic material is very important for attaining machine design without HRE materials. This project aligns with DOE goal of reducing or eliminating HRE materials from motor designs.

Reviewer 2

The reviewer noted the project addresses identifying alternative motor (complete and component) designs and manufacturing approaches to remove/reduce RE materials from motor designs for cost and energy security reasons.

Reviewer 3

The reviewer observed that if the project results in an SMC with improved properties, this can potentially improve the performance of some high frequency electrical machines.

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

Reviewer 1

The reviewer commented that the project has sufficient resources to achieve the milestones. The project received the FUJI Dr. Sinter Lab Jr.^{TM} SPS and successfully used it in the project. Initial Fe_4N samples were fabricated using SPS.

Reviewer 2

The reviewer observed the presentation did not state the total project budget, but rather the (low) annual funding in the $125,000 to $150,000 range. Given this, and the relative high costs of national laboratories and universities, the project outputs are impressive.

Reviewer 3

The reviewer stated the resources are sufficient.

Presentation Number: ELT217
Presentation Title: Integrated/Traction Drive Thermal Management
Principal Investigator: Bidzina Kekelia, National Renewable Energy Laboratory

Presenter

Bidzina Kekelia, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

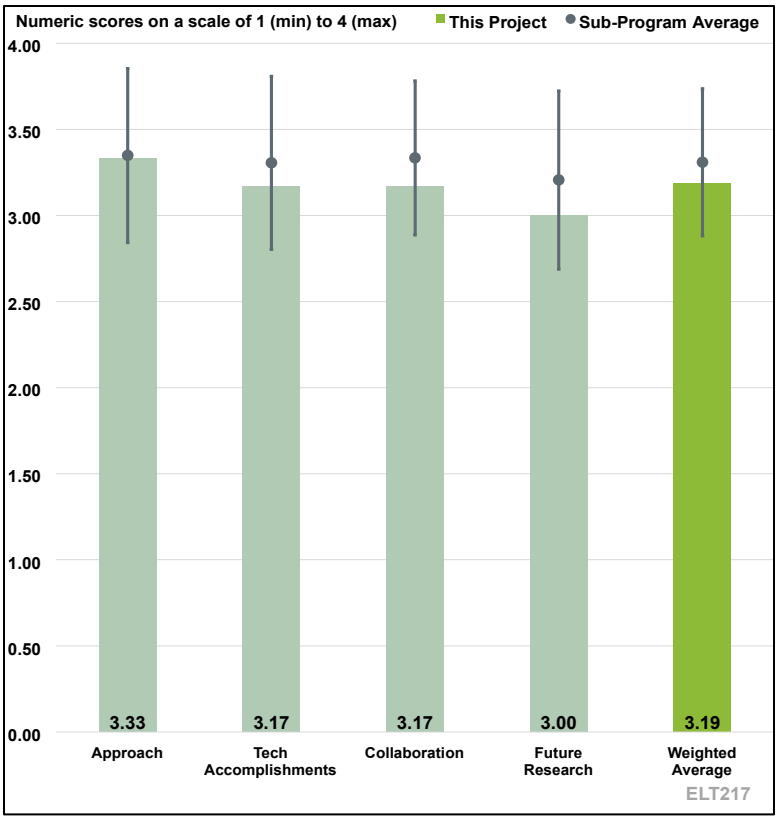

Figure 2-7. Presentation Number: ELT217 Presentation Title: Integrated/Traction Drive Thermal Management Principal Investigator: Bidzina Kekelia, National Renewable Energy Laboratory

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

Reviewer 1

The reviewer commented that the project had a well thought out approach for developing a thermal management system for the tractive drive, with the purpose of electric-drive integration and the power density increase. The approach includes various cooling strategies evaluation, cooling materials selection, and design, modeling and testing of the thermal management system.

Reviewer 2

The reviewer noted the proposed approach of embedding cooling in integrated drive/motor is challenging and ambitious but is a must for the future's high-voltage and high rpm EV powertrains.

Reviewer 3

The reviewer noted limitations in results exist in that the heat exchanges within the housing manufacturing made from ceramic aluminum with 3D printers within the aluminum oxide manifold were not completely leak proof and need continued testing. Also remaining challenges and barriers are in the material selection process with regards to cost reduction, power density reliability and lifetime thermal conductivity not short circuiting. The project appears to be well designed and the timeline reasonably planned for results in the short-term, but long-term results may differ.

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

Reviewer 1

The reviewer noted outstanding simulation work and excellent initial proof-of-concept experimentation.

Reviewer 2

The reviewer mentioned the technical progress is on track, as the project inputs have led to measurable milestones of generated output in the last 6 years and the project is 90% completed.

Reviewer 3

The reviewer commented that the project team has made reasonable progress in design and simulation of the thermal management system, but the challenge of the cracking during thermal post-processing does not seem to be resolved yet.

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

Reviewer 1

The reviewer observed that the team members are from national laboratories and universities. It is not very clear the tasks assigned to each of the partner. It seems there are two teams working in parallel on the design of the heat exchanger.

Reviewer 2

The reviewer noted excellent collaboration with the university and commercial partners.

Reviewer 3

The reviewer noted interactions and collaboration exist with multiple national laboratories as well as universities. Collaboration between laboratories and universities is sufficient for the needs of the project based on others conducting similar research projects, which can allow for comparison of results. More collaboration could possibly be used with reaching out to the housing manufacturer, EDM Technologies, to consider how to improve on existing limitations affecting results.

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

Reviewer 1

The reviewer commented that the team has identified a list of the remaining tasks, such as finalizing assembly of the coolant manifold disk, 3D printing of the heat exchangers, and finalizing the design and manufacturing of the cylindrical inverter housing. Considering the project timeframe, completing the listed tasks seem to be challenging.

Reviewer 2

The reviewer noted the purpose of future work is clearly defined. The likelihood of achieving future work will largely depend on the delivery of components from partners.

Reviewer 3

The reviewer noted future research and purpose will be to finalize system components and analysis of inlet/outlet of the thermal exchange in the production housing. Results of modeling are intended to be presented at the American Society of Mechanical Engineers (ASME) InterPACK Technology Conference in October 2024, but these proposed plans for future research to achieve meaningful

targeted results appear to be slightly ambitious and not completely attainable given the limited amount of time remaining until the next conference presentation and the amount of remaining technical challenges and barriers.

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

Reviewer 1

The reviewer stated that the project supports the aspect of transportation electrification in overall DOE objectives.

Reviewer 2

The reviewer affirmed the project supports the overall VTO ELT objectives.

Reviewer 3

The reviewer noted the project is very relevant to the overall VTO subprogram objectives, as developing a new technology for various methods of heat removal for cooling electric and power electronics components would generate a profound impact on the performance of machine systems in many industries and would indirectly improve supply chain manufacturing efficiencies and/or likely help improve the reduction of the carbon footprint output.

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

Reviewer 1

The reviewer stated that the resources for the project are sufficient, and the project is mostly on track.

Reviewer 2

The reviewer commented that more funding will help speed up the progress.

Reviewer 3

The reviewer observed multiple industry leading national laboratories and nationally recognized educational institution partners are collaborating on this project, so the resources provided appear to be sufficient to achieve stated milestones in a timely manner, as long as the goals are reasonable.

Presentation Number: ELT218
Presentation Title: Advanced Power Electronics Packages
Principal Investigator: Douglas DeVoto, National Renewable Energy Laboratory

Presenter

Douglas DeVoto, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

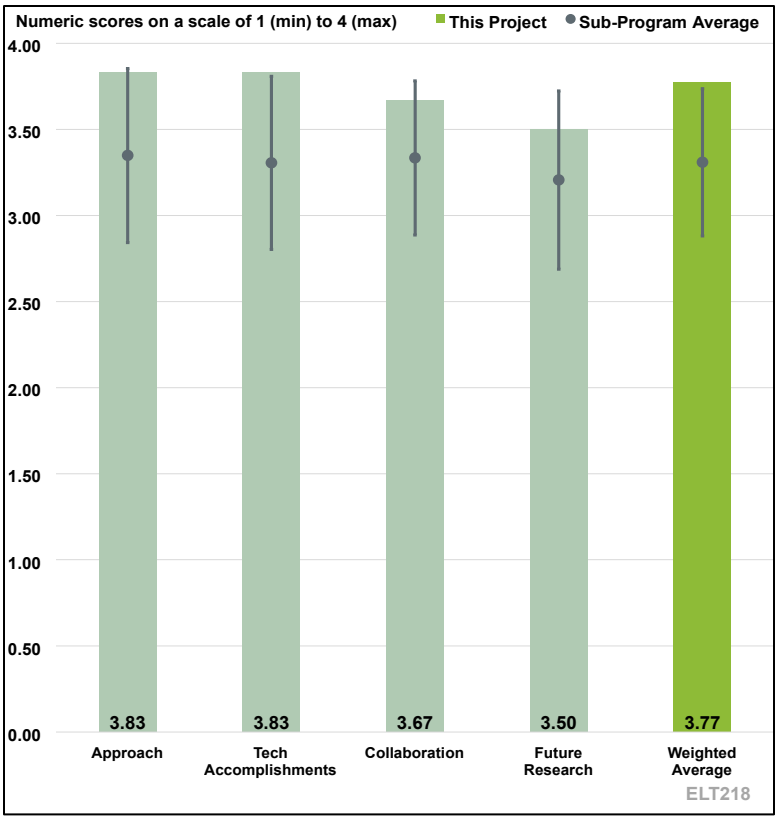

Figure 2-8. Presentation Number: ELT218 Presentation Title: Advanced Power Electronics Packages Principal Investigator: Douglas DeVoto, National Renewable Energy Laboratory

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

Reviewer 1

The reviewer noted the project is working towards new thermal packaging, which is a common challenge to achieving high power density and thermal performance. The new technology focuses on redesigning thermal substrate for high power chips. Use of a new unique material provides scope for lowering the device footprint. The timeline is reasonably planned.

Reviewer 2

The reviewer noted wide-gap semiconductors provide performance benefits (especially in power density), which can help in reaching VTO's power electronics performance targets; therefore, it makes sense to look for improved packaging designs, which can accommodate those semiconductors and to anticipate and address any issues that may be encountered in using them. This project seems to be well-focused on that singular objective. This reviewer found its approach and its sequence of steps to be logical and intuitive. Material analysis was conducted on polyimide to narrow optimum laser power and cutting speed; its stability was validated experimentally by fabricating a power electronics module in which it was incorporated, and multiphysics design optimization techniques were used in the design. The timeline seems to have been reasonably planned (although it was somewhat affected by unanticipated supply-chain issues).

Reviewer 3

The reviewer commented that the project addresses critical barriers associated with thermal performance and cost of packaged power modules for traction inverters.

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

Reviewer 1

The reviewer noted technical progress is adequate and as per the timeline.

Reviewer 2

The reviewer commented there was great progress made with testing DuPont's Temprion polyimide film.

Reviewer 3

The reviewer noted this multi-year project is now well into in its final year. It appears to have made excellent progress and completed many of the steps it set out to accomplish. However, thermal and reliability issues for the new packaging technology are not yet fully evaluated. Because the end objective is to demonstrate superior performance over traditional packaging in several areas (e.g., including superior thermal performance and greater reliability under thermal cycling, thermal aging, vibration, power cycling, and electrical high potential), it appears that a good amount of experimental work remains to be done, which might be challenging to complete in the relatively short amount of time remaining.

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

Reviewer 1

The reviewer observed this work is a major collaboration between NREL and ORNL, with support from industry partner DuPont. ORNL is involved from design perspective while NREL has been leading with material and component testing.

Reviewer 2

The reviewer noted NREL has maintained collaboration with two entities: DuPont and ORNL. DuPont provided the polyimide material, which met a basic need for this project, so that collaboration was essential. The contribution of ORNL is specified only broadly in the presentation but appears to have been in completing multiphysics modeling of the packaging system, an area in which ORNL may have good expertise. That expertise seems to have been well-utilized.

Reviewer 3

The reviewer mentioned there was great collaboration with university and commercial partners.

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

Reviewer 1

The reviewer noted proposed future research carries forward this work to device testing of the component. Future work is very likely to achieve its targets.

Reviewer 2

The reviewer commented future work was clearly defined.

Reviewer 3

The reviewer observed this multi-year project is now currently in its final year, so ideally not too much future research would remain. However, thermal and reliability issues for the new packaging technology have not yet been fully evaluated and might require more time to complete. Because the end objective is to demonstrate superior performance over traditional packaging in several areas (which require experimental work) it might be challenging to complete all of that in the relatively short amount of time remaining.

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

Reviewer 1

The reviewer mentioned the project aims to meet VTO ELT subprogram goals. Thermal design is very important and relevant technical work for achieving high power density targets.

Reviewer 2

The reviewer observed decreasing the thermal resistance pathway in power electronics packages is crucial to maximizing the performance of wide-bandgap devices. This can be accomplished by either replacing package layers with new materials that enable greater thermal, electrical, and reliability performance or eliminating layers and components through new packaging designs. Safe and robust operation of the power electronics requires electrical isolation of the high-voltage circuitry within the power electronics module and other considerations related to performance. Therefore, this reviewer considers this project as highly relevant to VTO ELT subprogram objectives.

Reviewer 3

The reviewer mentioned the project supports the overall VTO ELT objectives.

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

Reviewer 1

The reviewer commented that the project is adequately resourced.

Reviewer 2

The reviewer noted this is a six-year project (now in its final year) in which DOE put in $1 million. Of that, $150,000 was spent during the final year. So, the spending rate seems to have been well-matched to the resources that were planned.

Reviewer 3

The reviewer mentioned more funding would help speed up the progress.

Presentation Number: ELT221
Presentation Title: Integrated Electric Drive System
Principal Investigator: Shajjad Chowdhury, Oak Ridge National Laboratory

Presenter

Shajjad Chowdhury, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

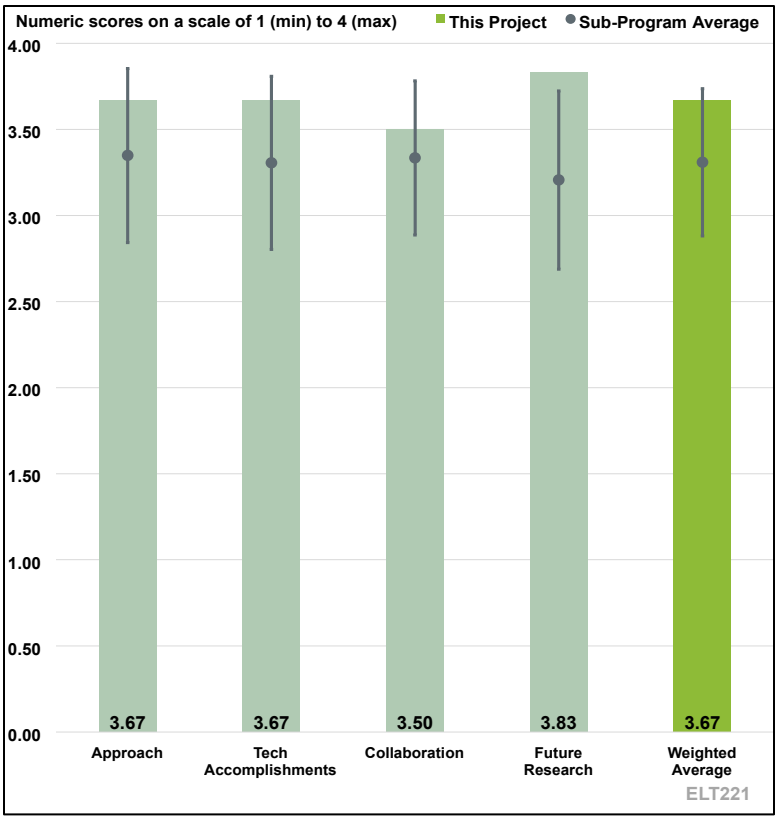

Figure 2-9. Presentation Number: ELT221 Presentation Title: Integrated Electric Drive System Principal Investigator: Shajjad Chowdhury, Oak Ridge National Laboratory

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

Reviewer 1

The reviewer commented the project targets designing and testing of motor and power electronics components in the electric drivetrain using newly designed materials and parts. It is well designed to provide an integrated view of the drivetrain. The project is well designed, and the most important technical barriers are addressed to enable high power density.

Reviewer 2

The reviewer noted 2025 DOE targets for motor drive for power-density is 33 kW/L. Putting an inverter in the cavity of the outer rotor motor will eliminate connectors and cables between the inverter and motor power terminals, resulting in development of a drive system that meets this power density target (33 kW/L). The project approach and technical progress are towards 33 kW/L power-density target. The reviewer questions whether the “commercialization pathway should be described in future reports submitted to DOE.”

Reviewer 3

The reviewer asserted this is an ambitious project that integrates active, passive, sensing, protection, and cooling elements of an electric drive, which is necessary for increasing the power density.

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

Reviewer 1

The reviewer noted the project designed a power block and various components that enable high power density performance. A new cooling design has been invented to address rotor-stator-power module geometry.

Reviewer 2

The reviewer commented that direct bonded copper and substrate assembly is characterized (power loss versus device temperature rise) over 25º C to 65º C coolant temperature. Static and dynamic performance evaluations of power module are completed. The power module front end module is completed. The Pro-E assembly of the power block is included in Slides 13 and 14 of the project report and looks quite impressive.

Reviewer 3

The reviewer noted great progress with the assembly and testing of the integration effort.

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

Reviewer 1

The reviewer observed this project includes collaboration among ORNL, NREL and Ames. Direct involvement of an industry partner would be beneficial.

Reviewer 2

The reviewer noted NREL, SNL and Ames are contributing to execution of project activities.

Reviewer 3

The reviewer mentioned great collaboration with all the partners.

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

Reviewer 1

The reviewer commented proposed future research will help in achieving 100 Kw/L power density. Future work is likely to achieve its target.

Reviewer 2

The reviewer noted electrical and thermal performance of the developed power boards of the inverter will be characterized. A prototype of a six-phase inverter will be assembled, followed by the inverter characterization.

Reviewer 3

The reviewer affirmed the future plan was clearly defined.

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

Reviewer 1

The reviewer stated the project is very relevant to the ELT subprogram.

Reviewer 2

The reviewer concluded the project activities are related to DOE 2025 targets for electric drive that include both inverter and motor.

Reviewer 3

The reviewer mentioned the project supports the overall VTO ELT objectives.

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

Reviewer 1

The reviewer said the resources for the program are sufficient.

Reviewer 2

The reviewer commented that the project team is staffed enough and has necessary financial resources. ORNL has excellent facilities to successfully execute tasks of this project.

Reviewer 3

The reviewer mentioned the project resources are sufficient.

Presentation Number: ELT236
Presentation Title: Direct-Current Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture
Principal Investigator: Watson Collins, EPRI

Presenter

Krish Gomatom, EPRI

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

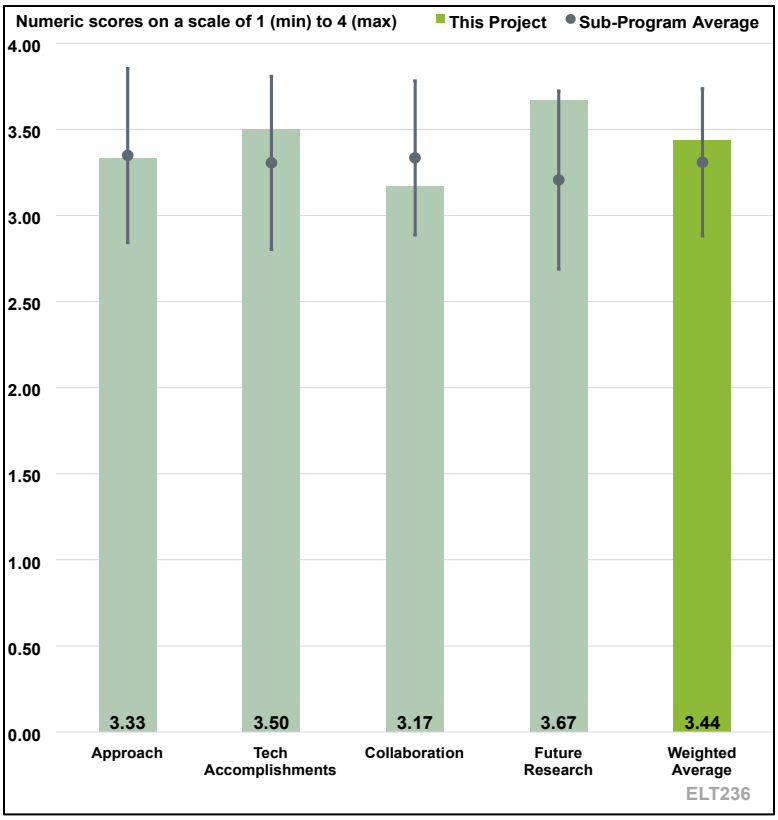

Figure 2-10. Presentation Number: ELT236 Presentation Title: Direct-Current Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture Principal Investigator: Watson Collins, EPRI

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

Reviewer 1

The reviewer commented that the approach taken by the research team is sound and effective.

Reviewer 2

The reviewer noted the approach was excellent on developing a foundational system for direct current (DC) connected EV charging that integrates with devices such as distributed energy resources (DERs), solar, wind and energy storage. The project addressed technical barriers of producing a 1 MW DC charging system. In relevance to DOE Grid and Charging Infrastructure Program Goals of developing an extreme fast charging (XFC), this project develops and tests DC technologies for XFC while minimizing impacts to the grid. This research helps to identify opportunities for interoperability and technical transfer activities. It also provides opportunity for EV grid integration and services. DC technologies could facilitate the integration of DERs to minimize the impact on the grid.

Reviewer 3

The reviewer said the technical and practical barriers to success were sizeable. Loss of a supplier for the solid-state transformer (SST) is a notable setback, and supply chain issues are a broad challenge to EV grid and infrastructure development. The pending success of the team securing a new SST vendor will speak for itself. The timeline seemed reasonably planned, with understandable adjustments given the unforeseen supplier and supply chain hurdles. Still, the work is timely and critical to help reduce cost and increase economic efficiency of EV charging infrastructure.

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

Reviewer 1

The reviewer said there was strong progress and accomplishments by the team.

Reviewer 2

The reviewer noted the technical accomplishments and progress in this project are excellent. The SST providing a medium-voltage converter module design has been completed and prototype cells are tested. The team evaluated multiple vendors capable of supplying an SST prototype solution. The project is significantly behind schedule due Covid-19 supply chain issues and vender churn rates.

Reviewer 3

The reviewer mentioned supplier and supply chain challenges notwithstanding, substantial progress was evident in this project, and it appears to be headed toward completion, though with a tight timeline ahead. Completions of designs and prototypes for the SST and DC load center support this, as has the delivery of the load center to NREL for standalone testing.

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

Reviewer 1

The reviewer noted collaboration across teams is good.

Reviewer 2

The reviewer commented that the collaboration has been excellent with the core group. The reviewer noted the Electric Power Research Institute (EPRI), as the Project Lead, Tritium, NREL, Argonne National Laboratory (ANL) and Missouri University of Science and Technology have all been good partners. There needs to be a stronger vetting process for contract vendors.

Reviewer 3

The reviewer mentioned the progress was understandably impeded by the loss of a hardware supplier partner. It is unclear if the project team could have known the likelihood of this loss in advance, but this could speak to room for improvement in selection/collaboration of the team.

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

Reviewer 1

The reviewer noted proposed future work is good.

Reviewer 2

The reviewer commented future research includes additional integration testing of DC microgrid with medium voltage converters, testing of hybrid plants within a DC microgrid, and analysis of dynamic response of multi-level converters to unexpected system conditions and failure modes. Reliability and resiliency monitoring of the DC infrastructure and DC distribution for fleet EV charging also needs to be analyzed.

Reviewer 3

The reviewer noted proposed future work, including new integration testing, hybrid plants, failure mode/reliability/resiliency monitoring are all critical. Megawatt charging (MWC) with fleet tests will be essential contributions.

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

Reviewer 1

The reviewer commented that the project supports infrastructure development for fast charging.

Reviewer 2

The reviewer said the project is very relevant to relief of the grid to provide charging infrastructure for EV charging. This project develops and tests DC technologies for XFC while minimizing impacts to the grid.

Reviewer 3

The reviewer noted reducing the complexity and cost of AC/DC conversion equipment for XFC sites is highly relevant to VTO objectives. The importance of EV charging infrastructure refinement cannot be overstated.

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

Reviewer 1

The reviewer mentioned resources provided for this project appear to be adequate.

Reviewer 2

The reviewer noted the project has sufficient resources.

Reviewer 3

The reviewer mentioned additional resources for this project and the future research areas identified by the team will be research funds well spent.

Presentation Number: ELT238
Presentation Title: Intelligent Grid-Friendly Modular Extreme Fast Charging System with Solid-State Direct-Current Protection
Principal Investigator: Srdjan Lukic, North Carolina State University

Presenter

Srdjan Lukic, North Carolina State University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

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

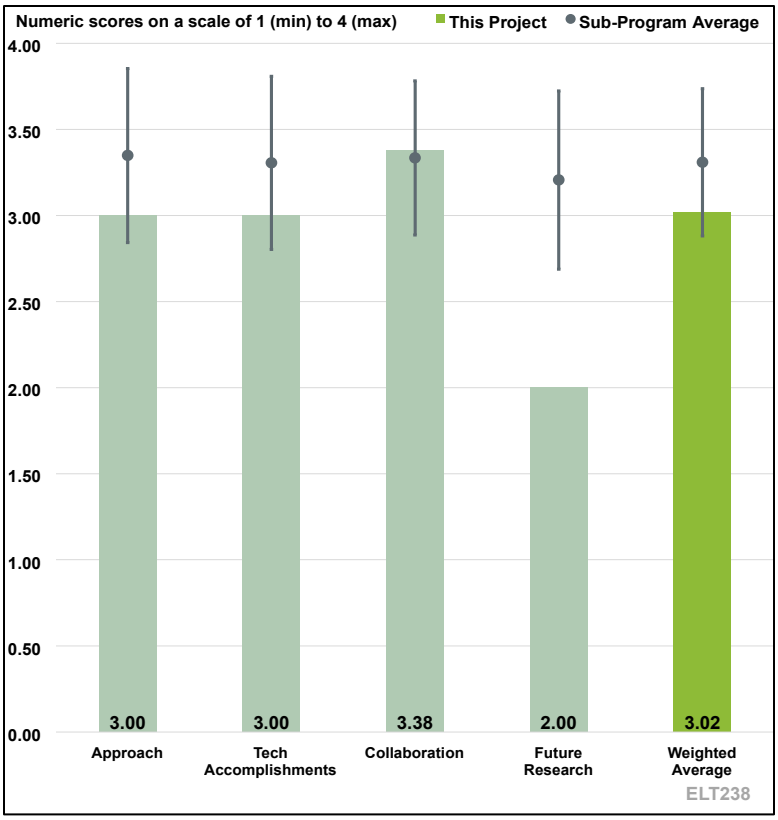

Figure 2-11. Presentation Number: ELT238 Presentation Title: Intelligent Grid-Friendly Modular Extreme Fast Charging System with Solid-State Direct-Current Protection Principal Investigator: Srdjan Lukic, North Carolina State University

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

Reviewer 1

The reviewer commented that the proposed modular XFC system appears to be a good and timely approach to address the barriers of integration of charging infrastructure at distribution voltage levels and DC protection.

Reviewer 2

The reviewer noted the project was able to accomplish the main goal of SST and DC distribution.

Reviewer 3

The reviewer noted the barriers are addressed well through the development, testing, and demonstration of the megavolt (MV) to DC charger, and the DC protection system. The potential cost increase or decrease is very important, but it does not appear to be within the scope of the project.

Reviewer 4

The reviewer commented that although there was a complete program plan, it relied on success at every level, including part lead times, cost and quality construction. When working with full prototype

systems additional time for optimal tuning of required systems and the possibility of delays in parts is recommended.

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

Reviewer 1

The reviewer commented that the project was completed by meeting all the project objectives and well addressing the barriers such as the system integration.

Reviewer 2

The reviewer commented that the project has a deployed system and has secured additional funding for future deployment.

Reviewer 3

The reviewer mentioned there were good technical accomplishments presented, showing the laboratory evaluation of prototype a megavolt (MV) SST, active front end (AFE), and the SST. The reviewer noted the field deployment was stopped due to a transformer failure and planned for re-deployment in fall 2024. The field demonstration was not accomplished within this project.

Reviewer 4

The reviewer commented that the ability of the team to overcome the transformer failure and incorporate a new design is noted as a success, but the chance of having a fully tested system is in jeopardy. The project made good advancements in a number of areas, but it is hard to deem the project as successful due to the limited testing.

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

Reviewer 1

The reviewer observed that the team members are from a university, industry and power authority. Each team member has contributed to the project from different perspectives, such as design, testing, and deployment, which indicates an effective collaboration.

Reviewer 2

The reviewer noted strong partnerships with North Carolina State University, and New York Power Authority.

Reviewer 3

The reviewer remarked that the team was comprised of the necessary organizations for the proper design, development, evaluation, and demonstration of the technology at the 1 MW scale.

Reviewer 4

The reviewer said although the team members seemed to complete most of their stated tasks, when some difficulties were encountered by the lead team, there might have been opportunity for other partners to leverage supply chain or technical design resources to facilitate a more robust design option or to alleviate parts shortage issues.

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

Reviewer 1

The reviewer observed the project has ended. The team has clearly identified a list of the future work, which appear to be appropriate and well thought out.

Reviewer 2

The reviewer stated not applicable.

Reviewer 3

The reviewer mentioned the proposed future work includes the re-deployment of the system in fall 2024, but noted the project is listed as 100% complete and raised the question of how this re-deployment will be accomplished.

Reviewer 4

The reviewer noted continued testing with designed and fabricated componentry would yield valuable information to the community with regards to SST, AFE and solid-state protection. The plan was not well described for fall 2024 redeployment, and with funding spent, it may be difficult for the team to follow through with future research plans.

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

Reviewer 1

The reviewer stated that the project supports the overall DOE objectives, in the aspect of transportation electrification. The proposed XFC system particularly supports the aspects of smaller system footprint and higher efficiency at lower system-level cost.

Reviewer 2

The reviewer noted the project supports VTO program goals for ELT.

Reviewer 3

The reviewer observed the reduction of the number of conversion stages from the grid distribution feeder to the EV charging infrastructure directly supports DOE objectives for improving efficiency and potentially improving costs.

Reviewer 4

The reviewer pointed out that technologies that advance the state of the art for high power charging deployments are all relevant as DOE looks to gain knowledge with industry as to the capabilities and flexibility of designs intended to expand the adoption of EVs. Examples of high-power chargers connected to MV utility lines offer advantages in deployment time, cost and efficiency.

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

Reviewer 1

The reviewer stated that the resources for the project are sufficient, and the project has completed by meeting all the objectives and addressing the barriers.

Reviewer 2

The reviewer noted overall resource commitment to the project was sufficient when initially funded. Circumstances changed during the program (many programs were affected) due to Covid-19 and supply chain issues, which impacted the program deliverables.

Reviewer 3

The reviewer mentioned resources are sufficient given the power level and size of the technology development and demonstration (approximately 1 MW). However, the field demonstration was not successfully accomplished in the project.

Reviewer 4

The reviewer noted the inability of the team to complete the project was impacted by funding levels, but it was not the primary reason for the incomplete results. The focus now would be whether the redeployment has the opportunity to be field tested and how those results are reported.

Presentation Number: ELT262
Presentation Title: Long-Range Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging
Principal Investigator: Ryan Reed, Kenworth

Presenter

Ryan Reed, Kenworth

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

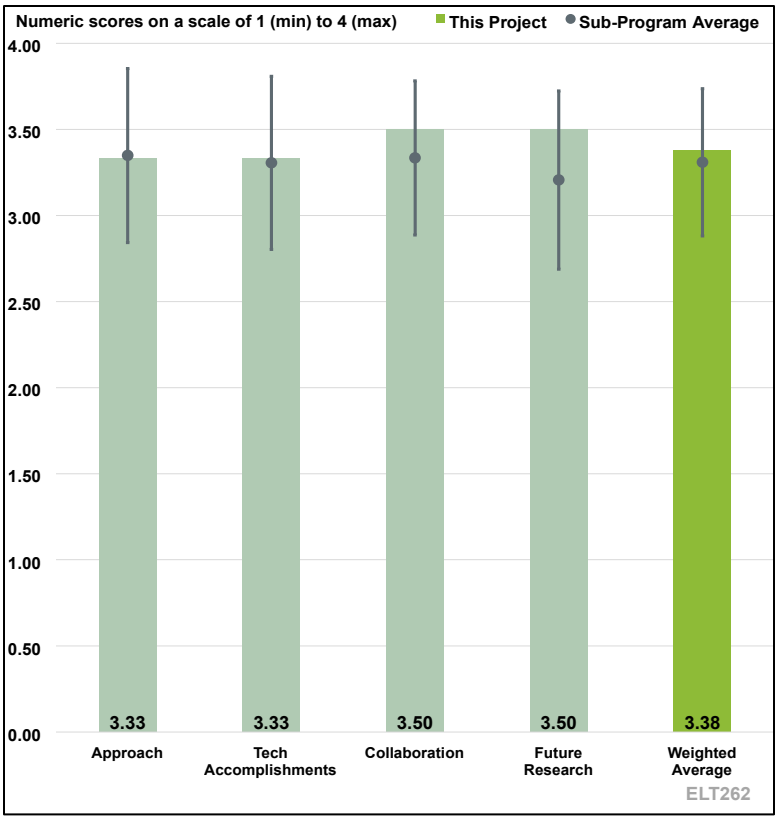

Figure 2-12. Presentation Number: ELT262 Presentation Title: Long-Range Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging Principal Investigator: Ryan Reed, Kenworth

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

Reviewer 1

The reviewer commented that the approach is excellent by starting with laboratory testing while designing the vehicle system for testing. The static is well defined, but the dynamic could use some definition as to the length of the primary coil for the road. The SAE J2954/2 standard identifies up to 500 kW power. The reviewer asked the question as to whether 1 MW is being proposed for the next update.

Reviewer 2

The reviewer praised the adjustments made by the project team, given this project is at 85% complete, like moving to an e-axle and moving to Utah instead of just plowing forward without regards to the outcomes for the project.

Reviewer 3

The reviewer praised the researchers for their thorough understanding of the many difficulties involved in carrying out their proposed plan and excellent team to address the challenges. However, the reviewer could not tell from the level of detail in the review document how the major issues are being attacked. For example, the truck needs a better, lighter battery, and it was not clear how this would be achieved.

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

Reviewer 1

The reviewer pointed out the equipment and laboratory effort show excellent planning, but also noted adding modeling of the efficiency, misalignment tolerance, and electromagnetic compatibility (EMC) levels should also be included. A comparison of using 500 kW energy transfer or other power levels to meet the goals should also be included. Size and weight of the secondary coil should be included in the presentation. Including polyphase is a proven means to reduce coil size and EMC and a good choice. There was no mention on how megawatt charging system (MCS) will be used for comparison to wireless power transfer (WPT). Is the MCS added to the United Transportation Union (UTU) site or used on the route?

Reviewer 2

The reviewer noted the team is finalizing the deliverables to complete the final testing to prove the project meets expectations 2 phase-shift operations, etc.

Reviewer 3

The reviewer observed all major issues are being addressed and most milestones have been met, but the remaining timeline seems to be overly optimistic. All of the major components have been designed, but there are key parts that have not been built yet, let alone installed. And there are still issues with actually getting stuff delivered. Permits are not in place, which could be a showstopper. The project started in 2019 and is supposed to end this calendar year, with a number of key milestones—installation, testing, operation—having been completed. The reviewer questioned how many milestones will be achieved. Perhaps the original schedule was unrealistic.

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

Reviewer 1

The reviewer commented that updating the Utah State University site is a good means to leverage existing effort while updating the power level. The goal is targeted at demonstrating a known route with mature suppliers to meet project goals using static, dWPT along with the MCS option.

Reviewer 2

The reviewer noted there appeared to be good cross collaboration on the project in general and on specific decisions that were made that the PI shared. The reviewer would have liked to see more evidence supporting this. The reviewer would like to see in future AMRs more specifics about what the project achieved.

Reviewer 3

The reviewer commented that the team has excellent skills, and all of the key areas seem to be well covered. The reviewer reiterated that installing and testing the equipment in the truck is the best proof of potential outcome.

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

Reviewer 1

The reviewer remarked that combinations of primary and secondary coils could be useful (circular, double D and polyphase). Perhaps a mix of power levels between the primary and secondary coils and their efficiency results could also be useful.

Reviewer 2

The reviewer noted there remains a good bit of work to complete on this project, and planned efforts could overrun or not be completed given 15% of the overall budget is remaining.

Reviewer 3

The reviewer observed the goals are clear and appropriate but noted there is insufficient technical detail to judge whether the goals, in terms of charging speed and range, can be achieved from this work. The reviewer suspects the project may not meet its schedules.

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

Reviewer 1

The reviewer observed that higher power is identified for this class of delivery vehicles. The reviewer noted 200 kW was identified in the past as the optimal power level and a comparison to 1 MW results is needed along with effects of route distance and terrain variations.

Reviewer 2

The reviewer commented that full electrification of heavy-duty (HD) trucks is a key goal useful for achieving decarbonization of transportation. Key issues are sufficient range and charging speed, both of which are addressed by this project.

Reviewer 3

The reviewer did not complete their remark.

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

Reviewer 1

The reviewer observed this project has managed resources between labs, suppliers, vehicles and test sites to maintain the full spectrum of effort required.

Reviewer 2

The reviewer noted the resources seem sufficient but is concerned about the project finishing.

Reviewer 3

The reviewer stated it is difficult to answer this question without additional detail on the costs of individual components of the program. Some of the costly components have not yet been built.

Presentation Number: ELT264
Presentation Title: Demonstration of Utility Managed Smart Charging for Multiple Benefit Streams
Principal Investigator: Stephanie Leach, Exelon/Pepco Holdings Inc.

Presenter

Stephanie Leach, Exelon/Pepco Holdings Inc.

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

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

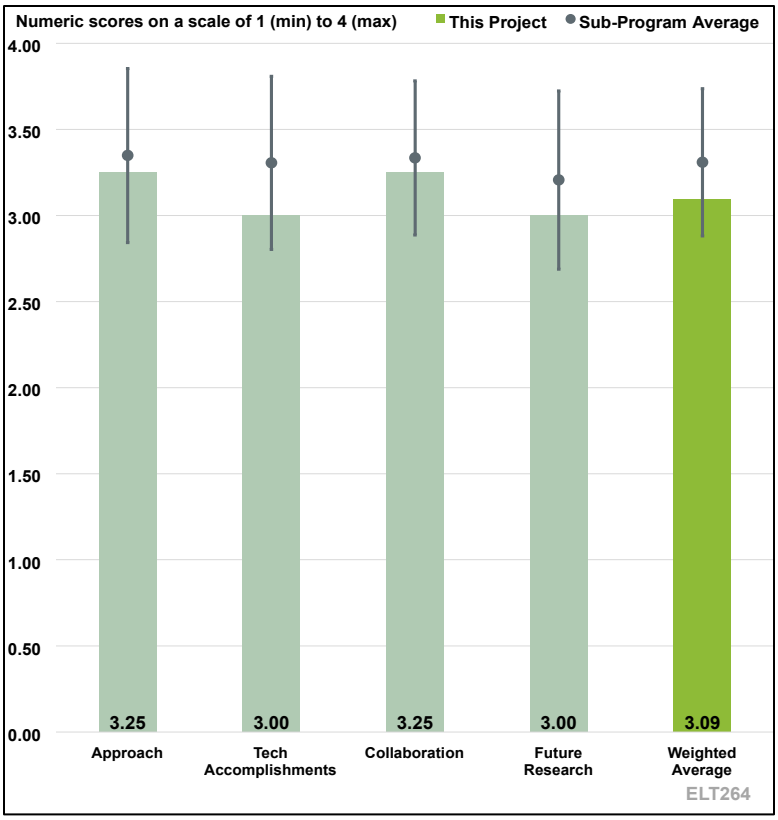

Figure 2-13. Presentation Number: ELT264 Presentation Title: Demonstration of Utility Managed Smart Charging for Multiple Benefit Streams Principal Investigator: Stephanie Leach, Exelon/Pepco Holdings Inc.

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

Reviewer 1

The reviewer noted the barriers of smart charge management (SCM) across residential, commercial, and public charging infrastructure are addressed through collection of customer data and modeling/simulation.

Reviewer 2

The reviewer remarked that most vehicles already have time of day and time of departure charging. This system uses similar techniques to manage grid loads and cost. The reviewer added that if this system is dropping customers from the best charging rate times so that the overall load is balanced, the customers could opt out more and force charging if cost savings are better than the rebate.

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

Reviewer 1

The reviewer noted excellent technical accomplishments were demonstrated by the residential program. Numerous customers were enrolled, and operational data was collected on time-of-use (TOU), Pennsylvania-New Jersey-Maryland Interconnection, and distributed asset protection. Replacing the commercial program with a vehicle-to-home (V2H) program is appropriate. No

accomplishment yet shown for V2H program as recruitment starts spring 2024.The presentation does not show accomplishments for the cyber-physical security (CPS) threat model, vulnerability assessment, and resilience matrices. Have the results and findings been published? (i.e., recommended best practices, findings or lessons learned, etc.). Was this work executed in previous years of the project (Budget Period [BP] 2 or BP 3), or is the cyber threat model development a future task?

Reviewer 2

The reviewer noted that while vehicle-to-gird (V2G) is not part of the project, promoting V2H will help getting to a more robust V2G solution.

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

Reviewer 1

The reviewer commented that the team is comprised of the necessary members to successfully complete the project goals.

Reviewer 2

The reviewer observed that all contributors are communicating and producing results as described by the presenter.

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

Reviewer 1

The reviewer noted the proposed future work of sharing the key outcomes from the cost benefit analysis is very important and beneficial. The addition of the V2H demonstration and operation is also appropriate for future work. The reviewer raised the questions of whether cybersecurity and CPS findings and best practices will be reported/published from the phases of the project (including residential, commercial, public, and newly added V2H residential). The reviewer noted the project was reviewed in 2023 but there are no responses to previous reviewer comments. [DOE Program Clarification: 2023 AMR comments were not available to PIs prior to the 2024 AMR.]

Reviewer 2

The reviewer noted the project is ending in 2024.

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

Reviewer 1

The reviewer commented that the project scope directly supports VTO’s mission to improve the cost and benefits of EV charging infrastructure.

Reviewer 2

The reviewer noted the project will help with decarbonization of energy use as it will provide more reliable grid to charge EVs.

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

Reviewer 1

The reviewer remarked that resources are sufficient to complete the project goals.

Reviewer 2

The reviewer commented that the project is concluding in 2024.

Presentation Number: ELT265
Presentation Title: A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicle's-At-Scale
Principal Investigator: Duncan Woodbury, Liberas

Presenter

Duncan Woodbury, Liberas

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

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

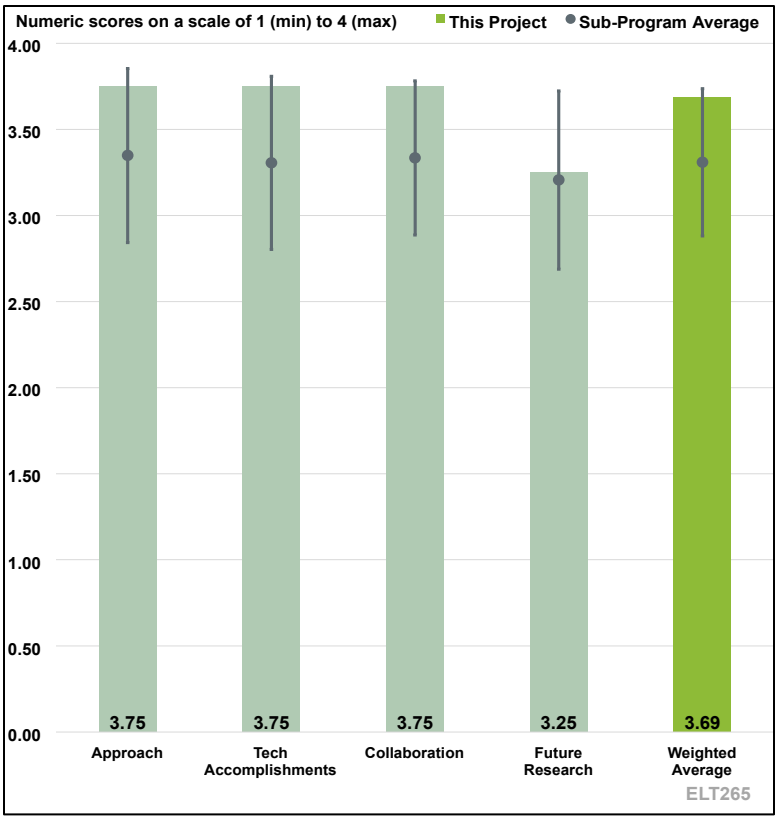

Figure 2-14. Presentation Number: ELT265 Presentation Title: A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicle's-At-Scale Principal Investigator: Duncan Woodbury, Liberas

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

Reviewer 1

The reviewer remarked that the implementation of a flexible middleware layer relies on the OpenFMB standard. This approach is appropriate given the diverse mix of system interfaces and applications being integrated. The project is on track timewise.

Reviewer 2

The reviewer commented that the project has clearly identified objectives, including to research and develop "an open source SCM system based on existing open standards with secure interoperability solutions that provide a standardized, extensible, and scalable interface to interact with legacy, modern, and future energy operational technology (OT) assets." The reviewer noted the project has clearly identified key barriers, including the lack of a standard interface, non-interoperability, and non-standardization of control/communication interfaces. The technical approach is presented at a high-level through five primary steps. The reviewer also noted the project and timeline appear well planned over a five-year period, evolving from demonstration of the OpenFMB implementation, laboratory demonstration of project use cases, and demonstration of system achievement of project goals. The reviewer concluded that each phase culminates with a go/no-go milestone and the identified sub-activities appear logical and appropriate.

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

Reviewer 1

The reviewer noted the primary objective of the project to demonstrate SCM over a widely distributed network of devices was achieved. The project tasks for BP 1 and BP 2 were completed successfully and the current tasks appear to be on track.

Reviewer 2

The reviewer concluded this project achieved prolific technical progress and appears on track to achieve its objectives. Recent accomplishments include: (1) first ever implementation of a remote SCM interface for a dWPT system, demonstrating relevance to multiple market segments and key industry-transforming technologies; (2) fielding and demonstrating the SCM, interoperability, and cybersecurity capabilities in six technology readiness level (TRL) 6 sites under a wide variety of scenarios; (3) transitioning to two wide-scale demonstration partners (Newlab and Michigan Central) with configurations for demonstration of more than 50 ports in 2024, as well as formalization of a partnership agreement for further wide-scale demonstration. The reviewer concluded by saying this was an impressive list of accomplishments over the last year.

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

Reviewer 1

The reviewer noted that the relevant partners needed have been assembled for a demonstration of the technology (a utility, software developers, NREL, and ORNL).

Reviewer 2

The reviewer observed the project has a well-balanced and diverse project team, which includes a utility; two demonstration partners; three industry partners to support system integration, cybersecurity, and technology demonstration; and two laboratory partners for modelling, simulation, dWPT integration, and cyber testing. The reviewer noted sufficient collaboration across the spectrum of project requirements is demonstrated, with no notable deficiencies.

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

Reviewer 1

The reviewer mentioned that the next steps are appropriate to further the work already completed. There seems to be an issue with getting EV drivers to sign up for the demonstration.

Reviewer 2

The reviewer noted the remaining challenges and barriers are identified at a high level, with “Integration with utility protection control systems” and “Integration in live DSO/ISO market programs” particularly noteworthy. The reviewer remarked that Further details and discussion with respect to specific challenges of integration, regulatory aspects, and cybersecurity, and how they will be overcome, would have been beneficial. The reviewer also noted the balance of activities for Fiscal Year (FY) 2024-FY 2025 appear to be continuation of the SCM platform integration and widescale demonstration of 50 or more charge points (CP)/DER and additional grid services. The reviewer expressed the expectation the project will successfully achieve these ends but noted the identification/development of a critical path/roadmap is needed to further achieve commercial viability and widespread implementation of the EVs-at-RISC SCM platform.

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

Reviewer 1

The reviewer noted the project supports development of flexible EV charging infrastructure that can leverage widely distributed resources to achieve the desired charging demand.

Reviewer 2

The reviewer remarked that successful development and implementation of SCM is essential to enable widespread EV market penetration, relatively seamless vehicle grid integration (VGI), and minimize impacts to the grid. Furthermore, SCM is essential to enable broad vehicle-to-everything (V2X) application.

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

Reviewer 1

The reviewer commented that the budget appears adequate to complete the tasks described. The PI did not mention budgetary constraints in implementing the work.

Reviewer 2

The reviewer noted this project is sufficiently resourced to meet its current objectives and milestones. Significant value has been achieved from VTO's investment in the EVs-at-RISC SCM platform. The reviewer also said additional resources should be considered for identification/development of the critical path/roadmap to overcome remaining technical and non-technical barriers to achieve widespread implementation.

Presentation Number: ELT274
Presentation Title: eMosaic Electrification Mosaic Platform for Grid-Informed Smart Charging Management
Principal Investigator: James Stoupis, ABB

Presenter

James Stoupis, ABB

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

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

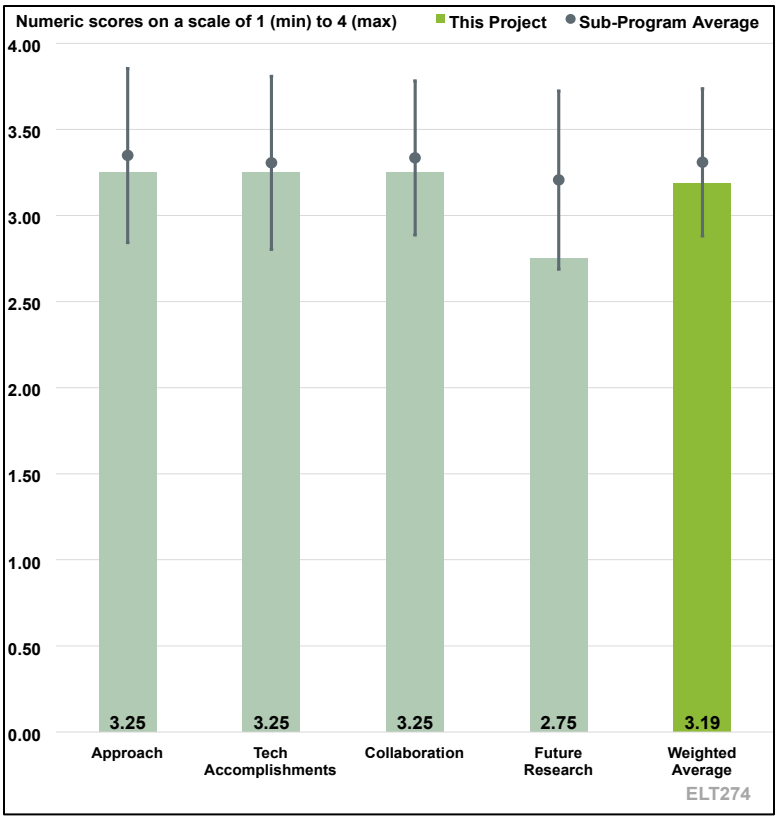

Figure 2-15. Presentation Number: ELT274 Presentation Title: eMosaic Electrification Mosaic Platform for Grid-Informed Smart Charging Management Principal Investigator: James Stoupis, ABB

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

Reviewer 1

The reviewer mentioned this monitoring and behavior modification can help blend peak demand where capacity limits will affect the grid. Long dwell might become a customer dissatisfier and protecting against overstaying reservations might become issues that need addressed later on.

Reviewer 2

The reviewer commented the project has identified clear objectives, with the primary being to "develop a scalable, secure, and resilient eMosaic (local and cloud) platform to provide localized and bulk grid services and SCM (load or congestion management), load forecasting, and dynamic reservations." The reviewer further noted the project outlines its approach in great detail including upfront through identification of multiple subtasks, as well as under approach within the discussion of the four use cases. The reviewer concluded the project and timeline appear well designed, focused upon the identified barriers, and on schedule.

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

Reviewer 1

The reviewer commented that the four potential use cases look well thought out and purposeful to the objective defined by “Grid Operators need more control to balance the load and avoid downtime.”

Reviewer 2

The reviewer observed that in the last year, the project has achieved a substantial number of accomplishments with regards to approach/methodology validation, and specific technological advances. This includes installation of 200 or more new communicating Level 2 (L2) charging ports at Rocky Mountain Power, Utah State University, and various public sites, it also includes development and use of a reinforcement learning (RL) agent to generate the price factor based on grid conditions and development of a local price-responsive algorithm to control L2 sessions. It includes deployment and demonstration of bus charge planning including charging rates at the station and discharge rates along the route and development of the solution architecture and demo/deployment planning for “fast demand response (DR)” and “slow DR / load limit setting” scenarios. The reviewer noted new features were added to the Reservations App, including limited booking access and restrictions, and visibility of reserved slots. The reviewer noted, regarding cybersecurity, the project conducted a representational state transfer (REST) application programming interface (API) test with Postman, confirming connections cannot be made without valid transport layer security certificates. The reviewer concluded, overall, the project achieved a strong list of accomplishments and adhered to the established timeline.

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

Reviewer 1

The reviewer noted all parties and researchers are developing material to achieve the stated goals. The deployment plan at Utah State University and the Utah Transit Authority appears to be complete and functional.

Reviewer 2

The reviewer observed the project has a strong, lean team with clearly defined roles and has identified internal/external communications and coordination mechanisms. Specific contributions are identified for each program participant. No notable areas are identified for more collaboration.

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

Reviewer 1

The reviewer agreed with the points on Slide 21 of gathering data to support development of the software functions/features. Adding charge ports will promote the use case participation needed for scalability studies.

Reviewer 2

The reviewer observed remaining challenges have been identified including: (1) maintaining embedded edge, server, and remote cloud infrastructure; (2) integrating, coordinating, and testing pilot sites, and (3) validating feasibility of development algorithms. Next steps have been identified including (1) gathering data, (2) finalizing and maintaining edge, server, and cloud infrastructure that

has been commissioned, and (3) scaling up as necessary to effectively support the pilot charger installations. The reviewer stated, though, that a clear pathway has not been presented to successfully commercialize this approach/technology that leads to widescale implementation. Future research should include the identification of specific future challenges and steps to achieve this end, and, at a minimum, this would encompass system/technology cost targets, other business challenges, privacy and regulatory issues, and further cybersecurity implications.

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

Reviewer 1

The reviewer commented that a reliable grid will assist the move to EVs, hence reducing CO_2 emissions from energy use.

Reviewer 2

The reviewer noted successful development and implementation of a robust, interoperable, and secure SCM and grid services system will promote greater EV market penetration, smoother VGI, and the reduction in grid impacts.

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

Reviewer 1

The reviewer remarked that all future objectives appear to be funded.

Reviewer 2

The reviewer concluded resources are sufficient to achieve currently identified objectives and milestones.

Presentation Number: ELT275
Presentation Title: Low-Cost Rare-Earth Free Electric Drivetrain Enabled by Novel Permanent Magnets Inverter Integrated Design and Advanced Thermal Management
Principal Investigator: Ayman El-Refaie, Marquette University

Presenter

Ayman El-Refaie, Marquette University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

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

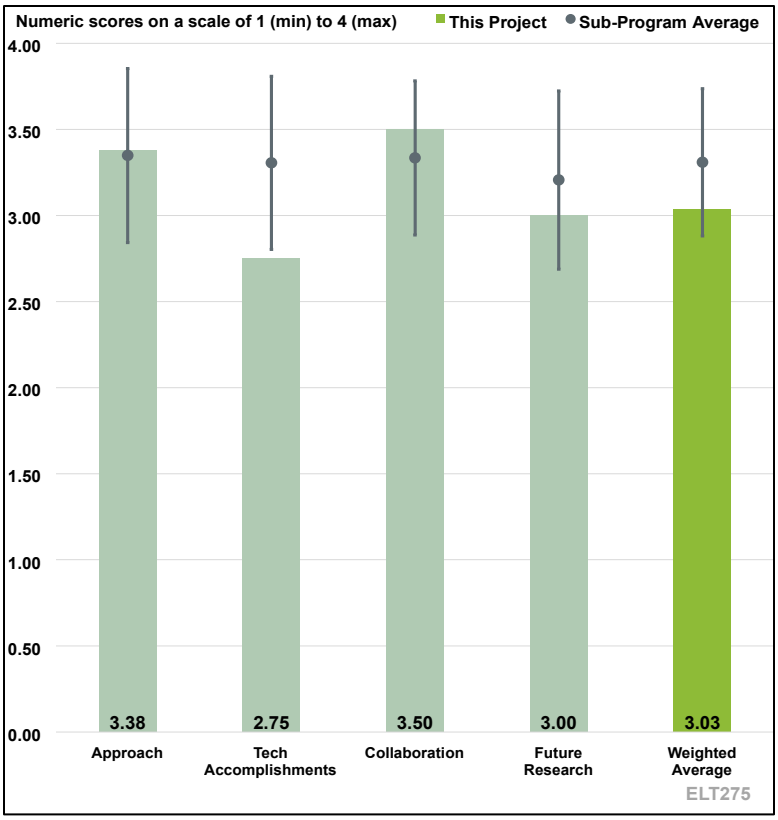

Figure 2-16. Presentation Number: ELT275 Presentation Title: Low-Cost Rare-Earth Free Electric Drivetrain Enabled by Novel Permanent Magnets Inverter Integrated Design and Advanced Thermal Management Principal Investigator: Ayman El-Refaie, Marquette University

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

Reviewer 1

The reviewer observed the program targets to deliver a non-RE motor with density greater than 12 KW/L. Technical barriers are adequately addressed and a wholesome approach is taken to resolve various assembly and component selection issues.

Reviewer 2

The reviewer remarked that the team creatively combine NdFeB and FeN magnets to mitigate the poor coercivity issue with the FeN magnets. Even saving only half of the NdFeB magnet in a motor will greatly reduce the criticality issue with the RE.

Reviewer 3

The reviewer commented that the project is well designed, and the timeline is reasonably planned.

Reviewer 4

The reviewer concluded the material presented lacks detail to justify how or why this approach will be able to meet the technical targets.

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

Reviewer 1

The reviewer observed technical progress has been achieved as per the original timeline.

Reviewer 2

The reviewer mentioned the project's technical progress is sufficient and appears on track with the project plan.

Reviewer 3

The reviewer noted the team is behind schedule due to the Covid-19 shutdown. The team did complete the trade-off study of various combination scenarios, but there is no report on the progress of FeN magnet development.

Reviewer 4

The reviewer observed significant budget has been consumed, yet the project has yet to make the BP 2 milestones. This seems to indicate that the aspirations of the project may be too much of a technical stretch to be accomplished.

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

Reviewer 1

The reviewer noted excellent coordination among various stakeholders has been maintained throughout.

Reviewer 2

The reviewer observed this is a large team, involving university, national lab, and industry. The PI did a good job getting everyone involved and coordinated.

Reviewer 3

The reviewer noted there is a diverse team that is well situated to provide strong technical advice.

Reviewer 4

The reviewer remarked there is a good mix and diversity of project team members. The team comprises university, national laboratory, and private industry researchers. The added that the private industry collaborators should be involved earlier in the process.

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

Reviewer 1

The reviewer said simply, yes.

Reviewer 2

The reviewer noted 36 MGOe is an aggressive target. The reviewer added FeN nanoparticle alignment is likely to be affected during the consolidation process, so perhaps 24 MGOe is a more realistic goal in a year.

Reviewer 3

The reviewer acknowledged the project has proposed future work but did not find the researchers connected how the proposed work aligned directly with VTO objectives.

Reviewer 4

The reviewer observed that executing the proposed work will help achieve the targets; however, the reviewer questioned whether the team could sustain the work needed to accomplish the goals.

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

Reviewer 1

The reviewer stated the project is relevant to the ELT subprogram and support VTO objectives.

Reviewer 2

The reviewer highlighted that if FeN can reach 36 MGOe, it will be a game changer for the PM motor. This work directly supports VTO's ELT subprogram objectives.

Reviewer 3

Thew reviewer commented that developing low-cost magnets are important for next generation motors.

Reviewer 4

The reviewer noted this project absolutely will contribute to electrified vehicle propulsion.

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

Reviewer 1

The reviewer concluded this project is effectively resourced.

Reviewer 2

The reviewer observed, for a large team led by a university, the requested budget of $5 million federal dollars is sufficient.

Reviewer 3

The reviewer said the resources appear to be sufficient.

Reviewer 4

The reviewer noted the overall project resources defined for this project is sufficient, but based on the project progress, it is unclear whether the team has sufficient resources remaining.

Presentation Number: ELT282
Presentation Title: Technology & Design Innovations to Maximize the Reduction Effect on DCFC Unit Cost Economics (Max-REDUCE)
Principal Investigator: Robert Keefover, BorgWarner

Presenter

Luca Di Carlo, BorgWarner

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

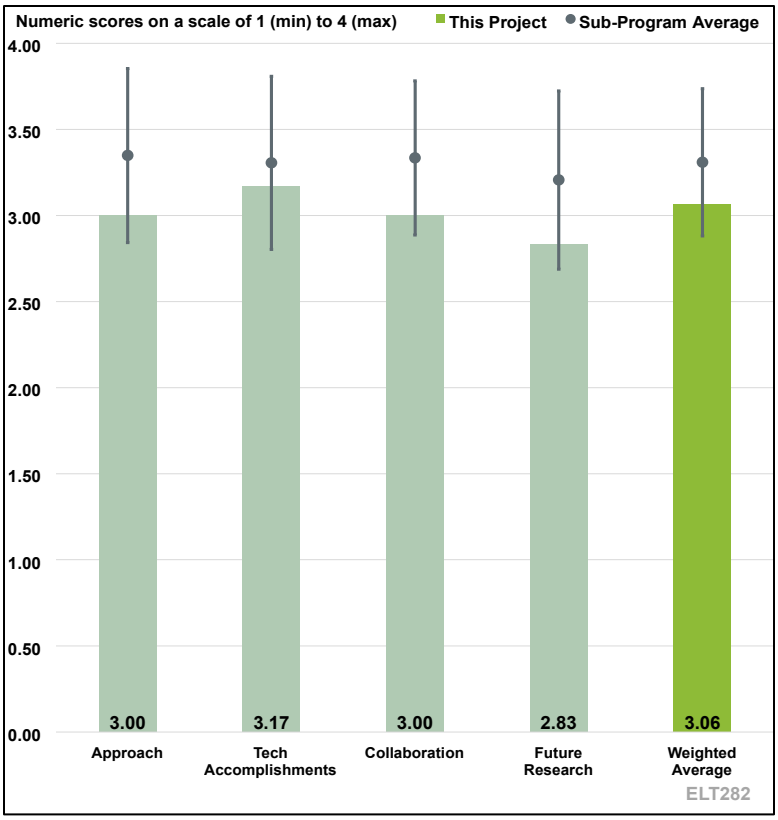

Figure 2-17. Presentation Number: ELT282 Presentation Title: Technology & Design Innovations to Maximize the Reduction Effect on DCFC Unit Cost Economics (Max-REDUCE) Principal Investigator: Robert Keefover, BorgWarner

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

Reviewer 1

The reviewer stated the project is sufficiently designed.

Reviewer 2

The reviewer commented that the project is focused on reducing costs and increasing the efficiency and reliability of higher-power direct current fast chargers (DCFCs). The approach focuses on developing 60 kW modules that can be configured together for over 150 kW units, particularly a 360 kW unit based upon six modules. The project plans to install the unit at a demonstration site as part of the validation process, though that installation is planned for almost at the end of the project, so there will not be much demonstration operation time examined.

Reviewer 3

The reviewer remarked the team has a solid plan for researching simplified architecture for DCFC, and results should lead to cost reduction and possibly improved reliability of units. The team has a straightforward plan laying out requirements, engaging models of architectures under study and simulated hardware evaluation.

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

Reviewer 1

The project team has completed design, validation plan, component readiness review, and system control plan. Most if not all milestones appear on schedule, though the design has changed a bit, adding some issues. The 60 kW design fits in a housing typically used for 30 kW units. Cooling was a particular area of investigation—the project team has developed an innovative top side cooling system. It appears the modulation system will allow increased efficiency, appearing to be in the area of 94% to 97%.

Reviewer 2

The reviewer remarked there were good technical accomplishments and progress on the timeline, though slightly behind schedule. The team has shown the ability to adapt from initial barriers and challenges and is progressing with the buildup of modules for higher power charge rates.

Reviewer 3

The reviewer remarked the project should have been done with the go/no-gos by the time of the AMR but it did not appear to be completed.

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

Reviewer 1

The reviewer noted the project has assembled a team that should allow for sufficient collaboration for project success. In particular, it is admirable that the team has included a construction firm and fleet to serve as the demonstration site. That is key for ensuring that the validation process can proceed in a useful manner. It is also interesting that the team has included the state as a partner, which could assist in future deployment.

Reviewer 2

The reviewer commented the project team appears a little deficient on theoretical support and suggested the team should include a national laboratory.

Reviewer 3

The reviewer observed the validation testing will go on beyond the current end of project, and questions if there would be a no cost extension. Once installations are done, that is when the full collaboration process will be able to be fully evaluated.

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

Reviewer 1

The reviewer commented that there was not a lot of discussion on the future proposed work.

Reviewer 2

The reviewer noted the project team identified the key remaining challenges as optimizing the complex control technique, completing final packaging (which is both power and component dense), and defining the final cooling system. These are significant issues to address.

Reviewer 3

The reviewer observed the plan to continue testing after installation will produce data that will need analysis and possibly partner assistance. The first hardware builds look good, but only when the fully assembled system is installed and tested in the field will the team be able to evaluate designs, including the cooling system. The ability of the partners to produce variations in source power will help with the evaluations of upstream transformer.

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

Reviewer 1

The reviewer remarked that the project supports VTO objectives.

Reviewer 2

The reviewer commented that the project is focused on improving charging technology, targeting high-power units. Greater deployment of EVs will require improved charging technology, particularly for public and fleet DCFCs.

Reviewer 3

The reviewer noted the project is very relevant based on the projections for continued increase in EV adoption and electric vehicle supply equipment (EVSE) network build up.

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

Reviewer 1

The reviewer commented there appears to be sufficient resources.

Reviewer 2

The reviewer noted no indication was made that the resources are not sufficient.

Reviewer 3

The reviewer mentioned that, though sufficient, it would be advantageous after successful initial deployments to have another set of hardware be produced for deployment in a hotter climate.

Presentation Number: ELT283
Presentation Title: A Solid State Technology Enabled Compact Modular Design to Reduce DC Fast Charging Cost and Footprint
Principal Investigator: Bogdan Borowy, Eaton

Presenter

Bogdan Borowy, Eaton

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

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

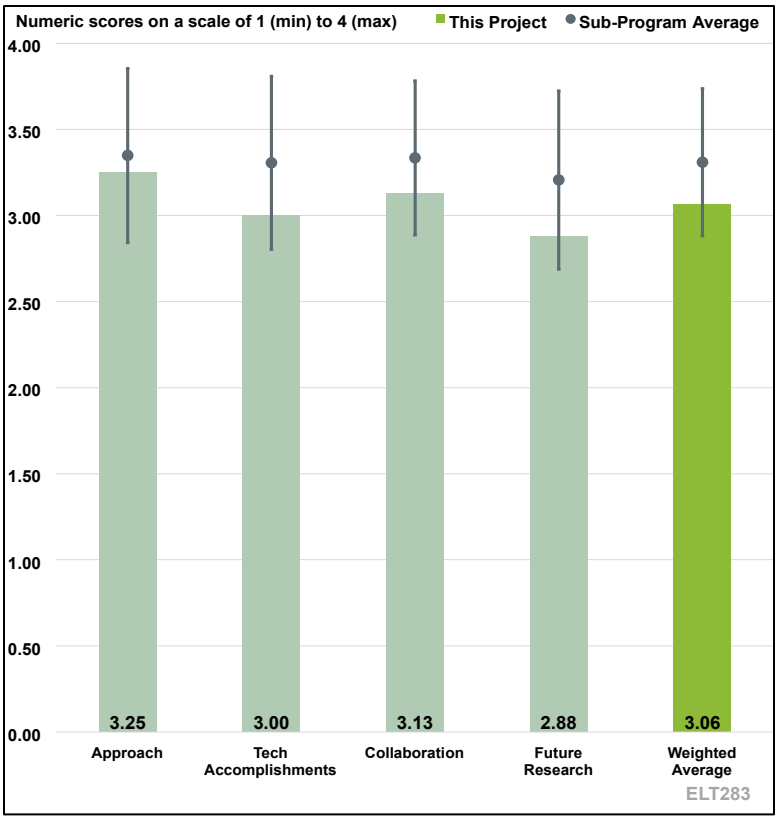

Figure 2-18. Presentation Number: ELT283 Presentation Title: A Solid State Technology Enabled Compact Modular Design to Reduce DC Fast Charging Cost and Footprint Principal Investigator: Bogdan Borowy, Eaton

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

Reviewer 1

The reviewer commented that the proposed solid-state technology enabled, integrated, modular charging system, appear to be a good approach to address the barriers of the footprint of EV DC charging infrastructure and the interoperability and grid connection compliance of the MWC infrastructure.

Reviewer 2

The reviewer remarked that the project is executing against technical barriers. The work is on track to meet the target of lowering cost for key components and packaging.

Reviewer 3

Thew reviewer commented that appropriate barriers are addressed by this project, including the cost of medium voltage connected components and reducing the footprint of the charging infrastructure.

Reviewer 4

The reviewer remarked this project has great architecture and encompasses many aspects of the high-power charging system as components of the overall MWC environment. If successful, the

project will yield paths to quicken installations at medium voltage connections to further enable the grid to support commercial vehicle electrification.

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

Reviewer 1

The reviewer commented that the project is almost on track. Some subsystems have been completed, such as the transformer, AFE, and dual-active bridge (DAB) stage. However, these components have yet been integrated for analysis and testing.

Reviewer 2

The reviewer concluded technical objectives are being met within magnetics, power electronics, battery charger, thermal, utility interface, and packaging.

Reviewer 3

The reviewer noted several design, modeling, and development accomplishments are detailed from numerous partners for packaging, thermal management, medium voltage interface, AFE, magnetics, and power electronics.

Reviewer 4

The reviewer mentioned there was good progress in many of the technical areas and design phases, but the hardware seems to be trailing some of the program timelines. As the project end date is just over a year out, the hardware phases need to progress without any issues to meet deployment and test cycles. If the deployments are met, there may still be the issue of proper variation in environmental conditions to ensure the field demonstration is adequately stressed with temperature ranges at various load states.

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

Reviewer 1

The reviewer commented that the team members are from industry, national laboratories and universities, and each team has carried out different tasks of the project, which indicates and effective collaboration.

Reviewer 2

The reviewer observed roles and tasks for program partners have been clearly defined.

Reviewer 3

The reviewer noted the team is comprised of good partners for the technical development of the SST system. For demonstration/pilot, planning for technology transfer, and utility requirements/standards for EV charging infrastructure connection to medium voltage consider including an electric utility partner as well as a charge service provider.

Reviewer 4

The reviewer commented, with site and other integration processes selections and definitions complete, the hardware success and testing of the integrated cooling system remain the project critical elements. Further, the identification of the lack of SST to utility standards and other barriers provide guidance for other future research and preparations areas.

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

Reviewer 1

The reviewer commented that the team has clearly identified a list of the remaining tasks and barriers, which appear to be appropriate yet challenging.

Reviewer 2

The reviewer said no comment.

Reviewer 3

The reviewer raised the question of whether future work will include a pilot or demonstration of this technology. Many accomplishments have been demonstrated through modeling and design of systems and subsystems used for this SST medium voltage charging infrastructure. A demonstration will highlight the full system capabilities and evaluate/validate the improved efficiency and smaller footprint benefits. No information was provided about BP 3 goals or tasks (i.e., Sept. 2024 – Aug. 2025). BP 3 appears to be a majority (around 70%) of the funding since the BP 1 and BP 2 funds total around $1.2 million, which is about 30% of the total DOE funding of $4.4 million. The reviewer noted there were no prior year reviewer comments. [DOE Program Clarification: 2023 AMR comments were not available to PIs prior to the 2024 AMR.]

Reviewer 4

The reviewer noted the project leads have identified a number of proposed research areas, and these are within the capability areas of the project team. These areas will need validated hardware to ensure the future research areas can be tested thoroughly. The long lead parts supply issues may need a plan “B” to get systems installed in time for full testing to take place.

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

Reviewer 1

The reviewer commented that the project supports the overall DOE objectives in the aspect of transportation electrification.

Reviewer 2

The reviewer concluded the project addresses VTO’s ELT subprogram goals.

Reviewer 3

The reviewer stated this project supports the improvements of EV charging infrastructure by focusing on improved efficiency and reduced footprint for medium voltage charging infrastructure.

Reviewer 4

The reviewer observed that, if successful, the project will enable quicker deployment of high-power chargers. The technology and processes being investigated will benefit the industry with a more flexible response to vehicle charging needs and allow for some of the quality control previously done on the installation site to be done in the factory prior to shipment to the site. The advancements in magnetics and bridge technology will enable medium voltage connections, which will help bring lower cost multiport EVSE deployments to the national network.

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

Reviewer 1

The reviewer commented that the resources for the project are sufficient.

Reviewer 2

The reviewer said resources are sufficient to achieve milestones.

Reviewer 3

The reviewer said resources are sufficient for the four partners of the projects to accomplish the project goals in BP 1 and BP 2.

Reviewer 4

The reviewer noted the resources are sufficient for this project, but the timeline for long lead parts will remain the critical item for project completion.

Presentation Number: ELT285
Presentation Title: Development and Demonstration of Zero-Emission Technologies for Commercial Fleets (Supertruck 3)
Principal Investigator: Maarten Meijer, PACCAR

Presenter

Maarten Meijer, PACCAR

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

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

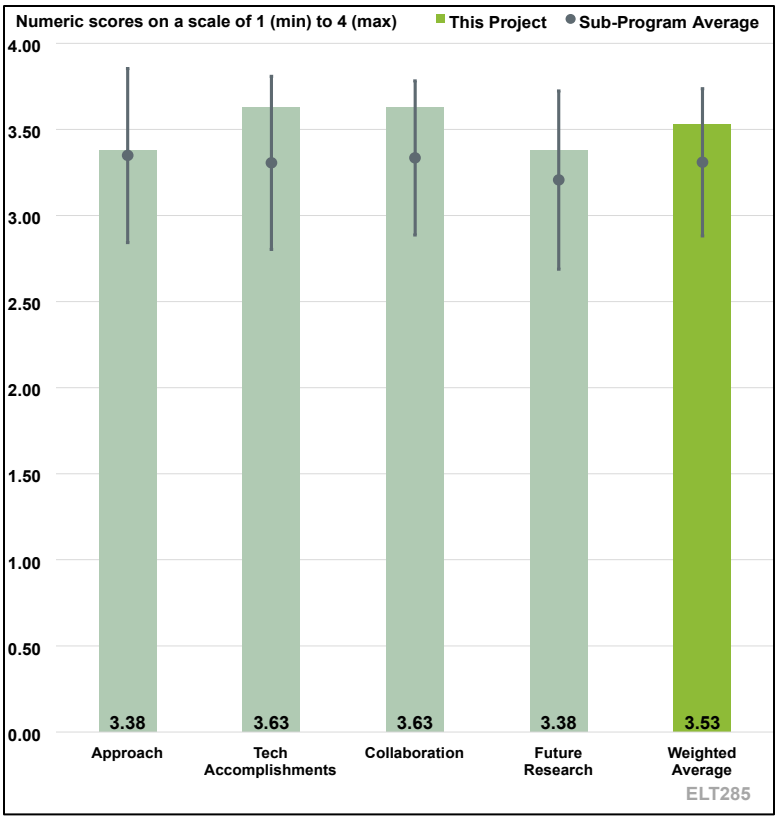

Figure 2-19. Presentation Number: ELT285 Presentation Title: Development and Demonstration of Zero-Emission Technologies for Commercial Fleets (Supertruck 3) Principal Investigator: Maarten Meijer, PACCAR

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

Reviewer 1

The reviewer stated that the project directly addresses technical barriers to deployment of long-haul Class-8 electric tractor-trailers such as high electric powertrain cost, low vehicle range, and the lack of charging infrastructure. The reviewer noted that the project is designed to achieve the objectives of a 75% or greater fleet-level CO2 reduction versus diesel and a 30% or greater total cost of ownership (TCO) versus current production Class 8 EVs by developing generation (Gen) 2+ and Gen3 vehicles, designing and installing megawatt charging facilities, and data acquisition and analysis to document vehicle and charging system performance. The reviewer indicated that the project is at the 40% completion point on a five-year timeline which appears to be sufficient to complete all activities.

Reviewer 2

The reviewer stated that in this BP the focus of the project was on deploying Gen 2 battery electric vehicles (BEVs), defining the components of Gen 2+ and Gen 3 BEVs, working on L2 advanced driver assistance systems (ADAS) and Fleet Connectivity Design, and the definition of the fuel cell electric vehicle (FCEV). The reviewer noted that the PACCAR nomenclature was difficult to follow and suggested reconsidering the Gen 2+ name.

Reviewer 3

The reviewer commented that PACCAR's SuperTruck 3 development approach, based on iterative and revolutionary improvements to the Class 8 long haul tractor, appears logical and well thought out. The reviewer mentioned that the PACCAR team will be able to see the gains made by the zero emission vehicle (ZEV) battery electric technology over different alternative solutions by assessing various levels of improvements, and that PACCAR's understanding of grid limitations has led the team to develop an off-grid 1.6MW recharging solution for these vehicles at the PACCAR Technical Center.

The reviewer affirmed the eTruck challenge as an excellent approach for engaging with college students, and expects similar results to EcoCAR and SAE-sponsored college vehicle activities.

The reviewer observed that PACCAR's enhancements to the eMotor align with the target specifications of the higher power SuperTruck 3 vehicle, and that novel solutions like steer-by-wire and new design for an air compressor are being integrated as part of the SuperTruck 3 design but cautioned that the proposed solution appears to be ignoring aerodynamic and possible tire improvements needed for the SuperTruck 3 vehicle.

Reviewer 4

The reviewer noted that it is a huge project with many iterations of electric trucks needing tracking and a significant number of analyses, and expressed concern that the team is overextending itself and will later on not be able to deliver to the plans.

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

Reviewer 1

The reviewer acknowledged an impressive project with a very discerning partner in Knight Swift and noted that a lot of decisions will be made with big goals. The reviewer affirmed that the accomplishments to date are solid and indicated that the reviewer is really rooting for this project to deliver answers to many BEV questions, including how to deliver sleepers.

Reviewer 2

The reviewer noted that progress on all technical activities is on track including 10 fast chargers installed at the Knight transportation micro-grid with battery energy storage and solar charging array nearing completion, and design work underway for 2026 deployment of MCS high-power charging at the PACCAR Technical Center. The reviewer commented that the Gen2+ BEV scope definition features increased range and charging rate and a 30% TCO reduction with vehicle retrofit starting in the third quarter of 2024 and that the Gen3 BEV concept definition is complete, and featuring an integrated 1 MWh battery pack, 1000V architecture, high-efficiency e-axles, and optimized accessories.

Reviewer 3

The reviewer noted that the progress seems appropriate as BEV connectivity is on-vehicle for proof of concept, vehicle-to-vehicle (V2V) perception data collection is underway, and there is work on vehicle architecture integration.

Reviewer 4

The reviewer commented that the project is well balanced with technical achievements, modeling and outreach, along with baseline trucks on the road collecting data. The reviewer remarked that the microgrid 1.6 KW charging solution is an excellent solution to alleviate grid charging challenges, and

that modeling fuel cells as part of the solution will provide critical data needed to make powertrain decisions. The reviewer noted that other impact areas for electric drive vehicles such as thermal management strategy, battery and fuel cell storage, hydrogen for fuel cells, eAxle drive solutions, and eAuxiliaries, are being addressed in a well-balanced approach, and mentioned that improvements in aerodynamics and tire design should be considered when the SuperTruck 3 design is finalized.

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

Reviewer 1

The reviewer affirmed the strong, well-integrated project team given the PACCAR umbrella and identified partners.

Reviewer 2

The reviewer noted that PACCAR Tech Center is the project leader with vehicle design, integration, and testing responsibilities. Schneider Electric is the microgrid and charging infrastructure lead. LG Energy Solution provides the high-energy density batteries. Cummins Accelera provides the e-axle systems. Argonne is the analysis lead, determining greenhouse gas (GHG) and TCO reductions. Knight Swift is the fleet partner, operating the vehicles in regular service. University collaborations include OSU (ADAS, V2X), University of North Texas (V2V), and University of Washington (e-Truck Challenge).

Reviewer 3

The reviewer stated that the PACCAR team composed of the PACCAR original equipment manufacturers (OEMs) Peterbilt and Kenworth, Schnider Electric, Knight Transportation and Swift Transportation, LG, Accelera, Argonne National Laboratory, OSU, University of North Texas and University of Washington are strong partners with discrete responsibilities. The only suggestion to enhance this team would be the addition of a tire manufacturer since these trucks will have significantly different weight and torque profiles than conventional trucks.

Reviewer 4

The reviewer acknowledged that collaborators were named but was confused on what the deliverables are from each.

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

Reviewer 1

The reviewer commented that this project appears to be addressing all required areas needed for the development of a successful SuperTruck 3. Data collection is occurring on several iterations of vehicles, fleet testing and feedback is occurring, modeling is underway regarding alternative drivetrain configuration, battery system and charging system design is nearly complete, and eAuxiliaries are being assessed and integrated into the final design. However, the addition of a tire impact assessment and the addition of a tire manufacturer to the team would strengthen the final SuperTruck 3 design.

Reviewer 2

The reviewer stated that specific areas proposed for future continued development include battery performance and life, connectivity deployment, and MCS/high-power charging deployment.

Achieving Gen 3 BEV targets is high risk and therefore appropriate for government-industry co-funding, but additional R&D to achieve TCO reduction beyond these targets will be necessary to reach cost parity with existing diesel powertrains in long-haul applications.

Reviewer 3

The reviewer remarked that the proposed work is in line with project objectives, but significant challenges remain in battery performance and life, connectivity deployment, high voltage architecture, and high-power charging.

Reviewer 4

The reviewer observed that a lot of future work is planned and expressed concern about enough resources and budget to do them all well.

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

Reviewer 1

The reviewer noted that the project is extremely relevant to program, VTO, EERE, and DOE objectives.

Reviewer 2

The reviewer remarked that the project is highly relevant to DOE goals and supports overall VTO subprogram objectives. ZEVs are the focus of the program and developing a ZEV Class 8 long haul tractor proof of concept fits well within the office's portfolio.

Reviewer 3

The reviewer indicated that the project is incredibly relevant and one of the most important projects DOE is funding right now. There is a strong need for 400+ miles on a single charge without huge weight and cost issues.

Reviewer 4

The reviewer said that the project supports VTO subprogram objectives in Analysis, Batteries, Electrification, EEMS, and Materials.

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

Reviewer 1

The reviewer noted that project resources are sufficient to achieve the stated milestones to meet the program schedule. Generation 2+ and 3 BEVs are under development, the charging microgrid is being installed, and the analysis activities are underway.

Reviewer 2

The reviewer stated that resources seem sufficient at this point.

Reviewer 3

The reviewer indicated that resources allocated to this project appear to be sufficient to bring it to completion but expressed uncertainty whether the redesign of a microgrid solution for the 1.6 MW charging station was covered under the original proposed budget. If the redesign was covered, kudos to PACCAR for pivoting quickly and developing a flexible solution within the original budget.

Reviewer 4

The reviewer commented that it was difficult to tell if resources are sufficient for the project given what was presented.

Presentation Number: ELT286
Presentation Title: A Zero Emission Freight Future (SuperTruck 3)
Principal Investigator: Eric Bond, Volvo

Presenter

Vivek Sunjan, Oak Ridge National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

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

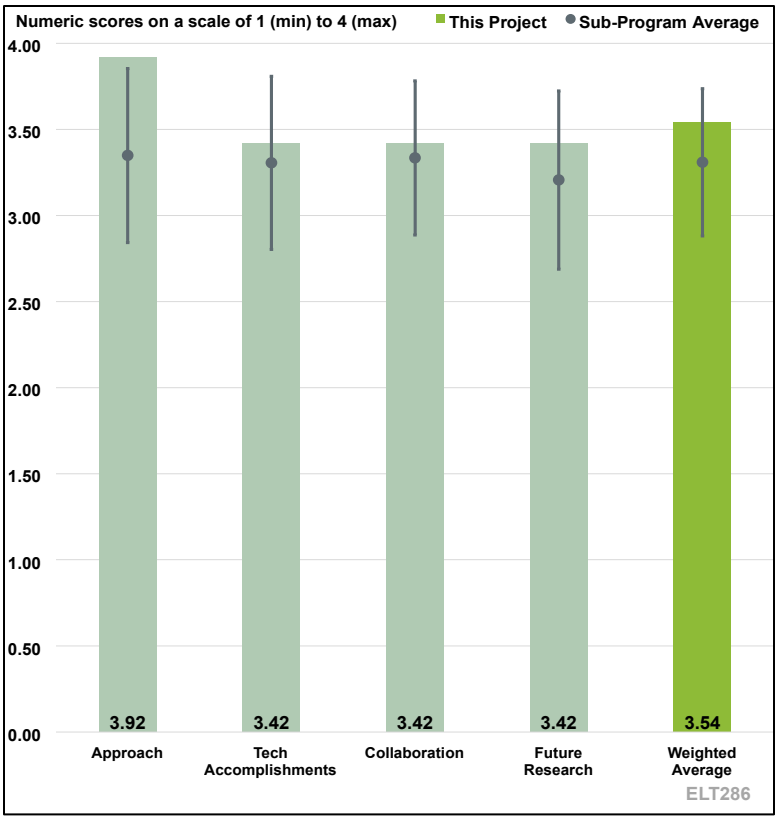

Figure 2-20. Presentation Number: ELT286 Presentation Title: A Zero Emission Freight Future (SuperTruck 3) Principal Investigator: Eric Bond, Volvo

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

Reviewer 1

The reviewer remarked that the SuperTruck 3 program continues to have some of the most impressive projects in the VTO stable, with some of the most incredible results. This project is no exception. The approach to achieving a 400 mile Class 8 BEV vehicle is comprehensive and builds upon the learnings from Super Trucks 1 and 2. The project planned demonstration requires the balance of 3 challenging areas with further improvements in efficiency, payload, and energy storage.

Reviewer 2

The reviewer noted that the timeline is reasonably planned, if also ambitious, for completion over 4 years. Tradeoffs are numerous among component packaging, durability, axle configurations and axle loads, rolling resistance, thermal management, aero, steel vs. aluminum castings, range, etc. End user practicality, serviceability, charging, and generalized costs are also vital considerations.

Reviewer 3

The reviewer noted that the heavy emphasis on the coupling between battery weight and the tire design is well justified. The team's approach is comprehensive.

Reviewer 4

The reviewer commented that the team is taking the requirements incredibly seriously and benefits from having delivered Super Truck (ST)1 and ST2 projects. Many tradeoffs around weight, cost, range, charge time, etc., are needed and will be interesting to follow. The reviewer like to see the use of waterfall charts for these projects.

Reviewer 5

The reviewer stated that the project directly addresses the technical barriers to deployment of long-haul Class-8 electric tractor-trailers. These barriers are high electric powertrain cost, low vehicle range, and the lack of high-power charging infrastructure. The project objectives are to develop and demonstrate a Class 8 BEV capable of 400 miles with a representative payload correlated to a defined freight corridor and urban area freight models and to demonstrate a 75% or greater fleet-level CO2 reduction versus diesel with an improvement in TCO. The project is at the 25% completion point on a four-year timeline that appears to be sufficient to complete all activities.

Reviewer 6

The reviewer stated that the work builds on SuperTruck 1 and 2 which was based on fuel efficiency. The baseline of SuperTruck 2 vehicle is an excellent starting point for a zero-emission solution. The BEV SuperTruck 3 and MCS address the 2 main barriers of the long-haul Class 8 electric truck solution: range and refueling time. Also, by using an existing Volvo shipping route, it allows a direct comparison to existing commercial operations and eliminates the risk of finding a committed fleet partner. Active drive axle balance and tire selection will be critical to obtaining maximum traction and minimum rolling resistance. Modeling the impact of a Fuel Cell powertrain system could show that a hybrid system is the better option. The work done on Freight Origin-Destination Synthesis (FODS) is not needed to be part of this project; other modeling such as alternate drive train configurations should be prioritized over FODS modeling. Also, the approach does not appear to include the eMotor when assessing the impact of the other vehicle parameters. The Volvo SuperTruck 3 eMotor performance parameters have not been determined (or shared because the eMotor parameters may be considered intellectual property by the project team).

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

Reviewer 1

The reviewer commented that progress on all technical activities is on track as summarized in the project Gantt chart shown on Slide 4. The chassis has been designed with 15% greater crashworthiness to protect the battery pack. A 20% lower rolling resistance is the target for drive and trailer tires. Battery pack requirements have been set and several cell form factors and chemistries are being evaluated. Analysis of the ST2 and production VNL cabs has been conducted with low drag optimization with an EV powertrain. Freight modeling is underway with a benchmark vehicle to enable future determination of effects of zero-emission trucks on the I-81 corridor.

Reviewer 2

The reviewer stated that simulation and analysis work leading to comparisons with real-world I-81 corridor freight flows will be very helpful for baseline/modeling/outcome comparison and assessing technical progress.

Reviewer 3

The reviewer noted that there is a lot to do, but the PI presented it well and with completeness and transparency. It becomes obvious when a project cannot share items given intellectual property

situations like the detailed chemistry of the battery decision making. There will be some critical decisions to be made in the next six months to keep this project on track.

Reviewer 4

The reviewer commented on excellent progress on the weight management, battery technology downselect, and aerodynamics, but expressed confusion about the milestones shown on Slide 4 that indicate “Fuel Cell Model Developed” and “Fuel Cell Model Available” as part of the freight modeling. Also, the FODS part of the freight modeling was not explained very clearly, so it is not clear how it contributes to the project’s objectives.

Reviewer 5

The reviewer remarked that significant technical progress has been made. The energy storage system (ESS) investigation has established the structure of a solution that could meet the objectives. Battery cell types (form/chemistry), energy/power density/capacity, charging performance, cycle life and cost are parameters that need to be optimized for this application. Other areas that are being addressed include thermal management strategy, aerodynamics, and drivetrain/axle balance. The reviewer believes that the FODS modeling has little value to this project.

Reviewer 6

The reviewer noted phenomenal progress across multiple technical areas—chassis assembly, tire development, freight modeling, and thermal management. Work is ongoing on aerodynamics and energy storage. There are difficult trade-offs in balancing range/vehicle weight, payload capacity, and cost for a HD long haul truck. There are significant barriers to be overcome in energy density versus total weight (which has impact on payload capacity) and costs that will be difficult to make progress on.

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

Reviewer 1

The reviewer remarked that Volvo is the project lead, performing simulations, system development, complete vehicle integration, testing and demonstration. ORNL is conducting vehicle and traffic modeling and simulation, scenario analysis, and TCO characterization. Rensselaer Polytechnic Institute is responsible for freight analysis and modeling of activity in the I-81 corridor and metro area. Michelin is the tire technology developer and manufacturer. Science, technology, engineering, and mathematics (STEM) related outreach is through Bluefield State and Pennsylvania State Universities. The fleet partner providing operational input and feedback to goals and deliverables has not yet been identified.

Reviewer 2

The reviewer stated that the scope of SuperTruck 3 demands strong collaboration among national laboratory, university, supplier and user partners. Depending on the fleet user identified, there could be charging supplier/partner coordination opportunities in the future.

Reviewer 3

The reviewer commented that Volvo Group North America has a good list of partners for collaboration: Michelin Tire, ORNL, Rensselaer Polytechnic Institute, Pennsylvania State University, and Bluefield State University. However, the team is significantly into the project and does not have a fleet partner identified. To alleviate this risk, an alternative approach has been employed by the

project team by selecting an internal Volvo I-81 shipping route that matched the parameters needed to assess the SuperTruck 3 concept vehicle.

Reviewer 4
The reviewer mentioned that collaborators are named but would like to see more definition of what each is doing.

Reviewer 5
The reviewer noted that the collaborations appear to be a mixed bag as there are some very strong partnerships in this project, for example with partners such as ORNL, Rensselaer Polytechnic Institute, and Michelin and then there are weaker collaborations (Bluefield State, Pennsylvania State University) that are listed as “STEM-related outreach” with no details given.

Reviewer 6
The reviewer wondered what exactly the STEM university outreach is doing that is related to this project. Fleet partner / customer is an important touch point, so need to identify them very soon.

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

Reviewer 1
The reviewer commented that Volvo will continue development of the ESS to increase energy density and overall system performance. Thermal management system simulations will continue to maximize efficiency and reduce heat loss. The impact of replacing the under-cab crossmember will be evaluated due to space availability in the frame. The team will continue to develop and calibrate detailed vehicle models for baseline and BEV trucks, developing micro-traffic simulation for I-81 corridor, and employing Real-Sim and Real-Twin capabilities to conduct high fidelity vehicle and micro-traffic co-simulation. This provides insight into the most promising use cases, defines the urban area base case and scenarios to be analyzed by the battery management system (BMS), and enables simulations of various ZEV systems and complete vehicle solutions for both BEV and FCEV vehicles. Volvo will initiate construction of charging site and place orders for long lead-time items.

Reviewer 2
The reviewer stated that both modeling/simulation and vehicle development are areas for future work potential. Continued simulation toward higher fidelity for broader virtual environments and expanding into wider operational domains, such as urban areas, will likely bring resultant innovations closer to deployment.

Reviewer 3
The reviewer noted that future activities to address the remaining challenges and barriers are clearly defined, including leveraging the modeling work that will accelerate the SuperTruck 3 vehicle design. Assuming the information surrounding the eMotor is proprietary and cannot be shared, the project team should determine if the infrastructure is sufficient for the MCSs. If it is not, the project team should engage with utilities or charging system provider to determine if any near-term potential solutions are possible.

Reviewer 4
The reviewer remarked that planned next steps in the project could have been clearer in the presentation. The needed steps are understood but more clarity would be helpful.

Reviewer 5
The reviewer remarked that there are significant barriers to be overcome in energy density versus total weight (which has impact on payload capacity) and costs that will be difficult to make progress on.

Reviewer 6
The reviewer questioned FCEV freight modeling as part of the future work plan, and requested an explanation about how it is relevant to this project.

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

Reviewer 1
The reviewer indicated that the project is incredibly relevant in that 400+ miles on a single charge without huge weight and cost issues is needed. It is one of the most important projects DOE is funding right now.

Reviewer 2
The reviewer said that yes, this project covers the objectives of multiple programs in VTO such as batteries, electrification, and EEMS.

Reviewer 3
The reviewer noted that the project is relevant to VTO priorities. The Class 8 long haul tractor segment is the most difficult to electrify. This project will provide the information VTO needs to determine if a battery electric class 8 long haul tractor is feasible.

Reviewer 4
The reviewer stated that the project clearly supports program, VTO, EERE, and DOE objectives.

Reviewer 5
The reviewer stated that the project broadly supports VTO objectives for heavy truck decarbonization. Modeling and simulation can contribute to Analysis area. Materials, Batteries and Electrification also benefit from this project.

Reviewer 6
The reviewer commented that the project supports VTO subprogram objectives in Analysis, Batteries, Electrification, EEMS, and Materials.

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

Reviewer 1
The reviewer remarked that project resources are sufficient to achieve the stated milestones to meet the program schedule. The program is in the second phase. The requirements to support concept decisions have been documented, and the design of the complete vehicle demonstrator is progressing, while simulation and analysis activities will continue into FY 2025. All technical milestones have been achieved, as well as the go/no-go preliminary design milestone. An investigation led the team in a new direction for the cab to be used on the demonstrator, and progress has been made regarding the energy storage and thermal management systems. Freight modeling activities involving university and national laboratory partners is underway, and the charge site is fullyapproved with construction ready to begin.

Reviewer 2
The reviewer commented that resources appear to be sufficient at this point.

Reviewer 3
The reviewer noted that funds are significant ($18 million in DOE funds + matching cost share). The project is still early, so will be able to better assess as the project matures.

Reviewer 4
The reviewer stated that funding appears sufficient; however, the project team should consider adjusting the modeling effort from FODS simulation and focus more on the alternative (Fuel Cell) powertrain configuration.

Reviewer 5
The reviewer stated that the project is ambitious, but funding is sufficient to achieve stated milestones, with some give and take anticipated as challenges are encountered. There is also ample future work of interest to VTO identified by the project team.

Reviewer 6
The reviewer commented that assessing resources is difficult. .

Presentation Number: ELT287
Presentation Title: Cummins High Power Density Inverter
Principal Investigator: Santhosh Krishnamoorthi, Cummins

Presenter

Santhosh Krishnamoorthi, Cummins

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

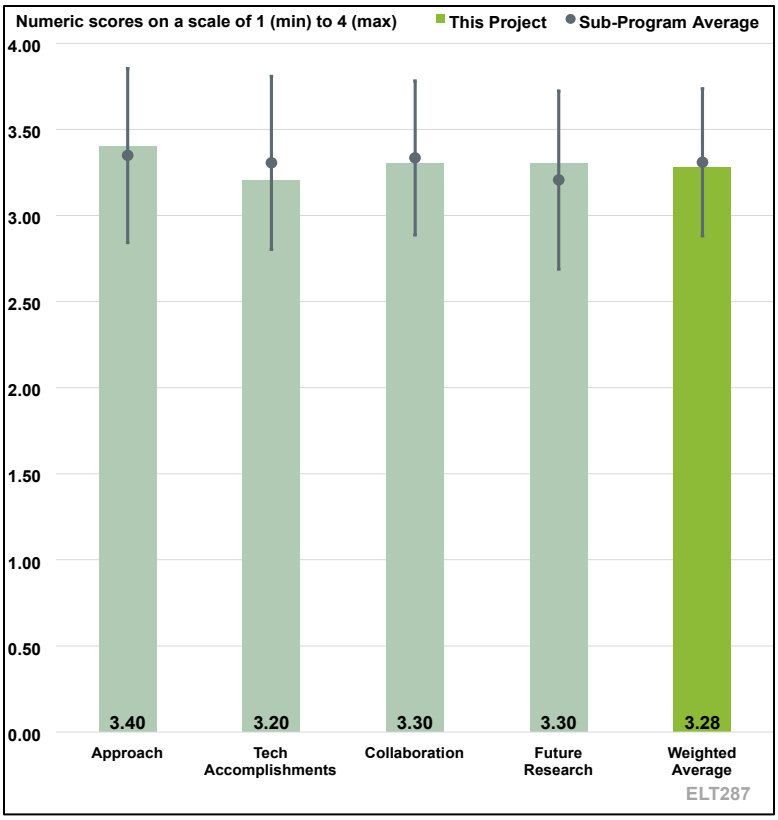

Figure 2-21. Presentation Number: ELT287 Presentation Title: Cummins High Power Density Inverter Principal Investigator: Santhosh Krishnamoorthi, Cummins

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

Reviewer 1

The reviewer commented that the project is well designed and the timeline reasonable.

Reviewer 2

The reviewer stated that the objective of the project is to develop and demonstrate a high-power density traction inverter for commercial vehicles to meet or exceed DOE's 2025 targets. The Cummins design goals are Peak Power ≥ 300 kW (which exceeds DOE 100 kW), Power Density ≥ 100 kW/L, Volume 100 kW/L, Operating DC Voltage ≥ 1000V (which exceeds DOE ≥ 650 V), Lifetime ≥ 750,000 miles (which exceeds DOE ≥ 30,000 miles) and Cost ≤ 2.7 $/kW. The project is designed to achieve power density using a suitable topology with tight packaging and an integrated gate driver and current sensors. DC bus voltage of 1000V is achieved with 1.7 kV SiC devices and high voltage capacitors. The project is at the 40% completion point with a June 2025 completion date that may have to be extended six months to complete all activities, due to initial component supply delays.

Reviewer 3

The reviewer noted that the project is focused on barriers that are key to seeing significant inroads of electrification in the medium-duty (MD) and HD space. This is accomplished by understanding the

drive cycles and addressing component configurations that allow a value-driven electrified system to be produced.

Reviewer 4

The reviewer remarked that the project's approach and technical progress indicates that activities are closely tied to overcoming barriers as the inverter is targeted for needs in commercial on-road HD vehicles. Application-specific requirements need customized components for the WBG inverter. The customized components for the Cummins inverter include a double-sided cooled SiC power module, a high energy density capacitor where the element fits in a customized package, and heat sink and electromagnetic interference (EMI) filter. The power module needs more careful considerations for thermal design.

Reviewer 5

The reviewer stated that the project addresses the technical barriers of high-power inverters. This project is well designed. However, it seems that the team spent too much time in initial system design such that the time scheduled for components fabrication and system integration may not be enough.

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

Reviewer 1

The reviewer stated that the power module design was complete and initial fabrication completed identifying build issues/learnings. The gate drive fabrication and testing were completed successfully. Initial bus bar design was completed and then Iterated. Heat sink design and fabrication, and manufacturing learnings have occurred. Capacitor selection and inverter packaging have occurred. EMI filter design options and their testing has occurred. Control board design and software have been completed. The analysis, fabrication of parts along with component level testing has identified some issues that are being addressed early. All in all, solid progress.

Reviewer 2

The reviewer noted that the project has made necessary progress and that technical accomplishments include gate drive and control board development.

Reviewer 3

The reviewer commented that the power module design was completed, and fabrication process was started. Die metallization, silver sintering/soldering with Mb posts, kelvin pins and terminals were completed but impurities were found on the surface of the dies metallized using a sputtering process requiring the use of pre-metallized dies from another supplier. The first version of the gate drive board design along with the power supply was completed and successfully tested. The bus bar design was changed to combat effects of high temperature on components and higher cost of using multiple heavy copper layers. Fabrication and assembly of heat sinks and power modules on either side of the bus bar board revealed crushed heat sink fins, an interference issue which still must be mitigated.

Reviewer 4

The reviewer remarked that technical progress for the project is good.

Reviewer 5

The reviewer commented that good progress has been made in heat sink fabrication, but it seems that the team has not made progress in the fabrication of key components such as the control board and film capacitor.

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

Reviewer 1

The reviewer noted that the Cummins led project has drawn team members from Virginia Tech, ORNL, and NREL. These entities are contributing in successful execution of project tasks.

Reviewer 2

The reviewer commented that Cummins is the project lead, developing requirements, designing the control board, developing software, building the inverter package, leading motor testing, developing cost models, and creating the final report. Virginia Tech is leading topology selection, determining the inverter system architecture, developing the power module, gate driver, sensors, fabricating and demonstrating the power stage, and developing lifetime models. ORNL is developing and testing capacitors, heat sinks, and EMI filters. NREL is developing thermal models and the cooling system, evaluating, refining, and verifying models, and supporting packaging development.

Reviewer 3

The reviewer acknowledged that the collaboration with partners appears sufficient.

Reviewer 4

The reviewer stated that the project is led by Cummins with the support from Virginia Tech, ORNL and NREL. ORNL has made significant contribution in heat sink development. The role of NREL in this project is to support the development of simulation model and model validation. After reviewing progress, it seems that the team should seek collaborators in high power electronics. The roles assigned to ORNL may be beyond its capability in this area.

Reviewer 5

The reviewer remarked that collaboration is excellent, but the reviewer would like to see Cummins leading the topology selection process instead of Virginia Tech. The reviewer believes this is a missed opportunity to better ground the design from a pragmatic standpoint.

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

Reviewer 1

The reviewer remarked that the project plan is solid, and the next steps are clear.

Reviewer 2

The reviewer stated that future research includes improvement in SiC power module, control board build, and inverter’s packaging. In FY 2025, the project team plans to test/verify the inverter with a 300 kW motor in addition to developing market plans and TCO analysis.

Reviewer 3

The reviewer stated that future project milestones are well defined, and it appears that future work will achieve targets. The FY 2024 milestones are: demonstrate bus bar prototype with distributed capacitor, demonstrate power module, demonstrate1 kV inverter phase-leg prototype with 99%

efficiency, complete optimized capacitor board and heat sink to achieve power density target, complete standalone 300 kW inverter tests, complete inverter tests with a 300 kW motor and complete technology to market plan and TCO analysis. In FY 2025, the tasks are: complete control board hardware build, complete integration of inverter components and prototype packaging and go/no-go 2, complete component validations and demonstration of 3 L inverter prototype package integration, and finally, complete WBG device lifetime assessment under full-operational mission profile for 750,000 miles.

Reviewer 4

The reviewer noted that the proposed future work appears to be on track to achieve its targets.

Reviewer 5

The reviewer commented that the future work proposed is well aligned with the purpose of this project. The team will achieve its target but may need longer time in system fabrication and demonstration than planned.

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

Reviewer 1

The reviewer stated that the project is relevant to electrification and supports VTO's objective in transportation electrification. The proposed work is excellent.

Reviewer 2

The reviewer commented that the project is critical in understanding the application of MD and HD drive cycles on inverter design.

Reviewer 3

The reviewer noted that the project supports VTO subprogram objectives in analysis, electrification, and materials.

Reviewer 4

The reviewer commented that the project supports VTO's objectives.

Reviewer 5

The reviewer remarked that one of the topics in the funding opportunity announcement (FOA) was power-dense inverter, the project activities are closely tied to the FOA objective, and the Cummins inverter is being developed for on-road HD vehicles, which has relevance with Cummins products.

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

Reviewer 1

The reviewer commented that the project is staffed enough and has necessary financial resources. Supported by the Virginia Tech, ORNL and NREL teams, the Cummins project team has necessary resources to successfully execute this project.

Reviewer 2

The reviewer stated that project resources are sufficient to achieve the stated milestones and to meet the program schedule.

Reviewer 3

The reviewer noted that resources appear to be sufficient for this project. Progress is what the reviewer would expect, and the fundamental issues are being addressed.

Reviewer 4

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

Reviewer 5

The reviewer stated that it seems that this team has enough funding and knowledge, but less expertise in know-how, and resources in component fabrication and system integration. This team may need another team member in the power electronic area. The difficulty and challenge in key components fabrication may be beyond the capability of Cummins and ORNL. ORNL is an excellent partner in providing technical support, but it may be difficult for ORNL to complete the fabrication of the capacitor and related components with cost and time in consideration. Such a concern is supported by the delay in component fabrication and system integration. The support from a partner with recourses in component fabrication other than buying components from a vendor will help this team.

Presentation Number: ELT288
Presentation Title: Scalable Ultra Power-Dense Extended Range (SUPER) Inverter
Principal Investigator: Harsha Nanjundaswamy, BorgWarner

Presenter

Harsha Nanjundaswamy, BorgWarner

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

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

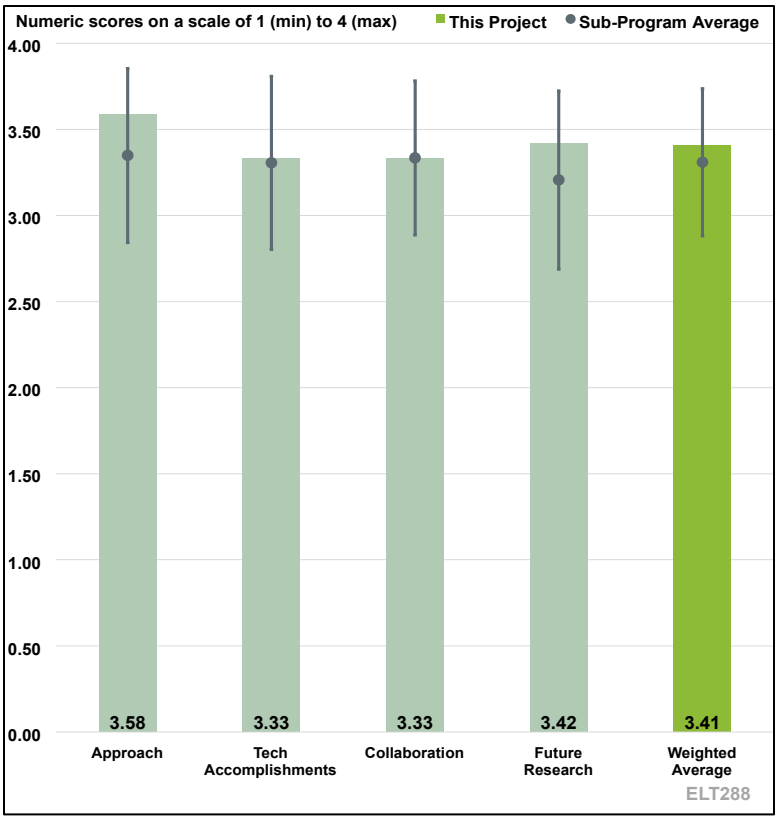

Figure 2-22. Presentation Number: ELT288 Presentation Title: Scalable Ultra Power-Dense Extended Range (SUPER) Inverter Principal Investigator: Harsha Nanjundaswamy, BorgWarner

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

Reviewer 1

The reviewer commented that the objective of this project is to develop and build a traction inverter with a new power module design in conjunction with a novel thermal solution and high temperature capacitor technology as well as new control architecture. This design will meet DOE's 2025 targets of power density ≥ 100 kW/L, operating voltage ≥ 800VDC (exceeds 650VDC DOE target) and $2.7/kW cost. The project is at the 66% completion point on a three-year timeline that appears to be sufficient to complete all activities by December 2024.

Reviewer 2

The reviewer stated that the technical thrust is right on with the addition of increasing flexibility of the design to accept different manufacturer die which is an often-overlooked aspect of these types of projects. BorgWarner is systematically attacking all the elements of the inverter design.

Reviewer 3

The reviewer noted that the team leverages BorgWarner's unique power module technology to develop a traction inverter that meets the DOE VTO's aggressive 2025 cost and power density targets.

Reviewer 4
The reviewer commented that the technical barriers were addressed. The project is well designed with a reasonable timeline.

Reviewer 5
The reviewer stated that the project work is tailored to meet a $2.7/kW cost target and 100kW/L power-density target; these metrics are included in 2025 DOE-VTO targets for power inverters. The project approach includes necessary activities for developing the power module, cooling of this module, and the high temperature capacitor. Micro and application-specific integrated circuit (ASIC)-based compute devices will be used to control system and for product safety (automotive safety integrity level D [ASIL-D]). SiC power module will use up to 8 die bare-die in package and form to deploy an exotic heatsink. Epoxy molding is used for fabrication and environment treatment of the SiC power module. The reviewer requested that the project team address the issue of coolant leaks and asked what the approach would be to make sure coolant flow is sealed from high voltage power electronics.

Reviewer 6
The reviewer commented that the project develops an inverter for EVs, which is a key component. The project is to some extent well designed and the timeline is reasonably planned. However, the effort has focused on system structure and less information is available about the cooling load requirement and its potential removing the heat generated, although the researcher may have presented the information last year. The reviewer expressed surprise with the large budget in BP 1 and BP 2 compared to the work completed in this project.

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

Reviewer 1
The reviewer noted excellent progress with the hardware construction.

Reviewer 2
The reviewer commented that progress on all technical activities is on track as summarized in the project milestone chart shown on Slide 4. The power module employs a single switch architecture with a patented topology to handle various sized SiC bare dies from separate manufacturers on the same pad layout without alteration of the core structure and the manufacturing process. The cooling module incorporates a patented fin design and a phase-change film with 40% lower pressure drop, 3.3% lower SiC die junction temperature, and 11° lower temperature deviation among the six power switches. The controller engineering sample has been released and features a single printed circuit board (PCB) assembly with micro controller, gate driver circuits, and two INSSAs.

Reviewer 3
The reviewer stated that the project has made necessary and appropriate progress.

Reviewer 4
The reviewer stated that progress is in line with what would be expected. Design, analysis, and fabrication of parts indicate a well-run project. The only thing that would be of concern is thermal stack up of the power module to the heat sink. Have any issues been identified in the parts that have been assembled?

Reviewer 5
The reviewer stated that technical progress appears to be behind to the project plan.

Reviewer 6

The reviewer commented that the project has been delayed for 4 months, and it not 100% sure that this team has completed the component fabrication and system integration and has the target inverter ready in April 2024. There seems no data supporting the delivery of test results of the current heat sink. The data shown in Slide 9 is simulation results.

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

Reviewer 1

The reviewer noted that BorgWarner has a complete and well-integrated team given the timely results they have achieved.

Reviewer 2

The reviewer noted great collaboration with university, labs, and vendors.

Reviewer 3

The reviewer commented that collaborative team members are drawn from PolyCharge, NREL, and Virginia Tech. It seems like collaborators are contributing in execution of relevant tasks in their functional area.

Reviewer 4

The reviewer commented that there appears to be good collaboration between project partners.

Reviewer 5

The reviewer stated that BorgWarner is the project lead responsible for design, fabrication, integration and testing of the inverter system. PolyCharge America developed and built the NanoLam block specification for 800VDC system, conducted thermal simulation/analyses and electronic system level (ESL) simulation and value extraction for the bulk capacitor assembly. NREL performed heat sink modeling and design as well as clamp plate design and analysis. NREL also ran the power cycle test to evaluate the power switch and cooling module. Virginia Tech ran the Saber model of a simplified SiC MOSFET die that enabled switch level analysis.

Reviewer 6

The reviewer noted that NREL is one of the two active partners in this budget period. However, it is not clear if NREL has completed the thermal resistance measurement and performed shear stress test for thermal interface material (TIM). The pressure distribution data of the clamp plate is not available in the presentation.

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

Reviewer 1

The reviewer noted that all the critical steps necessary for proving the technology works are identified in future research.

Reviewer 2

The reviewer noted that the work proposed for future research is excellent and the main deliverable of this project. With current progress in consideration, this project may need a no-cost extension as components fabrication, system integration and demonstration may take much longer than expected.

Reviewer 3
The reviewer stated that the plan for the remaining work has been clearly defined.

Reviewer 4
The reviewer stated that specific areas proposed for future continued development are well-defined. These activities include build and test of the initial 350 kW Inverter prototype hardware on an inductive load test bench, validation of the components and/or subassemblies in life and environmental tests (electrical and mechanical) relevant to overall project goals, and, finally, demonstration of the final 350 kW inverter performance and efficiency under adequate electric traction drive system conditions on a power-hardware-in-the-loop (P-HIL) test bench.

Reviewer 5
The reviewer remarked that the 350 kW inverter will be built and its verification will be carried out followed by demonstration in an application such as a driving electric motor using the BorgWarner inverter.

Reviewer 6
The reviewer commented that the proposed future work appears to be on track to achieve its targets.

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

Reviewer 1
The reviewer remarked that the project addresses all specified criteria and will contribute to the overall success of electrification.

Reviewer 2
The reviewer commented that the project work is related to DOE-VTO 2025 targets for power electronics and it seems like BorgWarner activities and their inverter metrics are approaching to meet 2025 VTO targets.

Reviewer 3
The reviewer stated that yes, the project supports the overall VTO ELT objectives.

Reviewer 4
The reviewer noted that the project is relevant to electrification, and supports the overall subprogram objective in promoting transportation electrification.

Reviewer 5
The reviewer indicated that the project supports VTO’s objectives.

Reviewer 6
The reviewer commented that the project supports VTO subprogram objectives in electrification and materials.

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

Reviewer 1
The reviewer noted that the scope of work for the project is appropriate and progress is moving along as expected. This is well spent money!

Reviewer 2
The reviewer remarked that the project has necessary financial resources and facilities and collaborators are supporting execution of projects tasks and delivery of milestones.

Reviewer 3
The reviewer commented that the team has sufficient resources to complete the project.

Reviewer 4
The reviewer stated that resources appear to be sufficient to meet the milestones.

Reviewer 5
The reviewer stated that the project resources are sufficient to achieve the stated milestones to meet the program schedule. The project lead will build and test of the initial 350 kW inverter prototype hardware, validate the components against overall project goals, and perform a final demonstration of the 350 kW inverter performance and efficiency under electric traction drive system conditions.

Reviewer 6
The reviewer commented that the team has sufficient resources for this project to achieve the milestones on time. However, it should be noted that this project may need a no cost extension. Such a extension is not due to the lack of resources but the time and effort needed in system fabrication, integration and demonstration.

Presentation Number: ELT290
Presentation Title: Behind-the-Meter-Storage
Principal Investigator: Anthony Burrell, National Renewable Energy Laboratory

Presenter

John Kisacikoglu, National Renewable Energy Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

50% of reviewers felt that the project was relevant to current DOE objectives, 50% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 50% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

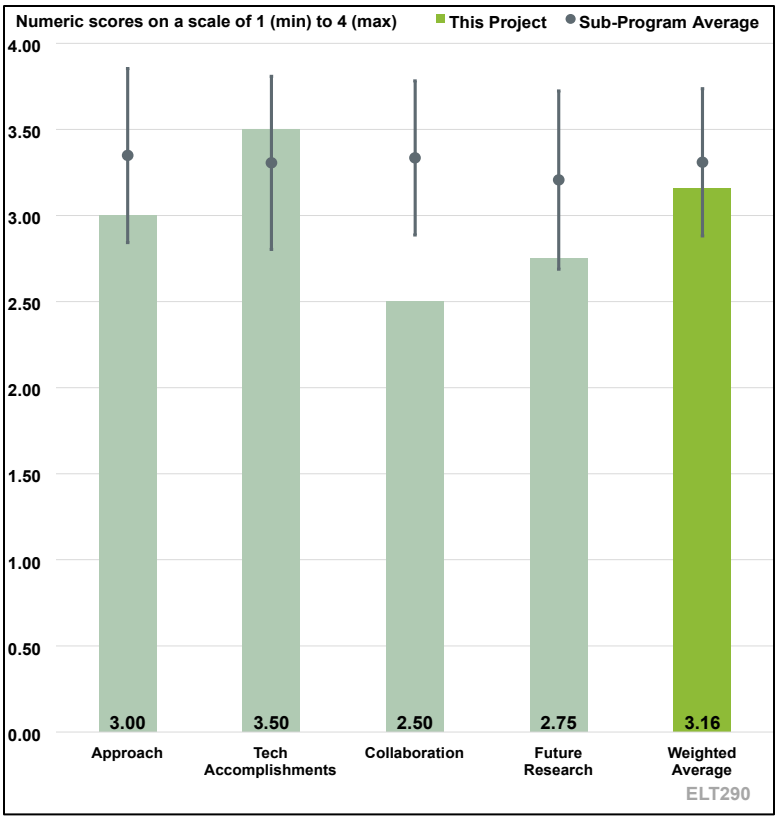

Figure 2-23. Presentation Number: ELT290 Presentation Title: Behind-the-Meter-Storage Principal Investigator: Anthony Burrell, National Renewable Energy Laboratory

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

Reviewer 1

The reviewer commented that the project directly addresses the cost, performance, and safety technical barriers to deployment of behind-the-meter energy storage (BTMS) to enable XFC of EVs and enable energy efficient grid interactive buildings to reduce vehicle charging costs. The project is at the 75% completion point on a five-year timeline that appears to be sufficient to complete all activities.

Reviewer 2

The reviewer remarked that two critical issues were not addressed by this study: whether electric utilities will legally authorize behind the electric meter storage because everything that is behind the meter (BTM) is in the legal domain and sovereignty of the electric utility, and whether there is a necessity for this work when the majority of EV users are commuters who can easily charge up their EVs at home after work hours during periods of non-peak electricity demand, do not require fast charging, and can afford the less than $3 per gallon equivalent charging cost. Only a minority of EV users will require fast charging during the daytime working hours; such EV users should pay the

premium (i.e., more than $3 per gallon charging equivalent) for fast charging during periods of peak electricity demand.

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

Reviewer 1

The reviewer remarked that progress on all technical activities is on track as summarized in the project milestone chart shown on Slide 5. The battery rack design and battery management system for active safety measures have been completed. Selection of non-flammable electrolytes for the cell build is complete and new LTO cells are on test at Idaho National Laboratory (INL). Engineering of high energy cells for delivery to SNL for safety testing in 18650 format is on track. Thermal and electrical testing in a less than 1 KWh rack is underway for delivery to SNL for safety testing. Design specifications for the fourth quarter FY 2024 rack build are under development.

Reviewer 2

The reviewer stated that investigators were able to complete the design of a BMS for active safety; select non-flammable electrolytes for the battery cells; optimize cost, cycle life (more than 18,000 cycles) and safety for the battery materials by focusing on lithium titanium oxide (anode)/lithium manganese oxide (cathode) at high voltage; demonstrate feasibility of mixing cells of different cell chemistries, densities, power, energy as well as age; and obviate maximizing energy and power density.

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

Reviewer 1

The reviewer commented that NREL is the project lead, integrating contributions of the other national laboratory partners into a BTMS system design for vehicle fast charging. SNL is conducting battery safety testing at the cell and rack level. INL is performing tests on the new LTO cells. Combined testing (SNL arc flash testing) and modeling (NREL multi-scale multi-domain [MSMD] models) is addressing trade-offs between fail-safe design and module energy density.

Reviewer 2

The reviewer noted that the project team failed to include representatives from electric power utilities and from utility industry groups, such as EPRI as well as from those with expertise in electric power distribution and building engineers.

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

Reviewer 1

The reviewer noted that specific areas proposed for future continued development in the BMS include exploring the potential benefits of state of health estimation for cell balancing and rack safety, use of machine learning (ML)/artificial intelligence (AI) active life models for improved BMS performance, investigating the reliability and safety of the battery management system with active balancing to mitigate thermal runaway and other failure modes. Integration of gas and temperature sensing and additional active/passive safety features into the BMS is also being investigated. In battery development, energy versus safe thermal design and LMO/LTO chemistry cost reduction will be explored. Non-flammable electrolytes and improved cycle life for higher energy cells than LTO/LMO are being pursued. Cell testing to characterize the life and performance and model

development of the NMC/LTO cells to be used for controls development/demonstration and failure testing will be conducted. Work with safety standard groups to help inform safety codes will also continue.

Reviewer 2

The reviewer referenced prior comments. The critical issues the reviewer raised definitely need to be answered before the reviewer, as program manager, would allow this work to proceed. Otherwise, the work is just purely academic.

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

Reviewer 1

The reviewer commented that the project supports VTO subprogram objectives in analysis, batteries, electrification, and materials.

Reviewer 2

The reviewer referenced prior comments and stated that the project is not a high priority because of the issues identified.

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

Reviewer 1

The reviewer stated that the project resources are sufficient to achieve the stated milestones to meet the program schedule. The national laboratory team members are on schedule with sufficient funding to complete the project.

Reviewer 2

The reviewer did not think that this research project requires $2.4 million to complete.

Presentation Number: ELT293
Presentation Title: Ruggedized Mobile Fast Charger for Off-Road Vehicles
Principal Investigator: Brij Singh, John Deere

Presenter

Brij Singh, John Deere

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

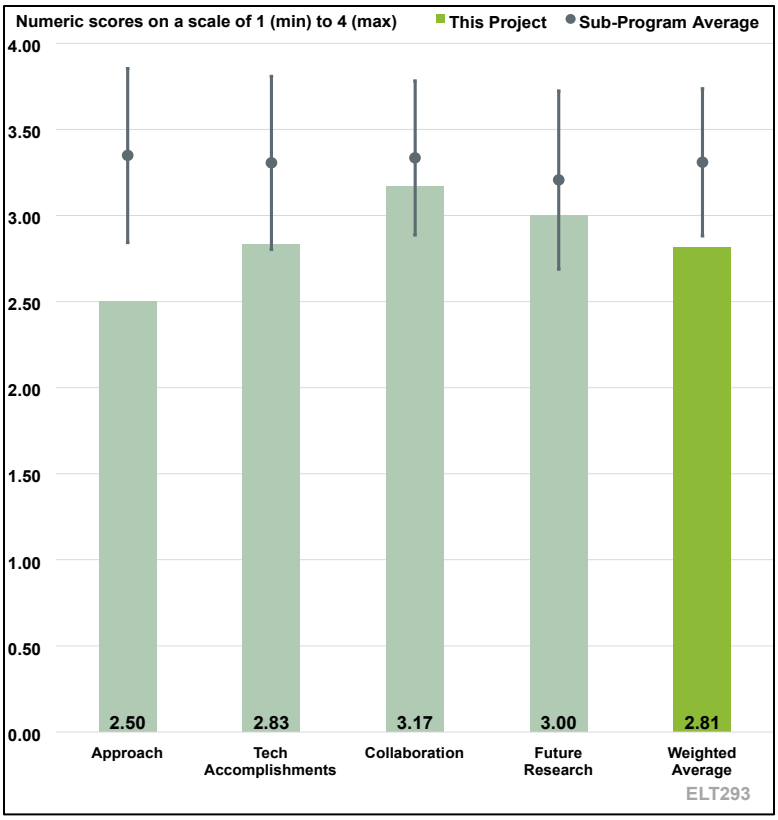

Figure 2-24. Presentation Number: ELT293 Presentation Title: Ruggedized Mobile Fast Charger for Off-Road Vehicles Principal Investigator: Brij Singh, John Deere

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

Reviewer 1

The reviewer commented that the team strives to develop innovative approaches to address diverse needs for off-road vehicles by developing an early prototype using existing power electronics hardware and controllers, and testing/verifying the early prototype to collect field data on the system charging multiple vehicles. The team proposes to model and simulate to evolve design and performance data. The team will look to integrate technology innovations into the design. The will also demonstrate multiple bi-directional V2X applications. This approach does not focus on the apparent priority for this technology, ruggedized components for the mobile charger. Performance parameters are missing (Military Specification Standard [MIL SPEC], other) and should be identified to ensure ruggedized technology performance is achieved.

Reviewer 2

The reviewer noted that the project started recently, thus the basis for assessing how well the team is addressing technical barriers is limited. However, electrified off-road equipment/vehicles are comparatively new, and accessibility of grid power is much more variable in the non-road equipment/vehicle segments. The PI has outlined barriers it seeks to address. Portability, ruggedization, voltage ranges are mentioned. Ease of operation, operator knowledge and safety protections are related concerns.

Reviewer 3

The reviewer remarked that the approach is general and does not provide any specific area of work. It is anticipated that the team will figure it out what they will do after they do exploratory work.

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

Reviewer 1

The reviewer stated that project participants developed a mobile fast charger concept for farming and construction EVs. The team completed a loss and thermal analysis of 200 kW SiC inverter to demonstrate 600 kW capacity is possible and verified fractional power DC interface for V2V functionality in laboratory scale experimentation. It is early in the project; significant accomplishments are expected for the next review.

Reviewer 2

The reviewer commented that the project has just begun but the groundwork of identifying system requirements, modeling/simulating use scenarios, developing the concept demo for V2V charging, assembling likely off-the-shelf hardware needs and anticipating potential integrations of new hardware like an SiC inverter currently under development by Deere show progress for BP1.

Reviewer 3

The reviewer did not see the level of work expected for the project given the dollars spent. Yes, there are simulation results that look encouraging, but there is no experimentation with hardware. Battery cell work and concept prototype are positive, but it is unclear where is this going.

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

Reviewer 1

The reviewer noted a very diverse and well qualified team.

Reviewer 2

The reviewer stated that the project team collaboration will be more evident as the budget period advances and each task is achieved. Still, the team comprising a university and national laboratory with Deere is a sound collaborative start.

Reviewer 3

The reviewer commented that John Deere is the project lead, with ORNL and University of Texas at Austin supporting Deere with research. There was no mention of a cooperative research and development agreement (CRADA); the reviewer would like to see one established.

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

Reviewer 1

The reviewer commented that hardware tests have been identified for next steps which are needed.

Reviewer 2

The reviewer stated that the focus should probably be adjusted to develop ruggedized charging components at a reduced cost. A power source to recharge this mobile charger appears to be an issue. Where is the power coming from to charge this mobile charger if electric grid power is not available or sufficient to recharge the mobile charger or the vehicles? What other type of recharging

solutions should be considered? Other applications beyond farm equipment should also be investigated/considered. Additional markets for this technology in Department of Defense and non-military applications should be researched.

Reviewer 3

The reviewer remarked that supply chain challenges add risk for pushing project periods longer than anticipated, especially in this technology area where parts supplies can require long lead times, as noted by the PI. The future research proposed is relevant, ambitious and important.

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

Reviewer 1

The reviewer commented that the project supports VTO, particularly in areas of Decarbonization of Off-Road, Rail, Marine, and Aviation (DORMA), Electrification, as well as Batteries subprograms to a certain extent.

Reviewer 2

The reviewer noted the need for John Deere to comply with: emission guidelines, Off-Road need for electrification technology, and ensuring productivity of equipment are all key elements.

Reviewer 3

The reviewer remarked that the project supports the overall VTO subprogram goals. However, other approaches to achieving a similar result may work better and at a lower cost.

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

Reviewer 1

The reviewer remarked that assumptions for future availability of hardware are valid but beyond control of the project team. More resources to the project would not likely impact these potential challenges. The scope of work planned seems appropriately funded and with the right partners.

Reviewer 2

The reviewer stated that adequate resources exist for this project based on the level of work being performed.

Reviewer 3

The reviewer commented that resources appear to be excessive for this project. This research is based on advancements in rugged mobile electronics. Mack Trucks has built a mobile off-grid charging system and there are other similar systems available. This technology is available today; research should focus on approaches to reduce the price of these systems.

Presentation Number: ELT294
Presentation Title: Modular Direct Current (DC) Back Bone Recharging System for Non-Road Vehicles in Austere Environments
Principal Investigator: Leandro Della Flora, Beta Technologies

Presenter

Leandro Della Flora, Beta Technologies

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

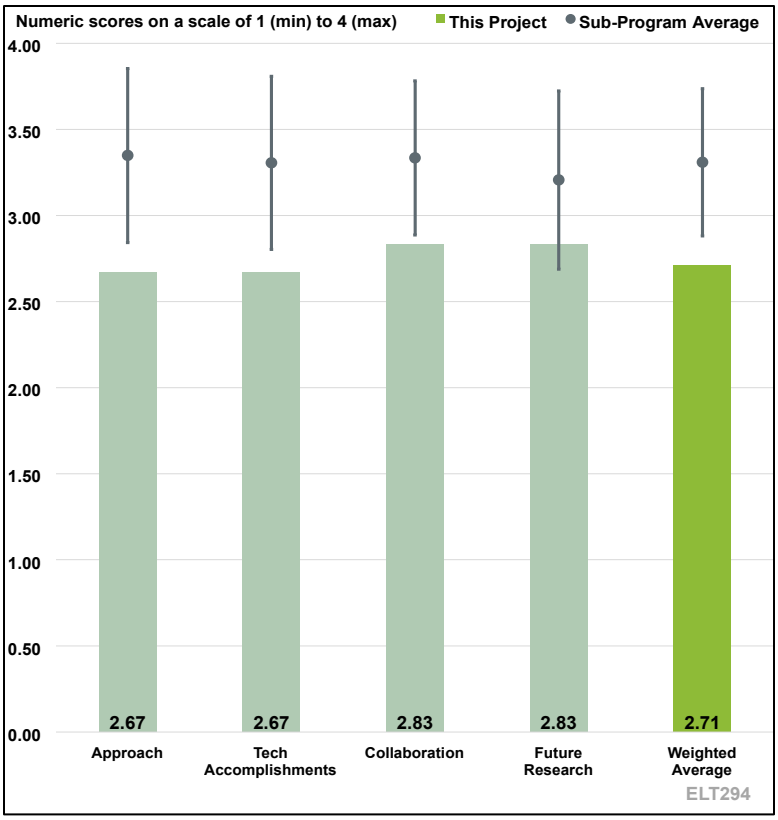

Figure 2-25. Presentation Number: ELT294 Presentation Title: Modular Direct Current (DC) Back Bone Recharging System for Non-Road Vehicles in Austere Environments Principal Investigator: Leandro Della Flora, Beta Technologies

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

Reviewer 1

The reviewer stated that the technical barriers are on track to be met.

Reviewer 2

The reviewer commented that the team proposed a non-road vehicle charging system, which is composed of a modular DC back bone charging architecture. It is not very clear how the proposed method can address some of the listed barriers, such as ease of use from cable management and grid communication and coordination of DER functions.

Reviewer 3

The reviewer remarked that the work is at a very early stage, and so it is very difficult to foresee what barriers the team might face. From the title of the presentation, the reviewer was thinking of vehicles like farm equipment, but the oral presentation seemed to have aircraft in mind. This difference in vehicle types would support the need for fast charge. The touch temperature goal seems more stringent than expected. Having reviewed the project using induction charging, which uses as a justification the cumbersome nature of charging cables, the reviewer wondered if just having them roll up is good enough for people charging off-road vehicles. Also, from the title, special

requirements for “austere environments” were expected but none were mentioned and austere was not defined.

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

Reviewer 1

The reviewer noted that the project just started and appears to be on track to plan.

Reviewer 2

The reviewer stated that the project has just begun, and the team is scoping it out. They have a basic idea and now need to flesh it out to make it practical. They would do well to look at specific cases to include rather than being so generic “off-road.”

Reviewer 3

The reviewer commented that the project seems to be delayed. After more than ¼ of the project timeline has passed, the system requirements definition and power converter topology selection are the only tasks that have been started and are still ongoing as of the project review presentation.

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

Reviewer 1

The reviewer observed that the team members are from national laboratories and industry, and each team has been assigned different tasks, which indicates an effective collaboration if the tasks are carried out as expected.

Reviewer 2

The reviewer commented that the laboratory partners are very strong but thinks the team could use actual users or manufacturers of off-road equipment.

Reviewer 3

The reviewer remarked that the project team is missing a strong contribution from a utility partner.

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

Reviewer 1

The reviewer stated that the proposed future work appears to be on track to achieve its targets.

Reviewer 2

The reviewer remarked that the basic plan is sound, but so little detail is provided that it is hard to judge the likelihood of success. The goal is fairly straightforward and logical, so no obvious pitfalls are foreseen.

Reviewer 3

The reviewer commented that the proposed future research seems to be aggressive considering the project timeline. While tasks in BP1 includes system definition, topology/component selection, and system simulation, in BP2, the tasks of sub-systems design, build and testing, and full-system assembly and demo seem to be very challenging to complete in a year.

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

Reviewer 1

The reviewer commented that the project supports the overall DOE objectives, particularly in transportation electrification.

Reviewer 2

The reviewer stated that the project supports VTO's objectives.

Reviewer 3

The reviewer noted that the off-road sector is often overlooked in transportation studies, but it is very important. This sector has significant potential for electrification without reliance on the already over-stressed grid.

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

Reviewer 1

The reviewer commented that the resources for the project seem to be sufficient.

Reviewer 2

The reviewer noted that the resources appear to be sufficient to meet the milestones.

Reviewer 3

The reviewer stated that without more details, it is hard to address this question. The project budgeting should not have relied on development of anything totally new, but rather rely on already-commercial equipment put together in new ways, so would not be subject to large uncertainties.

Presentation Number: ELT295
Presentation Title: EVs@Scale VGI & SCM
Principal Investigator: Jesse Bennett, National Renewable Energy Laboratory

Presenter

Jesse Bennett, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

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

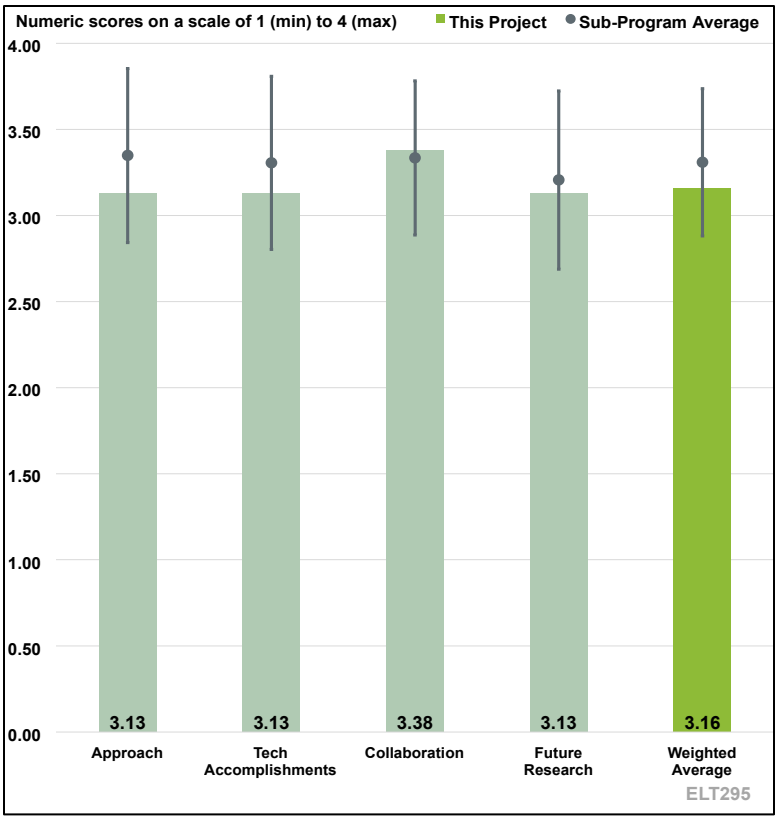

Figure 2-26. Presentation Number: ELT295 Presentation Title: EVs@Scale VGI & SCM Principal Investigator: Jesse Bennett, National Renewable Energy Laboratory

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

Reviewer 1

The reviewer stated that technical barriers are addressed well.

Reviewer 2

The reviewer noted an equally important focus planned on SCM/VGI analysis as well as laboratory demonstration.

Reviewer 3

The reviewer commented that the objective of the EVs@Scale Flexible Charging to Unify the Grid and Transportation Sectors (FUSE) project is to develop an adaptive ecosystem of SCM and VGI strategies and tools relevant to assess and reduce barriers to electrification throughout a wide geographic area and across numerous vocations. Outcomes include identifying limitations and gaps in existing SCM/VGI solutions and communicate the value potential in mitigating the grid impacts of EV charging to benefit the grid, EV drivers, and the public, and developing enabling technologies necessary to support a wide range of SCM/VGI solutions and demonstrating SCM/VGI approaches to identify the full ecosystems necessary to reduce grid impacts for light-duty (LD)/MD/HD EVs while accounting for operational and energy requirements.

The reviewer remarked that as it stands, the project is addressing a wide variety of barriers to the successful implementation of SCM. This includes SCM/VGI analysis activities including looking at uncontrolled charging grid impacts and the development and analysis of the effectiveness of various VGI and SCM strategies to mitigate grid impacts. Furthermore, the project is conducting SCM/VGI demonstration activities across a range of vehicles and vocations, and developing and testing the accuracy and efficacy of enabling technologies in the laboratory and with industry partners via field evaluations.

The reviewer stated that it is precisely the extremely broad and encompassing aspects of the FUSE project scope that the reviewer feels may be a liability to the overall success of the project. The potential value of SCM is undisputed, and the SCM/VGI space is complicated and will require efforts on many fronts (from multiple stakeholders) to successfully realize it benefits. Nonetheless, for FUSE, it important to focus on the areas that are most critical and appropriate for government to address and not try to cover too much of the SCM/VGI space. At this point, the reviewer believes the FUSE project would benefit from a strategic reassessment as to its best path moving forward. Specifically, this would include development of a plan with a clear critical path in consult with industry stakeholders and with the most pressing SCM/VGI challenges and potential solutions identified. Subsequently, consideration should be given to a significant narrowing of project focus, with adherence to the identified critical path, and emphasizing only the top showstoppers.

The reviewer noted that no timeline has been presented for specific FUSE projects.

Reviewer 4

The reviewer expressed concern that EV users do not want “long-dwell” and would prefer DCFC when in public. If long-dwell is a home-only solution does this become largely irrelevant? EVs owner currently tend to charge once every four days. If scheduling charging during the long dwell leaves the EV operator with less charge than expected due to change of plans, will they stop participating?

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

Reviewer 1

The reviewer commented that the FUSE Project has exhibited technical progress in a number of areas including travel/charging long-dwell analysis for LD EVs and MD EV vocational applications and SCM controls applications for medium and long dwell for LD, MD, and HD vehicles and day-ahead pricing control. The project has examined various strategies such as TOU immediate/random, Feeder Peak Avoidance, Volt/Watt, BTM/DER, and others. The project developed the HELICs Co-simulation framework to outline the communication and hardware needs for SCM controls and identified mid-route/concentrated charging needs including XFC access/need. The project conducted a broad analysis of SCM in El Paso Electric and ISO New England Vermont and a grid impact analysis in Dominion Energy territory. The project developed a number of enabling technologies including OptiQ, EVrest, and the Charge Scheduler Bridge. Overall, this is a solid list of achievements across a number of fronts.

Reviewer 2

The reviewer noted that technical accomplishments to date are good.

Reviewer 3

The reviewer suggested considering expanding analysis to several days to evaluate plug-in behavior and its impact on feeder total demand.

Reviewer 4

The reviewer remarked that the analysis uses good EV adoption rates, however, maybe more recent data could conclude the 52% of the fleet being EVs might be a little optimistic for 2040. On Slide 7, what is preventing school buses from reaching 100% adoption when local freight can achieve it?

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

Reviewer 1

The reviewer noted that collaboration across teams and areas is good.

Reviewer 2

The reviewer commented that Slides 14 to 18 show all participants contributing as expected and described by the presenter.

Reviewer 3

The reviewer commented that the project has successfully organized a strong laboratory team consisting of NREL, INL, ANL, and SNL. The project has utilized industry sources to obtain important travel (Wejo and Geotab) and utility feeder (Dominion Power) data to support project activities. The specific contributions of the laboratories is clearly elucidated. The reviewer asked if there is any way to include some formal industry representation on the FUSE team. This would provide a stronger business perspective and potentially help identify the most critical future pathways to pursue.

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

Reviewer 1

The reviewer stated that future work plans are well thought out.

Reviewer 2

The reviewer noted that all research proposed on Slide 19 fits the project goals.

Reviewer 3

The reviewer commented that proposed future research/next steps encompass four broad areas: travel/charging analyses, SCM/VGI controls, grid analysis impacts, and demonstrations. The reviewer expressed a perspective that that there are too many activities spread across too many fronts. A key question is, “How does everything fit together in the bigger VGI/SCM picture?” Are the critical VGI/SCM barriers being addressed to the extent feasible by FUSE? Furthermore, it may be beneficial to downscale any focus on long-term projections and place additional focus on immediate barriers impeding implementation of SCM. For example, how can enabling technology get into the hands of industry and be utilized? As mentioned above under the “Approach” section, the development of a specific plan with industry input and clearly defined critical path would be beneficial in guiding future FUSE research activities.

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

Reviewer 1

The reviewer noted that this project addresses the challenge of smart EV charging and helps to maximize the utilization of the infrastructure to cover as much of the EV population as possible.

Reviewer 2

The reviewer commented that the successful development and implementation of VGI/SCM technologies is essential to enable and manage the introduction of ever greater numbers of EVs in a cost-effective manner while reducing associated grid impacts. This project clearly supports overall VTO subprogram objectives.

Reviewer 3

The reviewer stated that a reliable grid will enable more robust EV charging experience and faster decarbonization of energy.

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

Reviewer 1

The reviewer stated that the identified resources of $3.15 million per year are sufficient to meet FUSE objectives in an acceptable timeframe.

Reviewer 2

The reviewer remarked that resources allocated are adequate.

Reviewer 3

The reviewer noted that all proposed work fits within the funding proposed.

Presentation Number: ELT296
Presentation Title: Charging Infrastructure Interconnection Simplification Resource CIISR
Principal Investigator: Watson Collins, EPRI

Presenter

Jennifer Robinson, EPRI

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

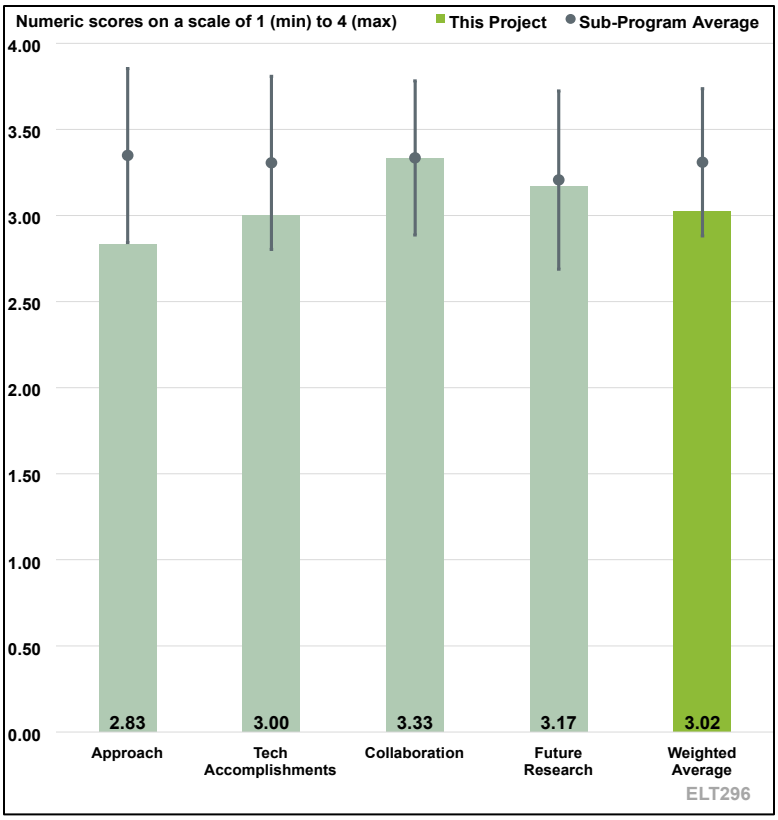

Figure 2-27. Presentation Number: ELT296 Presentation Title: Charging Infrastructure Interconnection Simplification Resource CIISR Principal Investigator: Watson Collins, EPRI

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

Reviewer 1

The reviewer commented that the project is addressing technical and educational barriers regarding utility connection. Additional clarity on types of interconnection being worked on and class of utility customers would be helpful as the project progresses.

Reviewer 2

The reviewer offered that one general comment is that there was extensive use of acronyms in the slides which were not spelled out which makes it difficult to understand what is being referenced. The problem as the reviewer understands it is to capture the needs of the customers and then communicate these to the electricity/grid suppliers to create a strategy on how best to meet both parties' needs. The project appears to be very focused on reaching out to various groups of customers but the reviewer did not see a clear plan on how these were to be collected and presented to the suppliers. Furthermore, it was not clear to the reviewer who is responsible for brainstorming ideas or if there would be regional differences in the grid/electricity supply which would need to be considered for any generalized solution.

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

Reviewer 1

The reviewer noted that the advisory structure has been set and that workshops have been scheduled for this summer and fall.

Reviewer 2

The reviewer commented that unfortunately Slide 4 (Milestones) did not include notation of whether individual milestones were completed or not and the timing. Slide 17 also did not indicate amount of completion, which makes it difficult to assess. Another issue is that this project aims to “Accelerate new grid service connections...” yet no baseline rate of connections was provided, and it is not apparent that the rate of connections was a metric being tracked. Also, since the project does not have the control over making said connections, “creating new grid service connections” is not a reasonable metric to assess this project. Slide 5 clearly states that the approach is to “Launch support website” which the reviewer assumed is the interconnection platform, and the successful launching of this would seem to be a good metric to evaluate the success of this project. The project presentation focused significantly on the data collection, and very little on the development of the support website and how GridFAST would be integrated. That appears to be the single largest technical hurdle which was not really addressed.

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

Reviewer 1

The reviewer stated that the project is doing a very good job of reaching out to other groups and organizations both regarding the stakeholder advisory group as well as ad-hoc connections as listed out on Slide 9. One idea for collaboration would be the effort to commonize the EV charger interface as this is the point where the EV customer and utilities connect.

Reviewer 2

The reviewer commented that the project has multiple stakeholders from utilities, community and workforce, and Clean Cities coalitions.

Reviewer 3

The reviewer noted that it is not clear how the end customer is represented in the advisory stakeholder list.

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

Reviewer 1

The reviewer commented that the project can achieve its targets. The timeline is tight but collaborators and partner are coordinated. The project would benefit from outreach to other DOE-funded programs which are deployment based such as EMPOWER and AMP.

Reviewer 2

The reviewer noted that this project has a singular focus to speed new grid service connections. This is a significant challenge in of itself but if successful, there are no lingering research questions that the reviewer sees.

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

Reviewer 1

The reviewer stated that the project addresses the softer barriers to deployment of EVSE's at scale.

Reviewer 2

The reviewer commented that increasing grid service connections will reduce the activation energy for potential EV customers and speed the overall EV adoption.

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

Reviewer 1

The reviewer commented that the project is resourced sufficiently.

Reviewer 2

The reviewer stated that of the six partners listed for this project, it is not clear what each partner will be contributing so it is a bit difficult to assess the overall committed resources.

Presentation Number: ELT297
Presentation Title: Electric Vehicle Smart Program Management Supporting Local Governments to Achieve Equitable Access to Electric Mobility
Principal Investigator: Ed Gilliland, irecusa.org

Presenter

Ed Gilliland, IREC

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

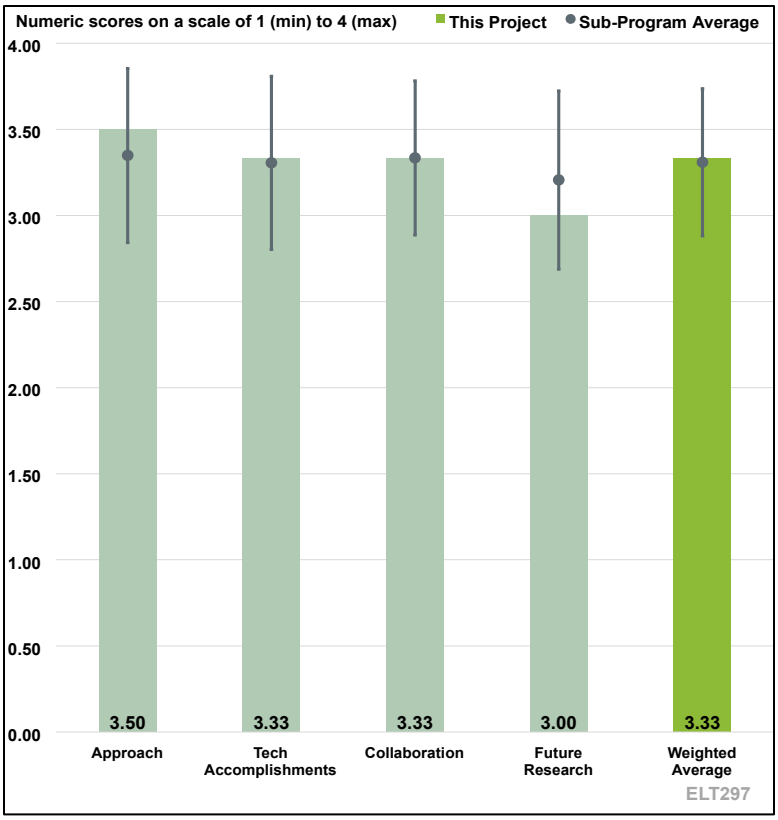

Figure 2-28. Presentation Number: ELT297 Presentation Title: Electric Vehicle Smart Program Management Supporting Local Governments to Achieve Equitable Access to Electric Mobility Principal Investigator: Ed Gilliland, irecusa.org

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

Reviewer 1

The reviewer stated that the project aims to break down barriers to planning and installing EVSE within communities and municipalities. It is based on a successful project for planning and installing solar within communities.

Reviewer 2

The reviewer commented that the project approach addresses barriers to EV charging infrastructure readiness by providing tools and information based on previously successful technical assistance programs.

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

Reviewer 1

The reviewer commented that the project has been piloted within 5 states in 2023 and early 2024.

Reviewer 2

The reviewer stated that this project defines the criteria status of EV charging readiness, and this project held kick-off meetings with several state entities. The project also states technical

accomplishments for 2023 and 2024 in several states, but details are not provided. Details of technical accomplishments would be beneficial for this AMR review. What actions and impacts can be detailed as resulting from this DOE-funded project? There is one slide example of a New Jersey permit for EV charging in parking lots. The reviewer is unsure if this is a successful change because of this project or an example for other states to follow. Are there other examples of successful changes accomplished by this project? There was no information or details on tasks, scope, or accomplishments associated with infrastructure modeling tools, or industry partner involvement.

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

Reviewer 1

The reviewer acknowledged a strong project team with public and industry partners.

Reviewer 2

The reviewer commented that the team is comprised of good partners. It is unclear as to the involvement of the industry partners and the modeling tool team.

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

Reviewer 1

The reviewer commented that the team will continue to launch new communities in 2024 with build out of program guide.

Reviewer 2

The reviewer noted that the proposed future work is good for including new states, but showing successful accomplishments of previous states as well as any lessons learned to enable improvements to the process is important prior to moving forward with new, additional states. How are lessons learned incorporated back into this process? Was this project reviewed last year? There was no information provided on last year's reviewer comments.

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

Reviewer 1

The reviewer stated that the project supports the VTO electrification goals.

Reviewer 2

The reviewer commented that enabling and improving EV charging infrastructure deployment is very relevant.

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

Reviewer 1

The reviewer noted that the program is adequately resourced.

Reviewer 2

The reviewer stated that the resources are sufficient.

Presentation Number: ELT298
Presentation Title: Bidirectional Power Flow for Medium-duty Vehicle-to-Grid Connectivity
Principal Investigator: Steven Sokolsky, CALSTART

Presenter

Omer Onar, ORNL

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

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

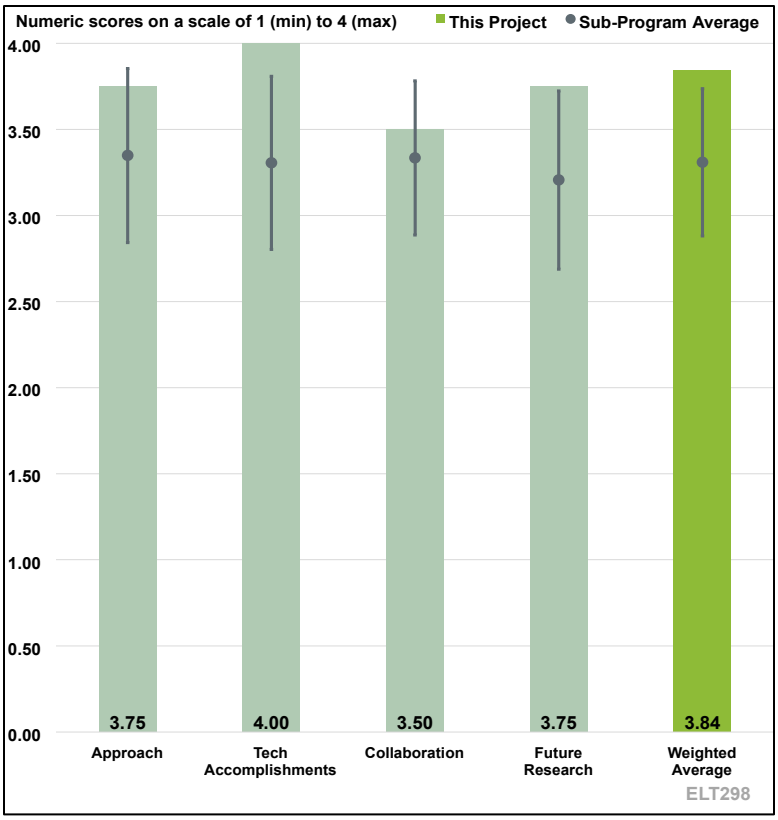

Figure 2-29. Presentation Number: ELT298 Presentation Title: Bidirectional Power Flow for Medium-duty Vehicle-to-Grid Connectivity Principal Investigator: Steven Sokolsky, CALSTART

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

Reviewer 1

The reviewer stated that the approach is excellent by starting with V2G (grid following) and including some of the regulation requirements for ride-thru. Other exporting requirements per Rule 21 in California and other states should also be tested. V2H where the inverter is grid-forming is also a desired option to include. This also shows a double D approach; circular and polyphase designs should also be considered.

Reviewer 2

The reviewer commented that this project team has been super careful to check out every possible function of their system since the project began. The team has also made sure to allow sufficient lead time so that glitches or redesigns could be accommodated without disrupting the flow of the research. This is especially obvious when contrasted with other similar projects with much higher budgets. The level of technical detail provided in the review is impressive, unfortunately time and space precluded explanations of the details for reviewers not intimately familiar with the technology. That is an inherent shortcoming of the review system.

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

Reviewer 1

The reviewer commented that the project adds an application interface as to placement of the primary and secondary coils for loading docks that is not included in standards to date. The project also points out additional features to interface with the vehicle during charging/discharging, etc., for the complete system approach.

Reviewer 2

The reviewer noted that these guys actually seem to get stuff built and tested and actually running, and on schedule. The reviewer is impressed and really wants to see how the truck and charging system operate in real-world situations.

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

Reviewer 1

The reviewer remarked that the system approaches are excellent with support from potential customer, OEM, project management and communication.

Reviewer 2

The reviewer stated that the pieces seem to fit together at the end, and that is the test of the collaboration. The reviews provide no picture of how the interactions among the partners actually worked, unless clear gaps are revealed, which did not happen in this project.

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

Reviewer 1

The reviewer suggested that combinations of primary and secondary coils could be useful (circular, double D and polyphase). Perhaps a mix of power levels between the primary and secondary coils with efficiency results could also be useful.

Reviewer 2

The reviewer expressed eagerness to see how this works when it is all put together and the truck is driving around in service and charging inductively. The reviewer is looking forward to advances in inductive charging so that plug-in hybrid EVs actually get charged, whether the owners care or not.

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

Reviewer 1

The reviewer commented that bidirectional power is already being deployed for Alternating Current (AC) and DC systems and WPT needs to be demonstrated and applied too.

Reviewer 2

The reviewer noted that both electrified transportation and inductive charging will help to advance decarbonization of the transport sector.

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

Reviewer 1

The reviewer stated that this project has managed resources between labs, vehicles and test sites to maintain the full spectrum of effort required.

Reviewer 2

The reviewer commented that the team seems to be pretty good at figuring out how much it is going to cost to build stuff.

Presentation Number: ELT299
Presentation Title: EVs@Scale High Power Charging Pillar
Principal Investigator: John Kisacikoglu, National Renewable Energy Laboratory

Presenter

John Kisacikoglu, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

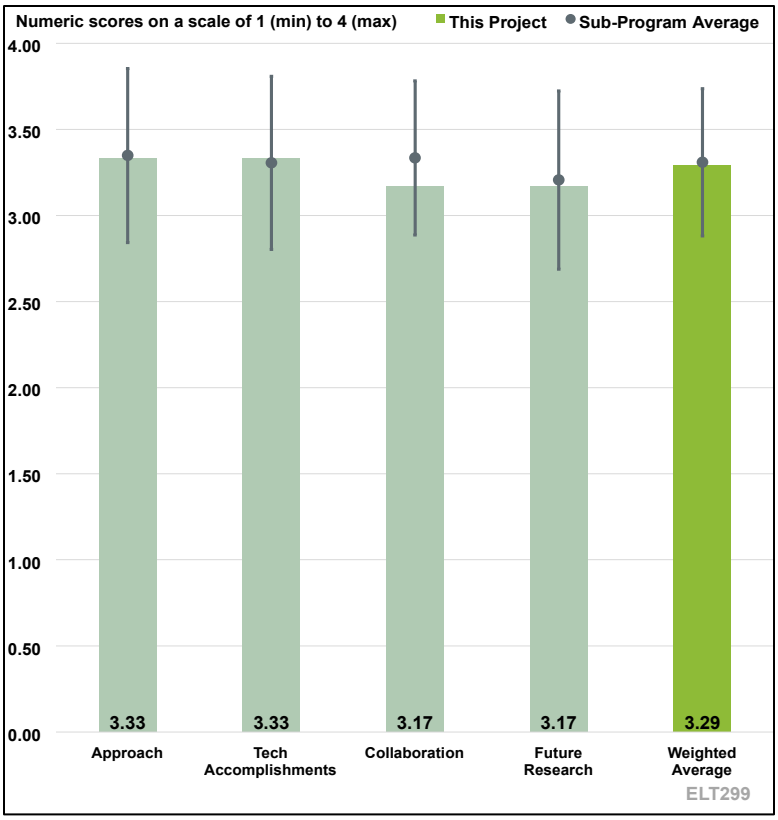

Figure 2-30. Presentation Number: ELT299 Presentation Title: EVs@Scale High Power Charging Pillar Principal Investigator: John Kisacikoglu, National Renewable Energy Laboratory

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

Reviewer 1

The reviewer noted a good work plan with well laid out timing, milestones and target definitions. It was easy to read and follow during the presentation.

Reviewer 2

The reviewer stated that the project combines both 400V and 800V vehicles along with DC, pantograph and WPT charging. DC and WPT may have similar charging use cases for passenger and freight vehicles, but pantograph may have unique profiles such as buses. These should be separated as demand charges would also vary for the vehicle use case variations, not combined.

Reviewer 3

The reviewer commented that the EVs@Scale high power charging pillar is broken into two tasks: Next Generation Profiles (NGP) and the Electric Vehicle Charging Integration Hub Platform (eCHIP).

The principal barrier, objective, and intended outcomes are clearly and concisely identified for the NGP task. The NGP project is divided into three clearly defined areas: EV profile capture, EVSE characterization, and fleet utilization with the assets, conditions, edge cases, and cadence defined for each. Fleet utilization, additionally, is divided by time-series categories and analysis types. A

strong NGP timeline is provided, with specific milestones, and a clear delineation of tasks. The technical barriers are clearly being addressed. The project is on or even somewhat ahead of schedule. Especially noteworthy is that milestones and activities for FY 2024 and FY 2025 of the project have already been scoped out at a high level.

The two principal barriers, objective, and intended outcomes are clearly and concisely identified for the eCHIP task. The overall approach is largely presented via discussion of the DC hub hardware platform and site energy management system (SEMS) based on ANL's Common Integration Platform (CIP.io). Further discussion of the approach is provided with regards to the universal power electronics regulator (UPER) / SpEC integration. It appears the technical barriers are largely being addressed; however, no specific eCHIP timeline, nor milestones, have been provided. The project is behind schedule is some areas, most notably UPER/SpEC integration/testing which is 6 months behind schedule with a currently planned completion in the fourth quarter 2024.

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

Reviewer 1

The reviewer stated that significant technical accomplishments have been achieved for NGP. Four technical reports were completed at the end of calendar year 2023 and a procedures draft document completed in March 2024. The team successfully secured additional assets including 6 EVs, 2 EVSEs, and 5 fleets in 2024. The team also finalized a thoughtful approach to dissemination of information policy to balance the availability of key data without de-incentivizing participation. The team captured 167 EV profiles across a wide swath of conditions and multiple charging types (connected charging system (CCS), pantograph, North American charging standard NACS, J3400, and WPT). The team conducted conductive and non-conductive power transfer EVSE characterization tests, high utilization tests, and XCEL Energy scaled profile tests. The team conducted EV and EVSE fleet analyses and increased the scope of capabilities. Overall, this is a very impressive list of technical accomplishments.

eCHIP has successfully demonstrated automated DR capability of the DC hub platform using battery energy storage system (BESS) support. Bidirectional power transfer (BPT) has been demonstrated for functionality and readiness. Further progress has been demonstrated in development of the controller hardware-in-the-loop (C-HIL) platform and the UPER. Despite being behind schedule, UPER/SpEC module integration/testing is progressing with the test specs and the ORNL integration test bed nearing completion in late June 2024. Integration/testing is planned for 4Q2024.

Reviewer 2

The reviewer noted great work in building the charging profiles and the use case for impact on the utility side of the EVSE connections. As charger deployment grows, the grid's capacity and DER plans will require this type of information for future improvements and planned implementations of new technology solutions. Identification of potential limitations and gaps in distribution capability is a strong suit for eCHIP. The everything-in-the-loop (XIL) testing for C-HIL serves to build predictions for EV adoption and the control plans for multiport EVSE hubs.

Reviewer 3

The reviewer commented that the profiles captured are low state of charge to 100% where low state of charge to 80% values should be compared to demand charge level requirements. The lower power levels of 80% to 100% could be the offset to allow continued charging but a time to not curtail higher power charging for other vehicles.

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

Reviewer 1

The reviewer stated that combining resources at all four laboratories provides a mix of vehicles and charging equipment. As expected, the 800-V vehicles are not as plentiful as desired for this project but the later years should increase that.

Reviewer 2

The reviewer commented that collaboration and coordination within the NGP laboratory team (ANL, INL, NREL, and ORNL) appears well-developed and strong. NGP interacts and coordinates with OEMs and industry for procedures development, testing assets, and report feedback and is demonstrating success securing testing assets from vehicle and EVSE OEMs, as well as lining up fleet partners. Collaboration and coordination of the eCHIP team with the NGP laboratory team appears reasonably well-developed, but may need adjustments based upon evidence of project timeline slippage. There is no mention of direct contributions to eCHIP from outside entities such as industry.

Reviewer 3

The reviewer noted a good group of national laboratory partners but wondered about utilities and industry or charging consortium. If there are laboratory personnel on other team calls, it should be linked to this project to indicate the scope of the information network.

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

Reviewer 1

The reviewer commented that mid-way through the project, there is good alignment with other ELT projects. The project has built a solid foundation for the advancement of EVSE controls/operations with profiles and grid side impact. Gaining additional testing assets (which is the plan) will help to build a representation of future needs and possible complications for the grid/EVSE network and vehicle load variation.

Reviewer 2

The reviewer noted that specific future challenges and barriers have been identified spanning NGP and eCHIP. There do not appear to be any real showstoppers with NGP and continued progression of the very successful NGP project is expected to continue on schedule as outlined in the project timeline. Appropriately, the proposed future work is largely continuation of business as usual. The platform, eCHIP, still faces some significant challenges including interoperability, DC protection, and reliable and scalable SEMS operation. Proposed future work includes implementation of more advanced SEMS, integration of UPER. SpEC modules in DC hub, scaling up the C-HIL platform, and continued demonstration of real world use cases. It is suggested that a timeline/milestones be established for the proposed future activities going out for at least 2 years. Furthermore, methodologies should be explored to encourage/enable greater industry participation in the eCHIP project potentially in an advisory capacity, as a technology contributor, and to provide ongoing business perspective.

Reviewer 3

The reviewer stated that it is not clear what the goal of V2X is for this project, other than showing photovoltaic (PV), ESS and perhaps hydrogen as DER resources. Optimizing these with DR and combinations of vehicles is an option for future research.

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

Reviewer 1

The reviewer noted very relevant work in providing a capable and consistent charging experience for users. This will be a more important aspect of EV adoption as the EV registrations grow in the coming years.

Reviewer 2

The reviewer commented that yes, both the NGP and eCHIP projects contribute to the overall VTO subprogram objectives. The development of high power charger (HPC) DC hub architectures that successfully integrate HPC for LD, MD, and HD EVs, as well as integration of BESS and renewable energy sources, are important to the continued growth of EV transportation and smooth VGI. A clear, consistent understanding of HPC profiles under different use cases and conditions is a primary enabler in this effort.

Reviewer 3

The reviewer stated that this project summarizes the goal of meeting charging requirements while not overloading the grid.

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

Reviewer 1

The reviewer remarked that this project has sufficient managed resources between labs, suppliers, vehicles and test sites to perform the full spectrum of effort required.

Reviewer 2

The reviewer stated that the resources identified are sufficient for both the NGP and eCHIP projects.

Reviewer 3

The reviewer commented that EVs@Scale is a wide range of projects, and each has shown good progress with resources available. As commercial vehicle electrification begins to ramp up, considerations for additional funding may be required to facilitate the creation of a larger representative and variable load case to test the grid responses.

Presentation Number: ELT300
Presentation Title: EVs@Scale Codes and Standards Pillar
Principal Investigator: Ted Bohn, Argonne National Laboratory

Presenter

Ted Bohn, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

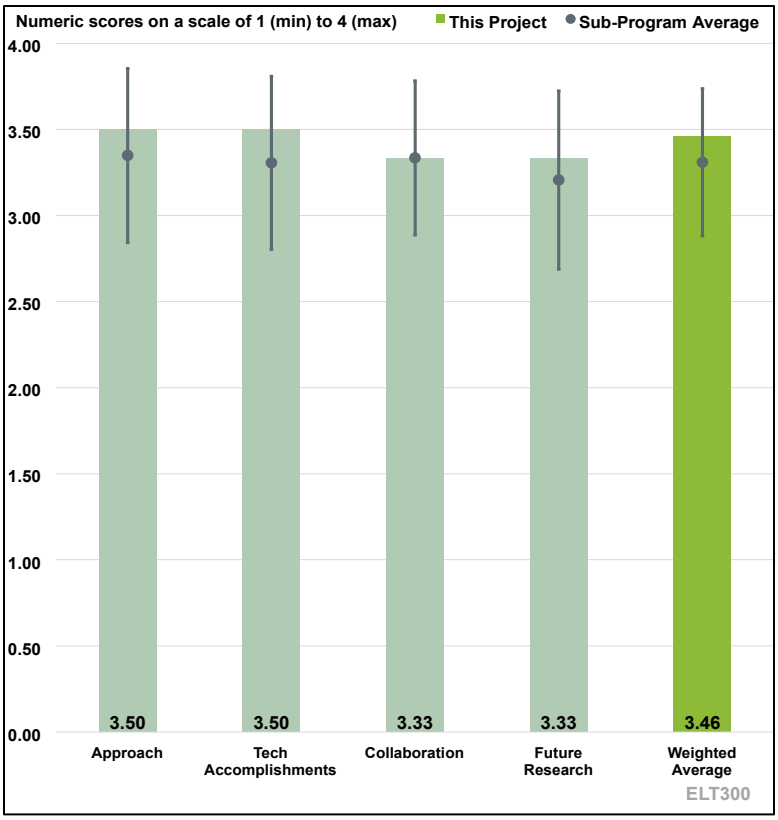

Figure 2-31. Presentation Number: ELT300 Presentation Title: EVs@Scale Codes and Standards Pillar Principal Investigator: Ted Bohn, Argonne National Laboratory

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

Reviewer 1

The reviewer stated that these are necessary standards for the industry to move to higher power charging and connector variations along with expanded utility factors and the associated effort. The SAE and Institute of Electrical and Electronics Engineers (IEEE) standards are continuing to be updated and the leadership from this project that includes testing provides the bases for this effort to move from info reports to standards.

Reviewer 2

The reviewer commented that the Codes and Standards pillar objective and expected outcomes are clearly and concisely identified upfront. The overall project is well designed and technical barriers are being directly addressed. A timeline of near term (FY 2024) activities is provided. The Codes and Standards piller has clearly defined priorty areas including scaling of charging capabilities for EVs@Scale standards, electric power delivery oriented standards, vehicle oriented system standards, and high power WPT standards.

The Codes and Standards pillar has adopted a “divide and conquer” approach with respect to standards. A very clear delineation of laboratory responsibilities has been identified therein. Given the high importance and extensive need with respect to to codes and standards and limited resources, this appears to be the correct approach. However, within this context, consideration

should be given to a modest narrowing of project scope, eliminating support to some lesser standards activities and increasing support to only the very most critical ones, thereby accelerating their development (for exemple J3400).

Reviewer 3

The reviewer noted that though the research areas are vast, the project lead has done a great job managing the scope of topics and building engagement with industry stakeholders. There needs to be a little work on the flow of the presentation and some limitations to the content on each slide.

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

Reviewer 1

The reviewer noted that steps taken are appropriate to lead to a mature system for the industry to follow. System level approaches provide the basis for what is required, then OEMs and equipment suppliers can focus on a common solution for AC, DC and wireless charging at various power levels and obtain interoperability.

Reviewer 2

The reviewer stated that the Codes and Standards pillar has demonstrated outstanding and prolific technical accomplishments across the board in the last year, including completion of the DOE/ANSI Roadmap of Standards and Codes for EVs@Scale, IEEE P2030.13 DCaaS functional specification for charging system feed, SAE J3400 NACS (expedited and extensive progress), megawatt level standards progression (J3271, AIR7357, International Electric Code [IEC] 8005-4, and extendable mobile control suite [xMCS]/mining), energy services exchange (ESX) implementation, weights and measures (meter drift study, handbook (HB) 44 test tool, and HB105 transfer standard guide), other SAE/IEEE standards on interoperability, reliability, safety, and recycling, an NREL-hosted MCS connectors testing event, an EV variability study, and wireless power standards (J2954/1) published, J2954/2 HD Technical Information Report released, J2954/3 dynamic charging.

Reviewer 3

The reviewer commented that this type of project needs some accountability to the various stakeholders and their engagement with consortia required to build acceptable industry standards. Even if difficulties arise, this would allow DOE to recognize trouble spots and/or gaps where additional support is required to meet with the expected pace of progress in technologies leading to EV adoption. Top 10 standards area coverage is a good start, but how do we prepare for the next “NACS” industry focus change (how OEMs switched charging port format very late in the game, etc.)?

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

Reviewer 1

The reviewer stated that each laboratory is adding their strengths to the project with design, testing and updates to the standards. The schedules are reasonable and with initial publication to additional testing and validation, the standards can be quickly moved to the next level of maturity.

Reviewer 2

The reviewer noted that good collaboration and coordination appears to exist amongst the five laboratory team members including ANL, INL, NREL, ORNL, and the Pacific Northwest National

Laboratory (PNNL). Each laboratory member has a clearly designated area of responsibility. Extensive industry collaboration exists primarily through the wide-ranging standards participation and development processes. Interaction/collaboration with other governmental entities (such as the National Institute of Standards and Technology [NIST]) is clearly evident.

Reviewer 3

The reviewer commented that the scope of this project really becomes the question. There is so much ground to cover in a number of related, though different technologies and application areas; this type of report out may require separate task/PI interaction at AMR to ensure that details (and possible needs) can be brought into the light.

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

Reviewer 1

The reviewer remarked that it was identified that WPT did not include BPT however this is nearly identical to DC BPT and needs to be included in the performance and communication standards. Additional testing should accommodate this but WPT wall box should be capable of V2G (grid following) and V2H (grid forming), same as the DC EVSE.

Reviewer 2

The reviewer commented that a clear description of near-term FY 2024 milestones/deliverables and next steps is provided. This includes input to, progression, and validation of specific standards and functional specs; test plan development; progress and testing report development; and work group and event participation. The Codes and Standards Pillar covers extensive ground with very limited funding. As mentioned above, consideration should be given to narrowing the project scope to fewer standards development activities in order to accelerate only those most critical.

Reviewer 3

The reviewer stated that with great laboratory participation, there is the question of industry, utility and academic participation. How is the whole consortia architecture understood? Are there any expectations of industry for support of plans for the next set of critical standards or provide data/information to help to create sensitivity projections to help highlight where resources should be applied next?

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

Reviewer 1

The reviewer commented that the Codes and Standards pillar unquestionably directly supports the overall VTO subprogram objectives. Codes and standards development is critical to furthering the successful implementation of EVs in the nation’s fleet along with smooth VGI. Ultimately, it is likely the most fundamentally salient area with regards to successful EV deployment. Unfortunately, codes and standards face numerous challenges across government, industry, and third parties including a significant lack of financial resources, the atherosclerotic nature of the standards process itself, the high-level of turnover of skilled standards personnel, requirements for global harmonization, and others.

Reviewer 2

The reviewer noted that the project is very relevant, and creation of industry standards and evaluation techniques is a fundamental role of the government. This work will help to encourage

technology adoption and allow for policies to be created to help industry make commitments and build sustainable business strategies.

Reviewer 3

The reviewer stated that this project summarizes the goal of meeting charging requirements while not overloading the grid.

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

Reviewer 1

The reviewer commented that MCS and higher power WPT is essential to meet automotive, truck, and bus requirements. The MCS connector interface and communication complements the existing connectors and the option of NACS will provide customers with additional charging stations to meet existing and future releases of vehicles. Seamless retries and extensible session description protocols (SDPs) are included in these updates as they lead to improvements in interoperability.

Reviewer 2

The reviewer stated that given the critical importance, overall cross-cutting nature, and the generally inherent long/arduous development processes (as a result of the industry consensus-based approach within the United States) of codes and standards, strong consideration should be given to significantly expanding the level of resources in support of codes and standards development.

Reviewer 3

The reviewer remarked that the scope of technology covered under this project requires a high level of support to properly engage industry and track progress for these and future required standards. Though there is a good mix of national laboratories involved, the progress on some of the tasks was less clear for specific project timeliness and impact of any late standards development on the industry. Additional task reporting may be a consideration as the project continues.

Presentation Number: ELT301
Presentation Title: EVs@Scale Cyber-Physical Security Pillar
Principal Investigator: Richard Carlson, Idaho National Laboratory

Presenter

Richard Carlson, Idaho National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 50% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

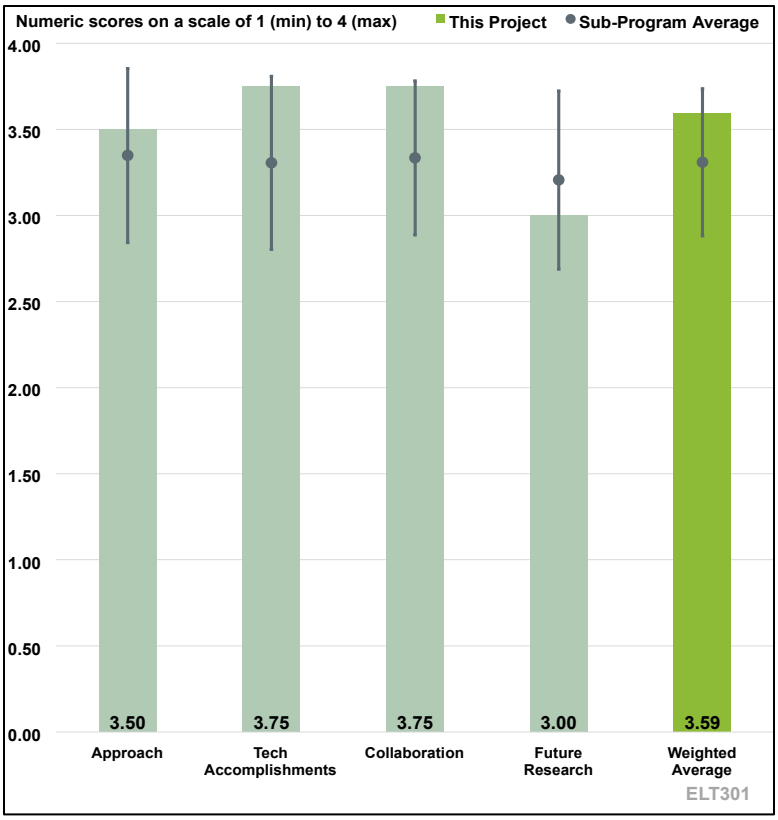

Figure 2-32. Presentation Number: ELT301 Presentation Title: EVs@Scale Cyber-Physical Security Pillar Principal Investigator: Richard Carlson, Idaho National Laboratory

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

Reviewer 1

The reviewer commented that the approach has 4 pillars which are all relevant. First is laboratory testing and emulation of state-of-the-art charging infrastructure and communication protocols. The second is analysis of attack vectors and potential impact severity. The third is reporting of results, findings, and best practices. The fourth is cybersecurity tools and mitigation solutions development. The approach does not have end users involved. There needs to be a fleet partner involved as this will be the community most impacted by cyber breaches.

Reviewer 2

The CPS pillar has identified a strong list of holistic cybersecurity barriers facing widescale implementation of EVs in the United States and successful vehicle-grid integration (VGI). Upfront, it may be beneficial to more clearly indicate which ones the CPS pillar is currently specifically addressing or planning to in the near future. It may be good to more sharply define the overall CPS pillar objective and include a timeline and a few high-level milestones.

Overall, the high-level approach is sound and includes conducting analysis of attack vectors and potential impact severity, conducting laboratory testing/emulation of state-of-the-art charging infrastructure and communication protocols, developing CPS tools and mitigation solutions, and reporting results, findings, and best practices. The pillar is well designed and addresses specific

technical barriers. The CPS pillar is clearly divided into two projects: CyberPUNC and Zero Trust (ZT) Architecture / Post-Quantum Cryptography (PQC). The objective, outcomes, and scope, as well as supporting background, of the ZT/PQC project are very clearly defined and explained, which is especially beneficial given the complicated nature of this domain.

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

Reviewer 1

The reviewer stated that the technical accomplishments include testing environment creation (aligned with industry needs and developments), completing first automated testing of many EV-EVSE device interactions, completing an EVSE security control catalog for cybersecurity risk assessments, developing mitigation solutions tools, continuing support of the Cyber Auto Challenge in colleges around the United States to help develop future cyber-crime fighters, and developing EVSE upstream and backend system analysis tools.

Reviewer 2

The reviewer remarked that the CPS pillar has demonstrated a prolific and impressive list of accomplishments over the last year. Notable CyberPUNC accomplishments include PKI testing environment creation, creating a scalable, repeatable environment for scenario evaluation and extends prior and upcoming EV charging industry public key infrastructure (PKI) testing events with SAE; identifying existing industry cyber tools, solutions, and capabilities, and mapping of these to EVSE security functions and needs; designing and demonstrating Cerberus, an R&D 100 award-winning cyber-physical anomaly detection and exploit mitigation solution; designing and implementing AcCSS, a system to evaluate CCS communication vulnerabilities and identifying exploitable vulnerabilities in some DC chargers; completing the first automated testing of EV-EVSE device interactions; completing an EVSE security control catalog for cybersecurity risk assessments; continuing support of the Cyber Auto Challenge; conducting an EVSE upstream and backend system analysis with open source intelligence gathering, processing, and analysis of backend systems; and developing cyber best practices for high power charging infrastructure (via the Office of Cybersecurity, Energy Security, and Emergency Response [CESER]).

Notable ZT/PQC accomplishments include identifying security objectives and assessing four prototypes to gauge ZT approaches; identifying traditional public key applications and exploring PQC adoption challenges; designing and developing an open change point protocol (OCPP) security service to counter grid-related high consequence events; and identifying a number of test and measure findings with respect to PQC keys, signatures, ciphertexts, and cryptosystems.

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

Reviewer 1

The reviewer stated that the CPS pillar encompasses six national labs, numerous collaborative partners, and industry work groups. Essentially the entirety of CPS pillar activities have extensive and ongoing collaboration with numerous industry, third party, and university stakeholders. Specific contributions are being made by all these entities. This is excellent and should continue to be aggressively pursued.

Reviewer 2

The reviewer commented that the project team is very strong as far as technical acumen is concerned. The laboratories involved are all very strong partners, and industry partners are very strong as well. The missing entity is a business end user.

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

Reviewer 1

The reviewer noted that future research on this project will help develop tailored cybersecurity mitigations and prioritized action items for the assessment outcomes, test facility-specific EVSE cybersecurity controls progress and needs, and maintain and update EVSE tools site and build connections between needs and solutions. The project should include inductive charging systems as well.

Reviewer 2

The reviewer stated that at a high level, the CPS pillar effectively identifies remaining challenges and future research. For many of the technical activities, future proposed activities/next steps are identified, while for others they are not; additional details on those not identified would be beneficial. Consideration should be given to laying out proposed future activities and associated milestones for the next 2 years or so.

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

Reviewer 1

The reviewer stated that the project has relevance in the fact that CPS is essential due to potential exploitable vulnerabilities impacting safety, grid impacts, hardware damage, denial of service, and theft or alteration of information. Continuous development and improvement to mitigation solutions is required to stay ahead of evolving threat actors and malicious exploits.

Reviewer 2

The reviewer commented that there is no question with respect to the relevance of CPS and that the pillar activities directly support VTO subprogram objectives. CPS is essential due to the large number of exploitable vulnerabilities, the potential severity of associated consequences, and the need for continuous development and improvement to mitigation solutions to stay ahead of evolving threats.

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

Reviewer 1

The reviewer commented that few areas are more critical than cybersecurity to the widescale implementation of EVs, successful VGI, and ultimate sustainment. At $4.05 million per year, the CPS pillar appears to be underfunded. Consideration could be given to increasing pillar resources.

Reviewer 2

The reviewer noted that the project has sufficient resources.

Presentation Number: ELT302
Presentation Title: EVs@Scale EV Modeling Toolkit
Principal Investigator: Andrew Satchwell, Lawrence Berkeley National Laboratory

Presenter

Andrew Satchwell, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

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

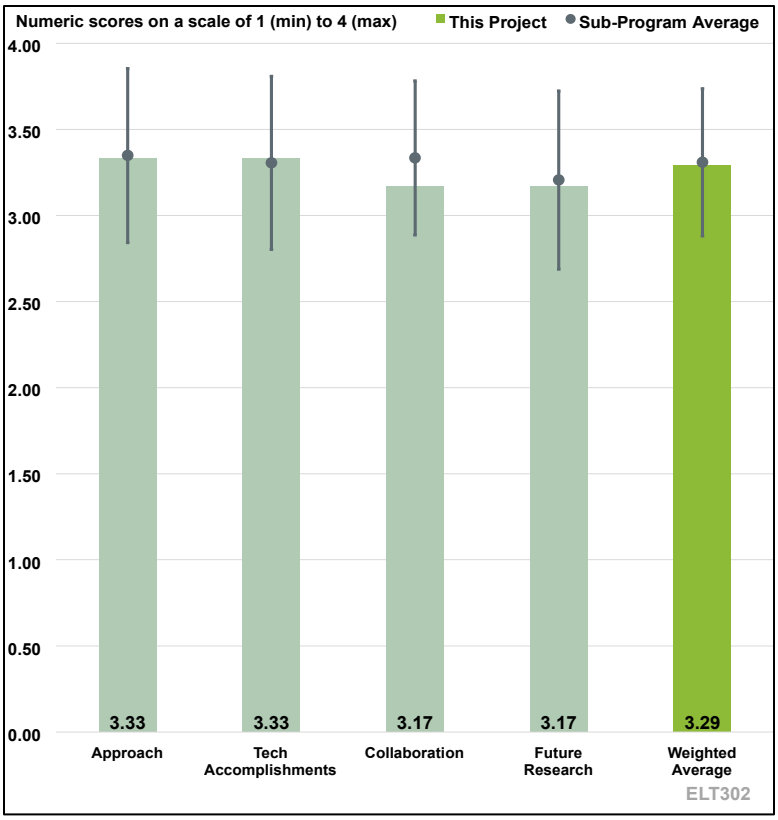

Figure 2-33. Presentation Number: ELT302 Presentation Title: EVs@Scale EV Modeling Toolkit Principal Investigator: Andrew Satchwell, Lawrence Berkeley National Laboratory

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

Reviewer 1

The reviewer stated that the EV Toolkit project satisfactorily identifies three salient barriers, the project objective, and impacts, although improved clarity and delineation therein would be beneficial. Four primary areas of interest have been identified and targeted including electricty system impact and planning, future EV adoption and load impacts, benefit-cost analysis, and EV infrastructure siting. These areas of interest were identified via comprehensive stakeholder consultation with four primary stakeholder groups including state utility regulators and state energy offices, third party providers and charging network operators, electric utilities and power system operators, and state Departments of Transportation. The work plan (task flow) appears logical and sound, with appropriate FY 2024-2025 milestones. The importance of ongoing efforts via Task 2 (stakeholder needs and gaps assessment) throughout the project duration can not be overstated. A reasonable, though somewhat ambitious, high-level timeline is provided.

Reviewer 2

The reviewer commented that the approach is appropriate for the task to the extent that knowing what tools are available and making them visible is a good first step. Providing links to the tools and

some information on their use is also a good idea. The project description does seem to imply some level of integration of the tools which is not clearly articulated.

Reviewer 3

The reviewer noted that regulators, charge network operators, and utilities are the focus, but should not this also be inclusive of OEMs and EV customers? Unidirectional smart charging (V1G) and V2G may need to be separated in the tool such that managed charging vs. DER functions have variations to their focus, capabilities and revenue.

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

Reviewer 1

The reviewer commented that sorting the available tools by function is an excellent first step. Engaging the potential users of the proposed web site is another excellent and necessary idea.

Reviewer 2

The reviewer remarked that to date, a solid listing of technical accomplishments has been demonstrated. This includes a tool inventory; identification of stakeholder needs and gaps broadly sourced from a 3-part DOE/national laboratory workshop, written summaries of stakeholder workshops and events, individual stakeholder discussions, and participation in industry events (the reviewer likes that results have been concisely categorized into three priorities of EV adoption, EV grid impacts, and VGI costs and benefits); website design and planning; and a draft overview of data and report library content and structure. Currently, the project appears on track, but it would not be surprising if there is timeline slippage mostly as a result of the scope of Task 4 activities.

Reviewer 3

The reviewer noted that ANL, INL, NREL, ORNL and PNNL have defined roles, but the role of Lawrence Berkeley National Laboratory (LBNL) is not identified other than just “leading” the project. The project objectives are clear but it is unclear what this project is adding that is not already in existing websites.

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

Reviewer 1

The reviewer stated that the tool owners and the PI are well coordinated and appear to be cooperating well in achieving the task aims.

Reviewer 2

The reviewer remarked that each laboratory is adding their effort and the workshops with utilities and regulators is included to make sure the tool meets their requirements.

Reviewer 3

The reviewer noted that the EV Toolkit project team consists of 6 labs, with the roles of each laboratory identified at least at the highest level but it is not clear how well the laboratories are coordinating their efforts. Contributions from industry and other external entities comes strictly through information and feedback to inform project activities.

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

Reviewer 1

The reviewer stated that future tasks are appropriate but very broadly defined and will probably need refinement.

Reviewer 2

The reviewer remarked that separation of V1G and V2X along with a combined VGI should be considered.

Reviewer 3

The reviewer commented that the remaining challenges and barriers have been identified and largely appear appropriate which include tool enhancements, website design, and toolkit dissemination. The proposed future research for FY 2024-2025 has been outlined and seems reasonable.

However, the reviewer strongly recommends two additional activities under future research: develop, implement, and actively monitor credible and salient EV toolkit metrics starting in FY 2025, and for FY 2025, clearly define exactly what development of a “sustainable” toolkit means and looks like. “Sustainable” is a very fluid term and a clear definition should be established early in the project. This will help eliminate confusion, frame current and future activities, and provides a basis moving forward.

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

Reviewer 1

The reviewer commented that the project aims to bring together tools for EV charging infrastructure development in one place to make them easily accessible to the people and organizations responsible for making EV infrastructure deployment a reality.

Reviewer 2

The reviewer stated that this project intends to consolidate and simplify the decision process for EV adoption and reduce grid impacts.

Reviewer 3

The reviewer remarked that yes, this project supports overall VTO subprogram objectives. There is a strong need to get analysis tools and other information materials in the hands of stakeholders to make educated VGI decisions. VTO has an extensive inventory of existing modelling and analysis tools; unfortunately, they have often been more geared to researchers as opposed to the broader swath of general stakeholders. Improved user-friendliness and reconfiguration is an excellent way get more bang for the buck out of prior VTO investments in modelling, simulation, and analysis tools.

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

Reviewer 1

The reviewer commented that the resources identified for the EV Toolkit are sufficient to meet identified objectives and milestones in a timely manner.

Reviewer 2

The reviewer stated that the stakeholders are expected to be provided with a user friendly site to simplify decisions based on data from the industry that is maintained and updated as needed.

Reviewer 3

The reviewer noted that the resources are certainly sufficient. It is a bit unclear how much budget is needed if the simplest form of the website (collecting links to existing tools and information) is implemented.

Acronyms and Abbreviations – ELT

Abbreviation	Definition
AAM	American Axle and Manufacturing
AC	Alternating current
AFE	Active Front End
AIR7357	SAE International MegaWatt and Extreme Fast Charging for Aircraft
AMP	Colorado-based recycling technology vendor AMP (formerly Amp Robotics)
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
BEV	Battery electric vehicle
BMS	Battery management system
BP	Budget Period
BPT	Bidirectional Power Transfer
BTM	Behind the meter
BTMS	Behind-the-meter energy storage
CCS	Combined Charging System
CPS	Cyber-Physical Security
DC	Direct current
DCaaS	Data Center as a Service
DCFC	Direct current fast charger
DER	Distributed energy resource(s)
DOE	U.S. Department of Energy
DR	Demand response
DSO	Distribution system operator
EEMS	VTO Energy Efficient Mobility Systems subprogram
EERE	Office of Energy Efficiency and Renewable Energy
ELT	VTO Electrification Technologies subprogram
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference

Abbreviation	Definition
EPRI	Electric Power Research Institute
ESS	Energy storage system
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FCEV	Fuel cell electric vehicle
FOA	Funding opportunity announcement
FODS	Freight Origin-Destination Synthesis
FUSE	Flexible charging to Unify the grid and transportation Sectors for EVs at scale
FY	Fiscal Year
Gen	Generation
HB	Handbook
HD	Heavy-duty
HPC	High power charger
HRE	Heavy rare earth
IEEE	Institute of Electrical and Electronics Engineers
INL	Idaho National Laboratory
ISO	Independent system operator
J2954	SAE International standard for Wireless Power Transfer (WPT) for EVs
J3271	SAE International standard for Megawatt Charging System for Electric Vehicles
J3400	SAE International standard charging connector
KW	Kilowatt
L2	Level 2
LD	Light-duty
LG	LG Energy Solution Ltd.
LTO	Lithium titanium oxide
MCS	Megawatt charging system
MD	Medium-duty
MOSFET	Metal–oxide–semiconductor field-effect transistor
MV	Megavolt

Abbreviation	Definition
MW	Megawatt
MWC	Megawatt charging
NACS	North American Charging Standard
NGP	Next Generation Profile(s)
NMC	Nickel manganese cobalt
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory
OSU	Ohio State University
P2030.13	Draft guide for creating a functional specification for electric vehicle (EV) fast charging stations
PACCAR	Successor company to the Pacific Car and Foundry Company
PEV	Plug-in electric vehicle
P-HIL	Power Hardware-in-the-Loop
PI	Principal investigator
PM	Permanent magnet
PNNL	Pacific Northwest National Laboratory
PQC	Post-Quantum Cryptography
Q3/Q4	Quarter 3/Quarter 4
RE	Rare earth
SCM	Smart charge management
SEMS	Site energy management system
SMC	Sheet molding compound
SNL	Sandia National Laboratories
SPS	Spark plasma sintering
SST	Solid-state transformer
ST1/ST2	SuperTruck 1/SuperTruck 2
STEM	Science, Technology, Engineering, Mathematics
SUNY	State University of New York

Abbreviation	Definition
TCO	Total cost of ownership
TMR	Tunnel magnetoresistance
TOU	Time-of-Use
UPER	Universal power electronics regulator
V1G	Unidirectional smart charging
V2G	Vehicle-to-grid
V2H	Vehicle-to-home
V2V	Vehicle-to-vehicle
V2X	Vehicle-to-everything
VDC	Volts direct current
VGI	Vehicle grid integration
VNL	Volvo VNL heavy-duty truck
VTO	Vehicle Technologies Office
WBG	Wide bandgap
WPT	Wireless power transfer
XFC	Extreme fast charge
ZEV	Zero emission vehicle
ZT	Zero Trust (ZT) Architecture