8. Vehicle Analysis

To strengthen national security, promote future economic growth, support American energy dominance, and increase transportation energy affordability for Americans, the Vehicle Technologies Office (VTO) funds early-stage, high-risk research. This research will generate knowledge that industry can advance to deploy innovative energy technologies to support affordable, secure, reliable, and efficient transportation systems across America. VTO leverages the unique capabilities and world-class expertise of the National Laboratory system to develop new innovations in electrification, including advanced battery technologies; advanced combustion engines and fuels, including co-optimized systems; advanced materials for lighter-weight vehicle structures and better powertrains; and 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. VTO is uniquely positioned to address early-stage challenges due to its strategic research partnerships with industry (e.g., the U.S. DRIVE and 21st Century Truck Partnerships) that leverage relevant technical and market expertise. These partnerships prevent duplication of effort, focus DOE research on the most critical research and development (R&D) barriers, and accelerate progress. The partnerships help VTO focus on research that industry does not have the technical capability to undertake on its own—usually because there is a high degree of scientific or technical uncertainty or it is too far from market realization to merit sufficient industry emphasis and resources. At the same time, VTO works with industry to ensure there are pathways for technology transfer from government to industry so that Federally-supported innovations have an opportunity to make their way into commercial application.

The Analysis (VAN) subprogram provides critical information and analyses to prioritize and inform VTO research portfolio planning through technology-, economic-, and interdisciplinary-based analysis, including target-setting and program benefits estimation. The VAN subprogram supports vehicle data, modeling and simulation, and integrated and applied analysis activities using the unique capabilities, analytical tools, and expertise resident in the National Laboratories. Trusted and public data are critical to VTO efforts and are an integral part of transportation and vehicle modeling and simulation. In addition, VAN supports the creation, maintenance, and utilization of vehicle and system models to explore energy impacts of new technologies relevant to the VTO portfolio. The VAN subprogram also supports integrated and applied analyses that bring together useful findings and analysis of the energy impacts of transportation systems through the integration of multiple models including vehicle simulation and energy accounting of the entire transportation system. The result creates holistic views of the transportation system, including the opportunities and benefits that advanced vehicle technologies create by strengthening national security, increasing reliability, and reducing costs for consumers and businesses. Overall, VAN activities explore energy-specific advancements in vehicles and transportation systems to inform VTO's early-stage research and offer analytical direction for potential and future research investments.

Project Feedback

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

Table 8-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
van019	ParaChoice Model	Camron Proctor (SNL)	8-3	3.36	3.14	3.50	3.14	**3.24**
van021	Transportation Energy Evolution Modeling (TEEM) Program	Zhenhong Lin (ORNL)	8-9	3.50	3.71	3.86	3.29	**3.63**
van023	Assessing the Energy and Cost Impact of Advanced Technologies of Light-Duty Vehicles	Aymeric Rousseau (ANL)	8-14	3.50	3.50	3.21	3.21	**3.43**
van026	Infrastructure Assessment	Eric Wood (NREL)	8-19	3.25	3.17	3.42	3.25	**3.23**
van028	VTO Program Benefits Analysis	Colin Sheppard (LBNL)	8-25	3.17	3.17	3.50	3.08	**3.20**
van029	Battery Recycling Supply Chain Analysis	Margaret Mann (NREL)	8-30	3.60	3.30	3.50	3.30	**3.40**
van031	Advanced Vehicle Cost and Energy-Use Model (AVCEM) - Overview, Recent Developments, and Preliminary Findings	Mark Delucchi (LBNL)	8-34	2.50	2.50	2.00	2.50	**2.44**
Overall Average				**3.27**	**3.21**	**3.28**	**3.11**	**3.22**

Presentation Number: van019
Presentation Title: ParaChoice Model
Principal Investigator: Camron Proctor (Sandia National Laboratories)

Presenter
Camron Proctor, Sandia National Laboratories

Reviewer Sample Size
A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
The reviewer asserted that the new project team has a sound approach for understanding existing methodologies and methodically documenting the underlying code. The project team should be commended for its efforts to improve the identification of anomalies and/or errors. These efforts will lead to overall model improvement, as well as more robust and transparent results. The reviewer added that a detailed gap analysis is another indicator of a well-structured project approach.

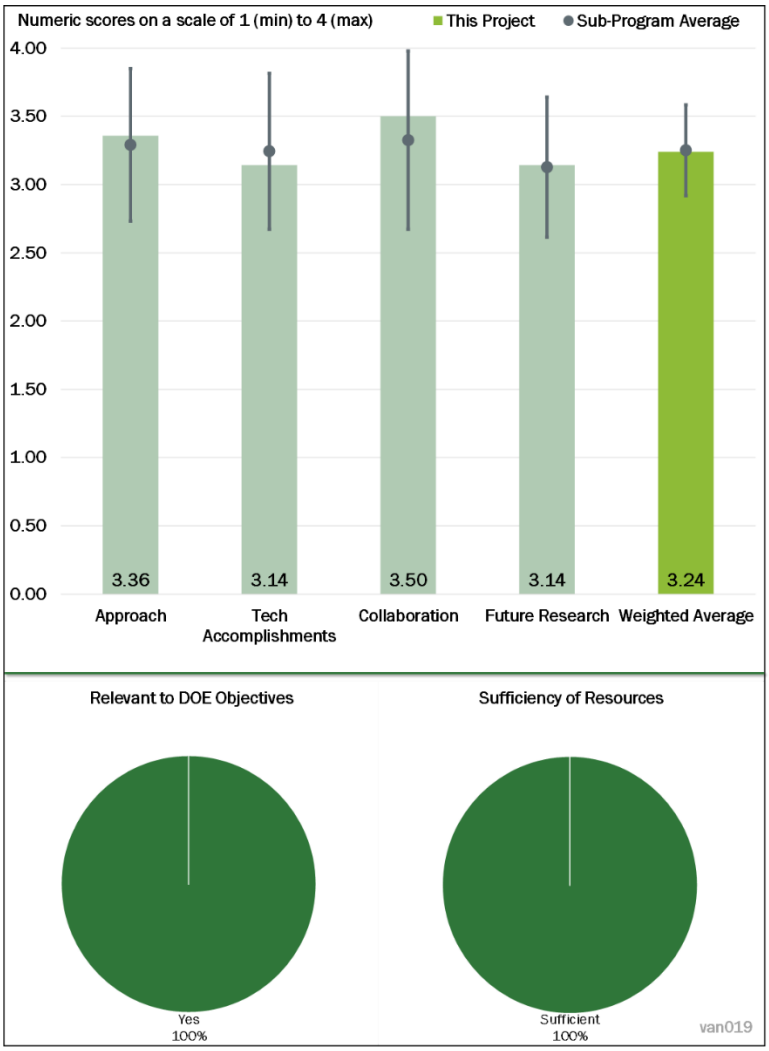

Figure 8-1 – Presentation Number: van019 Presentation Title: ParaChoice Model Principal Investigator: Camron Proctor (Sandia National Laboratories)

Reviewer 2:
This reviewer noted that the project has a sensible approach and is well integrated with related projects. The research team should be commended for its due diligence before building the next model iteration.

Reviewer 3:
This reviewer observed that the researchers are in an interesting place that seems to be near the beginning of the project. The team seemed to have a strong understanding of the ParaChoice Model purpose and what was reasonable to accomplish in this fiscal year (FY). The reviewer thought that one of the heavy-duty vehicle (HDV) model challenges will be finding the data needed to populate the model. Although it is true that the built-in uncertainty modeling leaves room for question marks, the reviewer indicated that there still needs to be a reasonable base from which to start. The HDV sector is notably more varied than light-duty vehicle (LDV); so, it can get more complicated. The reviewer felt that the team was cognizant of these potential issues and also noted that the timeline to collect data seemed reasonable.

Reviewer 4:
The reviewer commented that the plan for ongoing work is well-designed in response to previous reviewer feedback, and incorporates appropriate checkpoints to ensure that data inputs are of sufficient quality to be meaningful. The reviewer advised that a longer-term goal should include some integration of the LDV and

HDV segments, as technologies (fuel cells, batteries, etc.) are suitable for both vehicle classes and have potential infrastructure synergies.

Reviewer 5:

This reviewer stated that the project appears to be well-designed, although it seems like some effort and continuity was lost when the team of new personnel reformed in 2019. The reviewer wondered if this transition could have been managed more smoothly to prevent lost momentum and potential gaps. The project seems well organized at this point, with new team members up to speed and the project moving ahead in a reasonable fashion. The reviewer referenced Slide 2 as it refers to consumer subsidy and incentives from a policy viewpoint and wondered if it would be helpful to study how policies in other countries have impacted new technology adoption rates. This may be helpful to understand how policy in the United States could incentivize desired behavior and accelerate the implementation rate of best practices or best technologies to achieve regulatory and environmental priorities. It would be helpful to know if policy implementation in China, the United Kingdom, Scandinavia, or Japan, for example, are more effective at achieving higher implementation rates than the absence of strong governmental policy initiatives.

Reviewer 6:

The reviewer indicated that this newly formed team has set ambitious project goals with a good outline of the expected approach to update the ParaChoice model for HDV penetration projections. Building HDV capabilities requires a gap analysis of the project team's existing model and the team is on track conducting it. However, the reviewer pointed out that specific information with respect to modeling structure, stock updates, supply demand equilibrium, and costs analytics were not provided with great detail. The segmentation of HDV captures various important HDV characteristics that would drive fleet decisions, but the reviewer commented that other exogenous parameters such as logistics demand are not mentioned at all. In terms of implementing, calibrating, and validating the model as it is developed, this reviewer expected the research team to showcase the intricacies of its modeling approach and provide a concrete set of scenarios that would uncover interesting findings. Acknowledging that ParaChoice captures uncertainties with respect to LDV choices, the reviewer asked how it will be tailored to tackle profit maximization decisions for HDV fleets.

Reviewer 7:

The fundamental project challenge observed by this reviewer is that the barriers as described in Slide 2 are too generic. Subsequently, it is very difficult to judge if the modeling approach is well-designed when the question(s) to which the model will address are unclear. The reviewer is hopeful, however, that the team is aware of this challenge, and listed example questions on Slide 29. Going forward, the reviewer encourages the VTO Vehicle Analysis (VAN) team to work closely with the project team to define the audience and the target audience's questions of interest. Otherwise, a model like this will continue to grow in size and complexity until no one will understand what the model is doing.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

This reviewer remarked that the newly established research team is making excellent progress on updating the model.

Reviewer 2:

The reviewer commented that the new team has completed a detailed review of the existing inherited code and discovered areas for improvement leveraging existing capabilities. This reviewer explained that a detailed gaps analysis is used to inform code improvements. Furthermore, the reviewer asserted that the project team is establishing a strong foundation that will improve accuracy of results and expand the model's usefulness for other VTO projects and programs.

Reviewer 3:
The reviewer observed that the project appears to be on schedule. Even though the team is new, the reviewer felt that it had a solid and reasonable plan for the work ahead.

Reviewer 4:
This reviewer noted good progress; although personnel turnover resulted in some delays, it seems like the new team has an approach to get up to speed with the project.

Reviewer 5:
Regarding progress toward goals, this reviewer remarked that it seems like progress was slowed in the changeover to a new team. The reviewer asked what could have been done to smooth that transition.

Reviewer 6:
The reviewer indicated that the team very recently started performing this analysis. Technical accomplishments reported by this reviewer mainly include determining a pathway to accomplish project team goals, and identifying gaps in data, methods, as well as future needs.

Reviewer 7:
This reviewer commented that the presentation did not show substantive technical progress, due to the team change. The reviewer asserted that the gap analysis is definitely a worthy exercise, and encouraged the team to make the results public as soon as possible. The sensitivity analysis presents a good approach, but the reviewer observed a lack of results to assess actual progress.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer described the project as well-coordinated with other stakeholders.

Reviewer 2:
This reviewer remarked that new partnerships with other U.S. Department of Energy (DOE) technology offices, National Laboratories, and industry have demonstrated the new team's eagerness to collaborate and improve the programmatic approach and outputs.

Reviewer 3:
The reviewer observed that the team appears to be well-coordinated. The collaboration could benefit from expanding university partnerships as well as adding stakeholders and target audiences.

Reviewer 4:
This reviewer noted that the new team seems to have a plan in place to ensure that the model is well-understood and well-documented by the team. The reviewer suggested that more could be done to interface with users outside of DOE.

Reviewer 5:
The reviewer thought that this project will build its collaboration in future steps. As the project team starts trying to gather data and other information, having collaborators may be important to getting the latest information on vehicles and infrastructure, particularly from industry partners. The reviewer advised that this will be important because the advanced technologies are relatively new.

Reviewer 6:
This reviewer commented that the collaboration with partners seems to be well-supported. Some mention was made about needing more real-world data to support; of 100 sets of data required, approximately 60% have been identified. The reviewer asked whether more industry outreach would assist in the data collection.

Reviewer 7:
The reviewer suggested that connections with the private sector could be enhanced given the nature of the project (focus on HDV); datasets from and interviews with experts in this sector could enable gaining further insights on how HDV fleet update decisions are made. Additionally, this reviewer recommended that connections with universities also need to be reinforced, particularly those that have strong logistics teams to help address certain methodological issues while building the HDV version of ParaChoice.

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

Reviewer 1:
The reviewer asserted that all proposed tasks are aligned with meeting the existing set project goals. Greater interaction with the heavy-duty (HD) fleet managers is encouraged to improve realness of the decision-making process.

Reviewer 2:
This reviewer commented that proposed future work is technically relevant and the schedule for completion of the tasks is reasonable. Additionally, remaining challenges and barriers were articulated clearly. The reviewer opined that it would be interesting to investigate the influence of global policies, which could impact U.S. projections for technology research and development (R&D) and/or adoption. This reviewer expressed interest in seeing more public dissemination of information and looked forward to an integration of LDV and HDV models and the benefits results (i.e., technology synergies that could lead to more rapid development or deployment of energy-efficient systems).

Reviewer 3:
The reviewer remarked that future work seems well-planned for building out the HDV ParaChoice model. The reviewer thought the team could elaborate on how it plans to mitigate the risk of unavailable data given the newness of some of the vehicle technologies, but also thought some of that can be accounted for in the uncertainty built into the model.

Reviewer 4:
Although a bit more detail about a secondary plan and/or additional data collection methods could be necessary depending on the quality of the data, the reviewer noted that the gaps analysis is an effective way to assess the quality of available data. Beyond that, integration of the LDV and HDV models would help to identify any synergies between the two technology classes. The reviewer commented that the model is also well-poised to provide robust decision analyses (i.e. this technology is preferred unless x condition is true), which could be more explicitly incorporated into final outputs/deliverables.

Reviewer 5:
This reviewer concurred with modeling HDVs with a choice model.

Reviewer 6:
Extent of future work seemed uncertain to this reviewer, as funding seems to vary greatly on an annual basis. The general direction seems to be understood, but not the extent to which the work will be executed after FY 2020 and in subsequent years.

Reviewer 7:
The reviewer pointed out that the gap analysis presents a unique opportunity for the team to obtain feedback from stakeholders. The reviewer had no doubt that gaps will be many, and new capabilities aplenty. The key to a successful implementation of future research lies in prioritization. The reviewer offered two recommendations to the project team: come up with a solid stakeholder engagement plan to guide which new

capabilities to add, what questions to analyze, etc.; and consider opening the model up to the research community so that researchers can conduct their only analyses, the same way the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model is publicly available.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
This reviewer responded positively; having an understanding of the conditions that influence adoption of LDV/HDV vehicles is relevant for other DOE investments in vehicle technologies, especially as HDV market for alternative fuels continues to grow.

Reviewer 2:
The reviewer commented that results from the ParaChoice model can be used to inform and guide current and future DOE/VTO research programs in areas such as combustion, light weighting, and energy storage technologies.

Reviewer 3:
The reviewer asserted that this project is aligned with DOE's analysis team objectives. Alternative fuel HDV transitions is an important research question that could have significant effects on future energy needs for the transportation sector. Modeling capabilities for DOE could be enhanced with the HDV version of ParaChoice.

Reviewer 4:
The reviewer remarked that this project does support the overall DOE objectives and gives a systems-level evaluation of LDVs and HDVs, fuels, and infrastructure. These are essential pieces to understanding how the landscape of vehicles can change, and how likely those changes are expected to occur, which can feed back into thinking about impacts and different policies. The ParaChoice model seems to be a useful tool.

Reviewer 5:
This reviewer stated that objectives for improving ParaChoice models for HDV seem consistent with how the LDV models have been developed.

Reviewer 6:
The only concern expressed by this reviewer is the redundancy in the modeling efforts with other consumer choice models at DOE. Recognizing that each model has its own strengths and weaknesses, the reviewer opined that five consumer choice models seem excessive. Additional efforts should be made to conduct model comparisons, similar to Stephens, et al. (2017) https://publications.anl.gov/anlpubs/2017/12/140846.pdf.

Reviewer 7:
Referencing prior comments, this reviewer commented that the barriers presented in Slide 2 are so generic that it is difficult to judge how relevant this project is to overall DOE objectives. Of course, the project has the potential to enable sustainable transportation, but that is not a very strong statement. The reviewer noted that this burden is not entirely on the project team and recommended that VTO VAN should take the initiative to declare the specific objectives and questions that the Government wishes the team to address.

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

Reviewer 1:
This reviewer indicated that new partnerships will add new resources to the project. For now, the budget seems appropriate for the outlined tasks. However, the reviewer pointed out that additional funding could be needed as model improvements are implemented and new data streams are added.

Reviewer 2:
The resources appeared sufficient to this reviewer.

Reviewer 3:
Given the team size and budget, the milestones proposed seemed achievable from this reviewer's perspective.

Reviewer 4:
The reviewer found the resources to be sufficient. Additional attention should be paid to connecting better with the sector for which the project team is targeting for project adoption.

Reviewer 5:
Resources appear sufficient at this time, but this reviewer expressed interest in what was done prior to first quarter 2019 that resulted in a large project team turnover, and potential delays resulting from a new team starting up. The reviewer suggested that, perhaps, better planning in the future could lead to a smoother transition.

Reviewer 6:
The resources seemed sufficient to this reviewer, who commented that it will be important to track the collection of HDV data and see how that progresses.

Reviewer 7:
This reviewer reported that the research team is meeting pre-established milestones.

Presentation Number: van021
Presentation Title: Transportation Energy Evolution Modeling (TEEM) Program
Principal Investigator: Zhenhong Lin (Oak Ridge National Laboratory)

Presenter
Zhenhong Lin, Oak Ridge National Laboratory

Reviewer Sample Size
A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
The reviewer noted an approach that seems well-planned, with good collaboration among the team and outside the team to include International organizations and academic institutions that can bring a perspective of how alternative approaches are being taken and requirements met.

Reviewer 2:
This reviewer described the project approach as very well thought-out. The team engaged with stakeholders and clearly defined questions to be addressed by the model.

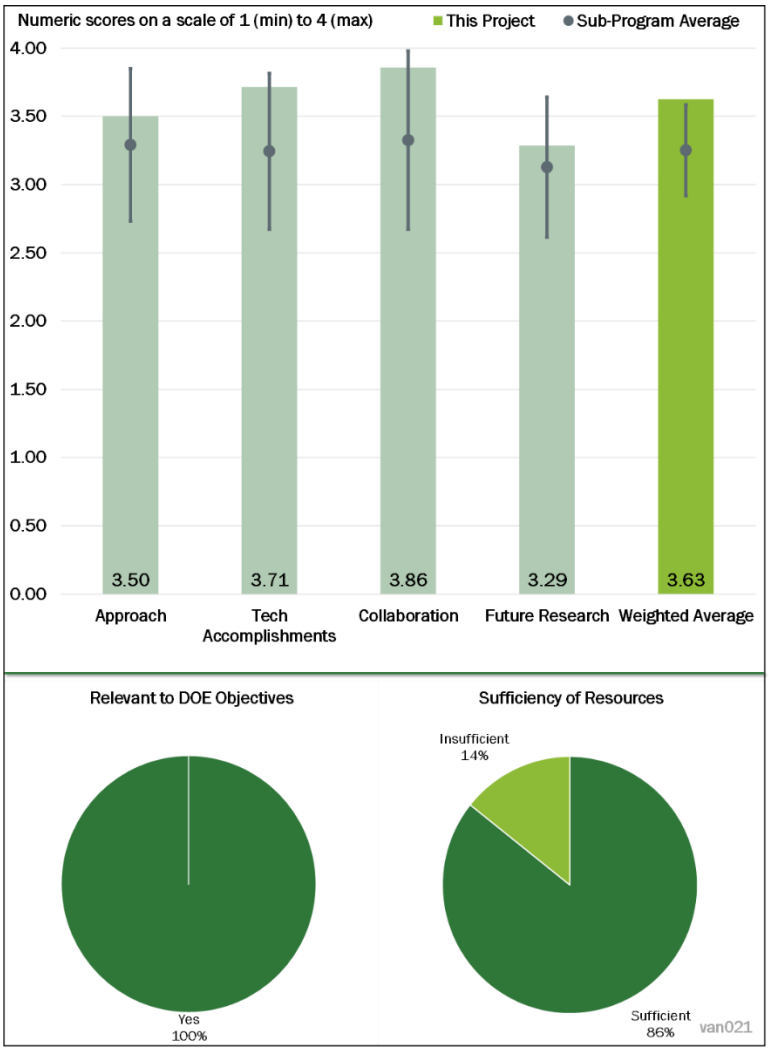

Figure 8-2 – Presentation Number: van021 Presentation Title: Transportation Energy Evolution Modeling (TEEM) Program Principal Investigator: Zhenhong Lin (Oak Ridge National Laboratory)

Reviewer 3:
This reviewer observed a methodical approach that accounts for a wide cross-section of assumptions and influences such as political, social, and technological. The model is useful to bound discussions in quantifiable means versus qualitative anecdotes.

Reviewer 4:
This reviewer remarked that the Transportation Energy Evolution Modeling (TEEM) program has achieved significant contributions through the development of models and tools that answer questions relevant to LDV electrification, emerging mobility service choices, and sustainable transportation operations. The project team is also on track with its Truck-Choice Market Acceptance of Advanced Automotive Technologies (MA3T) model. The reviewer reported that the MA3T validation procedure shows the potential of the project team's discrete choice platform to capture and explain attitudes. Furthermore, the TEEM team is advised by this reviewer to provide greater insights with respect to MA3T additions for its HDV version.

Reviewer 5:
From the reviewer's perspective, the project seems to be in more advanced stages of development because it is already being used to support publishable research projects. The researchers continuing to push forward with ways to expand the tool use is appreciated by this reviewer. Given that the tools are being used, the reviewer guessed that the expansion will be manageable because the team has a good base from which to build. As the team seems very output oriented, the reviewer cautioned that the team continues to make sure that the core mission remains in front and center as the project team moves forward with new models and validates existing ones.

Reviewer 6:
The reviewer commented that the model seems to be well-calibrated based on historical data, and suggested that the assumptions about calibrating to Annual Energy Outlook data are important to communicate in future results. Additionally, the reviewer experienced trouble with the Excel model while using a Mac and explained that the error seems to be related to the VB elements used in the calculation; running in Parallels/Windows version of Excel worked.

Reviewer 7:
The reviewer indicated that the project uses a rigorous approach to estimating consumer choice and described the model as well-established. Additionally, this reviewer was impressed with how aggressive the research team is in continuously looking for new and better data and in improving the model structure incrementally over time. The reviewer still had questions as to whether DOE needs five consumer choice model; so, the more the research team can identify unique contributions of TEEM, the more buy-in there will be from the wider research community.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
This reviewer asserted that the outstanding technical accomplishments and progress are evident through the analyses and publications shown in the presentation.

Reviewer 2:
Noting that the new version of the MA3T model was released, the reviewer explained that the model was calibrated using relevant and current data sources and validated using established guidelines for model validation as well as against results published in the literature. As evident in the 10 accepted or working paper publications cited, the reviewer also noted that the project team is very active in publishing results of the model findings. Furthermore, this reviewer pointed out that the team determined implementation of micro-hybrid systems leads to cost effective fuel savings without impacting adoption of other efficient technologies (e.g., battery electric vehicle, plug-in electric vehicle [PEV], or hybrid electric vehicles taking the primary share away from conventional internal combustion engine [ICE] vehicles).

Reviewer 3:
As the project and research team seem to be very results oriented, this reviewer did not doubt that the project will remain on schedule and meet the performance indicators.

Reviewer 4:
This reviewer reported that the model framework and tools have already been developed and modified for different markets, and that continued work seems well-scoped and on track to meet deadlines

Reviewer 5:
The reviewer commented that the research has met its milestones and is on track to meeting future milestones.

Reviewer 6:
This reviewer indicated that modeling, calibration, and validation appear to be continuing on schedule with satisfactory results.

Reviewer 7:
The reviewer remarked that technical accomplishments and progress are showcased by a plethora of TEEM program publications. This reviewer also stated that specific information with respect to problems solved and problems being addressed needs to be provided in a future Annual Merit Review (AMR) to help further evaluate accomplishments.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
This reviewer stated that an impressive list of national, state, academic, and international partners is included.

Reviewer 2:
The reviewer noted a wide spectrum covered on the collaborators list, including a good international point of view representing alternative approaches, combined with industry, academia, and government/lab partners.

Reviewer 3:
The reviewer praised the team for an excellent job making the model accessible and partnering with academia/industry in China and Europe to provide a global picture of electric vehicle (EV) choice and adoption.

Reviewer 4:
The reviewer indicated that the TEEM research team's amount of external collaboration for such a technically complex model is impressive.

Reviewer 5:
This reviewer observed a vast team of industry, academia, and government collaborators, from which tools, models, and results are integrated into the TEEM environment.

Reviewer 6:
This reviewer explained that the team seems to be very conscious of collaboration and appears to be making good contacts within and outside of DOE, which is apparent in the collaborations slide and also in the description of related publications.

Reviewer 7:
The reviewer remarked that collaboration and coordination efforts are clearly identified and delineated.

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

Reviewer 1:
This reviewer opined that research and timelines are reasonable and add value to the Analysis program.

Reviewer 2:
This reviewer stated that future research activities are reasonably defined.

Reviewer 3:
Future research directions made sense to this reviewer.

Reviewer 4:
Future plans seemed clearly laid out to this reviewer, although it was unclear whether funding is clearly defined for future years to carry on this work as outlined.

Reviewer 5:
The reviewer reported that TEEM program researchers provided a short list of future research focusing on range-anxiety definitions, micromobility, and the used plug-in electric vehicle PEV market. More ambitious goals using data-driven approaches to calibrate and validate the project team's existing models should also be considered.

Reviewer 6:
The reviewer commented that remaining project milestones seem reasonable and can leverage existing project infrastructure around the MA3T Model, with different vehicle and location-specific assumptions. Ideally, some future work might try to integrate some of the results to see if there are impacts of one model that could influence others (e.g. broad adoption of EVs in Europe influencing the LDV market in the United States, or electrification of HDVs influencing the LDV market). The continued tool maintenance that will occur after the primary development phase is completed and the main project ends (i.e., end of FY 2019) was unclear to this reviewer.

Reviewer 7:
The reviewer remarked that overall project goals are clear in terms of expanding models, and believed that the project team can get there. However, the reviewer did not have a great understanding of the types of barriers the project team might encounter. It seems like the barriers mostly center around finding appropriate data in order to make reasonable estimates. The reviewer suggested that the team could more clearly discuss how these barriers will be mitigated.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer remarked that the project team has a clearly defined objective focused on identifying the parameters influencing results versus predicting future outcomes. This is highly relevant to VTO and will aid the organization in developing a robust R&D portfolio.

Reviewer 2:
This reviewer commented that TEEM program goals are aligned with DOE objectives for modeling EV adoption, and understanding costs and penetration barriers. The project team's international collaborations and modeling outcomes can also help with gaining insights from international EV applications and suggesting implementation of analysis best practices.

Reviewer 3:
The reviewer indicated yes and commented that the project team has had significant academic/research impact (publications), and has made the research relevant at a global scale through collaboration with European/Chinese counterparts.

Reviewer 4:
This reviewer agreed that the project supports DOE's overall goals as it evaluates energy transitions for transportation, which is especially evident given its ability to be used by other researchers and models.

Reviewer 5:
The reviewer noted that the presentation clearly identified the project's relevancy to DOE.

Reviewer 6:
The reviewer observed relevant objectives. Stated goals of not predicting the future, but studying the models and identifying the impact of various inputs seems reasonable and consistent with the stated objectives.

Reviewer 7:
The reviewer stated that the project helps in prioritizing strategic investment in clean transportation.

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

Reviewer 1:
The research team has shown to this reviewer that it can be very productive at the given level of funding.

Reviewer 2:
The team seems to have been quite productive in terms of model upgrades and publications, and this reviewer assumed that there would be continued successful use of resources.

Reviewer 3:
The reviewer commented that resources seem adequate to accomplish the tasks in the identified timeline. This reviewer added that a wealth of collaborators provides ample data to achieve intended results.

Reviewer 4:
The reviewer found resources to be sufficient.

Reviewer 5:
The resources appeared sufficient from this reviewer's perspective.

Reviewer 6:
The reviewer indicated that resources for the rest of the project seemed reasonable for the model modifications required, but it was unclear how the project will be maintained beyond the end of FY 2019.

Reviewer 7:
This reviewer reported that current budget is 80% completed and plans or budget for 2020 are unclear; no FY 2020 budget was shown.

Presentation Number: van023
Presentation Title: Assessing the Energy and Cost Impact of Advanced Technologies of Light-Duty Vehicles
Principal Investigator: Aymeric Rousseau (Argonne National Laboratory)

Presenter
Aymeric Rousseau, Argonne National Laboratory

Reviewer Sample Size
A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
This reviewer asserted that the project has done a good job of leveraging both computational resources and expertise in machine learning (ML) to enable quick iterations through different scenarios/parameter combinations.

Reviewer 2:
This reviewer explained that the development of Autonomie is rooted in VTO technical targets and accounts for the broad portfolio of research included but not limited to light weighting, fuel type, performance, and vehicle type. Addressing vehicle types, technology configurations, and performance attributes is a sound progression for this tool.

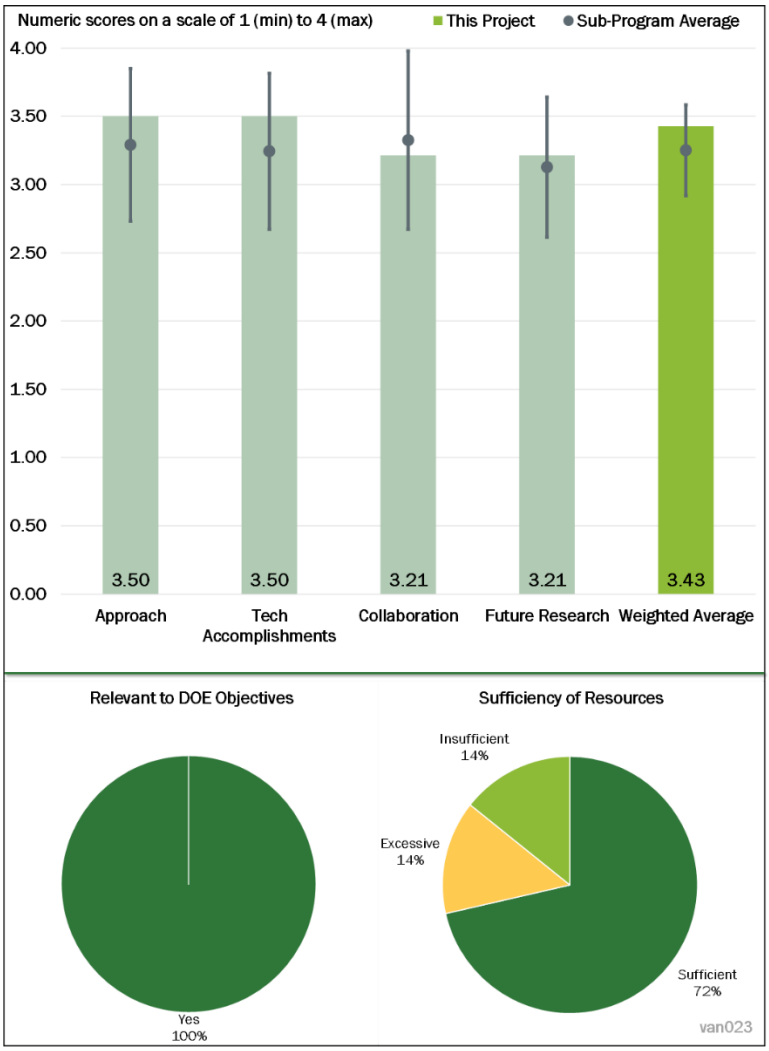

Figure 8-3 – Presentation Number: van023 Presentation Title: Assessing the Energy and Cost Impact of Advanced Technologies of Light-Duty Vehicles Principal Investigator: Aymeric Rousseau (Argonne National Laboratory)

Reviewer 3:
This reviewer observed a well-defined and executed project, and liked the focus on technologies and being able to understand the breadth of what vehicles could look like and what that could mean for greater VTO goals on understanding energy use. The inclusion of a range (rather than a point) of estimates provides great value to the results. The reviewer could also see how the results could be input or used in other evaluative models. Furthermore, this reviewer opined that a helpful metric would be understanding configuration costs, as well as possibly understanding the likelihood of development to better indicate most likely scenarios.

Reviewer 4:
The reviewer indicated that an overview of the approaches and the methodologies used to achieve the simulation of every single potential technology and their combinations is provided. Additionally, this reviewer pointed out that the researchers use cutting edge computational methods, e.g., machine learning and high-performance computing to improve the efficiency and reduce the resource expense to perform their tasks.

Reviewer 5:
The reviewer noted that the research team is taking a comprehensive, data-driven approach to its research and sets the bar for providing informative findings on technology costs, barriers, performance, and energy use. The research is clearly going in a good direction. This reviewer suggested that a publicly available version of Autonomie based on a simple graphic user interface—similar to Electric Vehicle Infrastructure Projection (EVI-Pro) Lite—could be extremely beneficial to the wider academic, government, and consulting community, and could help leverage DOE funds.

Reviewer 6:
Although the overall approach is sound, the reviewer wondered if simulation is the only way to approach this problem (i.e. to assess the benefits of VTO sponsored technologies). An alternative approach would provide two benefits: it will serve as a cross-validation to the simulation approach presented in this study; and it may prove less cumbersome and costly to carry out the analyses.

Reviewer 7:
This reviewer described the approach as generally good and offered that it appears to have some difficulty with "consumer reluctance to purchase new technologies," implying a lack of understanding of what is truly causing the adoption rate of the relevant technologies. The reviewer suggested that correlation of model to actual adoption rate data is using data that is up to four years old, and the project team could be missing an opportunity to adjust models that reflect actual industry trends in terms of what the consumer is willing to buy and why. Subsequently, it seemed to this reviewer that significant effort is being expended to understand the many variables that effect charging infrastructure investment and the adoption of EV technologies.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
Accomplishments are well-laid out and clearly explained from this reviewer's perspective.

Reviewer 2:
The reviewer reported that the project has hit major milestones, is able to make use of existing data for inferential analyses, and seems to be on track for initial report out.

Reviewer 3:
This reviewer commented that the technical accomplishments are significant and the researchers are on track with respect to achieving their progress goals. Additionally, the reviewer suggested that more comparisons with existing market options could be useful when presenting the results in Slide 10.

Reviewer 4:
The reviewer noted that model updates have drastically increased the number of scenarios that can be considered for a particular analysis. This improves accuracy and fidelity of the results, which will allow identification of deficiencies and, thus, implementation of targeted research projects to fill technology gaps. The reviewer explained that electrified powertrains are disproportionately impacted by rolling resistance, coefficient of drag, and frontal area when compared to ICE vehicles. By updating these parameters, the reviewer indicated that the model can better predict the true benefits of electrified powertrains. Expansion of vehicle configurations from the thousands to the millions has allowed the implementation of ML models, which can reduce computational burdens while improving the accuracy of the results.

Reviewer 5:
This reviewer observed that the project seems to have made good and significant progress and appears to be on schedule. The reviewer could see the model continuing to be refined and believed that results of this analysis will be interesting to many researchers and within the DOE. The team will need to decide where to cut off the project for the purposes of project timeline.

Reviewer 6:
The reviewer indicated that the presentation has showcased the accomplishments well and highlighted that the charts are well-designed. However, additional quantitative results would be desirable from this reviewer's perspective. For example, Slide 9 and Slide 10 only show visual differences across technologies; it would be more rigorous to present the results in percent improvement and the statistical significance.

Reviewer 7:
The reviewer stated that this research is critically needed—not only for VTO, but also for any organization that needs reliable vehicle cost and performance information.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
This reviewer remarked that the project does a good job of leveraging existing expertise in ML and other computational areas across DOE National Laboratories, and drawing information and relevant parameters from other groups focused on specific technology areas.

Reviewer 2:
The reviewer noted that the project team is collaborating with government regulatory agencies, automotive manufacturers, and internal high performance computing (HPC) and ML experts to validate and improve the capability of the tool. These are the proper stakeholders needed to keep the tool relevant into the future.

Reviewer 3:
This reviewer reported that evidence of good collaboration and coordination with stakeholder groups and institutions was presented.

Reviewer 4:
Collaborations with private entities (e.g., original equipment manufacturers [OEMs]) and academic partners could be established to further enhance the capabilities and visibility of the outputs of this assessment of energy and cost of advanced technologies of LDVs.

Reviewer 5:
Referencing prior comments, this reviewer recommended that DOE consider the costs and benefits of developing a more user-friendly Autonomie model that can be accessed through a graphical user interface or website, similar to EVI-Pro Lite.

Reviewer 6:
Although collaboration seems adequate for this project, the reviewer suggested that the researchers could look to academics to determine if there is similar modeling-type work that might help with some of the remaining barriers.

Reviewer 7:
It appeared to this reviewer that the project team is functioning well even though the presenter did not talk specifically about team collaboration.

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

Reviewer 1:
This reviewer praised the good, excellent job of the turbo engine targets. The reviewer also suggested that looking a bit at some of the bigger energy storage targets (e.g., Battery500) could be interesting, especially

because the targets were focused on specific energy (kWh/kg) rather than energy density (kWh/L) as was traditionally thought to be the more limiting factor for EV batteries.

Reviewer 2:
The future work seemed well planned out to this reviewer. Although what the project team has built to this point seems valuable, the reviewer stated that the researchers will need to prioritize how time is spent completing the analysis because there is not a ton of time left. If this is being connected to other VTO projects or models, then also making sure that is an easy process will be important.

Reviewer 3:
This reviewer described future work tasks and motivations as very clearly outlined. Future goals could also include communication of findings with public, private, and academic partners to improve modeling approaches and increase the visibility of this research product.

Reviewer 4:
The reviewer reported that the research team's slides mention several future tasks and motivations for those tasks.

Reviewer 5:
This reviewer indicated that future work follows a natural progression of integrating other tools and models into the project ecosystem. It is not lost on the researcher that adding the tools will add complexity and increase computational time/resources. To counter the increased computational needs, this reviewer suggested that the researcher consider further developing and implementing ML algorithms into the project.

Reviewer 6:
The future work seemed logical to this reviewer. However, referencing prior comments, the reviewer questioned the value of continuing the same path of running more and more simulations. It seems more pressing to benchmark the existing model as well as contemplate alternative and potentially more cost-effective methods of analysis.

Reviewer 7:
This reviewer stated that future work is described, including medium-duty (MD) and HD commercial vehicle analysis and total cost of ownership (TCO) analysis. The presented work seems to complete a four-year funding cycle, so it was unclear to this reviewer where the future funding levels will be to support the proposed future work.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer asserted that this project is most definitely in line with the DOE objectives. Focusing on vehicle technologies is very important to understanding how vehicle components impact a fleet, which then impacts energy use and other broader, but important, national areas of concern.

Reviewer 2:
This reviewer remarked that the task is very relevant to the VTO portfolio, assisting with computing alternative fuel vehicle (AFV) energy and costs outcomes from accurate technology combination simulations.

Reviewer 3:
The reviewer stated yes and agreed that this project does an excellent job of informing how specific technologies and policies implemented by DOE impact overall emissions. This reviewer added that drawing parameters from both current technologies on the market and future parameters from other projects makes it clear how combinations of efforts can influence future costs and emissions.

Reviewer 4:
This reviewer indicated yes; charging infrastructure is fundamental to encouraging adoption rate of EVs, and this work is necessary to support that understanding.

Reviewer 5:
This reviewer responded that this work is relevant to DOE objectives.

Reviewer 6:
The reviewer described this research as foundational to the Argonne National Laboratory (ANL)-developed Autonomie model, which is broadly used throughout DOE and industry to make accurate predictions of the benefits of certain vehicle-related technologies.

Reviewer 7:
The reviewer noted that this research is needed to understand tradeoffs in the DOE's strategic investment (e.g., batteries versus lightweighting).

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

Reviewer 1:
The reviewer commented that funding for this project is adequate at this time. However, as more data streams are added to the model, the reliance on HPC and need for ML will grow. Subsequently, this reviewer indicated that additional resources may be required to keep the same pace of development should HPC and ML technologies be more heavily leveraged.

Reviewer 2:
Funding levels appeared sufficient to this reviewer; the research team is meeting deadlines and has a long list of future work lined up.

Reviewer 3:
Given the team size, budget, and previous project the milestones proposed seemed achievable from this reviewer's perspective.

Reviewer 4:
The reviewer stated that resources seem sufficient to meet the milestones given what the team has accomplished thus far.

Reviewer 5:
This reviewer found the resources to be sufficient.

Reviewer 6:
Current resources appeared adequate to this reviewer. Future resource availability is undefined to continue with proposed future work plans.

Reviewer 7:
With the model already constructed, it appears to be fairly costly to run the analysis from this reviewer's perspective. One would expect that a mature model would significantly reduce of the cost of repeated analysis.

Presentation Number: van026
Presentation Title: Infrastructure Assessment
Principal Investigator: Eric Wood (National Renewable Energy Laboratory)

Presenter
Eric Wood, National Renewable Energy Laboratory

Reviewer Sample Size
A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
This reviewer remarked that a sound approach was presented.

Reviewer 2:
The reviewer stated that the National Renewable Energy Laboratory (NREL) has developed a diverse and well-appointed suite of analytic tools with access to relevant and important data streams. The project team has clearly defined the ecosystem and is using technical targets and data to inform model architecture and drive modeling simulations.

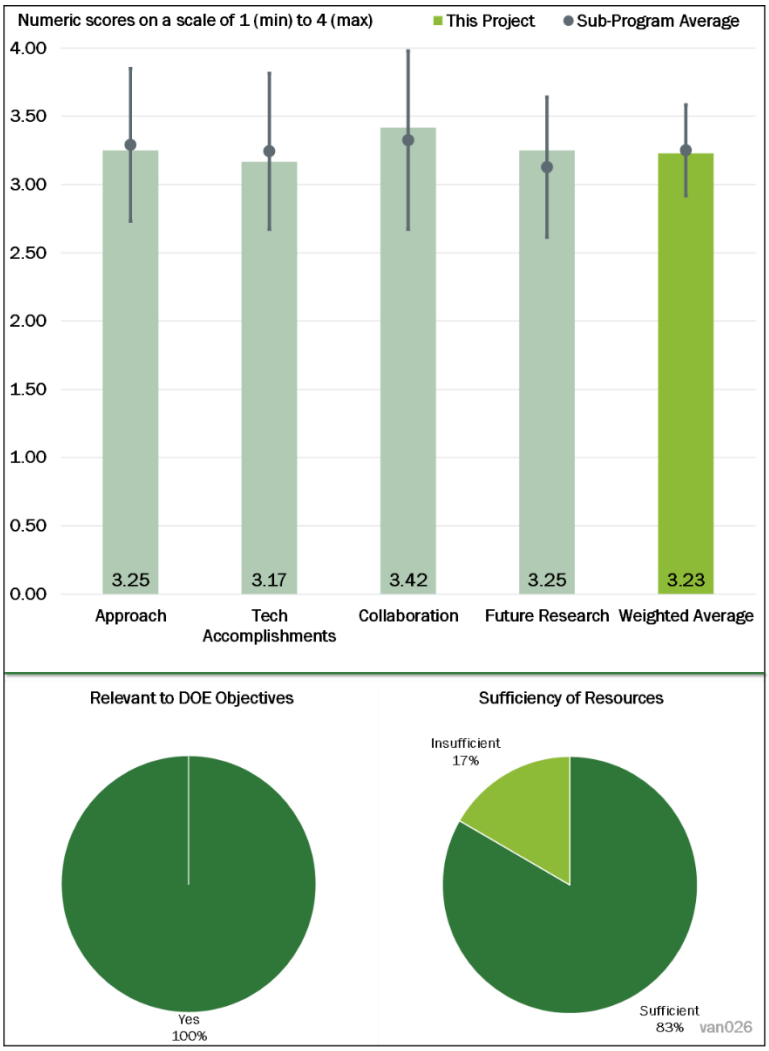

Figure 8-4 – Presentation Number: van026 Presentation Title: Infrastructure Assessment Principal Investigator: Eric Wood (National Renewable Energy Laboratory)

Reviewer 3:
The reviewer observed an extremely well-designed and well-executed research project. The questions asked by the project team are the right questions and the data sources and methodologies are the right ones. This reviewer encouraged the research team to think deeply about the unique contribution of the Adopt model. It is unclear to the reviewer why DOE needs multiple consumer choice models that allow examining policies. Greater effort to elucidate the model's role should be made by the Adopt team (and the teams developing the other choice models). It should be incumbent upon DOE headquarter staff to ensure there is no unnecessary redundancy between models.

Of all the tools from this research team, the reviewer found the most practical use for EVI-Pro and EVI-Pro Lite. All of the comments provided by this reviewer pertain to EVI-Pro Lite because this is the tool of greatest familiarity to this reviewer. Municipal and regional governments typically do not have the resources to understand their charging infrastructure needs. Having a quick online tool that gives a ballpark estimate of charging needs is a deeply helpful service. The reviewer has witnessed first-hand the amazement when city-level sustainability staff first use EVI-Pro Lite. In this regard, this reviewer highly encouraged the research team to seek opportunities to expand the functionality of EVI-Pro lite. This could include adding more user

inputs, providing more built-in data, and expanding output detail. The reviewer offered that, perhaps, there could be an "advanced" tab that gives an advanced user much more flexibility.

Additionally, this reviewer recommended that it would be helpful to add resources pointing the user towards how to estimate the inputs. For example, the input, "Percent of drivers with access to home charging," is a challenging variable to measure for local governments; suggested resources or methods for estimating this would be helpful. Lastly, the exact boundaries of the city/urban area analysis were unclear to this reviewer. Specifically, please identify if these are the city-boundaries, the metropolitan statistical area, or some other boundary.

Reviewer 4:

The reviewer noted that the research team and its collaborators have set several objectives as part of the nine-part research approach. It seems that the last steps of the approach (e.g., pricing variability, residential recharging propensity, etc.) could have informed the initial analysis of national charging infrastructure needs and capture future EV market needs in greater detail. In the near future, this reviewer expressed interest in seeing how new information generated from these research tasks is used in an iterative manner to improve initial findings with respect to charging infrastructure deployment and the expected benefits.

Reviewer 5:

Individually, the projects within the program were interesting, but this reviewer remarked that the selection of topics could be a bit more systematic.

Reviewer 6:

The reviewer noted that there are nine distinct projects in this ensemble of work, so it is difficult to speak in general terms about the approaches across projects. One high-level observation is that the target audience and their questions do not appear clearly defined. As such, the nine projects do not form a coherent succession of analyses.

The reviewer offered several observations on each individual project presented during the 2019 AMR. Referencing Slide 7 and Slide 8, the benefits appeared evident to this reviewer, though it could be argued that the progress is not aggressive enough if PEV sales only get to less than 50% by 2050. This analysis may serve as a discussion point for VTO to set target. Regarding Slide 9 and Slide 10, the conclusion or implication one can draw from this analysis was unclear to this reviewer. Furthermore, the chart on Slide 9 presents very little useful information.

Concerning Slide 11 to Slide 13, the reviewer indicated that this set of analysis suffers the same as above in terms of asking the question, "so what?" The reviewer inquired about the implication for VTO, the implication for building managers, and what can be done about this. Also, the analysis lacks statistical rigor. This reviewer further commented that there is significantly more useful information that can be extracted from the survey data using formal statistical procedures than some simple bar charts.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

This reviewer remarked that the progress and results were clearly explained and interesting observations were made regarding the effect of semi-autonomous shared EVs on the light-duty sector and the potential influence on the population of vehicles in service.

Reviewer 2:

This reviewer said the team is on track and meeting milestones.

Reviewer 3:
The reviewer noted the projects make use of existing models where appropriate, and seem to be reasonably on track.

Reviewer 4:
The reviewer stated that the team could benefit from more statistical rigor to deliver useful and usable information from the data.

Reviewer 5:
The reviewer said that the research team, apart from the insights gained from the application of ADOPT (which the project team articulated very well), could be more specific regarding the methods used to better capture EV sales results under different scenarios of technology improvement, etc. For example, the reviewer inquired as to which research questions the project team aims to answer successfully in order to achieve seamless integration between ADOPT and EVI-PRO, or EVI-PRO and EVFAST. Additionally, this reviewer expressed interest in knowing how the progress and technical accomplishments are going to be used to inform better charging deployment decisions and projections.

Reviewer 6:
This reviewer stated that the project could go to greater lengths to tease out the key influencers impacting the Benefits Timing Analysis. For example, the reviewer expressed interest in knowing which of VTO's technical targets have the greatest influence on PEV adoption. These findings could help inform the technology areas best suited for VTO program investment.

Although thought provoking, the relevance of the Dynamic Power Transfer on Interstates analysis as a PEV adoption driver was questionable to this reviewer, as this technology is immature and widely viewed as cost prohibitive. The limited data sets for dynamic power transfer bring to question the accuracy of this predictive analysis.

This reviewer commented that the PEV Charging Financial analysis proves to be very relevant to both consumers and industry stakeholders (i.e., charging network owners/operation, utilities, and vehicle OEMs). Education and information dissemination around charging pricing and charging types (i.e., direct current fast, residential, and workplace) continue to prove as worthwhile endeavors in support of broader PEV adoption. The reviewer added that analysis reinforced with real-world datasets, such as those presented by the NREL, serve as reliable assets to policy makers, advocacy groups, and businesses looking to make informed decisions.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer observed an extremely impressive list of external collaborators. Additionally, the reviewer found these tools to be the most user-friendly to the general public as all DOE tools.

Reviewer 2:
This reviewer noted that NREL continues to engage, partner, and collaborate with stakeholders across industry, academia, and government to provide informed and relevant research to the community.

Reviewer 3:
This reviewer stated that the projects are well-coordinated with partners from academia, industry, and other labs.

Reviewer 4:
The team appeared to be well-coordinated from this reviewer's perspective.

Reviewer 5:
This reviewer noted a long list of connections with the private sector and extensive collaborations with the rest of the National Laboratories. The research team could aim to establish future collaborations with more academic partners, utilities, and potential state agencies or stakeholders.

Reviewer 6:
The reviewer suggested that a broader list of collaboration partners for insight from industry and Transportation Network Companies would be helpful to get a broader view of potential scenarios that will influence shared autonomous electric vehicle (SAEV) deployment and utilization. This might help to address the stated barrier, "Relating component-level technologies to national-level benefits."

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

Reviewer 1:
The reviewer asserted that the focus on MD/HD is on point and needed across industry, and further remarked that charging behavior coupled with micromobility energy opportunities are extremely relevant topics deserving of future research.

Reviewer 2:
This reviewer said the future work appears to be reasonable.

Reviewer 3:
The reviewer remarked that charging HD vehicles will undoubtedly play a substantial role in transportation electrification, but there may be more to look at for LDVs that is not included in the scope. While residential charging has been important in early EV adoption, this reviewer noted that the existing work presented could better capture the tradeoff between the ability to capture low electricity prices available if renewable electricity generation capacity continues to increase. Understanding how EV owners, especially those without home charging access, value these services would be relevant to guide their adoption. This reviewer also suggested it could be interesting to compare the population densities/vehicle ownership rates within states that have EV adoption policies and those that do not have such polices, because that could be driving some of the discussion surrounding multi-unit dwelling charging, even if they account for a relatively small portion of the United States LDV fleet.

Reviewer 4:
This reviewer noted that the proposed future research is focusing on tacking new problems (which is great), but it continuing data analytics and feeding the new knowledge generated to further improve existing modeling efforts (e.g. EVI-Pro assumptions) would be important) This reviewer expected to gain better understanding of how the knowledge gained from the LDV analysis will inform future tasks related to MD and HD analysis needs, with respect to charging infrastructure, costs, and benefits.

Reviewer 5:
Although upcoming work in FY 2019 was presented, but the reviewer was unclear about how any future work beyond FY 2019 will proceed based on uncertain funding. This future work is described as adding more sources of e-transportation (including TNCs) as well as trucking, transit, and micromobility.

Reviewer 6:
While glad to see the research team thinking about topics like micromobility and the associated analysis needs, the reviewer commented that it is important to keep in mind that micromobility is a minor mode share and will likely stay that way into the future. This reviewer expressed interest in seeing continued DOE resource focus

on vehicle charging because there is still much to do in this regard. Additionally, analyses around MD and HD charging is a very good use of DOE funds.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
This reviewer noted that the project is aligned with DOE's analysis team objectives regarding transportation energy use diversification, project benefits, and solving consumer and fleet barriers to EV adoption and operation.

Reviewer 2:
The reviewer stated that this research supports the DOE's mission of ensuring America's prosperity through sound science that informs the public discussion and decision-making around energy issues.

Reviewer 3:
This reviewer noted that the questions put forth by the project team, coupled with the supporting analysis, seem relevant to state, national, and industry stakeholders.

Reviewer 4:
This reviewer responded yes; this project supports overall DOE objectives. Vehicle grid is a critical enabler to EV adoption and the control parameters including technology, infrastructure, and policy are critical to an accurate understanding of how to advance these technologies, what barriers might exist, and what potential benefits could be achieved. The reviewer suggested that it would be helpful to study how policy actions in other countries have supported (or incentivized) the desired growth of EVs and how the grid has changed to support that growth.

Reviewer 5:
Though generally relevant to DOE, this reviewer commented that the individual projects could benefit from more specific links to the questions VTO looks to answer.

Reviewer 6:
The reviewer said that while the analyses are informative to other DOE programs, a bit more coordination across some of the individual projects could really help to make the analyses more relevant to policymakers. While, individually, each project provides information about some technology tradeoffs, there is little discussion about whether certain technology pathways are more advantageous. For example, the reviewer explained that there is information about the costs of implementing fast charging, but not whether the fast charging makes more sense than larger battery packs with slower charging).

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

Reviewer 1:
The reviewer found resources to be sufficient and proposed greater integration of data-driven outputs with the significant existing modeling capabilities of the team.

Reviewer 2:
Overall, the reviewer saw this as a relatively modest budget for the amount of useful tools and information coming from this research group. Resources were described by this reviewer as sufficient because the research team has clearly performed on-time and made useful contributions to the public discussion.

Reviewer 3:
This reviewer noted that future resources are not defined past the FY 2019 budget year.

Reviewer 4:
This reviewer said the project resources seem sufficient for the goals outlined, but would probably need to be increased a bit to do a more holistic analysis/combination of the individual pieces.

Reviewer 5:
The resources appeared sufficient to this reviewer, who also asserted that the funding level warrants more rigorous statistical analyses.

Reviewer 6:
Access to the most current datasets appeared to be the largest limitation for the NREL team from this reviewer's perspective. Access to these datasets would only improve the quality of work and increase the relevance to stakeholders and other VTO projects. Furthermore, this reviewer indicated that financial resources appear to be adequate.

Presentation Number: van028
Presentation Title: VTO Program Benefits Analysis
Principal Investigator: Colin Sheppard (Lawrence Berkeley National Laboratory)

Presenter
Alan Jenn, University of California, Davis

Reviewer Sample Size
A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

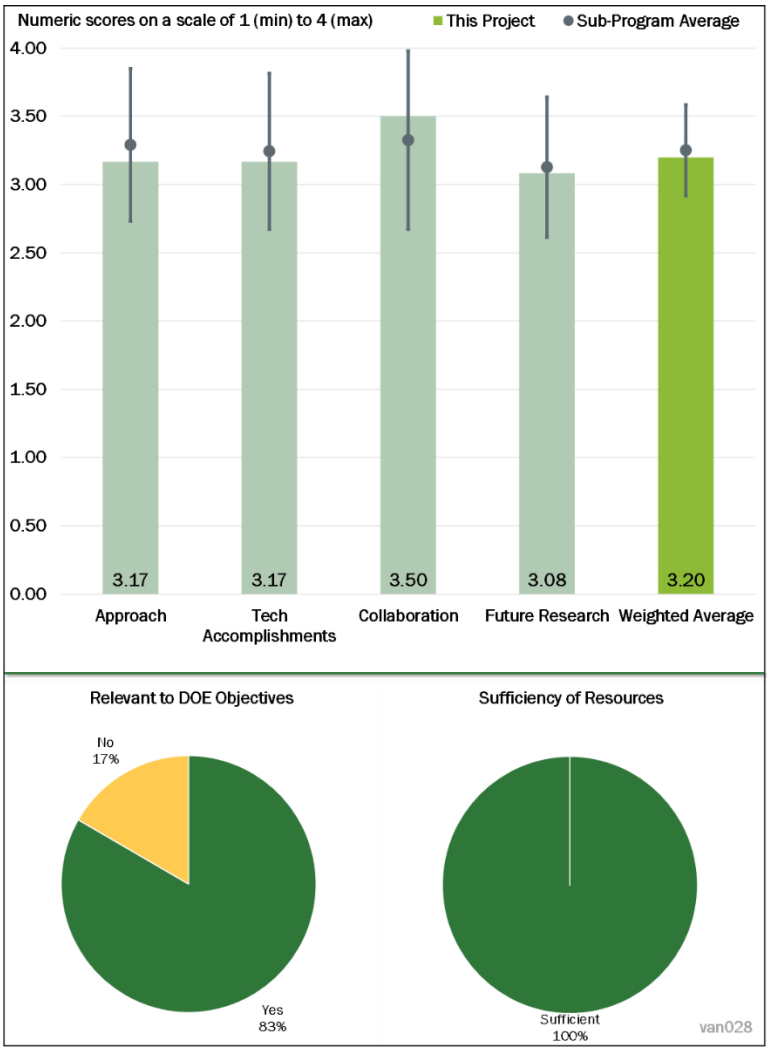

Figure 8-5 – Presentation Number: van028 Presentation Title: VTO Program Benefits Analysis Principal Investigator: Colin Sheppard (Lawrence Berkeley National Laboratory)

Reviewer 1:
Although the approach seemed very thorough, the reviewer would have liked to see the MDT and HDT poster session included as part of the program review.

Reviewer 2:
The reviewer noted that the approach proposed captures the interdependencies of the transportation (EVs) and energy sectors. However, it is not clear which stakeholder the objective function of the proposed model serves. This reviewer explained that a rational fleet manager would make fleet decisions to maximize profit and, in a similar manner, the utility would solve a unit commitment problem. A bi-level model structure could better capture the decisions of these stakeholders. The rest of the analysis was very insightful to this reviewer, and the examples provided serve as good discussion points with respect to understanding expected loads and the potential benefits from controlled EV charging management. The reviewer noted that it was unclear why the focus of certain examples has been 100% shared connected and EV fleets instead of focusing more on transitions.

Reviewer 3:
The reviewer stated that the researchers are asking relevant questions to future of mobility problems. Researchers are sourcing data and input from multiple stakeholders, which creates a nice cross-section of information to build model/simulation architecture. However, this reviewer pointed out that the presenter stated the assumptions are intentionally vague, which makes it difficult to determine what problems this research is intending to solve, on what timeline the solutions will be realized, and what specific technologies must be enabled to achieve the intended results.

Reviewer 4:
The reviewer remarked that this is a very ambitious project with an approach to match, and commended the researchers on a straightforward methodology that helps provide incredible insights into the benefits and costs of a world with SAEVs. Optimization models seem like a good choice of model for a futuristic world in which computers make decisions based upon optimal allocation of resources. The reviewer questioned whether the constraint of batteries beginning and ending full is sound. The reviewer asked if battery state of charge at the beginning/end of a charge event could be a decision variable, and added that one would expect that optimized SAEVs may find the lowest cost solution is to partially charge (just like human EV drivers today).

The reviewer highlighted that the project title is "VTO Program Benefits," which does not appear to match the research. Adjusting the title or conveying how the project is measuring the VTO program benefits was recommended by this reviewer.

The indicated that the Slide 6 question about faster or slower chargers is a major technology decision that charging system providers and local and state governments are wrestling with at the moment. For example, these organizations are debating about the optimal power level when building fast charging stations. Higher power is faster and allows higher station utilization, but is also more expensive; subsequently, fewer stations can be deployed. This reviewer noted that any insights that can be provided based on the project team's research would be useful.

Reviewer 5:
This reviewer believed the researchers have made an effort to create a very thorough model, and is accounting for many different factors and also incorporating as many applicable datasets as possible, including more novel ones like the StreetLight global positioning system data. Having this new data that can give insight into travel behavior is particularly important when thinking about SAEVs. This reviewer expressed concern with the connection between the models and datasets because it appears that they vary by geographic scale with datasets aggregating up to the regions shown in Slide 5. From the presentation, it was unclear how the model gets validated, and the reviewer inquired about whether the submodels are validated before entering into the Grid-integrated Electric Mobility (GEM) model, and whether there is a risk that the model is overly complex for the intended results. The reviewer did not think this is the case, as being able to show the loads over time is an interesting and valuable output.

Reviewer 6:
The reviewer observed well-designed work, but would have appreciated more detailed information than just the slides. For example, it is very difficult to understand the implications and validity of charts on Slide 14 to Slide 16. The reviewer also had concerns and questions on the statistical rigor as shown on Slide 11, but there was not enough information to ascertain; a report or publication would be very helpful.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
The reviewer observed reported progress that appears to be achieving the desired objectives in a thorough fashion.

Reviewer 2:
This reviewer stated that all milestones are either complete or on schedule. Getting this model to run and provide insightful results is a major technical accomplishment.

Reviewer 3:
The reviewer described accomplishments and progress as satisfactory. The analysis team could focus more on the transitions to electric, shared, and connected and automated vehicle fleets, instead of setting off directly to

evaluate 100% transition scenarios, because the former are more likely to be pertinent to DOE's short run evaluation needs.

Reviewer 4:
The reviewer noted that established milestones are complete or are tracking on schedule, although it is difficult to reconcile the milestones and presented technical accomplishments and progress. The assumption that all vehicles in some future scenario are electric, fully shared, and fully autonomous is an ideal situation. The reviewer explained that these assumptions can skew results or lead to obvious conclusions (i.e., smart charging leads to smoother grid loads, or fewer vehicles and less electricity are required if transportation is 100% electric, shared, and autonomous).

Reviewer 5:
The reviewer remarked that the researchers appear to be on schedule, and pointed out that the issue will be making sure the researchers have time to complete all of the planned modeling scenarios given the admittedly large optimization problem, particularly when simulating over more days. It will be important for the researchers to think this through sooner than later.

Reviewer 6:
This reviewer said the project appears to have made good progress, but publications and presentations are lacking.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
This reviewer said it is good to see a combination of National Laboratories, research universities, and private firms.

Reviewer 2:
The reviewer stated that there appears to be seamless collaboration between Lawrence Berkeley National Laboratory and University of California, Davis (UC Davis).

Reviewer 3:
The reviewer remarked that this project has great connections with the private and public sector, as well as with academic partners, and involvement from all of those. Including more utilities as reviewers/collaborators for the analysis is encouraged.

Reviewer 4:
This reviewer observed good project collaboration at the government, National Laboratory, and industry level. The reviewer suggested increasing industry collaboration to add further insight into evolving technologies that are planned for inclusion in future modelling work.

Reviewer 5:
This reviewer noted that the project has many collaborations across academia and National Laboratories. Coordination between partners could be stronger or more clearly defined (i.e., the data delivered to partner A filled a need and the output from this collaboration was X).

Reviewer 6:
The reviewer noted that the research team made an effort to expand collaboration over the last year. As more results start to emerge from the modeling, this reviewer wondered if there are collaborators to help validate the results or work with the submodels to help validate those. The reviewer suggested considering the value of industry partners.

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

Reviewer 1:
This reviewer agreed with the research team that tackling the computational efficiency needs to be a high priority for next steps. Doing so will allow great numbers of insights on the optimized SAEV world.

Reviewer 2:
This reviewer noted that the future research aims to tackle mostly theoretical and modeling difficulties. This reviewer also expects to see the definition of new scenarios representative of short and long run transportation electrification penetration.

Reviewer 3:
The reviewer said the project has good plans for future work, although the future budget allocation is not defined, so the reviewer is unsure what timeline is associated with the proposed future work. The PI should add more detail regarding the expected suite of future vehicle technologies to be included in the modelling, such as advanced driver assistance systems, connected automated vehicles, powertrain technologies, electrification, and variable compression ratio engines.

Reviewer 4:
This reviewer noted that proposed future research seeks to add more sources of transportation electrification. However, the presenter stated the simulation time horizon has a performance bottleneck. The reviewer opined that the solution to solve this bottleneck is vague and hints that the solution may not be available at this time. Adding more sources of transportation electrification will likely exacerbate this bottleneck. This reviewer noted the intent to improve model computational efficiency and adapt the model to run in a HPC environment, but indicated that the researcher does not offer the level of effort to achieve these task.

Reviewer 5:
The reviewer thought the researchers will continue hitting technical barriers as the model is built and believed that the project team will be able to overcome the barriers. This reviewer expressed curiosity in seeing the changes that will be made in the team's approach to get reasonable/timely results. This model is valuable, but not if it is too cumbersome to run. The reviewer asked if it is valuable to look at more current or nearer-term future scenarios as well, as opposed to the full SAEV picture. It seemed to the reviewer that the model could do that too.

Reviewer 6:
As the team recognized, the reviewer commented that the optimization problem quickly becomes too large to solve. As such, it is of utmost priority that the team work closely with VTO VAN to prioritize stakeholders, and rank optimization by both relevance and usefulness. Although HPC is a plausible path to pursue, this reviewer recommended that the team resist every temptation to conduct analysis for analysis' sake, and orient the work towards impact.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
The reviewer said this project is relevant to VTO objectives to understand and quantify the benefits from electrified transportation for both transportation energy use reduction and for maintaining the electricity grid's reliability.

Reviewer 2:
This reviewer believed that the project supports DOE and VTO goals. This is a data driven analysis of future technology, and the model assesses costs and benefits to the grid and transportation with the inclusion of SAEVs.

Reviewer 3:
The reviewer noted that the work is definitely relevant, but the impact has yet to come into focus.

Reviewer 4:
This reviewer remarked that the project has demonstrated relevance of assessing the cost impact of advanced technologies for LD vehicles.

Reviewer 5:
The reviewer asserted that the research definitely informs DOE's objective of transformative research, which results in technology investment. However, this reviewer offered one comment on the objective of this research project—the title of this project is "VTO Program Benefits," which does not appear to match the research. Subsequently, the reviewer asked how the project team measures the VTO program benefits.

Reviewer 6:
The reviewer said the project lacks bounds and definitions to produce useful results and, therefore, is not relevant to DOE

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

Reviewer 1:
The resources were found to be sufficient by this reviewer.

Reviewer 2:
This reviewer described project resources as adequate to achieve the milestones on schedule.

Reviewer 3:
Resources seemed sufficient to this reviewer, who also thought the project team will be able to adjust to meet the project goals, if necessary.

Reviewer 4:
The reviewer observed sufficient resources.

Reviewer 5:
The researcher noted sufficient resources for current FY plans, but observed no view of future budget to support the future work that was described.

Reviewer 6:
This researcher indicated that the resources are sufficient because it appears the research team has already produced results on its given annual budget. However, this reviewer did not have a good sense of the cost of HPC needed for large optimization models. This line of research is deeply needed and greater resources for this research team could generate even more useful insights.

Presentation Number: van029
Presentation Title: Battery Recycling Supply Chain Analysis
Principal Investigator: Margaret Mann (National Renewable Energy Laboratory)

Presenter
Margaret Mann, National Renewable Energy Laboratory

Reviewer Sample Size
A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
The reviewer observed well-designed work and well-defined research questions and audience.

Reviewer 2:
This reviewer described the presentation of approach as clear.

Reviewer 3:
The reviewer thought that this topic and project is of great need. Acknowledging having looked, this reviewer remarked that there is a surprisingly small amount of research about this topic. In addition to adding functionality to the Lithium-ion Battery Recycling Analysis (LIBRA) model, much of the data on transnational commodity flows and value chains would be useful to the wider research and government community and could be a way to leverage DOE dollars to help answer the questions posed on Slide 6. The reviewer urged the research team to continue looking for ways to make its data and calculations public.

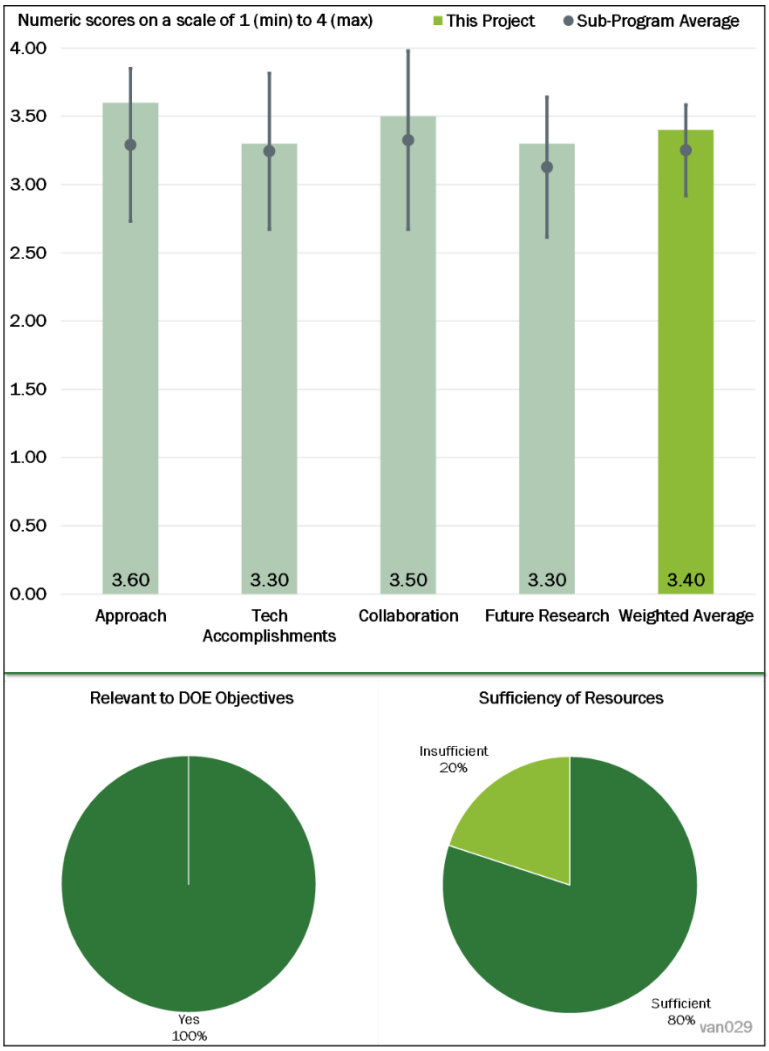

Figure 8-6 – Presentation Number: van029 Presentation Title: Battery Recycling Supply Chain Analysis Principal Investigator: Margaret Mann (National Renewable Energy Laboratory)

Reviewer 4:
The reviewer asserted that the battery supply chain and its recycling potential have great implications for United States competitiveness in this field. The research team provided a great overview of its approach to model the supply chain of EV batteries and identify material recycling needs with the appropriate system dynamics approach. In the future, this reviewer encouraged the research team to include more details of the causal loops in its system dynamics modeling approach.

Reviewer 5:
This reviewer remarked that the project seems well-scoped, and priorities are aligned with the most globally constrained materials as the project priority. Understanding current uses through ongoing deployments of EVs

and stationary storage is an effective way to bound future material flows. Scoping the deployment of stationary storage and specific battery chemistries will be an important step in these estimates. The reviewer commented that discussion of the value chain for manufacturing batteries could be a bit more descriptive; most of the manufacturing cost is associated with materials, which will increase as the costs of other inputs continues to decrease. The reviewer explained that the value of these steps is not necessarily the same thing as cost and suggested that it would be helpful to make the distinction between these assumptions.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:
Although the project seems on track with current targets, this reviewer noted that the user interface is a bit basic, but functional.

Reviewer 2:
The reviewer stated that accomplishments through the first half of FY 2019 and the progress to plan were presented. The project appeared to be on track, and the reviewer further reported that the LIBRA model is being developed to provide a simplified framework that increases accessibility of the analysis to the user community.

Reviewer 3:
The reviewer indicated that the work has progressed well and the user interface is especially helpful. The team was encouraged by this reviewer to open source the model for better transparency and reproducibility.

Reviewer 4:
This reviewer commented that significant progress has been made to answer the key questions identified in the AMR presentation. The LIBRA model outcomes could be also enhanced to uncover tipping points for recharging providers' profitability, lag periods, and uncertainty quantification under various scenarios, capturing international supply chains dynamics.

Reviewer 5:
The reviewer did not know the level of effort needed to put together the datasets on value chains. However, the reviewer was a little surprised that this research has been conducted since 2015 and is only now putting together a basic model to represent the battery value chain; three and a half years is a long time. The reviewer acknowledged possibly misunderstanding the current status of the project, and asked that this comment be taken with a grain of salt.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
The reviewer described collaboration and coordination across the project team as well-integrated with other projects across VTO/DOE broadly.

Reviewer 2:
This reviewer noted that the researchers are teaming with a good mix of organizations.

Reviewer 3:
The reviewer stated that the team is closely collaborating with stakeholders, which is crucial to the project's success.

Reviewer 4:
This reviewer said that evidence was presented showing good collaboration with government, National Laboratories, and industry. As industry is beginning to evaluate business models around battery recycling,

remanufacture, and reuse, the reviewer suggested that this might be an area where more intense collaboration with industry would be mutually beneficial.

Reviewer 5:
The reviewer asserted that a longer list of international collaborators and academic institutions would be of great importance in order to increase the visibility of this analysis and gain greater international feedback and insights.

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

Reviewer 1:
This reviewer commented that the researchers' next steps and research questions are excellent and that the LIBRA user interface should be a top priority.

Reviewer 2:
The reviewer remarked that including demand for stationary storage applications will be a critical factor for estimating the scale of lithium-ion battery material demands. While there were some informal discussions of the team's approaches for making these estimates, this reviewer stated that scoping out the range of stationary applications (by either scale or user) will be important.

Reviewer 3:
The reviewer noted that the future research outline aims to provide remedies for the limited available data by intensifying data collection efforts and proposing sets of relevant scenarios for the U.S. market. The reviewer suggested exploring how VTO-funded models that project EV adoption can be used iteratively in LIBRA to capture demand for batteries.

Reviewer 4:
Future work reported by this reviewer includes assessment of the MD and HD vehicle sectors, which can be a potentially important growth sector and area for early adopters. Perhaps a higher priority should be placed on the commercial vehicle sectors where EVs could see potentially rapid growth, and where addressing the business issues around battery recycling, remanufacturing, and reuse could be critical enablers to a more rapid adoption rate.

Reviewer 5:
Although the presentation pointed out stationary storage as one of the remaining challenges, the reviewer indicated that the proposed future work does not appear to address that challenge. The team should consider obtaining inputs from experts on stationary storage and conduct analysis that simultaneously considers transportation and stationary storage.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
This reviewer stated yes, the project is relevant to vehicle electrification trends and well-integrated to provide supporting analyses for related DOE programs—battery chemistry research, and recycling research.

Reviewer 2:
The reviewer observed very relevant work on a battery resources supply chain that would benefit DOE and its objectives with respect to tracking battery material global supply chains and identifying benefits from EV battery recycling.

Reviewer 3:
The reviewer noted that the relevance was clearly articulated.

Reviewer 4:
The reviewer said this research supports DOE's mission of enabling strategic decision making in clean technology.

Reviewer 5:
The reviewer asserted that this project is relevant to DOE objectives, especially in terms of avoiding unintended consequences.

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

Reviewer 1:
This reviewer indicated that the funding and team, with support from collaborators, is sufficient to meet project goals.

Reviewer 2:
Resources appeared sufficient for the current FY planned work from this reviewer's perspective. However, the presentation did not show future funding to support future work.

Reviewer 3:
This reviewer observed sufficient resources.

Reviewer 4:
The reviewer commented that the funding level appears appropriate.

Reviewer 5:
This reviewer recommended that resources should be further extended to better capture the global supply chain. EV demand could be integrated from existing VTO and DOE-funded projects to meet U.S. battery needs.

Presentation Number: van031
Presentation Title: Advanced Vehicle Cost and Energy-Use Model (AVCEM) - Overview, Recent Developments, and Preliminary Findings
Principal Investigator: Mark Delucchi (Lawrence Berkeley National Laboratory)

Presenter
Mark Delucchi, Lawrence Berkeley National Laboratory

Reviewer Sample Size
A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed and well-planned.

Reviewer 1:
This reviewer remarked that the team provided an extensive presentation on its proposed approach by specifically outlining social, business, and personal cost differences that it would expect to capture for AFVs. The DEEP GREEN modeling system has the potential to not only capture AFV costs and externalities, but to also evaluate national-level quantitative scenarios. The reviewer also reported that the research team has specified the integration of sophisticated sub-models in order to improve accuracy.

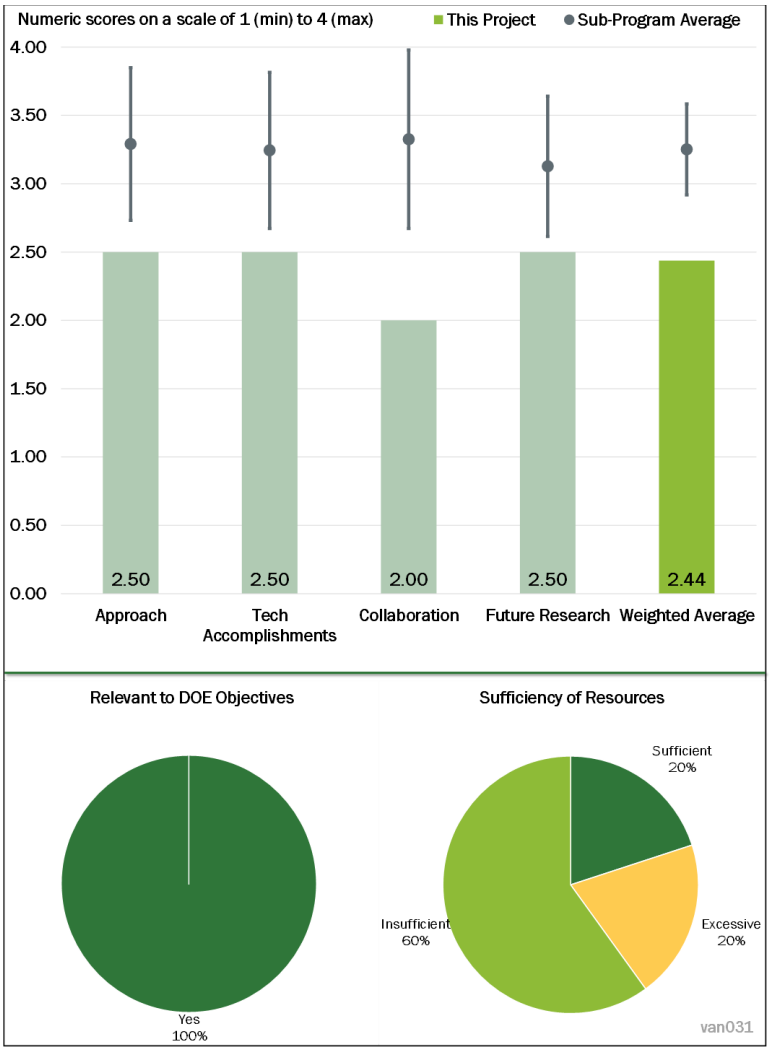

Figure 8-7 – Presentation Number: van031 Presentation Title: Advanced Vehicle Cost and Energy-Use Model (AVCEM) - Overview, Recent Developments, and Preliminary Findings Principal Investigator: Mark Delucchi (Lawrence Berkeley National Laboratory)

Reviewer 2:
As presented, it seemed to this reviewer that there has been a shift in the original project objectives to encompass both a full reworking of the conceptual framework of the TCO, and then the construction of a social cost model. With respect to the newly proposed TCO model, while some interesting concepts were proposed, there did not seem to be a sufficient plan presented for confirming some assumptions with social science research/other methods. Regarding the existing consumer/social cost models, it was not entirely clear to this reviewer how fully developed each model component is, or the degree to which data should be updated with new technology and model data. For example, BatPaC has been updated numerous times throughout the project timeframe; it is not clear which version is being adapted here.

Reviewer 3:
This reviewer indicated that the presenter was unsure whether the methodology was adequate and whether there was an intention to make revisions. The robustness of this analysis value to date, as well as how the evolution of this model might render work completed to this point as invaluable, was confusing to this

reviewer. It was unclear if the intended improvements were intended to make a good model better, or if the existing version/status of the model was wasted effort.

Reviewer 4:

The reviewer commented that this work is very difficult to evaluate because it is still a work in progress. The Principal Investigator (PI) still seems to be working out the conceptual framework that considers three perspectives—social, business, consumer—and it is unclear how these three perspectives are, or will be, represented in the Advanced Vehicle Cost and Energy-Use Model (AVCEM). Also, recent AVCEM updates made, or needed to be made, by the PI were unclear to this reviewer based on presentation. Also, Slides 25 to 26 are "FY18 Accomplishments," but everything listed is an "Expected Product." Thus, it was unclear to the reviewer whether these are complete or incomplete.

Reviewer 5:

This reviewer noted that the boundary of the model is too all-encompassing, and the component interactions are too complex for any model to be effective. Referencing the famous statistician George P. Box, the reviewer stated that all models are wrong; some are useful. When a model system becomes so complex, it is really not clear how this can be useful.

Question 2: Technical Accomplishments and Progress toward overall project goals—the degree to which progress has been made and plan is on schedule.

Reviewer 1:

This reviewer remarked that progress has been made towards defining different cost components that need to be integrated in the analysis from a societal, business, and personal perspective. This thorough analysis is important for building a modeling framework that would accurately calculate such costs and energy use from advanced vehicles.

Reviewer 2:

The reviewer noted that the list of tasks presented does not include milestones to truly assess whether certain tasks have been completed on schedule, and it is unclear whether some of the descriptions have been completed or are future goals. Additionally, given the duration of the project, this reviewer expected more targets to include data/assumption updates with technology evolution, which most of the other analysis projects make use of and/or incorporate in their project objectives.

Reviewer 3:

This reviewer referenced prior comments and observed that the presenter commented the model was "constantly being revised." Subsequently, the reviewer inquired about the following: if there is a plan for the work; if the presenter is managing the work according to a plan; or if it is in a constant state of revision. It was unclear what progress to plan had been made based on the presenter's comments. This reviewer was conflicted between the creative process versus the ability to deliver expected results, and reported that the presenter said, "there is a lot I didn't explain because I just work that way." Although not intended to criticize the PI's creative process, the reviewer was unsure where the project progress stands, and what accomplishments have occurred. This reviewer did acknowledge evidence that progress is being made based on progress reported on 17 of the 20 tasks.

Reviewer 4:

The reviewer said that in the past, the AVCEM model has provided numerous insights on social costs of the transportation system for academic and policymaking communities. As previously noted by this reviewer, the new conceptual framework of AVCEM with three perspectives (social, business, personal) appears to be a work in progress and is difficult to evaluate at this time. There does not appear to be substantial technical accomplishments when using the three perspectives because the conceptual framework is new and unvetted.

Reviewer 5:
This reviewer indicated that peer-reviewed articles are really lacking from this project. All publications listed are reports, which are not indicative of the quality. The reviewer recommended that the team actively seek feedback from fellow researchers through journal publications.

Question 3: Collaboration and Coordination Across Project Team.

Reviewer 1:
Although collaboration was mentioned with UC Davis, ANL, NREL, and the Technical University of Munich, the reviewer was uncertain how much benefit was derived from the collaboration.

Reviewer 2:
The reviewer suggested that a greater list of collaborators would help towards evaluating and testing the proposed model. Industry, public sector, and additional academic partners could support this endeavor.

Reviewer 3:
Only minimal external collaboration was noted by this reviewer.

Reviewer 4:
The reviewer commented that this project seems fairly isolated within broader DOE activities, especially with respect to broader vehicle electrification efforts.

Reviewer 5:
Except for the one visiting scholar from Technical University of Munich, which is a dated collaboration, the PI did not appear to have any collaborators from this reviewer's perspective.

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

Reviewer 1:
This reviewer noted that the future work outline includes proposed tasks, expected products, current status, and next steps updates in a very comprehensive manner. Performing and evaluating these tasks, and greater connections with collaborators in other National Laboratories and academia could be established.

Reviewer 2:
The reviewer reported that the project lists several expected outcomes for future years.

Reviewer 3:
This reviewer stated that the project leaves most public-facing results (reports, user tools) until the final stage of the project, rather than building resources for existing/completed models (e.g. current battery vehicle model), which could make the process smoother and/or produce some useful outputs even if specific technology models remain incomplete. The schedule for completing the model and scope of work also seemed ambitious to this reviewer given the resources and project team size.

Reviewer 4:
Although progress was described in 17 of the 20 tasks outlined, the reviewer reported that the presenter described some weaknesses in the modelling completed thus far. Where future work was headed was unclear to this reviewer, as was how much of the work to date is useful as-is, needs to be modified, or needs to be redone with the expected model revisions that were generally referenced.

Reviewer 5:
The reviewer pointed out that the presentation did not explicitly call out future research.

Question 5: Relevance—Does this project support the overall DOE objectives?

Reviewer 1:
This reviewer commented that the proposed analysis is relevant to VTO DOE's analysis objectives; the model has the potential to capture costs and energy outcomes of advanced vehicles using an accurate and sophisticated approach.

Reviewer 2:
The reviewer asserted that understanding social costs of transportation is critical for prioritization of investment and creation of policy.

Reviewer 3:
The reviewer stated yes, the project supports overall DOE objectives, and reported that relevance of the AVCEM model was described.

Reviewer 4:
While understanding the differences in ownership costs of vehicle technologies is an important goal, the reviewer commented that current model parameters are out of sync with broader DOE efforts to develop technologies for these alternative fuel vehicles, and the model does not make use of the most recent technical data or parameters.

Reviewer 5:
Although the work is relevant, this reviewer was not confident in its usefulness.

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

Reviewer 1:
This reviewer described the budget as insufficient because, as noted by the PI, the budget in FY18 was $0.

Reviewer 2:
Apart from national data averages, the reviewer indicated that the model could be used to quantify impacts of inputs with spatial and temporal variation. This would be enabled by additional data collection efforts and scenario definitions.

Reviewer 3:
The reviewer expressed difficulty in determining whether resources are sufficient for future work because the future plan was unclear. The presenter did not identify that resources were a constraint to the successful delivery of the model.

Reviewer 4:
Overall, the original budget seemed sufficient to fund the project from this reviewer's perspective. However, given the scope of work to be completed and relative to the completed work, it was unclear to the reviewer how the current team (and proposed budget) would support project completion.

Reviewer 5:
It was not clear to this reviewer how the funding level is justified unless the project proves impactful and useful in answering some key questions.

Acronyms and Abbreviations

AFV	Alternative fuel vehicles
AMR	Annual Merit Review
ANL	Argonne National Laboratory
AVCEM	Advanced Vehicle Cost and Energy-Use Model
DOE	U.S. Department of Energy
EV	Electric vehicle
EVI-Pro	Electric Vehicle Infrastructure Projection
FY	Fiscal year
GREET®	Greenhouse gas, Regulated Emissions, and Energy use in Transportation model
HD	Heavy-duty
HDV	Heavy-duty vehicle
HPC	High performance computing
ICE	Internal combustion engine
LDV	Light-duty vehicle
MA^{3}T	Market Acceptance of Advanced Automotive Technologies model by ORNL
MD	Medium-duty
ML	Machine learning
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory
PEV	Plug-in electric vehicle
R&D	Research and development
TEEM	Transportation Energy Evolution Modeling program at ORNL
UC Davis	University of California, Davis
VAN	Vehicle Analysis (VTO program)
VB	Visual Basic

VTO	Vehicle Technologies Office