1. Advanced Combustion Systems

The Vehicle Technologies Office (VTO) supports early-stage research and development (R&D) to generate knowledge upon which industry can develop and deploy innovative energy technologies for the efficient and secure transportation of people and goods across America. VTO focuses on research that industry either does not have the technical capability to undertake or is too far from market realization to merit sufficient industry focus and critical mass. In addition, VTO leverages the unique capabilities and world-class expertise of the national laboratory system to develop new innovations for significant energy-efficiency improvement. VTO is also uniquely positioned to address early-stage challenges due to its strategic public-private research partnerships with industry (e.g., U.S. DRIVE and 21st Century Truck Partnerships) that leverage relevant technical and market expertise, prevent duplication, ensure public funding remains focused on the most critical R&D barriers that are the proper role of government, and accelerate progress—at no cost to the Government.

The Advanced Combustion Systems (ACS) subprogram supports early-stage R&D to improve our understanding of, and ability to manipulate, combustion processes, generating knowledge and insight necessary for industry to develop the next generation of engines and fuels. The ACS subprogram utilizes unique facilities and capabilities at national laboratories to develop knowledge, new concepts and research tools that industry can use to develop advanced combustion engines. Facilities include the Combustion Research Facility at Sandia National Laboratories (SNL), the Advanced Photon Source at Argonne National Laboratory (ANL), the Institute for Integrated Catalysts at Pacific Northwest National Laboratory (PNNL), and the Spallation Neutron Source at Oak Ridge National Laboratory (ORNL). Major activities include: predictive modeling; experimental combustion including fuels and engines; and emission control. Predictive, high-fidelity models simulate the fundamental physics of fuel injection sprays, heat transfer, turbulence and combustion phenomena using high-performance computing resources. Experimental combustion processes develop data to establish quantitative relationships between fuel properties and efficiency improvement potential for engines operating in advanced compression ignition and multi-mode spark ignition/compression ignition regimes. Emission control experiments are conducted using high-resolution microscopy to understand chemical reactions at the atomic level on catalyst surfaces and within the catalysts that have the potential to reduce emissions at low exhaust temperatures.

Subprogram Feedback

The U.S. Department of Energy (DOE) received feedback on the overall technical subprogram areas presented during the 2017 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

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

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

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

Question 3: Were important issues and challenges identified?

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

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

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

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

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

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

Question 10: Has the program area engaged appropriate partners?

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

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

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

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

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

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

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

Presentation Number: acs000 Presentation Title: Overview of the VTO Advanced Combustion Systems Program
Principal Investigator: Gurpreet Singh (U.S. Department of Energy)

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

Reviewer 1:
The reviewer said yes, that strategy, drivers, specific approaches, plans, challenges, and accomplishments were all covered.

Reviewer 2:
The reviewer stated that, yes, these topics were adequately covered.

Reviewer 3:
The reviewer believed that these topics were adequately covered.

Reviewer 4:
The reviewer remarked that the program area and strategy were well-covered. Background on fuel consumption was nicely presented. The three-pronged approach of fundamental combustion, aftertreatment, and cost reduction seemed reasonable to the reviewer. However, the reviewer pointed out several potential issues. The 2009 baseline presented was obsolete. The U.S. Environmental Protection Agency (EPA) is using 2015 in its Technical Assessment Report. On heavy-duty (HD) vehicles, this is a false baseline, as efficiency improved significantly when selective catalytic reduction (SCR) was added in 2010. The reviewer also questioned whether DOE should be concerned at this stage about costs. The reviewer suggested that DOE ought to keep costs in mind, but offer technical solutions and let industry cost reduce these options.

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

Reviewer 1:
The reviewer commented that the role of DOE and the national laboratories R&D should primarily be focused on mid- and long-term R&D, while very near-term development and/or commercialization is the role of industry. The current program balance appeared, to the reviewer, to be consistent with this viewpoint.

Reviewer 2:
The reviewer said that it was well balanced.

Reviewer 3:
The reviewer stated that there appears to be appropriate balance. The reviewer also stated that the program would benefit from the integration of control technologies into being part of the program. This will be especially important for improving transient operations.

Reviewer 4:
The reviewer commented that project scopes seemed well-balanced. This reviewer argued there is little here for near-term (0 to 5 years) but that was acceptable. A zero to three-year timeframe “left the station.” A four to five-year timeframe would be CTS, some of the work at ANL on gasoline direct injection (GDI) particulate number (PN), lean burn, and fuel injector visualization and resolution. Medium term is most of the light-duty (LD) vehicle combustion work. Long term scopes would be all the collaboration with Basic Energy Sciences (BES), and the fundamental combustion work.

The reviewer further commented that given that plug-in electric vehicles (PEVs) are coming around the corner, it seems LD work ought to focus on the pre-2025 timeframe for implementation. For example, Japan is not doing internal combustion engine (ICE) research work after 2025.

Question 3: Were important issues and challenges identified?

Reviewer 1:
The reviewer said that yes, the important issues and challenges were clearly identified for the various program areas (advanced combustion, emissions mitigation, and control systems, etc.).

Reviewer 2:
The reviewer stated that yes, the important issues and challenges were clearly identified.

Reviewer 3:
The reviewer commented that the important issues and challenges were identified. The program addressed the critical high-level challenges that need to be addressed for improving efficiency and reducing environmental impact. This project also realizes that the potential benefits are very large because the ICEs are predominant as power plants, and will be for decades to come.

Reviewer 4:
The reviewer reiterated that the issues identified are to maximize efficiency, work on aftertreatment gaps, and reduce cost. Emerging and future LD (and HD) powertrains will have some electrification. Given this, a missing challenge is calibrating for hybrid operation with advanced combustion regimes. It is fair to say that all LD will have some hybrid electric vehicle (HEV) operation in 2025 and beyond, so the reviewer questioned what these challenges would be.

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

Reviewer 1:
The reviewer stated that yes, the plans for the various program areas were discussed.

Reviewer 2:
The reviewer said the plans were identified.

Reviewer 3:
The reviewer remarked that plans were presented at a very high level, which is appropriate for the scope of this presentation.

Reviewer 4:
The reviewer commented that the plans on fundamental low-temperature combustion (LTC) are impressive and yielded interesting results. The LD combustion projects cover the main opportunities. However, as suggested previously, the project ought to consider how hybridization fits in, as this may be complex and some of the combustion strategies might be enabled by it. Also, some of the aftertreatment projects might want to consider consolidation of functionality and synergies, such as zone coating and layering SCR (and diesel oxidation catalyst [DOC]) catalysts, and four-way catalyst (ANL was looking at coated gasoline particulate filters [GPF]). Also, the first layout of pre-turbo exhaust components was seen (Delphi gasoline direct compression ignition engine [GDCI]; Cummins). As DOC formulations seem to be hitting a wall when T90 is approximately 200°C, these components are a very attractive possibility. Much more fundamental work is needed on pre-turbo DOC, SCR, filters, and three-way catalyst (TWC).

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

Reviewer 1:
The reviewer said that yes, it was clearly benchmarked.

Reviewer 2:
The reviewer commented that progress was presented as a timeline chart covering multiple years of progress, which, for this level of presentation, is appropriate. It would be impractical to highlight individual project progress for the scope of this overview. The overall progress of this program is excellent.

Reviewer 3:
The reviewer remarked that some progress was mentioned, but not specifically over the previous year.

Reviewer 4:
The reviewer stated that it was difficult to assess this question from the presentation alone due to the many projects and progress on each. The 2050 fuel consumption projects show nominally a 25% cut due to these DOE programs versus the business as usual case, which is impressive. The chosen examples show progress, but much more is shown in the detailed presentations. The reviewer also stated that the start-up of the SuperTruck II Program is significant.

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

Reviewer 1:
The reviewer said that yes, the projects were focused on improved engine and vehicle efficiency, reduced emissions through improved engine design and better aftertreatment systems, and cost reductions.

Reviewer 2:
The reviewer said that the projects were addressing the broad problems and barriers.

Reviewer 3:
The reviewer stated that, in general, there was a good mixture. Barriers are identified and projects are designed to address them.

Reviewer 4:
The reviewer remarked that the experimental projects were very adequate. However, the reviewer expressed that the computational projects were not so adequate.

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

Reviewer 1:
The reviewer stated that the program area did appear to be focused, well-managed, and effective.

Reviewer 2:
The reviewer commented that yes, the programs were focused on existing VTO "needs". The reviewer, however questions whether those "needs" will be/are being re-defined to meet the new administration's priorities.

Reviewer 3:
The reviewer commented that the program area was focused. However, it was difficult to make an assessment of the level of management from an overview presentation. The reviewer's observations based on experiences outside of this review are that the program is very well managed.

Reviewer 4:
The reviewer stated that the funding seemed adequate. The programs have excellent collaboration and state-of-the-art investigations, with nothing even close to this elsewhere. As PEV costs come down and ICE costs go up, the ICE will still be used but with decreasing emphasis and impact. On the LD side, the reviewer remarked

that the program needs to start shifting to this reality. Perhaps this can be accomplished by incorporating hybridization into each LD program; looking at smaller, less powerful engines (like range extenders); and looking at fundamentals of second-by-second power supplement by electric motors.

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

Reviewer 1:
The reviewer considered a key strength to be the combined use of engine and vehicle testing and simulation and/or modeling work. No key weaknesses were given by the reviewer.

Reviewer 2:
The reviewer commented that the program brings together the fundamental capabilities of the national laboratories into conducting advanced research that industry no longer performs, yet couples the work with industry R&D efforts, who have the understanding of what is required for a technology to be incorporated in a product. There is not such a large interface with universities, unfortunately. Working groups, Memoranda of Understanding (MOUs), and research review meetings give ample opportunity for stakeholders to engage and offer input, and take important learning back to their respective R&D efforts.

Reviewer 3:
The reviewer suggested that the project needed more consideration of hybridization into the LD engine strategy, as discussed earlier. The fundamental combustion work is state-of-the-art and world-class. The reviewer did not really see much information on cost reduction, but as mentioned, this was acceptable as industry needs to choose the options offered by these DOE projects and reduce cost themselves.

Reviewer 4:
The reviewer listed a key strength as experimental diagnostics of advanced combustion engines. Several key weaknesses were listed. The computational efforts at the Sandia Combustion Research Facility (CRF) are adequate; however, the computational fluid dynamics (CFD) efforts led by ANL using the commercial code (i.e., the commercial CFD software CONVERGE) are not proper. The scientific merit and impacts of Argonne's CFD work by Sibendu Som are not up to the standard of a national laboratory. The ANL work is low-level CFD and can be easily accomplished by mediocre universities. In the meantime, the KIVA work at Los Alamos does not seem to have value or impact. Nowadays, every company, university, and national laboratory has its own in-house engine codes. The reviewer stated that it is unlikely that anyone will use the new KIVA in the future. Every institution has been migrated to Open Source Field Operation and Manipulation (OpenFOAM) for open-source code development. The inertia is too big to switch to the new KIVA. The reviewer considers it a waste of resources to continue the KIVA code development.

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

Reviewer 1:
The reviewer stated that there seemed to be novel and innovative approaches to the barriers. The reviewer further highlighted the key value of the national laboratories is fundamental exploration of novel concepts.

Reviewer 2:
The reviewer said yes, the projects do represent novel and/or innovative ways to approach the barriers.

Reviewer 3:
The reviewer remarked that the projects are packed with creativity and novel approaches. DOE has shown flexibility and ability to adjust. One example is moving to gasoline on the Achates engine (not presented here). The reviewer suggested that scientists be given some general goals, given resources, and let them adjust to

deliver results. The reviewer stated that it is acceptable to change goals, as long as the team is delivering good results.

Reviewer 4:
The reviewer noted that the experimental work is valuable, but the computational works by Argonne and Los Alamos are not novel or innovative.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:
The reviewer commented that excellent collaboration was obvious on all fronts. The reviewer was very impressed and stated that there were no concerns.

Reviewer 2:
The reviewer commented that appropriate partners were mentioned, such as the engine and vehicle manufacturers and energy companies in the Advanced Engine Combustion (AEC) MOU partnership; a catalyst company in the emissions catalyst R&D; and PPG for the improved tire materials.

Reviewer 3:
The reviewer said that yes, appropriate partners had been engaged.

Reviewer 4:
The reviewer said that yes, appropriate partners had been engaged.

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

Reviewer 1:
The reviewer said yes, the program is collaborating effectively.

Reviewer 2:
The reviewer said yes, the program is collaborating effectively. This reviewer also suggested that this question should be incorporated into the previous one.

Reviewer 3:
The reviewer said yes, the program is collaborating effectively.

Reviewer 4:
The reviewer stated that good progress seemed to be made, but from the presentation material, it was not possible to determine the specific effectiveness and/or quality of the collaborations (i.e., it is theoretically possible that there is no significant collaboration with industry partners and all progress is being made by the national laboratories with minimal industry collaboration).

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

Reviewer 1:
The reviewer noted that it seemed that including more controls (for example, development of model based control approaches) will be an important area for improving transient performance. The reviewer asked if there fundamental barriers that need to be addressed to facilitate industry's development of model based, proactive, and predictive control systems. It was the reviewer's opinion that this will be an important enabler for using LTC approaches during transient operation.

Reviewer 2:
The reviewer stated that the portfolio does not have gaps. On the contrary, the reviewer commented that the work is a bit too extensive, and that computational work at ANL and Los Alamos was unnecessary.

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

Reviewer 1:
The reviewer said that topics were being adequately addressed.

Reviewer 2:
The reviewer referenced previous comments.

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

Reviewers either said that there were no other areas, or they reference answers to prior questions.

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

Reviewer 1:
The reviewer stated that the program has innovative collaboration utilizing the R&D capabilities of the United States. No further recommendations were given.

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

Reviewer 1:
The reviewer commented that the program appears to be well organized and doing effective work, maximizing the results and effectiveness within the budget that exists.

Reviewer 2:
The reviewer suggested that the Directions in Engine Efficiency and Emissions Research conference ought to be renewed. This is essential to communicating the results to industry. It was very-well attended and covered multiple areas very well. The reviewer asserted that this is a major gap and deficiency in the program.

Reviewer 3:
The reviewer commented that, regarding the computational efforts, the universities (rather than the national laboratories) should be allowed to develop advanced numerical models.

Reviewer 4:
The reviewer suggested marketing this review a little more to those organizations that can help deliver desired change (i.e., software/app developers, marketing people, leaders at the truck builders who integrate so many of these technologies, and fleets).

Project Feedback

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

Table 1-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
acs001	Heavy-Duty Low-Temperature and Diesel Combustion and Heavy-Duty Combustion Modeling	Mark Musculus (SNL)	1-15	3.50	3.75	3.63	3.50	**3.64**
acs002	Light-Duty Diesel Combustion	Stephen Busch (SNL)	1-18	3.00	3.13	3.00	3.00	**3.06**
acs004	Low-Temperature Gasoline Combustion (LTGC) Engine Research	John Dec (SNL)	1-22	2.75	2.88	3.50	3.13	**2.95**
acs005	Spray Combustion Cross-Cut Engine Research	Lyle Pickett (SNL)	1-25	3.40	3.30	3.60	3.30	**3.36**
acs006	Gasoline Combustion Fundamentals	Isaac Ekoto (SNL)	1-28	3.25	2.75	3.13	2.75	**2.92**
acs007	Large Eddy Simulation (LES) Applied to Advanced Engine Combustion Research	Joe Oefelein (SNL)	1-31	3.50	3.63	3.63	3.38	**3.56**
acs010	Fuel Injection and Spray Research Using X-Ray Diagnostics	Christopher Powell (ANL)	1-34	3.42	3.08	2.92	3.00	**3.14**
acs011	Advances in High-Efficiency Gasoline Compression Ignition	Steve Ciatti (ANL)	1-37	2.90	3.00	2.80	2.90	**2.94**
acs012	Model Development and Analysis of Clean & Efficient Engine Combustion	Russell Whitesides (LLNL)	1-40	3.75	3.50	3.25	3.38	**3.52**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
acs013	Chemical Kinetic Models for Advanced Engine Combustion	Bill Pitz (LLNL)	1-42	3.70	3.60	3.50	3.40	**3.59**
acs014	2016 KIVA-hpFE Development: A Robust and Accurate Engine Modeling Software	David Carrington (LANL)	1-46	2.90	3.00	2.60	2.90	**2.91**
acs015	Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes	Jim Szybist (ORNL)	1-52	3.38	3.38	2.88	2.75	**3.23**
acs016	High-Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines	Scott Curran (ORNL)	1-55	3.07	3.36	3.29	3.07	**3.24**
acs017	Accelerating Predictive Simulation of IC Engines with High Performance Computing	K. Dean Edwards (ORNL)	1-59	2.88	3.00	3.25	2.88	**2.98**
acs022	Joint Development and Coordination of Emissions Control Data and Models (Cross-cut Lean Exhaust Emissions Reduction Simulations Analysis and Coordination)	Josh Pihl (ORNL)	1-62	3.13	3.13	3.50	3.13	**3.17**
acs023	Cross-cut Lean Exhaust Emissions Reduction Simulation: Aftertreatment Modeling and Analysis	Yong Wang (PNNL)	1-66	3.10	3.20	3.40	2.90	**3.16**
acs024	Ash-Durable Catalyzed Filters for Gasoline Direct Injection (GDI) Engines	Hee Je Seong (ANL)	1-71	2.90	3.00	3.10	2.90	**2.98**
acs027	Next-Generation Selective Catalytic Reduction-Dosing System Investigation	Abhijeet Karkamkar (PNNL)	1-75	2.75	2.75	2.63	2.50	**2.70**
acs032	Cummins-ORNL Emissions CRADA: NO_x Control and Measurement Technology for Heavy-Duty Diesel Engines	Bill Partridge (ORNL)	1-79	3.00	2.75	3.38	2.63	**2.88**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
acs033	Emissions Control for Lean Gasoline Engines	Jim Parks (ORNL)	1-83	3.38	3.25	3.63	3.25	**3.33**
acs052	Neutron Imaging of Advanced Transportation Technologies	Todd Toops (ORNL)	1-86	3.20	3.00	3.10	3.20	**3.09**
acs054	Rapid Compression Machine Studies to Enable Gasoline-Relevant Low-Temperature Combustion	Scott Goldsborough (ANL)	1-89	3.38	3.50	3.38	3.00	**3.39**
acs056	Fuel-Neutral Studies of Particulate Matter Transport Emissions	Mark Stewart (PNNL)	1-92	3.20	3.50	3.70	3.20	**3.41**
acs075	Advancements in Fuel Spray and Combustion Modeling with High-Performance Computing Resources	Sibendu Som (ANL)	1-95	3.21	3.14	3.36	3.07	**3.18**
acs076	Improved Solvers for Advanced Engine Combustion Simulation	Matthew McNenly (LLNL)	1-101	3.75	3.63	3.38	3.50	**3.61**
acs084	Advanced Ignition Systems for Gasoline Direct Injection (GDI) Engines	Riccardo Scarcelli (ANL)	1-104	3.13	3.38	3.25	3.25	**3.28**
acs085	Low-Temperature Emission Control to Enable Fuel-Efficient Engine Commercialization	Todd Toops (ORNL)	1-107	3.60	3.50	3.10	3.40	**3.46**
acs092	High-Efficiency Variable Compression Ratio Engine with Variable Valve Actuation and New Supercharging Technology	Charles Mendler (Envera LLC)	1-110	2.79	2.86	2.93	2.79	**2.84**
acs093	Lean Miller Cycle System Development for Light-Duty Vehicles	David Sczomak (General Motors)	1-115	3.67	3.50	3.17	3.33	**3.48**
acs094	Ultra-Efficient Light-Duty Powertrain with Gasoline Low-Temperature Combustion	Keith Confer (Delphi Powertrain)	1-118	3.50	3.67	3.17	3.50	**3.54**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
acs095	Metal Oxide Nano-Array Catalysts for Low-Temperature Diesel Oxidation	Pu-Xian Gao (U. of Connecticut)	1-122	2.83	2.92	2.75	2.75	**2.85**
acs097	Affordable Rankine Cycle (ARC) Waste Heat Recovery for Heavy-Duty Trucks	Swami Subramanian (Eaton)	1-126	2.75	2.42	3.00	3.00	**2.33**
acs098	Cummins 55% Brake Thermal Efficiency Project	Lyle E. Kocher (Cummins)	1-130	3.43	3.29	2.36	3.00	**3.17**
acs099	Improved Fuel Efficiency through Adaptive Radio Frequency Controls and Diagnostics for Advanced Catalyst Systems	Alexander Sappok (Filter Sensing Technologies, Inc.)	1-135	3.58	3.33	3.58	3.42	**3.44**
acs100	Engine Improving Transportation Efficiency through Integrated Vehicle, and Powertrain Research SuperTruck II	Justin Yee (Daimler Trucks North America)	1-139	3.43	3.21	3.50	3.57	**3.35**
acs101	Volvo SuperTruck II: Pathway to Cost-Effective Commercialized Freight Efficiency	Pascal Amar (Volvo)	1-144	3.58	3.33	3.58	3.33	**3.43**
acs102	Cummins/ Peterbilt SuperTruck II	Michael Ruth (Cummins)	1-149	3.79	3.43	3.57	3.64	**3.56**
acs103	Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer—SuperTruck	Russ Zukouski (Navistar)	1-154	3.14	3.29	3.07	3.14	**3.21**
acs104	Cavitation Within Fuel Injectors: Development and Multiscale Validation of Euler-Lagrange based Computational Methods for Modeling Cavitation within Fuel Injectors	Emily Ryan (Boston U.)	1-159	3.13	3.25	3.13	3.13	**3.19**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
acs105	Turbulent Spray Atomization Model for Diesel Engine Simulations	Caroline Genzale (Georgia Institute of Technology)	1-164	3.25	3.38	3.25	3.25	**3.31**
acs106	Multi-Component Fuel Vaporization and Flash Boiling	Chia-Fon Lee (U. of Illinois)	1-169	2.50	2.38	2.63	2.50	**2.45**
acs107	High-Pressure Supercritical Fuel Injection at Diesel Conditions	Ajay Agrawal (U. of Alabama)	1-174	3.00	3.00	3.17	2.83	**3.00**
acs108	Spray-Wall Interaction at High-Pressure and High-Temperature Conditions	Seung-Young Lee (Michigan Technological University)	1-177	3.25	2.88	3.25	3.00	**3.03**
acs109	Predictive Models for In-Cylinder Radiation and Heat Transfer	Dan Haworth (Penn State)	1-180	3.67	3.50	3.67	3.50	**3.56**
acs110	Engine Knock Prediction	Seung Hyun Kim (Ohio State U.)	1-183	3.00	3.13	3.25	2.88	**3.08**
acs111	Lagrangian Soot Model Considering Gas Kinetics and Surface Chemistry	Sage Kokjohn (U. of Wisconsin)	1-186	3.50	3.17	3.33	3.50	**3.31**
acs112	Integrated Boosting and Hybridization for Extreme Fuel Economy and Downsizing	Chinmaya Patil (Eaton)	1-189	3.25	3.38	2.75	3.38	**3.27**
acs113	DOE's Effort to Improve Heavy Vehicle Fuel Efficiency through Improved Aerodynamics	Kambiz Salari (LLNL)	1-193	3.50	3.75	3.75	3.25	**3.63**
acs114	Improved Tire Efficiency through Elastomeric Polymers Enhanced with Carbon-Based Nanostructured Materials	Georgios Polyzos (ORNL)	1-198	3.25	3.38	2.88	3.00	**3.23**
acs115	Advanced Bus and Truck Radial Materials for Fuel Efficiency	Lucas Dos Santos Freire (PPG)	1-202	3.50	3.63	3.63	3.38	**3.56**

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
acs116	Advanced Non-Tread Materials for Fuel-Efficient Tires	Tim Okel (PPG)	1-206	3.25	3.13	3.38	2.88	**3.16**
acs117†	HD Powertrain Optimization	Paul Chambon (ORNL)	1-210	3.33	3.50	3.33	3.33	**3.42**
acs118	Advanced Emission Control for High-Efficiency Engines	Janos Szanyi (PNNL)	1-213	3.10	3.10	3.40	3.00	**3.13**
acs119	Development and Optimization of a Multi-Functional SCR-DPF Aftertreatment System for Heavy-Duty NO_x and Soot Emission Reduction	Ken Rappe (PNNL)	1-218	3.20	3.10	3.10	3.10	**3.13**
Overall Average				**3.24**	**3.21**	**3.22**	**3.12**	**3.20**

† Denotes a poster presentation.

Presentation Number: acs001
Presentation Title: Heavy-Duty Low-Temperature and Diesel Combustion and Heavy-Duty Combustion Modeling
Principal Investigator: Mark Musculus (Sandia National Laboratories)

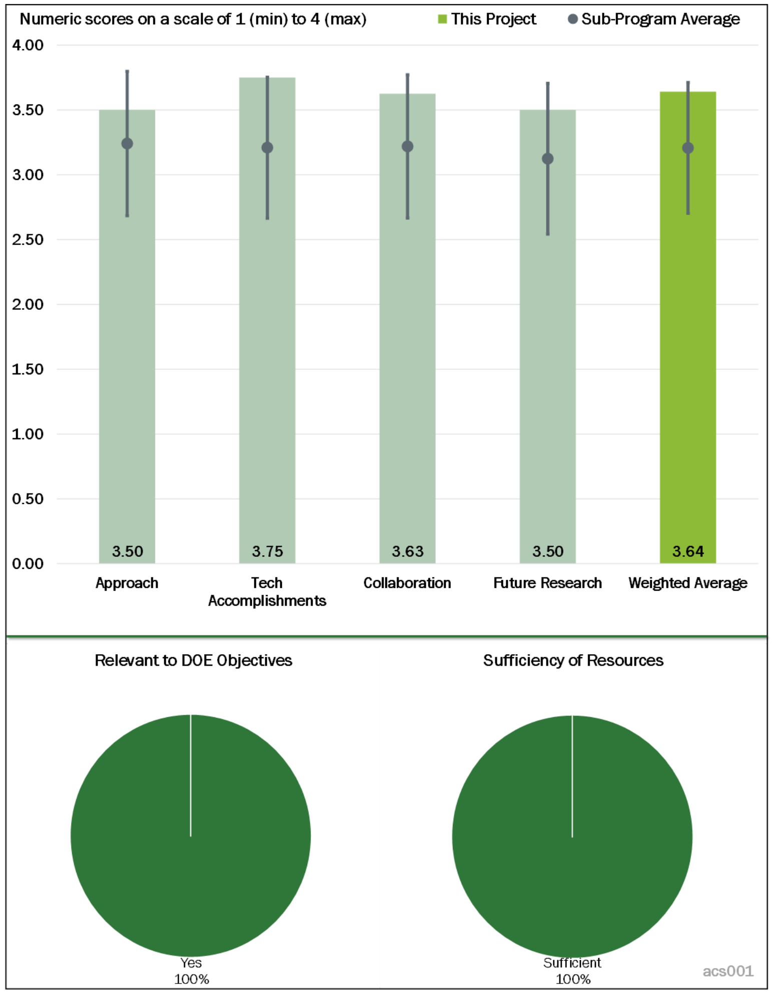

Figure 1-1 - Presentation Number: acs001 Presentation Title: Heavy-Duty Low-Temperature and Diesel Combustion and Heavy-Duty Combustion Modeling Principal Investigator: Mark Musculus (Sandia National Laboratories)

Presenter

Mark Musculus, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The approach of using experimental optical studies with modeling for elucidating initial soot production and oxidation is excellent in this reviewer's opinion. Additionally, coupling diffuse back illuminated with natural luminosity imaging seems to be a very effective technique for quantifying net soot production.

Reviewer 2:

The reviewer noted that overall, this is well thought out and planned project. The PI has given great thought toward using experimental techniques to better quantify the impact of late cycle injection on the controlling physics for reducing soot. The project includes a modeling CFD portion that is also very helpful in better understanding and quantifying the controlling physics. The idea toward developing a concept model for soot formation/reduction as a function of post injection parameters is a great idea, but the reviewer indicated concern that the experimental conditions are not broad enough to support such an effort at this point in time. The reviewer recommended that it would be helpful to better quantify time scale effects such as engine speed and injection pressure on post injection and timing on soot oxidation.

Reviewer 3:

The reviewer observed that the approach utilizes a good balance of experiments along with simulation for a fundamental understanding of diesel combustion.

The reviewer recommended further understanding and insight regarding multi-injection schedules would be helpful in order to improve overall engine efficiency.

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

Reviewer 1:
The reviewer noted that very good progress has been made to better elucidate and quantify soot production from post injection. The results are very helpful for better fundamental understanding and to resolve apparent conflicting results from prior studies.

Reviewer 2:
The reviewer indicated that this project has made significant contribution toward understanding of soot oxidation and soot production with pilot, main and post injection strategies.

Reviewer 3:
The presented results have helped the engine community better quantify why post injection leads to soot reduction under certain operating conditions. The reviewer thanked the PI for focusing on supplying such important quantitative data to the community over the past year. As a possible side effect from this great effort, it was not clear to the reviewer if the PI was also closely watching the impact on indicated efficiency from various post injection strategies used in this project.

Reviewer 4:
The reviewer observed that additional geometries should be investigated for spray to spray interactions.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that the project made good use of the Engine Combustion Network (ECN).

Reviewer 2:
The reviewer observed that collaboration and coordination with other institutions has been excellent in this project.

Reviewer 3:
It has been apparent over the years that the principal investigator (PI) is excellent at collaboration with various partners. In this reviewer's opinion, this is one of many strengths of the PI's past and current work.

Reviewer 4:
There appears to be collaborations with some specific industry partners (such as Cummins, Delphi, and Convergent Science) as well as several universities (University of Wisconsin [UW] and Lund University). The reviewer noted that collaboration with the organizations involved in the AEC MOU is mentioned, but outside of the two presentations per year, it was unclear to this reviewer how much collaboration with those organizations takes place.

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

Reviewer 1:
The reviewer indicated that proposed plans of continuing to gain fundamental insights from experiments and models; building conceptual models; and determining how in-cylinder processes affect efficiency across a range of combustion modes and in-cylinder geometries seem very reasonable and useful.

Reviewer 2:
The proposed research plan is very good. The reviewer recommended that, if time permits, the project could expand the experimental work to better understand time scale effects on post injection/soot oxidation/soot formation by varying engine speed and injection pressure in light of any future conceptual model development.

Reviewer 3:
The reviewer suggested that proposed future research regarding in-cylinder temperature and heat transfer across combustion modes to efficiency will be helpful. The reviewer wondered if thermal barrier coating on pistons can be included in this study for optimizing thickness and material conductivity.

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

Reviewer 1:
This reviewer indicated that a fundamental understanding of soot production and how to reduce it should lead to improved aftertreatment systems, which may lead to less fuel required for regeneration. Also, less fuel converted to soot presumably means higher combustion and engine efficiency.

Reviewer 2:
This reviewer stated that the project does support the overall DOE objectives of petroleum displacement because this study has a direct impact on improving overall efficiency of combustion engines.

Reviewer 3:
The reviewer said in short, yes. The post injection strategy for soot oxidation may allow for a more aggressive main combustion strategy approach that could increase indicated thermal efficiency, thus addressing DOE goals. This reviewer noted that although this past year the focus did not appear to be on efficiency, the quantitative data supplied to understand soot oxidation/formation as a function of post injection strategy was worthwhile.

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

Reviewer 1:
This reviewer stated that the resources seem sufficient and that the project seems to be meeting goals seem with current funding levels.

Reviewer 2:
This reviewer indicated that funding seems to be sufficient.

Reviewer 3:
This reviewer suggested that, based on availability of resources, allocating additional resources for modeling work would greatly benefit further advancement of the study.

Presentation Number: acs002
Presentation Title: Light-Duty Diesel Combustion
Principal Investigator: Stephen Busch (Sandia National Laboratories)

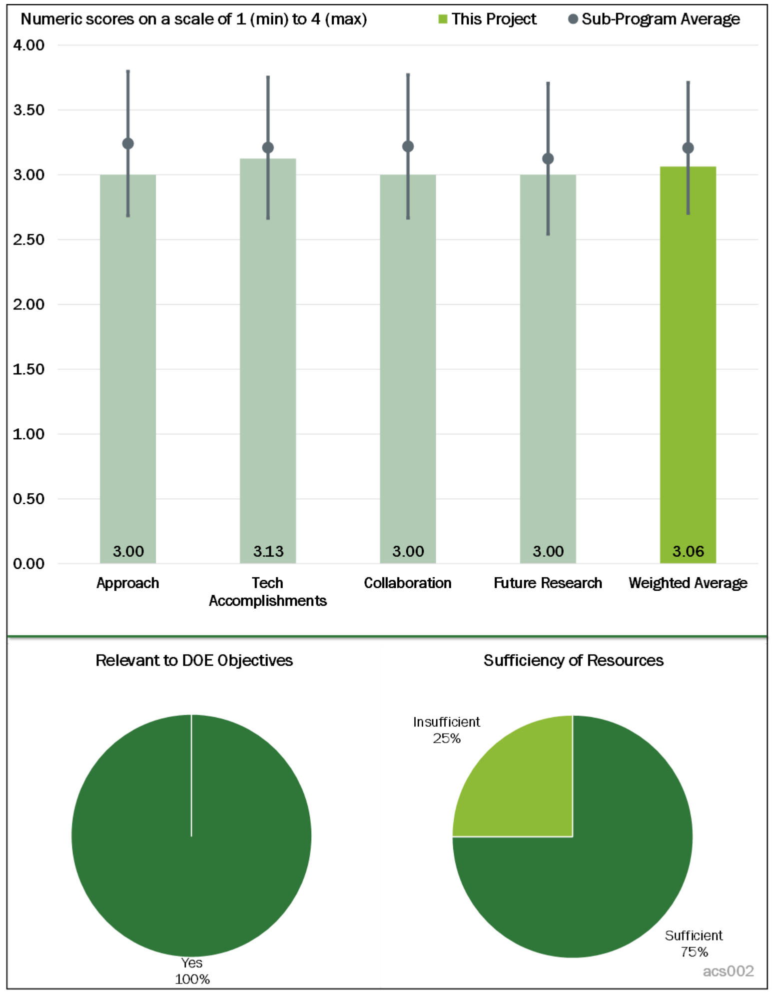

Figure 1-2 - Presentation Number: acs002 Presentation Title: Light-Duty Diesel Combustion Principal Investigator: Stephen Busch (Sandia National Laboratories)

Presenter

Stephen Busch, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The approach is sound, addressing the fundamentals of diesel combustion and the work is made up of primarily optical engine work, looking at injection, ignition, and combustion processes with a focus on exposing fundamental knowledge. This reviewer noted that the work is supported with simulations by UW with their Fast and Reliable Engine Simulation Code (FRESCO) code and Convergent Science.

Reviewer 2:

The current study for piston bowl geometry for overall thermal efficiency and emissions is promising. But, a parametric study CFD for assessing really sensitive piston bowl parameters for thermal efficiency and validation using experimental studies will be vital to the engine community in this reviewer's opinion.

Reviewer 3:

The reviewer said that this is a great example for collaboration between experimental and simulation work. This reviewer did note one concern, raised by another reviewer, wondering if the observed differences between piston geometries was at less than peak efficiency. At peak efficiency, there was not much of a difference, which leads to the question of which bowl parameters are most important and how can they be isolated in the experimental approach. This reviewer wondered if, now that the tools have been developed using the chosen piston profiles, they can be used to look at optimizing and ranking different bowl features with the ultimate goal being to provide guidance to the design process.

Reviewer 4:

The project provides unique data for the combustion process with the dedicated optical engine and that this is very important and useful.

The reviewer did note that it appears the project lacks the definition over its design space to make the study of diesel combustion and predictive CFD tools useful. The study focuses on only on two combustion bowls. For any practical "use," the reviewer recommended that the study would need to consider a space of air-fuel ratio, boost, injection spray, and compression ratio, in addition to bowl geometry.

The reviewer also recommended that the project could benefit from more concrete targets or benchmarks. For example, this person thought the project should focus on efficiency regions near or higher than the baseline, rather than exploring the late timings that operate at poor efficiency.

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

Reviewer 1:
This reviewer wondered if the post-processing techniques that are developed to extract additional insights about in-cylinder processes and support experimental findings are specific to FRESCO software or if they can also be used with other CFD software.

Reviewer 2:
This reviewer recommended thinking about how the design space for bowl design can be narrowed.

Reviewer 3:
This reviewer stated that progress seems slow and wondered if the Programmatic approach in Slide 5 can be accelerated. Noise measurements, following Advanced Combustion and Emissions Control (ACEC) guidelines, and tradeoffs with efficiency were proposed last year and this reviewer was encouraged to see that the suggestion to do a First-Law analysis last year were followed.

This reviewer wondered if care was taken to ensure that the conventional bowl and stepped-lip bowl were nearly the same in all other respects, with the only main difference being the stepped-lipped feature. In other words, this person asked if the results can be confounded by geometry differences other than the stepped lip.

This reviewer also wondered if there are any piston-lip geometry issues or design guidelines that can maximize efficiency.

Reviewer 4:
This reviewer commended that the work provides useful images of both experimental and simulation of the diesel combustion, but provides little new insights on the nature of diesel combustion. Focusing on heat release and energy loss spanning very late injection timing are of little practical value as the efficiencies reported are very low. This reviewer recommended that the study focus on the efficiency roadmap (established at the goal of the program) to provide information of any practical pathways beyond what the industry state of the art is.

The report showed similar performance on the two bowls considered at peak efficiency; this is very telling and could have been treated in greater length in this reviewer's opinion.

This reviewer recommended reporting a better description of test conditions as well as exploring future ranges.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer noted that it seems like there is good collaboration with General Motors (GM) and Ford.

Reviewer 2:
While two large original equipment manufacturers (OEMs) are involved, it is unclear to this reviewer how much guidance they provide or the quality of this guidance.

One aspect that is of concern to this reviewer is the lack of reference to previous studies done in this area.

Reviewer 3:
This reviewer recommended collaborations to expand into catalyst heating.

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 project proposed multiple efforts regarding injection strategies, catalyst heating, and different experimental studies along with noise-efficiency trade off study.

The reviewer noted that the noise efficiency study date should be changed to summer 2017 instead of 2016, but is not sure how the noise efficiency is relevant to overall scope of this project.

Reviewer 2:
Researchers are encouraged to align their work in the context of previous work in this area, emphasizing new approaches and pathways toward improved combustion efficiency and clean combustion. This work needs to be guided by clear benchmarks targets that support their capability to improve the state of the art. The reviewer got the impression that there is no “picture” of success.

Reviewer 3:
While many pieces of future research are proposed in a somewhat ad hoc manner, this reviewer asked if there is a macro direction to this research. The reviewer asked what the “big research proposal/idea” is that is being investigated. This person wondered if after supplying an initial body of data for simulation comparisons, is it the responsibility of this project to continue to “educate” and calibrate CFD models, or, should this project go on to investigate the next high-efficiency or emissions reduction concept.

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

Reviewer 1:
This reviewer indicated that yes, the project aims to provide fundamental understanding of efficiency-increasing and emissions-reducing concepts in LD diesel engines.

Reviewer 2:
This reviewer stated that the project by nature does, but observed that its present approach does not appear to have the elements to make significant contributions to this objective.

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

Reviewer 1:
This reviewer commented that based on what has been accomplished in this project so far, the funding for this project has been more than sufficient.

Reviewer 2:
This reviewer indicated that resources are sufficient.

Reviewer 3:
This reviewer observed that current resources are sufficient but future reductions would jeopardize output.

Reviewer 4:

This reviewer suggested that the team try to enlist more active participation from a technical expert in the combustion-fuel-system-air management to help guide the work toward a place where a significant breakthrough can be attained. Without this, this person indicated that it is unlikely that the team will continue to produce data of little relevance.

Presentation Number: acs004
Presentation Title: Low-Temperature Gasoline Combustion (LTGC) Engine Research
Principal Investigator: John Dec (Sandia National Laboratories)

Presenter
John Dec, Sandia National Laboratories

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

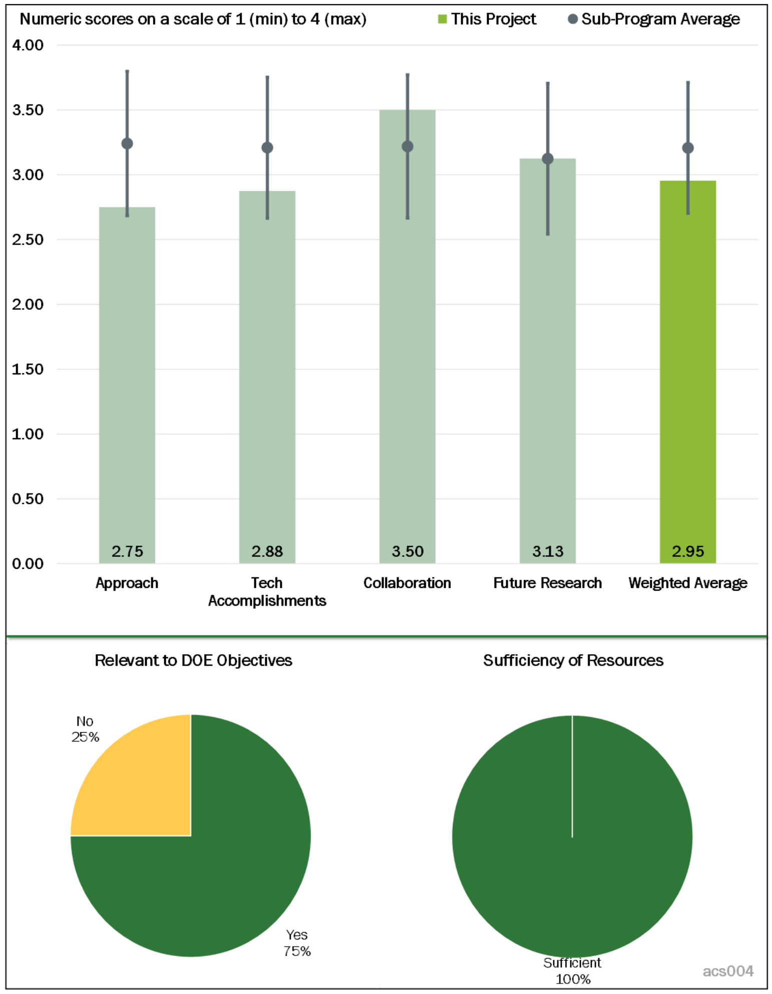

Figure 1-3 - Presentation Number: acs004 Presentation Title: Low-Temperature Gasoline Combustion (LTGC) Engine Research Principal Investigator: John Dec (Sandia National Laboratories)

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

Reviewer 1:
The work represents a comprehensive experimental investigation of the engine operating parameters affecting the gasoline compression ignition (GCI) engine operation. The work is very high quality and useful; however, the reviewer noted that the data shown to date are already largely available in the literature, albeit not as precisely defined and extensively evaluated. In this person's opinion, the most significant contribution of this work will occur when the work moves into the optical diagnostics, the arena in which SNL and this PI excel.

Reviewer 2:
This reviewer recommended running compression ignition (CI) combustion mode on candidate hardware to better show baseline versus LTC results.

Reviewer 3:
The reviewer said that a 1.0 liter (L)/cylinder is large for a LD application and gives higher brake thermal efficiency (BTE) than a more typical 0.5 L/cylinder. The reviewer wondered if the BTE data being provided to the Autonomie simulations will be corrected for this effect. This reviewer noted that the project should also keep an eye on combustion noise (CN), as CN should not have abrupt transitions during combustion mode and/or load changes.

Reviewer 4:
This reviewer observed that aftertreatment implications have not been adequately considered because hydrocarbon (HC) and carbon monoxide (CO) were not reported and exhaust temperature was stated to be below typical catalyst light off temperature.

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

Reviewer 1:

This reviewer applauded the use of the uncertainty quantification (UQ) and wondered if this analysis can be used to set requirements for parameters used to control the combustion phasing such as intake charge temperature and pressure.

Reviewer 2:

This reviewer appreciated the very nice and detailed data; however, the level of detail presented in the figures in the slides is far beyond what is needed to make the points covered in this review. The net result was that the presentation was very hard to follow. The reviewer commends the PI for integrating and addressing the uncertainty of the results into his analysis; however, it is not clear from the presentation what aspects of the results have been subjected to the uncertainty analysis. This reviewer was uncertain of the fuel consumption and efficiency performance of the results.

Working with the different stakeholders to make BTE projections was an important addition to the work. This person wondered if estimates of the range of confidence of this projections would be helpful—for example, what would the investigators think the uncertainty is of using a sequence of steady state points to evaluate the performance over a driving cycle.

Reviewer 3:

More progress has been made exploring engine operation and improving indicated efficiency, but the vehicle fuel economy estimate which compares the engine in an HEV application to a production Toyota Prius engine is only 6% better in spite of a cylinder size double the Prius and being skip fired. This reviewer believed that in the time that it takes for this concept to get to market, conventional hybrid engines will improve more than 6%.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer observed that the interaction with the various stakeholders appears to be excellent.

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

Reviewer 1:

The results presented are consistent with, and represent a very nice refinement of, the current understanding of the approaches to controlling the combustion timing for GCI. This reviewer looks forward to when the research moves into the optical engine phase of the project.

Reviewer 2:

This reviewer indicated that future work appears to be aligned with barriers to implementation such as controls and transients.

Reviewer 3:

This reviewer suggested that future work should include sensitivity of the combustion behavior to boundary conditions. For example, how much can the intake temperature or pressure vary from a typical set point and still maintain combustion within the operating constraints of noise, knock, combustion phasing for efficiency, and emissions. In addition, playing an audio recording of the engine running in the test cell at the AMR will inform the audience of the sound that comes out of the engine at 5 MW/m^2.

Reviewer 4:

This reviewer was concerned that current proposed future research would not meaningfully move barriers to LTC and suggested the team use an increased variety of hardware in experimental efforts.

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

Reviewer 1:

This reviewer indicated that the project is very relevant for the DOE objectives. There is potential for a significant fuel consumption reduction with this combustion approach, but there are fundamental challenges that need to be understood. This work address that.

Reviewer 2:

This reviewer suggested that the project needs more hardware variety (fuel injected engine [FIE], pressures and geometry, combustion chamber geometry, etc.)

Reviewer 3:

This reviewer commented that the predicted brake efficiency improvement is not large enough to be relevant in the time frame that this concept could be implemented, so no petroleum displacement will result.

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

Reviewer 1:

This reviewer stated it seems that the PI is making good progress with the resources he has, or he has appropriately adjusted the scope of his efforts to account for the funding and available physical resources.

Presentation Number: acs005
Presentation Title: Spray Combustion Cross-Cut Engine Research
Principal Investigator: Lyle Pickett (Sandia National Laboratories)

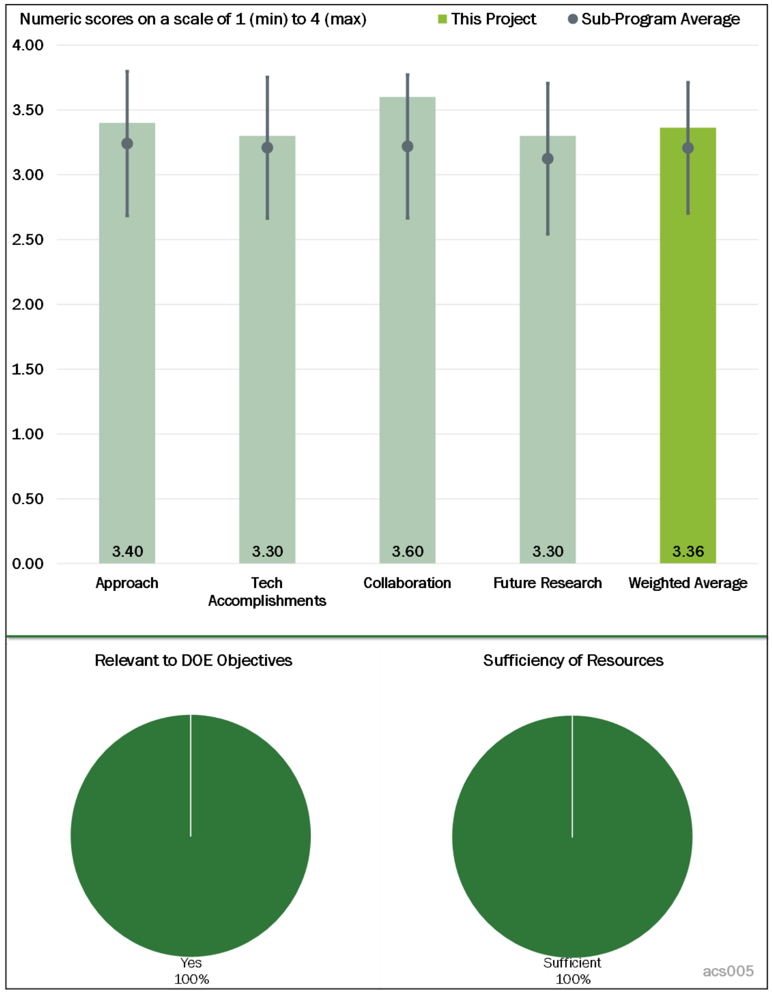

Figure 1-4 - Presentation Number: acs005 Presentation Title: Spray Combustion Cross-Cut Engine Research Principal Investigator: Lyle Pickett (Sandia National Laboratories)

Presenter

Lyle Pickett, Sandia National Laboratories

Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the project directly addresses important technical barriers associated with gaps in understanding for fuel sprays. Clearly this project is closely linked to a multitude of other efforts, via the ECN. The PI made a convincing case that work is closely coupled with modeling efforts, which was apparently an area that was criticized in previous years.

Reviewer 2:

The reviewer commented that by measuring and understanding spray characteristics, this work provides information to link fuel spray and air mixing with the combustion and emissions process.

Reviewer 3:

This reviewer wondered how priorities are chosen for the experimentation at engine relevant spray conditions for development of predictive computational tools.

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

Reviewer 1:

This reviewer wondered how simulation contributions for ECN listed in the presentation were used. As stated in the presentation, some simulations are Reynolds-averaged Navier-Stokes equations (RANS) and others are large eddy simulation (LES). This reviewer also wondered how LES can be less expensive to define boundary conditions used for more expensive simulations.

Reviewer 2:
The gas velocity measurement between plumes is a major result for CFD evaluation; however, the differences among the measurement and the computations are quite large. This reviewer suggested conducting a more detailed analysis of the uncertainties of the results and explanation of the differences.

Reviewer 3:
The reviewer said that progress has been satisfactory, but output can be increased. This reviewer found the measurement of soot with the diffused back illumination method very interesting. In particular, the difference between the environment (carbon dioxide [CO_2] and water [H_2O] versus oxygen [O_2] and nitrogen) and the effect of cavitation on soot both very interesting.

This reviewer wondered about work that was proposed last year to probe particulate formation at the tip of gasoline injectors; it was not reported on this year.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that this project has close collaborations with software vendors, OEMs, and other research institutions around the world.

Reviewer 2:
The reviewer commented that there is no question that the collaboration is excellent; however, care must be taken to collaborate efficiently and not just for collaboration's sake.

Reviewer 3:
The reviewer said that a clear case has been made for the degree of collaboration with others, particularly with those developing models of spray behavior and effects of sprays on engine combustion. This has apparently been criticized in the past, and was corrected here. This person agrees with another reviewer who pointed out, however, that perhaps too much emphasis was placed on this aspect. The focus of the presentation should be on your technical accomplishments, and while you must address collaborations, you should not be expected to use your own valuable presentation time to promote or highlight modeling accomplishments.

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 finds the new high-throughput spray facility particularly interesting and exciting. There have been results from the SNL spray bomb for many years, and now there will finally be better results with improved understanding of uncertainty/repeatability. The reviewer wondered what the fate of the spray bomb is, and asked if the new facility makes the spray bomb obsolete, or will you continue to do work in that chamber.

Reviewer 2:
The reviewer asked if the project PI is planning to leverage the particulate formation for GDI systems from the project ACS001 regarding multiple injections.

Reviewer 3:
The reviewer suggested that the investigation of particulate formation in GDCI engines be given very high priority, especially with regard to soot from large droplets produced when the pintel closes at the end of injection.

The reviewer also recommended a further study of the collapsing behavior of gasoline multi-hole sprays. Other variables that are of great interest to the industry are the back pressure, the conicity of the nozzle, the pitch diameter of the circle where the holes are located, and the number of holes.

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

Reviewer 1:
The reviewer noted that the collaborative research from this project through ECN accelerating CFD model development supports overall DOE objectives of petroleum displacement.

Reviewer 2:
The reviewer stated, yes, the project provides fundamental understanding of the behavior of sprays as well as data for improving CFD models.

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

Reviewer 1:
This reviewer observed that the budget is high but justified, considering the extent of the work that will be done.

Reviewer 2:
This reviewer suggested that it would be beneficial to split and allocate resources for labor, testing, simulation resources, and miscellaneous items, such as travel, for further understanding of overall resource sufficiency.

Presentation Number: acs006
Presentation Title: Gasoline Combustion Fundamentals
Principal Investigator: Isaac Ekoto (Sandia National Laboratories)

Presenter

Isaac Ekoto, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

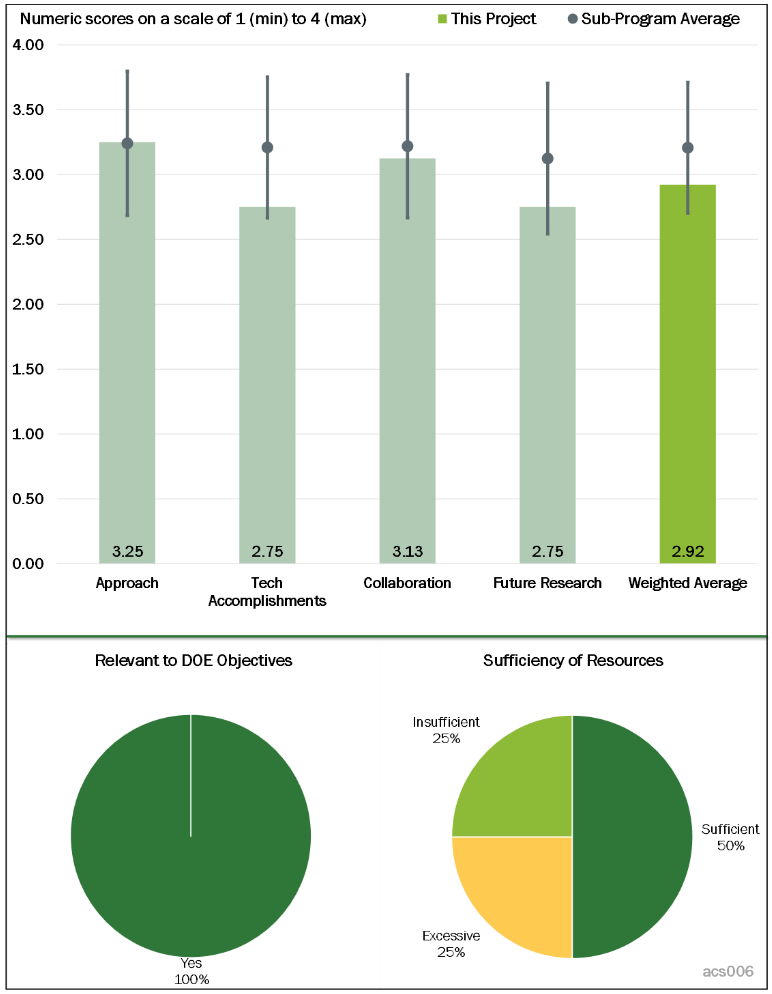

Figure 1-5 - Presentation Number: acs006 Presentation Title: Gasoline Combustion Fundamentals Principal Investigator: Isaac Ekoto (Sandia National Laboratories)

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

Reviewer 1:

The reviewer noted that the approach of conducting basic screening tests in an optical calorimeter plus tests in a new engine capable of operating under low-temperature gasoline combustion (LTGC), dilute spark ignition (SI), and boosted SI seems reasonable.

Reviewer 2:

This reviewer stated this was a good approach to determine the physical behavior of new, alternative ignition systems. The detailed bench tests and measurements can help provide insight to address shortcomings.

Reviewer 3:

The reviewer commented on the good work done to close out the negative valve overlap (NVO) study, even though results did not improve efficiency.

Reviewer 4:

The single cylinder engine combustion system is a relevant system to conduct these experiments of lean combustion; however, the ignition process is being studied to a great amount of detail. The reviewer suggested that perhaps the project should adopt a more pragmatic approach to studying ignition systems.

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

Reviewer 1:

The reviewer commented that progress seems to have improved with the test cell revamp.

Reviewer 2:
The reviewer noted that the ignition system behavior measurements provide insight into their fundamental operation and should identify areas of improvement.

Reviewer 3:
The reviewer stated that there was good progress on identifying failure modes on low-temperature (LT) plasma, but the team needs to develop plans to quickly identify the go/no-go decision points on this approach.

Reviewer 4:
While the quality of work is good, the pace of work is not and progress has been very slow over the last 3-4 years. The transition from NVO homogeneous charge compression ignition (HCCI) to ignition system research has taken a long time. This reviewer wonders if there a way to accelerate the pace of work and results in the future.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer observed several industry collaborations with OEMs and suppliers (GM, Ford, Fiat Chrysler Automobiles [FCA], Cummins, and Mahle) and collaborations with three universities.

Reviewer 2:
This reviewer stated that the collaboration is good.

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

Reviewer 1:
This reviewer stated that the proposed plans seem reasonable.

Reviewer 2:
This reviewer suggested that future work should focus on the fundamental measurements of the ignition system to provide detailed information for ignition system sub-models for combustion simulations.

Reviewer 3:
The reviewer asked what will be different about this turbulent jet ignition project from the one just concluded by Mahle a year ago. The reviewer also asked if the main barrier to lean combustion is extended dilution tolerance or lack of a cost-effective lean aftertreatment system.

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

Reviewer 1:
This reviewer indicated that, if successful, new/improved ignition systems have the potential to enable to modes/methods of engine operation not currently possible with conventional systems and thus improve engine efficiency and fuel economy.

Reviewer 2:
The reviewer commented that the ignition system behavior measurements provide foundational information for engine combustion simulation tools that are important for engine developers to improve engine efficiency.

Reviewer 3:
Yes, it does. However, the reviewer also noted that quantity of work over the last few years has been minimal and has had minimal impact.

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 should be increased to accelerate progress on ignition system behavior measurements.

Reviewer 2:
The reviewer noted that the project is making faster progress so resources seem adequate.

Reviewer 3:
The reviewer stated that the project is overfunded when compared with the pace of work reported over the last three to 4 years.

Presentation Number: acs007
Presentation Title: Large Eddy Simulation (LES) Applied to Advanced Engine Combustion Research
Principal Investigator: Joe Oefelein (Sandia National Laboratories)

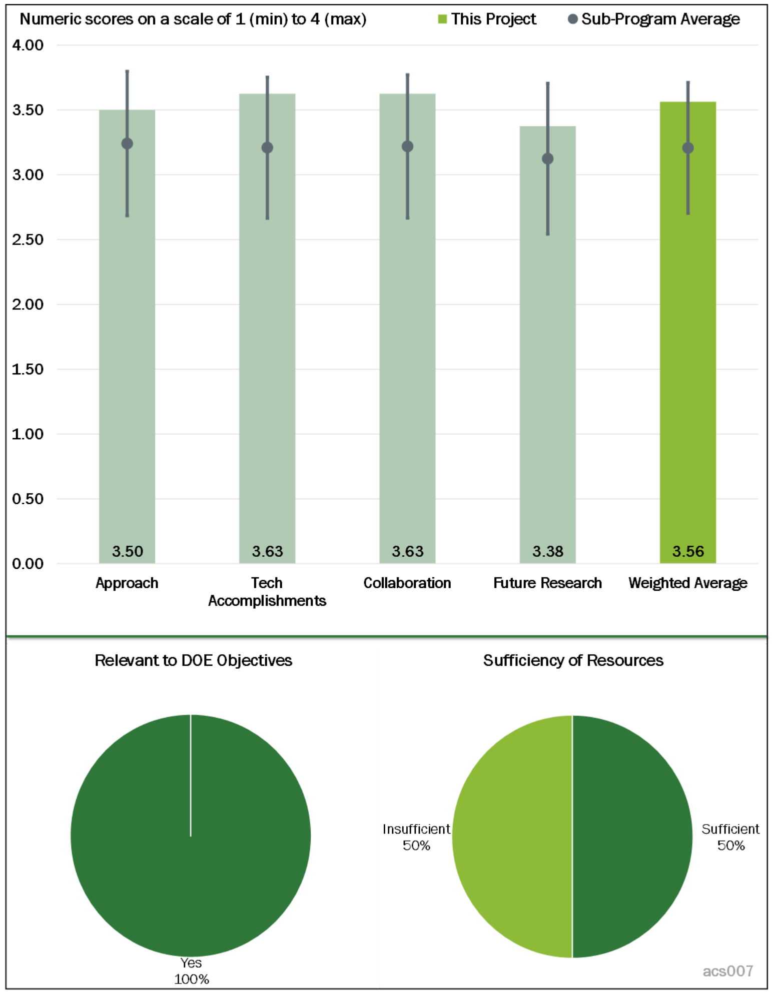

Figure 1-6 - Presentation Number: acs007 Presentation Title: Large Eddy Simulation (LES) Applied to Advanced Engine Combustion Research Principal Investigator: Joe Oefelein (Sandia National Laboratories)

Presenter

Joe Oefelein, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer indicated that the study, which is focused on the fundamental understanding of spray and combustion based on LES, is very promising.

This person observed that the overall approach highlights the challenges in modeling and simultaneously details the simulation aspects that complement experiments.

Reviewer 2:

The reviewer commented that LES is applied to provide unique insight.

Reviewer 3:

The approach of developing and applying detailed first-principles models for complex in-cylinder processes is excellent; however, it probably will take a long time before it can actually simulate something close to engine spray and combustion. The reviewer observed that it would probably be beneficial in the process of developing to also utilize the tool to conduct detailed numerical experiments to supplement data for model verification and development in the cases that experimental measurements are very difficult or inaccurate.

Reviewer 4:

The reviewer noted that the technical barriers are well identified. Individuals in the field agree and understand that the LES can predict the physics with much higher accuracy than current engineering code; however, the project needs a plan to make this computational tool more viable for engineering. In other words, is there a way to relieve computational requirements without (or with minimal) accuracy compromise.

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

Reviewer 1:

The reviewer congratulated an excellent accomplishment and stated that the content covers the declared milestones well.

Reviewer 2:

The reviewer observed that project details regarding a cascade of nonlinearity coupled interactions highlights liquid injection and combustion and also, all the different efforts and studies that are being worked on for achieving the objective.

Reviewer 3:

The reviewer wondered how more funding would meaningfully affect progress.

Reviewer 4:

This reviewer understands that this research is advanced and very difficult, so the small progress relative to 2016 is possibly due to a lack of resources. Nevertheless, the progress toward the main goal seems to be too slow.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer commended the great list of collaborations and the clear direction for future plans but recommends considering interactions with industry to address the on-going demand.

Reviewer 2:

This reviewer suggested that collaboration with industry partners would be useful for the overall advancement of the project.

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

Reviewer 1:

The plan is very clear with measurable and achievable goals. As indicated in the "Remaining Challenges and Barriers" slide, the reviewer agreed it is going to be critical to define common area of interest across academia and industry. This is going to take the current model based engineering to next level.

Reviewer 2:

The reviewer commented that the proposed optimal workflow for model validation and verification is promising, but indicated concern that the computational barriers for the full up engine modeling using LES may prohibit industry from embracing it.

Reviewer 3:

The reviewer stated that the future work on ECN diesel sprays will be constrained because collision phenomena in diesel spray is important and the collision model implementation is not even proposed in the future work.

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

Reviewer 1:

The reviewer observed that the project is working to develop a high-fidelity LES tool to explore conditions where an experiment is not feasible, and/or deepen understandings of physics by decoding unmeasurable details. This will surely help to extend our understanding and develop new designs.

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

Reviewer 1:

The reviewer complimented the PI on his organization of the project in that it appears well under control with the given resources and budget.

Reviewer 2:

The reviewer suggested that adding more advanced computational staff would contribute to significant progress in this research. More collaboration and coordination with academia and national laboratories may be helpful as well.

Presentation Number: acs010
Presentation Title: Fuel Injection and Spray Research Using X-Ray Diagnostics
Principal Investigator: Christopher Powell (Argonne National Laboratory)

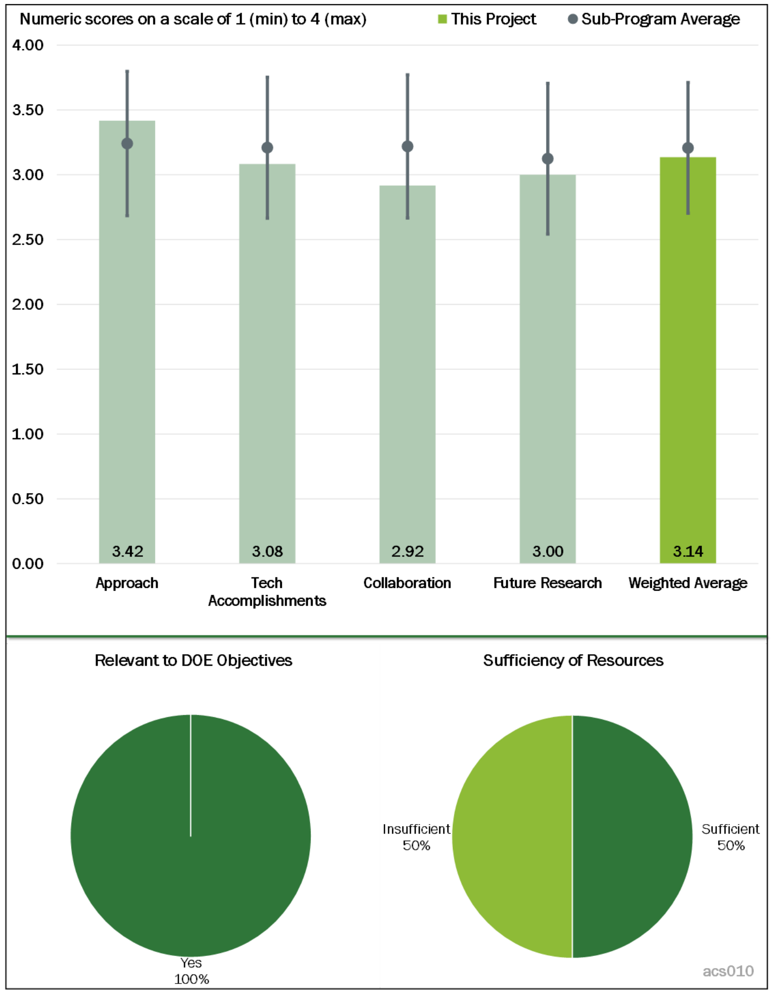

Figure 1-7 - Presentation Number: acs010 Presentation Title: Fuel Injection and Spray Research Using X-Ray Diagnostics Principal Investigator: Christopher Powell (Argonne National Laboratory)

Presenter
Christopher Powell, Argonne National Laboratories

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

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

Reviewer 1:
This project directly addresses technical barriers related to fuel injectors and sprays, and is focused on how the boundary conditions (e.g., detailed internal injector geometry) affect spray behavior/characteristics. Overall, the project seems well-conceived to this reviewer, and is clearly very well integrated with ECN and modeling community. The project also demonstrates that it is complementary to work being done by ORNL on neutron imaging and SNL on optical diagnostics of fuel sprays.

Reviewer 2:
The reviewer complimented the unique capabilities of the project and noted that combining X-ray imaging with neutron imaging gives a very thorough measurement of the injector important for CFD. This person suggested that the project should focus on, and name as a goal, the ranking of injector features most important to the spray and ultimately combustion and emissions.

Reviewer 3:
The project covers a number of areas on interest and the reviewer complimented the authors for doing a very good job describing a number of flow patterns; however, the approach is very one-dimensional and takes place in an apparent vacuum. This person suggested that some of the areas studied need to be put into much greater focus.

For example, on their first project, concern of cavitation and erosion could be accompanied by examination of existing hardware nozzles showing (or not) the severity of the cavitation issue, correlated with usage (e.g. vehicle miles); the drift over the original calibration; and examination across a small sample size, etc. This work may prove to be key to the diagnostics provided. The use of krypton to capture the flow reversal is insightful.

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

Reviewer 1:
The reviewer commented that there was great improvement in the resolution of the X-ray technique.

Reviewer 2:
Clearly the project has made good progress, but the reviewer wondered about the listed accomplishment related to “ducted combustion” work at SNL. This person observed that although it was mentioned once or twice later, the presenter more or less swept right past this in the presentation and it was not clear how this aspect of the project contributes to DOE goals and objectives.

Reviewer 3:
The evaluation of the effects of geometric variability on fuel mass variability is very valuable; however, the linear equation used for the correlation between geometric variability and fuel mass variability might not be appropriate because the correlations are relatively weak, especially for hole inlet and outlet corners. This reviewer stated that the effects of the corners have been demonstrated to be important in previous research, but the effects were not clearly shown in this research.

Reviewer 4:
The reviewer observed that the accomplishments rely on reporting of imaging exercises. The information is insightful, such as the cavitation and geometric variability on the ECN G-spray injector; however, this person noted that the report is rather limited and seems to need the guidance from an experienced combustion and engine engineer. The reviewer suggested that the project put both the cavitation and geometric work in much greater perspective and asks that the presenter see notes on erosion and cavitation. The ECN G-spray geometries could have been (should have been) correlated with both the geometrical tolerances of the parts and to the flow specifications. This may point to what hardware is evaluated.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The collaborations are very well described here but this reviewer would note agreement with another reviewer, however, that the discussion of collaborations was quite extensive and approached too much. This was clearly a response to reviewer comments from previous years, but it is not the PI’s job to highlight accomplishments of others (i.e., modelers in this case).

Reviewer 2:
The reviewer suggested that the collaborative team be expanded to include a member or members to help steer the work to a more practical and industrial framework. This person asks the project members to refer to the earlier discussion on cavitation and manufacturing tolerances.

Reviewer 3:
This reviewer recommended a continued pursuit of collaborations with injector suppliers.

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

Reviewer 1:
The reviewer commented that the multiple direct injection (DI) impact on fuel spray is good.

Reviewer 2:
The reviewer suggested that a thorough review of the project would help direct its work to a more practical level.

Reviewer 3:
The reviewer noted that proposed future work comes across as incremental. This may reflect the somewhat lower budget, but it seems as though one of the major parts of future work is simply to support other VTO projects.

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

Reviewer 1:
This reviewer stated this project could play a lot more effectively to supporting the DOE goals; as is, however, this work will have limited applicability.

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

Reviewer 1:
This reviewer complimented the impressive progress made with a limited budget, noting that resources for this project are extremely expensive.

Reviewer 2:
The reviewer commented that the upcoming year's budget is significantly lower compared to the previous year, but the proposed upcoming work is also somewhat more limited, so it is probably a good match between the budget and expected milestones.

Reviewer 3:
The reviewer recommended the team seek an experienced engine-combustion-fuel system specialist to help them guide their work.

Presentation Number: acs011
Presentation Title: Advances in High-Efficiency Gasoline Compression Ignition
Principal Investigator: Steve Ciatti (Argonne National Laboratory)

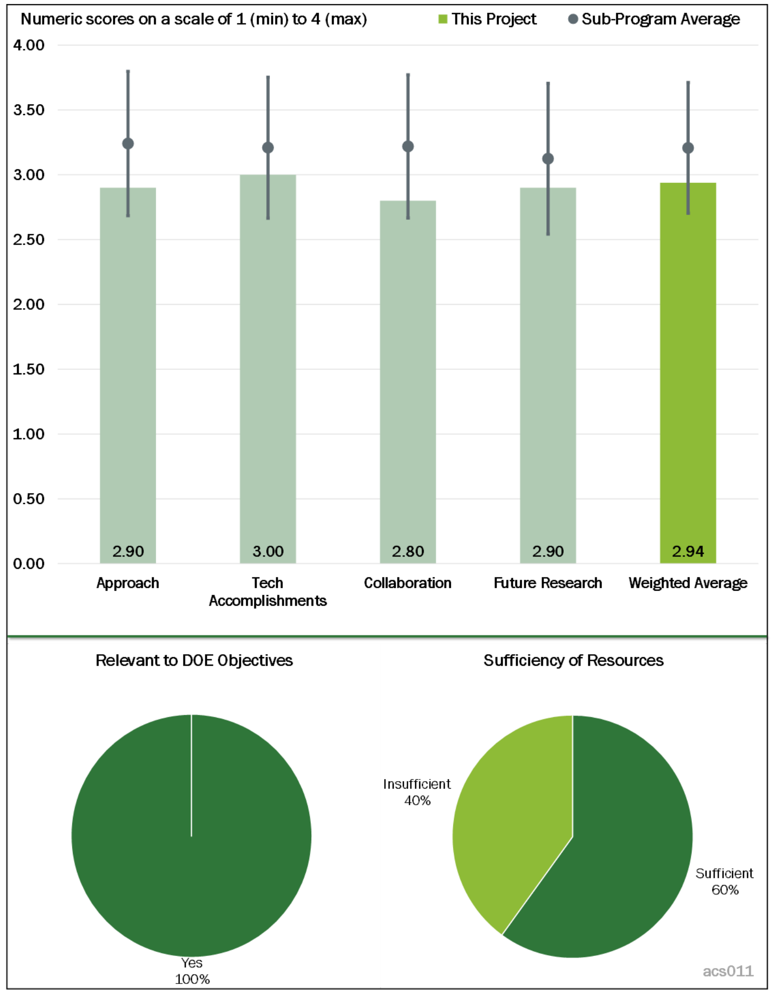

Figure 1-8 - Presentation Number: acs011 Presentation Title: Advances in High-Efficiency Gasoline Compression Ignition Principal Investigator: Steve Ciatti (Argonne National Laboratory)

Presenter

Steve Ciatti, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the approach of conducting parametric engine studies of sweeps of start of ignition (SOI), split ratio, injection pressures, and exhaust gas recirculation (EGR) rates is an excellent way to provide better understanding of GCI fundamentals and how to improve performance.

Reviewer 2:

The reviewer commented that the project is well-designed and well-integrated with other efforts (academia, national laboratories, and industry) that investigate GCI on a multi-cylinder engine setup under conditions representative of actual engine applications.

Reviewer 3:

The reviewer observed that the project's approach seems to look for local optimums in engine performance by sweeping injection timings or studying the effect of EGR and that the project is also studying particulate matter (PM) morphology.

This person wondered if such an approach will solve the challenges of LTC, for example: lack of adequate crank angle position at which 50% of heat is released (CA50) control, challenges in transient control, challenges in switching between combustion modes, high combustion noise, high HC and CO emissions, need for a lean-oxides of nitrogen (NO_x) exhaust aftertreatment system, challenges in cold operation, limited speed and load range, low exhaust temperature, etc.

Reviewer 4:

The reviewer commented that the GM 1.9 L engine may not be most appropriate platform for future use.

Reviewer 5:
The reviewer noted that it appears the project is exploring DI calibration space to optimize a given GCI combustion approach. This person observed that the attribute constrained efficiency is quite poor, though relative to a conventional diesel for instance and recommended the team identify an approach that results in a go/no-go decision on the concept.

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

Reviewer 1:
The project followed its milestones and the outcomes are in line with current DOE program goals regarding vehicle efficiency and emissions. The reviewer noted that it seems that a lot of the issues or barriers were hardware dependent and would like to see more about how these barriers translate in real engine applications that can use various technical approaches (due to cost restraints).

Reviewer 2:
The reviewer commented that the tasks have been completed in a timely manner but notes that the higher brake specific fuel consumption (BSFC) values at the target values for combustion noise (less than 90 A-weighted decibels [dBA]), filter smoke number (FSN; less than 0.5), HC plus NO_x (less than 4.0 g/kW-hr) and CO (10.0 g/kW-hr) are a concern.

Reviewer 3:
The reviewer wondered if enough of the calibration space has been mapped to allow a multi-parameter model and optimization.

Reviewer 4:
The reviewer was disappointed with the reported BSFC values and noted that one reason given was a turbo charger that might need some optimization. The other reason noted was related to meeting United States Council for Automotive Research (USCAR) guidelines on combustion noise and other engine out emissions targets. This person wondered if this means that this combustion concept is no longer a viable concept for LD commercialization.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed some collaboration with industry (GM and Eaton) and commented that the presenter also mentioned members of the AEC MOU, but noted there was no information given on the extent of the collaboration with those members other than the two meeting presentations per year.

Reviewer 2:
The reviewer suggested collaborating with domestic institutions also, as there are multiple research groups in U.S. academia that have similar interests.

Reviewer 3:
The reviewer wondered if there is any collaboration with a LD OEM that is willing to put such a concept into production someday.

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 highlighted that future research continues the PI's excellent GCI work up to this point. The reviewer suggests solving the turbocharger issue under current budget limitations and would also like to see more collaborations for future optical investigations with U.S. universities that have similar or complementary optical facilities. This is important to support and maintain all the GCI work that is performed in the United States under current budget limitations.

Reviewer 2:
Continuing the work to understand how GCI can be optimized is important. The results presented suggest that engine efficiency values have dropped when the targets of noise (less than 90 dBA), FSN (less than 0.5), HC plus NO_x (less than 4.0 g/kWhr), and CO (less than 0.0 g/kWhr) are applied. The reviewer stressed that determining how or whether engine efficiencies can be approved in GCI is critically important, much more important at this point than characterizing the structure of the soot that is formed.

Reviewer 3:
The reviewer suggested that perhaps future work should be focused on proving why this concept may not be promising for LD commercialization.

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

Reviewer 1:
The reviewer stated that the project is well aligned with the overall DOE objectives of improving transportation efficiency and reducing the environmental effects.

Reviewer 2:
The reviewer noted that, if successful, GCI should improve engine efficiency, thus improving fuel economy and reducing fuel/petroleum consumption.

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

Reviewer 1:
There was no indication to this reviewer that resources are not sufficient to accomplish the milestones.

Reviewer 2:
The reviewer commented that novel experimental work requires a good funding stream, especially when the project needs good hardware to accomplish the outcome or when collaborations are required (e.g., student support at ANL, but understands the budget limitations.

Reviewer 3:
The reviewer suggested expansion of experimental efforts across additional combustion systems (effects of swirl versus tumble on LTC, etc.).

Presentation Number: acs012
Presentation Title: Model Development and Analysis of Clean and Efficient Engine Combustion
Principal Investigator: Russell Whitesides (Lawrence Livermore National Laboratory)

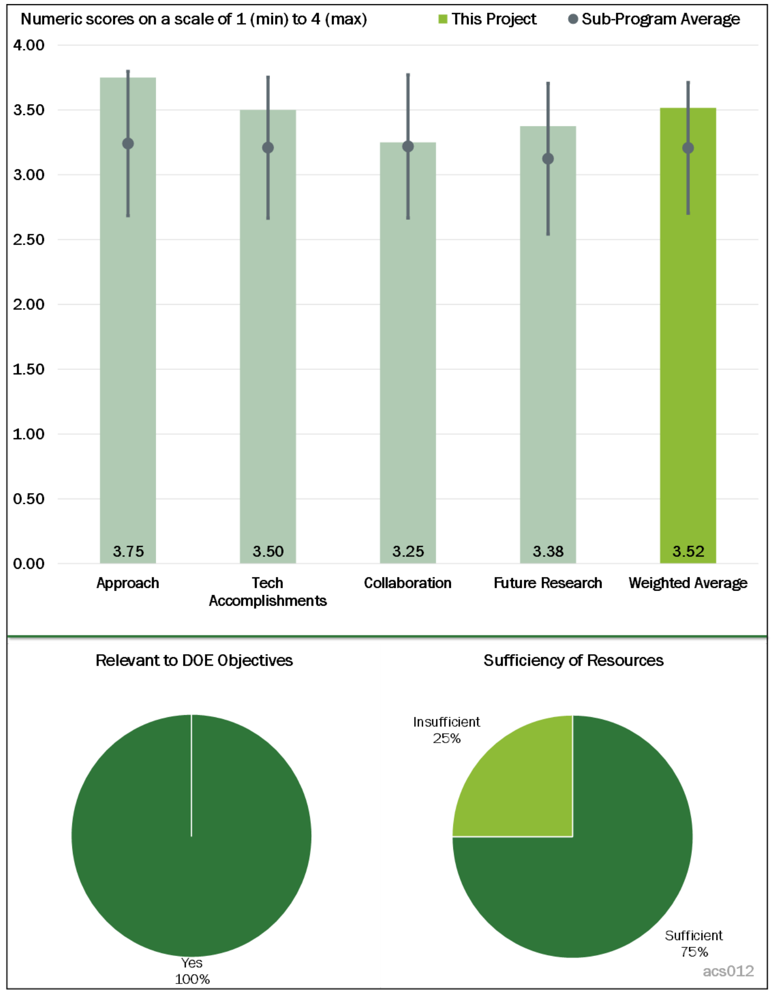

Figure 1-9 - Presentation Number: acs012 Presentation Title: Model Development and Analysis of Clean and Efficient Engine Combustion Principal Investigator: Russell Whitesides (Lawrence Livermore National Laboratory)

Presenter

Russell Whitesides, Lawrence Livermore National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that the fast-chemistry solver is critical to advance the state-of-the-art in engine simulation and indicates the project is well designed, feasible, and very well integrated with others.

Reviewer 2:

The reviewer stated that the UQ and the graphics processing unit (GPU) acceleration work that the project is doing are very useful for building confidence in simulation and reducing overall simulation turn-around time.

Reviewer 3:

The reviewer described the uncertainty analysis strikes as essentially a gauge repeatability and reproducibility (R&R) for simulation and experimental work and wondered if it is possible to rank the variables having the most influence on the model predictions or experimental measurements.

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

Reviewer 1:

The reviewer indicated that the work being done to reduce the computational time for chemical kinetics in collaboration with ACS076 is essential for the engine community to adapt the details chemical kinetics.

Reviewer 2:

The reviewer commented that the new algorithms dramatically improves the computational speed and the work related to uncertainty analysis is very valuable. This person recommended that the PIs provide guidelines to reduce uncertainty.

Reviewer 3:

The reviewer recommended that as the team members employ chemistry to the CFD, they should note that the predictions of engine out emissions (HC and NO_x) are not as important as efficiency.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the project is, overall, well connected with industry to commercialize the solver; however, the reviewer noted that CONVERGE is a commercial software and wonders if there is a plan to make the solver more widely available to others.

Reviewer 2:

The collaboration with industry, laboratories, and software vendors that is being pursued for the project is good, but the reviewer indicates that a combination of central processing unit/GPU optimization may be necessary for CFD run time reduction.

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 compliments the well-designed plan for the CFD work, the future plan is well designed, but wonders about the uncertainty analysis.

Reviewer 2:

The reviewer indicated that the PI's fiscal year (FY) 2018 proposed work of UQ in reacting flow CFD sounds interesting.

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

Reviewer 1:

Yes, this reviewer agreed that the project supports the overall DOE objectives of petroleum displacement and states that CFD tools will play a more and more important role in future engine development.

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

Reviewer 1:

The reviewer indicated there are sufficient resources for the project to achieve the stated milestones in a timely fashion.

Reviewer 2:

The reviewer noted that combining with ACS076 and a reduced budget will reduce output.

Presentation Number: acs013
Presentation Title: Chemical Kinetic Models for Advanced Engine Combustion
Principal Investigator: Bill Pitz (Lawrence Livermore National Laboratory)

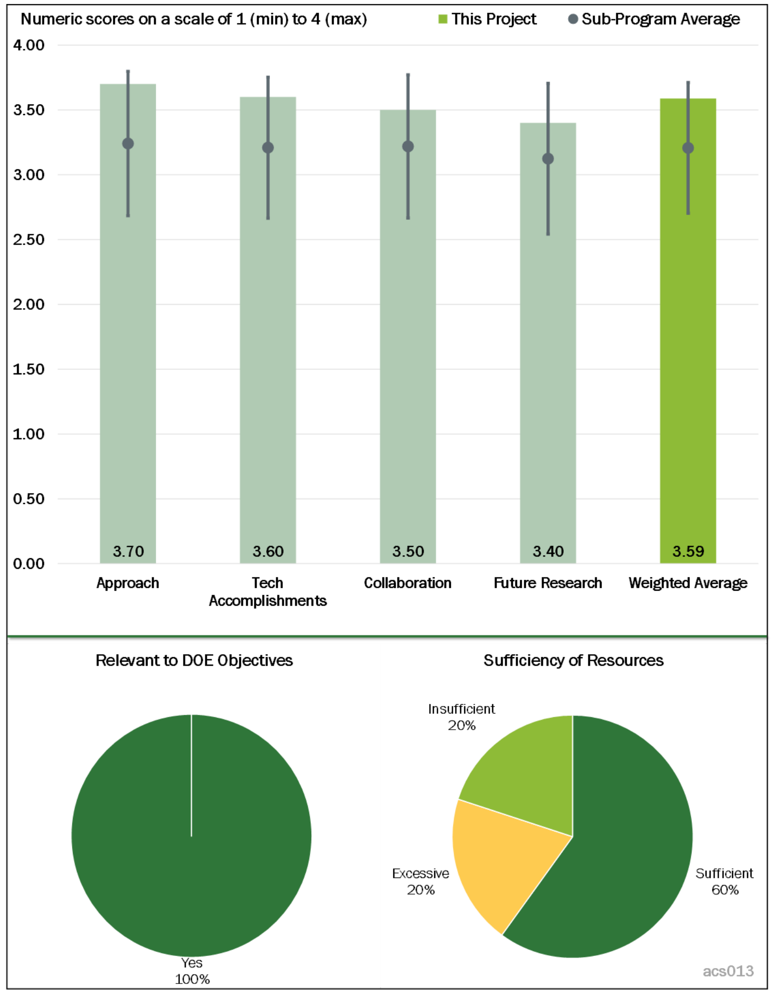

Figure 1-10 - Presentation Number: acs013 Presentation Title: Chemical Kinetic Models for Advanced Engine Combustion Principal Investigator: Bill Pitz (Lawrence Livermore National Laboratory)

Presenter

Bill Pitz, Lawrence Livermore National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The work in this project is to develop predictive chemical kinetic models for gasoline, diesel, and other fuels and is key to designing improved engines with higher efficiency and lower emissions. The efforts to validate those models against experimental data from shock tubes, rapid compression machines (RCMs), etc., is very valuable. Further, the reviewer noted that the work to combine the kinetic mechanisms of individual components to form fuel surrogates of complex fuels and evaluate their performance versus those of the complex fuels is very important for development of reduced, tractable models that represent "real" fuels, but are more amenable for use in design of engines.

Reviewer 2:

The reviewer noted that developing predictive chemical kinetic models for gasoline, diesel, and next generation fuels is critical to better design high efficiency and clean combustion engines. The team makes remarkable progress every year to deliver more accurate models and add new molecules. The project is well designed, feasible, and extremely well integrated with others.

Reviewer 3:

The reviewer commented that this is critically important work that lays the foundation for engine combustion simulations and approves of the work on gasoline components as well because it is the dominant fuel in the LD marketplace.

Reviewer 4:

The team is generating chemical kinetic models as surrogate fuels for gasoline and diesel and that they validate these models by comparison to fundamental experimental ignition data taken in a RCM or shock tube. The reviewer stated that such models have become more important in recent years with the growing interest in LTC and the ability to model the combustion process with a detailed chemistry approach.

Reviewer 5:
According to this reviewer, the development of chemical kinetics models in this study is fundamental for accurate engine combustion CFD. And, as the PI noted, this level of detailed chemistry requires a lot of computational resources.

This person suggested partnering with other investigators for innovative ways (the ANL flamelet model is an example) to reduce overall computational effort, which would make it easier for CFD modelers to embrace these models.

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

Reviewer 1:
The reviewer applauded the excellent progress made in developing and validating new, and/or improving existing, kinetic mechanisms for the components present in gasoline, diesel, and biofuels.

Reviewer 2:
Overall, the reviewer noted that the project is making significant progress, including the improved gasoline surrogate models, assembled kinetic model of the Coordinating Council Research (CRC) diesel surrogate palette with preliminary validation, and the collection of more data for mechanism validation.

Reviewer 3:
The reviewer compliments the very good progress on modeling a nine-component model for the CRC AVFL-18 diesel surrogate fuel.

The reviewer recognized that the model for the 10-component surrogate model for gasoline was improved, noting that it has also been applied to engine combustion experiments at SNL and the knock tests at ORNL.

Reviewer 4:
The reviewer commented on the good progress for both diesel components and gasoline components, but would like to see accelerated progress on gasoline components and the accuracy of gasoline components, especially considering dilute, boosted stoichiometric operation. Near-term LD engines will be boosted running stoichiometric with high rates of EGR. The reviewer indicated that the engine efficiency limit for these engines is due to knock at full load, so accurately simulating these operating conditions is critical to improving engines.

Reviewer 5:
The reviewer would like to see the project prioritize the testing of these kinetic models for more engine relevant conditions with changing EGR, equivalence ration and fuel composition.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer approved of the excellent collaboration with industries, universities, and national laboratories globally.

Reviewer 2:
The reviewer noted that collaboration with the relevant RCM, shock tube, and engine tests at the various labs is very good.

Reviewer 3:

The reviewer complimented the very good interactions and contributions to industry through participation in projects sponsored by the CRC, a consortium of automakers and energy companies (CRC Fuels for Advanced Combustion Engines [FACE] working group and CRC projects such as AVFL-18a). This person also noted considerable interactions and coordination with others involved in developing kinetic models and engine simulations at the national laboratories and universities.

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

Reviewer 1:

The reviewer stated that the proposed plans are very logical and will continue the excellent work in this project.

Reviewer 2:

The reviewer highlights that the proposed future work is very carefully planned, but the team may need to put more efforts on the fuels (such as high-octane ethanol blends) that are urgently needed by the auto industry.

Reviewer 3:

The reviewer would like to see accelerated progress on gasoline surrogate components.

Reviewer 4:

The reviewer recommended that the team give the highest priority to modeling the ignition behavior of the gasoline-ethanol blends in the RCM tests at ANL. This person also indicated that the industry is very interested in gasoline ethanol blends with a high research octane number (RON) and high sensitivity. These fuel types have the potential of working successfully in both flame propagation combustion as well as LT combustion systems. This person stressed that the development of models for these fuels should be given very high priority.

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

Reviewer 1:

Yes, development and validation of chemical kinetic models and surrogate fuel models are very important to enable the development of engines with higher efficiencies and lower emissions, which will lead to higher fuel economies and lower fuel consumption in this reviewer's opinion.

Reviewer 2:

This project supports the overall DOE objectives of petroleum displacement. The reviewer noted that development of predictive chemical kinetic models for gasoline, diesel, and next generation fuels is critical to better design high-efficiency and clean combustion engines, which will reduce petroleum demand.

Reviewer 3:

The reviewer stated that improving the accuracy of chemical kinetics has a direct impact on engine combustion simulation tools that help engine developers improve engine efficiency.

Reviewer 4:

The reviewer commented that, while indirect, this work is very critical in enabling modeling and improving fundamental understanding of ignition and knock processes in a wide variety of combustion systems.

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

Reviewer 1:
The reviewer noted that it appears the team is meeting milestones on a timely basis and so resources seem appropriate.

Reviewer 2:
The reviewer observed that the team is well connected with other researchers to provide experimental data for model validation.

Reviewer 3:
The reviewer suggested that additional funding could help accelerate progress in this critical area.

Presentation Number: acs014
Presentation Title: 2016 KIVA-hpFE Development: A Robust and Accurate Engine Modeling Software
Principal Investigator: David Carrington (Los Alamos National Laboratory)

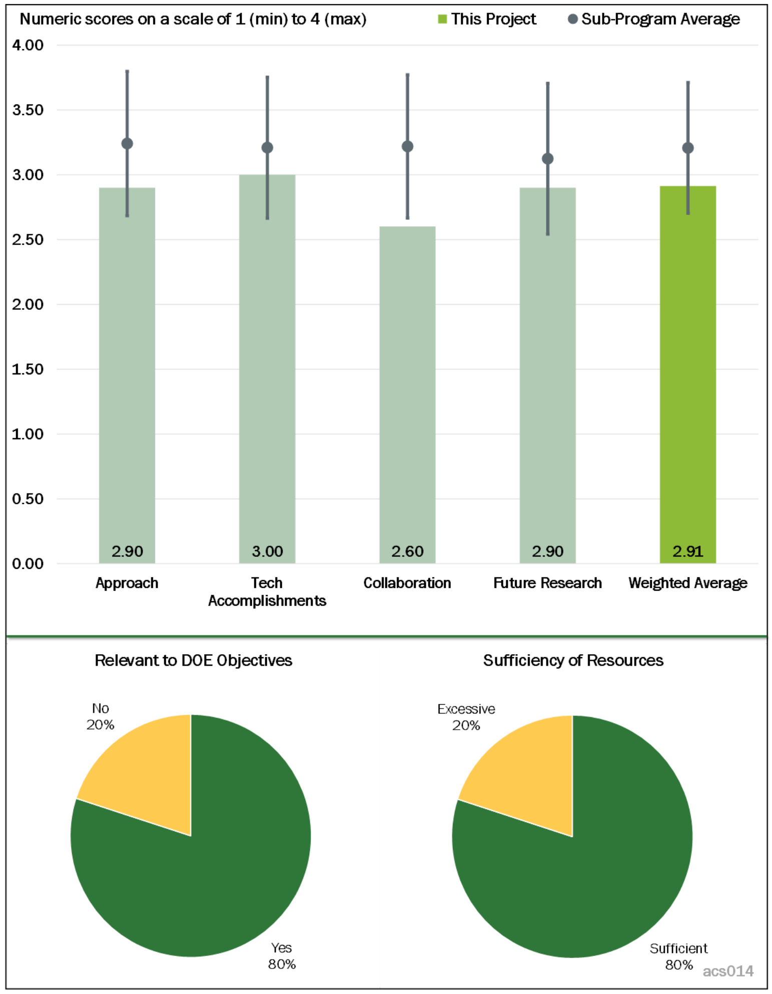

Figure 1-11 - Presentation Number: acs014 Presentation Title: 2016 KIVA-hpFE Development: A Robust and Accurate Engine Modeling Software Principal Investigator: David Carrington (Los Alamos National Laboratory)

Presenter

David Carrington, Los Alamos National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer complimented the great work and persistent effort, noting the project has a well-defined goal and that much effort has been put toward it. The PI has been doing a great job in incorporating all the effort aligned with well-defined direction.

Reviewer 2:

According to the reviewer, the technical approach pursued for valve motion using overset meshes and volume of fluid method for injection spray are appealing and advanced compared to what commercial CFD codes had to offer. But, the reviewer noted that the implemented methods need to be validated for full-up engine CFD by the DOE labs and industry. The question remains whether a small team with limited resources for KIVA-hpFE can compete with a commercial software vendor with respect to software development, support, and software maintenance.

Reviewer 3:

The reviewer observed that the approach over the past year has been to incorporate some new capabilities in KIVA that would enhance its usefulness. These include various approaches to modeling sub-processes and improving some computational aspects to make the solution to the governing equations more efficient and less time-consuming. The view is to improve engine efficiency and reduce harmful emissions. KIVA has been around a long time and its virtue is open-source (e.g., unlike for-profit codes like CONVERGE) along with its significant capabilities. Efforts include employing LES to model engine flows, spray modeling grid generation capabilities, and multistep kinetics using Chemkin-pro.

Fuels are multicomponent, especially surrogates, and the PI is starting to work on this problem. The reviewer commented that some discussion of how multicomponent effects would be addressed should be included. This person wondered how confident the PIs are that their property database for mixtures is robust, and what about mixing rules, etc., combustion chemistries of multicomponent liquid mixtures, etc.

KIVA ostensibly relies on certain adjustable inputs (e.g., because it is not an ab-initio solver) and asks if that understanding is correct. The reviewer recommended the team provide a concise list of what needs to be adjusted for predictions and data prior to using KIVA. Also, the reviewer commented it would be nice to have one slide in the review presentations that lists the sub-models needed for KIVA to work.

The presenter mentioned a volume of fluid (VOF) approach for sprays and the reviewer asked if the resulting simulation capability will be at the level of a code like RAPTOR (SNL), which simulates jet injection and its ultimate development into a spray.

The reviewer approved of the pursuit of utilizing dynamic LES for capturing the transition from laminar to turbulent flow and a subsequent move away from the law-of-the-wall.

The reviewer would like a further discussion of the PI's comment that he has "validated with experimental data" the dynamic LES and wondered if this is the backward-facing step and isolated drop configurations mentioned in the proposal. If so, the reviewer also asked how these configurations are related to in-cylinder processes where KIVA is to be applied. The reviewer would also like a better definition for what "validated" meant. The reviewer asked if there a targeted percentage difference between simulation and experiment where "validation" would be considered as having been met, and asked what the contingency is if the agreement is poor. The reviewer requested elaboration of details.

Reviewer 4:
The reviewer reminded the team that DOE funded projects should be developing new technologies that push the boundaries of what is possible and observed that this work is merely making a competitor to commercially available simulation tools without a clear technical superiority.

Reviewer 5:
The reviewer repeated comments that were provided last year, as they felt the comments were still relevant this year.

KIVA-3 and KIVA-4 are seeing less and less use within industry. KIVA has become more of a free resource to universities that want an open-source type format so they can do physical modeling. But even there, other competitors like OpenFOAM are taking over the market share.

The reviewer recommended that the team conduct a serious evaluation of the business model. It would really be healthy to continue to have KIVA as a competitor to other commercial codes. The reviewer wondered what can be done to hasten the development and deployment of KIVA within industry.

The reviewer remarked that the key issue now is whether industry is really interested in KIVA-hpFE, and also questioned why, if the answer is no. The reviewer reiterated that it is a free code, but yet industry prefers to use other commercial codes. The reviewer asked what can be done to make the usefulness and deployment of KIVA-hpFE within industry faster.

The reviewer pondered that perhaps a new business model that increases the chances of KIVA not fading away in the next few years would demand different types of collaborations.

Last year it was mentioned that RFI and ANSYS will be explored to commercialize the code and make it competitive with other codes so that industry can get interested in using it. The reviewer thought it would be healthy to have more competitive CFD codes in the marketplace.

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

Reviewer 1:
The reviewer observed more validations and described progress as steady and aligned with the goal. The reviewer additionally noted that making the grid generation part easy is a smart move.

Reviewer 2:
The reviewer observed that the team undertook and completed several new and model-enhancing initiatives (Slide 8).

The reviewer complimented the good work done continuing to improve robustness, accuracy, and efficiency of the code.

Reviewer 3:
The reviewer noted that the code framework has been validated for standard benchmark test cases, but full-up engine simulations still need to be validated with spray, chemistry and various sub-models.

Reviewer 4:
The reviewer heard the presenter state that the long-term project of revamping KIVA was 85% complete, but would have liked to have seen a roadmap that showed what was done, what was accomplished over the past year, and what is left to complete the overall project.

Reviewer 5:
In the past year there are been significant advances in improving KIVA's capabilities. The improvements seem to be in the sub-models for things like turbulence, spray injection, transition from finite volume (FV) to finite element modeling (FEM) with significant improvements in computational time, grid generation, etc., and comparisons are shown for basic configurations like 3D flow past a cylinder and the pressure field around an isolated droplet. None of this is easy and the reviewer commended the PI for doing so much. The reviewer suggested that perhaps additional discussions would help to highlight how these improvements will impact the larger purpose of making KIVA a more robust in-cylinder predictor.

The efforts pursued include validation. For example, the PI notes that a dynamic LES approach is "validated with experimental data for pertinent problems." The reviewer wondered what the problems used for validation (cylinder, drop, etc.) are and recommended expanding the concept of validation with discussions. The reviewer asked what is being validated, what happens if there are gaps, how they are closed, and what metrics are used to assess if "validation" has been achieved.

For sprays, the PI noted "true multiphase flow modeling" and the reviewer requested that the PI elaborate, asking if this is like direct numerical simulation (DNS) for sprays. The reviewer also wondered if the spray can include multi-injector nozzles.

The reviewer found the spray modeling particularly exciting and commented that other national laboratories are also developing robust computational capabilities for spray (e.g., RAPTOR). The reviewer asked about KIVA's capabilities compare with RAPTOR's and if there is any duplication of effort here.

The "surface tension test" on a three-dimensional (3D) "static drop" seems interesting; however, it was not clear precisely to the reviewer what the PI was simulating, wondering if it was evaporation, combustion, convection over the drop, etc. Flow symmetry seems to be assumed as a base case, although the reviewer requested confirmation of that assumption, and a pressure field computed around the drop. The reviewer asked what the boundary conditions are and requested more clarity with that information.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that collaboration and coordination has been good with universities, but noted that eventual usage by other DOE labs for engine CFD will be a good validation for the technical capability of the software.

Reviewer 2:
The PI has a range of collaborators, including some from the national laboratories, developers of CHEMKIN-Pro, universities, and one industry. However, the reviewer articulated that the project needs a stronger connection to OEMs who would be the ultimate users, presumably, of a code like KIVA. The reviewer wondered if OEMs have significant interest in KIVA and commented that CONVERGE seems in a better position to aid industry, which is using CONVERGE in design. The reviewer commented that KIVA deserves a place in there too, recommending that the PI and his team get some OEMs on boards to establish relevance and interest.

Reviewer 3:
The reviewer suggested that the team seek more engagement from industry. This would allow for more validation in real engine geometry and operating conditions.

Reviewer 4:
The reviewer noted that collaboration with potential users in industry, where engines are designed and manufactured is poor, suggesting that the KIVA-hpFE code needs more real use in industry.

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

Reviewer 1:
The PI has identified a number of challenges for future work, including turbulence and spray modeling and conjugate heat transfer. The reviewer appreciated that the PI notes the need for incorporating heat transfer to the engine block which seems to be a move away from correlations for heat transfer coefficient, but does request confirmation of this understanding.

The reviewer recommended that the PI consider not only engine block thermal considerations but materials stress matters associated with significant temperature gradients within the cylinder for future work. In this reviewer's opinion, that may not have been considered but would separate KIVA from other codes. Engines may not operate indefinitely at peak efficiency if the materials from which they are fabricated fail. The reviewer suggested it is time to incorporate this consideration in robust engine solvers.

The reviewer recommended that, in future work, the PI include on his team of "partners" at least one OEM with some commitment to adopt KIVA for prototype engine design if certain conditions are met (the PI can work with the OEM to define the conditions). Doing so will enhance the relevance of the project to DOE's interests.

Reviewer 2:
The reviewer suggested that future work should focus on developing improved sub-models that commercial codes can incorporate into their software.

Reviewer 3:
Grid pro software is known for orthogonality near the wall with algebraic smoothing. This reviewer wondered why the project needs a hexahedral mesh approach if the team is also pursuing self-damping at the wall and

also, why not tetrahedral meshes for engine flow with finite elements methods that would allow adaptive meshing and mesh morphing.

Reviewer 4:

The reviewer complimented the great list of future work items, especially the critical work on conjugate heat transfer (CHT). In this reviewer's opinion, the industry would appreciate one single software to do all and recommended that the team consider extending the capability of the code instead of residing only in the in-cylinder combustion area.

Reviewer 5:

This reviewer suggested focusing on the business model for marketing KIVA and asks how the industry can be convinced to use it on a regular basis.

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

Reviewer 1:

This reviewer commented yes; once validated for full-up engine modeling, the software will help improve overall thermal efficiency of in-cylinder combustion.

Reviewer 2:

The reviewer noted that the new software should provide more accurate solutions with better computational efficiency. This is to replace or at least encourage the exiting commercial software based on a several decades old platform in order to adopt latest approach.

Reviewer 3:

The project is relevant from a broad perspective and it addresses processes that would improve engine performance. But ultimate evidence of this should come from those using KIVA, which has been in development for a long time. The reviewer appreciated the excellent capabilities that are accessible to the wider community at essentially no cost; however, OEMs apparently do not use it to design engines (at least on a wide-ranging scale), although the PI states that "...most of the following attributes are those heralded by industry as necessities." The reviewer suggested that if the PI is working to provide more relevance of KIVA's capabilities to OEMs, it may be helpful to have some discussions concerning OEMs' thinking on why they may not be embracing KIVA the way they are with other codes (e.g., CONVERGE). This person wondered if it is the open source feature of KIVA and proprietary issues that OEMs do not want to reveal.

Additionally, the reviewer asked for whom is KIVA is targeted in its current form, and stated if it is university researchers, that is fine. KIVA will then assist in the education of the next generation of computational scientist being trained in simulations and that is a good thing.

Reviewer 4:

The reviewer stated that KIVA does not have an impact on industrial users of engine simulation codes and therefore will not contribute to petroleum displacement.

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

Reviewer 1:

The reviewer noted that in order to validate the code and bring the software to the user community, the project would require more resources in the short term.

Reviewer 2:

The reviewer suggested that perhaps some funds should be redirected toward promoting greater use by industry and providing support.

Reviewer 3:

The reviewer stated that resources seem adequate although ultimate judgement would have to come from a cost/benefit analysis based on DOE’s investment relative to the commercialization potential.

Reviewer 4:

The reviewer appreciated the adaptability of subjecting future milestones to the budget; however, this person recommended putting more effort into, and maybe presenting a grand plan, enhancing the model with additional capabilities. In this reviewer’s opinion, adding CHT was a great move and suggests also having KIVA-hpFE as a standard platform for all the effort being made at national laboratories with CONVERGE, which is a commercial code. There are numerous comments from PIs saying they are working with Convergent Science because of a willingness to work together. This reviewer requested confirmation on whether KIVA-hpFE is the real “open” code for everyone with the latest numerical scheme.

Reviewer 5:

The reviewer indicated that resources are excessive given the result of the project and the lack of relevance.

Presentation Number: acs015
Presentation Title: Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes
Principal Investigator: Jim Szybist (Oak Ridge National Laboratory)

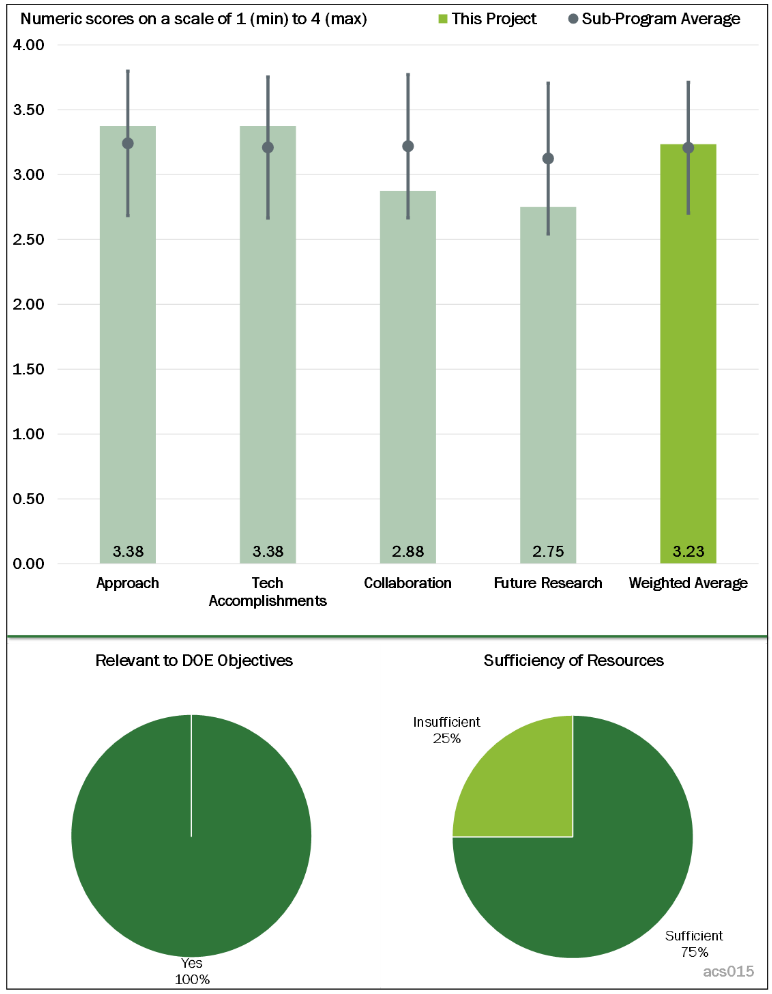

Figure 1-12 - Presentation Number: acs015 Presentation Title: Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes Principal Investigator: Jim Szybist (Oak Ridge National Laboratory)

Presenter
Jim Szybist, Oak Ridge National Laboratory

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

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

Reviewer 1:
This is an interesting approach, different from dedicated EGR (DEGR), to altering the combustible composition in the cylinder as a means to improve combustion. This reviewer highlighted that the work is anchored by good thermodynamic analysis and includes good catalytic work, good thermodynamic analysis, and good experimental work covering a large range of operating parameters and stated the analysis is well done and the presentation was easy to follow.

Reviewer 2:
On the surface, this looks to be the same as Southwest Research Institute's (SwRI) DEGR concept; however, the creative approach of running lean in-cylinder and using a post injection to reform fuel across the catalyst distinguishes the work from the DEGR concept in this reviewer's opinion. The reviewer appreciated the novel concept, and believes it is this type of creativity that will identify new approaches to improving engine efficiency.

Reviewer 3:
The project appears well organized and follows a previous program on thermochemical recuperation beginning in 2011. The project utilizes partial oxidation reforming to improve steam reforming (exhibited limitations due to enthalpies of reaction and sulfur [S]). The reviewer commented that the team has a strong fundamental grasp of the technical problem, is innovative in its approach, and does a good job in documenting progress.

The reviewer asked if the program could provide more detail on the basic findings, such as what the pressure is and heat release rate (HRR) traces across the conditions studied including the dedicated cylinder and power cylinders.

Reviewer 4:
The reviewer recommended that the team think about emissions opportunities and barriers with this concept.

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

Reviewer 1:
The reviewer complimented the technical accomplishments, highlighting the team's thoughtful analysis and interpretation of the results with a good assessment of what the results mean and what to do next.

Reviewer 2:
Considering the project is less than 1 year old, the reviewer complimented the good progress so far, observing that work continues to build on previous approaches and the team is utilizing a good science basis and explanations for observed phenomenon.

Reviewer 3:
The reviewer appreciated seeing multi-cylinder engine test results with an actual catalyst under test; however, given the importance of temperature on the thermochemical recuperation, this person recommended evaluations of more speed/load points to assess the impact of exhaust.

Reviewer 4:
The work provides an extensive optimization between lean combustion and post-injection fueling for operation of the catalyst; however, the reviewer thought the flows reported seem rather large. For example, 10 grams per minute would be at the 2,000 revolutions per minute (RPM) speed 20mg per stroke. The reviewer stated that optimal regions use higher fuelings and thought it was surprising that these amounts can actually be offset by the other cylinders to attain the gains reported over the baseline.

The reviewer indicated that it is not clear how the modeling results correlate with the engine tests: the thermochemical recuperation and engine efficiency regions appear in rather different areas of the O_2-equivalence ratio plots.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The team has connected with appropriate colleagues for contribution in areas where they lack the expertise; however, the reviewer noted that some of the collaborations are recent, so this person will wait until next year before rating it as excellent.

Reviewer 2:
While there is a list of collaborators, the reviewer saw no particular information given to specific contributions from any of these. Additionally, this person noted an apparent lack of involvement from industrial partners.

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

Reviewer 1:
The reviewer commented that the analysis has been thoughtful and there has been a good assessment of what to do next.

Reviewer 2:
The reviewer complimented the team's idea to include a S-poisoning study, but suggested that future work should also explore the entire engine speed/load map to determine where adequate exhaust temperature is available to achieve good thermochemical recuperation.

Reviewer 3:
The reviewer indicated that this was not discussed in any significant detail and stated it would have been interesting to see how the technical partners would contribute to the work, as in the nature of the catalyst formulations.

Reviewer 4:
The reviewer recommended that the team add emissions opportunities and barriers to the proposed future work, namely a cold start approach.

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

Reviewer 1:
Yes, this reviewer stated that the nature of the work is of interest to explore how reforming could impact future engine configurations.

Reviewer 2:
The reviewer noted that, if successful, this work could demonstrate an approach that could be readily integrated into combustion systems, stationary or mobile, while preserving the application of existing emission technology—stoichiometric TWC.

Reviewer 3:
The reviewer commented that the approach, which shows a 10% benefit over a boosted, cooled EGR baseline, is a promising improvement and could lead to improved vehicle fuel economy.

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

Reviewer 1:
The reviewer stated that this was good work within the constraints of their budget.

Reviewer 2:
The reviewer noted that resources seem adequate, but it is hard to evaluate as future work description is not given.

Reviewer 3:
The reviewer recommended more resources to accelerate project progress and develop the concept.

Presentation Number: acs016
Presentation Title: High-Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines
Principal Investigator: Scott Curran (Oak Ridge National Laboratory)

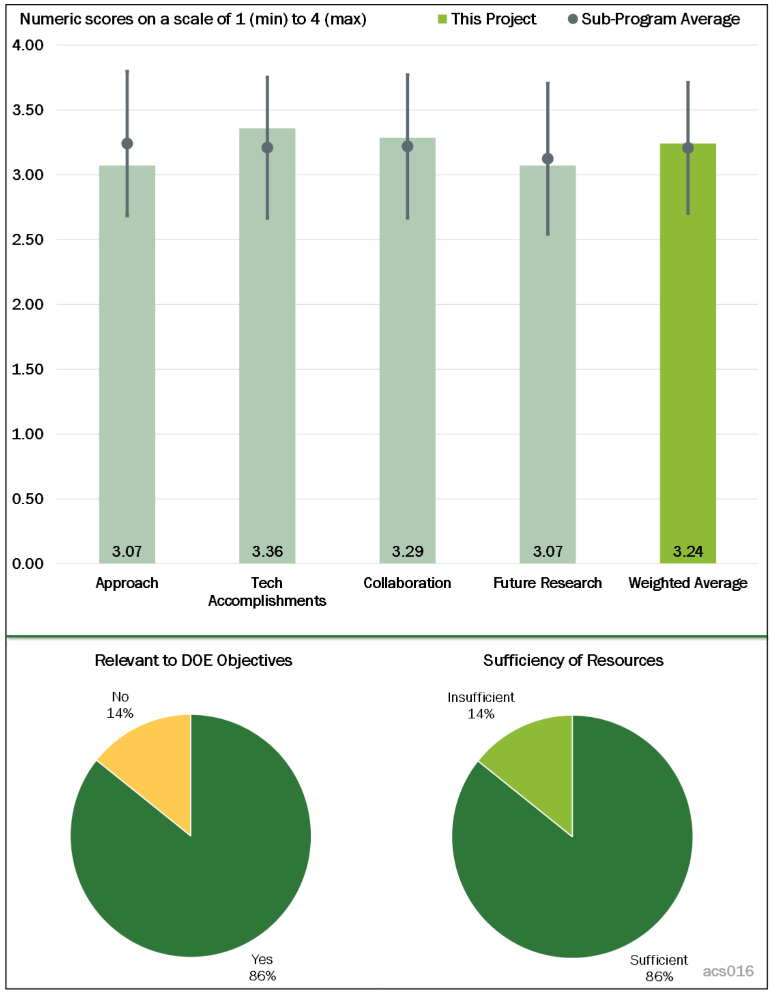

Figure 1-13 - Presentation Number: acs016 Presentation Title: High-Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines Principal Investigator: Scott Curran (Oak Ridge National Laboratory)

Presenter

Scott Curran, 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, feasible, and integrated with other efforts.

Reviewer 1:

Evaluating high-efficiency, clean combustion (HECC) concepts in a multi-cylinder engine is important for understanding potential in a system that is closer to commercial platforms. The reviewer also approved of the team’s experimental and modeling study of transients related to mode switching between reactivity controlled compression ignition (RCCI) and conventional mixing controlled diesel combustion.

Reviewer 2:

The reviewer appreciated that the project is well-designed and well-integrated with other efforts (academia, national laboratories, industry) that investigate advanced combustion regimes for high-efficiency LD engines.

Reviewer 3:

The PI refocused part of this project based on last year’s feedback toward transient control. The reviewer found the initial results interesting to say the least and noted they were driving a significant portion of the current effort and approach. The reviewer hopes that this will lead to new answers next year for this key question.

Reviewer 4:

The reviewer appreciated the objective of the project, but noted that it is important that the team present the basic characteristics of the fuel. At a minimum, the reviewer asks what are the RON and motor octane number and suggested that this should be put in perspective with the in-cylinder thermodynamics at the engine operating conditions investigated. These results might be incongruent with the simulations which use primary reference fuels (PRFs) with a sensitivity of zero.

Reviewer 5:

It is unreasonable to expect a LD vehicle customer to be willing to fill two different fuel tanks, thus calling into question the premise of the RCCI approach. For this combustion approach to be viable, the reviewer recommended a single fuel tank and some sort of fuel separator that can provide the two fuels onboard a vehicle.

Reviewer 6:

The reviewer said that the team should revisit the approach in a significant way, stating there are many barriers to the RCCI concept that a national laboratory can work on. The reviewer recommended ordering these barriers and focusing on the top one or two. Obviously, the barrier is not high efficiency, as it has been demonstrated frequently. The reviewer asked if the barrier would be high engine output of HC and CO, or if it would be the need to have two fuel systems and two fuels onboard.

The reviewer identified another high-level question that this project should answer, specifically, the reviewer asked if this is a LD or a LD concept. Answering this question will help greatly narrow the scope of the work and maybe lead to better progress. The approach of exploring high- and low-delta reactivity effects on RCCI combustion sounds promising to this reviewer.

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

Reviewer 1:

The reviewer thought the presentation was well organized and scoped for accomplishments and progress.

Reviewer 2:

Progress seemed good, according to this reviewer; the team is meeting milestones.

Reviewer 3:

The reviewer stated that the project followed its milestones and the outcomes are in line with the DOE program regarding LD vehicle efficiency and emissions.

Reviewer 4:

The effort of incorporating hardware-in-the-loop (HIL) with adjustments to transition between RCCI and conventional diesel combustion (CDC) was instructive and encouraging for this reviewer. It seems that there are viable approaches to handle transient engine operation.

Reviewer 5:

The reviewer understood that the stated accomplishment was mapping, but did not see a fuel consumption or engine efficiency map presented. The reviewer stated that mode switching between RCCI and CDC as well as the transient dynamometer cycle simulation addresses a major question from the past regarding transient behavior of the engine.

Reviewer 6:

The reviewer indicated that the transient results and the understanding generated by comparing steady-state RCCI low/high reactivity with CDC was valuable; however, it would have been nice to see any equivalence ratio effects. The reviewer wondered if results will be coming in the future.

Reviewer 7:

While progress has been satisfactory, the reviewer commented that it does not seem to have impacted the long list of challenges with the RCCI concept.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that the team has identified and constructively engaged with appropriate collaborators.

Reviewer 2:
This project has included appropriate partners in the past, including this past year. There has been excellent integration of necessary resources, in this reviewer's opinion.

Reviewer 3:
The reviewer noted some collaboration with industry (GM, Mahle, and Honeywell cited) and universities (UW, University of Michigan, and Clemson cited).

Reviewer 4:
The project shows very good collaboration and coordination with the other academic, national laboratories, and industry partners. While the reviewer commended the PI for including several academic partners, this person suggested also interacting with other universities that have common research interests. This is extremely necessary under current budgetary restraints.

Reviewer 5:
The reviewer asked if there is collaboration with a LD OEM that is willing to consider commercializing this concept someday.

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:
Future research continues the PIs excellent work on translating advanced combustion concepts to real engine/vehicle applications. If the budget is further reduced, this reviewer thought that it will affect the project outcome. As a suggestion, the reviewer would like to have seen more details about the fuel property effects on the strategies used in this project, especially if these properties would have a large effect on the interaction between various engine systems (i.e., air and fuel delivery, mixing, combustion, aftertreatment, etc.).

Reviewer 2:
This reviewer recommended extending studies to other engine platforms such as a GDI engine.

Reviewer 3:
The reviewer commented that the research is focusing on how best to incorporate advanced combustion processes into engine operation, as opposed to identifying a particular combustion approach and constraining what can be done to the engine to maintain this combustion approach.

Reviewer 4:
It was unclear to this reviewer how repeating RCCI work on a gasoline based engine platform will result in any different conclusions.

Reviewer 5:
There is a lot of work to do this coming year, but the reviewer would like to see some equivalence ratio effect studies within this project next year.

Reviewer 6:
Multi-cylinder work on the RCCI concept, which has such a long list of barriers, did not make sense to this reviewer.

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

Reviewer 1:
Yes, evaluating advanced combustion concepts in multi-cylinder engines potentially improves the feasibility of identifying and solving issues associated with more production-like engines. The reviewer stated that if HECC is successfully commercialized, it would result in improved fuel economy and lower fuel consumption.

Reviewer 2:
The reviewer noted the project is well-aligned with the DOE objectives of improving the efficiency and emissions for LD engines.

Reviewer 3:
Yes, this is a very relevant hardware demonstration project showing near real world effects of various combustion strategies on LD engine fuel economy and emissions performance. The reviewer commented this was one of the more practical combustion projects.

Reviewer 4:
The reviewer said yes.

Reviewer 5:
As a dual fuel approach, this concept will not impact the objective of petroleum displacement because two fuel tanks in a LD product will not be acceptable to consumers in this reviewer's opinion.

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

Reviewer 1:
Novel experimental work requires a steady stream of funding. This reviewer commended the PI for such a good work considering the budget limitations.

Reviewer 2:
Milestones are being accomplished in a timely manner; this reviewer did not see any indication that funding is insufficient.

Reviewer 3:
It seems that the PI is doing good work with the resources available. It did not appear to this reviewer that the results have been constrained by lack of resources.

Reviewer 4:
Funding was noticeably decreased this past year; it was not clear to this reviewer if funding is an issue with this project and the presenter did not address any such issue.

Presentation Number: acs017
Presentation Title: Accelerating Predictive Simulation of IC Engines with High Performance Computing
Principal Investigator: K. Dean Edwards (Oak Ridge National Laboratory)

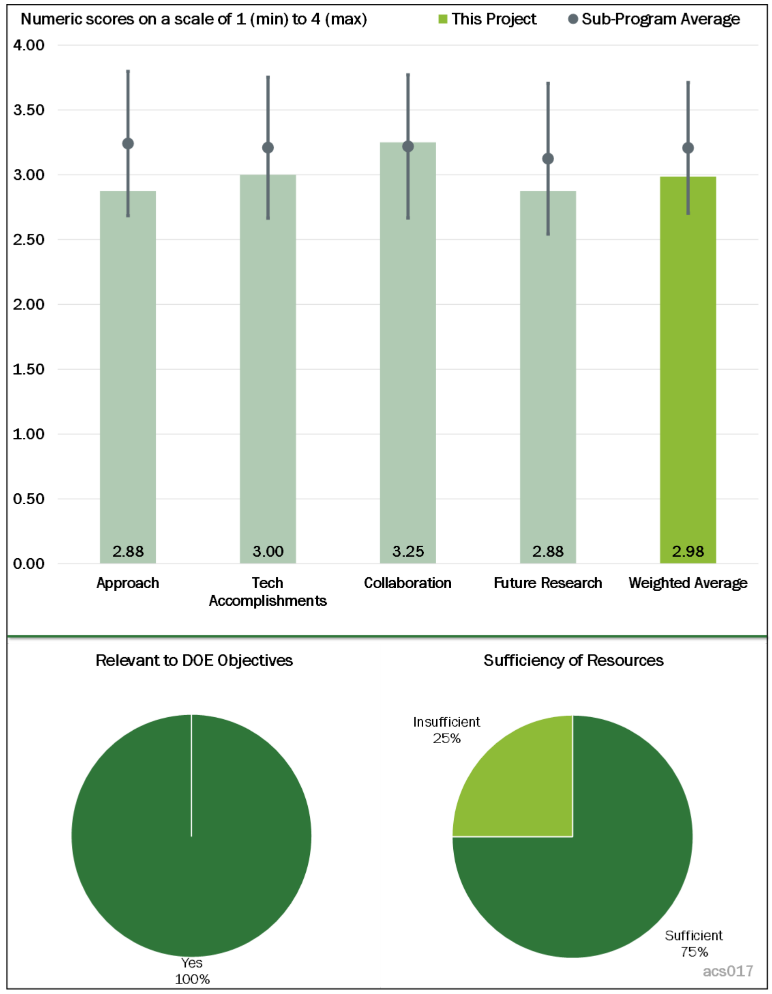

Figure 1-14 - Presentation Number: acs017 Presentation Title: Accelerating Predictive Simulation of IC Engines with High Performance Computing Principal Investigator: K. Dean Edwards (Oak Ridge National Laboratory)

Presenter

K. Dean Edwards, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that industry does not have the high-performance computing (HPC) resources that the national laboratories have. This project is a good example of using that resource well and paving the way for what is possible and what needs to be done to make virtual engine design and calibration possible.

Reviewer 2:

The reviewer noted that this is an ongoing project initiated in 2012 on accelerating the predictive simulation capabilities through HPC. The project targets three case studies, which appears to be a well-defined pathway to apply the intensive commutation across a variety of problems and to report progress. The reviewer commented that it is unclear how effective this project is or its ultimate impact. The availability of these intense resources for computation is important, but it should be accompanied with an understanding of physics. For example, the project might address how the improved computation closed the gap in knowledge. The reviewer stated that we have seen over time effective modeling with limited resources yielding useful results when a good understanding of physics is present.

Reviewer 3:

The reviewer stated that the project is trying to tackle multiple different challenges simultaneously that need HPC resources without a clear focus for the project.

The reviewer commented that to be feasible and to have a quick impact on the engine development community, it is better to concentrate on one challenge such as “virtual engine design and calibration” and to come up with an innovative framework using either genetic algorithms or Bayesian models.

Reviewer 4:
The reviewer commented that the project needs to identify how the model will be used once it is validated. If the goal is to optimize calibration and design features, it may be time and cost prohibitive considering the huge design space. The reviewer stated that perhaps identifying some interesting operating points from the experimental or OEM data could help narrow the focus.

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

Reviewer 1:
The reviewer noted that this is a good use of DOE funds to address projects that OEMs cannot.

Reviewer 2:
The reviewer acknowledged that good progress has been made investigating a variety of variables (EGR, sprays, speed, SOI rail pressure, etc.) as well as detailed chemistry models on engine design and calibration.

Reviewer 3:
The reviewer observed that the parameters identified for the design of experiments for virtual engine design and calibration are comprehensive. The reviewer noted that instead of running a whole suite of experiments, it would have been better to run a few extreme cases and compare simulation results with experimental results to make sure whether chemistry fidelity and spray parameters are sufficient.

Reviewer 4:
The reviewer stated that the results show a mix of improved fidelity and failure in reproducing real world results. Some discussion is presented as to why the gap occurs, but as the years go by in this program, there appears to be no concrete revelation. The reviewer noted that authors are encouraged to provide a short overview of the virtual engine project; however, in the case of the engine configuration evaluated, the presenter did not seem familiar with it. The reviewer remarked that to pick up on one of the goals sought, it may be useful to have a "kick-off" calibration exercise to see how the new computing capability can improve the current process or what new technical approach may be developed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed that good collaboration exists with GM.

Reviewer 2:
The reviewer commented that there are significant collaborators noted. In some cases, the ties are very strong, such as SNL's engine work on premixed combustion. The team may report how other players such as the industrial partner contribute to the project specifically.

Reviewer 3:
The reviewer noted that, in general, the project has good collaboration with industry and national laboratories.

The reviewer commented that for the virtual engine and calibration project, it would have been better to collaborate with ANL regarding best practices of running simulations and other workflow manager tools such as "SWIFT" to manage multiple cases.

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

Reviewer 1:

The reviewer commented that the proposed future research is computationally intensive and was not really sure whether it is practical to accomplish all the proposed work in a reasonable time. The reviewer illustrated the issue with the case of multiple simulations with conjugate heat transfer, full cycle, and detailed chemical for virtual engine design and calibration project.

Reviewer 2:

The reviewer noted that concerning the virtual engine work, it is surprising to read that after several years of work, it is only in 2018 that "full cycle simulation" will be considered to capture the mixing and blow-down process. The reviewer questioned if there a reason why this is introduced so late in the program. The reviewer commented that the impact it will have in the previous effort will be interesting to see. A smaller focused design of experiments may be useful before initiating such a large effort on the whole map.

The reviewer requested that the project provide a more comprehensive review of the dual fuel work. The reviewer observed that the project did not indicate the OEM or engine considered. The partial fuel stratification HCCI work on the other hand is more descriptive.

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

Reviewer 1:

The reviewer stated, yes, this work has the potential to impact DOE objectives.

Reviewer 2:

The reviewer stated that it is important to capture key learnings and knowledge from experiments into models so that at the end of the day we have a tool to help with engine design and calibration.

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

Reviewer 1:

The reviewer stated that it seems adequate.

Reviewer 2:

The reviewer stated that resources are sufficient.

Presentation Number: acs022
Presentation Title: Joint Development and Coordination of Emissions Control Data and Models (Cross-cut Lean Exhaust Emissions Reduction Simulations Analysis and Coordination)
Principal Investigator: Josh Pihl (Oak Ridge National Laboratory)

Presenter
Josh Pihl, Oak Ridge National Laboratory

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

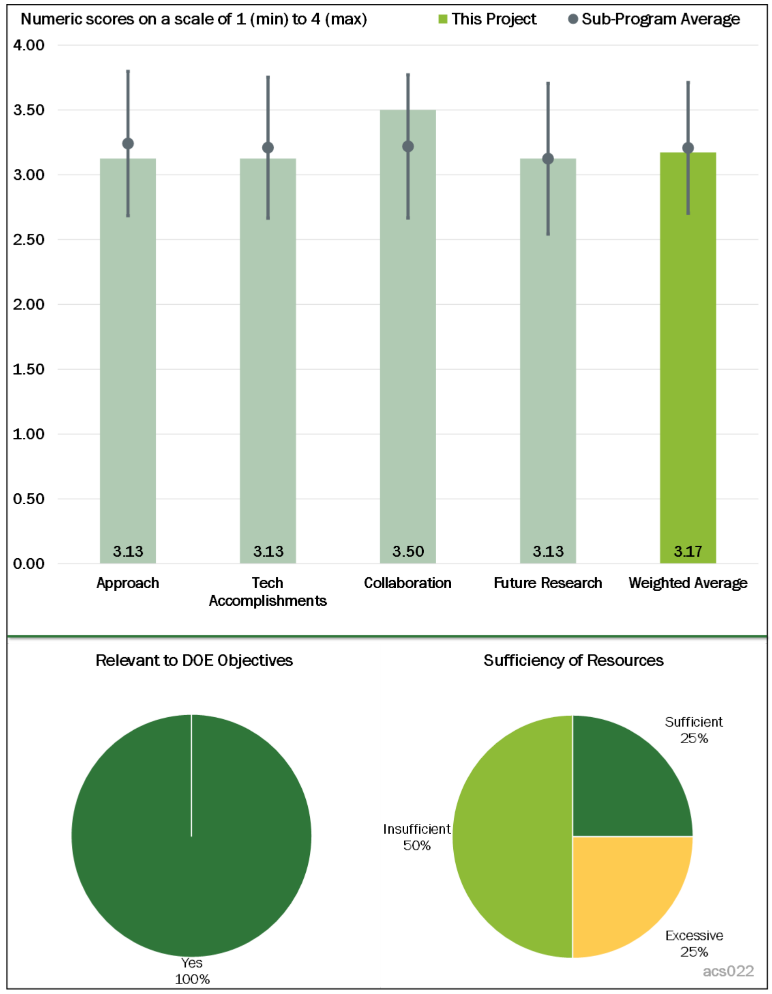

Figure 1-15 - Presentation Number: acs022 Presentation Title: Joint Development and Coordination of Emissions Control Data and Models (Cross-cut Lean Exhaust Emissions Reduction Simulations Analysis and Coordination) Principal Investigator: Josh Pihl (Oak Ridge National Laboratory

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

Reviewer 1:
The reviewer stated the project was a very good approach to engage USCAR for requirements and to confirm interest with regular meetings and symposiums with a record of industry and academia attendance/participation. The reviewer observed that this project could be outstanding with a simple survey of participants for strengths, weaknesses, and solutions, possibly through a low-cost survey such as Survey Monkey.

Reviewer 2:
The reviewer stated that cross-cut lean exhaust emissions reduction simulations (CLEERS) Workshops and focus group teleconferences continue to provide an effective forum for sharing results and exchanging ideas related to exhaust aftertreatment modeling among participants from OEMs, academia, and national laboratories. Publication of select papers presented at the 2016 workshop in a special edition of *Emission Control Science & Technology* is also effective at promoting the CLEERS missions and activities. The reviewer commented that the recent focus on HC and NO_x storage catalysts and LT oxidation catalysts are timely in view of additional emission control challenges created by low exhaust temperatures from next-generation fuel-efficient engines. One important area where the reviewer hoped to see more activity is catalyst aging and deactivation (including those for TWCs); however, limited resources may well be the problem. The reviewer praised the introduction of a broad mix of speakers, including those from non-OEMs and for the focus group teleconferences, but felt that it would be important to continue to select presentation topics of potential interest to a wide spectrum of the CLEERS members.

Reviewer 3:

The reviewer stated that the approach to address needed research is well grounded in CLEERS surveys conducted with OEMs and the catalyst community. The CLEERS organization has demonstrated its ability to adapt its emphasis to areas of catalyst research that is of high interest to OEMs. A good example of this is the research shift toward passive NO_x adsorber (PNA) characterization and optimization that is needed by aftertreatment groups to provide viable system solutions for LT operating conditions. Continued research in the area of SCR characterization and performance prediction is very desirable from an OEM standpoint given the current and future use of this technology in many lean aftertreatment systems. Just as important, the embracing of LT catalyst formulations and characterizations is critical to helping enable future powertrains enter the LD truck market. However, real world aging conditions and catalyst poisons, along with the effects of temperature on greenhouse gas (GHG) selectivity must be included early in model development efforts.

Reviewer 4:

The reviewer stated that it is not clear how CLEERS is contributing to the lack of cost-effective emission control because it seems to be studying the same technologies as everyone else. The reviewer questioned next steps once CLEERS has data and models. The reviewer remarked that CLEERS should stick to promoting collaborations through workshops and teleconferences.

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

Reviewer 1:

The reviewer stated that the project demonstrated accomplishments that can be attributed somewhat to the CLEERS effort. The reviewer noted that it would be good to provide a few examples of success stories and/or papers that referenced CLEERS work or can be attributed to the work. The reviewer mentioned that metrics on the number of meetings and attendance is a good indication of performance with specific technological performance highlighted outstanding.

Reviewer 2:

The reviewer noted that the publication of select papers presented at the 2016 workshop in a special edition of *Emission Control Science & Technology* as well as new CLEERS newsletters would further increase the visibility of the CLEERS mission and activities. Also, the recent focus on HC and NO_x storage catalysts and LT catalyst development are in direct support of the LT emission control problem which would become increasingly important with the introduction of more fuel-efficient engines and advanced combustion modes in the future.

Reviewer 3:

The reviewer stated that continuing to provide understanding of the functionality and chemical state of copper (Cu) in SCR formulations is of value to the OEM community. The additional effort now directed at providing tools and methods to characterize PNA functionality and formulation effects on NO_x storage and release is equally important to provide a potential solution for LT NO_x control. However, the reviewer observed that better understanding of multiple NO_x desorption states and formulation methods for manipulating those states is needed. CLEERS contributions to characterization and testing protocols is also of high value to the catalyst community and offers the potential to more easily understand catalyst functionality and sharing of data between research facilities.

Reviewer 4:

The reviewer noted that there is no proof that the CLEERS mission of accelerating development of emission control technologies is being fulfilled. Rather, the development is led by suppliers and OEMs that do not share competitive information. The reviewer commented that CLEERS is supporting collaborations and providing data that mainly helps academics. The reviewer observed that some data is not pre-competitive and most data actually seems post-competitive. The reviewer was very tired of hearing about Cu/chabazite (CHA). The reviewer commented that work on cold nitric oxide (NO) and HC traps is good. The CLEERS survey and workshops are worthwhile. The coordination of DOE national laboratories results is a mixed bag. The reviewer remarked that LT catalysis is meaningful while lean gasoline is going nowhere. The reviewer observed that cooperative research and development agreements (CRADA) with Cummins are perennial.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer praised the collaborative and highly coordinated structure of the CLEERS work as outstanding. The use of yearly symposiums, bi-monthly ACEC engagement, monthly teleconferences, and bi-weekly low-temperature aftertreatment (LTAT) meetings are instrumental to the successful research direction and efforts performed under the CLEERS umbrella. These connections with the OEM, supplier, and research communities allow the efficient exchange of information and feedback for productive research projects. This works well unless resources are too thinly dispersed in the multiple research areas.

Reviewer 2:

The reviewer commented on the excellent pre-competitive work as demonstrated by the record of participants from industry, academia, and national laboratories.

Reviewer 3:

The reviewer noted the good and effective collaboration between engine/vehicle manufacturers, universities, national laboratories, and component/software suppliers.

Reviewer 4:

The reviewer noted that CLEERS is collaborative by design.

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

Reviewer 1:

The reviewer commented that the movement toward PNA supporting activities is appropriate as is the continued effort to provide additional SCR characterization. The reviewer pointed out that the area of multifunctional catalyst development and characterization has not yet been incorporated into the CLEERS activities. This is one area OEMs would probably encourage more effort.

Reviewer 2:

The reviewer requested that the project please continue the teleconferences and workshops. The reviewer noted that the forward-looking focus on cold NO and HC traps is good and continued that if some data collection/modeling at national laboratories must be included, make sure it is using relevant samples for exhaust gas such as thermally stable, robust to S, etc.

Reviewer 3:

The reviewer commented that the project has a good plan for future research with a focus on USCAR input such as lean NO_x, LT catalysts, and integrated catalysts/diesel particulate filters (DPF) with priorities identified. This roadmap could possibly be used to raise the bar for other projects not in scope (not pre-competitive or within funding limits).

Reviewer 4:

The reviewer expressed a desire to see more activities addressing catalyst aging/deactivation mechanisms and modeling, if resources permit. The reviewer stressed that this is a critically important area that has a direct impact on emission compliance during actual vehicle use as well as platinum group metal (PGM) thrifting potential for emission control catalysts.

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

Reviewer 1:

The reviewer stated that this project well supports the overall DOE objectives by focusing on efficient ways to reduce exhaust emissions while at the same time improving fuel efficiency.

Reviewer 2:

The reviewer commented that the CLEERS activities directly support the advanced aftertreatment research areas of interest to OEMs. The CLEERS work in the area of PNA, SCR, and TWC characterization is important. The reviewer also noted that the LT aftertreatment research is consistent with the direction given by the U.S. DRIVE and ACEC groups to help support the introduction of advanced engine combustion strategies.

Reviewer 3:

The reviewer noted that some of the most cost-effective high-efficiency engine technologies require improvements in aftertreatment technology to become practical in the real-world fleet. The reviewer noted that the CLEERS effort supports high priority aftertreatment solutions to enable fuel efficiency savings.

Reviewer 4:

The reviewer commented that, theoretically, the answer is yes. The reviewer stated that the support is there but the results have yet to be determined.

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

Reviewer 1:

The reviewer stated that the funding is sufficient for the scope. The reviewer noted the benefit of identifying roadmaps and collaborative connections. The reviewer commented that additional significant funding was needed for more detailed work in the target areas identified in the CLEERS roadmap.

Reviewer 2:

The reviewer commented that more funding would be appropriate to support the many research area needs in both stoichiometric and lean aftertreatment catalyst technologies.

Reviewer 3:

The reviewer noted that the coordination in funding is good but was not sure about “Analysis” funding, or how Cummins CRADA fits in.

Reviewer 4:

The reviewer observed that this project involves both coordination and support/execution of emission control research. The reviewer noted that it appears that the coordination effort alone takes up a fair amount of resources, leaving behind insufficient resources for the other part.

Presentation Number: acs023
Presentation Title: Cross-cut Lean Exhaust Emissions Reduction Simulation: Aftertreatment Modeling and Analysis
Principal Investigator: Yong Wang (Pacific Northwest National Laboratory)

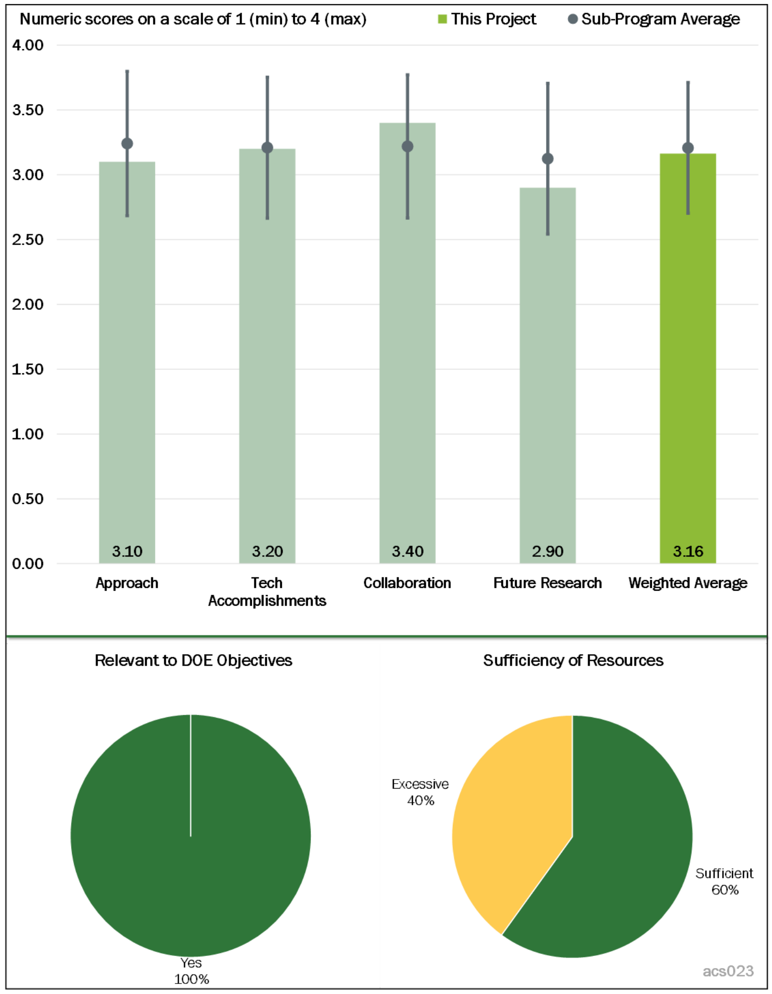

Figure 1-16 - Presentation Number: acs023 Presentation Title: Cross-cut Lean Exhaust Emissions Reduction Simulation: Aftertreatment Modeling and Analysis Principal Investigator: Yong Wang (Pacific Northwest National Laboratory)

Presenter

Yong Wang, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer found the approach to evaluating Cu^{2+} and Cu^{2+}/OH valuable along with the effects of hydrothermal aging on $Cu(OH)^{+}$.

Reviewer 2:

The reviewer commented that the approach described in this project is classic: develop fundamental understanding which then facilitates modeling work from computational chemistry which then leads to application as well as further compositional work. The project hits on major key barriers and gaps in conventional and emerging aftertreatment: SCR, selective catalytic reduction on filter (SCRF), PNA, etc. The reviewer observed that a GPF is missing but part of future direction. This application is very important, emerging, and ripe for optimization, especially when looking at complex catalyst architectures (layering, zoning) on a filter.

Reviewer 3:

The reviewer noted that while the topics are very relevant to modern emission control systems, it is not clear to the reviewer that any insights were gained that were not already known from patent literature.

Reviewer 4:

The reviewer found that the approach of looking at LT performance of SCR, PNA, and LTAT and defining the operational barriers was outstanding. Copper hydroxide (CuOH) limiting of performance at 700°C was particularly illuminating; however, it does not appear that the research has focus. The reviewer commented that it seems from the presentation that the money given to PNNL is not used for specific designed projects but for areas that PNNL researchers find interesting.

Reviewer 5:

The reviewer commented that, first, it bears mention that the organization of the presentation did not show off the work/approach/progress to its best advantage. The reviewer stated that the ORNL portion of the CLEERS talk (Pihl, ACS022) was much more clearly organized and recommended following that format because it benefits the reviewers who need to make detailed comments on the approach, accomplishments, etc. of the project.

Further, the reviewer noted that in the question session it became clear that there are not specific projects funded by the DOE CLEERS money, but rather, somewhat general studies in the four aftertreatment areas: SCR, LTAT, PNA, particulate/filtration. The reviewer commented that this general study approach has some significant weaknesses as it seems to be by happenstance rather than by hypothesis-driven research questions.

The reviewer recommended significantly more specific projects with well-defined tasks and deliverables to which an approach can be formulated and justified in terms of specific barriers. This reviewer requested that they be mentioned and referenced 2.3.1B-G.

The reviewer noted that on Slide 4, the two statements regarding the relationship between the CLEERS work and the CRADA work seem to be in opposition: "Utilize open CLEERS work to support industry CRADA activities, e.g., fundamental SCR studies led to the new CRADAs with FCA and Cummins" and "Maintain clear separation between CLEERS and CRADA activities." The reviewer questioned how there could be separation if the CLEERS work is used to support the CRADA work. The reviewer commented that it seems that the CLEERS money is being used to investigate fundamental questions that arise during the CRADA work, rather than hypothesis-driven research questions.

The reviewer noted that goals need to be "SMART" (specific, measurable, achievable, relevant, and time bound) and questioned how "fundamental understanding" can be measured. The reviewer questioned how the project team will know when this has been achieved. The reviewer recommended defining specific projects that would allow for specific goals that are easily evaluated by reviewers.

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

Reviewer 1:

The reviewer stated that the accomplishments are valuable to the industry.

Reviewer 2:

The reviewer noted that advances in SCR, LTAT, and PNA are impressive.

Reviewer 3:

The reviewer noted that the results on LT SCR mechanisms on copper sulfanide (CuZ) are significant. The work is utilizing state-of-the art methods to break down the reaction mechanisms that have been proposed by others using experimental methods. Furthermore, the results are being corroborated here using experiments. The reviewer commented that work on PNAs is helping to explain the relationship between NO and nitrogen dioxide (NO_2) adsorption on modern adsorbers. The palladium oxide mechanism is interesting and will likely lead to optimizing palladium (Pd) utility in these systems. The work on SCRF coating location is quite preliminary, but interesting. As proposed, this work needs to extend GPF.

The reviewer stated that finalization of test protocols is very important and will now provide a harmonized method for evaluating results from different laboratories.

Reviewer 4:

The reviewer was not sure what was accomplished that was new.

Reviewer 5:

The reviewer requested that the project team call out the specific DOE barriers that the work is targeting (2.3.1B-G for cost, durability and fuel penalties of the emissions control devices) especially in each project area. The reviewer noted that because the "projects" funded by this work are not specific with measurable milestones, it is very difficult to determine whether or not the milestones have been met. The reviewer commented that on Slide 5, the first milestone is marked as on track, but the reviewer questioned how the project team will know when the project team has achieved understanding. The reviewer stated that these vague milestones are a side effect of the "approach" to the work.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the project is receiving excellent guidance from industry consortia and focus groups. More collaboration is needed with the catalyzers, especially as the project moves on SCR filter catalyst distribution and interactions with the substrate. They are well equipped to help guide the project, provide contemporary materials, and to apply the results.

Reviewer 2:

The reviewer stated that it seems appropriate.

Reviewer 3:

The reviewer commented that CLEERS has a good mix of collaborators.

Reviewer 4:

The reviewer commented that it would be good to know what portions were used successfully by the companies involved in the project.

Reviewer 5:

The reviewer noted that the strong collaboration with CLEERS lead partner ORNL and the CLEERS industrial and academic partners are a strong feature of this work. Collaboration with the industry partners which is predominant with CRADA projects seems to be what keeps the work done in this project relevant to DOE goals.

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

Reviewer 1:

The reviewer praised the proposed future work in SCR, PNA, and LTAT as outstanding. The reviewer did not notice the future work in PM traps.

Reviewer 2:

The reviewer noted that CuZs have a major problem that is not being addressed here: S tolerance and reactivation. The reviewer cautioned that this ought to be addressed sooner rather than later because the proposed project directions may make the matter worse.

The reviewer commented that SCR filters are emerging now in LD and non-road applications and form the basis of HD low-NO_x remediation. Fundamental understanding is needed on catalyst distribution and substrate interactions, so addressing this is valuable. The reviewer cautioned that formulations and coating architecture is still evolving, so aim for universal understanding rather than that specific to the SCR filter in hand. The reviewer noted that the barriers/challenges description on particulate filtration correctly identifies GPF issues;

however, the project team did not indicate their future direction on this. The reviewer stated that PNA and LTAT directions are okay.

Reviewer 3:

The reviewer noted that the areas of work continue to seem like a characterization of the current state-of-the-art technologies, not necessarily moving technologies forward or discovering anything new. The reviewer questioned what the next steps are once the project team has all the data and models.

Reviewer 4:

The reviewer commented that it would be beneficial if the project team had end-of-life catalyst aging data that can correlate with the hydrothermal aging conditions. The reviewer proposed that the project team consider the following proposals either independently or in partnership with other organizations: Engine testing will age the catalyst radially proportional to the flowrate while hydrothermal ages nearly uniformly; it would be valuable to show SCR performance at beginning of life, mid-life, and end-of-life and show performance as radial function of the catalyst; and, consider adding scope to piece together semi hydrothermal aging as a function of radial position.

The reviewer further recommended the following proposals for the model that exists: Use the models that exist for each hydrothermal aging to consider and estimate a profile of end-of-life aging as a function of radial position; piecemeal the hydrothermal aging curves as a function of radial position to create a pseudo real life aging model; and, use this piecemeal model to predict performance.

Reviewer 5:

The reviewer noted that the future work for this project (Slide 22) seems to be somewhat more specific for SCR in regard to the in operando studies on the copper oxidation state for the models. However, the reviewer described the “new zeolite” supports as much too vague. The reviewer inquired about whether the project team will evaluate them, for what reason, if co-catalysts will be investigated, and how the project team defines “superior” NO activation.

The reviewer commented that the future work for the PNA is all very vague. The reviewer asked to know what will be learned from the synchrotron studies, and what will be evaluated. The reviewer also questioned the following: whether the objective is to simply put the sample in the synchrotron; whether hydrothermal aging effects will be studied as related to efficacy, or on the catalyst morphology; and how the project team will investigate S and HC tolerance, such as on power samples or on cores). The reviewer stated that the future work for the particulate work is well-defined, and commented that the future work for the LTAT is again very vague.

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

Reviewer 1:

The reviewer stated that the emphasis on LT emissions performance and filtration are central to future high-efficient engine platforms.

Reviewer 2:

The reviewer noted that the technologies potentially enable more efficient powertrains with lower temperature exhaust.

Reviewer 3:

The reviewer observed that improving catalyst performance for NO_x has a direct link to fuel efficiency.

Reviewer 4:

The reviewer cautioned that with the recent EPA actions against FCA, it is apparent that CLEERS has more work to do to improve aftertreatment performance and durability.

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

Reviewer 1:

The reviewer stated that the project looks on track.

Reviewer 2:

The reviewer commented that $770,000 for three to four projects seems appropriate. The results demonstrate this.

Reviewer 3:

The reviewer noted that the resources seem excessive for characterization of state-of-the-art technologies.

Reviewer 4:

The reviewer indicated surprise at how low the funding was for the amount of work that was performed. While the work done was impressive, it was not apparent that the funding was being directed to specific topics or projects.

Reviewer 5:

The reviewer stated that the funding should support well-defined, hypothesis-driven research that is more focused.

Presentation Number: acs024
Presentation Title: Ash-Durable Catalyzed Filters for Gasoline Direct Injection (GDI) Engines
Principal Investigator: Hee Je Seong (Argonne National Laboratory)

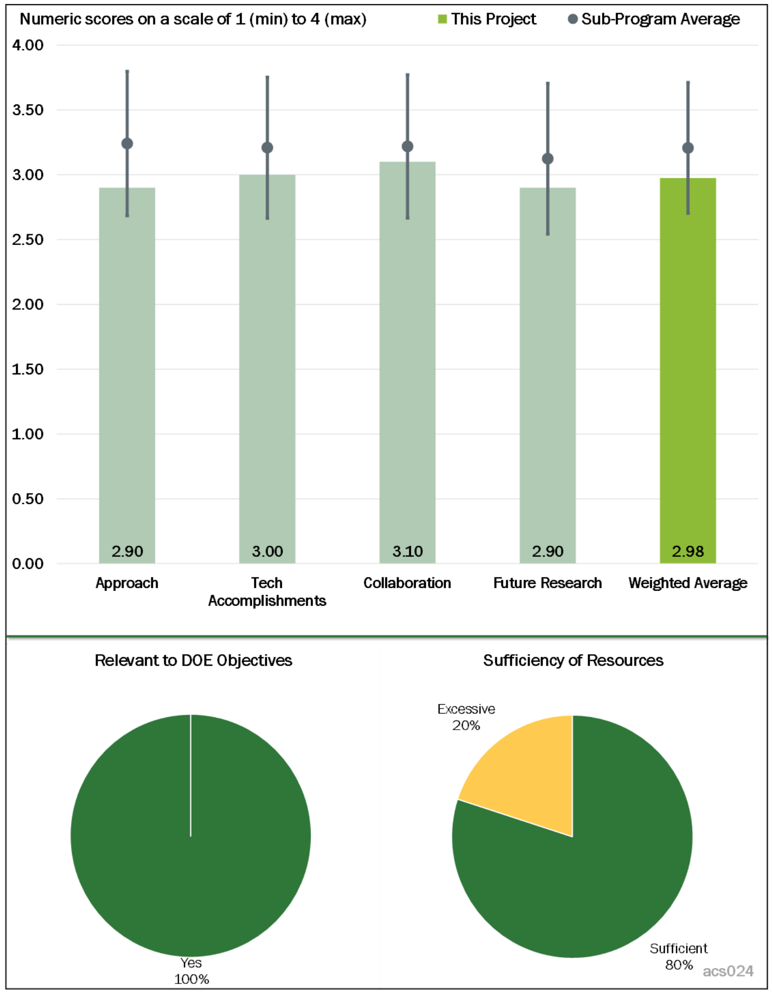

Figure 1-17 - Presentation Number: acs024 Presentation Title: Ash-Durable Catalyzed Filters for Gasoline Direct Injection (GDI) Engines Principal Investigator: Hee Je Seong (Argonne National Laboratory)

Presenter

Hee Je Seong, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that the approach is good and the use of the team's resources is excellent. Once ash loading is representative of the real-world ash loading, this project will have the potential to produce outstanding results.

Reviewer 2:

The reviewer stated that the approach is reasonable. The emphasis on ash character, composition effects, and impact is spot-on. The reviewer cautioned the project team to make sure that accelerated bench methods are representative of what happens in the field. There were differences in ash density that might impact the project team's conclusions. The reviewer thought that the project team had a handle on this.

Reviewer 3:

The reviewer commented that the approach on this project has improved from previous years. The project now seems focused on phosphorus (P) poisoning of the washcoat in the GPF and how that affects cerium (Ce) state. Chemical performance was shown. The reviewer noted that the project did not comment on improvement of soot oxidation with oxygen storage capacity (OSC) and did not show (or measure) total OSC, which will tell you how much Ce is useful. The reviewer stated that a TWC in front will absorb most of the P. The TWC washcoat in the GPF will see less P.

Reviewer 4:

The reviewer commented that the approach seemed fine but the presentation of results was somewhat difficult to link to the approach.

Reviewer 5:

The reviewer noted a large improvement to the approach as compared to previous years, with an especially big improvement in focus and in including ORNL for the characterization work of the catalysts.

The reviewer commented that the reactor setup that is shown in the slides does not separate the mass transfer and kinetic limitations. The reviewer stated that when working on core samples, both effects are present, unless you can experimentally prove (investigate flow rate effects) otherwise, which there is no evidence of. The reviewer remarked that if the project team is interested in kinetic control, then the team needs to work on the powder scale or with single channels.

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

Reviewer 1:

The reviewer found the results quite interesting. The ash impact on the temperature at which 50% conversion occurs (T50) is immediate with ash loading. This reviewer continued that conversion of emissions versus lambda and temperature points to a catalyst reactivity issue rather than diffusion through the ash, for example. The shift away from lambda 1 for both the reducing and oxidizing reactions points to an OSC issue and the team is appropriately delving into this. The puzzle is which ash component is causing the deterioration. The loss of activity suggests a component that affects more than the surface catalyst. The team seems to be getting a handle on this.

Reviewer 2:

The reviewer observed that a key result was that light off temps ranged between 270°-310°C with ash loads of 0 to 20 gallons/liter (gal/L). The reviewer noted that many charts were provided and suggested highlighting the main takeaways.

Reviewer 3:

The reviewer noted that the approach of using the different expertise of the teams, including other national laboratories, allows for success in this project. The reviewer observed that the identification of compounds and penetration of compounds in the trap led to interesting discoveries.

Reviewer 4:

The reviewer stated that the technical accomplishments for the year were good. The ash loading from the current experimental setup was shown not to be as densely packed as field aged samples—this is important in terms of the particle contact, for sintering and for pressure drop effects. The reviewer suggested that in order to match field conditions in the lab, the project needs to run higher flowrates through the core samples, which could mean adding a pump and pulling flow through the core rather than pushing flow, which seems to be how it is done now. The reviewer observed that the Ford work referenced on Slide 28 goes to higher temperature (1,000°C, where S is oxidized) as compared to this work. The reviewer advised that the new reactor should be benchmarked against the ORNL bench reactor or other known reactor systems.

Reviewer 5:

The reviewer noted that ash loading addresses one aspect of GPF (P poisoning of washcoat), but does not represent any other important aspects like backpressure and filtration efficiency. The reviewer stated that the expectations for GPF chemical performance in this project are unclear. The reviewer observed that X-ray absorption near edge structure analysis did not give much real quantitative information and proposed that sample weights and X-ray fluorescence would have given more information. The reviewer commented that just because the project team has a synchrotron does not make it the best tool to use. The reviewer suggested that funds could be more effectively used.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer praised the use of national laboratories, universities, and industry as outstanding.

Reviewer 2:
The reviewer identified the collaboration with ORNL as a strong factor improving the scores of this project. The reviewer recommended that the project team consider some additional collaboration in the characterization of the kinetics.

Reviewer 3:
The reviewer noted that this was a question from last year and the presenters identified the linkage at the end of the presentation.

Reviewer 4:
The reviewer observed that good collaboration with universities and industrial partners is evident here in the analyses and direction. The reviewer recommended that the team needs to reach out more to catalyzers, if only on a consulting basis, to make sure the results are pertinent to application. The reviewer advised that having a partnership with Afton is critical if changes in oil formulation is indicated.

Reviewer 5:
The reviewer stated that Corning and Hyundai do not appear to have very frequent involvement and are only consulted as needed. The project team did not mention meeting frequency. The reviewer noted that it appears that Corning gave filters and Hyundai gave a motor.

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

Reviewer 1:
The reviewer commented that this project is about midway through its term and has identified interesting future research that it plans to address in the future work.

Reviewer 2:
The reviewer noted that the future work proposed seems appropriate.

Reviewer 3:
The reviewer observed that continuing the work on elucidating accelerated aging versus field aging, and determining deactivation mechanisms seems the right path. The reviewer noted that given the impacts on OSC, the team might consider getting a peek at how OSC formulation changes might impact results.

Reviewer 4:
The reviewer stated that is was not clear what the ash distribution was in the field aged filter and questioned what this project was aiming to mimic. The reviewer continued that the project should include a measurement of OSC if the aim is to determine the effect of P on Ce. Further, the reviewer questioned why a liquid source of P, such as phosphoric acid, was not applied to the catalyst because gaseous P would be much more difficult.

Reviewer 5:
The reviewer noted that it is unclear that the future work planned will actually achieve the project goals, especially in regard to the reaction kinetics. The reviewer recommended that the project team consider additional collaboration.

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

Reviewer 1:
The reviewer observed that improving catalyst performances has a direct link to fuel efficiency.

Reviewer 2:
The reviewer noted that better aftertreatment allows for more efficient engine operation.

Reviewer 3:
The reviewer noted that GDIs are playing a key role in reducing LD fuel consumption, but observed a PN problem. The reviewer noted that this topic is very timely, as GPFs are being utilized in the European Union this year and China in subsequent years, with OEMs considering the United States as a way of harmonizing technology. About 70% of the GPFs in the first introductions are uncoated, but the trend is towards increasing coated GPF penetration. The reviewer concluded that ash impacts on GPF TWC performance is still not well known.

Reviewer 4:
The reviewer stated that this project might support the overall DOE objectives of petroleum displacement because the application of filters to GDI will create backpressure that will negate a portion of the fuel economy benefit of these powertrains.

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

Reviewer 1:
The reviewer observed that the project team has an impressive amount of resources between the laboratories and industry.

Reviewer 2:
The reviewer noted that this seems appropriate.

Reviewer 3:
The reviewer noted that the project team seems to have a plan in place if funding is cut short and continued that sponsors need to know what will lapse if this is this case.

Reviewer 4:
The reviewer stated that the budget seems excessive and that there were at least more technical accomplishments this time.

Presentation Number: acs027
Presentation Title: Next-Generation Selective Catalytic Reduction-Dosing System Investigation
Principal Investigator: Abhijeet Karkamkar (Pacific Northwest National Laboratory)

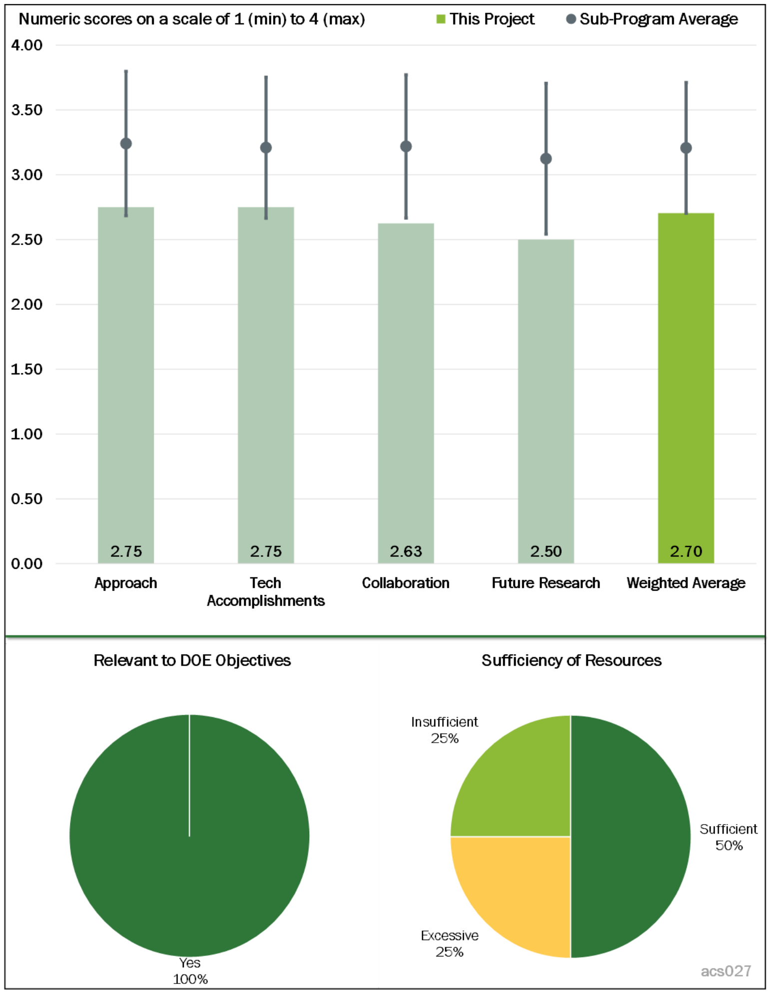

Figure 1-18 - Presentation Number: acs027 Presentation Title: Next Generation Selective Catalytic Reduction-Dosing System Investigation Principal Investigator: Abhijeet Karkamkar (Pacific Northwest National Laboratory)

Presenter
Abhijeet Karkamkar, Pacific Northwest National Laboratory

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

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

Reviewer 1:
The reviewer observed that a study on ways to generate ammonia (NH_3) other than urea is coming up again because of the need for LT NO_x conversion. The reviewer commented that the simplest thing would be to increase the exhaust temperature and continue to use the eutectic mixture of urea in H_2O.

Reviewer 2:
The reviewer stated that the project was a good approach considering the interest in alternative SCR dosing systems from USCAR. The reviewer noted that the evaluation of a full list of possible materials to support solid SCR delivery systems was good. The reviewer continued that the approach could be improved by considering up front the overall requirements for vapor delivery systems such as metering vapor, material volume, material expansion, and two-way process as well as whether the overall cost is improved with a LT vapor system plus a high-temperature traditional injection system. The reviewer explained that some background on possible improvements/costs/risks relative to potential improvements to traditional urea injection would improve the score. The reviewer concluded that substantial effort in injector design targeting, droplet size, and mixing of traditional designs may eliminate the need for a two-step system.

Reviewer 3:
The reviewer noted that LT dosing can have a significant effect on NO_x emissions especially for engines which are often operating at exhaust temperatures below 200°C which is a lower limit for urea dosing. As a result, the reviewer was not convinced of the value of density functional theory (DFT) for this work. The reviewer continued stating that it is appropriate to evaluate the effect of inadvertent exposure of the material to exhaust gases as keeping the exhaust steam out of the storage material is important; however, it was unclear to the reviewer how the project team was accomplishing this. The reviewer questioned the relevance of molten salts

and asked if the salts molten at engine exhaust temperatures. The reviewer's biggest concern was the project team putting so much emphasis on chloride compounds which seems unwise because of the risk of hydrochloric acid (HCl). The reviewer was uncertain if this project is headed in a useful direction.

Reviewer 4:

The reviewer observed that emissions standards are progressively becoming more demanding, while at the same time exhaust temperatures are decreasing due to higher efficiency engines entering the marketplace to achieve fuel economy requirements. The reviewer noted that these trends are not compatible with the use of urea as a NO_x reductant. The reviewer continued that this activity supports the search for alternative materials that can supply the NH_3 required for NO_x reduction in lean aftertreatment systems without the LT limitations associated with urea. The reviewer stated that developing materials that exhibit higher NH_3 density storage and have appropriate release temperatures will be needed to reach the level of NO_x control and customer satisfaction needed by OEMs. However, the reviewer cautioned that the cost of these materials and their ability to be reconstituted easily should provide additional constraints for choosing materials. Simply characterizing known materials is not necessarily the best use of national laboratory resources. The basic bench testing required is also something that could be performed by an independent laboratory.

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

Reviewer 1:

The reviewer observed that the technical accomplishments seem reasonable; however, there is very little background given as to the need for some of the accomplishments. The reviewer questioned, for example, the mitigation approaches for HCl. The reviewer continued stating that investing so much time trying to mitigate the volume change for the chlorides is not necessarily helpful if the chlorides are judged to be too risky. The reviewer concluded that the downselect to the MgCl seemed abrupt.

Reviewer 2:

The reviewer observed that with respect to project goals, better definition of target release temperatures and maximum recovery of NH_3 are needed. However, the tunable nature of the material combinations under study is a desirable property. The reviewer continued stating that this project would benefit from an understanding of the kinetics involved for the different formulations, so that a model can predict the optimal combination and composition of binary salt materials. The reviewer concluded that the level of testing in this project does not seem to be the best use of laboratory resources.

Reviewer 3:

The reviewer noted that this project has been in place for quite a while, since October 2014, and is ending in September 2017. It appears unlikely that a materials candidate will be found to replace or use with aqueous urea.

Reviewer 4:

The reviewer praised the project as a solid accomplishment to downselect material that can perform properly without significant increase in volume and is two-way lithium chloride-magnesium dichloride double salts, and to assess impacts of other constituents. The reviewer noted that because requirements for vapor delivery have not been identified, the project team could improve the score with this assessment for downselected materials (i.e., how to use unstable release temperature of NH_3 in control system). This reviewer further suggested that the method to achieve system assumption/requirement that the material does not come in contact with exhaust gases should be at least conceptualized.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that the project demonstrated good collaboration with USCAR industry input.

Reviewer 2:
The reviewer noted that USCAR and PNNL are pretty insular collaboration groups. The reviewer questioned if the project team could bring a supplier into this activity.

Reviewer 3:
The reviewer noted that partnering with USCAR OEM members for their input on the material requirements is very appropriate. However, the reviewer commented that the use of PNNL resources to perform the base level testing and formulation is not as appropriate. The use of an outside vendor should have been considered for the testing and preparing the new salt combinations used in the testing. The reviewer stated that PNNL should support novel material development and kinetic insight into the NH_3 storage and release functionality.

Reviewer 4:
The reviewer observed that PNNL meets with USCAR partners every three months, and this seems infrequent. Further, it was not clear to the reviewer what each OEM is actually contributing other than advice.

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

Reviewer 1:
The reviewer commented that this project is due to end this year and the deliverables are consistent with this timeline.

Reviewer 2:
The reviewer commented that the future work plan is good and the project team should consider a cursory look at hardware and control system design requirements and overall cost first. The reviewer cautioned that too much focus on materials science without considering the overall system design and guidance cost may result in outstanding material requirements to meet vapor reactant needs with an overall system cost which is prohibitive.

Reviewer 3:
The reviewer noted that proposed future research was very vague and the project did not include suggestions for other materials.

Reviewer 4:
The reviewer observed that there is not much time left in this project, the items proposed are minimal, and the likelihood of discovering a useful material is very low. Even if the project team did, the work would need to include heating the material in a timely, efficient manner and dosing NH_3 vapor into an exhaust stream. The reviewer cautioned that any generation of NH_3at pressure would need a safety evaluation.

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

Reviewer 1:
The reviewer observed that getting NH_3 to the SCR catalyst at temperatures below 200°C will greatly improve the NO_x reduction. The reviewer stated that this project has great potential.

Reviewer 2:
The reviewer noted that the project meets DOE goals as it supports USCAR's need to develop LT SCR to enable LT combustion and NO_x reduction at low temperatures in traditional combustion cycles.

Reviewer 3:
The reviewer commented that the urea reductant alternatives under investigation in this work show promise in providing suitable, higher NH_3 density storage materials that can be used by OEMs. The ability of these materials to selectively release NH_3 species at low temperatures is an important need for lean aftertreatment systems that must function at lower exhaust temperatures. However, the reviewer cautioned that establishing a target metric for this function is required. In addition, maximizing the service interval between reductant replacements is a very desirable consideration from a customer satisfaction perspective and for packing/servicing in vehicles.

Reviewer 4:
The reviewer observed that if a material could be discovered that might deliver NH_3 earlier during a cold start or at lower temperatures than aqueous urea, this would seem to promote more efficient powertrains. The reviewer noted that if something feasible were discovered, it would become necessary to study the temperature required for NH_3 release and how to get that temperature quickly, which will cost energy. An energy balance would be needed to ascertain if the powertrain were overall more efficient or not.

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

Reviewer 1:
The reviewer noted that funding for the current scope is good. The reviewer added that additional funding to assess system design and cost could improve the potential of the project for production success.

Reviewer 2:
The reviewer commented that there is no indication that aspects of the inquiry have been skipped because of a lack of resources.

Reviewer 3:
The reviewer stated that better use of national laboratory resources and skills should be considered. The reviewer noted that aspects of this project could be performed by a third-party laboratory, while leveraging the modeling and formulation capabilities of PNNL more effectively.

Reviewer 4:
The reviewer commented that more funding would be needed to understand the true usefulness of the proposed materials. The reviewer noted that additional areas in need of consideration are NH_3 vapor dosing, fast heat up of the materials to release the NH_3, and a safety review of any NH_3 pressure on the vehicle.

Presentation Number: acs032
Presentation Title: Cummins-ORNL Emissions CRADA: NO_x Control and Measurement Technology for Heavy-Duty Diesel Engines
Principal Investigator: Bill Partridge (Oak Ridge National Laboratory)

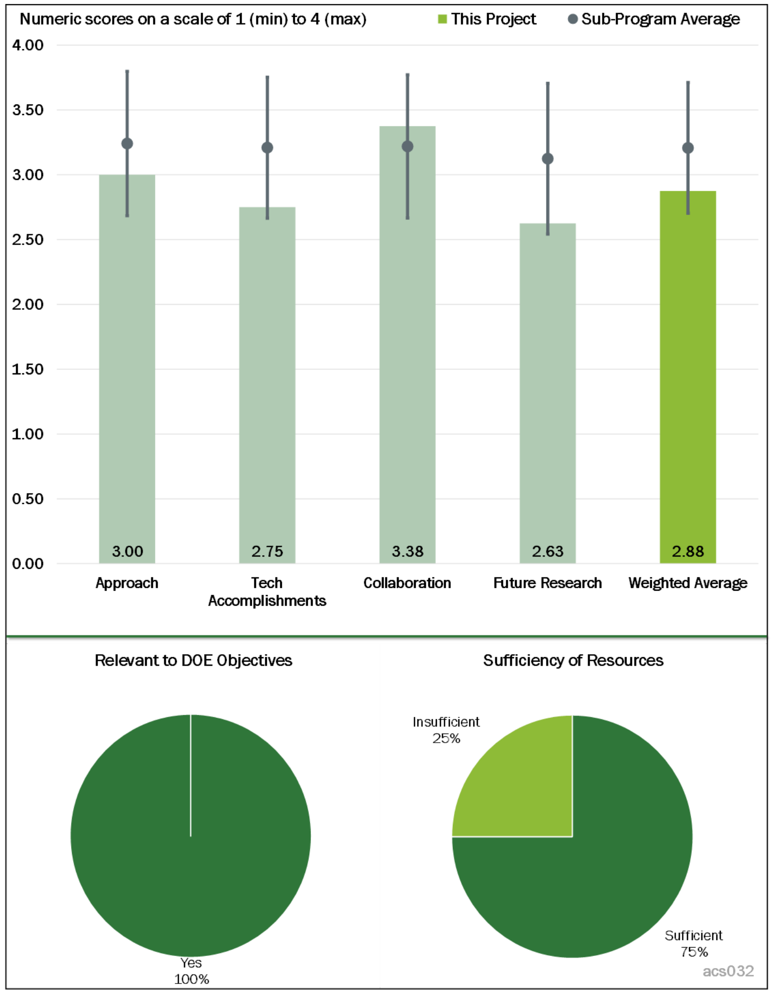

Figure 1-19 - Presentation Number: acs032 Presentation Title: Cummins-ORNL Emissions CRADA: NOx Control and Measurement Technology for Heavy-Duty Diesel Engines Principal Investigator: Bill Partridge (Oak Ridge National Laboratory)

Presenter

Bill Partridge, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that the focus of this work is to refine a model for the SCR catalyst. The reviewer observed that the project is especially focused on the transient portions of the testing and also attempts to tune the reaction mechanism to the spatially local (along the channel) concentrations and storage of the catalyst. Especially important is describing the inflections which are an indicator of the transients which occur in all of the driving cycles. The selection of a field aged Cu/CHA is especially encouraging because it is pretty much the state-of-the-art commercial catalyst.

The reviewer questioned if the Cummins model has been published. In addition, the reviewer asked if the space velocity of the laboratory experiments was known. The reviewer noted that if there is any mismatch between the experimental space velocity and the model space velocity the differences will show most dramatically in the high gradient regions. The reviewer questioned if there was a chance that the spatially resolved capillary inlet mass spectrometer (SpaciMS) probe is causing a change in the space velocity. The reviewer questioned what an inflection point means kinetically if the measurements are still integral reactors.

Reviewer 2:

The reviewer commented that it was not really clear what impact the project will have regarding new insights into SCR catalyst behavior during field aging because details the of model could not be shared.

Reviewer 3:

The reviewer commented that this CRADA project is focused on developing a method to “sense” the state of a catalyst in order to better understand the functionality condition of the catalyst and to derive better models to optimize control of the catalyst and catalyst system. The reviewer noted that at the center of this technique is the ability to observe and record "conversion inflections" to assess the state of the catalyst. The reviewer stated that this is a novel approach to in-situ measurements of how well a catalyst is performing reactions that support its function, but sufficient details of how the data was were obtained was not presented. The reviewer noted that some information is CRADA protected but more information was needed to sufficiently determine the merits of the approach.

Reviewer 4:

The reviewer commented that the project was a good approach to facilitate improvements to SCR durability performance and diagnostics with system modeling. The reviewer noted that the project could be improved with specific targets which are being investigated such as SCR catalyst degradation detection and subsequent dosing strategies; or SCR catalyst degradation mechanisms and detection with state estimator to minimize degradation. The reviewer stated that a list of common issues with SCR catalysts and how state detection could improve with focus on priority concerns could improve the approach and score.

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

Reviewer 1:

The reviewer praised the time resolution (or apparent resolution) of the concentrations as impressive. The reviewer commented that it allows the resolution of concentrations so subtle that inflection points can be analyzed. The reviewer was uncertain if the information on the storage condition of the catalyst is easily extracted from this data. The reviewer stated that consistent comparison with a model makes this a very helpful collaboration; however, the reviewer did not notice a reference to the detailed kinetic model; consequently, developing confidence in relation of the measurements to the model are a bit problematic. The reviewer did not know what the form of the inhibition term is.

Reviewer 2:

The reviewer stated that it was somewhat difficult to properly assess the technical approach of the project due to the presenter's concerns related to CRADA protected information. However, some of the data from different catalyst samples required a constant space velocity to accurately compare results, this was not obvious from the presentation. Additionally, it did not appear that portions of the transients were captured well, nor was there good agreement between model prediction and experimentally measured inflection data. The reason for this was not well communicated. Also, much of the transient work appears to be using standard SCR conditions. To be more useful in many applications, fast SCR results would be of value.

Reviewer 3:

The reviewer stated that CRADA has limitations that does not allow for full disclosure of details so it was hard to judge the technical progress made.

Reviewer 4:

The reviewer noted limited visible accomplishment. The CRADA claim of proprietary models is valid and does limit what data can be made available, however, some high-level results should be presented and related to specific SCR catalyst durability, performance, or diagnostic concerns. The reviewer stated that sharing high-level results related to objectives could improve the score (i.e., how the chlorine phenomenon can be modeled and related to an on-board diagnostics (OBD) metric, or dosing strategy).

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the combination of Cummins, Politecnico di Milano, and ORNL is a powerful team. It incorporates industry, Europe, and national laboratories. The reviewer commented that it would be hard to improve on this.

Reviewer 2:

The reviewer commented that partnering with Cummins in this area of SCR characterization is very appropriate and expected, given their level of knowledge and model development to predict catalyst behavior. However, the reviewer noted that the connection to CLEERS for new research is not evident. The reviewer observed that their help could be better leveraged to help explain some of the anomalies between the inflection model predictions and the actual data.

Reviewer 3:

The reviewer noted that the project appears to include a significant collaboration between ORNL and Cummins given that Cummins is contributing work-in-kind and not cash. The reviewer noted that university is also included, as well as coordination with CLEERS.

Reviewer 4:

The reviewer observed that CRADA with Cummins indicates a corporate interest and there seems to be some cooperation concerning models. The reviewer suggested a designated partner with focus to extract non-proprietary content for general use (an individual in CLEERS or other project) to possibly improve the collaboration score.

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

Reviewer 1:

The reviewer would like to have seen a variation of space velocity to be included in the future plans. The reviewer would also like to have seen sharing of the SCR model for other institutions to test.

Reviewer 2:

The reviewer observed that a more demonstrated understanding of the differences between CI predictions and experimental data must be addressed going forward. Also, the reviewer noted that applying an accurate model to OBD monitoring strategies should be one of the important deliverables of this work.

Reviewer 3:

The reviewer noted that due to nature of CRADA, the future work is not written very clearly; consequently, the reviewer found it difficult to judge if the proposed tasks will logically address overcoming barriers.

Reviewer 4:

The reviewer commented that the characterization of CI approach is ongoing topic. The reviewer noted that the "mining" of results should have a hypothesis, physical model approach, or other construct which is being proved, disproved or improved with clear ideas on what this is.

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

Reviewer 1:

The reviewer stated that the topic is relevant to DOE goals as modeling of SCR performance and degradation can improve performance of fuel efficient technologies over useful life.

Reviewer 2:

The reviewer commented that increasing the effectiveness of SCR catalysts will make the implementation of small consumer diesels and lean gasoline engines more likely.

Reviewer 3:

The reviewer observed that more insight into SCR catalyst behavior over mileage might improve the NO_x conversion with more fuel savings, but this really is not clear from the presentation.

Reviewer 4:

The reviewer noted that understanding the state of an SCR under transient conditions is an important aspect of system development work to achieve super ultra-low emissions vehicle (SULEV) emissions standards. However, the reviewer observed that some of the work shown here has been performed by other groups. The reviewer commented that with only 1 year left on the project, there may not be enough time remaining to adequately address all the intended goals.

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

Reviewer 1:

The reviewer stated that the current level of funding should be ample to acquire the necessary data and model refinement.

Reviewer 2:

The reviewer commented that resources seem sufficient for 1:1 CRADA given that Cummins is contributing work-in-kind, assuming this is in an adequate amount.

Reviewer 3:

The reviewer stated that the funding level is difficult to assess without clearer goals on what is being modeled and the value proposition of a successful result.

Reviewer 4:

The reviewer noted that funding for this project has been eroding over the years, even though it has continued to be successful. The reviewer commented that this project is lacking sufficient manpower and that issue needs to be addressed. Consequently, it is very likely that more than the final year will be required to bring this project to its full usefulness.

Presentation Number: acs033
Presentation Title: Emissions Control for Lean Gasoline Engines
Principal Investigator: Jim Parks (Oak Ridge National Laboratory)

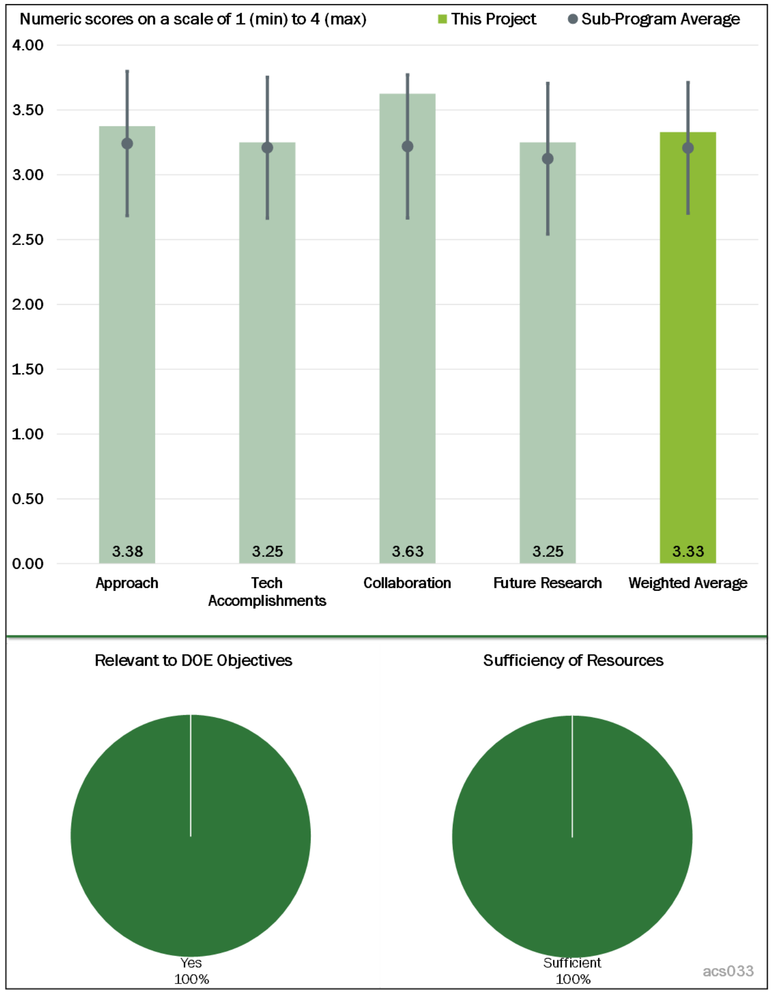

Figure 1-20 - Presentation Number: acs033 Presentation Title: Emissions Control for Lean Gasoline Engines Principal Investigator: Jim Parks (Oak Ridge National Laboratory)

Presenter

Jim Parks, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that this project employed a systematic, well-integrated approach to the problem, which involves engine control as well as catalyst formulations for TWC and SCR.

Reviewer 2:

The reviewer noted that this project addresses the need for an alternative approach to lean gasoline NO_x reduction other than urea. With decreasing exhaust temperatures driven by more efficient lean engines, where urea is not appropriate, passive NO_x control systems represent an attractive option to meet SULEV30 emissions standards without sacrificing significant fuel economy. The reviewer observed that much of the catalyst characterization presented in this project relies on technologies that will be able to function at lower exhaust temperatures as demonstrated by aftertreatment system testing on a fully functional and controllable engine. As such, combining elements of both TWC and lean NO_x trap (LNT) catalysts upstream of a SCR is an innovative approach to meet the need for simultaneous three-way emission control. However, because these systems will need to operate at lower temperatures, both GHG and criteria emissions will require stringent control. Therefore, NO_2 emissions must be inventoried at multiple operating points to access the emissions over a Federal Test Procedure (FTP) cycle. Also, because this is a gasoline application, aging of the SCR under conditions other than high temperature must also be investigated to determine the feasibility of a SCR system for 150,000-mile durability. Finally, the reviewer noted that when considering the cost of the various systems studied here, the catalyst represents a relatively smaller portion of the total system cost relative to a purely TWC system. Lean aftertreatment system costs are driven more by hardware expense such as sensors and additional components as well as controls and OBD needs.

Reviewer 3:

The reviewer commented that one significant barrier to lean gasoline engines is cost and this was partially addressed in this project. The reviewer noted that another significant part of the cost is OBD and the sensors required; however, this was not addressed in this project.

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

Reviewer 1:

The reviewer noted that it is obvious much effort has been applied to this project to characterize a variety of passive lean gasoline aftertreatment systems on an actual engine. Incorporating engine controls into optimizing aftertreatment performance is a highly desirable capability to properly assess aftertreatment effectiveness and efficiency. The reviewer stated that addressing the required transient operation of these systems through the project test plan is well thought out and appropriate. The reviewer said that because these systems must work under both rich and lean conditions, the upstream catalyst must be thoroughly characterized to ensure it is providing the required level of NH_3 under rich conditions and NO_x storage and HC/CO oxidation under lean conditions. This functionality is clearly demonstrated in this project, as well as different aging effects and sulfur poisoning degradation. Additionally, this work has shown that attention must be paid to strategies that minimize fuel use to regenerate the upstream catalyst, while still providing a level of emissions control.

Reviewer 2:

The reviewer commented that the data on faster NH_3 generation was especially interesting when comparing catalysts with and without NO_x storage materials.

Reviewer 3:

The reviewer noted that the well-integrated, system-level approach used has identified some promising conditions for NH_3 production, one of the requirements for the passive SCR strategy investigated in this project. The reviewer commented that although sufficient amounts of NH_3 production over the TWC are desired, it would have been more interesting to show how the additional NH_3 production translates into tailpipe NO_x emission reduction under realistic operating conditions.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that this project is an excellent example of how to greatly leverage the knowledge learned in one area and apply it to many more. The data provided in this work is very useful within the CLEERS organization as well as to the supplier base (Umicore), OEMs (GM), and the university partner. The reviewer noted that the collaboration and coordination associated with this project is well thought out and maximizes the value associated with the results.

Reviewer 2:

The reviewer stated that the project appears well coordinated between partners including university, OEM, and supplier.

Reviewer 3:

The reviewer commented that the PIs have had very close interaction with OEM (GM) and catalyst supplier (Umicore). However, it is not clear how University of South Carolina fits in to the program.

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

Reviewer 1:

The reviewer commented that focusing future activities on understanding the effects of various aging scenarios on system performance and selectivity is critical for determining the feasibility of this approach for passive, lean aftertreatment systems. Including the optimization of fuel utilization during regeneration events, both NO_x and sulfur oxides (SO_x), is also important for assessing the overall system functionality. Finally, using challenging speed/load points in the analysis will benefit the usefulness of the data.

Reviewer 2:

The reviewer stated that the PIs seem to well recognize the remaining challenges; namely, NO_x emission performance during transient drive cycle operation, HC/CO clean-up, and SCR deactivation, especially under high-temperature stoichiometric or rich conditions. Also, there is a literature report that NH_3 production during the NO reduction in the presence of sulfur dioxide tends to be suppressed (as observed here), but at the expense of increasing nitrous oxide (N_2O) production. Thus, it would be important to keep an eye on N_2O emissions in future work.

Reviewer 3:

The reviewer identified a need to assess OBD impact and cost because more components add cost and complexity that was not addressed in the project. The reviewer added that the project team needs to consider what to do when the current engine is at end of life.

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

Reviewer 1:

The reviewer commented that this project addresses multiple needs for future, lean aftertreatment systems: LT performance, selectivity toward N_2/CO_2, minimal fuel use, and Tier III/low emission vehicle (LEV) III capability.

Reviewer 2:

The reviewer stated that lean burn is one potential way to increase fuel efficiency.

Reviewer 3:

The reviewer commented that lean-burn gasoline engines that this project focuses on can provide significantly higher fuel efficiencies compared to conventional stoichiometric gasoline engines, but there is no cost-effective, reliable, production-ready emission control system available yet.

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

Reviewer 1:

The reviewer commented that this project should continue to be funded at this level or higher as a significant amount of useful data can be derived from this work.

Reviewer 2:

The reviewer noted that it appears that the resources for this project would be sufficient provided that a similar level of funding continues for the third year.

Presentation Number: acs052
Presentation Title: Neutron Imaging of Advanced Transportation Technologies
Principal Investigator: Todd Toops (Oak Ridge National Laboratory)

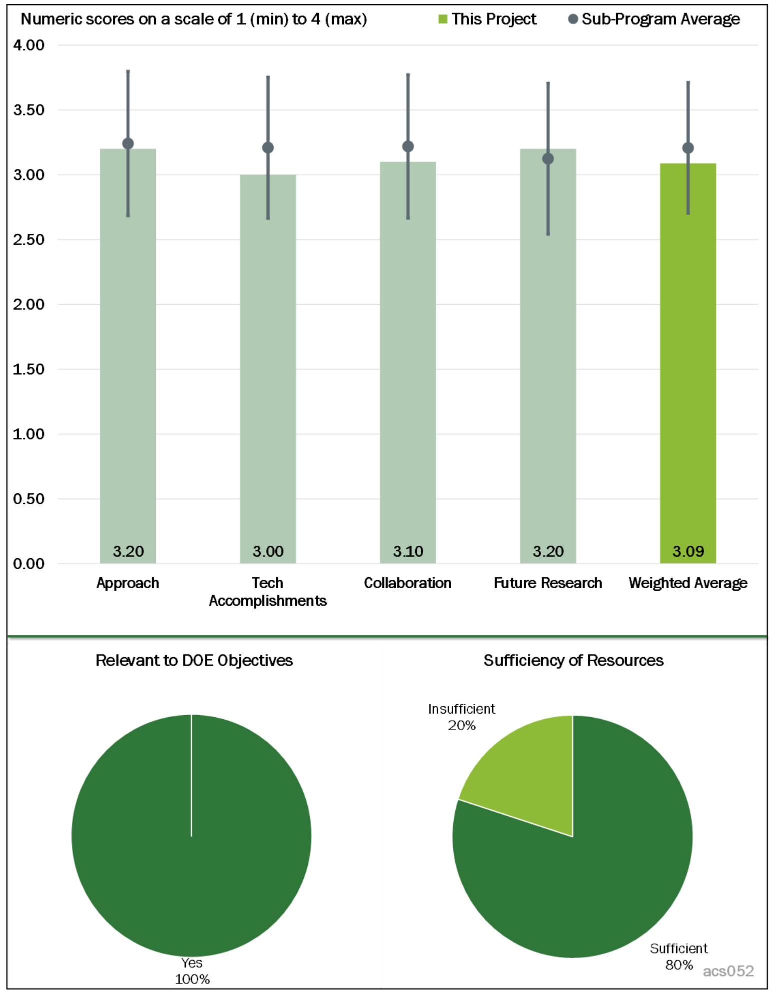

Figure 1-21 - Presentation Number: acs052 Presentation Title: Neutron Imaging of Advanced Transportation Technologies Principal Investigator: Todd Toops (Oak Ridge National Laboratory)

Presenter

Charles Finney, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that this project uses a novel approach to non-destructively investigate injectors and particulate filters. This is the sort of creative application of technology that DOE should be supporting.

Reviewer 2:

The reviewer commented that this research uses unique measurement capabilities to generate new learning relative to internal phenomenon in injectors and particulate filters that should be useful to industry. The reviewer noted that industry does not have the capabilities to make these measurements.

Reviewer 3:

The reviewer noted that this project is a good example of using tools and capabilities such as neutron imaging that are only available at the national laboratories to diagnose engine-related problems.

Reviewer 4:

The reviewer noted that stated barriers addressed by the project are fine, but it is not clear if/how the project is actually addressing these barriers. For example, the first stated barrier relates to cost-effective emission control, and the project is claiming to address this by leading to “improved regeneration efficiency in particulate filters.” The reviewer commented that while the project does have some rudimentary measurements of soot on particulate filters, the connection between this and improved regeneration efficiency remains unclear. It is also not clear how this project will lead to better understanding of fuel injector durability.

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

Reviewer 1:
The reviewer commented that the project has progressed and there are some neutron beam images of injectors in various scenarios. It does not seem, however, as though there are a lot of data that have been acquired or analyzed. The reviewer stated that it seems that competition for "beam time" is an issue, as emphasized by the presenter.

Reviewer 2:
The reviewer noted that the researchers have made good progress in acquiring detailed images of fluid dynamics within GDI injectors, along with internal loading and regeneration phenomenon in particulate filters. The reviewer commented that the researchers have also advanced their analytical capabilities as evidenced in determining the liquid mass leaving the nozzle.

Reviewer 3:
The reviewer stated that the insight gained from the particulate filter tests is great and is not attainable in any other way. However, the resolution of the injector tests is still not good enough to draw significant conclusions. In addition, the injector pulse width of 0.25 millisecond (ms) may be low enough to be in the non-linear, non-repeatable range of the injector operation, introducing shot to shot variation in the injector spray.

Reviewer 4:
The reviewer noted that more progress has been made in providing some insights for gasoline fuel injector behavior for flashing versus non-flashing operating conditions. However, compared to last year, the incremental progress has been somewhat limited. The resolution of this technique is limited. The reviewer questioned if the point of diminishing returns on the capability of this tool has been reached.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that collaboration with ANL gives a very nice synergy to this effort. The reviewer praised the project for using the strengths of the two programs combined to increase the quality and extent of the data.

Reviewer 2:
The reviewer commented that collaboration was not a highlight of this presentation. It was not clear to the reviewer if there are strong collaborations here, nor was it clear if the modeling community can make good use of the neutron imaging data. The reviewer noted that fuel injection/spray modelers should be interested, and so should modelers of particulate filters and regeneration but the presenter did not indicate strong collaborations in these areas.

Reviewer 3:
The reviewer noted that collaboration should be sought with more fuel injector suppliers like Bosch or Delphi as they know the issues needing to be solved in detail and stand to benefit the most, indirectly impacting the OEMs.

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

Reviewer 1:
The reviewer noted that the proposed future work seems to address deficiencies that the reviewer has mentioned in earlier comments. The project will strengthen collaboration with modelers, and work will progress toward the study of interesting scientific problems such as multiple injections and gasoline soot versus diesel soot.

Reviewer 2:
The reviewer noted that the project has a good plan for carrying this work forward and expanding the reach of the work.

Reviewer 3:
The reviewer commented on the need to include efforts to increase the flux for the fuel injector tests in order to improve resolution.

Reviewer 4:
The reviewer stated that discussions should be initiated with fuel injector and particulate filter suppliers to know their critical issues with these parts.

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

Reviewer 1:
The reviewer commented that this project is an excellent of example of a using a unique national laboratory capability to make measurements and generate new knowledge about fundamental phenomenon that industry would like to know and yet does not have the resources to pursue.

Reviewer 2:
The reviewer noted that improved understanding of particulate filter behavior can help engine designers improve engine efficiency.

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

Reviewer 1:
The reviewer noted that the project team is dealing with the reduced financial resources well and that more support would be nice, of course.

Reviewer 2:
The reviewer commented that this is a low-budget project, particularly compared to the efforts using X-ray imaging at ANL and optical diagnostics of fuel sprays at SNL. The reviewer stated that the information that could be gained in this project is complementary to those efforts, and appears to need more resources to accomplish more.

Presentation Number: acs054
Presentation Title: Rapid Compression Machine Studies to Enable Gasoline-Relevant Low-Temperature Combustion
Principal Investigator: Scott Goldsborough (Argonne National Laboratory)

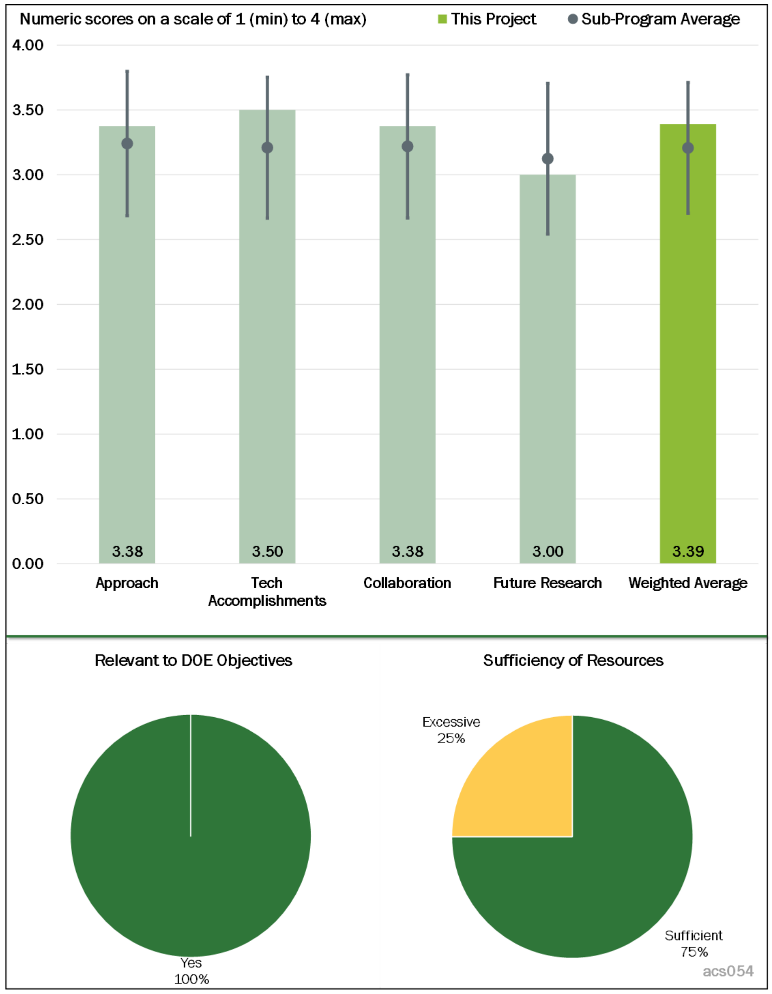

Figure 1-22 - Presentation Number: acs054 Presentation Title: Rapid Compression Machine Studies to Enable Gasoline-Relevant Low-Temperature Combustion Principal Investigator: Scott Goldsborough (Argonne National Laboratory)

Presenter

Scott Goldsborough, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that the project is well-designed and well-integrated with other efforts (academia, national laboratories, and industry) that investigate LT combustion using gasoline fuels.

Reviewer 2:

The reviewer commented that fundamental data are critical to develop/validate/refine chemical kinetic and relevant models for transportation-relevant fuels at conditions representative of advanced combustion regimes. An RCM is an excellent tool to do this work. The work is aligned well with other projects, such as ACS013. The PI also put a tremendous amount of efforts to organize the RCM workshop, which is critical to expanding understanding of RCM and providing high-fidelity RCM data. The reviewer found that, overall, the project is well designed, feasible, and integrated with other efforts.

Reviewer 3:

The reviewer noted that data of ignition delays expand from 3-100 ms. The reviewer remarked many important engine combustion chemistries take place in real life at approximately the 0-2 ms range, and cycles can be completed in 20 ms. Whereas pressure and temperature regimes are matched, the time scales appear to be significantly slower. The author explained the need for regions where fidelity can be attained, whereas data may be extrapolated. Still, it would be of interest to understand better this gap. The reviewer noted that variability in the machine at times below 2 ms should be fixed.

Reviewer 4:

The reviewer asked if upgrades were made to track piston location and improve operation of the RCM, does this make previous data suspect. The reviewer also questioned how fuels are chosen.

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

Reviewer 1:
The reviewer praised the project for excellent outcomes. The reviewer noted that the project is important for the great effort done to correctly determine the differences in results between experiments and models. The work is extremely important for the development of chemical kinetic models at conditions representative of modern combustion strategies. The reviewer commended the PI for his involvement in organizing the RCM workshop.

Reviewer 2:
The reviewer commented that good progress was made to measure ignition delay (ID) of gasoline/ethanol blends and map combustion regimes. The reviewer complimented the project team for excellent work in organizing the RCM workshop.

Reviewer 3:
The reviewer noted that the project provides important data of auto-ignition behavior of full boiling range fuels with surrogates (aphthenes) and ethanol mixtures. The reviewer requested that the figures on Slide 10 (ID labels a and b should be explained).

Reviewer 4:
The reviewer commented that it is important to support data that feeds kinetic models at Lawrence Livermore National Laboratory (LLNL). The reviewer questioned if the project team was working on problems most relevant to LLNL.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that the project shows very good collaboration and coordination with the other national laboratories and industry partners. The reviewer suggested that the project team also interact more with universities that have common research interests outside the RCM workshop. The reviewer thought this is extremely necessary under current budgetary restraints.

Reviewer 2:
The reviewer commented that the project was well connected with CRC and provided data for LLNL for model validation. The reviewer stressed again the excellent work done in organizing the RCM workshop.

Reviewer 3:
The reviewer stated that the work on the consolidation of data across multiple RCM machines is welcome. The reviewer commented that the presentation could have explained practical insights (if any exist) where the gaps were closed.

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

Reviewer 1:
The reviewer noted that the project work is outlined. The reviewer commented that there could have been more description on Slide 25 of the work such as what “individual components” are being planned for testing, what “various techniques” are being planned, what “surrogate blends,” and what “engine conditions.”

Reviewer 2:
The reviewer commented that the accurate ignition delay measurements at conditions representative of advanced combustion strategies are very important for both fundamental and applied engine work. The reviewer observed that future research will continue the PI's excellent work on helping the industry to implement advanced combustion concepts to real engine/vehicle applications via improved engine simulations. The reviewer noted that if the budget is further reduced, it will affect project outcome.

Reviewer 3:
The reviewer noted that the future plan is well designed to provide more data for model validation. The reviewer questioned in addition to ID measurement and intermediate speciation, what else RCM can do to advance our knowledge of the combustion in ICEs and ultimately advance engine technology.

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

Reviewer 1:
The reviewer stated, yes, the work will positively impact DOE objectives.

Reviewer 2:
The reviewer commented that the project is well-aligned with DOE objectives of improving efficiency and emissions in the transportation sector.

Reviewer 3:
The reviewer stated, yes, this project supports the overall DOE objectives of petroleum displacement. Providing high-fidelity experimental data for validating and refining chemical kinetic models is critical to better design high-efficiency and clean combustion engines, which will reduce petroleum demand.

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 novel, experimental work requires a steady stream of funding and commended the PI for such good work considering the budget limitations.

Reviewer 2:
The reviewer stated that it seems adequate.

Reviewer 3:
The reviewer stated that resources are sufficient.

Presentation Number: acs056
Presentation Title: Fuel-Neutral Studies of Particulate Matter Transport Emissions
Principal Investigator: Mark Stewart (Pacific Northwest National Laboratory)

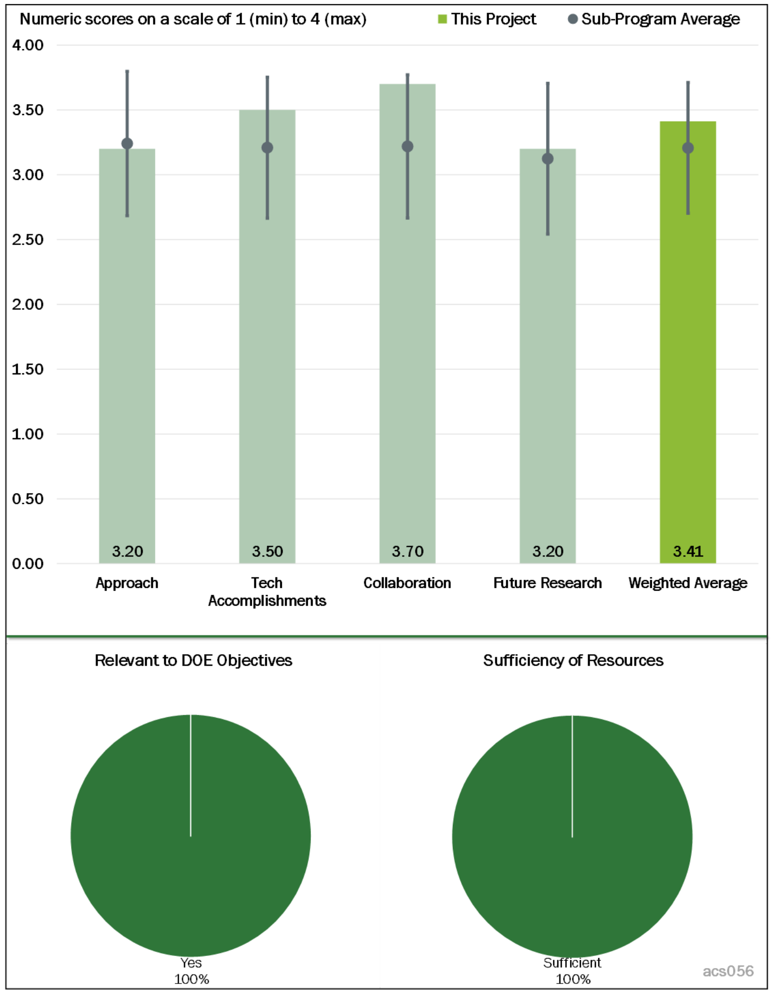

Figure 1-23 - Presentation Number: acs056 Presentation Title: Fuel-Neutral Studies of Particulate Matter Transport Emissions Principal Investigator: Mark Stewart (Pacific Northwest National Laboratory)

Presenter

Mark Stewart, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented on the strong approach to the work, good collaboration with Wisconsin and Massachusetts Institute of Technology (MIT), great progress in converting the spherical unit collector model to the constricted tube model, and in investigating the geometrical pore networks.

Reviewer 2:

The reviewer commented that the researcher used a large number of approaches to determine flow path tortuosity and void volume. This is a good fundamental research project

Reviewer 3:

The reviewer stated that the approach of characterizing the particles and filter porosity and then correlating this to filter performance is generally excellent. The extension into modeling is worth a try to help hasten material development. This may minimize the need to make filters to test compositions. The reviewer was impressed with the wide range of analytical tools that are being used. The reviewer cautioned that the team needs to be cognizant that fresh filters are applicable only for the first thousands of miles, and then ash begins impacting efficiency and back pressure.

Reviewer 4:

The reviewer stated that the approach looks good from the fundamental experiments (spark ignition direct injection [SIDI]) particulate characterization, filter characterization and exhaust measurements) to the improved filter models.

Reviewer 5:
The reviewer noted that it is not clear how this project is going to address all the barriers listed. The project addresses filter technology but no path is shown to save cost. Emissions data on a SIDI engine were mentioned yet no connection was made to improved filtration ability or if a filter is still needed. Existing filters were characterized and modeled. The reviewer asked what follows once the project team has a model.

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

Reviewer 1:
The reviewer commented that the technical work on filter characterization is nice and detailed.

Reviewer 2:
The reviewer noted that the technical accomplishments were presented well.

Reviewer 3:
The reviewer observed that the model is coming along very well

Reviewer 4:
The reviewer noted that the team is certainly pushing the analytical technology to new horizons with this world class work. The capillary flow porometry versus mercury intrusion porosimetry work is interesting and yielding results. The reviewer is anxious to see how ash affects these. The reviewer commented that the pore model development is also bearing fruit, with correlations between pore diameter and throat diameter for the different compositions and then correlating this to back pressure. This is very critical and probably more important than initial filtration efficiency in application. The lattice-Boltzmann simulations are also now being applied by corroborating them with observations and pulling in permeability. With all these tools and results, the reviewer expressed interest in a summary of how all this fits together in a story (i.e., back pressure is impacted by [pore or throat] diameter, but this shifts with catalyst loading, ash, etc.). The reviewer would like to know what the best compromise is of the trade-offs.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that the team of UW-Madison) and MIT is extremely impressive.

Reviewer 2:
The reviewer noted the excellent interaction between PNNL, GM, UW-Madison, and MIT has allowed for great progress in the past year.

Reviewer 3:
The reviewer commented that the collaboration between PNNL, GM, UW-Madison, and MIT is evident.

Reviewer 4:
The reviewer noted that the results and direction show that good collaboration is accomplished. As the project team is now getting into catalyzed filters, some consultation with catalyzers may be beneficial.

Reviewer 5:
The reviewer noted good collaboration with GM, UW-Madison, and MIT.

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 looks forward to seeing the model in its final form

Reviewer 2:
The reviewer noted that the project had a good plan for moving forward and continuing to improve modeling. The reviewer was looking forward to the eventual inclusion of the reaction kinetics for regeneration being incorporated into the model.

Reviewer 3:
The reviewer recommended that the study include both uncatalyzed and catalyzed filters.

Reviewer 4:
The reviewer commented that extending the testing to LT and HT seems reasonable. Model improvement is needed with extensions into different catalyst, ash, and soot loadings. The reviewer noted that one consideration will be to look at gaseous impacts; for example, how pore structure affects back diffusion of NO_2 in a catalyzed soot filter or SCR filter. SCR filters are emerging and significantly degrade passive regeneration. This can be partially remediated with catalyst architecture, such as putting the catalyst on the exit wall.

Reviewer 5:
The reviewer questioned next steps once the project team has data on existing filters and an improved model. The reviewer asked if any of this work helps us design lower backpressure, higher efficiency filters, or will it help us with new technology to avoid conventional filters on gasoline vehicles.

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

Reviewer 1:
The reviewer commented, yes, improving catalyst efficiency promotes better fuel efficiency.

Reviewer 2:
The reviewer noted that it is conceivable that all engines will have filters and filters can have a big impact on engine efficiency. This team is developing fundamental knowledge to help.

Reviewer 3:
The reviewer commented that it is unfortunate that future, more fuel-efficient engines may require filters that put backpressure on the engine, negating part of the fuel efficiency.

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

Reviewer 1:
The reviewer commented that resources seem tight, but the team has delivered excellent value.

Reviewer 2:
The reviewer commented that the resources seem appropriate.

Presentation Number: acs075
Presentation Title: Advancements in Fuel Spray and Combustion Modeling with High-Performance Computing Resources
Principal Investigator: Sibendu Som (Argonne National Laboratory)

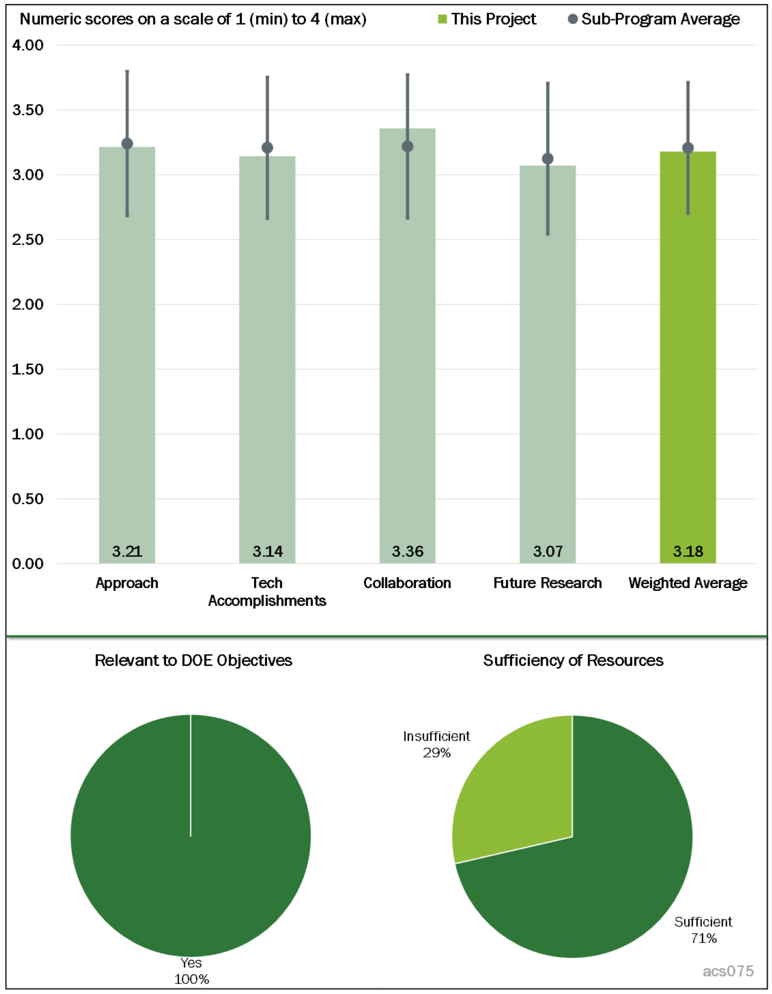

Figure 1-24 - Presentation Number: acs075 Presentation Title: Advancements in Fuel Spray and Combustion Modeling with High-Performance Computing Resources Principal Investigator: Sibendu Som (Argonne National Laboratory)

Presenter
Sibendu Som, 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, feasible, and integrated with other efforts.

Reviewer 1:
The reviewer commented that the project addresses a wide range of elements to improving in-cylinder processes in combustion engines. Included are incorporation of detailed kinetic mechanisms and HPC tools related to spray processes. The PI wants to move away from tuning exercises that will match experimental data, which is good. The framework is the code CONVERGE, which is extensively used by OEMs. A "one-way" coupling approach is employed that will allow near nozzle simulations to be coupled with nozzle flow simulations.

The PI covers a lot of bases and is to be commended for attempting to bring a lot of elements together that will result in a robust and improved code for engine performance prediction (perhaps too much, or perhaps the project should be more focused). The reviewer stated that this is a very good project.

Reviewer 2:
The reviewer stated that the project is well-designed and well-integrated with other efforts (academia, national laboratories, and industry) that investigate fuel spray and combustion modeling.

Reviewer 3:
The reviewer commented that the overall approach for engineering best practices for the industry are helpful for optimization of the engine analysis work flow.

Reviewer 4:
The reviewer stated that, overall, plan and efforts are well organized towards the identified barriers. It is nice to see that analysis is leading the effort around to address physics and deepen understandings.

Reviewer 5:
The reviewer commented that the approach involves developing spray and combustion models and validating and improving the models against ECN and other available engine data.

Reviewer 6:
The reviewer commented that the approach of incorporating more detailed chemistry into the combustion model and the use of LES one-way coupling for nozzle and spray seems very reasonable. The reviewer also noted that it was good that the model predictions are compared to experimental data.

Reviewer 7:
The reviewer noted that the quality of the work, tools, and documentation process is very high. The reviewer stated that the driving factors for such an in-depth focus on phenomena such as hole-specific differences are unclear. The question arises because there is no foundation given of typical deviations in modern hardware, how dependent this is on injector design configuration, and very importantly what effect these deviations have on combustion performance. The reviewer continued stating that there are a number of other unexpected approaches on key parts of the work, such as the work presented under "extensive" validation of a thickened flame model (TFM). It is unclear why the project team chose the optical engine data with methyl decanoate fuel for validation. The reviewer asked why the choice of this fuel, why the choice of a two-hole injector and the very unusual HRR rate. There are many more applicable test data available of interest to the combustion community.

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

Reviewer 1:
The reviewer noted that the project followed its milestones as much as the budget allowed it. The reviewer commended the PI for the excellent work done in modeling the fuel spray under conventional and advanced combustion conditions.

Reviewer 2:
The reviewer stated that technical accomplishments are made using one code from a CFD vendor. The reviewer noted that it will be beneficial for DOE goals to assess codes such as KIVA-hpFE technical capability and provide feedback for overall development.

Reviewer 3:
The reviewer noted that very good progress has been made; milestone 1 is complete and milestone 3 is 60% complete.

Reviewer 4:
The reviewer commented that good progress had been made in modeling individual flow and spray differences in a multi-hole gasoline injector. The reviewer observed that spray simulations can better predict SNL entrainment and collapse data with the exception of higher temperature evaporation data. TFM combustion model was exercised for LTC. The reviewer also commented on LES modeling with a four-component diesel surrogate mechanism.

Reviewer 5:
The reviewer noted that the 2017 milestones included validating one-way coupling against diesel and gasoline nozzle flow in collaboration with a CRADA with Cummins and CSI, as well as simulating performance of a

four component diesel surrogate kinetic mechanism. The reviewer commented that this component is apparently not yet completed. The reviewer recommended that the PI should provide some discussion of precisely what the PI means by “validation.” Precisely what is being compared to simulation and when is the difference sufficiently small that the PI will conclude that the code has been “validated.” The reviewer noted that a surrogate is being simulated and that this is a miscible mixture. The reviewer recommended that some discussion of the properties used in the simulation be included in future presentations as well as how the mixture properties were estimated. The reviewer asked what, specifically, are the properties of interest, especially relevant to a spray (e.g., surface tension, viscosity, etc.). The reviewer observed that this is a multicomponent problem and would not seem to be trivial. The reviewer noted that an ECN injector is employed in the nozzle flow simulation. The reviewer questioned what the ECN brings to this problem and who supplied the injector. The reviewer noted that the plume cone angle was simulated and the results look impressive when compared to photographic visualization. The reviewer asked if the PI has more quantitative comparison beyond the qualitative comparisons shown. The reviewer noted that a high-fidelity turbulence model based on LES is being used to predict liquid penetration. The reviewer questioned how this approach compares to the RAPTOR simulations being done at SNL and if there is collaboration between ANL and the SNL group that is doing a first-principles approach to the spray injection problem. The reviewer noted that the simulations also cover situations where flash boiling is occurring for an iso-octane/ethanol blend. The reviewer recommended that this problem be further discussed in future presentations including the criteria for flash boiling and the physics involved. The reviewer concluded stating that the accomplishments include comparisons of ignition delay between the experiment and the simulation. The PI notes that the comparisons shown prove that the simulations have been validated against the experiment. However, at lower ambient temperatures (less than 1,000 Kelvin [K]) and O_2 concentrations this does not seem to be the case, or perhaps the PIs notion of validation is very liberal.

Reviewer 6:

The reviewer noted nice progress overall. But, it is not very clear if the achievements are being made in a timely manner. It would be nice to have a high-level road map of the development. The reviewer suggested that the project team create a table showing a table of milestones in a long run, perhaps for 3 years or so. In that way, the community can easily figure out the way forward and direct the effort. Also, it is not very clear what exactly ANL’s role in the project is. The reviewer posited model development, or running the calculations, or organizing the overall progress. The reviewer requested that the project team please elaborate in more detail.

Reviewer 7:

The reviewer observed that the project is working on important sub-model development, studying the impact of grid size, development of tabulated flamelet and homogenous reactor models for turbulence-chemistry interaction, and in-nozzle flows and spray models. The reviewer noted that the work reported is rather extensive and there is a lot of information provided. How it will impact real world simulation or faithful prediction is a big question for this reviewer. One-way coupling allows the differentiation over individual nozzle holes and the report highlights back flow of chamber gases into a gasoline injector counter-bore. The reviewer stated that it is unclear how significant this is in real life, or how necessary it is, or how it would be incorporated and used in standard tools. LES was used to capture the collapse of GDI sprays, and this is another example of a very particular situation that may not be very universal.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the project had a good group of collaborators. The Virtual Engine Research Institute and Fuels Initiative (VERIFI) workshop is a very good initiative.

Reviewer 2:
The reviewer commented that the PI is an example of collaboration with academia, national laboratories, and industry.

Reviewer 3:
The reviewer observed collaboration with some engine manufacturers (Cummins and GM), the members of CRC AVFL-18a project, the participants in the VERIFI workshops, software developers, universities, and other national laboratories were mentioned.

Reviewer 4:
The reviewer noted that regular collaboration exists with other laboratories, universities, Convergent Science, and industry.

Reviewer 5:
The reviewer noted that this project is collaborating with other institutions and universities for research and experimental data.

Reviewer 6:
The reviewer observed that the team is well organized with necessary expertise around. It has been pointed out several times that having a single software vendor as a partner might be limiting opportunities of impact. The PI illustrated the project team's effort to extend an invitation for collaboration in that regards, which is nice but needs to be pushed again.

Reviewer 7:
The reviewer noted that BES is noted among the leveraging collaborations. The reviewer questioned what they are providing to the project.

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

Reviewer 1:
The reviewer noted that the project plans to continue to extend models to multicomponent mixtures, to extend the one-way coupling approach and coupling with TFM, and to validate the four-component surrogate model against experimental data seem reasonable.

Reviewer 2:
The reviewer commented that the proposed work on uncertainty analysis will be beneficial for industry partners with engine development and calibration.

Reviewer 3:
The reviewer commented that future research will continue the PI's excellent work on translating advanced combustion concepts to real engine/vehicle applications via state-of-the-art engine models. The reviewer cautioned that if the budget is further reduced it will likely affect project outcome.

Reviewer 4:
The reviewer noted that all of the future work proposed is relevant. However, plans should be made to continue to model all the issues around multi-hole gasoline spray collapse in conjunction with the experimental work at SNL.

Reviewer 5:

The reviewer commented that future work seems reasonable. The reviewer encouraged the PI to devote more discussions to the notion of validation and articulate regions where agreement is good and where it is not and what the strategy going forward would be to close the gaps. The reviewer observed that the list of future tasks mentions validating a four component diesel surrogate against the TFM for a constant volume combustion and optical engine. This approach would seem to only be valid if either of these configurations can be simulated with a first-principles (*ab-initio*) approach (no tunable constants). The reviewer noted that it is not clear if this is the case at this stage and requested that the project team please elaborate.

Reviewer 6:

The reviewer noted that the project could use more guidance from expert OEM representatives or subject experts to align the LAB capabilities towards challenges and barriers that are more closely tied to the roadmap to more efficient and clean combustion. The reviewer recommended that the team align the work with data that show sensitivity to the issues studied. This may require a relook at the work scope.

Reviewer 7:

The reviewer observed that it seems that the plan needs a better road map. It is getting a little difficult to figure out the focus. The reviewer asked how the PI is going to prioritize the tasks.

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

Reviewer 1:

The reviewer stated that the project is well-aligned with the DOE objectives of improving the efficiency and emissions in the transportation sector.

Reviewer 2:

The reviewer observed that this project does support overall DOE objectives of petroleum displacement through collaboration with industrial partners and transfer of engineering best practices.

Reviewer 3:

The reviewer commented that working on a more predictive analytical tool definitely assists in the quick development of fuel efficient engines.

Reviewer 4:

The reviewer commented that improved spray and combustion models lead to more accurate, robust models needed for faster development of higher efficiency, lower emissions engines.

Reviewer 5:

The reviewer stated that fundamental understanding of the injection process is key for optimized engine design.

Reviewer 6:

The reviewer answered, yes, from a broad perspective and noted that this work is very much needed. The PI is doing a lot and should be commended. The reviewer expressed concern that too much is included in the project that defocuses the impact.

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

Reviewer 1:

The reviewer noted that the PI's work requires a steady stream of funding. The reviewer commended the PI for such a good work considering the budget limitations.

Reviewer 2:
The reviewer commented that the resources allocated for the project are sufficient because this project leverages other projects.

Reviewer 3:
The reviewer observed that milestones are being met on a timely basis, so there is no indication that resources are not appropriate.

Reviewer 4:
The reviewer stated that resources seem adequate although ultimate judgement would have to come from a cost/benefit analysis based on DOE's investment relative to the commercialization potential.

Reviewer 5:
The reviewer stated that the project team needs better direction from OEM subject experts to define the areas of research that can make significant impacts to higher efficiency and clean engines.

Reviewer 6:
The reviewer commented that, frankly, the information presented is not sufficient to make a judgement, because the roles and the scope of work between collaborating partners is not well understood. For example, if ANL is developing the model, the reviewer asked why it was not included on the collaboration slide.

Presentation Number: acs076
Presentation Title: Improved Solvers for Advanced Engine Combustion Simulation
Principal Investigator: Matthew McNenly (Lawrence Livermore National Laboratory)

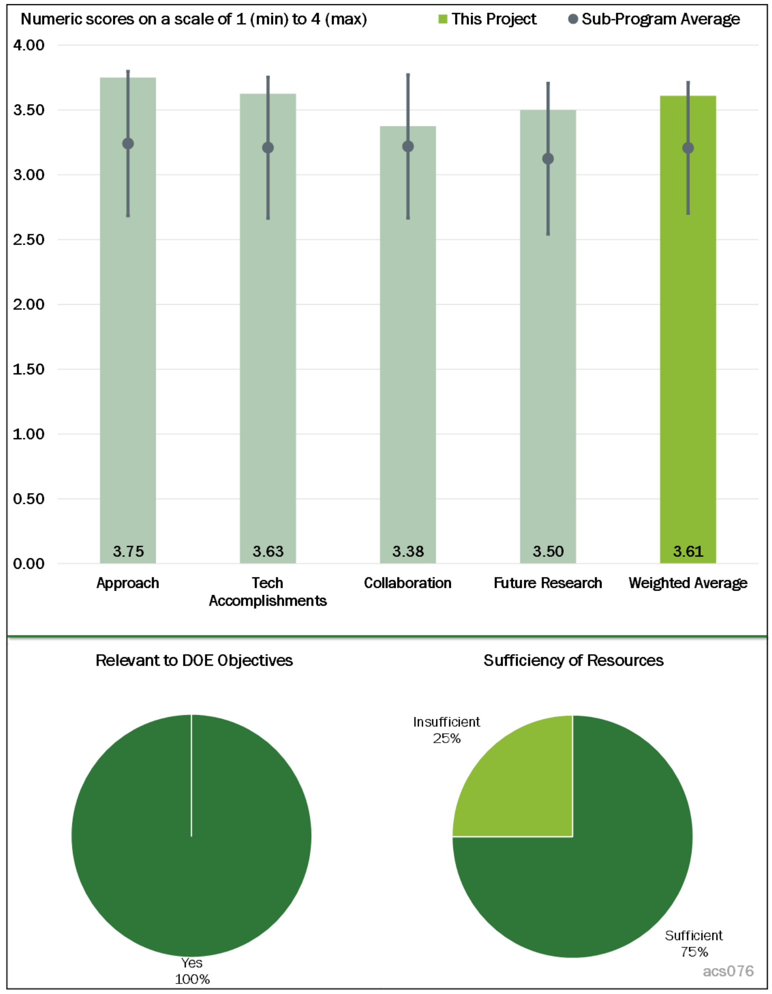

Figure 1-25 - Presentation Number: acs076 Presentation Title: Improved Solvers for Advanced Engine Combustion Simulation Principal Investigator: Matthew McNenly (Lawrence Livermore National Laboratory)

Presenter

Matthew McNenly, Lawrence Livermore National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the approach to reduce the computational cost associated with chemistry solvers is very promising. This research will have enormous impact as more simulations are being done with detailed chemical kinetics involving thousands of reactions.

Reviewer 2:

The reviewer commented that the technical barriers are clearly identified and addressed. It is clear that exploration of new combustion regimes is often attempted with computational methods and its accuracy is dependent on the computational cost due to the depth of physics included. In the era of optimizing fuel properties as well as engine hardware, it becomes ever more important to speed up the solver. The project team's work is sharply focused on the topic in that regard.

Reviewer 3:

The reviewer commented that the web based tool to diagnose simulation errors is good.

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

Reviewer 1:

The reviewer noted that overall project progress towards extending the Zero-order Reaction Kinetics chemistry solver to more applications impacting VTO research has been promising.

Reviewer 2:
The reviewer commented that it appears that more effort has been put towards validation of the tool over applications and making the tool available to public.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that collaboration and coordination mentioned in the presentation with industry, academia, and national laboratories has been exemplary.

Reviewer 2:
The reviewer observed a lot of evidence indicating good collaboration; the results are being used by a number of projects.

Reviewer 3:
The reviewer noted that it would be ideal to contact multiple software vendors for the solver implementation and utilization for the maximum impact.

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

Reviewer 1:
The reviewer noted that joint sensitivity for rapid reaction rate screening is promising. The reviewer questioned if this sensitivity could be developed into a library with the capability of being coupled with any general purpose CFD code. The reviewer observed that the detailed spray dynamics with reduced computational cost proposed in FY 2018 and beyond will have great impact on engine modeling accuracy.

Reviewer 2:
The reviewer noted that publishing a web based tool to diagnose simulation errors looks promising.

Reviewer 3:
The reviewer commented that while high-level targets are well poised, details of the plan are not well illustrated. The reviewer questioned if the author was planning to check and improve all the numerical scheme of software or is the improvement to be done for a single platform.

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

Reviewer 1:
The reviewer commented that this project supports overall DOE objectives by increasing the speed and accuracy of various VTO modeling efforts.

Reviewer 2:
The reviewer observed that the goal of this project is speeding up the numerical solver for faster turnaround to explore better engine design with less fuel consumption. The savings of computational time itself (power consumption/design evaluation) also saves energy.

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

Reviewer 1:
The reviewer noted that additional information would be useful.

Reviewer 2:

The reviewer commented that proposed future research work is ambitious with the resources requested. The reviewer suggested that progress can be made by leveraging research with other initiatives mentioned in the study.

Reviewer 3:

The reviewer commented that combining with ACS012 and sharing the budget will inhibit project deliverables.

Presentation Number: acs084
Presentation Title: Advanced Ignition Systems for Gasoline Direct Injection (GDI) Engines
Principal Investigator: Riccardo Scarcelli (Argonne National Laboratory)

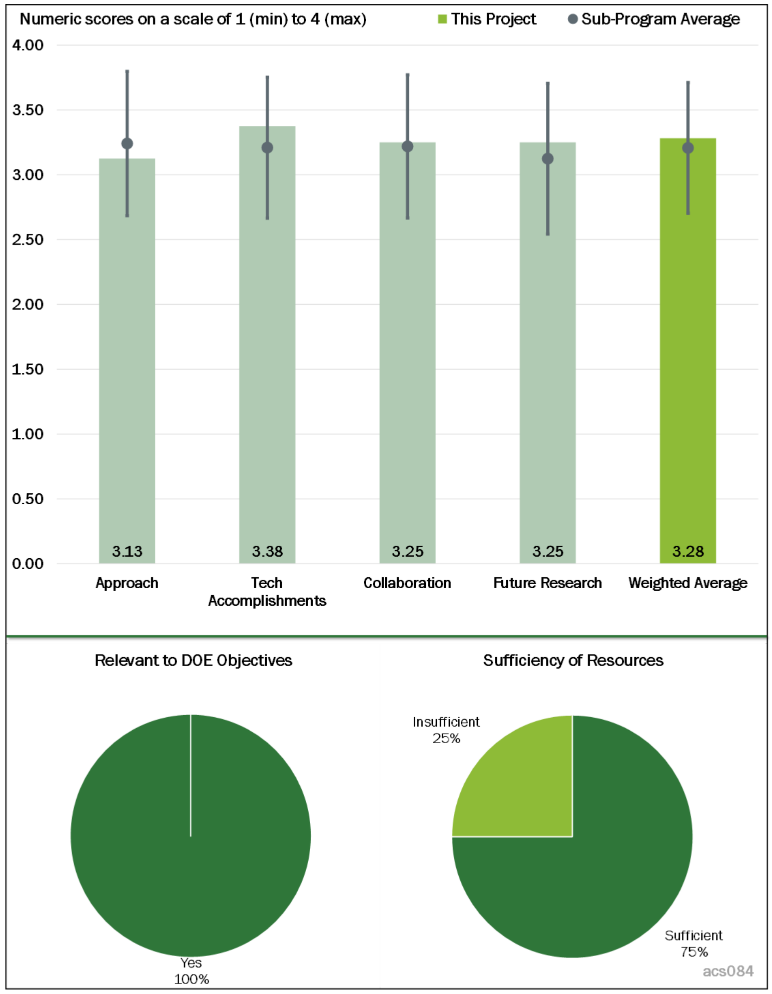

Figure 1-26 - Presentation Number: acs084 Presentation Title: Advanced Ignition Systems for Gasoline Direct Injection (GDI) Engines Principal Investigator: Riccardo Scarcelli (Argonne National Laboratory)

Presenter

Riccardo Scarcelli, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the work being done in this project regarding the ignition systems is unique and needs to be accelerated as the automotive industry moves towards GDI, downsizing displacement, and boosting with a turbocharger.

Reviewer 2:

The reviewer stated that the approach of comparing model predictions to experimental data were good.

Reviewer 3:

The reviewer stated that this was an effective coupling of experimental and modeling efforts.

Reviewer 4:

The reviewer mentioned that this approach uses CFD modeling of the arc and plasma to understand the physics. The experimental learnings are being captured in the code.

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

Reviewer 1:

The reviewer stated that the project's technical progress appears to be good. The milestones up through March 2017 have been completed (the next milestone dated June, 2017 is listed as "on-track").

Reviewer 2:
The reviewer commented that progress has been made in modeling conventional arcs as well as non-equilibrium plasmas. The effect of laser ignition location has also been evaluated.

Reviewer 3:
The reviewer wondered if non-equilibrium plasma modeling that requires expensive chemistry could use some of the advanced solvers from project ACS012 or ACS076 to reduce the overall computational cost.

Reviewer 4:
The reviewer stated that there should be additional efforts on laser ignition, funding permitting.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer commented that the existing collaboration with Ford and relevant ignition companies was good.

Reviewer 2:
This review noted that it looks like more collaboration has been initiated with the automakers (Ford and USCAR mentioned) in response to issues raised last year by evaluators and reviewers.

Reviewer 3:
The collaboration with Sandia National Laboratories appears effective to this reviewer.

Reviewer 4:
This reviewer pointed out that for computational efficiency, the PI may need to collaborate with the LLNL algorithm investigators.

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

Reviewer 1:
The reviewer stated that further understanding of the ignition process is key to LD efficiency, especially as dilution increases (lean and/or EGR).

Reviewer 2:
The reviewer commented that proposed future work in FY 2018 to build/validate a comprehensive ignition model accounting for different plasma technologies/characteristics is reasonable provided that plasma technologies continue to offer promise as improved ignition systems.

Reviewer 3:
The reviewer questioned whether the proposed work in FY 2018 for cyclic variability requires LES. If yes, that can add significant computational cost to the already expensive chemistry for plasma modeling.

Reviewer 4:
The reviewer questioned if the proposed work will have an impact in removing barriers to high-dilution engines.

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

Reviewer 1:
The reviewer noted that the ignition system is novel and advanced for GDI engines and has the potential to improve engine efficiency which supports DOE objectives.

Reviewer 2:
The reviewer commented that the project supports the overall DOE objectives of petroleum displacement by performing research related to various ignition technologies.

Reviewer 3:
The reviewer stated that ignition is still key in multi-mode LTC or dilute combustion.

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 modeling efforts should be accelerated.

Reviewer 2:
The reviewer stated that milestones are being met in a timely manner, which suggests that the resources are sufficient.

Presentation Number: acs085
Presentation Title: Low-Temperature Emission Control to Enable Fuel-Efficient Engine Commercialization
Principal Investigator: Todd Toops (Oak Ridge National Laboratory)

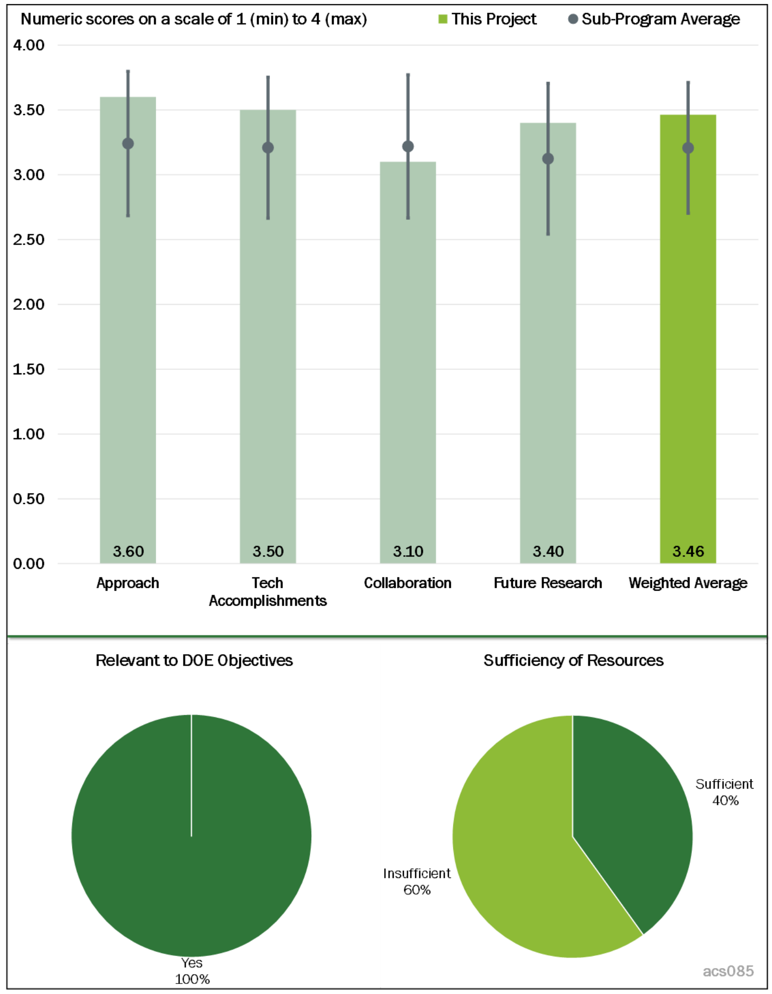

Figure 1-27 - Presentation Number: acs085 Presentation Title: Low-Temperature Emission Control to Enable Fuel-Efficient Engine Commercialization Principal Investigator: Todd Toops (Oak Ridge National Laboratory)

Presenter
Todd Toops, Oak Ridge National Laboratory

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

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

Reviewer 1:
The reviewer observed that this project has an excellent approach in collaborating with universities and scientists funded through BES. The reviewer stated that this is a great way to leverage funding to learn fundamental information regarding applied systems.

Reviewer 2:
The reviewer noted that the four-pronged approach of optimizing conventional catalysts, exploring fundamentals, taking novel approaches (PGM-free), and incorporating traps is yielding interesting results using the LT test protocol. The reviewer expressed that looping back to real-world exhaust is missing, wherein checks with actual exhaust might be prudent before focusing on any given formulation.

Reviewer 3:
The reviewer noted that the project approach is comprehensive, involving many key steps, such as support modification, trapping material development, and PGM-free mixed metal oxides. The reviewer went on to state that aging impact needed to be addressed. For example, the results shown in Slide 16 indicate that meeting 150^{0}C target is also challenging for all other species shown in the plot after 800^{0}C 10 hours aging in addition to propane because T90 points moving to right direction, or higher temperature is quite evident.

Reviewer 4:
The reviewer expressed that the multi-laboratory and university approach is a great way to leverage resources, equipment, and expertise. The reviewer stated that it seems to have high organizational overhead—in terms of team meetings and especially at the AMR, where the reviewers could only get the briefest of overviews into the six projects covered by this talk. The reviewer expressed that all of the projects in this section are focused

and on highly important topics. The reviewer went on to state that none of these fuels or combustion concepts is deployable without meeting emissions so the emissions control is therefore a key area.

Reviewer 5:

The reviewer stated that the approach is appropriate.

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

Reviewer 1:

The reviewer commented that advances are being accomplished on all fronts, with the silicon dioxide-zirconium dioxide shell and core design still showing the best results. However, the reviewer stated that after all this effort the T90 goal is still approximately 50^{0}C away with diminishing returns. The reviewer went on to say that there seems to be some potential here if the different approaches are integrated.

Reviewer 2:

The reviewer noted that several of these projects were on-going and re-branded as co-optima, so there is very good progress under the relatively young co-optima banner. The reviewer observed that the interaction between the fuels, emissions, and emissions control catalysts is key to evaluating the future of the fuels.

Reviewer 3:

The reviewer was unsure whether 800°C aging for 10 hours is the right aging criteria, and referenced Slide 16, but noted that this was different from Slides 7 and 8. The reviewer suggested making the aging criteria and protocol clearer.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer acknowledged that this is a complex but well-managed project with a diverse set of players. The reviewer commented that the collaborations will be tested when integrated approaches are implemented.

Reviewer 2:

The reviewer acknowledged the good inter-lab collaboration, but would like to see more work with university and industry stakeholders.

Reviewer 3:

The reviewer noted that the university partner used 700^{0}C aging for 100 hours. The reviewer suggested seeing how the project can share the results or show how these worked together to summarize the results.

Reviewer 4:

The reviewer noted that the lack of industry support makes the program less valuable in terms of DOE program objective.

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

Reviewer 1:

The reviewer remarked how no single approach is getting the project to its goals. The reviewer would like to see further integration of the varied approaches here. An illustrative example is using the strong electrostatic adsorption PGM application on the ZrO_2-SiO_2 shell and core catalyst, layered with the co-precipitated CuO_X, CoO_y, and CeO_2 catalyst and trapping materials. The reviewer recommended that the project pick its best shots and begin to move in this direction. Tweaking of formulations along the way will likely be needed. The reviewer suggested that the project consider looping back with real exhaust and S tolerance before going too far down this path. Also, as any lean NO_x approach will need NO_x aftertreatment, the reviewer recommended that the project consider nitrogen dioxide (NO_2) more seriously. Finally, the reviewer recommended that the project look at exotherm impact with faster ramp or test cycle simulation.

Reviewer 2:

The reviewer suggested adding engine aged catalysts to the study. The reviewer noted that this would be valuable as engine aging deactivates the catalyst radially.

Reviewer 3:

The reviewer noted that the project's future directions are stated in Slide 25. The reviewer expressed a desire for this project to work more actively with industry.

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

Reviewer 1:

The reviewer stated that the LTC methods are showing the best promise for highly efficient engines, but the project has a LT HC plus CO issue. The reviewer expressed that this project will be very critical to their success.

Reviewer 2:

The reviewer acknowledged that improving catalyst performance yields better fuel economy.

Reviewer 3:

The reviewer remarked yes, if the project can demonstrate the benefits with an engine dynamometer, teaming with a vehicle OEM.

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

Reviewer 1:

The reviewer said that the project should be able to achieve the program goal with the resource it has. Having internal funding to explore potential commercialization is helpful.

Reviewer 2:

The reviewer commented that if the team moves into integration of the best methods, for example into complex layered or zoned catalysts, combined with some engine testing, more resources might be needed. The reviewer stated that $400,000 seems to not be enough.

Reviewer 3:

The reviewer stated that this seems appropriate.

Reviewer 4:

The reviewer warned that more resources are clearly necessary to meet program goals.

Presentation Number: acs092
Presentation Title: High-Efficiency Variable Compression Ratio Engine with Variable Valve Actuation and New Supercharging Technology
Principal Investigator: Charles Mendler (Envera LLC)

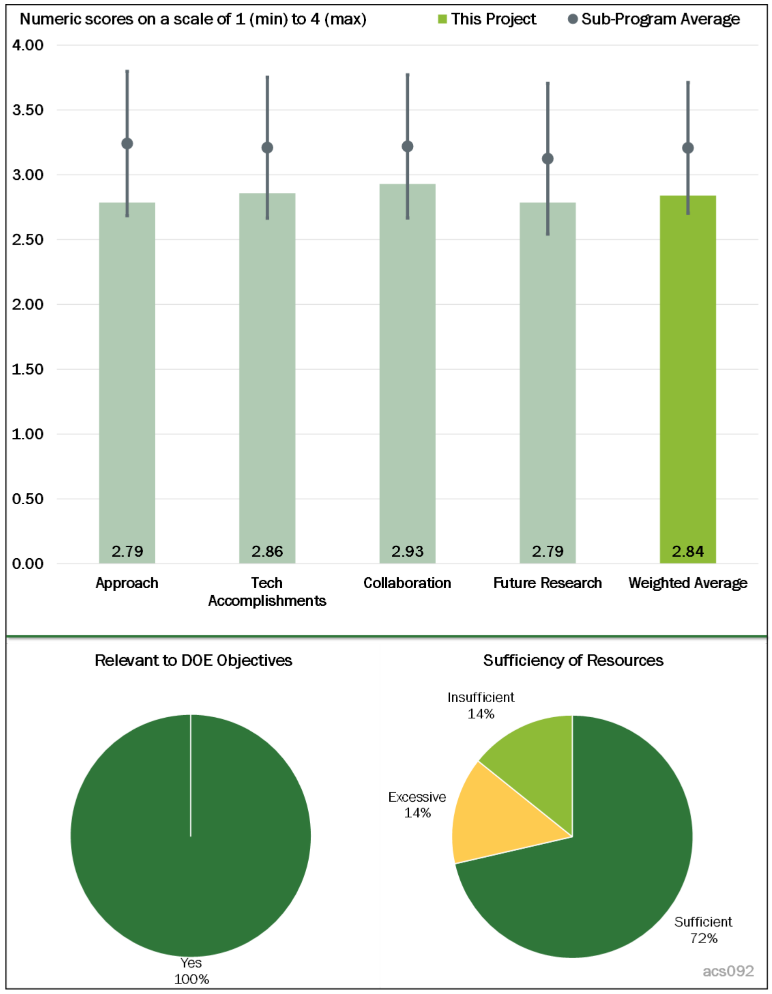

Figure 1-28 - Presentation Number: acs092 Presentation Title: High-Efficiency Variable Compression Ratio Engine with Variable Valve Actuation and New Supercharging Technology Principal Investigator: Charles Mendler (Envera LLC)

Presenter

Charles Mendler, Envera LLC

Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that this is an interesting approach and the researchers have made good progress over the last year. The reviewer acknowledged that the project is just starting its data collection now, so the next year's testing will be critical to the overall assessment of its success.

Reviewer 2:

The reviewer commented that a big concern with variable compression ratio (VCR) engines is long term durability. The reviewer acknowledged that a superficial analysis of this project seems to indicate an attention to high-quality parts. The reviewer warned that it is more difficult to identify a systemic problem which is a major danger here.

With VCR, the reviewer questioned whether the cylinder residual change was appreciably from a non-VCR engine. The reviewer pointed out that this could have an impact on the EGR conclusion.

Reviewer 3:

The reviewer stated that the project within itself is achieving near fuel efficiency goals, but went on to comment that the goals are not exceptionally challenging and could possibly be met with less complex technology.

Reviewer 4:

The reviewer remarked that VCR is a promising technology to improve engine efficiency. However, the reviewer noted that the approach seems heavy, which will impact the actuator power required to change the CR, and the response time to change the CR. The reviewer stated that the impact of response time on engine efficiency over a drive cycle has not been considered and will reduce the improvement from this approach.

Reviewer 5:

The reviewer was concerned that too much emphasis is being spent on convincing others of the benefits of VCR, variable valve actuation (VVA), and boosting to achieve high efficiency. The reviewer would like to see more emphasis on the technical barriers of the VCR mechanism's life expectancy.

The reviewer remarked that a demonstration with 87 octane fuel would be more relevant; that the project is not really finding the real world, knock limiting operation. The reviewer observed that demonstrating high efficiency at part load, with high compression ratio and 93 octane fuel could be done by existing high-performance engines that require premium fuel.

Reviewer 6:

The reviewer observed that the project seeks to use VCR to improve engine efficiency over the operating map by adjusting CR with the Envera designed engine. The reviewer stated that the fundamentals of the approach are sound as combustion efficiency at different loads depends strongly on CR. The design has been implemented to build hardware, and collaborators are evaluating the engine, however, the reviewer commented that there are several aspects of the project approach that could be improved. The reviewer remarked that the engine is operating with port fuel injection when GDI would be more appropriate for improving efficiency relative to existing state-of-the-art. Boosting is also not addressed significantly which also needs to be included for fair comparison to (and advancement from) state of-the-art. Finally, the reviewer stated that the system is complex, and durability needs to be part of the research.

Reviewer 7:

The reviewer was not convinced why this program requires two expensive technologies, VVA and VCR, as a package to achieve the program goal. The reviewer stated that the key is what is next after the end of this program. The reviewer questioned who would potentially use these two technologies for production because of cost and reliability issues for many years to come.

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

Reviewer 1:

The reviewer noted that the engine is built and on a test stand which is a great accomplishment. The reviewer asked what the interim fuel economy and emissions are. The reviewer remarked that this is crucial.

Reviewer 2:

The reviewer acknowledged that the project has made good progress in the past year. The reviewer stated that the project's mechanism integrates nicely into the engine block and tests with statically varied CR give desired results. The reviewer remarked that the real test will be whether these advantages hold up under full dynamic operation of the engine and mechanism. The reviewer looks forward to seeing the project's final results.

Reviewer 3:

The reviewer stated that the project has been successful in buildup of the engine with VVA and VCR and has generated some preliminary data. The reviewer noted that this, in itself, is not a trivial achievement. The reviewer remarked that the project must remember, however, that this team and their VCR approach have gone through a number of iterations over many years.

Reviewer 4:

The reviewer noted that building and testing a prototype engine is no small or easy task, so good progress has been shown towards this and getting measurable data from the engine prototype.

Reviewer 5:
The reviewer remarked that the project does show some impressive progress at the cost of the complicated technologies as a whole, however, it only shows the selected modes. The reviewer noted that it still relies largely on simulation with GT-Power models. The reviewer commented that it would be better if baseline results can be shown for comparisons in its tests results.

Reviewer 6:
The reviewer was expecting to see much more in terms of engine test results given that the project ends this year. The reviewer stated that showing a couple of points running naturally aspirated is not enough to demonstrate that a boosted Miller engine meets the goals or is going to be successful. The reviewer noted that burn rate is slow for a modern boosted engine.

Reviewer 7:
The reviewer remarked that while designs have been implemented in hardware and engine efficiency made, the project has not addressed transient operation to the degree one would expect for a project at this point in the project cycle (last year of a four-year project). The reviewer commented that more results are needed. The reviewer stated that other important data that would be useful for the project to provide would be emissions. The reviewer wondered if there are there emission advantages to the variable compression approach. The reviewer noted that the project is primarily funded by DOE, but no publications are cited in the work. The reviewer commented that Envera owns patents of the technology, but public funding is supporting the research, therefore, the research should be provided to the public in journal or conference papers; even if details related to proprietary design are not included in the publication, the research results on efficiency would be valuable to the public.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that coordinating all of the parts development and delivery with multiple partners is a major challenge. The reviewer remarked that this has been done well.

Reviewer 2:
The reviewer stated that it seems that this project has good participation with appropriate stakeholders.

Reviewer 3:
The reviewer commented that the project has engaged an exceptional test site in Mahle and has received good support from Eaton. The reviewer noted that a missing feature of the project is a side-by-side comparison to one of the other VCR engines or an engine map from one of the other engines. The reviewer said that this project lacks benchmarking other engines (at least this year).

Reviewer 4:
The reviewer stated that this project has a good, well qualified team of Envera, Eaton, and Mahle.

Reviewer 5:
The reviewer remarked that the project seems to have all partners involved in the program.

Reviewer 6:
The reviewer stated that Eaton and Mahle are collaborators/partners on the project and that there are some other smaller industry roles. The reviewer remarked that this project would benefit from an OEM partner who would be the ultimate customer for this technology.

Reviewer 7:
The reviewer stated that listed collaborators are really suppliers.

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

Reviewer 1:
The reviewer stated that at this point in the project the future plans are obvious. The reviewer observes that no major speed bump seems to have occurred which is a testimony to the planning from the prior work on the project.

The reviewer prefers a continuous evaluation of the fuel economy of the engine. The presentation does not really tell the reviewer if the project has reached its goals.

Reviewer 2:
The reviewer stated that the project is nearing completion. The reviewer commented that development of an engine map and exercising that map in an engine and vehicle simulation are appropriate final steps.

Reviewer 3:
The reviewer remarked that proposed demonstration of operation over a wide speed/load range will be a good achievement as the project comes to a close at the end of the FY.

Reviewer 4:
The reviewer stated the project needs to complete their testing.

Reviewer 5:
The reviewer acknowledged that limited time is available in the remainder of the project. The reviewer commented that transient results would be of interest, but it is unclear what can be accomplished in the remaining time.

Reviewer 6:
The reviewer stated that the project includes a lot of details on the R&D and future plan. The reviewer commented that it is helpful to have 12 test points as the future plan, but that it would be important to compare the results with the baseline engine that does not have such sophisticated technologies.

Reviewer 7:
The reviewer acknowledged that 12-part load mapping points are barely adequate to predict vehicle fuel consumption. The reviewer commented that additional points would provide more robust results.

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

Reviewer 1:
Assuming the engine reaches the projected fuel economy and has tolerable emissions then, yes the reviewer commented that the project will have reached its goals.

Reviewer 2:
The reviewer stated that the concept and potential of variable compression ratio is known. If this concept is successful, viable, and able to be manufactured it would have beneficial impact on operational efficiency.

Reviewer 3:
The reviewer noted that variable compression ratio is a pathway to improve engine efficiency.

Reviewer 4:
The reviewer remarked that high efficiency demonstration of the engine concepts meets the DOE objectives.

Reviewer 5:
The reviewer noted that variable compression technology can increase fuel efficiency and reduce petroleum use if the barriers can be overcome.

Reviewer 6:
The reviewer said yes, but it is too expensive to achieve the program goal.

Reviewer 7:
The reviewer remarked that the project is attempting to show VCR as a path to improved fuel consumption. The reviewer noted that to some extent this particular approach has been largely overtaken by the performance and efficiency of other prototype and even production engines. The reviewer commented that the project still has emissions compliance to prove.

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

Reviewer 1:
The reviewer wondered whether the project has enough resources remaining with 89% of the budget gone, while the program is still largely in the modeling stage.

Reviewer 2:
The reviewer remarked that it appears that the researchers will be able to complete the work in their statements of tasks within the allotted budget.

Reviewer 3:
The reviewer commented that this project was funded at a significant level for over 4 years, allowing it to achieve the stated goals and objectives.

Reviewer 4:
The reviewer sees no indication that the project is starved for money.

Reviewer 5:
The reviewer noted that resources have been sustained for a number of years. The reviewer stated that building engine prototypes is pretty costly.

Reviewer 6:
The reviewer noted that DOE has provided approximately 80% of the total project cost. In comparison to other industry-led DOE projects, the reviewer stated this government funding proportion is quite high (a 50/50 mix is more common). The reviewer remarked that more investment from industry for the project would be preferred and would justify relevance to industry.

Presentation Number: acs093
Presentation Title: Lean Miller Cycle System Development for Light-Duty Vehicles
Principal Investigator: David Sczomak (General Motors)

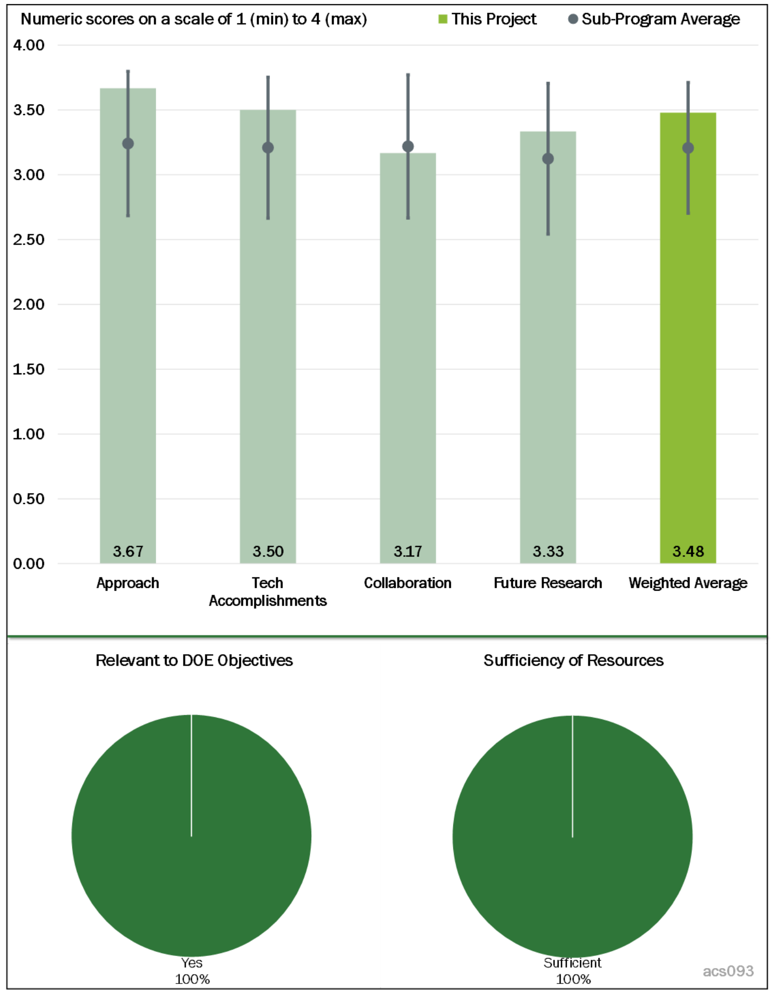

Figure 1-29 - Presentation Number: acs093 Presentation Title: Lean Miller Cycle System Development for Light-Duty Vehicles Principal Investigator: David Sczomak (General Motors)

Presenter

David Sczomak, General Motors

Reviewer Sample Size

A total of three reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that this is a rather complex project with many facets—variable valve timing (VVT), lean, supercharging, EGR, FIE, and advanced thermal management. The reviewer noted that the approach is utilizing the best of all "incremental technology" approaches that are all in the market today but not yet integrated. The reviewer likes the parallel tasking approach—testing, simulation, aftertreatment, engine build, etc. occurring in parallel. The reviewer stated that this will be very interesting to see it develop.

Reviewer 2:

The reviewer stated that the multi-faceted approach looks comprehensive and should lead to a successful outcome. The reviewer noted that the spray imaging appears to be giving significant insight into the project.

Reviewer 3:

The reviewer noted that the approach is appropriate for the stated goals of the project. The lean miller cycle is projected to be capable of exceeding the downsized boosted stretch goal of 35% at 20% load at 2,000 RPM and the 2 bar 2000 RPM goal of 26% with 36 and 31%, respectively. The reviewer recommended that the project also examine stretching the range of lean miller cycle operation.

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

Reviewer 1:

This reviewer stated that the project has already demonstrated exceeding two of the three stretch DOE targets on the single cylinder engine.

Reviewer 2:

The reviewer remarked that multiple accomplishments were reported here, which are making significant progress to meeting goals. The reviewer commented that important work on fuel injection is multi-pronged and is showing focus. The main hardware options are scoped out on all fronts—FIE, head design, supercharging—and the CFD seems on target to this reviewer. The reviewer commented that chances are good BSFC targets will be hit. The reviewer said that aftertreatment system has several options, but for brake mean effective pressure less than 3 bar there will be challenges. An electrically heated catalyst is a possible option, but LNT may make more sense, as this is the preferred system for light-duty diesel (LDD).

Reviewer 3:

The reviewer remarked that fuel spray evaluations were well done and the description of the spray plume breakup as bushy was amusing. The reviewer would have liked to see more engine data.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the necessary parties are present, and seem to be working together.

Reviewer 2:

The reviewer noted that there are many suppliers involved in the project, although it is not clear the exact level of input they each had.

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

Reviewer 1:

The reviewer stated that the multi cylinder build and dynamometer demonstration is laid out nicely to follow the extended single cylinder phase.

Reviewer 2:

The reviewer noted that the research plan for this project looked good. The reviewer recommends that it go forward.

Reviewer 3:

The reviewer expressed that the project tasks are nicely laid out. The reviewer went on to state that the project is utilizing classic engine development approaches. The reviewer has a little concern on the aftertreatment work, as this might be more difficult than envisioned at low load, however, one can borrow much from LDD: LNT/ TWC+SCRF+ SCR.

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

Reviewer 1:
This reviewer stated that the project is combining various production technologies into a new package with optimization. The reviewer noted that the project stands a good chance of meeting the goals, and being that it is "incremental," it might be implemented sooner than more risky approaches.

Reviewer 2:
This reviewer commented that the project directly addresses the DOE thermal efficiency goals, which will achieve petroleum displacement.

Reviewer 3:
The reviewer said that low load efficiency is necessary to lower petroleum consumption because that is where the engine operates a majority of the time.

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

Reviewer 1:
The reviewer remarked that extension of intermediate timing indicates some resource issues, but the plan looks like targets will be met on time.

Presentation Number: acs094
Presentation Title: Ultra-Efficient Light-Duty Powertrain with Gasoline Low-Temperature Combustion
Principal Investigator: Keith Confer (Delphi Powertrain)

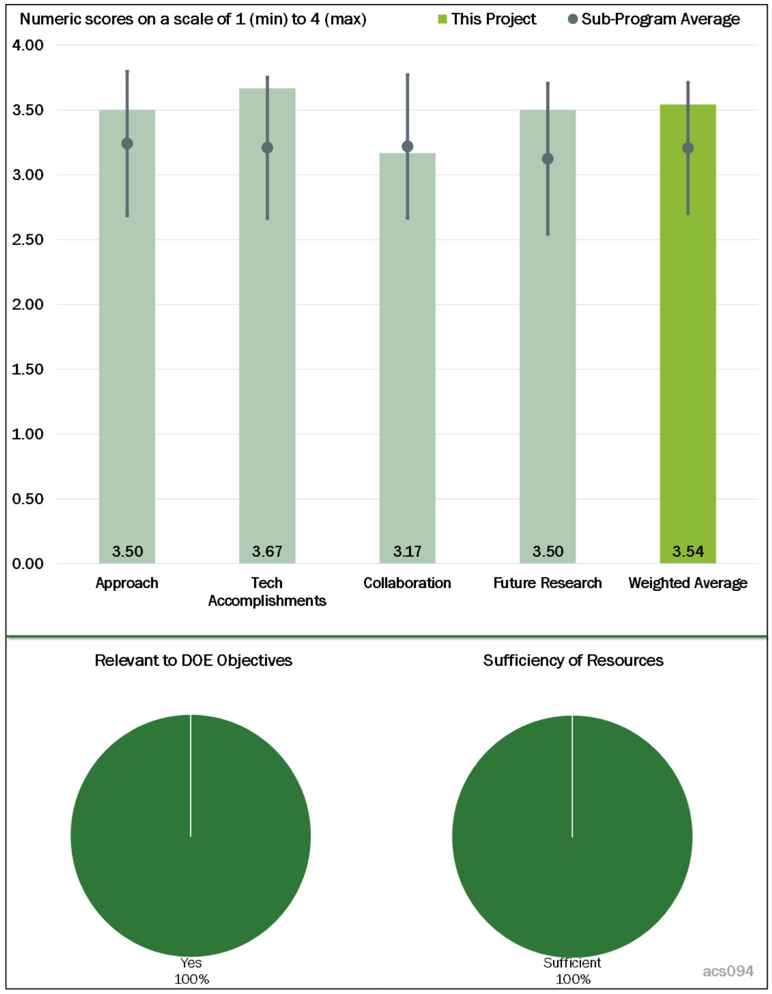

Figure 1-30 - Presentation Number: acs094 Presentation Title: Ultra-Efficient Light-Duty Powertrain with Gasoline Low-Temperature Combustion Principal Investigator: Keith Confer (Delphi Powertrain)

Presenter

Keith Confer, Delphi Powertrain

Reviewer Sample Size

A total of three reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that this is a strong project approach focused on utilizing unique LTC called GDCI combustion to achieve the targeted fuel economy and also focusing on the aftertreatment system appropriate for meeting Tier III emission standards for this new concept. The reviewer remarked that this Advanced Technology Powertrain (ATP) II project builds on the Delphi DOE ATP I project that utilized single cylinder, multi-cylinder engine, and complete vehicle that met the fuel efficiency target. The reviewer observed that the final outcome is for the Gen three 3 GDCI engine to meet the 35% vehicle fuel economy improvement target in early FY 2019 while meeting the Tier III emissions.

Reviewer 2:

The reviewer stated that developing a highly efficient combustion engine is strongly encouraged given the reality that combustion engines will power commercial LD powertrains for many years to come. The reviewer noted that the engineering work to improve the base engine efficiency by 32% is noteworthy for this combustion approach. The reviewer expressed that this benchmark level of improved efficiency, however, negatively affects the exhaust energy needed by current day aftertreatment technologies. The reviewer noted that exhaust temperatures associated with the combustion strategy used in this engine and aftertreatment development project are insufficient for providing the level of emissions control needed with the proposed aftertreatment. Several aftertreatment areas of concern for this reviewer include first, the use of urea for such LT NO_x control. The reviewer stated that because the level of engine out NO_x is low, other options for directly providing NH_3 for NO_x reduction are more suitable or the use of NO_x traps for LT operation. Second, the production of GHG is excess of un-penalized levels is a possibility given the use of PGM in components and the LT environment. Third, desulfation of components will be necessary to maintain the level of efficiency needed to meet Tier III/LEV III standards, but clearly identified methods for providing additional heat in the exhaust stream have not been presented. Fourth, passive GPF may not work in this temperature environment, unless additional heat energy is available.

Reviewer 3:

The reviewer remarked that borrowing from previous efforts, the Delphi team identified the barriers for the present effort to be gasoline direct fuel injection system and aftertreatment system that can operate at very low (175°-350°C) temperatures. The reviewer stated that subsequently, the project focused its efforts in developing technologies to overcome these two barriers.

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

Reviewer 1:

The reviewer stated that there are many technical accomplishments on the engine portion of this project. The reviewer expressed that the project has clearly demonstrated very good performance and stability of the engine, however, the aftertreatment approach is insufficient to provide the level of emission control that would allow this powertrain to enter the market as a Tier III/LEV III system. The reviewer concluded that immediate effort is needed to ascertain the modal cycle emissions, so that an appropriate aftertreatment can be developed.

Reviewer 2:

The reviewer stated that the project has demonstrated significant progress and appears to be on track. The reviewer remarked that the project has managed to design, build, and perform initial testing on a Gen3 GDCI engine on a dynamometer platform. The reviewer also noted that the project compares the engine's efficiency and emissions performance with previous versions.

Reviewer 3:

The reviewer observed good progress on the vehicle level including controls refinement (combustion phasing and stability on Gen 2 engine hardware). The reviewer mentioned that the design and build is completed on the Gen3 GDCI. The reviewer pointed out that the Gen 2 GDCI vehicle is being used to develop the controls with focus on transient operation. The reviewer went on to state that the "Wetless" fuel system concept has been developed for low smoke because injector and spray characteristics are one of the most important design factors for successful GDCI combustion control. Finally, the reviewer stated that an exhaust aftertreatment system has been designed and is undergoing testing but the challenge is efficient operation at low engine-out temperatures.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that Delphi has partnered with ORNL whose role is to perform measurements and analyze data, and with University of Wisconsin, Madison, whose role is performance characterization of the fuel injection system. The reviewer stated that the listing of publications that have resulted from this work by these two partners would be appreciated in future reviews.

Reviewer 2:

The reviewer stated that while initial vehicle OEM is no longer part of the project, Delphi secured a vehicle OEM alliance to help advise the program. The reviewer noted that Delphi has all of the needed engine development expertise and a good track record of DOE co-sponsored engine development projects while Umicore and ORNL are experts at emission control characterization and catalyst development. The reviewer stated that the project is collaborating with other DOE national laboratories with relevant combustion expertise (ANL, ORNL, and SNL). The reviewer stated that the project team also includes the University of Wisconsin, Madison for characterization testing of fuel injectors.

Reviewer 3:

The reviewer remarked that the project may have suffered some loss of momentum due to the withdrawal of one of the original participants. The reviewer noted that the use of an "alliance" of partners, drawing from domestic OEMs, may not be as effective due to their level of engagement and differing needs and approaches. The use of Umicore and ORNL for aftertreatment development is very appropriate, but the reviewer acknowledged that their influence does not appear adequately reflected in the design of the aftertreatment system.

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

Reviewer 1:

The reviewer commented that the Delphi team appears to have identified a sound approach to developing a GDCI engine, i.e., of designing and developing an engine along with the combustion system, fuel injection system, and aftertreatment system. The reviewer remarked that subsequently, they install the engine in a vehicle to optimize the control system for the vehicle. The reviewer concluded that the approach that the Delphi team is taking cannot be any more ideal.

Reviewer 2:

The reviewer noted that engine development is very clear and appears well thought out. The reviewer stated that the aftertreatment approach that will be coupled with the engine is not as well defined.

Reviewer 3:

The reviewer stated that there is appropriate future work to meet project milestones and targets including: dynamometer calibration for performance and emissions, vehicle controls development, and building Gen 3 GDCI vehicle for testing.

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

Reviewer 1:

The reviewer noted that the combustion strategy and development work associated with the project address the stated need for this type of technology within both the DOE and OEM organization as well as USCAR. However, for this combustion approach to be marketable, the reviewer stated that it must be coupled with an aftertreatment system that is capable of SULEV30. The reviewer remarked that this has not been demonstrated yet.

Reviewer 2:

The reviewer said that the Delphi team is trying to develop a practical engine for LD vehicles that can offer significant fuel savings, as high as 35%, compared to current SI engine technology. The reviewer commented that such fuel savings can aid in reducing the overall petroleum consumption in the United States, which is one of the main objectives of DOE.

Reviewer 3:

The reviewer stated yes, this project supports the DOE VTO's goal to improve the efficiency of LD engines for passenger vehicles through advanced combustion and minimization of thermal and parasitic losses. The reviewer noted that it is also developing aftertreatment technologies integrated with combustion strategies for emissions compliance and minimization of efficiency penalty. The reviewer concluded that a highly efficient engine that meets the emissions standard would significantly reduce LD vehicle petroleum use.

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

Reviewer 1:

The reviewer remarked that there is a significant amount of funding on this project from both of the funding partners. The reviewer noted that resources appear adequate.

Reviewer 2:

The reviewer stated that the allocated funds are sufficient for the proposed development.

Reviewer 3:

This is a well-funded, nearly $25 million, five-year project that includes the needed partners and resources to complete the project targets.

Presentation Number: acs095
Presentation Title: Metal Oxide Nano-Array Catalysts for Low-Temperature Diesel Oxidation
Principal Investigator: Pu-Xian Gao (University of Connecticut)

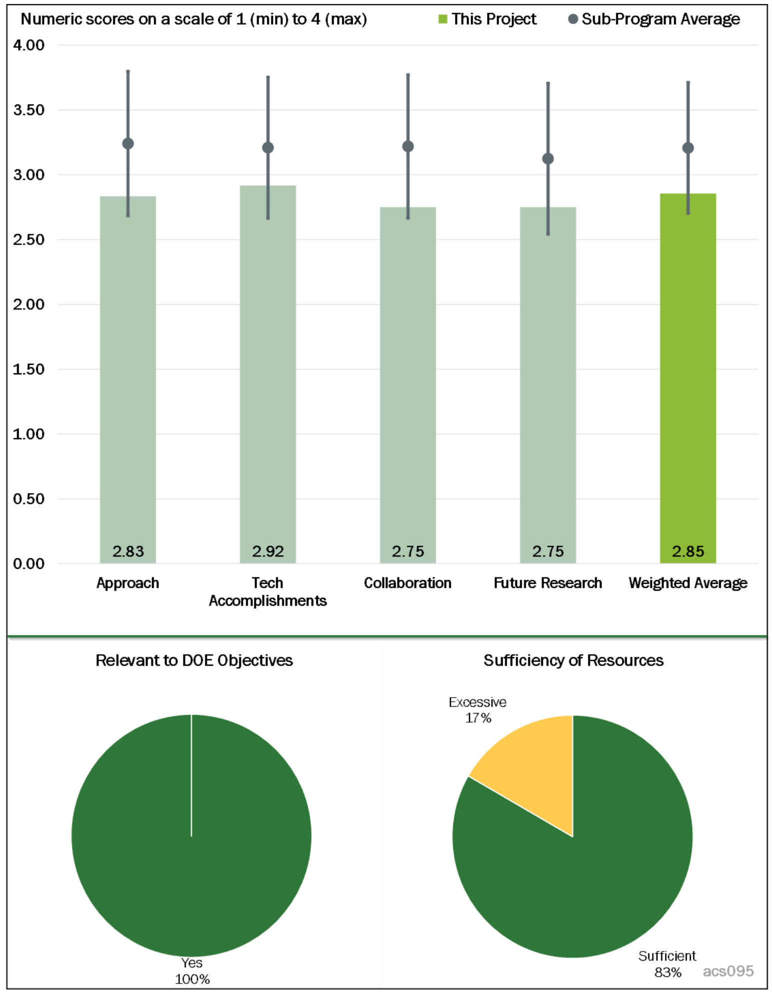

Figure 1-31 - Presentation Number: acs095 Presentation Title: Metal Oxide Nano-Array Catalysts for Low-Temperature Diesel Oxidation Principal Investigator: Pu-Xian Gao (University of Connecticut)

Presenter

Pu-Xian Gao, University of Connecticut

Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the steps to test and validate the nano-array seem to have been done. The reviewer stated that the approach is logical and little is left to do to close out the project.

Reviewer 2:

The reviewer commented that the project incorporates lower precious metal loading on a titania support. The reviewer noted that titania is used in rutile phase, so it would seem to be durable for the higher temperatures seen in exhaust. However, the catalyst was incorporated onto a metal support, which is rarely used due to washcoat adhesion issues with thermal cycling in vehicle exhaust. The reviewer went on to state that cordierite was offered as an alternative; the adhesion is presumed to be better but this was not shown (if it was tested). The reviewer observed that there was no direct comparison to commercial DOC under realistic aging conditions. The reviewer noted that 700°C is a degreening.

Reviewer 3:

The reviewer stated that the approach was appropriate.

Reviewer 4:

The reviewer stated that it is a very unique approach, but the value can only be proven if it can be realized in engine dynamometer supported by a vehicle OEM.

Reviewer 5:

The reviewer remarked that the thought process behind the evaluation is fine; however, the execution was flawed. The reviewer noted that the comparisons of catalyst appear to be apples and oranges.

Reviewer 6:
The reviewer commented that the goal of the project is indeed targeting some of the key barriers, namely LT conversion, but it is not clear that the approach undertaken in this project will actually get there, especially because 80% of the project is complete now.

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

Reviewer 1:
The reviewer acknowledged that it was impressive that the project got to engine testing this year.

Reviewer 2:
The reviewer remarked that the key here is to show that the nano-array geometry offers significant benefits over standard washcoated methods, and opined that it seems so. The reviewer stated that relative to washcoated samples with the same platinum (Pt) loading on TiO_2, the nanoarray delivers 50°-100°C lower light-off temperatures. The reviewer noted that this is impressive. The reviewer commented that hydothermal aging is done, as is S tolerance- both are acceptable. The reviewer expressed that the only thing missing is long-term durability like erosion and ash impacts. The project mentions back pressure benefits but does not give data.

Reviewer 3:
The reviewer remarked that more realistic testing conditions were used this year. The reviewer noted that more realistic aging conditions are needed, such as 800°-850°C. The reviewer stated that desulfation also needs to be more realistic, as in high O_2 without hydrogen present and higher temperatures. The scale-up efforts were not clear to the reviewer.

Reviewer 4:
The reviewer commented that the project showed that Pt dispersion was stable after 700°C at four hours. The reviewer went on to state that going to 100 hours, T90 increases less than 40°C.

Reviewer 5:
The reviewer stated that progress has been made in aging and S poisoning. The reviewer observed that hydrothermal aging shown in Slide 14 is good, but it seems not too encouraging even though the performance may be still on par. It would be clearer to the reviewer if comparisons can be made between aging and fresh results on Slide 14. The reviewer remarked that it is not clear why both structural and catalytic performance got better after desulfation, which is interesting but needs a better explanation.

Reviewer 6:
The reviewer pointed out that this project followed too many simultaneous paths. The reviewer expressed that the project made minor progress in a number of areas rather than any significant progress in one area.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that the testing collaboration with ORNL and Umicore is good. The reviewer pointed out that fabrication and characterization work is done in-house which is sufficient collaboration for this type of study.

Reviewer 2:
The reviewer identified Corning, Umicore, and 3D Array Tech. as partners.

Reviewer 3:
The reviewer noted some collaboration, however, the frequency of contact and closeness of the relationships was not really explained.

Reviewer 4:
The reviewer remarked that collaborations with ORNL and Umicore are important to this work.

Reviewer 5:
The reviewer pointed out that the National Energy Technology Laboratory (NETL) is not a collaboration. The reviewer stated that NETL is a project management arm of DOE (distributes funding).

Reviewer 6:
The reviewer stated that the program can have meaning if it can have vehicle OEM involvement in terms of DOE objectives. The reviewer noted that lack of industrial partner is one of the issues of this program after many years of development.

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

Reviewer 1:
The reviewer stated that the work plan is appropriate. The reviewer suggested that the project compare the 800°C aging to the commercial version, if possible.

Reviewer 2:
The reviewer commented that the project has reached the end of its lifespan.

Reviewer 3:
The reviewer noted that the project is ending this calendar year.

Reviewer 4:
The reviewer stated that future work should focus more on engine dynamometer tests and try to get vehicle OEM involvement.

Reviewer 5:
The reviewer remarked that the true test will be a sample tested apples-to-apples on the engine dynamometer. The reviewer noted that the team chose the Pt-titanium dioxide (TiO_{2f}) system; however, a standard washcoated DOC with the same PGM and washcoat ought to be compared. The reviewer stated that the nano-array seems perfectly suited for a GPF wherein the ash might be kept from contacting the catalyst; and back pressure might be reduced.

Reviewer 6:
The reviewer stated that scale-up feasibility and cost was not addressed very clearly. The reviewer asked if the assumed increased cost of manufacture be offset by precious metal savings or if this technology can ever be mass-produced.

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

Reviewer 1:
The reviewer remarked that yes, improving catalyst efficiency will promote better fuel efficiency.

Reviewer 2:
The reviewer noted that yes, advanced aftertreatment allows for more efficient engines.

Reviewer 3:
The reviewer commented that reducing light-off of oxidation catalysts will be critical to enabling efficiency LTC engines.

Reviewer 4:
The reviewer stated that oxidation catalysts are needed for engines that run lean and are more fuel efficient.

Reviewer 5:
The reviewer stated that this can only be proven relevant if the technology can be recognized by industry.

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

Reviewer 1:
The reviewer mentioned that although the remaining budget is not shown, it appears dynamometer testing is the main next step to close out the project, and that this is done by partners.

Reviewer 2:
The reviewer remarked that only 20% of the project remains.

Reviewer 3:
The reviewer answered that it seems appropriate.

Reviewer 4:
The reviewer concluded that the funding seems excessive for the progress made.

Presentation Number: acs097
Presentation Title: Affordable Rankine Cycle (ARC) Waste Heat Recovery for Heavy-Duty Trucks
Principal Investigator: Swami Subramanian (Eaton)

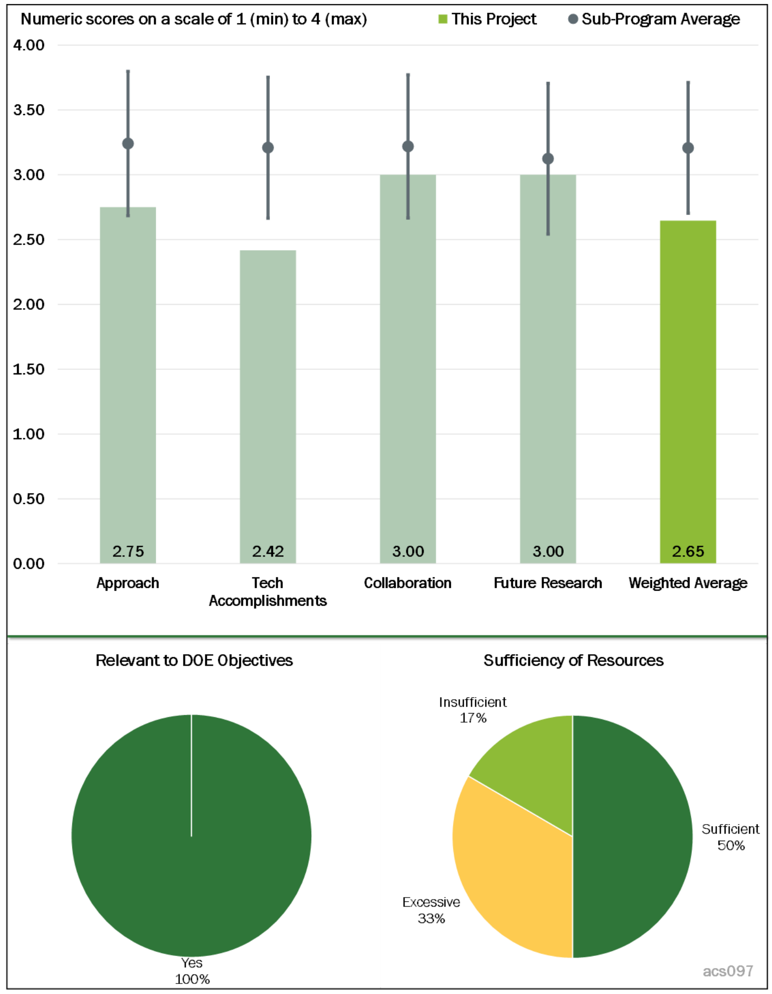

Figure 1-32 - Presentation Number: acs097 Presentation Title: Affordable Rankine Cycle (ARC) Waste Heat Recovery for Heavy-Duty Trucks Principal Investigator: Swami Subramanian (Eaton)

Presenter

Swami Subramanian, Eaton

Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that using engine coolant in a waste heat recovery (WHR) system with Roots expander was an innovative idea toward lower cost and good performing WHR systems.

Reviewer 2:

The reviewer remarked that the approach is to use a low-cost working fluid (engine coolant) for the Rankine cycle to increase overall engine system efficiency. This reviewer stated that this approach is worthy of research and investigation. The reviewer said that the project has been carried out with multiple collaborators and partners. Appropriate research plans have been conducted with suitable attention to critical parameters of interest for determining feasibility of the approach.

Reviewer 3:

The reviewer was impressed that this project got to a go/no-go point and chose the no-go. The reviewer noted that that happens very infrequently. The reviewer stated that it appears as if the engineering requirements were made without a thorough analysis of the system. The reviewer noted that the project was not at all clear as to why the 5% efficiency point was such a hard target—4% seemed reasonable. The reviewer wondered why the character of the engine coolant played such a crucial role. The reviewer inquired why the team could not work with a coolant which did not have such a limiting degradation point, and asked why the other WHR-using engine coolant not have this problem.

Reviewer 4:

The reviewer stated that the project's approach is technically sound, however, achieving its target of a 5% fuel economy gain will be dependent on the efficiency of the base engine from which they start. The reviewer remarked that as the base engine gets more efficient the amount of "waste heat" goes down; and as the waste heat available goes down there will likely be design changes that need to be made to maximize the recovery of the WHR system. That is, the development of a WHR systems needs to be done in conjunction with development of a specific engine. The reviewer commented that this seems to be consistent with the assessment of the researchers and offers a concise explanation for why they have stopped the program.

Reviewer 5:
The reviewer stated that the potential efficiency improvement of the project could be increased by challenging the assumptions that are constraining the performance.

Reviewer 6:
The reviewer stated that the program objective in Phase 1 is good if and only if the project can achieve the program goal, which proves to be unachievable.

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

Reviewer 1:
The reviewer commented that the project did a nice analysis of the WHR system and what is needed.

Reviewer 2:
The reviewer remarked that analysis was conducted with satisfactory detail to determine the limitations and issues with this type of system.

Reviewer 3:
The reviewer observed that it seems as if the coolant feasibility analysis should have been done prior to the project initiation. The reviewer pointed out that it feels like the technical accomplishments were just to prove the concept could work instead of finding a way to do it.

Reviewer 4:
The reviewer stated that technical accomplishments were not well described by the presentation. It is difficult for the reviewer to tell what was done based on the paucity of results presented.

Reviewer 5:
The reviewer commented that technical accomplishments were good in the sense that the research plan was carried out. Unfortunately, the reviewer observed that results were not as positive as desired, but overall, the progress in getting the results and the quality of the data were good.

Reviewer 6:
The reviewer said that there is no surprise that this project fails to achieve the program goal, because fundamentally the approach suffers from a major flaw—using coolant as a working fluid. The reviewer stated that this should be common knowledge.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer remarked that regardless of the outcome of this program, it shows that there were a lot of collaboration among the team members.

Reviewer 2:
The reviewer stated that the project had a good group of collaborators.

Reviewer 3:
The reviewer answered that it seems reasonable.

Reviewer 4:
The reviewer observed that a large team of collaborators was involved in the project.

Reviewer 5:
The reviewer commented that perhaps stronger involvement and influence by an engine or system development partner was needed.

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

Reviewer 1:
The reviewer stated that the project is finished.

Reviewer 2:
The reviewer remarked that the project is ending. The reviewer learned that the system had some potential but it was not sufficient for the project goals. The reviewer said that stopping is appropriate.

Reviewer 3:
The reviewer commented that the team has chosen to end the research based on the results that did not show suitable performance. The reviewer stated that this is the correct plan of action (thus, the "good" rating). This reviewer recommends publicizing the work in journal or conference papers so that future efforts can reference the research performed here which entailed substantial investment.

Reviewer 4:
The reviewer remarked that if the technical team cannot find a way to make the project a success, then the reviewer sees no reason to continue the project.

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

Reviewer 1:
The reviewer acknowledged improved fuel economy.

Reviewer 2:
The reviewer said that even though the project is not proceeding, there was relevant learning that took place.

Reviewer 3:
The reviewer stated that WHR is very solidly known as important for reaching stretch engine efficiency targets.

Reviewer 4:
The reviewer commented that WHR is a pathway to improve vehicle fuel economy.

Reviewer 5:
The reviewer remarked that heat recovery via Rankine cycle can increase fuel efficiency and reduce petroleum use.

Reviewer 6:
The reviewer stated that yes, only if the program can achieve the goal.

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

Reviewer 1:
The reviewer commented that the costs seem high for the progress made before the decision point.

Reviewer 2:
The reviewer thought that the pre-work was insufficient and consequently excessive funds were used.

Reviewer 3:
The reviewer remarked that using engine coolant as a working fluid is a non-starter.

Presentation Number: acs098
Presentation Title: Cummins 55% Brake Thermal Efficiency Project
Principal Investigator: Lyle E. Kocher (Cummins)

Presenter

Lyle E. Kocher, Cummins

Reviewer Sample Size

A total of seven reviewers evaluated this project.

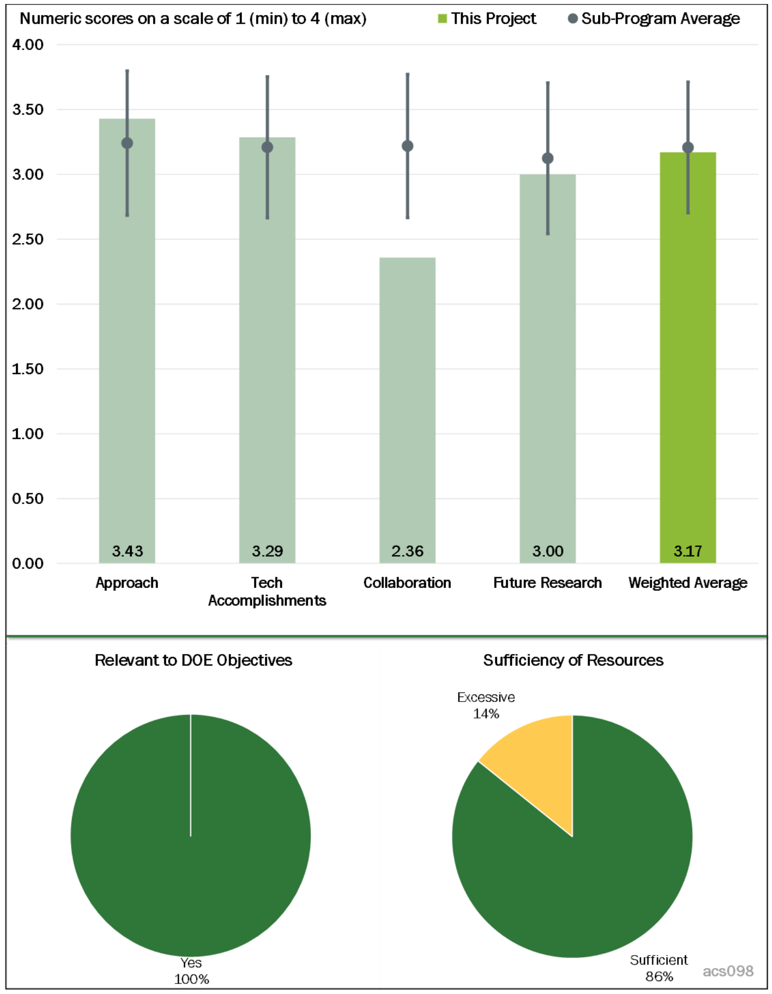

Figure 1-33 - Presentation Number: acs098 Presentation Title: Cummins 55% Brake Thermal Efficiency Project Principal Investigator: Lyle Kocher E. (Cummins)

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

Reviewer 1:

The reviewer mentioned that this is an exceptionally well thought-out and analyzed approach to achieving 55%, exploiting measures to reduce essentially all of the loss paths in ICEs.

Reviewer 2:

The reviewer remarked that this project exhibits a very high level of technical work; addressing all the energy flows within the engine. The reviewer observed that it is a direct extension of the project's SuperTruck activities.

Reviewer 3:

The reviewer stated that it is good to take a holistic approach to the engine system efficiency; to consider the interactions between all of the different components involved in the engine.

Reviewer 4:

The reviewer said that the technical approach timeline looks to be logical, although the mule engine demo for the go/no-go fell behind schedule.

Reviewer 5:

The reviewer stated that this program pushes the limits that each of the key technologies can achieve. Virtual updates on all sub-systems are certainly helpful; however, the current status only achieves 49.2% BTE. It largely relies on WHR to achieve the remaining in order to reach the goal. In the meantime, it is confusing to the reviewer that in the backup table (Slide 20) only 0.2% BTE can be obtained with newer WHR. As the program states, it is likely that high engine-out NO_x would be used, and then the question for the reviewer is more than just OBD. The key question is whether this engine can pass 2010 emission on NO_x due to the cold part of FTP.

Reviewer 6:

The reviewer observed that this is a system refinement approach. This assumes that there are no low-hanging fruit options, so it is an approach that addresses edges. The reviewer remarked that Cummins has been good at that, but the edges are getting steadily less productive.

The reviewer said that there does not seem to be a desire to go out of the project's standard combustion strategy comfort zone. Mostly the project is sanding off the rough edges. The reviewer is not expecting any revolutionary improvements. This approach is not the high-risk development that the reviewer believed is the mission of the DOE.

Reviewer 7:

The reviewer noted that the challenge for the project (55% BTE) is quite significant. The project team realizes that an array of approaches and technologies/components are needed to achieve this goal. The array of strategies employed is being well coordinated and the project lead (Cummins) has significant expertise to combine the components into an engine system for evaluation. The reviewer noted that there are some high-risk approaches like the new WHR turbine design. The reviewer acknowledged that such efforts are in line with government funded research (which enables industry to perform research that would be too high risk for industry alone).

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

Reviewer 1:

The reviewer noted excellent progress. The project is even working through the issue of air-handling and turbocharger sizing. The reviewer remarked that the project is close to the start testing.

Reviewer 2:

The reviewer observed that the project has a relatively short time frame overall (2 years). The reviewer stated that very good progress has been shown to date in a project with an aggressive schedule.

Reviewer 3:

The reviewer observed that the project is making progress toward the 55% goal.

Reviewer 4:

The reviewer stated that the project has essentially reached the objectives except for a minor issue with the procurement of the air-handling component. Considerable innovation was achieved in the design and implementation of the new WHR devices, low heat loss pistons, fuel injection, etc.

Reviewer 5:

The reviewer acknowledged that these accomplishments seem to be what OEM's do to improve their product. The reviewer noted that there is not much risk here.

Reviewer 6:

The reviewer noted that very good progress is shown on the injectors and low heat transfer pistons, and parasitic load reduction. The reviewer mentioned that the new WHR expander design seems risky for the small amount of efficiency gain, but it is recognized that the project has to go after everything to get the 55% BTE.

Reviewer 7:

The reviewer stated that not too much progress has been made in hardware in an integrated manner as far as the whole engine is concerned, while it still has 5.8% more in BTE to go.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer acknowledged a very strong industry supplier-based team in addition to core internal Cummins teams of multiple disciplines.

Reviewer 2:
The reviewer observed that all of the collaborations seem to be with Cummins which seems very insular. The reviewer noted that there is no real evidence of outside idea cross fertilization.

Reviewer 3:
The reviewer noted that an answer to this question is not very relevant. The reviewer observed that the project collaborates with their supply base, which also sells components to their competitors. Most of the significant collaborations are with internal suppliers.

Reviewer 4:
The reviewer stated that there was no significant collaboration.

Reviewer 5:
The reviewer remarked that the logic behind the limited collaborators makes sense, but it still does not justify a higher rating considering this is an all Cummins internal team.

Reviewer 6:
This reviewer noted that the project is primarily being performed at Cummins. Suppliers were cited as collaborators during the presentation, but no specific examples were given to substantiate their role as collaborators (as opposed to basic suppliers). The reviewer was wondering what research or new innovation was enabled at these suppliers as part of the project. The reviewer went on to question what contributions for concepts and new approaches were supplied by the suppliers and whether these contributions were the result of Cummins-supplier interactions/collaborations. The reviewer asked how public research funding provides the supplier companies with the ability to perform research or studies that are beyond the capabilities supported by their normal industry operations. The reviewer stated that much more could be done in the area of collaborations in this project.

Reviewer 7:
The reviewer stated that it would be politically incorrect if you run a DOE program without any partner. The reviewer noted that the money is not very well spent. [DOE Program Clarification: There is 50% industry cost share for this project, which was competitively selected.]

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

Reviewer 1:
The reviewer remarked that the work to date leaves them with a high level of confidence that the program will be successful.

Reviewer 2:
The reviewer remarked that a good path forward was communicated for the remainder of the project.

Reviewer 3:
The reviewer stated that the plan forward looks sound.

Reviewer 4:
The reviewer pointed out that development engineers have all of the same problems and they do that for internal products. The reviewer is not excited.

Reviewer 5:
The reviewer noted that future work is described as completing the tasks at hand. The reviewer remarked that there was not much detail provided, but all is on a solid path.

Reviewer 6:
The reviewer noted that the future work stated in Slide 16 is in the right direction, but the barriers seems too big, specifically the delay on hardware delivery. The reviewer is unsure if the project can accomplish the program goal in time.

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

Reviewer 1:
The reviewer said that improving over the road fuel efficiency will have an enormous impact on oil consumption, so this project does strongly support the DOE objective.

Reviewer 2:
The reviewer commented that yes, higher efficiency translates to petroleum displacement.

Reviewer 3:
The reviewer noted that the engines of focus in the project and the ambitious targets support fuel savings in the largest fuel-using segment (Class 8) of HD vehicles. Overall, HD vehicles are the fastest growing fuel user and GHG contributor.

Reviewer 4:
The reviewer stated that improved heavy truck engines can have a significant impact on reducing petroleum consumption.

Reviewer 5:
The reviewer remarked that this work really pushes the limits of pragmatic efficiency of an engine. The reviewer stated that the learning is very beneficial in regards to what can be done, and the cost and complexity of those actions versus the benefit.

Reviewer 6:
The reviewer noted that improving brake thermal (fuel) efficiency, which is the objective of this project, directly reduces petroleum use.

Reviewer 7:
The reviewer remarked that yes, only if the project can achieve the program goal in a timely manner.

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

Reviewer 1:
The reviewer noted that it appears that the project will be able to complete the work within the allotted budget. Of course, the reviewer does not know exactly what Cummins is spending internally. The reviewer stated that the work is very high caliber.

Reviewer 2:
The reviewer commented that resources have been effectively used for such a multifaceted approach.

Reviewer 3:

The reviewer remarked that the project should have what it needs, considering that Cummins is the only OEM that got this program plus SuperTruck II program.

Reviewer 4:

The reviewer stated that it feels like the DOE is supporting Cummins' product development. The reviewer thought that Cummins should be paying for more of this work with internal funds. [DOE Program Clarification: Cummins provides 50% cost share for this project.]

Presentation Number: acs099
Presentation Title: Improved Fuel Efficiency through Adaptive Radio Frequency Controls and Diagnostics for Advanced Catalyst Systems
Principal Investigator: Alexander Sappok (Filter Sensing Technologies, LLC)

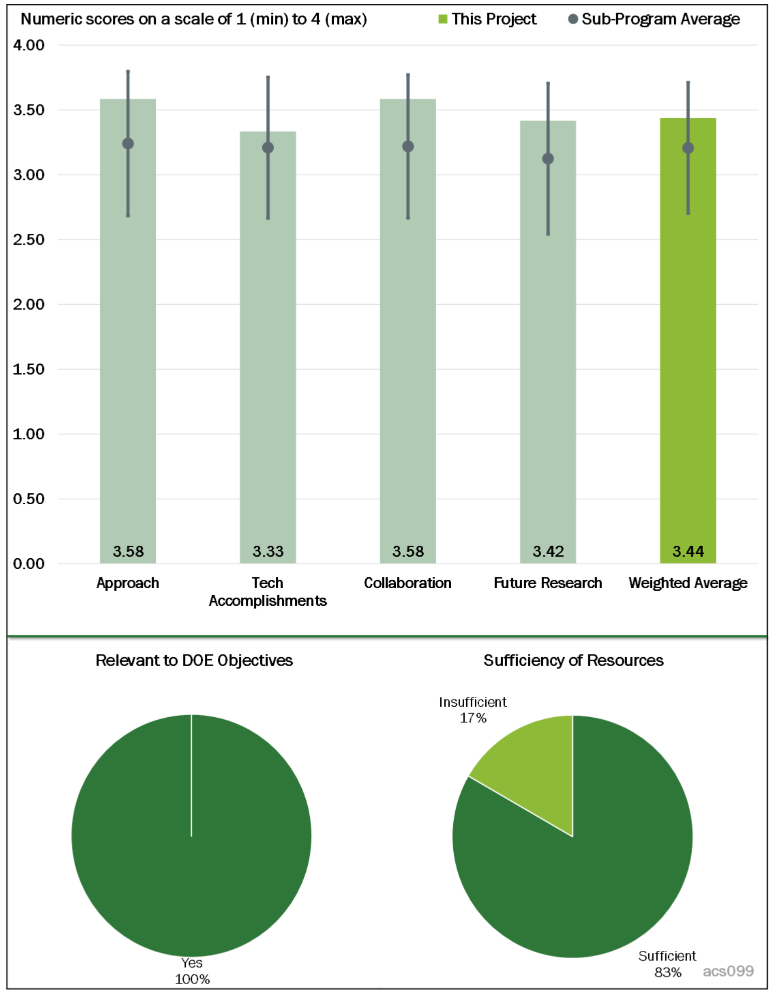

Figure 1-34 - Presentation Number: acs099 Presentation Title: Improved Fuel Efficiency through Adaptive Radio Frequency Controls and Diagnostics for Advanced Catalyst Systems Principal Investigator: Alexander Sappok (Filter Sensing Technologies, LLC)

Presenter

Alexander Sappok, Filter Sensing Technologies, LLC

Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer remarked that this is an excellent work plan with significant partners.

Reviewer 2:

The reviewer said that this is a novel approach to catalyst sensing and exactly the type of project that DOE funding should support.

Reviewer 3:

The reviewer commented that one sensor with a radio frequency (RF) concept that works for many kinds of applications (NH_3, O_2, HC and PM) is something really exciting. However, it is not clear to the reviewer if the hardware and software would be the exact same when applied to different measurements. For example, the reviewer questioned whether a RF sensor used for PM could be exactly the same as one used for NH_3, etc. If so, this reviewer suggested to state it, which is a great achievement of this program.

Reviewer 4:

The reviewer remarked that this is an interesting application of sensor development for enabling effective aftertreatment management.

Reviewer 5:

The reviewer noted that the approach builds on past work on the DPF sensor which was mostly successful. The reviewer stated that this is a diverse and highly capable team and generally a novel sensing method.

Reviewer 6:

The reviewer stated that detecting the catalyst state in real time will make engine calibration and controls much more effective. That should improve fuel efficiency and perhaps catalyst thrifting. For TWC systems, the reviewer remarked that calibrators have estimates of the OSC of the catalyst depending on the history of the catalyst. This approach can give them a real-time measure of the OSC. The reviewer noted that the real-time measure of the OSC could refine the calibration on the fly. Refining the engine controls on the fly should fine tune the emissions in order to get better fuel economy. The reviewer commented that essentially, the same is true for the SCR catalyst; however, the effect on the calibration will be different, but should provide the same benefits. The reviewer concluded that this technology provides information for engine calibration that was not previously available.

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

Reviewer 1:

The reviewer stated that significant progress has been made in demonstrating that the sensing approach shows that this technology has potential.

Reviewer 2:

The reviewer noted that the decision point criterion has been met and progress on other fronts also looks very good.

Reviewer 3:

The reviewer remarked that the results are encouraging. The vehicle fleet test is on the way and it would be very interesting to the reviewer to see how the sensors respond to real world driving condition. However, there is no need to the parent company (CTS) in Slide 9. The reviewer remarked that this would make the program too commercial and dilute its excellent achievements.

Reviewer 4:

The reviewer remarked that the project is making good progress. The reviewer also acknowledged that the project is working on a no cost extension due to some difficulties in getting the testing done.

Reviewer 5:

Significant early feasibility established of detection of NH_3 storage on catalyst. Progress is evident for the TWC application, which is significant for a new project.

Reviewer 6:

The reviewer noted that the technical accomplishments are those which are needed to move this technology along. The weakness is the effect of H_2O on the catalyst state. The reviewer stated that this is true for the SCR and TWC. Water storage either left over from the previous use or ambient H_2O will have an effect on the signal. It is unclear to the reviewer if those effects have been appropriately accounted for.

The reviewer said that testing the sensor technology on a range of engines with different displacements is attractive because each of these engines will have different calibration needs. Fleet testing is especially encouraging to the reviewer.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that there is an outstanding diversity of partners involved and their roles were clearly defined.

Reviewer 2:
The reviewer noted that there is excellent collaboration with other team members. The project clearly defined their roles and how these members help the program (Slide 22).

Reviewer 3:
The reviewer stated that the project has a good mixture of collaborators which can help take this concept to application.

Reviewer 4:
The reviewer noted that the project is collaborating with the appropriate stakeholders

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

Reviewer 1:
The reviewer said that the project has moved to demonstration which gives evidence of project success. The reviewer observed that the project will be complete in about seven months and that the future plans seem a bit optimistic for the amount of time left.

Reviewer 2:
The reviewer remarked that the project appears to be on track to complete its tasks within the additional time allotted through the no cost extension. The results of its final round of testing will be the most important data to see.

Reviewer 3:
The reviewer noted that the project has a solid path forward of modeling, bench work, engine validation, and eventually decisions on its commercialization potential.

Reviewer 4:
Regarding efficiency to stay aligned with DOE mission, the reviewer noted that future work should focus on developing estimates of overall system efficiency gains via RF control and quantifying system-level fuel savings.

Reviewer 5:
The reviewer observed that future work is defined in Slide 23. The reviewer stated that it would be better if the project can talk more about control and how this control with open or close loop can help the program.

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

Reviewer 1:
The reviewer stated that sensor development is an important aspect of the total energy flow management within the vehicle. This sensor could be very helpful in terms of optimizing the interface between the engine and the exhaust gas aftertreatment system. The reviewer remarked that the fact that the project is engaged in fleet testing indicates that there is interest in evaluating the technology's viability in market application.

Reviewer 2:
The reviewer observed that new sensing methods improve function of aftertreatment systems, reduce energy penalty, and possibly reduce cost for better market acceptance.

Reviewer 3:
The reviewer asserted that improved sensing systems can have direct and indirect impacts on vehicle fuel consumption.

Reviewer 4:
The reviewer commented that improved aftertreatment system efficiency is the goal, which aligns with DOE's petroleum displacement objective.

Reviewer 5:
The reviewer remarked that by providing additional data for the engine controls, this project allows tighter control over the emissions and consequently will minimize the fuel economy penalty.

Reviewer 6:
The reviewer stated that yes, if it can show how this program can improve the aftertreatment and engine performance and save fuel. The reviewer observed that it looks very promising, but has not demonstrated that yet.

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

Reviewer 1:
The reviewer remarked that the project has made good progress at the current funding level and appears to be on track to achieve the overall objectives.

Reviewer 2:
The reviewer noted that it appears as if the researchers will be able to meet the deliverables with the budget supplied.

Reviewer 3:
The reviewer stated that yes, the project seems to have enough resources to meet the program needs.

Reviewer 4:
The reviewer is unsure if the project has sufficient resources and time to complete the fleet testing.

Presentation Number: acs100
Presentation Title: Improving Transportation Efficiency through Integrated Vehicle, Engine, and Powertrain Research—SuperTruck II
Principal Investigator: Justin Yee (Daimler Trucks North America)

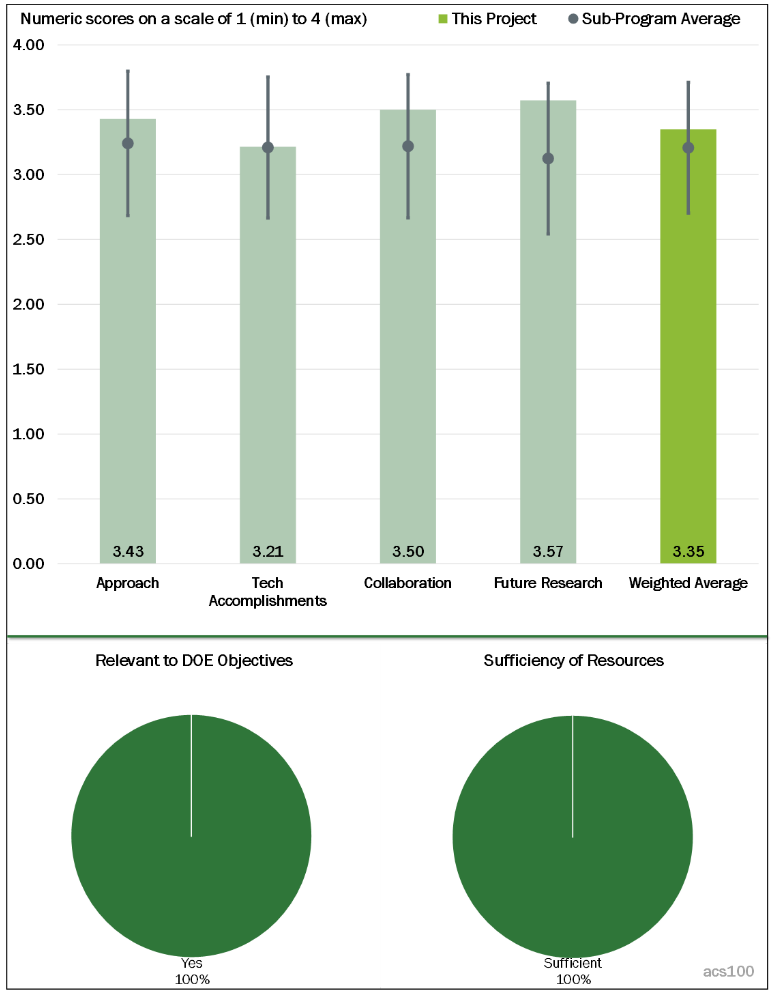

Figure 1-35 - Presentation Number: acs100 Presentation Title: Improving Transportation Efficiency through Integrated Vehicle, Engine, and Powertrain Research—SuperTruck II Principal Investigator: Yee, Justin (Daimler Trucks North America)

Presenter
Justin Yee, Daimler Trucks North America

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

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

Reviewer 1:
The reviewer noted the freight efficiency target of 115% over the 2009 Cascadia baseline. As the reviewer understands, the 2017 Cascadia has technologies that leave 34% remaining as indicated on Slide 4. The reviewer stated that it would be reasonable to assume the seven or so vehicle technologies laid out in Slide 5 have a good chance of contributing to the targeted efficiency, as well as the engine and drivetrain approach shown in both Slide 4 and in Slide 12.

Reviewer 2:
The reviewer stated that the plan appears to be sound and should achieve program goals. Though the presentation focused mostly on the powertrain, the reviewer stated that it would have been nice to hear a little more on the vehicle side.

Reviewer 3:
The reviewer noted that even though the project was just getting started in 2017, the project had a solid approach with “Potential Topics for Investigation” mapped, considering mild electrification (48 Volt) and potential electrification of parasitics as well as strong focus on aerodynamics while using tools and approaches from SuperTruck I.

Reviewer 4:
The reviewer noted SuperTruck I had been a very successful project for Daimler reaching 115% of the baseline vehicle. This project is an attempt to exceed that. The reviewer was concerned that some improvements would not be considered because Daimler already has a success with those technologies in the first SuperTruck project.

High fuel efficiency (FE) tires will be used on this project, but there is no collaboration to improve the tires specifically for this application. The reviewer noted that tires have a significant effect on the fuel economy and expected a more aggressive approach would have been taken to refine and improve the tires specifically for this project.

Reviewer 5:

The reviewer noted that this project represents a continuation of the activities of SuperTruck I. It is a more aggressive pursuit of the technologies that were worked on in SuperTruck I, and technologies that were "left on the shelf" during that program.

Reviewer 6:

The reviewer believed that the overall approach to the project was comprehensive. This reviewer noted specifically that the program's goal of a three-year payback time as a guidance demonstrates the project team's strong intention to make the technology commercially viable. However, this reviewer stated that the program is conservative with 115% improvement as a goal, and that this goal had already been achieved in the SuperTruck I program; therefore, the project team should do better under this program.

Reviewer 7:

The reviewer stated that though the project has some potential, though there was only a very minor emphasis on weight reduction.

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

Reviewer 1:

The reviewer noted that the plan and preliminary approach established for new project were good.

Reviewer 2:

The reviewer stated the progress is okay considering time since started, and that the project is just getting underway.

Reviewer 3:

The reviewer thought that the program was just getting started and was still in the early stages of defining the sub-program leaderships, organizational structure and timelines. Therefore, the project had shown limited technical progress at this time.

Reviewer 4:

This reviewer questioned if the limited engine improvements on this project were sufficient payback items. The reviewer also noted that the focus is strongly on the peripheral technologies. The reviewer added that reducing engine friction effects in the engine may be a consideration for the project to attain its goals.

Reviewer 5:

The reviewer thought the project was planned very well, however, the stated barriers seem largely internal (budget, resources, etc.). This reviewer also noted that the staged timeline seems reasonable and that the cooperation with ORNL on engine evaluation was impressive.

Reviewer 6:

The reviewer believed that the technical road maps, for example, in Slide 5 for vehicle and Slide 12 for powertrain, should be more specific. The project team mentioning all possible technologies was too vague, which may show lack of confidence. The reviewer noted that the project team's previous SuperTruck I program made striking progresses.

Reviewer 7:
The reviewer stated that it was difficult to evaluate because it was so early in the project (only 5% of the program completed).

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that the program consisted of a large team with representation from suppliers, national laboratory and universities and that the project was well done in this area.

Reviewer 2:
The reviewer stated that there was a strong team with key members identified at leading Universities, Tier 1 aftertreatment, tire and driveline, suppliers, national laboratories and fleet level.

Reviewer 3:
The reviewer believed the program had very good partnerships and that this would help lead the program to a successful outcome.

Reviewer 4:
The reviewer stated that the project team had engaged many relevant stakeholders.

Reviewer 5:
This reviewer believed that the project has a comprehensive team, which included a large fleet operator.

Reviewer 6:
The reviewer commented that OEM supplier relationships dominated the collaborations for the project and that it was not clear where Ohio State University and UM fit into the project plan.

Reviewer 7:
The reviewer stated that it seemed as though the main collaborations are on the powertrain side as shown in the org chart (ORNL, UM, Bosch). The reviewer then noted that most of the vehicle work was internal to Daimler Trucks North America, adding that this was not a concern at this stage in the project. The reviewer commented that the diversity of partners was adequate for the project, and hoped that these partners are leveraged as the project proceeds; not only to achieve project success, but to enhance technology transfer, which is a key objective of a publicly financed program like this.

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

Reviewer 1:
The reviewer stated that the future plan for the program was excellent—continue scoping to lay out the game plan. The reviewer further noted there were many opportunities in this program and the reviewer was confident the stretch goal would be reached.

Reviewer 2:
The reviewer commented that the research activities as planned were carefully thought out and integrated so that the program would look for synergistic opportunities. The reviewer then summarized that the project team was building on the experience gained from SuperTruck I.

Reviewer 3:
The reviewer believed that there was a solid preliminary roadmap for future plan, considering the January 2017 start.

Reviewer 4:
The reviewer stated that the future work described in the presentation (Slide 8 and Slide 9 for vehicle and in Slide 16 and Slide 17 for powertrain) clearly identified the barriers and the future research needed.

Reviewer 5:
This reviewer believed that the plans were well-described and comprehensive.

Reviewer 6:
The reviewer said that nearly everything presented was future research because the project just started. The reviewer added that the pathways forward look to be clearly defined, though the presentation felt like the reviewers were basically reviewing the proposal.

Reviewer 7:
The reviewer believed that Daimler has clearly learned from earlier SuperTruck I experience and had a clearly defined path for SuperTruck II. This reviewer was concerned that "out of the box" thinking will suffer because of that.

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

Reviewer 1:
The reviewer believed that demonstrating another 25% reduction in fuel consumption (84%-115% freight efficiency) was certainly relevant to the DOE mission. The reviewer stated that many of these technologies would hit the market within the EPA Phase 2 HD GHG timing (2027).

Reviewer 2:
The reviewer commented that the program goals of 115% freight efficiency improvement and 55% engine BTE directly target the DOE petroleum displacement objective.

Reviewer 3:
The reviewer stated that the project scope to meet SuperTruck II goals was in alignment with DOE objectives.

Reviewer 4:
The reviewer noted that this program clearly supports DOE primary objectives

Reviewer 5:
The reviewer stated that the SuperTruck II program clearly addresses the reduction of reliance on oil. The reviewer also commented that to make the project successful, the OEMs will need to incorporate the technologies developed from the project into their commercial product.

Reviewer 6:
The reviewer noted that there was the potential for much learning to occur in terms of how advanced technologies interact when used together on a vehicle, and the potential and possible timelines for introducing these technologies into market products.

Reviewer 7:
The reviewer believed that this project focused on largest fuel use sector of freight movement, which is also the fastest growing GHG contributor in transportation.

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

Reviewer 1:
The reviewer was concerned if the funding would be sufficient to be able to compete for resources within each of the companies included in the program.

Reviewer 2:
The reviewer believed that this was a good level of funding to achieve more than incremental improvement, and that the project had substantive funding and goals.

Reviewer 3:
The reviewer commented that the project team had all they need to achieve the program goals

Reviewer 4:
The reviewer believed that it was too early to see issues.

Reviewer 5:
This reviewer noted that if was difficult to evaluate (so early in the project).

Reviewer 6:
The reviewer said that it is a lot of money, and expectations will be high.

Presentation Number: acs101
Presentation Title: Volvo SuperTruck II: Pathway to Cost-Effective Commercialized Freight Efficiency
Principal Investigator: Pascal Amar (Volvo)

Presenter

Pascal Amar, Volvo

Reviewer Sample Size

A total of six reviewers evaluated this project.

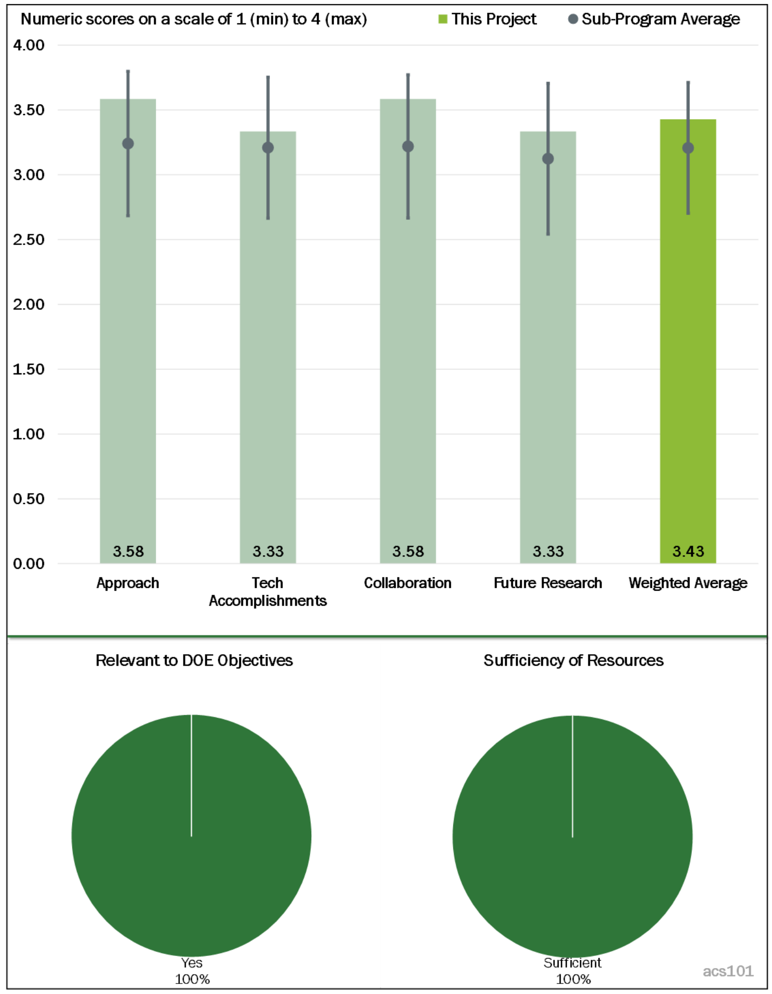

Figure 1-36 - Presentation Number: acs101 Presentation Title: Volvo SuperTruck II: Pathway to Cost-Effective Commercialized Freight Efficiency Principal Investigator: Amar, Pascal (Volvo)

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

Reviewer 1:

The reviewer commented that learning curve from SuperTruck I has had a major impact on the approach for SuperTruck II and that the approach to this project was much more like a new vehicle development program than an exercise in engineering learning. This reviewer further noted that the strong focus on predictive energy management was a strong plus for this program. This focus has shown that a downsized engine allows the project team to operate within the “sweet spots” defined by the energy management system.

The reviewer stated that there was no apparent plan to leverage the hotel batteries to improve the cruising fuel economy. This reviewer would have liked to have seen projections of when the hotel batteries would reach full charge and if the batteries were charged before needed. This reviewer noted that if the hotel batteries were at full capacity before needed, then there is energy being wasted.

Reviewer 2:

The reviewer stated that this project was similar to the other SuperTruck II programs, and is building on the project team’s previous successes and trying to push further product efficiencies.

Reviewer 3:

This reviewer noted the Interesting and likely effective emphasis on energy management and weight reduction. The reviewer also commented that there was not much emphasis on aerodynamics R&D, which may be at diminishing returns. The reviewed noted that though several options were still under consideration for 55% path, it was good to see that a couple have been downselected.

Reviewer 4:
This reviewer recognized that in addition to the typical powertrain and vehicle improvements, the team had captured another project focus, which is that of energy management. The reviewer further noted that though the other project teams have versions of energy management, Volvo set the energy management focus aside as a separate item, indicating a greater emphasis would be placed on this topic. Also, the reviewer saw that the analysis of hotel load and drivability was unique.

Reviewer 5:
This reviewer stated that the program plan was clearly laid out. Then the reviewer stated that because the project is in the early stages (15% completion), evaluation of the approach was difficult.

Reviewer 6:
This reviewer stated that though the overall approach taken was technically sound and comprehensive, there was no clear identification regarding what kind of the engine would be used for the program (as indicated in Slide 22). The reviewer then raised a level of concern due to his opinion that there was no reason to believe that, at this stage, a novel engine can bring any value to the program.

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

Reviewer 1:
The reviewer noted that the analyses were well underway, with downselecting in progress. The energy management analyses are impressive, as is the lightweighting. This reviewer summarized that the analyses that have been performed have been applied to balancing the vehicle loads with a downsized powertrain, and that this approach seems more advanced than the other SuperTruck II projects.

Reviewer 2:
This reviewer stated that SuperTruck I was clearly a success, and now there is a clear plan to project the technologies from SuperTruck I into new applications, though those technologies will need to be refined to reach the goals for SuperTruck II.

Reviewer 3:
This reviewer noted that because the program was just beginning and that currently the project leaders were developing the teams, timelines and organizational structure.

Reviewer 4:
This reviewer stated that the project had interesting and effective use of SuperTruck I efforts for exploratory work on SuperTruck II.

Reviewer 5:
This reviewer stated that it was too early in this project to properly evaluate the accomplishments.

Reviewer 6:
This reviewer questioned why Volvo would still spend time on a novel engine development. This reviewer then commented that the introduction of solar panel on the roof of cab was something new, but it was not clear if the trailer would use the energy from the solar panel as well.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer noted that the project had very well-developed team/partnerships.

Reviewer 2:
The reviewer commented that the team consisted of all key partners from suppliers, national laboratories to universities, and that the team was impressive.

Reviewer 3:
The reviewer stated that the team was in place with an impressive list of players, and that some work on the project has started.

Reviewer 4:
This reviewer noted that this was an OEM plus supplier development project and did not understand what input UM would have to this project.

Reviewer 5:
As a minor point, this reviewer recommended explaining partners and their roles early in the presentation or at each point in the description instead of near the end. The reviewer commented that the fleet partner, the ultimate customer and user of the truck, could be making contributions and is perhaps doing so. The partners are not really mentioned in the plans or progress.

Reviewer 6:
This reviewer noted that there was an overlap between the collaborators in this project with another SuperTruck II team. When this was pointed out the audience was told that program management is aware of the overlap of partners with other projects, and that DOE was monitoring the situation for potential conflicts.

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

Reviewer 1:
The reviewer noted that because this project had just begun, most of the presentation was on future work, and the future work looked like a good, comprehensive plan. This reviewer then commented that the concept downselect process looks to be working well to define the pathway forward for this project.

Reviewer 2:
This reviewer noted that the project was well laid out, and that it was now time for the work to start.

Reviewer 3:
The reviewer summarized that this project has a clear direction and very definable deliverables though the reviewer was worried that the project had a development structure that was too rigid and could lose the benefit of unexpected technology opportunities.

Reviewer 4:
The reviewed commented that the discussion of future work was a bit disorganized and clouded with ongoing technical progress. The reviewer stated that the future work would basically follow a good plan, but the presentation should have been more explicit on major future decisions and outcomes. This reviewer was surprised that aerodynamic improvement was essentially not discussed, but was interested to hear more on the details of connectivity exploitation. Finally, this reviewer noted that the advanced novel engine was not discussed this time.

Reviewer 5:
This reviewer commented that the downselecting process had started, and that it was most critical to choose an engine approach, because in the reviewer's opinion everything else is dependent on this. This reviewer would like to see a unique approach with significant downsizing.

Reviewer 6:

The reviewer commented that although Slide 22 provided a sense of the future work, the program does not provide a specific section to talk about the future research. Also, this reviewer was surprised that the future work still considers a novel engine design as a possibility because the effort for this change would impact the overall project.

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

Reviewer 1:

The reviewer stated that SuperTruck programs are targeted to significant fuel savings for materials transport by Class 8 trucks, and because over-the-road freight hauling consumes approximately 20% of the oil consumed in the United States, improving freight hauling efficiency can have an appreciable payback.

Reviewer 2:

The reviewer referenced comments made for the other SuperTruck programs.

Reviewer 3:

The reviewer noted that the project strives to achieve higher freight-moving efficiency, and that HD vehicles are fastest growing fuel user and GHG source.

Reviewer 4:

The reviewer commented that SuperTruck II was key to reducing freight energy demands, and that Volvo has some unique approaches that feed into reducing freight energy demands, with an emphasis on commercialization.

Reviewer 5:

The reviewer stated that a 55% engine BTE demonstration and 120% stretch goal on vehicle efficiency improvement are directly aligned with the DOE petroleum displacement objective.

Reviewer 6:

This reviewer confirmed that the program specifically targets the program objectives defined by DOE.

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

Reviewer 1:

The reviewer assumed because Volvo has developed a project plan that the project team must find the budgeting sufficient.

Reviewer 2:

This reviewer stated that the project team should have sufficient funding to achieve the program goals.

Reviewer 3:

This reviewer believed that because no issues were brought up in the presentation, there must be sufficient funding.

Reviewer 4:

The reviewer said big money, high expectations.

Reviewer 5:

The reviewer stated that it was difficult to evaluate at this very early stage of the program.

Reviewer 6:

This reviewer had no comment.

Presentation Number: acs102
Presentation Title: Cummins/Peterbilt SuperTruck II
Principal Investigator: Michael Ruth (Cummins)

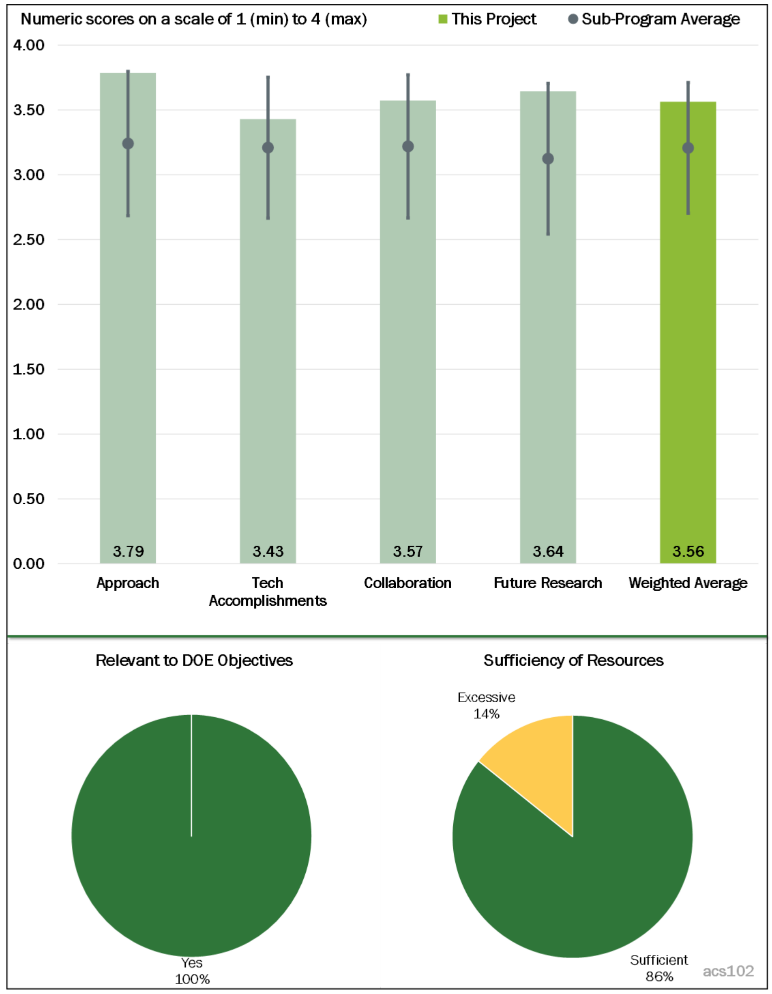

Figure 1-37 - Presentation Number: acs102 Presentation Title: Cummins/Peterbilt SuperTruck II Principal Investigator: Ruth, Michael (Cummins)

Presenter

Michael Ruth, Cummins

Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

This reviewer appreciated that the project team separated the powertrain development from the aerodynamic development. The reviewer commented that this approach gives a fresh set of eyes and opinions to balance the project. Further, the reviewer recognized that Cummins is “world class” in powertrain development and rightfully is focusing on that part of the project. The reviewer stated that Cummins had presented justification for each of the engine development choices, and that was confidence building for the success of the project.

This reviewer also recognized that the Peterbilt aerodynamics portion of the project was equivalently well justified. The reviewer noted that the yaw mitigation portion of the project was not one the reviewer had been previously exposed to; however, it was a reasonable approach and is clearly an appropriate target for fuel savings. The reviewer noted that the focus on reducing tire loss was also important, and that the partnership with Bridgestone brings in a high level of expertise to reduce the overall rolling resistance.

The reviewer summarized that there was a clear understanding of regulatory requirements in both parts of the program. Though it was not clear to the reviewer that each of the improvements would benefit equally short haul and long-haul applications, it would have been helpful to categorize the focus areas into long hauler short haul improvement areas.

Reviewer 2:

The reviewer noted that the approach was very thorough, including an analysis of routes and drives cycles and essentially every reasonable aspect of truck technologies and systems for reducing fuel consumption. Further, the reviewer recognized that work on tires, where one might have concluded a point of diminishing returns, was commendable. The reviewer stated that inclusion of weight reduction is on target, where this part of project is sometimes mistakenly assumed to be of no value except for weight-limited situations. Finally, this reviewer commented that the fleet/customer partnership was a strong addition to the project.

Reviewer 3:

This reviewer noted that the project had just started in 2016. The reviewer believed that there was an excellent management approach to promote cost effective solutions considering three-year payback and customer feedback for payback considerations. The reviewer viewed the project team's technical approach as excellent with engagement of key suppliers to develop productive solutions (transmission, driveline, WHR). The reviewer also appreciated the aggressive approach to integrate a WHR system as the cooling system.

Reviewer 4:

The reviewer commented that the Cummins/Peterbilt team has done impressive analyses to achieve another 56% freight efficiency improvement to get to 115% over the original baseline. The reviewer recognized that the effort on the base engine was a good start, and quantification of the opportunity with the HEV analysis was impressive. Further, the reviewer stated that on the vehicle side of the project the aero, tire resistance, and speed control work efforts provide excellent opportunities for further improvements.

Reviewer 5:

The reviewer stated that the project had a well-defined approach, with a good tie into the 55% engine BTE enabling technologies efforts. However, the reviewer noted that was too early (10% completed) to determine if any course corrections are appropriate.

Reviewer 6:

This reviewer stated that the project team's approach was comprehensive, and provided a fairly detailed technical scope, road map with quantitative measurements. The reviewer further noted that targeting a minimum of 125% improvement was impressive, if the project can achieve it. The reviewer recognized that prioritizing the solutions with three-year payback is encouraging, and summarized that this was a very strong program.

Reviewer 7:

This reviewer simply commented that this project was a continuation of efforts from SuperTruck I.

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

Reviewer 1:

The reviewer noted that progress had been reported in the tire and chassis portions of the vehicle, and also that the energy recovery, friction reduction, and engine design/analysis were competed. Further, the reviewer commented that this effort was completed in just the first few months of the project, so the reviewer believed that the project was off to a very good start.

Reviewer 2:

This reviewer noted excellent progress with clear definition of program goals, reasonable allocations of improvements to subsystems and initial analysis to support.

Reviewer 3:

The reviewer noted that though the technical accomplishments were mainly analytical, the analysis provided excellent direction. The reviewer noted that breaking down the engine opportunities shows high probability of demonstrating 55% BTE, and that the results on HEV requirements (electrical storage and motor requirements) and ring friction reduction are excellent starts. The engine layout plan is complete. The route evaluation focuses the effort on bang for the buck. On the vehicle side, the reviewer commented that the aerodynamic analyses were very impressive, especially concerning the impact of vehicle yaw with respect to air flow. The reviewer believed that the weight reduction goals seem reasonable (500 lbs. from the tractor, 500 lbs. from the trailer), and the results and initiation of the tire side of the project were also impressive.

Looking at the HEV aspect, the reviewer recognized that engine braking was chosen for slowing the vehicle in steeper slopes and wondered if the team evaluated ultra-capacitors (UC) teamed with a smaller battery, as part of the 3-4 kWh storage requirements. The reviewer noted that UCs can soak up that high power for more efficient storage.

Reviewer 4:

The reviewer believed that the SuperTruck I project was a solid success, and that the direction this project was headed has been well defined. The reviewer saw that establishing the direction in the early stage of the project was a significant accomplishment.

Reviewer 5:

This reviewer noted that with less than a year of work, the project team had performed analysis, developed some tools, and conducted preliminary designs. However, the reviewer also commented that because the program has spent nearly $1 million spent, this reviewer expected a little more achievement.

Reviewer 6:

The reviewer recognized that the program was just starting and had establishing the teams, organizational structures, time lines, and procuring parts.

Reviewer 7:

The reviewer noted that progress has been made on the new engine platform, and that the expected benefits shown on Slide 10 were detailed. However, the reviewer was confused on the WHR benefit, which only shows 0.2% benefits, and the reviewer believed that this benefit needed to be larger in order to achieve the program goals.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted excellent collaboration with a vehicle OEM, an engine OEM, transmission supplier, Tier 1 suppliers and fleet.

Reviewer 2:

The reviewer said that the team is off and running. The route evaluation with the NREL and Walmart is exceptional and guides the program for most impact. Bridgestone has started on tire improvements. Eaton is part of the drivetrain team, and Johnson Matthey on aftertreatment. Peterbilt is well-equipped to do the vehicle side and coordinate the efforts.

Reviewer 3:

The reviewer stated that the project seems to have a good team.

Reviewer 4:

This reviewer noted that Walmart’s participation was a strong feature because Walmart had been exploring advanced technologies themselves.

Reviewer 5:

The reviewer noted that Purdue University and NREL were mentioned in the presentation, but are not listed as partners/collaborators. The reviewer questioned if there was a reason for this, such as the size of their role. The reviewer summarized that the rest of the team looks strong, and including a trailer manufacturer in SuperTruck II is an excellent addition.

Reviewer 6:
The reviewer believed that the collaboration seemed to lack participation from academic institutions and national laboratories, and was concerned that this might limit the innovation elements of the technology development.

Reviewer 7:
The reviewer believed that the team only consists of industrial partners, and there are no partners from universities or the national laboratory system shown on Slide 2, although Purdue University was mentioned in Slide 18.

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

Reviewer 1:
The reviewer commented that the plan was in place and looks excellent. The reviewer recognized that the project was focusing on the big items, such as combustion, aerodynamics, and rolling resistance, and believed that the HEV part was also exciting, and the layout and approach seems reasonable.

Reviewer 2:
The reviewer noted that specific plans for work are already in place, for both the powertrain and the vehicle. The reviewer summarized that the project team seems to be well on their way to identifying specific technological approaches, and have made estimates of the expected benefits.

Reviewer 3:
The reviewer noted that the technical plan was comprehensive and paths appear sound. The reviewer also commented that there was good attention to commercialization potential, and this was where regulatory issues were often involved.

Reviewer 4:
This reviewer noted that most of the presentation was on work started and future work because this project just got started. The reviewer then stated that the proposed future work looks good.

Reviewer 5:
This reviewer stated that the project had a solid preliminary roadmap of future activities to achieve targets.

Reviewer 6:
This reviewer questioned how well coordinated the two research projects would be.

Reviewer 7:
The reviewer noted that the entire presentation did not provide a specific section to talk about future research, even though future work direction can be interpreted from some of slides. Therefore, the reviewer believed that the presentation was not very well organized in this sense.

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

Reviewer 1:
This reviewer believed that the project was absolutely relevant with the clear program road map to achieve the program objective.

Reviewer 2:
The reviewer noted that there would be a lot of learning about the interaction between different technologies when integrated onto a vehicle from this project, as well as the technologies' potential benefits, and the potential for getting those technologies into the market.

Reviewer 3:
The reviewer commented that demonstrating 36% fuel consumption reduction from the SuperTruck I program certainly would be relevant to DOE objectives, and that the team has a good start in commercializing the technologies.

Reviewer 4:
The reviewer believed that the project planning seemed to be complete and there was no evidence that there were insufficient funds.

Reviewer 5:
This reviewer noted that 55% engine BTE and 125% FTE improvement are directly in line with DOE's objective for petroleum displacement.

Reviewer 6:
The reviewer identified that this project pertains to Class 8 trucks, which is the category of largest freight fuel consumer and overall HD vehicles are fastest growing fuel use sector.

Reviewer 7:
The reviewer noted that the project scope to meet SuperTruck II goals which has been engineered to meet DOE objectives.

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

Reviewer 1:
This reviewer believed that both the DOE and OEMs have the SuperTruck I experience in hand so that the cost of the project should be well understood.

Reviewer 2:
The reviewer commented that these projects are heavily cost shared by the industry partners, so the achievement potential per government dollar is satisfactory.

Reviewer 3:
The reviewer commented that no requests or issues have been raised by the project team regarding project funding.

Reviewer 4:
The reviewer noted that the project had a large amount of funding and that the expectations for success would be high.

Reviewer 5:
The reviewer believed that the project had a good level of funding to achieve more than incremental improvement, and that the project had substantive funding and goals.

Reviewer 6:
The reviewer pointed out that Cummins also has another DOE program on 55% BTE, making this program resource significantly more as compared to their competitors. In addition, the engine program also shows that Cummins has all they need to achieve the program goals.

Presentation Number: acs103
Presentation Title: Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer–SuperTruck
Principal Investigator: Russ Zukouski (Navistar)

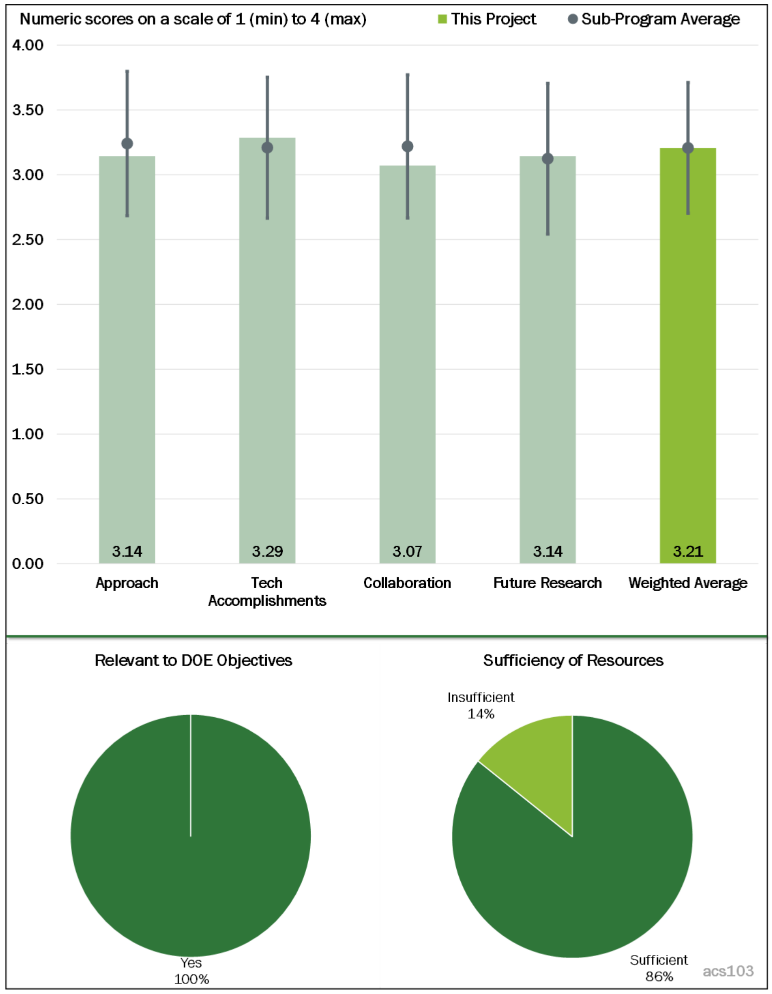

Figure 1-38 - Presentation Number: acs103 Presentation Title: Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer—SuperTruck Principal Investigator: Russ Zukouski (Navistar)

Presenter

Russ Zukouski, Navistar

Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted a good approach to fuel efficiency improvement through the scope of this project. Standard areas of combustion efficiency, friction, down-speeding for turbo efficiency and aero on target list. The reviewer further commented that is was a novel and potentially promising approach to consider a kinetic recovery system (KERS) for energy recovery in this application. The reviewer also noted that GCI development was new for industry so the value proposition and benefit should have preliminary characterization. (i.e., eliminate SCR, eliminate DPF, or efficiency gains greater than diesel).

Reviewer 2:

The reviewer believed that the approach presented was a systems approach, where multiple technology improvements and additions are utilized to meet the challenging goals of this SuperTruck II project. The reviewer noted that the multiple strategies were well coordinated by the project team, and that the team had diverse set of expertise which would be required for a project like this.

The reviewer noted that the presenter did not use the format for the VTO AMR presentation, and because of this, there are several aspects of the project that were unclear relative to the review criteria.

Reviewer 3:

The reviewer believed that the program had all of the key components to achieve the program goals, but was not sure why a GCI concept shown on Slide 10 was needed for this program. The reviewer was concerned that the GCI effort may divert the program focus and resources. The reviewer said that transient control and durability are two of many concerns; these can be extremely challenging to bring the concept into potential market place. The reviewer also noted that the program did not identify what the stretch goal was and listed only “XXX%.” The reviewer stated that the project team should be more specific.

Reviewer 4:

The reviewer noted that going after a new approach GCI engine is very intriguing, unfortunately the approach presented by the project team appears to be a “kitchen sink” approach (i.e., put everything in that you can think of). This reviewer believed that the project team needed to reference the knowledge gained from the first SuperTruck program or the experiences of the other SuperTruck I programs. Also, this reviewer believed that there was not enough attention given to an improved tire technology, which was concluded as a very important aspect in the other SuperTruck II projects.

Reviewer 5:

This reviewer believed that the work listed for this project was a continuation and extension of the work the project team did for SuperTruck I.

Reviewer 6:

This reviewer was concerned that low-pressure EGR would be adequate on its own for meeting prevailing emissions regulations, and noted the need for some consideration and mention of after-treatment strategy, which would strengthen the presentation/project. This reviewer was also concerned that it was not clear whether GCI was a prime path or an alternative path to have ready.

Reviewer 7:

The reviewer noted that the project team approach to 100% freight efficiency improvement did not show the starting point (SuperTruck I final results), but the opportunities were defined for the engine and vehicle. This reviewer commented that unique approaches, like GCI, more light-weighting than others, stop/start, and integrated starter/generator HEV would be desirable and have interesting application paths. This reviewer noted that a comparison between the Navistar approach to HEV and the Cummins approach would be of value and that the technology choices seem to fit well with the North American vehicle market. This reviewer also commented that there was no mention of the MAN developments in Class 8 technologies and how MAN might participate.

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

Reviewer 1:

The reviewer commented that the project team was off to a good start with advances in analyses, and that the engine friction analyses, air system, and WHR point the way for the project. This reviewer remarked that GCI was a different approach from the other projects and it would be interesting to see how GCI impacts the project. The reviewer also said that the vehicle analyses on aero, cooling, HEV, and axles was a good start.

Reviewer 2:

This reviewer stated that a good plan and preliminary approach had been established for this new project.

Reviewer 3:

The reviewer noted that the project was in the beginning stages; thus, not much progress has occurred. But, the reviewer remarked, what progress had occurred (mostly planning and implementing the team) has been good and thorough.

Reviewer 4:

The reviewer stated that though the project just starting, a good plan had been compiled.

Reviewer 5:
The reviewer commented that the project had just started, and that the effort to date has been largely organizational and managerial. The reviewer also noted that efforts to reduce the rolling resistance of the vehicle's tires was not listed a part of the team's effort to reduce fuel consumption.

Reviewer 6:
The reviewer noted that the project team had put together a project plan, but the plan seemed a bit hap hazard. Additionally, this reviewer commented that there was no budget shown on the slides.

Reviewer 7:
The reviewer commented although the program shows progress with modeling on the engine side, the project has a lack of specific details with quantitative and measurable results/milestones which should be shown on the roadmaps; milestones which are required to achieve the overall program goals.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer noted an excellent team had been assembled with a wide range of technical capabilities and commercialization potential.

Reviewer 2:
The reviewer noted a very solid and diverse team has been assembled, though a tire company would add strength.

Reviewer 3:
The reviewer remarked that the partners in the collaboration were interesting, but the coordination for the project seemed a bit loose.

Reviewer 4:
This reviewer was surprised that the project team did not have a tire company among their collaborators.

Reviewer 5:
This reviewer remarked on the progress of specific team members; ANL has started some GCI analyses, LLNL was doing aero, Bosch was doing the fueling system and Dana seemed to have started on axle evaluation with TPI doing some weight reduction. The reviewer noted that given the role of WHR in meeting the objective, perhaps the project team might want to find a participant in that area.

Reviewer 6:
The reviewer noted good coordination with national laboratories, a body fabricator, and an axle manufacturer. This reviewer further commented that collaboration could be improved with clear mapping of electrification function responsibilities for the project and that expertise in system implementation for KERS, hybrid, and 48 V areas were not implicitly obvious and would be important for project success.

Reviewer 7:
The reviewer noted that there was no university involvement in the project, which was a concern.

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

Reviewer 1:
The reviewer remarked that an excellent plan had been compiled, and referenced prior comments on emission control path.

Reviewer 2:
The reviewer noted a solid preliminary roadmap/future plan to achieve targets.

Reviewer 3:
The reviewer commented that the approach was sound for addressing the challenging project goals.

Reviewer 4:
The reviewer stated that though the initiatives were very interesting, there was not much justification given for the selection of each initiative.

Reviewer 5:
The reviewer remarked that the project plans were still being formulated, but for those steps that were solidified the work has started. Then this reviewer questioned whether MAN would play a future role in the project.

Reviewer 6:
The reviewer noted that the description of the plans was very general, much more so than the other SuperTruck II teams, which had specific detail.

Reviewer 7:
The reviewer noted that the presentation did not provide a specific section to discuss future research. Although some future work can be sensed, piece-by-piece, from different slides, it was not a very well-organized presentation.

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

Reviewer 1:
The reviewer remarked that the project team was looking at advanced concepts in composite frames and significantly enhanced electrification on the vehicle, such as totally electrified heating, air conditioning, and ventilation, and coolant etc., and noted that this would be important learning.

Reviewer 2:
The reviewer affirmed that reducing fuel consumption from HD trucks will directly reduce petroleum use in the United States.

Reviewer 3:
The reviewer stated that the project supports the overall DOE program objectives when achieving DOE BTE and vehicle freight efficiency goals.

Reviewer 4:
The reviewer compared this project to SuperTruck I, with additional emphasis on affordability, which should help ensure real-world fuel savings.

Reviewer 5:

The reviewer said that if any of the individual parts are successful, it could be a breakthrough. That would be an enormous benefit and would take the project out of the straight forward engineering development that we are seeing from the other SuperTruck II projects.

Reviewer 6:

The reviewer observed that Navistar has a big vocational vehicle emphasis, and said that much of the technologies from this project could be pertinent there.

Reviewer 7:

The reviewer summarized that the project scope was developed to meet SuperTruck II goals, which has been engineered to meet DOE objectives.

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

Reviewer 1:

The reviewer observed that because the budget for this project was not shared during the presentation, budget related questions were difficult question to answer. However, the reviewer noted, with the high-risk initiatives of this project, it will be very hard to estimate costs and most likely the costs will be estimated low.

Reviewer 2:

The reviewer noted that the project had a large amount of funding and that the expectations for success would be high.

Reviewer 3:

The reviewer was hopeful that resources would materialize and enable the project to be successful.

Reviewer 4:

The reviewer found no funding issues yet.

Reviewer 5:

The reviewer believed that the project had a good level of funding to achieve more than incremental improvement, and that the project had substantive funding and goals.

Reviewer 6:

The reviewer commented that it was unclear how sufficient the resources for the project were, because the budget details were not provided in the presentation, and summarized that the team should provide more funding and budget information in future reviews.

Reviewer 7:

The reviewer noted that the project team should have all they need to achieve the program goals.

Presentation Number: acs104
Presentation Title: Cavitation Within Fuel Injectors: Development and Multiscale Validation of Euler-Lagrange based Computational Methods for Modeling Cavitation within Fuel Injectors
Principal Investigator: Emily Ryan (Boston University)

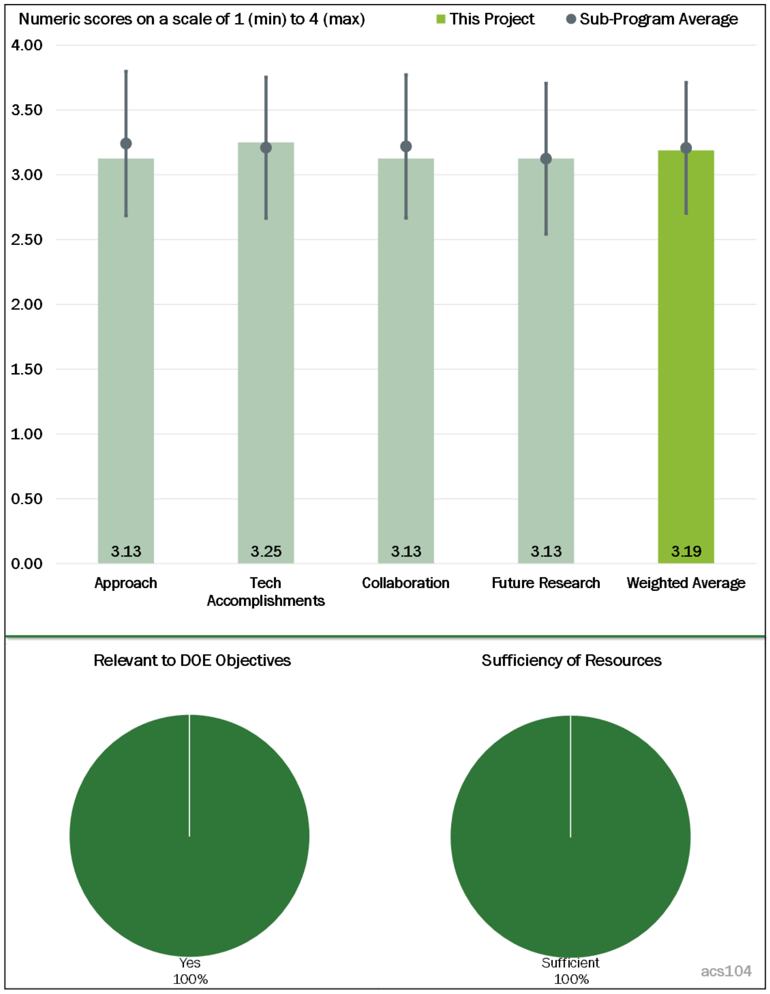

Figure 1-39 - Presentation Number: acs104 Presentation Title: Cavitation Within Fuel Injectors: Development and Multiscale Validation of Euler-Lagrange based Computational Methods for Modeling Cavitation within Fuel Injectors Prin. Investigator: Emily Ryan (Boston University)

Presenter

Emily Ryan, Boston University

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that overall, the technical barriers are well identified and addressed milestones are feasible. It is a little unclear to the reviewer why the smooth particle hydrodynamics (SPH) is the method of choice over the conventional approach and what benefit/improvements are expected, given the anticipated computational cost increment.

Reviewer 2:

The reviewer commented that the approach over the past year has been to incorporate some new capabilities in KIVA that would enhance its usefulness. These include various approaches to modeling sub-processes and improving some computational aspects to make the solution to the governing equations more efficient and less time-consuming. The reviewer noted that the view is to improve engine efficiency and reduce harmful emissions.

The reviewer stated that KIVA has been around a long time and its virtue is open-source (e.g., unlike for-profit codes like CONVERGE) along with its significant capabilities. Efforts include employing LES to model engine flows, spray modeling grid generation capabilities, and multistep kinetics using Chemkin-pro. Fuels are multicomponent, especially surrogates. The reviewer commented that some discussion of how multicomponent effects would be addressed should be included. The reviewer asked how confident the PIs are that their property database for mixtures is robust. The reviewer also asked about mixing rules, etc., combustion chemistries of multicomponent liquid mixtures.

KIVA ostensibly relies on certain adjustable inputs (e.g., because it is not an ab-initio solver); the reviewer asked if that is right. The reviewer noted that it would be good to have a concise list of what needs to be adjusted for predictions and data prior to using KIVA.

The reviewer observed that a VOF approach for sprays is mentioned. The reviewer asked if the resulting simulation capability will be at the level of a code like RAPTOR (SNL) which simulates jet injection and its ultimate development into a spray.

Dynamic LES for capturing the transition from laminar to turbulent flow and a move away from the law-of-the-wall is being pursued which the reviewer noted is good.

The PI noted that the team has “validated with experimental data” the dynamic LES. The reviewer stated that this needs to be further discussed. The reviewer asked if this is the backward-facing step and isolated drop configurations mentioned in the proposal and if so, how are these configurations related to in-cylinder processes where KIVA is to be applied. The reviewer also asked what “validated” means, and asked if there is a targeted percent difference between simulation and experiment where “validation” would be considered as having been met, and what the contingency is if the agreement is poor. The reviewer would like the project to elaborate with details.

Reviewer 3:

The reviewer asked how SPH is exactly incorporated. The project mentioned VOF will be used in the simulation, but VOF is for the Eulerian scheme while SPH is a particle method. The method should be stated more clearly. The boundary conditions would appear the most difficult to handle; combining the methods is critical to understanding if this system will be successful.

Reviewer 4:

The reviewer remarked that as another reviewer noted, there are some issues related to the use of H_2O as a fluid in this project. Researchers are strongly urged to consider doing experiments, particularly the simple geometry experiments at Boston University, as well as computations using more realistic fuels or fuel-like fluids. The only other effort this project is aligned with is the neutron imaging at ORNL. The reviewer wonders why this work is not connected to the X-ray measurements being done at Argonne National Laboratory (ANL). It seems like those measurements are better suited to experimental demonstration of cavitation, which would be readily compared with these modeling efforts.

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

Reviewer 1:

The reviewer observed steady and timely progress on the experimental side. Base setup on the computational side is ongoing. The reviewer is looking forward to seeing validation against the measurement data.

Reviewer 2:

The reviewer noted that progress in the first year seems fine, but efforts need to be ramped up to make the project more productive.

Reviewer 3:

The reviewer remarked that in the past year there are significant advances in improving KIVA’s capabilities. The improvements seem to be in the sub-models for things like turbulence, spray injection, transition from FV to FEM with significant improvements in computational time, grid generation, etc., and comparisons are shown for basic configurations like 3D flow past a cylinder and the pressure field around an isolated droplet. In the end, the reviewer stated that it was not clear how these significant capabilities will fold into the larger scheme of KIVA as an in-cylinder predictor. The reviewer noted that some discussion on this point would help.

The reviewer noted that efforts pursued include validation. For example, the PI notes that a dynamic LES approach is validated with experimental data for pertinent problems. The reviewer asked what problems are used for validation (cylinder, drop, etc.). The concept of validation should be expanded with discussions, but the reviewer asked what is being validated. The reviewer went on to also ask what happens if there are gaps and how the gaps close. The reviewer asked what metrics are used to assess if "validation" has been achieved.

For sprays, the PI notes "true multiphase flow modeling." The reviewer would like the PI to elaborate, and asked if this is like DNS for sprays.

The spray modeling is particularly exciting to the reviewer. The reviewer asked if the spray modeling in KIVA include multi-injector configurations. Other national laboratories are also developing robust computational capabilities for spray (e.g., RAPTOR); the reviewer asked how KIVA's capabilities compare with RAPTOR. The reviewer inquired if there is any collaboration with other national laboratories where their capabilities can further help inform KIVA's development of spray modeling.

The "surface tension test" on a 3D "static drop" seems interesting to the reviewer; however, it was not clear precisely what the PI was simulating. The reviewer inquired if it was evaporation, combustion, convection over the drop, etc. Flow symmetry seems to be assumed as a base case and a pressure field computed around the drop. The reviewer questions what the boundary conditions are. More clarity will help here for the reviewer.

Reviewer 4:
The reviewer noted that the models and experiments have been started. The reviewer observed that there remains a good deal of work to show that coupling SPH methods with an Eulerian Fluid solver is an effective process to incorporate the resolved SPH bubble dynamics into the Eulerian Finite Volume RANS Navier-Stokes solver of OpenFOAM. The reviewer commented that it would be advisable for the PIs to expressly state the mathematical foundation of the models and how the system will work mathematically.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that the project is a good collaboration between universities and laboratories.

Reviewer 2:
The reviewer said that the project involves a collaboration with ORNL, but the direct connection between cavitation modeling and the flash-boiling experiments at ORNL is not well demonstrated. In addition, it seems to the reviewer like this project should be closely coupled with other ongoing DOE-funded efforts, such as the work at ANL (as already noted in a previous comment).

Reviewer 3:
The reviewer remarked that the PI has a range of collaborators that include some from national laboratories, developers of CHEMKIN-Pro, universities, and one industry. The reviewer pointed out that perhaps the latter is the problem as there does not seem to be enough interest or collaborative representation of OEMs in KIVA. The reviewer commented that the PI and his team should get some OEMs on boards to establish better relevance and interest to industry's needs.

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:
For this reviewer to understand the proposed work, the precise formulations of the models should be presented.

Reviewer 2:

The reviewer commented that the project feels that it is conservative in setting its goal and driving for it. Maybe once it makes it through the go/no-go decision point, more challenging milestones will be presented.

Reviewer 3:

The reviewer stated that, as noted previously, the work should target other fluids besides H_2O, as well as more realistic injector nozzle geometries. The work should also aim to link up with other efforts (e.g., ANL's X-ray measurements).

Reviewer 4:

The reviewer remarked that the PI has identified a number of challenges for future work. These include turbulence and spray modeling and conjugate heat transfer. The reviewer observed that the PI noted the need for incorporating heat transfer to the engine block which seems to be a move away from correlations for heat transfer coefficient, which is good.

The reviewer stated that a consideration for future work that would separate KIVA from other codes, but not apparently considered, is engine block thermal considerations and materials stress matters associated with significant temperature gradients within the cylinder. Engines may not operate indefinitely at peak efficiency if the materials of which they are fabricated fail. The reviewer remarked that it is time to incorporate this consideration in to robust engine solvers.

The reviewer recommended that the PI include on his team of "partners" at least one OEM with some commitment to adopt KIVA for prototype engine design if certain conditions are met (the PI can work with the OEM to define the conditions). The reviewer stated that doing so will enhance the relevance of the project to DOE's interests.

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

Reviewer 1:

The reviewer stated that the project is very relevant at addressing the understanding of the effects of cavitation and turbulence within the injector on the overall performance of the engine, since injection physics highly influence the performance and combustion products.

Reviewer 2:

The reviewer commented that predictive model development is aligned with the DOE objectives.

Reviewer 3:

The reviewer remarked that KIVA is relevant from a broad perspective. The reviewer noted that robust capabilities for predicting in-cylinder performance are needed and that the PI is working toward that end. However, if KIVA is to be relevant to industry's needs, the reviewer stated that some evidence of that is important to demonstrate. There are no OEMs on the PI's team. The reviewer asked if that mean that OEMs have no interest in using KIVA to design engines (at least on a wide-ranging scale). The reviewer said that the PI did note that "...most of the following attributes are those heralded by industry as necessities."

That is great, but if the PI is working to provide more relevance of KIVA's capabilities to OEMs needs, the reviewer asked why the OEMs are not embracing KIVA the way they are other codes (e.g., CONVERGE). The reviewer noted that it would be good for the PI to answer this question in future presentations. Along with the answer will come another answer, specifically, who the audience KIVA is targeted for. If the audience is OEMs, the reviewer remarked that they should be brought in. If it is university researchers, fine. KIVA will then assist in the education of the next generation of computational scientist being trained in simulations and there is nothing wrong with that, but the reviewer thought that it should be known.

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

Reviewer 1:

The reviewer said that it looks that the budget is sufficient for the plan.

Reviewer 2:

The reviewer stated that resources seem adequate although ultimate judgement would have to come from a cost/benefit analysis based on DOE's investment relative to the commercialization potential.

Presentation Number: acs105
Presentation Title: Turbulent Spray Atomization Model for Diesel Engine Simulations
Principal Investigator: Caroline Genzale (Georgia Institute of Technology)

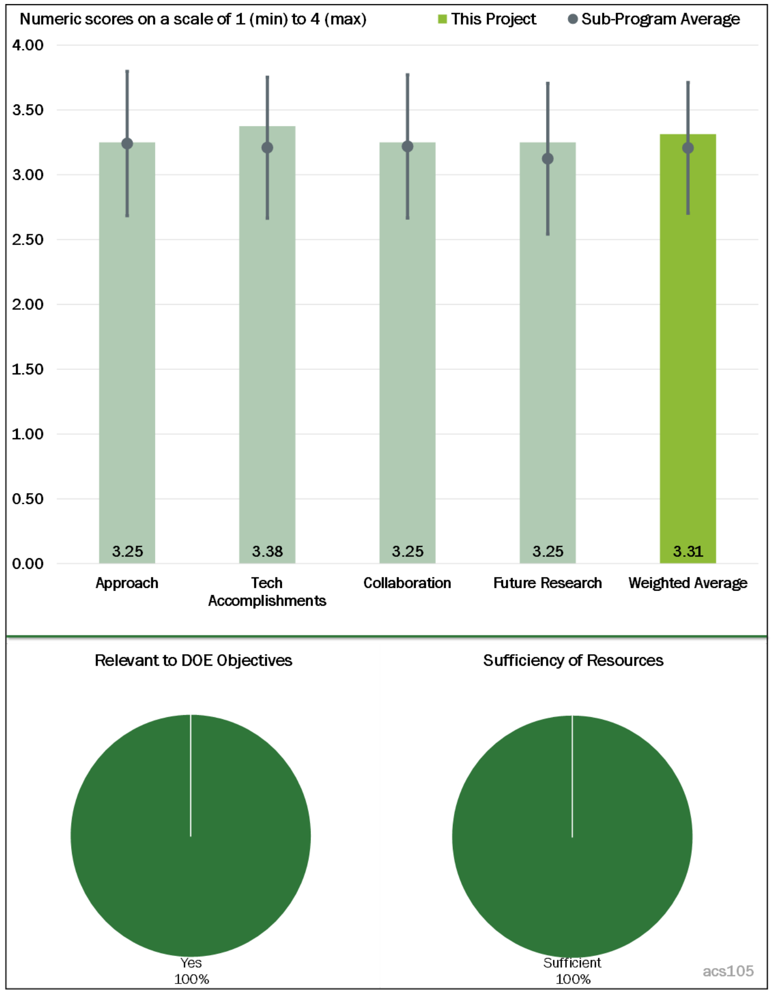

Figure 1-40 - Presentation Number: acs105 Presentation Title: Turbulent Spray Atomization Model for Diesel Engine Simulations Principal Investigator: Caroline Genzale (Georgia Institute of Technology)

Presenter

Caroline Genzale, Georgia Institute of Technology

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that, as highlighted in several other DOE-funded projects, better understanding of spray processes addresses several critical technical barriers to improving engine combustion efficiency and emissions. This project, while only through 1 year, is off to an impressive start and appears to be very well conceived. The reviewer is looking forward to seeing how this work proceeds. In addition, the reviewer noted that the project is collaborating with appropriate researchers conducting other efforts, both directly with ANL and somewhat indirectly through the ECN.

Reviewer 2:

The reviewer commented that the approach is comparatively a new way to measure spray morphology providing quantitative measurements for the spray modeling. The reviewer remarked that the method is well proposed. The reviewer asked why OpenFOAM is only being used to implement this model, not other software, e.g. KIVA. The reviewer is unsure why the Kelvin-Helmholtz Rayleigh-Taylor (KH-RT) model is not being utilized, just the KH model. It could be that the realm of spray condition is not sufficient to show that the RT model is useful. Perhaps the RT part of the KH model is not developed properly in OpenFOAM. The reviewer observed that using a KIVA code would at least solve that problem, by simply adding the KH model or using UW's Engine Research Center's (ERC) version of KIVA which has the KH type Reitz version of spray combined with the RT or use of CONVERGE software. The reviewer stated that the accuracy of the numerical method used in OpenFOAM, in addition to the fact that it is overly complex, requiring re-meshing the topology for moving parts, seems like a better choice over the KIVA codes or CONVERGE.

Reviewer 3:

The reviewer remarked that the project is developed around the (correct) belief that there is a lack of basic knowledge of how sprays impact engine performance. In response, the reviewer said that the PI is developing a predictive capability based on OpenFOAM that will incorporate a new turbulent atomization model relevant to low ambient density.

The reviewer noted that the PI and team are outstanding and the results they are working toward—a validated predictive spray model—will be significant if successful. Some additional comments about the approach are given below.

In framing the approach, it was not quite clear to the reviewer precisely what will be simulated using OpenFOAM and what the experimental data will provide. Many things were mentioned. The reviewer questioned if it is Sauter mean diameter (SMD), density etc.

The reviewer noted that validation is important, though it would be helpful to provide more information about how the model will be validated, and what data would be used in the validation. The reviewer presumes the PI has in mind certain specific properties OpenFOAM will predict, and the Georgia Tech team has the capability to provide data on those spray properties. The reviewer wondered what the properties are (such as SMD, and density) and what the criteria for "validate" is. The reviewer noted that some thought needs to be given to this question.

In the approach, a go/no-go point is indicated that concerns "validation" of benchmark sprays. The reviewer would like the project to provide more details of what is meant by "validation."

The reviewer remarked that the PI notes that mechanisms of atomization are unknown. It might be necessary to modify this claim. Books have been written on this very subject. The reviewer noted that a lot is known about how sprays are formed. Less clear, perhaps, is what happens inside the atomizer itself, which the reviewer presumes is where the ANL collaboration comes in.

The reviewer observed that the approach is to combine data from new diagnostics that characterize sprays and use the data to validate a Lagrangian spray atomization model. The modeling aspect will be performed using the OpenFOAM code. Well characterized atomizers will be used in the experiments which the reviewer noted is good.

It was not clear to the reviewer how the ANL data would be used in the spray validation process. The reviewer noted that some discussion of this should be included in future presentations.

Reviewer 4:

The reviewer commented that the project certainly addresses the technical barriers of having a spray model for a wider range of application with more physics included. The reviewer noted that the content looks a little weighted toward the experimental side. It is not clear to the reviewer where the current models need improvement. It is claimed to be investigated, but the models to be tested have been around for decades. The reviewer stated that it would be nice to have directions for model development described in more detail.

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

Reviewer 1:

The reviewer remarked that the PI has done a lot of work in the first year which is impressive. Work at ANL also provided information on liquid volume fraction that allowed determining the distribution of liquid mass with position. Data on SMD were reported at various axial distances and a new diagnostic to resolve diesel sprays was used to infer droplet size, number density, and volume fraction. The main concern for the reviewer is what the PI means by "validation". The reviewer presumes these matters will be addressed in future presentations.

The reviewer would not consider this a technical accomplishment if carried out, but recommended the PI consider doing an extensive literature search on sprays to ensure that there are no useful data in the literature that can be used in the OpenFOAM validation process. It seems to the reviewer that some of the types of information reported here—SMD in particular—has a rich literature, though with data obtained by different means.

The reviewer noted that the work performed in the reporting period also included simulations using OpenFOAM to predict the evolution of liquid penetration and of SMD with axial distance.

Reviewer 2:

The reviewer noted that although the project has only completed its first year, it seems to be making very good progress toward its objectives. The reviewer went on to comment that the PI also seems to be keenly aware of areas that need to be addressed and honest about the difficulties of doing these measurements and computations.

Reviewer 3:

The reviewer pointed out that the work meets the general technical accomplishments and progress toward overall project and DOE goals. The reviewer noted that if budget period one is the main base for the other two phases, this project is on track to meet the overall goals.

Reviewer 4:

The reviewer remarked that the project's progress meets milestones. The reviewer has a small concern with the grid convergence. The reviewer asked if the parcel count convergence check was with 0.25 millimeter (mm) and 0.125 mm grids. The reviewer is looking forward to seeing in-depth comparison of the model benchmark results.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the project appears to have very good collaboration, particularly considering its budget.

Reviewer 2:

The reviewer noted that there is a good combination of expertise. The reviewer commented that project coordination also looks nice.

Reviewer 3:

The reviewer said that the project collaborations include a direct connection to ANL and participation in ECN, both of which are highly appropriate, however, the work might benefit from collaboration with additional researchers, such as those doing experimental and computation work on cavitation and nozzle geometry. It would seem to the reviewer that spray behavior and characteristics depend on initial and boundary conditions, which would include how the flow passes through and exits the nozzle. The reviewer remarked that perhaps such collaborations could come along in later years.

Reviewer 4:

The reviewer noted that there seems to be one outside collaborator for the project (ANL) who will provide expertise on their X-ray visualization facility. The reviewer remarked that this facility has capabilities to view the regions within an atomizer. The reviewer is unsure if that is what the PI is using the ANL facility for (i.e., get data on the interior atomization process of a nozzle) as it was not clear.

The reviewer stated that the PI should consider bringing another national laboratory in as a partner who is doing detailed LES simulations of sprays (the Oefelein group at SNL). Furthermore, the reviewer commented that it might be worthwhile to reach out to an OEM who has a need for the type of model that PI is endeavoring to develop for sprays.

The reviewer observed that the PI is partnering with colleagues at Georgia Tech University (GT) who have unique facilities to characterize sprays. As the reviewer remarked previously, it is not clear if the PI was able to find some relevant literature data. There is vast literature on sprays. While the GT group has certain capabilities that others might not have, the reviewer stated that the PI should see if there are other groups that can also be brought into her team.

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

Reviewer 1:
The reviewer commented that the plan makes sense and is aligned with initial goals. The reviewer asked the project to elaborate on why the correlation by Faeth, et al, is to be evaluated.

Reviewer 2:
The plans for future work seems appropriate and solid, but the reviewer suggests that the PI incorporate existing spray data when comparing to models, and not focus only on new data being taken in the GT flow chamber.

Reviewer 3:
The reviewer recommended that the PI endeavor to search the literature for spray studies that may be relevant. The reviewer noted that perhaps that had been done in the proposal phase, though in the presentation, the way the project is framed, there are no relevant data. If that is correct, the reviewer stated that it would be good to note it.

Reviewer 4:
The reviewer observed that the results shown are still not enough to support the modeling. The reviewer noted that fully concluding budget period one results are needed in order to move on.

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

Reviewer 1:
The reviewer remarked that the project is relevant from a broad perspective.

Reviewer 2:
The reviewer stated that the project will help the modeling of sprays and injection in engines, give more understanding, and provide a tool for design and research to industry.

Reviewer 3:
The reviewer said that this project will shed light on spray modeling uncertainties. This is to improve the current modeling capabilities and help accelerate future engine development.

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

Reviewer 1:
The reviewer stated that the budget is substantial, but so is the work.

Reviewer 2:
The reviewer commented that the resources look sufficient

Reviewer 3:
The reviewer stated that resources seem adequate although ultimate judgement would have to come from a cost/benefit analysis based on DOE's investment relative to the commercialization potential.

Reviewer 4:
The reviewer stated that considering the cost of experiments, the resources are low. In addition, the reviewer noted that it would be better if another modeling software is incorporated, such as KIVA or CONVERGEnt. The reviewer said that the project should do a fair comparison and validation for the measurement along with demonstrating how the new model can be incorporated in to industry mainstay tools.

Presentation Number: acs106
Presentation Title: Multi-Component Fuel Vaporization and Flash Boiling
Principal Investigator: Chia-Fon Lee (University of Illinois)

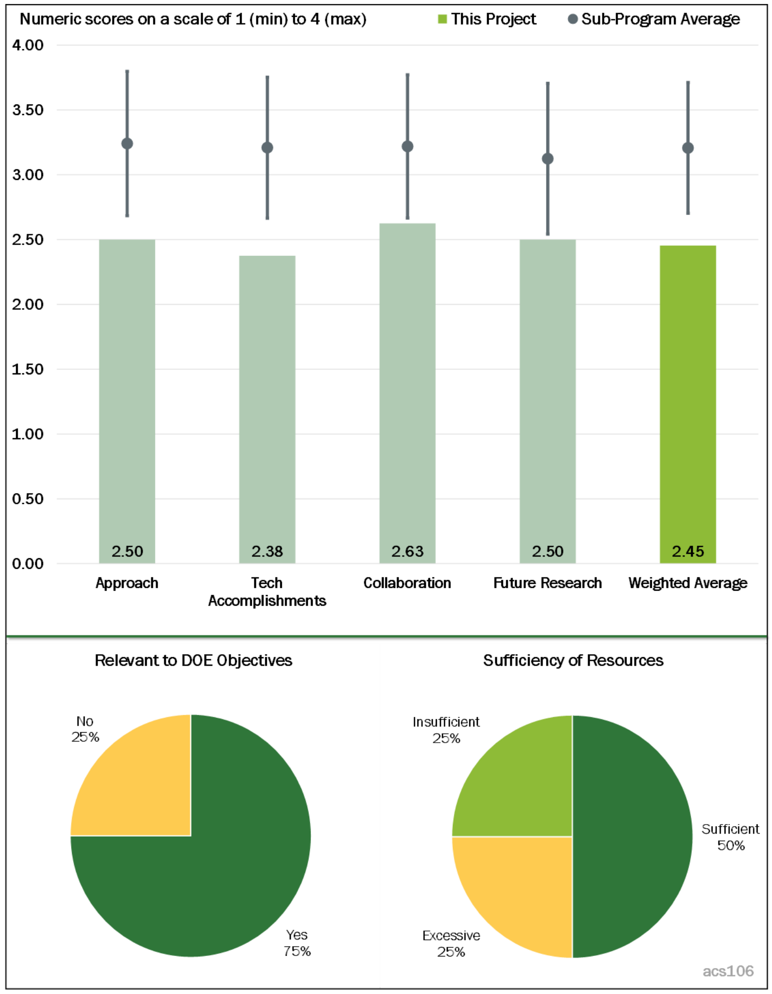

Figure 1-41 - Presentation Number: acs106 Presentation Title: Multi-Component Fuel Vaporization and Flash Boiling Principal Investigator: Chia Lee-Fon (University of Illinois)

Presenter

Chia-Fon Lee, University of Illinois

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that this is a good study and very relevant project. However, the reviewer recommended the project needs more focus. The PI is doing a lot, though it is not clear to the reviewer how the elements all connect: droplets, sprays, film, ANL modeling. This person suggested that a better connection should be established for how these parts of the project fit together.

Given that real fuels and surrogates are multicomponent, the project seeks to understand the influence of miscible constituents on the process. The reviewer stated that this fact raises a plethora of issues associated with property predictions, though the project did not touch on the challenges of property predictions especially for more than simple binary systems. To be relevant it is needed, as the title notes, "multicomponent" effects. The reviewer commented that this project could easily turn into addressing the property prediction process, and suggested the PI should come up with a list of properties that dictate flash boiling and focus on trying to predict those.

The PI discussed a droplet and spray set-up. For this reviewer, it was not quite clear precisely what the experiments were intended to show related to flash boiling. The reviewer asked about the expectation for the droplets for flash boiling.

The droplet experimental configuration was somewhat unclear. This individual wanted to see a schematic illustrating precisely what is intended to be derived from the experiments. The reviewer wondered if the droplets are ignited (and how), or if the droplets are evaporating. The reviewer asked what data the modelers want from the droplet and spray experiments. This individual remarked that the PI is right to note the importance of drop temperature in flash boiling and measurement of drop temperature. This is an important variable (though this is the first year of the project and the PI is to be commended for doing a lot).

It was not quite clear to this reviewer how the droplet evaporation data—the D2 profiles reported—related to flash boiling. The reviewer asked whether the PI is trying to connect the D2 profiles with flash boiling; and the origin for the enhancement of the droplet diameter (flash boiling or droplet heating effects).

The reviewer suggested that the droplet configuration perhaps needs more thought to ensure there are no artifacts of the design that can creep into the results. This individual stated the PI notes "floating," "non-convective evaporation" configurations and recommended the PI include a schematic of these configurations to give a sense of what they are and how they are experimentally created.

This reviewer expressed that the spray studies are very useful. This person noted that the fuels systems seem to be single component. This reviewer asked where the flash boiling is triggered in the spray—whether it is downstream of the nozzle. The reviewer further asked how such images will be used to quantify flash boiling and precisely what data from them will be used in any model of flash boiling.

The reviewer offered that there should be some effort, whether theoretical or experimental, that connects liquid composition to variables that related to flash boiling. The approach did not seem to address this matter so in the end it was unclear to the reviewer how the results might be useful to modelers charged with predicting in-cylinder processes where this effect could occur. This reviewer suggested that visualizations on droplet, sprays and films are fine: we just need more quantitative insights about fundamental processes that bring about the flash boiling process.

The reviewer stated that the ANL flash boiling model is unclear, and asked what physics of flash boiling does ANL incorporate.

Reviewer 2:

Clearly stating the models in a mathematical way is needed to understand the approach better for flash boiling of multi-component fuels sprays.

Reviewer 3:

The project aims cutting into a less explored area of modeling, multi-component fuel flash boiling. Modeling of the flash boiling often rely on simple empirical correlation. The reviewer affirmed that comprehensive study with highly relevant measurement data, as planned in this project, would help clear uncertainties.

Reviewer 4:

The reviewer stated that the experiments were poorly designed. This person asserted the experiments do not capture the basic physics of drop and film vaporization in ICEs. While the fundamentals of multi-component droplet vaporization are of interest, the reviewer doubted the models, if validated with these experimental results, will contribute to improving the accuracy of fuel vaporization in ICEs. The project is probably better suited to be funded by the National Science Foundation.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:

The PI, in the first year, has done a lot: lots of spray experiments to scope out expectations for flash boiling and some droplet experiments that will lead to measurement of the droplet temperature during evaporation.

The PI has made progress on a "droplet liquid phase model," though it was not quite clear what the model was. In particular for flash boiling, precisely how boiling would be initiated and what happens after boiling is initiated, should be better articulated.

The presentation noted that the Peng-Robinson equation of state (EOS) would be used, but the reviewer stated it is not clear what the EOS will be used for. It was not clear how this (or any other EOS) connected with flash boiling. The reviewer asked two questions about EOS: What the role of EOS is in flash boiling (whether it is to set a thermodynamic condition or triggering), and why the Peng-Robinson EOS is being used instead of another EOS.

In the accomplishments, a "current model" is noted in one of the figures (Slide 12), and the reviewer asked what this model is. For the literature data reported, the reviewer asked whether the droplets are evaporating in a high-temperature environment. The reviewer noted that if the droplets are evaporating in a high-temperature environment, precisely how the initial conditions are simulated could influence the subsequent evaporation history. The reviewer stated that the literature experiments are not very clean on this point (initial conditions). Not enough about the model and its relationship to the experiments is provided. The agreement shown is good in some cases and poor others. For either, the question is "why" it is so good or not so good. The reviewer wondered if it is "good" whether that means the model (whatever it is) is proven.

The reviewer asked if flash boiling is expected to occur in a tetradecane/hexadecane mixture.

The ANL simulations reported are interesting. As noted previously, the physics of the boiling process (does it occur within the atomizer for the ANL simulations) are not clear from what was reported, in particular what the criteria used in the model that triggers it.

Reviewer 2:

The model for spray atomization and evaporation is not at all stated. This reviewer recommended that differences in current models should be stated and clear mathematical formulations provided. One might assume the model is generally similar to those used in open source codes such as KIVA with multi-component spray modeling and typically found in commercial codes with some slight modifications. The reviewer re-asserted that clearly stating the models are needed. The reviewer noted that good progress is shown with the experimentation and measurements.

Reviewer 3:

The reviewer is a little concerned about data quality (droplet size measurement), and would like to see improvement next time.

Reviewer 4:

The reviewer observed that the project is only 35% complete with about 50% time left. No plan was presented for 2018. No details presented on how to address challenges and barriers. The reviewer asked what the plan is for integrating into the VOF framework.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The main partner is ANL. They are bringing to the project a capability to simulate engine/flow conditions. Flash boiling processes would seem to be inputs to their simulation, which the PI is providing. More details of ANL's flash boiling efforts (i.e., just what is happening in the model that the liquid knows it is about to cavitate or boil) should be provided in future presentations.

Reviewer 2:

This reviewer stated it is good to see the national laboratory ANL involved, and expressed that the people and co-PI's at ANL need to be named in the report. Credit to particular individuals is important.

Reviewer 3:

The reviewer observed that the PI showed collaboration with ANL, but no details and collaboration plan were presented.

Reviewer 4:

This reviewer stated it is not very clear how the collaborations are coordinated. It looks like the multi-component vaporization model is to be coupled with CONVERGE with which ANL is to attempt flash-boiling calculations. The reviewer asked who is going to perform flash boiling spray experiments.

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

Reviewer 1:

The reviewer noted that the future work will include a range of tasks related to droplet and spray experiments.

This person remarked that the work on film vaporization was somewhat unclear, and asked how it relates to the project.

For the spray experiments, the reviewer asked what the PI hopes to derive from phase Doppler anemometry (PDA) and planar droplet sizing measurements, and how ANL will use the spray information.

The reviewer offered that the greatest effort should be directed to the two-color temperature measurements. That alone is a significant undertaking. If the PI pulled back from other tasks (e.g., film studies noted above) and put more effort into tracking droplet temperature, it would be a more fruitful and useful undertaking.

Reviewer 2:

The reviewer expressed that the work on the modeling is hard to judge, because the presentation should have supplied precise detail in references and technical slides. The work in the experimental arena is good. It would be good to see an open source code being used as well for the modeling, something proven in the spray-modeling arena for engines. This would assure that public funds being used would be available to all. DOE funds work on the CFD open source codes for engines, so that using those codes, such as OpenFOAM and KIVA, would demonstrate multiplier on the DOE support. Simply demonstrating the models being developed will work in the open source codes would be sufficient to assure general use of work being developed.

Reviewer 3:

The reviewer desired more details of flash boiling spray experiments.

Reviewer 4:

The reviewer stated that it is poorly presented, lacking details on how to address barriers and risk mitigation plan.

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

Reviewer 1:

Yes, from a broad perspective. The reviewer stated that flash boiling is an important problem. Its development dictates to an extent the efficacy of multi-hole injectors in which several liquid jets are directed into the combustion zone. If it occurs, the jets merge due to their expansion from internal bubble nucleation and growth, which will defeat the purpose of the multi-hole concept. Hence, conditions are avoided that would lead to this outcome. Additionally, flash boiling can also occur within a nozzle due to cavitation processes if the fluid pressures within the atomizer drop below some critical value (the cavitation pressure) that could influence the quality of the atomization process itself. The triggering physics are the same.

The reviewer observed that the project addresses this problem from a somewhat fundamental perspective in that engine studies themselves are not specifically studied but rather experiments and analysis are pursued on sprays and droplets to try to understand the basic physics involved. The reviewer asserted that this is the right approach as other DOE projects are dealing more with engine studies and injector designs. Multiple projects within the DOE portfolio could use the results of this project depending on how the results are developed and formulated into a concise criterion for flash boiling.

Reviewer 2:
This project is relevant to petrol displacement, noted the reviewer, because the work is related to a significant portion of physics affecting engine dynamics.

Reviewer 3:
The reviewer affirmed that this project is to improve the current model capabilities, which is to impact efficiency in developing future engines and understand physics better.

Reviewer 4:
The project could support the overall DOE objectives of petroleum displacement. Better vaporization model is critical for combustion modeling. However, the reviewer remarked that this project is not well designed to achieve this goal.

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

Reviewer 1:
The reviewer stated that it seems the resources are sufficient.

Reviewer 2:
The reviewer stated that resources seem adequate although ultimate judgement would have to come from a cost/benefit analysis based on DOE’s investment relative to the commercialization potential.

Reviewer 3:
This person noted that without knowing exactly what the models being produced, what is novel over existing models, leaves some doubt about the extent of the model development effort required.

Reviewer 4:
The reviewer remarked that the PI did not provide many details on what facility is available and what will be accomplished. For example, the reviewer wondered when the lasers will be delivered to perform laser diagnostics for fuel characteristics.

Presentation Number: acs107
Presentation Title: High-Pressure Supercritical Fuel Injection at Diesel Conditions
Principal Investigator: Ajay Agrawal (University of Alabama)

Presenter

Ajay Agrawal, University of Alabama

Reviewer Sample Size

A total of three reviewers evaluated this project.

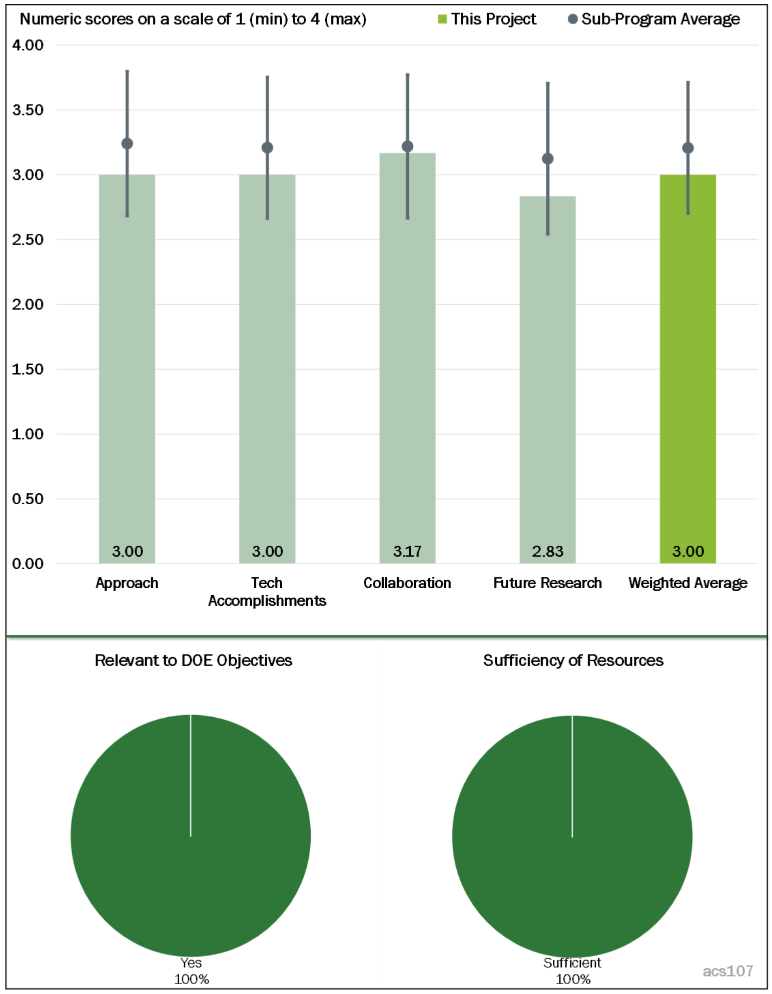

Figure 1-42 - Presentation Number: acs107 Presentation Title: High-Pressure Supercritical Fuel Injection at Diesel Conditions Principal Investigator: Ajay Agrawal (University of Alabama)

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

Reviewer 1:

The reviewer comments that the approach is good, well designed and feasible. It could be integrated more with other efforts if an open source code were used that had similar capability. But if the models are available in open source after completion of the project, then using public tax dollars is warranted. But if the models only enhance a private sector CFD modeling capability then the approach should be modified to include open source code work too.

The reviewer believes it should have been mentioned in detail how the Eulerian-Eulerian method will work in mathematical statements. The supercritical liquid fluid and the gas fluid in Eulerian phases is feasible and others are working on this type of problem, it is essentially a form of the VOF method. However, the reviewer believes discussion on the interface dynamics between the phases of the fluids must be presented. The species going from one phase to another is a scalar flux calculation requiring a surface reconstruction between the supercritical fluid and the gas phase, as this is essential where the flux of liquid species needs to be accounted for across the phase changes within a computational element. More discussion or references for the ELSA model in CONVERGE code would be good to present.

Reviewer 2:

The reviewer is not sure if the diesel fuel in the injector is at the supercritical condition. The pressure is higher than critical pressure (P_c), but the temperature is usually lower than critical temperature (T_c). Some light components might vaporize causing cavitation, but most will be at liquid phase before leaving the nozzle. Sufficient fuel-air mixing is needed to elevate the fuel temperature above T_c. But, in that condition, it is a mixture of fuel and air, and no longer pure fuel anymore. Fuel liquid was very clearly observed by optical engine experiments.

The reviewer stated it is still valuable to further advance our knowledge of diesel spray and mixing process. However, the reviewer would like the PI to better explain the definition of "supercritical fuel injection" in future, and asked what the major difference is between this experiment and fuel spray experiments.

Reviewer 3:

The reviewer affirmed that supercritical diesel injection does have a potential for great reduction of engine out emissions, so it is worth taking a look. The model and measurement data to be collected will serve the community for developing advanced combustion concept.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:

This reviewer remarked that the accomplishments for the term are sufficient, moving toward the goal well. Good headway and accomplishment have been made on both the experimental work and on the EOS work. The team should be moving well along soon.

Reviewer 2:

This reviewer noted that overall, the PI made good progress.

Reviewer 3:

Overall good progress, commented the reviewer. In Slide 10, density against temperature is from the National Institute of Standards and Technology data in high pressure. The reviewer would like to see the PI elaborate on why and whether this is a problem.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that this project has a good mix of team members from academia and a national laboratory.

Reviewer 2:

This reviewer remarked that the collaboration with ANL is sufficient to implement the models in CFD software.

Reviewer 3:

The reviewer stated that it is doubtful to have the commercial code vendor involved. It is not very clear what their role in the project is, while they are not an official partner.

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

Reviewer 1:

This reviewer stated that future research is planned in a logical manner.

Reviewer 2:

The reviewer suggested that mentioning which open source codes this work will be created in would have been helpful, would demonstrate the team has been considering this for a period and knows the effort required to put the work in open source. I believe that open source is required if taxpayer's money is being spent, so that good work and good funds benefit all researchers and not just a single private commercial software.

Reviewer 3:
This reviewer observed that it is not very clear which open source CFD code is to be used for validation of the new model and to what extent. It is also not very clear about the target "supercritical" condition for test/model.

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

Reviewer 1:
The reviewer stated that this work explores the realm of fuel injection physics not yet well characterized and which could well be useful to improving engine efficiency and reducing impact of burning hydrocarbons.

Reviewer 2:
This reviewer stated that yes, this project supports the overall DOE objectives of petroleum displacement. The research will provide a better understanding of fuel spray and provide better models for diesel combustion.

Reviewer 3:
The reviewer noted that this project does serve the DOE objectives in the context of data/model readiness for advanced engine combustion concept development.

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 there are sufficient resources for this project to achieve the stated milestones in a timely manner.

Reviewer 2:
The reviewer noted that the resources look sufficient for the planned activities.

Presentation Number: acs108
Presentation Title: Spray-Wall Interaction at High-Pressure and High-Temperature Conditions
Principal Investigator: Seung-Young Lee (Michigan Technological University)

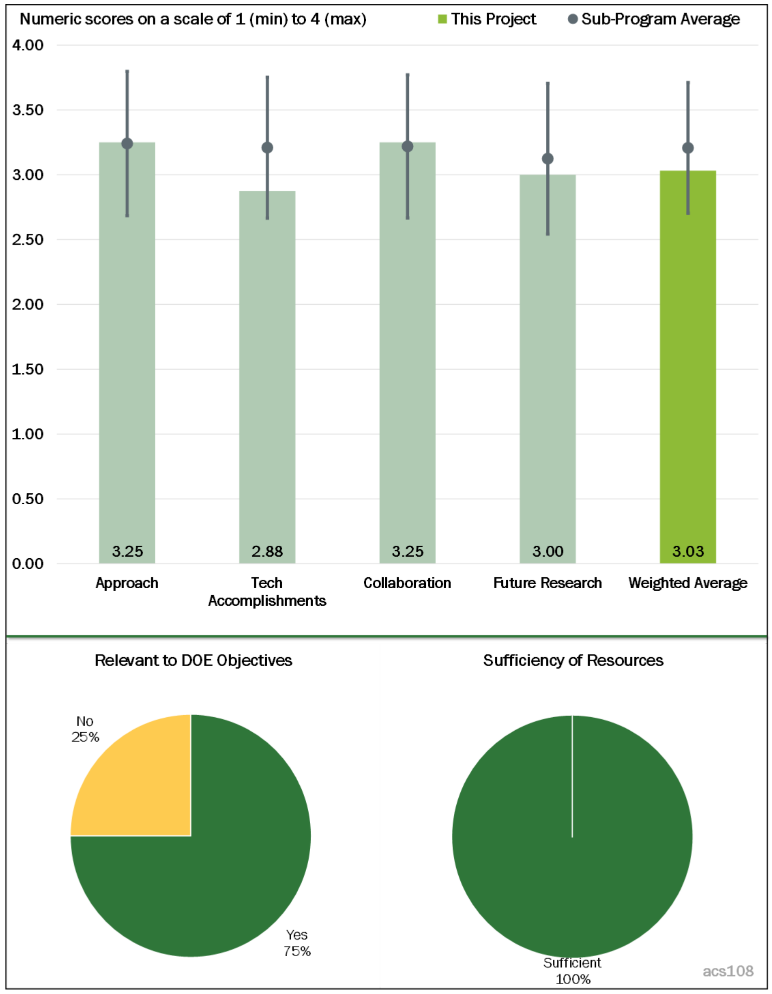

Figure 1-43 - Presentation Number: acs108 Presentation Title: Spray-Wall Interaction at High-Pressure and High-Temperature Conditions Principal Investigator: Seung-Young Lee (Michigan Technological University)

Presenter

Seung-Young Lee, Michigan Technological University

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that fuel filming and subsequent evaporation of the fuel pool is critical to understanding portions of the combustion process that generally lie outside the desired combustion regime. Hence, understanding the effects of film formation, evaporation, and even lubrication solvency, is important to predictive simulation of engine dynamics and engine out emissions. This reviewer remarked that the approach is solid although specific details of how the DNS simulations and experimental data will be incorporated into a CFD sub-model is not developed in detail. Knowing which RANS equations methods will be used and what wall model will be present is important, as most turbulence RANS require a law of the wall model and certain assumptions for not only fluid boundary layer but heat and mass transport processes.

Reviewer 2:

The reviewer commented that the project plan is well designed to address the technical barrier. The reviewer reiterated the PI’s statement that the spray-wall interaction model has been under a shade for a long time with the excuse of less importance in conventional engine operating conditions. However, as software platforms and other sub-models are improved, its relative uncertainties are increasing.

Reviewer 3:

This reviewer noted that the approach is very standard. This type of approach has been taken by many others to derive the existing sub-models. Therefore, it is not clear why this work, using the similar approach (perhaps the diagnostics is a bit better) can yield much better knowledge or sub-models.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:
This reviewer stated the project is on track to meet the overall project goals and DOE's goals. Indicators show good progress.

Reviewer 2:
The reviewer commented that the progress has been made to meet the goals. One thing that this reviewer noted is that typical diesel engines have complex bowl geometry. The reviewer suggested that it would make sense to include the spray-wall angle as a parameter in text matrix.

Reviewer 3:
This reviewer noted that the spray-wall interaction results are very "global." The usefulness of such global spray results remains to be seen.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
Regarding collaboration and coordination, the reviewer stated it is an excellent arrangement. It covers from fundamentals to application, experiment to computation. This represents a very nice example of collaboration.

Reviewer 2:
The reviewer stated that this project has a good mixture of academics and the national laboratory system on a difficult problem to model and understand. It is not always possible to entertain an industry partner, particularly during early phases of work. As the model becomes solidified validation or demonstration of usefulness of the effort on an industry problem, engine could be beneficial.

Reviewer 3:
This reviewer noted that the project collaboration is reasonable.

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

Reviewer 1:
The reviewer said the plan for proposed future research is reasonable.

This reviewer stated that in particular, the VOF based evaporative system for mass and heat flux will require a good interface reconstruction system and likely an iterative method to converge the flux per time step. The reviewer wondered whether, alternatively, the scheme will be an engineering model, similar to droplet evaporation, and use a Spalding number that is currently done in O'Rourke and Amsden, with interface reconstruction performed mostly for visualization of film thickness. This reviewer said details on the how the future methods are to proceed would be helpful.

Reviewer 2:
This reviewer said it is not clear if two-way thermal interactions between the film and the wall is to be taken into account in the model.

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

Reviewer 1:

This reviewer stated that yes of course, all portions of fuel delivery and thermodynamic conditions properly modeled will quickly go toward petroleum displacement.

Reviewer 2:

The reviewer noted that this project is about model improvement and validation data generation. The project meets the objectives.

Reviewer 3:

The reviewer stated that this project is not about using non-petroleum fuels.

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

Reviewer 1:

The reviewer stated that the resources are reasonable.

Reviewer 2:

The reviewer had no comment.

Presentation Number: acs109
Presentation Title: Predictive Models for In-Cylinder Radiation and Heat Transfer
Principal Investigator: Dan Haworth (Pennsylvania State University)

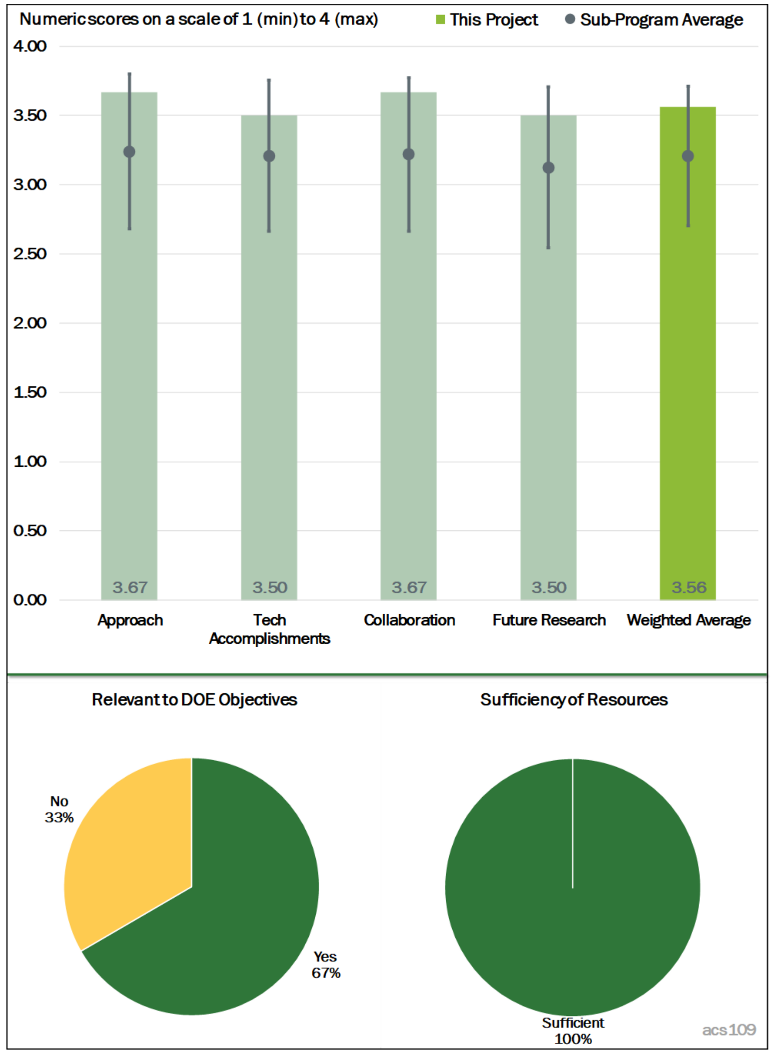

Figure 1-44 - Presentation Number: acs109 Presentation Title: Predictive Models for In-Cylinder Radiation and Heat Transfer Principal Investigator: Dan Haworth (Pennsylvania State University)

Presenter

Dan Haworth, Pennsylvania State University

Reviewer Sample Size

A total of three reviewers evaluated this project.

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

Reviewer 1:

The reviewer expressed no major concern with the plan and approach. Figuring out how important the radiation portion in the total heat transfer budget has been a challenge. The project has well defined layers of approach that are supplementary systematically.

Reviewer 2:

The reviewer remarked that it is a very nice approach.

Reviewer 3:

This reviewer noted that the approach is well designed, first to find the radiation influences on what and from what species to ascertain the overall effects of radiation heat transfer in engines and in particular, effect on boundary layer heat transfer is excellent to see. The reviewer wondered just how the current boundary layer modeling might need changed could be conjectured at this point as perhaps in a general equation form.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:

This reviewer noted that the program is progressing well, showing a need to understand the effects of radiation heat transfer in engines, particularly influences of the heat transfer in the boundary layer. The upshot will eventually be going to improved or adjustments in the wall-laws for use with RANS closure methods. Other progress toward objectives is doing well.

Reviewer 2:
This reviewer remarked that there has been good progress.

Reviewer 3:
This reviewer indicated no major concern so far. The progress has been solid and steady. The reviewer was looking forward to seeing the second-year result as a lot of validation test will be attempted.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer remarked the project has great collaboration with two national laboratories and another university partner.

Reviewer 2:
This reviewer noted that the project collaboration is reasonable.

Reviewer 3:
This reviewer commented that the project team represents a classic collaboration model with partners with distinctive expertise.

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 research plan is tightly aligned with the milestones. There is no foreseeable risk at the moment.

Reviewer 2:
This reviewer commented that the future research plan is very good.

Reviewer 3:
This reviewer stated that good planning and proper execution is being followed. A little more information on the models that might be employed as an outcome of the research here for general radiation heat transfer in a CFD code would be helpful.

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

Reviewer 1:
This reviewer stated that this project is very relevant to modeling the engine heat transfer processes, which is critical to knowing just what is being missed by not modeling radiation heat transfer.

Reviewer 2:
The reviewer observed that the project is going to shed light on radiative heat transfer which has been under a shade for quite a while. Evaluation of its effect in different engine configurations will help engineers anticipate its behavior better so as to be more effective in future engine development for better fuel economy.

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

Reviewer 1:
This reviewer commented that given the scope of the work, and how the work has progressed, the funding is sufficient.

Reviewer 2:
The reviewer said the resources are reasonable.

Reviewer 3:
This reviewer said that the budget seems to be sufficient to meet the goal in comparison with other projects.

Presentation Number: acs110
Presentation Title: Engine Knock Prediction
Principal Investigator: Seung Hyun Kim (Ohio State University)

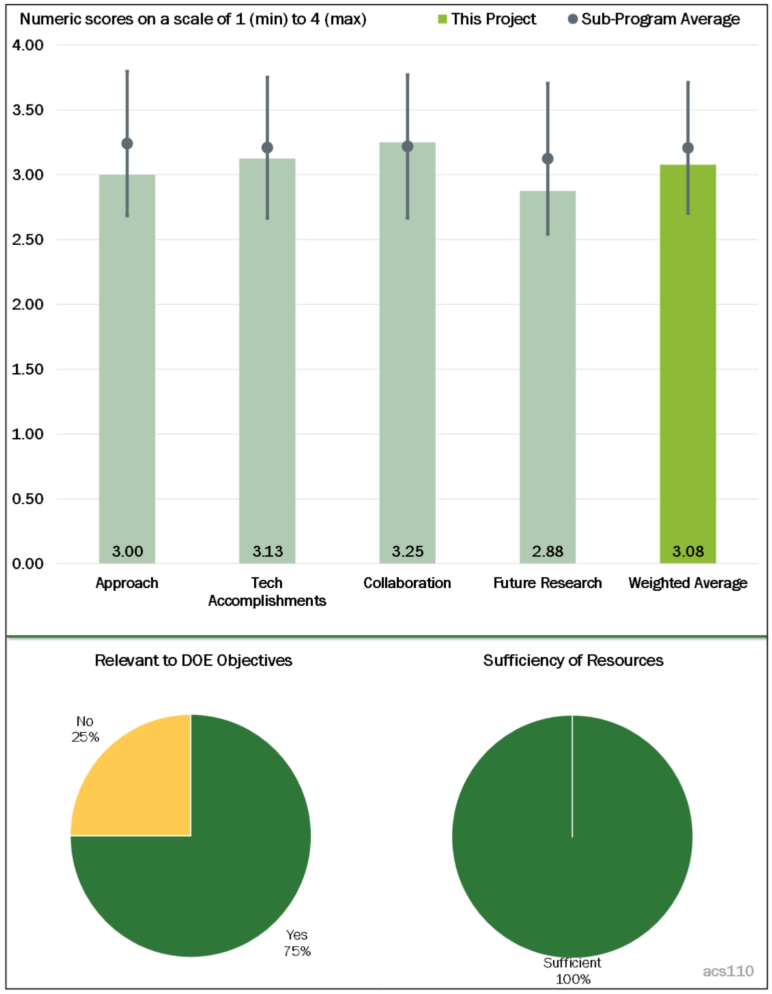

Figure 1-45 - Presentation Number: acs110 Presentation Title: Engine Knock Prediction Principal Investigator: Seung Hyun Kim (Ohio State University)

Presenter

Seung Hyun Kim, Ohio State University

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

This reviewer stated that the team seeks to provide a detailed insight to turbulence chemistry interaction during engine knock. The approach brings a physics model based on LES to capture cycle-to-cycle variations, prediction of HRR. Benchmarks and validations are done through DNS and engine experiments.

Reviewer 2:

This reviewer noted that the burn models compare well with DNS, yes and that is an admirable goal. The reviewer recommends that the PI provide more detail on the LES model itself to understand the resolutions involved, and wondered whether the LES is so fine that it is essentially DNS. This person recommended that presentation of how the surface averaging proceeds with mathematical statements are required, at least in the technical slides. The reviewer also wondered how these models are applicable to less resolved engine modeling problems, more URANS systems.

Reviewer 3:

This reviewer commented that the project uses a very standard and idealistic approach. It is not very novel, but it is hoped that the approach can lead to desirable results.

Reviewer 4:

The reviewer stated that this project is going to add details in conventional computational approach. However, it is not very clear if turbulence-chemistry interactions are critical in predicting engine knock. The reviewer wondered what benefit the PI expects over the current approach.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:
The reviewer remarked that there has been excellent progress on this project toward the overall goals and DOE goals as shown in the presentation.

Reviewer 2:
This reviewer noted that progress has been made without any foreseeable obstacles.

Reviewer 3:
The reviewer commented that the accomplishments and progress are reasonable.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that collaboration and coordination is reasonable.

Reviewer 2:
This reviewer remarked that the project has nice coordination and collaborations.

Reviewer 3:
This reviewer stated the project has a good mix of academia and national laboratories. The reviewer is curious as to why Convergent Science Inc., was chosen to be used versus codes available in the open. The reviewer wonders whether Convergent brings expertise in developing the methods, and if so, whether the public funds being used will make available the models to any code.

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

Reviewer 1:
The reviewer noted that the proposed future research plan is reasonable.

Reviewer 2:
This reviewer stated that it would be nice to see the engine experiment plan for year two with operating conditions in detail.

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

Reviewer 1:
This reviewer noted the project helps researchers and industry with tools that provide for overall better understanding of spontaneous ignition, while also providing for good burn modeling with LES.

Reviewer 2:
The reviewer noted the project is to improve and add details in the current modeling approach.

Reviewer 3:
The reviewer had no comment.

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

Reviewer 1:
This reviewer commented that the resources are reasonable.

Reviewer 2:
The reviewer stated there is nothing to comment yet.

Presentation Number: acs111
Presentation Title: Lagrangian Soot Model Considering Gas Kinetics and Surface Chemistry
Principal Investigator: Sage Kokjohn (University of Wisconsin)

Presenter

Sage Kokjohn, University of Wisconsin

Reviewer Sample Size

A total of three reviewers evaluated this project.

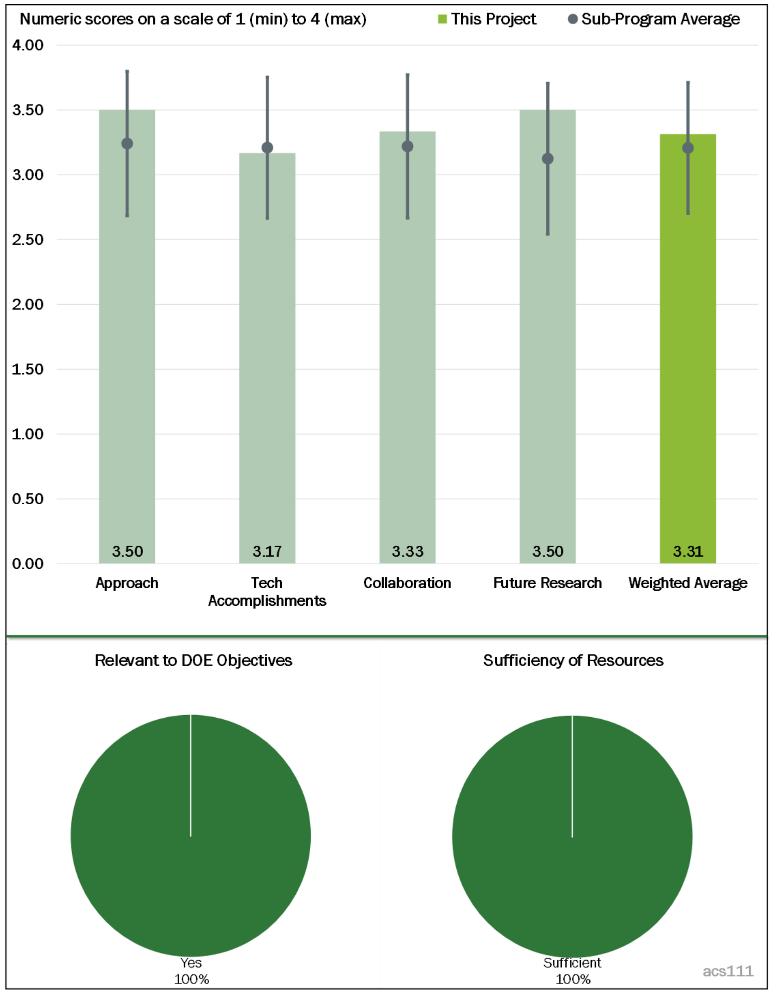

Figure 1-46 - Presentation Number: acs111 Presentation Title: Lagrangian Soot Model Considering Gas Kinetics and Surface Chemistry Principal Investigator: Sage Kokjohn (University of Wisconsin)

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

Reviewer 1:

The reviewer remarked that the approach is good, certainly a big step forward to predictive modeling for soot formation and transport. It is good that the effort is going into a code of open source origin, ERC’s version of KIVA, and not just being tailored for a commercial software vendor. As such, this increases the integration with other efforts being pursued by DOE.

Reviewer 2:

This reviewer commented that project has a very nice approach.

Reviewer 3:

The reviewer noted that soot prediction has been a big challenge for modeling. The project is aiming the technical barrier effectively in collaboration of partners with proper expertise.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:

The reviewer stated the progress is quite good. The authors should include specific references for the soot models used such as the moments method and provide mathematical details in the technical slides for the Monte Carlo method.

Reviewer 2:

This reviewer said the progress is very good.

Reviewer 3:
The reviewer noted this project has well-paced progress and accomplishments. There is no major concern in meeting the goals. It would be nice to have the in-house research code and the commercial code side by side and compare validation/calibration against the measurement.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer noted the project has a good mix of partners from lab, academia and software providers.

Reviewer 2:
The reviewer stated that collaboration is very good in this project.

Reviewer 3:
This reviewer suggested that it would be nice to invite other software vendors as partners for even better impact/penetration to industrial use of the new model.

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

Reviewer 1:
The reviewer remarked the project has a very good plan.

Reviewer 2:
This reviewer commented that further activities are planned nicely. The reviewer looked forward to seeing model performance/cost trade off.

Reviewer 3:
The reviewer observed that the work is proceeding in a reasonable and logical manner. The results of the effort will be very beneficial. The work should be made available in open source if public funds are used, and ERC's KIVA code is not an open source code to this reviewer's understanding of the KIVA codes. Showing how the effort is linked into KIVA in the end and how one might link it into other open source code should also be included in the effort.

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

Reviewer 1:
The reviewer said that soot prediction has been one of the biggest challenges. The project is sharply focused on exploring an improved approach.

Reviewer 2:
This reviewer noted that soot modeling and understanding the formation of soot is critical to finding the best regimes under which to operate and engine and hence goes toward petroleum displacement.

Reviewer 3:
The reviewer stated this project can be applied to biofuel combustion.

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

Reviewer 1:

The reviewer affirmed that this project has very good resources.

Reviewer 2:

This reviewer said it looks like the resources are sufficient.

Presentation Number: acs112
Presentation Title: Integrated Boosting and Hybridization for Extreme Fuel Economy and Downsizing
Principal Investigator: Chinmaya Patil (Eaton)

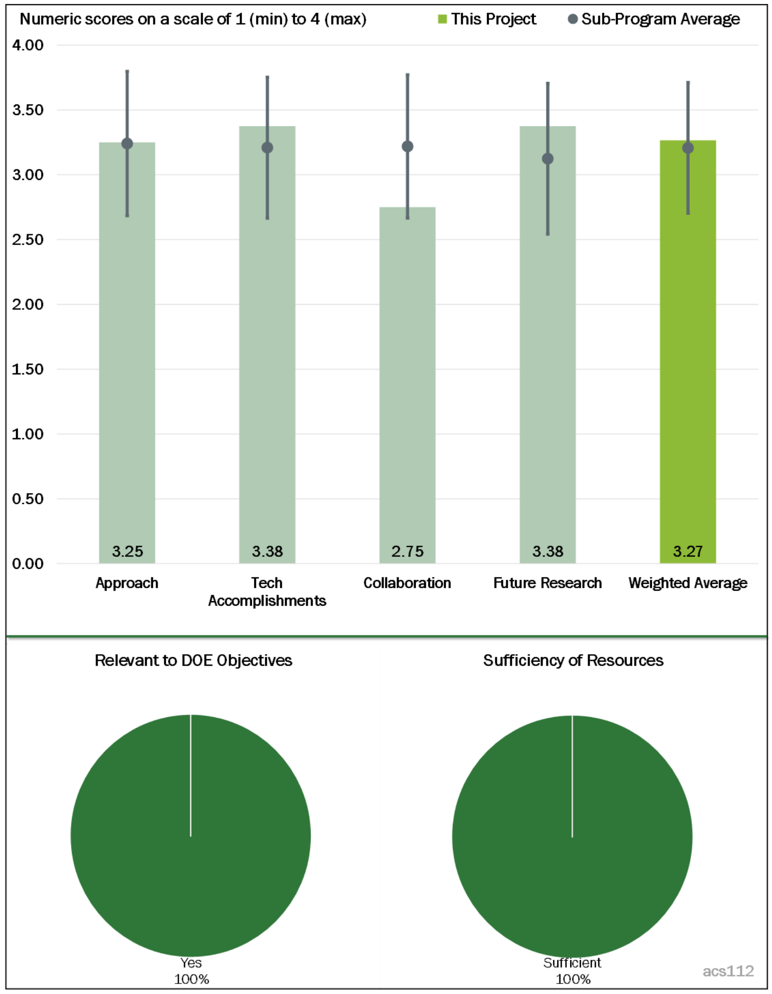

Figure 1-47 - Presentation Number: acs112 Presentation Title: Integrated Boosting and Hybridization for Extreme Fuel Economy and Downsizing Principal Investigator: Chinmaya Patil (Eaton)

Presenter

Chinmaya Patil, Eaton

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

This reviewer stated that the Eaton team proposes development of an electrified expander to perform WHR in engine exhaust, and also use an electrified supercharger (EAVS). These two also aid with torque assist, braking and engine start/stop and potentially could result in 20% fuel efficiency improvement in diesel engines. Overall, these concepts being novel merit evaluation by prototyping.

The approach comprises of system modeling to size the components, which is followed by prototype electric WHR (eWHR) and EAVS development for a downsized diesel engine. Engine performance evaluation will be followed by performance evaluation on a vehicle. The reviewer said that overall, the team has identified the technical barriers and component level design targets through a modeling effort, and then laid out a very logical scope of work.

Reviewer 2:

The reviewer asserted that trying to get similar performance from a 1.8 L diesel with added components to a 2.6L diesel appears to be a reasonable approach.

Reviewer 3:

This reviewer noted that, based on the presentation, which is all we have for 2016 and 2017, the model and simulation of the entire system at the powertrain or vehicle level needs some further detail in the presentation. Perhaps a comparison at the powertrain or engine level, such as showing an engine map, would be helpful along with global vehicle simulation. The traditional fuel economy drive cycles should be presented. As the components are developed, and perhaps the system configuration is adjusted, it would be advisable to update the simulations and present updated results each year.

Reviewer 4:

This reviewer commented that this is an interesting idea. It is not clear that the researchers have done the basic thermodynamic analysis—for the available energy within the exhaust, the regenerating braking efficiency, the efficiencies of the energy exchanges between the electricity generation, power electronics and the battery—in order to demonstrate that this approach is indeed feasible. The researchers should at least bench mark what performance that will be necessary for the individual subsystems of their system.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:

This reviewer remarked that the project team appears to be making good progress. The reviewer would be more comfortable if a thermodynamic analysis had been presented to demonstrate feasibility.

Reviewer 2:

The reviewer observed good progress on component designs and starting component builds, as well as progress on control system design and models. It is not clear how the Isuzu engine control unit is in the program without Isuzu being formally under contract.

Reviewer 3:

This reviewer expressed that the technical progress appears to be on track. So far, the Eaton team has identified the design targets for the eWHR and EAVS components through a system model. Subsequently, these systems were designed confirming two architectures: Mule 1 and Mule 2. Currently, the associated control schemes have been developed and the Mule 1 components have been evaluated. They will be integrated into an engine and a system level performance evaluation will commence soon. Additionally, the Eaton team has partnered with Isuzu as the OEM partner. An Isuzu engine of appropriate size has been set up in an engine test cell to serve as the test platform.

Reviewer 4:

The reviewer stated that the team has now designed the necessary components for EAVS and eWHR and have moved to the testing stage as planned in project

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that Eaton has partnered with Isuzu, who specialize in LD diesel engines. Additionally, the project team has partnered with SwRI to evaluate supercharger and eWHR component performance under EGR conditions. Overall, the team is cohesive with individual partner expertise being complementary and leveraged fully.

Reviewer 2:

This reviewer observed that according to the presentation, Isuzu is not yet a collaborator. If they are, or when they become one, their collaboration will be excellent,

Reviewer 3:

The reviewer noted that the auto company partner seemed a little late to join the project, but that it is good to see them under contract now. The reviewer also noted the status of SwRI participation does not appear to have changed since last year. The inclusion of SwRI would address a potential show-stopper. The reviewer commented that it should have been further along early in project, and needs a backup plan.

Reviewer 4:

The reviewer observed that the project is now 50% completed but the project is still in the contract stage with a vehicle supplier. This reviewer remarked that they appear to be behind.

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

Reviewer 1:
The reviewer remarked that the proposed future work comprises evaluating the performance of their Mule 2 architecture and is a logical extension of the work performed so far. This will be followed by integration with a vehicle and its subsequent evaluation.

Reviewer 2:
This reviewer commented that the outline of future work testing system for functionality and durability is logical.

Reviewer 3:
The reviewer indicated that their plan for future work seems sound. The reviewer highlighted however, that no discussion of cost targets was presented.

Reviewer 4:
The future work includes vehicle integration in addition to resolving or understanding the potentially significant issue of EGR deleterious effects on the roots devices. The future work is appropriate, but appears very daunting to achieve in the last 15 months of the effort. A time extension may be needed.

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

Reviewer 1:
This reviewer expressed that if this works and is cost effective, it could offer significant improvement in engine overall efficiency.

Reviewer 2:
The reviewer commented that the potential application to HD engines and vehicles is interesting and important.

Reviewer 3:
This reviewer stated that the proposed technology, if proven successful, would result in a reduction of petroleum use in transportation vehicles, specifically those using diesel engines, by 20%. As a result, this project aligns with the DOE goal of reduced petroleum use in the United States.

Reviewer 4:
The reviewer affirmed that downsized boosting is a logical strategy to reducing energy consumption and vehicle weight. This project moves in this direction.

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

Reviewer 1:
The reviewer stated that it appears the research will be able to meet their program objectives within their budget constraints.

Reviewer 2:
The reviewer said that the allocated funds are commensurate with the projected scope of work.

Reviewer 3:

The reviewer remarked that the team has demonstrated the capability to design, build, and develop control systems for their system. The team has also contacted an independent team, Southwest Research, to study the durability.

Reviewer 4:

This reviewer offered that the resources are perhaps adequate for a first level of vehicle validation, but not likely adequate for full optimization. The reviewer suggested considering resources for medium or HD vehicles after go/no-go point in 2017.

Presentation Number: acs113
Presentation Title: DOE's Effort to Improve Heavy Vehicle Fuel Efficiency through Improved Aerodynamics
Principal Investigator: Kambiz Salari (Lawrence Livermore National Laboratory)

Presenter

Kambiz Salari, Lawrence Livermore National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

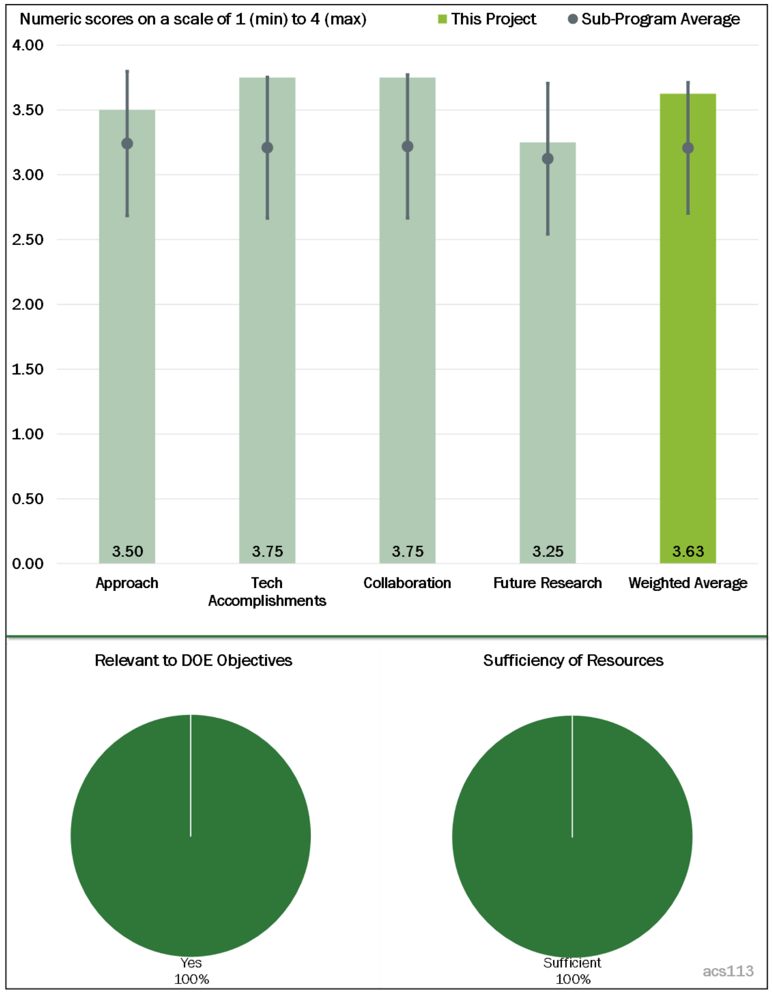

Figure 1-48 – Presentation Number: acs113 Presentation Title: DOE's Effort to Improve Heavy Vehicle Fuel Efficiency through Improved Aerodynamics Principal Investigator: Kambiz Salari (Lawrence Livermore National Laboratory)

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

Reviewer 1:

The reviewer stated that the project approach continues to be very well-thought-out and carefully aligned to DOE goals and industry needs. The generalized information on commercial vehicle aerodynamics adds greatly to the public discussion about how far to push aerodynamic drag reduction. The reviewer observed that the generic speed forms are a good way to start "the conversation" about aerodynamics advances by demonstrating the potential drag reduction.

The reviewer recognized that tanker trailers are a good place to focus activities and that this project would be addressing a low fuel economy sector with relatively simple technologies that should be well-received. The reviewer stated that little work has been focused in recent years on technologies for dry van trailers, so this work was an excellent area for DOE to help push drag reduction technologies even further.

The reviewer said that this project was a good focus on early-stage research using government facilities that industry cannot access otherwise. The researchers on the project team have many years of experience in this field and can use that experience to take advantage of the computational and wind tunnel resources available to the team.

The reviewer summarized that the science-based approach of this project lends credibility to the results and creates defensible and logical outcomes. The project team's approach pursues specific technologies and broader focus areas in a logical manner.

Reviewer 2:

The reviewer remarked that the approach included a design, test, validation and then a demonstration phase, which was a solid project approach.

Reviewer 3:

The reviewer commented that the project was taking a systematic approach and making good strides to understand the physics behind the aerodynamic improvements. The reviewer summarized that the project was proving theories through experimentation and physical testing.

Reviewer 4:

The reviewer observed that the project was well designed to evaluate the opportunities for additional aerodynamic drag reduction. The reviewer stated that the project was well integrated with DOE SuperTruck effort (Navistar). The reviewer remarked that a tractor trailer integration approach decreases aerodynamic drag, resulting in up to 40% reduction in fuel use. The same approach applies to tanker trucks as well (tanker trailers account for 1.3% of U.S. petroleum consumption). The reviewer summarized that the project was a good science based approach, starting with virtual test environment before proceeding to wind tunnel and track/road testing with fleets.

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

Reviewer 1:

The reviewer remarked that the 2nd generation generic speed form (GSF2) geometry is adding significantly to the discussion of “what is possible” in truck aerodynamics. Performance of this geometry represents a breakthrough that should help OEMs create novel real-world shapes for production vehicles. The reviewer noted that because this configuration performs so drastically different from the standard tractor and trailer combination, both the project and the GSF2 should attract the attention of vehicle and trailer OEMs: indeed, it appears to have already garnered interest from the SuperTruck II teams. The reviewer highlighted that these early-stage research accomplishments should build the case for additional work with both DOE and industry.

The reviewer summarized that the project team has made important accomplishments in vehicle platooning that cover the significant issues such as following distance and offset/misalignment. Aerodynamic drag reduction is one of the key mechanisms for fuel savings for platooning and needs to be explored fully in order to understand how best to implement the technology. The reviewer said that this new work has done a good job in addressing previous concerns raised by NREL research about cooling flow challenges with platooning of vehicles, and that the project team has done very thorough work on separation distance as a key parameter for platooning fuel savings. Interesting findings show that offset does not have big effect on drag but does have big effect on cooling air.

Finally, the reviewer affirmed that the project team has been influential in helping guide the aerodynamics work within the SuperTruck program and that the project team’s work with Navistar to validate the performance of their final SuperTruck I vehicle in the full-scale wind tunnel was very important.

Reviewer 2:

The reviewer stated that significant progress has been made in the past year on this project, specifically calling out the platooning work as quite interesting. The reviewer noted that the project partners appear to be in sync and well managed resulting in a good transition of work from one stage to another.

Reviewer 3:

The reviewer commented that the project made great progress in measuring the effects of platooning, and different aerodynamic aids. There was a lot of interest in the theory of platooning, because of the potential fuel savings for fleet operators. The reviewer noted that having quantitative data, from this project would to help drive decisions and promote acceptance and adoption of the project recommendations. The reviewer summarized that this effort helps DOE meet its goals, as fleet operators have a financial incentive (through fuel savings) to implement new technologies. The reviewer affirmed that the measured data had unexpected results and showed benefits over a much wider operating range then was previously understood.

Reviewer 4:

The reviewer observed that the project team conducted scaled experiments to investigate aerodynamic benefits of platooning (first of its kind testing with various two to three vehicle configurations, including vehicle offset). Integrated skirt and tail configurations were evaluated showing an optimal distance between 20 and 60 feet between vehicles. Also, the reviewer noted that the project team had previously supported Navistar SuperTruck I project, which achieved significant freight efficiency improvement in large part due to the aerodynamic drag reduction.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the project team was well aligned and that each project team member's strengths appear synergistic. The reviewer commented that the project team needed to discuss each industry partner's contributions to the project (Navistar, Kentucky Trailer, Freight Wing, Frito-Lay, etc.) in greater detail. The reviewer stated that the project members are mentioned on the overview slide but there was no information about what the role each partner performed this work.

Reviewer 2:

The reviewer stated that the project had a very good team, consisting of vehicle and trailer OEMs, end fleet owners, and multiple government agencies and research laboratories.

Reviewer 3:

The reviewer applauded the project team for having very good collaboration with seven industry manufacturers and suppliers, three large user fleets, as well as other research laboratories (NREL, National Aeronautics and Space Administration [NASA], U.S. Air Force, and U.S. Army). Further, the reviewer noted that it was nice to see truck and trailer manufacturers as well as other suppliers (tires and aerodynamic devices) collaborating on this project.

Reviewer 4:

The reviewer stated that the Navistar SuperTruck collaboration was very good and that the collaboration was important to demonstrate how the LLNL work and researcher expertise can connect theory and practice. The reviewer affirmed that the project team's work on platooning shows a very good collaborative effort with NREL, as this project addressed areas of concern in platooning that initial NREL research had identified (e.g., cooling air supply). The also commented that the collaboration with NASA, Air Force, and Army was essential to give the team access to wind tunnel facilities at a range of scales.

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

Reviewer 1:

The reviewer commented that the additional research was good, but the presentation required more information on what deliverables were being created that industry could pick up and implement. The reviewer then noted that no capital costs of the proposed changes were discussed, and that caused difficulty in understanding the true financial benefit from this project and whether the results dictate that the return on investment was sufficient for trucking companies to implement the proposed technologies. The reviewer summarized that information regarding how the fabrication costs of the new components compare to the savings was required for future reports. The reviewer expressed that the wind tunnel and validation data was good, and that a good deliverable for industry might be some final design specifications or requirements.

Reviewer 2:

The reviewer stated that the tasks listed were appropriate for the project in general, but the tasks was not tied to a timetable (other than sometime during the remainder of the project), and also that the decision points, barriers and risk mitigation pathways were not listed.

Reviewer 3:

The reviewer observed that the project had good future plans for tractor trailer integration shape design and design of the next generation of highly aerodynamic tankers. Also, the reviewer commented that the continued investigations of truck platooning aerodynamics and collaboration with NREL as connected and autonomous vehicles would likely be a key contributor to minimizing the energy use in future freight mobility systems.

Reviewer 4:

The future research plan appears to be a very logical and reasonable extension of the current work and builds upon the areas of greatest success and future opportunity. Because of the great interest in platooning as a fuel saving opportunity, the future research in this area was essential for ensuring these systems maximize fuel economy improvement and thus their marketability. If the team’s concepts for next generation tanker trailers were as advanced and successful as those for the van trailer, they should advance the state-of-the-art in this sector considerably.

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

Reviewer 1:

The reviewer surmised that because tractor-trailer freight operations represent a significant portion of the petroleum consumption in the United States, reduction in tractor-trailer fuel consumption has the potential to impact petroleum displacement.

Reviewer 2:

The reviewer commented that the testing and suggested improvements to truck and trailer aerodynamics presented by this work directly reduces petroleum required in truck operations.

Reviewer 3:

The reviewer stated that Class 7-8 tractor trailers are responsible for 11% of the U.S. petroleum consumption, and that tractor trailer integration can radically decrease aerodynamic drag reducing fuel consumption up to 40%. The reviewer concluded that a 15% reduction in fuel use was equivalent to 4.2 billion gallons of diesel fuel saved per year and 42 million tons of CO_2 emissions, which aligns with DOE’s goals.

Reviewer 4:

The reviewer noted that aerodynamic drag was a major contributor to commercial truck fuel use and addressing drag was extremely important for meeting DOE petroleum displacement objectives. Therefore, the reviewer concluded that reduction in aerodynamic drag for commercial vehicles was directly related to decreasing petroleum use through efficiency improvement.

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

Reviewer 1:

The reviewer affirmed that the project team has done great work with the resources made available and that the project team has extended their reach by collaborations with others (e.g., NASA). The reviewed stated that the freight hauling community receives quite a bit of exceptional work with the funds DOE invests in this team.

Reviewer 2:
The reviewer observed that nearly $1 million per year funding for this project over the past few years has been money well spent because tractor trailer aerodynamics play such a large role in Class 8 long haul truck fuel consumption. The reviewer concluded that contributions from this project were evident in the DOE SuperTruck program outcomes, and that funding was appropriate given the number and complexity of presented milestones.

Reviewer 3:
The reviewer noted that the project team was making great progress on the funds provided.

Reviewer 4:
The reviewer commented that the project appears to be progressing well.

Presentation Number: acs114
Presentation Title: Improved Tire Efficiency through Elastomeric Polymers Enhanced with Carbon-Based Nanostructured Materials
Principal Investigator: Georgios Polyzos (Oak Ridge National Laboratory)

Presenter

Georgios Polyzos, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

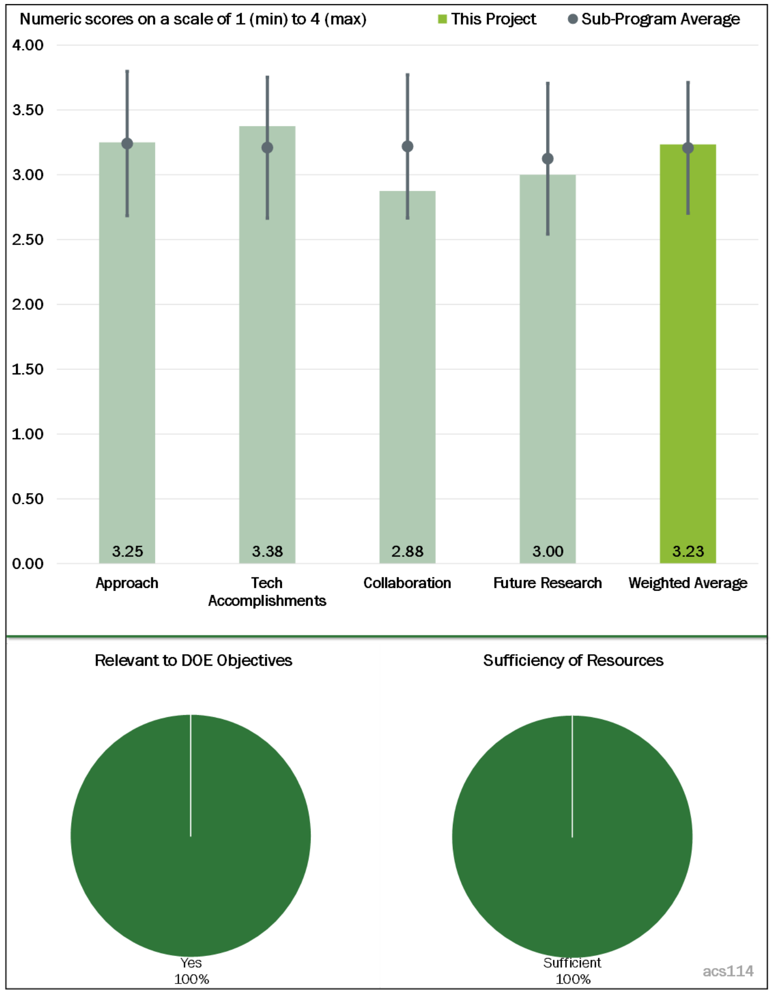

Figure 1-49 - Presentation Number: acs114 Presentation Title: Improved Tire Efficiency through Elastomeric Polymers Enhanced with Carbon-Based Nanostructured Materials Principal Investigator: Georgios Polyzos (Oak Ridge National Laboratory)

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

Reviewer 1:

This reviewer remarked that the approach being used for this project is excellent and provides a good method to address the barriers of the development of new technologies with parallel paths and the development of cost competitive options.

Reviewer 2:

This reviewer said the overall approach is excellent. Paths to overcome most technical barriers are addressed. Further follow-on discussion/elaboration regarding the commercialization and production-scale-up potential of the graphene nano-platelet filler material would be beneficial as significant challenges could exist here.

Reviewer 3:

The reviewer noted that the approach is focused on the materials characteristics needed to improve tire efficiency. The project is relatively short-term in length (less than 2 years total). Therefore, ORNL’s approach had to focus rather specifically on only a few materials changes to be explored, both composition and structures.

Reviewer 4:

This reviewer indicated there are some questions that are not answered in the presentation that may be better suited for a paper. The first question that could be addressed is what evidence suggests the new fillers will be a better substitute than carbon black in terms of meeting the objectives. The second question is why the 50 gigapascal target was chosen.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:
This person remarked that the accomplishments shown in this project to date have been excellent. The accomplishments have provided necessary information to allow the project to successfully meet its FY 2016 and FY 2017 milestones and has put the project in a position to complete the remaining milestones which will lead to a successful completion of the project later this year.

Reviewer 2:
This reviewer noted that the project team seems to have moved its way through the evaluation of candidate materials in 2016. Later last year, the project focused on the processing conditions, including a look at the structures resulting from different approaches. In addition, ORNL established baseline characteristics based upon samples from the industrial partner. Most recently, the project has focused upon moving through refining material designs, and then evaluating performance. The results appear to indicate that it is feasible to obtain a 4% fuel savings through this approach to tire efficiency improvements. The reviewer remarked that in fact, the results appear far better than the target values originally identified.

Reviewer 3:
The reviewer stated that Effort Milestones are on track. A 4% fuel savings potential has been demonstrated. The reviewer noted that this project advances the DOE goal of significantly reducing life-cycle energy consumption via the production/use of advanced technology.

Reviewer 4:
This reviewer highlighted that the dispersal issues were achieved without demonstration of performance with or without the desired target, which was not defined. The reviewer further highlighted that there is no demonstrated description of why 50 GPa target was chosen for the silica nanofibers. This reviewer questions how prototype materials are manufactured for mechanical testing to verify hysteresis reduction targets and what standard test methods are applied. The reviewer also asks what the impacts of the Tan delta values at low temperatures are on potential tire performance.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that ORNL is collaborating with a major tire manufacturer, which is exactly the type of organization needed to complete this project (tire expertise). The industrial partner itself will not move forward with what is learned under this project because it produces tires and not the tire materials, so material manufacturers are now being sought for moving forward.

Reviewer 2:
This reviewer said a key relationship is established with a major tire OEM industrial partner. Developing collaboration relationships with industrial graphene and silica suppliers would be ideal for follow-on efforts.

Reviewer 3:
The reviewer noted that the "industrial partner" was not identified, which could cause a perception of potential bias. The reviewer recommended using an industry association that represents multiple manufacturers.

Reviewer 4:
This reviewer observed that the only reference to collaboration is that there is work with a major tire manufacturer. The reviewer suggested that it would be good if the project could indicate what kind of input the tire manufacturer has made to the work, if any.

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 remarked that the proposed future work in this project will provide very good information which will provide for a successful completion of the project. It is especially good that the project will find suitable industrial partners for the scale-up for the developed fillers.

Reviewer 2:
The reviewer said future project work is effectively planned in a logical path with appropriate milestones. The approach contributes to overcoming most barriers. The reviewer suggested that additional barriers/concerns that may warrant further discussion could include; maintaining (not-degrading) tire ozone resistance and further elaboration on the commercialization and production scalability of the new proposed fillers (especially the functionalized graphene nano-platelets).

Reviewer 3:
This reviewer noted that it does not appear that there is much left to complete this year—the key item seems to be to finding an industrial partner to move forward with the production of the new materials. The current industrial partner makes tires, not the materials. The rest of the activities are focused on finishing off the efforts underway, such as fully curing tires made from materials identified.

Reviewer 4:
The reviewer observed that due to the lack of prototype material fabrication and mechanical testing results, along with the identification or description of the industrial partner, there is some risk that the proposed approach can be achieved toward the goals of the project.

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

Reviewer 1:
The reviewer affirmed that this project definitely supports the overall DOE objective of petroleum displacement by achieving a 25%-30% reduction in rolling resistance that will translate into fuel mileage increase of up to 4%. The objective of the project is to improve tire efficiency and meet DOE's fuel consumption reduction target of 4%, while maintaining or improving tire wear characteristics which supports DOE's objectives.

Reviewer 2:
This reviewer noted that the project's focus is on reducing the impact of rolling resistance on fuel consumption, clearly within VTO's objectives.

Reviewer 3:
This reviewer asserted that yes, this project most definitely supports the overall DOE objective of petroleum displacement. A 4% improvement in fuel efficiency is achievable.

Reviewer 4:
The reviewer commented that, provided there is incentive for manufacturers to bring the "improved" tire technology to market on a large, fleet-wide scale, then yes, this project is relevant.

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

Reviewer 1:

The reviewer stated that resources appear to be sufficient to complete the project this year.

Reviewer 2:

This reviewer said that no indication was made that funding is not sufficient.

Reviewer 3:

The reviewer remarked that this question is difficult to determine without seeing the complete experimental protocol. For example, the reviewer wants to know what the metrics are for mechanical testing and quality assurance in manufacturing.

Reviewer 4:

This reviewer suggested that additional funding could be helpful to formalize the relationship with the unknown tire OEM industrial partner and potential filler manufacturers. The reviewer noted that currently the cost/benefit economics are unknown for a full-scale production scenario. That is, the cost of the new technology versus the fuel economy benefit. Perhaps it is premature at this stage, but it would be good to better understand the potential financial benefits at play.

Presentation Number: acs115
Presentation Title: Advanced Bus and Truck Radial Materials for Fuel Efficiency
Principal Investigator: Lucas Dos Santos Freire (PPG)

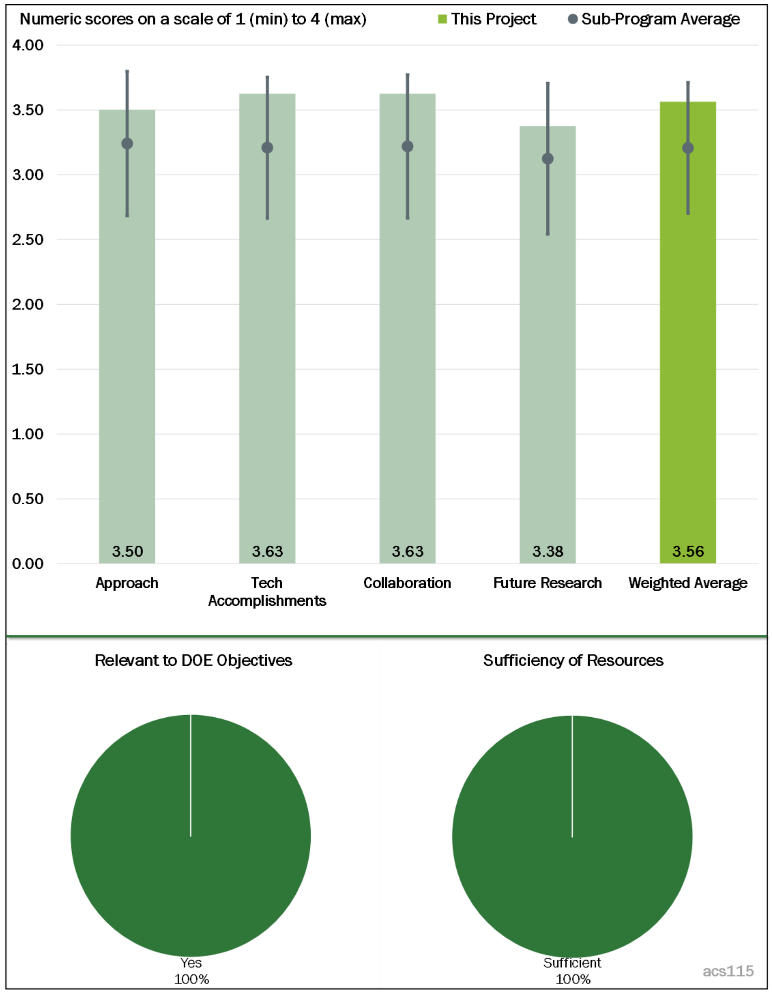

Figure 1-50 - Presentation Number: acs115 Presentation Title: Advanced Bus and Truck Radial Materials for Fuel Efficiency Principal Investigator: Lucas Dos Santos Freire (PPG)

Presenter

Lucas Dos Santos Freire, PPG

Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

This reviewer affirmed that the project includes a reasoned approach for accomplishing desired goals, through first focusing on tread compounds, then tire production, and finally tire testing for validation of results.

Reviewer 2:

The reviewer remarked that the overall approach is excellent. Paths to overcome most technical barriers are addressed. Further follow-on iterative efforts are required to meet the rolling resistance target and slightly improve wear and abrasion resistance.

Reviewer 3:

This reviewer stated that the approach to extend the rolling resistance benefits of silica from passenger car tires to commercial truck tires while retaining the other benefits of natural rubber for truck tires is logical and reasonable. The team has applied a methodical process for identifying the necessary silica surface treatment chemistries and to relate these to the desired performance both with lab tests and full-scale tire production and testing. The inclusion of real-world tire manufacturing and testing is a critical part of the approach that is essential for moving this work from the lab to industry so its benefits can be realized.

Reviewer 4:

The reviewer observed that the project leads identify performance metrics with which to judge future progress. The project team understands the optimization problem with regard to lower hysteresis and tire performance

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:
The reviewer observed that the project appears to have been making progress in line with the plan for the project. A number of candidate materials have been evaluated, with a downselect initially to two compositions. They then conducted a number of compound studies to evaluate these candidates, to determine optimized composition. They also found that the production conditions were very important. Two prototypes compounds were produced for comparison to the control (baseline) composition. The reviewer commented that results were promising, exceeding or close to goals for all performance criteria.

Reviewer 2:
This reviewer stated that effort Milestones are on track. A 4%-6% fuel savings potential is achievable. This project advances the DOE goal of significantly reducing life-cycle energy consumption via the production/use of advanced technology.

Reviewer 3:
The reviewer remarked that the team has achieved a significant amount of work in the timeframe of the project to date. The team has completed all of the treated silica parameter evaluations, developed bench-scale processing evaluations, and built real tires for standardized testing. The last accomplishment (building tires using the silica-treated compound in a standard truck tire production line) is one of the more important accomplishments as it demonstrates the feasibility of the new material to achieve both low rolling resistance and production feasibility. The team has achieved a significant improvement in rolling resistance tread compound parameters and good improvement in rolling resistance in real tires—the team is very close to the 20% reduction project goal and has a path to achieve the project goal. There is value in the team's work in identifying the important related considerations for incorporating the surface-treated silica into tire rubber (such as mixing conditions and silica loadings) as these will be important in ensuring the surface-treated silica can be used most effectively.

Reviewer 4:
The reviewer noted that the project team holds to their performance metrics and stands with them. The project team approaches their method with self-skepticism and presents the results in an objective manner.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that the team has a tire manufacturer as close collaborator and this is very important. They have chosen the largest tire manufacturer in the world and have ensured they are very involved in the material development and process evaluation. The team has responded to previous reviewer questions about customer feedback by embarking on good outreach to some fleets who have shown support and positive feedback. The combination of tire OEM and fleet participation should ensure success.

Reviewer 2:
The reviewer notes that PPG is working closely with Bridgestone. The United States Army Tank Automotive Research, Development and Engineering Center is also serving as an observer. The project team has reached out to several trucking companies for feedback, and has obtained a number of letters of support from these ultimate users of the technologies under development.

Reviewer 3:
The reviewer commented that a key relationship is established with Bridgestone, the largest tire manufacturer in the world.

Reviewer 4:
This reviewer noted the project team describe the specific contributions of their private partners and express concerns regarding potential influence.

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 notes that the project team still needs to decrease rolling resistance a bit more, and confirm the wear target. The PI did present ideas for future efforts beyond the project.

Reviewer 2:
This reviewer observed that the team has good plans to address the issue of increased wear and push toward the rolling resistance target. It is good to see that PPG is looking toward using results from this work to expand the benefit to other natural rubber tires—this will expand the impact of DOE work and leverage VTO's investment. The team also has plans in place to improve the wear characteristics of these tire compounds as this will be important for eventual commercialization (better business case for using these tires).

Reviewer 3:
The reviewer noted that the project team provided no discussion of potential economic impacts of the silica formulation to tire manufacturers and their customers. There are no specific descriptions of the test methods that will be used to demonstrate the performance metrics. There are no acknowledgments of related research and how collaboration may synergize efforts.

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

Reviewer 1:
The reviewer noted that the project is focused upon increasing vehicle efficiency through better tires, resulting in significant petroleum savings.

Reviewer 2:
This reviewer affirmed that yes, this project most definitely supports the overall DOE objective of petroleum displacement. An approximate 5% improvement in fuel efficiency is achievable.

Reviewer 3:
The reviewer noted that this project provides the opportunity to save petroleum through a four to 6% improvement in fuel efficiency by reducing rolling resistance of truck and bus tires is very relevant and directly addresses petroleum displacement objectives.

Reviewer 4:
This reviewer stated yes, because any slight reduction in fuel per trip will reduce our emissions and increase efficiency, especially if it results in extended tire life.

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

Reviewer 1:
The reviewer said that funding appears sufficient.

Reviewer 2:

This reviewer observed that the resources of this project appear reasonable for the timeframe and accomplishments to date as well as for completing the project by the end date.

Reviewer 3:

The reviewer stated that it appears the relationship between the DOE, the researcher and their partners are strong enough to fulfill the obligations to the project objectives.

Reviewer 4:

The reviewer provided a general comment that the cost/benefit economics are currently unknown for a full-scale production scenario. That is, the cost of utilizing the new silica technology (in comparison to a baseline carbon-black product) versus the fuel economy benefit. Perhaps it is premature at this stage, but it would be good to better understand and quantify the potential financial fleet benefits.

Presentation Number: acs116
Presentation Title: Advanced Non-Tread Materials for Fuel-Efficient Tires
Principal Investigator: Tim Okel (PPG)

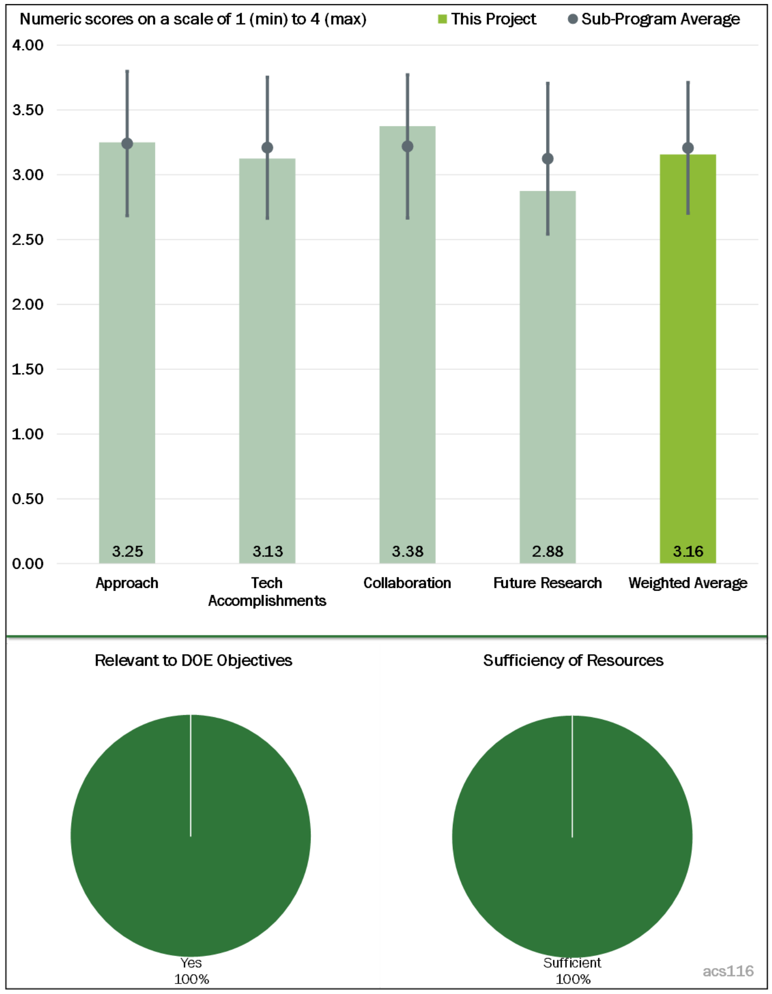

Figure 1-51 - Presentation Number: acs116 Presentation Title: Advanced Non-Tread Materials for Fuel-Efficient Tires Principal Investigator: Tim Okel (PPG)

Presenter
Tim Okel, PPG

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

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

Reviewer 1:
This reviewer remarked that the approach identified in the three budget periods to document tradeoffs with existing materials, to predict and develop optimal reinforcing filler and finally to optimize compound formulations is excellent.

Reviewer 2:
This reviewer notes that the project is focused on non-tread (particularly sidewall) materials, where little work has been completed to date. This information does not appear in previous studies. PPG believes non-tread component impact on fuel efficiency is equal to that of the tread, and the sidewall is likely 20% of overall tire impact. However, changes in sidewall efficiency must be balanced against performance. The reviewer remarked that the project approach seems rational and focused on desired results.

Reviewer 3:
This reviewer stated that the technical barriers identified are not relevant to the actual work.

The reviewer wondered how the proprietary products used influenced the results and how were they selected in the first place.

This reviewer stated that there does not appear to be any economic aspect to the project. This person wonders whether the tire industry would be compelled to change their formulation with a maximum potential of 2% efficiency gained for their customers.

The reviewer also commented that there does not appear to be any engagement with the Rubber Manufacturer’s Association to get buy-in on future work.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:

The reviewer stated that the accomplishments to date have been adequate. The project has successfully met its scheduled milestones and is on track to meet other milestones described in the project. Accomplishments to date including commercial fillers that have been selected and are currently being tested and other surface chemistries which have been defined will provide for an excellent opportunity to allow future milestones to be met.

Reviewer 2:

This reviewer observed that the accomplishments appear on track so far—the project only started last fall. The project appears to have made interesting progress, including development of tests for some characteristics. Eleven commercial reinforcing filler systems have been selected. Most of testing on these has been completed and data compiled. This testing identified electrical surface resistivity as a property to be monitored. This reviewer commented that overall results to date look promising concerning efficiency improvements.

Reviewer 3:

The reviewer stated that effort milestones are on track. A 2% fuel savings potential is achievable. This project advances the DOE goal of significantly reducing life-cycle energy consumption via the production/use of advanced technology.

Reviewer 4:

This reviewer stated that the accomplishments are on par with the maturity of the project. The reviewer wondered how the researchers justify the relationship between tan delta and fuel efficiency.

The reviewer questioned how economic implications will be weighed against the potential for project objective achievement. If performance is less than 100% of control, it does not appear that a manufacturer will be on board.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer highlighted the Akron Rubber Development Laboratory as an excellent partner in this project. Their expertise and laboratory capabilities provide additional resources to ensure the success of the project.

Reviewer 2:

The reviewer observed that the project includes the specifically and highly qualified Akron Rubber Development Laboratory as a partner. The project has also reached out to several tire manufacturers (the ultimate users of the materials), and obtained letters of support.

Reviewer 3:

This reviewer noted that a key relationship is established with Akron Rubber Development Laboratory, an industry leader in tire testing and research/development. Ideally, tire manufacturer interest (perhaps Goodyear and/or Bridgestone) can be obtained for industrial partnership in follow-on task efforts.

Reviewer 4:

This reviewer highlighted that although the partners are identified, not all of their roles have been. This person wondered what roles the proprietary products manufacturers are playing, and how they were selected.

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

Reviewer 1:
The reviewer expressed that the proposed future work is adequate. A major challenge that was identified is to gain tire manufacturers' interest in pursuing this technology. The reviewer suggested it would be useful if the project team could identify a method to meet this challenge.

Reviewer 2:
This reviewer noted that the plan for addressing remaining challenges and barriers is logically developed, focused on predictions, compound development, and testing/validation.

Reviewer 3:
The reviewer commented that there is not enough description of how the work will be performed, by what method and by whom.

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

Reviewer 1:
The reviewer remarked that the objective of this project to develop new silica filler that increases fuel efficiency by 2%, while maximizing performance properties in non-tread tire components compared to current filler systems, definitely supports the DOE objective of petroleum displacement.

Reviewer 2:
This reviewer commented that the project is focused on increasing vehicle efficiency due to improved tires through modifications to non-tread materials. A 25% improvement in sidewall efficiency is projected to result in an overall 1% fuel efficiency increase for the vehicle.

Reviewer 3:
The reviewer said yes, this project most definitely supports the overall DOE objective of petroleum displacement. An approximate 2% improvement in fuel efficiency is achievable.

Reviewer 4:
The reviewer said this project does support the DOE objectives of petroleum displacement; however, there is no explanation of the fundamental differences between the formulations that make up non-tread vs. tread component and how the researchers are or are not collaborating with other DOE research projects.

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

Reviewer 1:
The reviewer stated that the funds provided by DOE for the completion of this project appear to be sufficient.

Reviewer 2:
The reviewer noted there was no indication of funding concerns.

Reviewer 3:
This reviewer commented that additional funding could be helpful to formalize the relationship(s) with tire OEM industrial partner(s) to produce prototype tires for testing.

Reviewer 4:

The reviewer remarked that the resources appear to be sufficient provided that the proper buy-in is achieved from the RMA and other stakeholders.

Presentation Number: acs117
Presentation Title: HD Powertrain Optimization
Principal Investigator: Paul Chambon (Oak Ridge National Laboratory)

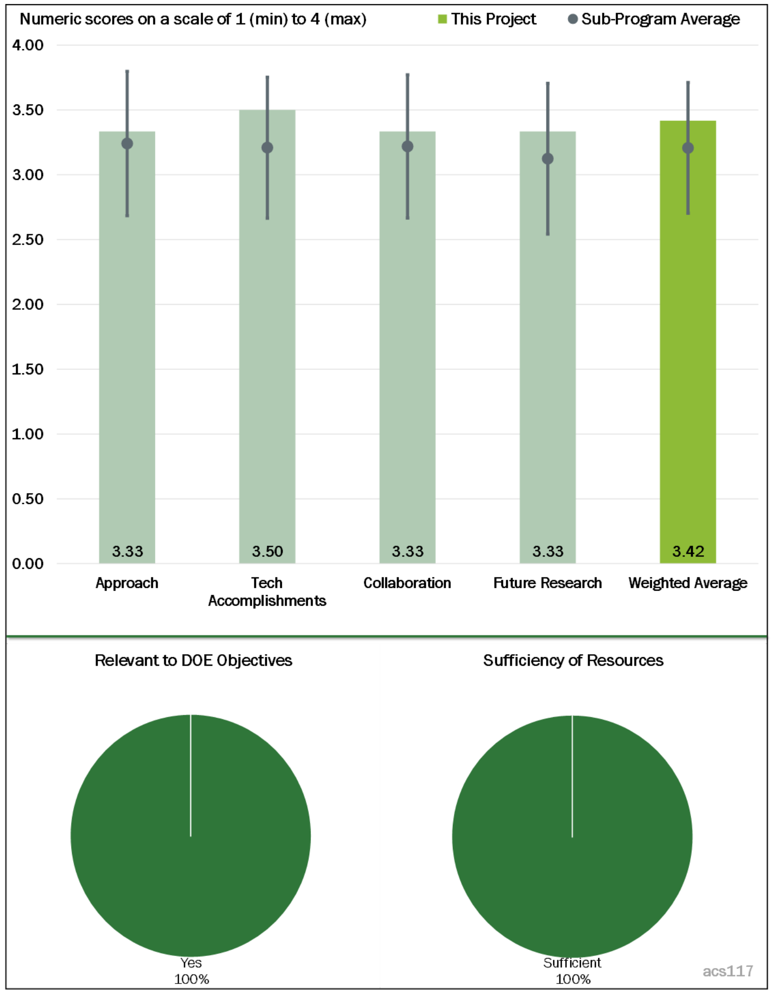

Figure 1-52 - Presentation Number: acs117 Presentation Title: HD Powertrain Optimization Principal Investigator: Paul Chambon (Oak Ridge National Laboratory)

Presenter

Paul Chambon, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

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

Reviewer 1:

This reviewer said it is a very creative approach to re-use data previously collected for Phase II EPA rulemaking for the optimization assessment of the Cummins + Eaton powertrain. This will be done at a precompetitive R&D component and system-level, to ensure all OEMS/Tier 1 suppliers have access to the results.

Reviewer 2:

The reviewer suggested that the project team define the roadmap for improving fuel economy and form a hypothesis for this work.

Reviewer 3:

This reviewer noted that the project uses special equipment to optimize powertrains. This is close to development work.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:

The reviewer stated that the PI is doing excellent work in optimizing powertrains

Reviewer 2:

This agile approach using existing laboratory capabilities is flexible and can be modified on the fly—in fact, this is the case as Cummins' newest engine (X15) has recently been delivered. This pre-production engine is the latest state-of-the-art technology available. This enables ORNL to test this engine as part of the project in the ORNL HIL test lab.

Reviewer 3:

This reviewer noted that the project seems to be just starting. The reviewer suggested making the baseline clear. This person believes that this is the 2012 version and the SmartAdvantage version. This will make it easier to understand.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that there is good collaboration with industry

Reviewer 2:

This reviewer said that the project has a good spread of industry participation (Cummins, Eaton). The reviewer suggested that the project could integrate an academic institution to help round out the team.

Reviewer 3:

This reviewer recommended clarifying who the partners are in this DOE project, and asked whether all the organizations listed on Slide 2 are project partners.

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

Reviewer 1:

The reviewer commented that the project has well laid out metrics and milestones. Project has a definitive end date and a target set of accomplishments.

Reviewer 2:

This reviewer suggested determining what knobs have been left unturned on SmartAdvantage, which the reviewer thought is the focus on this work.

Reviewer 3:

The reviewer noted that future research is more optimization of powertrain technologies.

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

Reviewer 1:

The reviewer said yes, this project improves fuel economy by making the engine and transmission more efficient.

Reviewer 2:

This person noted that the project results in improved fuel economy of HD vehicles.

Reviewer 3:

This reviewer stated that optimizing the powertrain will result in efficiency gains.

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

Reviewer 1:

The reviewer said yes, and noted that the PI changed jobs before the review. The reviewer suggests that the project needs to be transferred to another person.

Reviewer 2:

The reviewer remarked that the funding level appears adequate to complete the project.

Presentation Number: acs118
Presentation Title: Advanced Emission Control for High-Efficiency Engines
Principal Investigator: Janos Szanyi (Pacific Northwest National Laboratory)

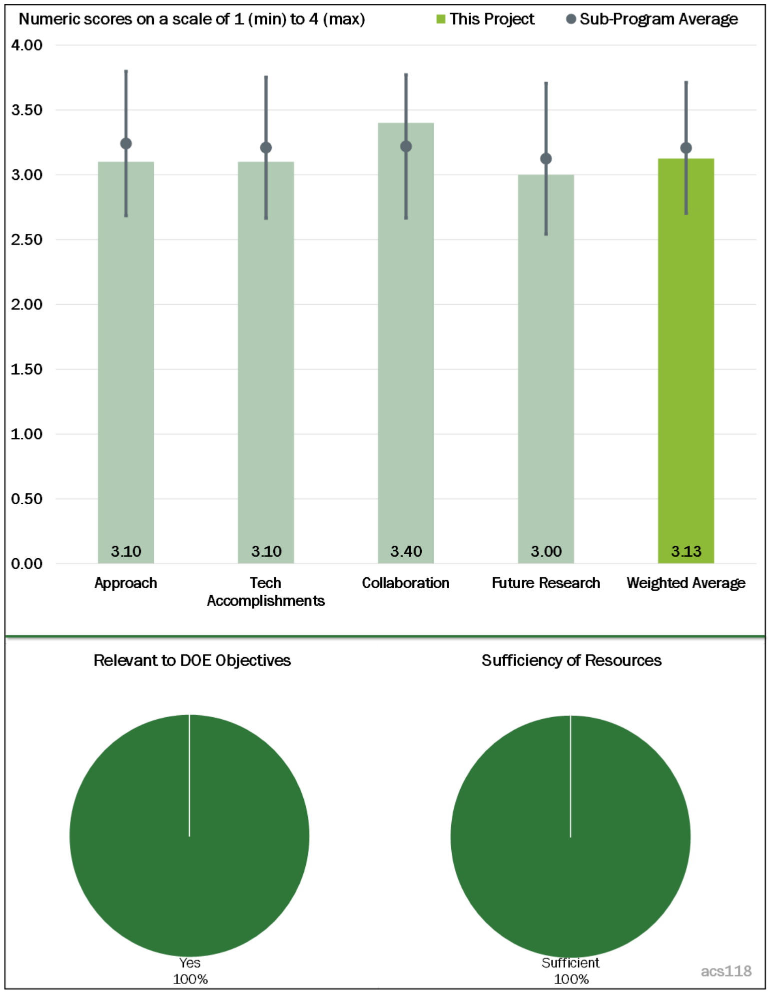

Figure 1-53 - Presentation Number: acs118 Presentation Title: Advanced Emission Control for High-Efficiency Engines Principal Investigator: Janos Szanyi (Pacific Northwest National Laboratory)

Presenter

Yong Wang, Pacific Northwest National laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

This reviewer said the project has an outstanding approach to work with practical pathways (catalysts, systems, durability) for lean NO_x aftertreatment identified, mapped and status provided, including cost considerations and input from OEMs for most practical pathways.

Reviewer 2:

The reviewer expressed that there are three projects here. Each is relevant for the DOE. The PNA work is relevant and the use of the PNNL characterization technology is a big plus. For the CNG work, the reviewer saw no advances in this work beyond what the suppliers have already done. The reviewer said the particulate work is relevant and interesting.

Reviewer 3:

This reviewer noted that effort is focused on three separate areas of research and development. The PNA development plan and collaboration is very appropriate for advancing material development in this area to address the need for LT NO_x control. Developing materials that will couple with the LT capture of NO_x with release at the right temperature for efficient downstream NO_x reduction is important for lean systems. The reviewer remarked that duplicating efforts of catalyst washcoaters in this area should be minimized. This reviewer commented that CNG methane oxidation catalyst research is also required to achieve more stringent emissions standards. However, the relative market addressed by this research is much smaller than the gasoline and diesel markets the PNA work is addressing. The reviewer concluded that much effort has already been applied to filter/particle characterization and overlap of activities with other labs and suppliers should be closely monitored.

Reviewer 4:

The reviewer commented that the project appears to address the major issues with advanced lean emission control (NO_x, small alkane oxidation, PM).

Reviewer 5:

This reviewer noted that the project addresses three distinct topics (NO_x storage, saturated HC oxidation, particulate properties), each of which is relevant to emission control for high-efficiency engines. However, the reviewer suggested that the technical issues/barriers involved and the approaches to tackle the problems are so different in nature that it seems difficult/unlikely to expect synergy among the three areas under investigation here. (Almost like three independent subprojects within the project.) This may likely create a situation where resources are spread thin, potentially slowing down progress significantly. Also, the work plan described in the "milestones" slide includes the "standard" items pretty generic in nature, not providing enough uniqueness or novelty of this project in terms of the technical issues to tackle, the approaches used and the significance/ultimate goals of this work.

The reviewer observed that for both the NO_x adsorber and methane/ethane oxidation studies, S resistance and thermal stability are planned to be tested last, but such a work plan may not be efficient because some materials that look promising at their fresh state can turn out to be unacceptably poor performers when tested under more realistic conditions. (Detailed kinetic/spectroscopic studies on such materials would, then, become a waste of time/effort/resources.) Thus, it is recommended that steps 1.3 and 1.4 as well as steps 2.2 and 2.3 be integrated to a certain degree rather than being carried out sequentially (one step after another), as indicated in the current plan.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:

This reviewer said that excellent results were presented, showing capability to meet the targets and a practical system solution to execute in a cost-effective manner.

Reviewer 2:

The reviewer said that given this project essentially started in 2016, the technical accomplishments shown seem okay.

Reviewer 3:

This reviewer commented that this is a relatively new project so it is a bit hard to judge the technical progress. The work on the PNA portion leverages a generic study done in CLEERS on Pd/zeolites. The progress seems adequate for 1 year given that there are two industry partners.

Reviewer 4:

The reviewer remarked that the PNA project mostly just showed that the catalysts are sensitive to H_2O. This person did not find that surprising. The summary had substantially more information than was in the talk. The summary information is helpful.

The reviewer expressed that there is not much helpful in the methane catalysis work. The reviewer noted that for the analysis of engine produced particles, the project team did not give us much information about the engine. Consequently, it is hard to understand the meaning of the results. The results are interesting, but difficult to extrapolate to engines with somewhat different combustion configurations.

Reviewer 5:

This reviewer said that the technical progress in the area of PNA development appears on time and in a direction that is consistent with advanced work occurring in the catalyst supplier area. Duplication of effort should be minimized, while PNNL characterization efforts will better serve the development need in this area.

Progress in the methane catalyst development area is providing interesting catalyst solutions. New materials in the PNA and methane catalyst area of R&D, that address LT activity, are very important to both the LD and HD OEMs. Particle characterization, although useful, is also being addressed at other research and development centers globally. Some results are already known.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer remarked that the team has a good range of collaborators with different perspectives on the projects.

Reviewer 2:
The reviewer said that overall, this project has a good coupling between PNNL and appropriate OEM/suppliers. Although the work in the PNA and filtration is HD centric, it would also benefit from a LD OEM in this area. Similarly, CNG applications are present in both HD and LD programs.

Reviewer 3:
This reviewer noted that there is a very clear partnership with Cummins and Johnson Matthey.

Reviewer 4:
The reviewer observed that the project team has good collaboration with auto OEMS, catalyst suppliers and national laboratories to develop an integrated system with solid results.

Reviewer 5:
The reviewer stated that the plan to take advantage of strengths from the partners involved makes sense. However, it appears that full collaboration between the partners has not happened yet.

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

Reviewer 1:
The reviewer said the planned future work addresses the three technologies in the project directly, and is aimed at further understanding.

Reviewer 2:
The reviewer said that few remaining pathways to consider are included in future work plan as is assessment of risk and durability.

Reviewer 3:
The reviewer referenced prior comments.

Reviewer 4:
The reviewer noted that the PNA future plans seem to imply there is a down select to the Pd-alumina. Certainly, knowing the aging effects and poisoning effects is the next step.

This reviewer did not understand the reason for the selection of alloys for evaluation for the methane oxidation, and therefore suggested the project team provide background information on why the alloys were selected.

The reviewer observed that the proposed particulate future work was a laundry list of perhaps more than they can accomplish. The reviewer suggested one focus for the future work.

Reviewer 5:

Both the PNA and methane catalyst characterization work will help illuminate deactivation mechanisms that these catalyst technologies will be exposed to under operating conditions. This is useful information for others in this area of R&D. Developing novel catalysts in these areas will also supports the need for new materials active at lower temperatures. However, the researchers should continue to monitor progress in this area by others to avoid duplication of effort. Activities in the area particulate characterization are not increasing the level of understanding as much, because other work in this area is also well advanced. A better use of resources may be to focus on two projects instead of the three reported here.

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

Reviewer 1:

The reviewer stated that all three of the projects are emission related and can contribute to higher fuel economy vehicles that meet emission standards.

Reviewer 2:

The reviewer said the LT PNA and methane catalysis are consistent with the need in the aftertreatment community.

This reviewer does not believe the particulate work is of high value.

Reviewer 3:

This person noted that the project includes catalyst and filter technologies that are important for highly efficient powertrains.

Reviewer 4:

The reviewer expressed that lean (primarily NO_X) aftertreatment solutions can enable substantial fuel savings by facilitating production solutions for various lean combustion regimes. This nearly fully developed system solution can enable aggressive lean operation with critical systems, cost and durability considerations considered or addressed.

Reviewer 5:

The reviewer affirmed that this project addresses the areas of critical importance in petroleum consumption reduction via fuel efficiency improvement and utilizing alternative fuels.

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

Reviewer 1:

The reviewer stated that it is a good level of funding for work generating outstanding results extremely useful at OEM level.

Reviewer 2:

The reviewer stated that the resources seem sufficient.

Reviewer 3:

This reviewer noted that the project has 50/50 cost share with Cummins.

Reviewer 4:

The reviewer noted that the resources seem to be sufficient to carry out the planned work.

Reviewer 5:

This reviewer observed that funding in this area appears sufficient. However, the reviewer commented that resources to cover the needs of the three different projects appears marginal. The reviewer suggested that perhaps focusing on two projects is a better use of resources.

Presentation Number: acs119
Presentation Title: Development and Optimization of a Multi-Functional SCR-DPF Aftertreatment System for Heavy-Duty NO_X and Soot Emission Reduction
Principal Investigator: Ken Rappe (Pacific Northwest National Laboratory)

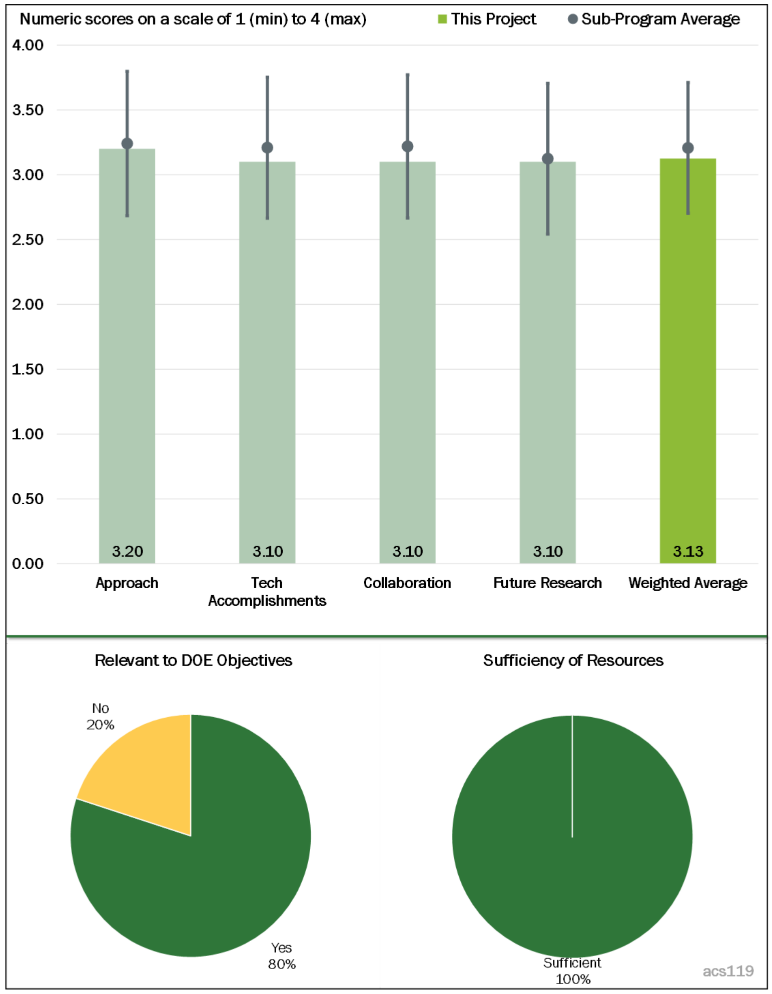

Figure 1-54 - Presentation Number: acs119 Presentation Title: Development and Optimization of a Multi-Functional SCR-DPF Aftertreatment System for Heavy-Duty NO_X and Soot Emission Reduction Principal Investigator: Ken Rappe (Pacific Northwest National Laboratory)

Presenter

Ken Rappe, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that this is the number one issue on SCRF implementation in HD, loss of passive regeneration. The approach is novel and the reviewer thought nearly impossible. The reviewer wondered how the project team oxidized NO with minimal impact on NH_3. As such other approaches utilize SCR architecture with modest results like in Slide 13. The reviewer said the project team has proposed a novel approach using a weak oxidation catalyst located upstream of the SCR catalyst that might increase NO_2 in proximity to the soot, without oxidizing NH_3. This reviewer applauded the approach and hoped that the project team's concept works.

Reviewer 2:

This reviewer affirmed that investigation of SCR on DPF is valuable for the industry. This person remarked that the project has a good approach—broken up by phase using building blocks commencing with full scale demonstration. The reviewer also noted the following: The project is looking at scalability and minimizing the amount of SCR development, although there will be some SCR.

The reviewer commented that the distribution of SCR catalyst across the substrate/filter is not well defined, but the PI went to great lengths to describe the problems in NO/NO_2 conversion if the catalyst is in a DPF wall. The reviewer is not sure how the control of this loading is effecting the performance of the system.

Reviewer 3:

This reviewer observed that this CRADA project is working to develop a SCRF system for HD applications. The approach seems to be mainly driven by the CRADA partner. Incorporation of an oxy-cat into the SCR is designed to promote oxidation of NO to NO_2 to improve the passive oxidation of PM, thereby improving the backpressure in the SCRF. The reviewer remarked that the Milestones seem to have already gotten off-schedule with the February 2017 milestone still marked in progress as of April.

Reviewer 4:

This reviewer commented that the approach seems naive. This reviewer stated that it will be extremely difficult, if not impossible, to balance high SCR conversion with high soot oxidation. The SCR performance as presented was not state of the art. The reviewer said that relying on NO_2 is not a viable long-term strategy.

Question 2: Technical accomplishments and progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance

Reviewer 1:

The reviewer said that there is incredible progress in only 1 year. The reviewer noted that the project team has screened selective catalytic oxidation (SCO) catalysts, as indicated by the fast SCR reaction and NO_2 generation for various catalysts (Slide 10). This slide shows high NO_2 generation (inset) and impact on SCR performance, with the strong SCO showing the slowest SCR and highest NO_2 emission. This seems to imply a moderate catalyst is best, and if you go too high on NO_2 oxidation, you risk NH_3 oxidation (worst SCR and higher NO_2 emission). The reviewer acknowledged the project showed that optimization involves a holistic approach with Cu and SCO. The impact on passive regeneration is modest (drops T approximately 30°C) at around 500°C. Thermodynamic NO_2 levels are very low at this temperature, but generate much NO_2 at the lower temperatures. This indicates the concept does not seem to impact passive regeneration at the typical temperatures used in “active-passive regen” (increase T to activate passive regen) of about 45°C. The reviewer offered that CO_2 might not be a good metric for passive regeneration, as CO is the main product.

Reviewer 2:

This reviewer affirmed that it was good to show the effects of the fast and standard SCR reactions.

Reviewer 3:

The reviewer noted that the project is on schedule and the current data look promising. It is early in the project and the reviewer looks forward to seeing how the performance of the system is optimized.

Reviewer 4:

The reviewer observed that this project is in the beginning stages (approximately 15% complete) and to date, has shown that the NO_2 balance is impacted by the oxy-cat addition, and shown the impact of particulates on the SCR reaction.

Reviewer 5:

The reviewer said that work with Cu-ZSM-5 was not relevant. The reviewer noted that it is unclear how the filters are being coated.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer remarked that the project has good collaboration with PACCAR and component suppliers.

Reviewer 2:

The reviewer suggested that due to the nature of the CRADA, the collaboration is good, though it would be nice to have an academic partner who might focus on some of the characterization work.

Reviewer 3:

The reviewer noted that there is one partner in this CRADA, which is not surprising but also not very collaborative.

Reviewer 4:
The reviewer commented that it is difficult to see how the team behind PACCAR is involved, but this person does not see any miss-steps with the PNNL-PACCAR relationship.

Reviewer 5:
This reviewer observed that it is not clear who PACCAR is collaborating with. No other companies were named except Corning.

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

Reviewer 1:
The reviewer remarked that it is obvious from the proposed future research that the researcher has a plan for reaching the project objective.

Reviewer 2:
This reviewer said that the continuing optimization and evaluation seems logical.

Reviewer 3:
This reviewer stated that many in the industry use an aggregate SCR NO_x conversion efficiency. The reviewer suggested combining the fast and standard SCR NO_x conversion data into an aggregate (with assumptions), as this will be valuable to the industry.

Reviewer 4:
The reviewer opined that work on ZSM-5 is a waste of time. This reviewer affirmed that moving to SSZ-13 is correct. The reviewer further remarked that the most important part of the project is the durability study, and S effects need to be included.

Reviewer 5:
The reviewer observed that the proposed future work is an appropriate, but daunting list. This person suggested that if possible (not sure if it is given the CRADA status)—it might be useful to bring in a university partner to help with the characterization work, because there is a lot to do and the impression that this reviewer gets is that things are already starting to fall behind.

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

Reviewer 1:
This reviewer said yes, SCR NO_x conversion improvements will yield better engine plus after-treatment fuel efficiency.

Reviewer 2:
The reviewer stated that diesel engines are inherently more efficient than spark ignited engines. Their drawback are emissions. This person affirmed that if this project plays out and NO/NO_2 emissions are more efficiently reduced, the technology will allow for petroleum displacement.

Reviewer 3:
The reviewer commented that SCR filter regeneration in the SwRI California Air Resources Board low-NO_x program costs a cycle-average nominal 1%-3% fuel penalty. This is approximately one BTE point.

Reviewer 4:

This reviewer said that expecting high SCR performance on a washcoat limited part and also expecting passive soot oxidation is unrealistic to meet any goals for higher efficiency powertrains.

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

Reviewer 1:

The reviewer said that there has been much progress in 1 year. The budget to take next steps seems reasonable.

Reviewer 2:

The reviewer said yes.

Reviewer 3:

This reviewer noted that the PACCAR cost share is 50%.

Acronyms and Abbreviations

3D	Three dimensional
ACEC	Advanced Combustion and Emissions Control
AEC	Advanced Engine Combustion
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ATP	Advanced Technology Powertrain
BES	Basic Energy Sciences
BMEP	Brake mean effective pressure
BSFC	Brake-specific fuel consumption
BTE	Brake thermal efficiency
C	Celsius
CA50	Crank angle position at which 50% of heat is released
CDC	Conventional diesel combustion
Ce	Cerium
CHA	Chabazite
CHT	Conjugate heat transfer
CI	Compression Ignition
CLEERS	Cross-cut Lean Exhaust Emissions Reduction Simulations
CN	Combustion noise
CO	Carbon monoxide
CO_2	Carbon dioxide
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council
CRF	Combustion Research Facility
Cu	Copper
CuOH	Copper hydroxide
CuZ	Copper sulfanide

dBA	A-weighted decibels
DEGR	Dedicated exhaust gas recirculation
DI	Direct injection
DNS	Direct numerical simulation
DOC	Diesel oxidation catalyst
DOE	U.S. Department of Energy
DPF	Diesel particulate filter
EAVS	Electrically Assisted Variable Speed
ECN	Engine Combustion Network
EGR	Exhaust gas recirculation
EOS	Equation of state
EPA	U.S. Environmental Protection Agency
ERC	Engine Research Center
eWHR	Electric waste heat recovery
FCA	Fiat Chrysler Automobiles
FE	Fuel economy, fuel efficiency
FEM	Finite element modeling
FIE	Fuel injected engine
FRESCO	Fast and Reliable Engine Simulation Code
FTP	Federal Test Procedure
FV	Finite volume
FY	Fiscal year
g	Gram
G	Giga
GCI	Gasoline compression ignition
GDCI	Gasoline direct compression ignition
GDI	Gasoline direct-injected
GHG	Greenhouse gas

GM	General Motors Corporation
GPF	Gasoline particulate filter
GPU	Graphics processing unit
GSF	Generic speed form
H_2O	Water
HC	Hydrocarbon
HCCI	Homogeneous charge compression ignition
HCl	Hydrochloric acid
HD	Heavy-duty
HECC	High efficiency clean combustion
HEV	Hybrid electric vehicle
HIL	Hardware-in-the-loop
HPC	High-performance computing
hr	Hour
HRR	Heat release rate
ICE	Internal combustion engine
ID	Ignition delay
K	Kelvin
KERS	Kinetic recovery system
KH-RT	Kelvin-Helmholtz Rayleigh-Taylor
kW	Kilowatt
L	Liter
LD	Light-duty
LDD	Light-duty diesel
LES	Large eddy simulation
LEV	Low-emission vehicle
LLNL	Lawrence Livermore National Laboratory
LNT	Lean NO_x trap

LT	Low temperature
LTAT	Low-temperature aftertreatment
LTC	Low-temperature combustion
LTGC	Low temperature gasoline combustion
m	Meter
MIT	Massachusetts Institute of Technology
mm	Millimeter
MOU	Memorandum of Understanding
ms	Milliseconds
MW	Megawatt
NASA	National Aeronautics and Space Administration
NETL	National Energy Technology Laboratory
NH_3	Ammonia
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NVO	Negative valve overlap
O_2	Oxygen
OBD	On-board diagnostics
OEM	Original equipment manufacturer
OH	Hydroxide
OpenFOAM	Open source Field Operation And Manipulation
ORNL	Oak Ridge National Laboratory
OSC	Oxygen storage capacity
P	Phosphorus
*P*c	Compressed pressure
Pd	Palladium
PEV	Plug-in electric vehicle

PGM	Platinum group metals
PI	Principal Investigator
PM	Particulate matter
PN	Particulate number
PNA	Passive NO_x adsorber
PNNL	Pacific Northwest National Laboratory
Pt	Platinum
R&D	Research and development
RANS	Reynolds-Averaged Navier Stokes
RCCI	Reactivity controlled compression ignition
RCM	Rapid compression machines
RF	Radio frequency
RON	Research octane number
RPM	Revolutions per minute
S	Sulfur
SCO	Selective catalytic oxidation
SCR	Selective catalytic reduction
SCRF	Selective catalytic reduction on filter
SI	Spark ignition
SIDI	Spark ignition direct injection
SMART	Specific, measurable, achievable, relevant, and time bound
SMD	Sauter mean diameter
SNL	Sandia National Laboratories
SOI	Start of ignition
SPH	Smoothed particle hydrodynamics
SULEV	Super ultra-low emission vehicle
SwRI	Southwest Research Institute
T50	Temperature at which 50% conversion occurs

*T*c	Compressed temperature
TFM	Thickened flame model
TWC	Three-way catalyst
U.S. DRIVE	United States Driving Research and Innovation for Vehicle Efficiency and Energy sustainability
UC	Ultra-capacitor
UM	University of Michigan
UQ	Uncertainty quantification
USCAR	United States Council for Automotive Research
UW	University of Wisconsin
VCR	Variable compression ratio
VERIFY	Virtual Engine Research Institute and Fuels Initiative
VOF	Volume of fluid
VTO	Vehicle Technologies Office
VVA	Variable valve actuation
VVT	Variable valve timing
W	Watt
WHR	Waste heat recovery

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