4. Advanced Combustion Engine Technologies

The Advanced Combustion Engine R&D subprogram of the U.S. Department of Energy's Vehicle Technologies Program (VTP) is improving the fuel economy of passenger vehicles (cars and light trucks) and commercial vehicles (medium-duty and commercial trucks) by increasing the efficiency of the engines that power them. Work is done in collaboration with industry, national laboratories, and universities, as well as in conjunction with the U.S. DRIVE Partnership for passenger vehicle applications and the 21st Century Truck Partnership for commercial vehicle applications.

Research and development (R&D) efforts focus on improving engine efficiency while meeting future Federal and state emissions regulations through a combination of: combustion technologies that minimize in-cylinder formation of emissions; aftertreatment technologies that further reduce exhaust emissions; and understanding fuel property impacts on combustion and emissions. Technologies that improve the overall engine performance are also pursued.

During this merit review, each reviewer was asked to answer a series of questions using multiple-choice responses (and with explanatory comments when requested), as well as using numeric scores *(on a scale of 1 to 4)*. In the following pages, reviewer responses to each question for each project are summarized, the multiple choice and numeric score questions are presented in graph form, and the explanatory text responses are summarized for each question. The summary table below lists the average numeric score for each question and for each of the projects.

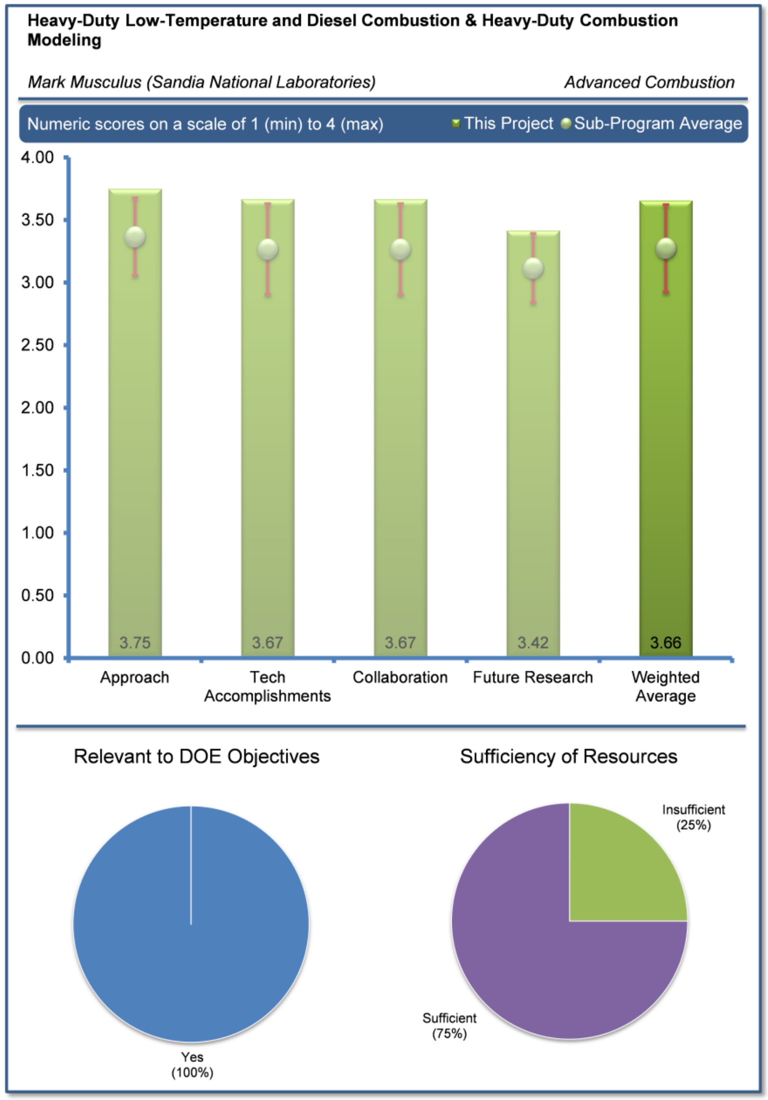
Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling	Mark Musculus (Sandia National Laboratories)	4-5	3.75	3.67	3.67	3.42	3.66
Low-Temperature Automotive Diesel Combustion	Paul Miles (Sandia National Laboratories)	4-9	3.58	3.25	3.25	3.08	3.31
HCCI and Stratified-Charge CI Engine Combustion Research	John Dec (Sandia National Laboratories)	4-12	3.36	3.55	3.55	3.27	3.47
Spray Combustion Cross-Cut Engine Research	Lyle Pickett (Sandia National Laboratories)	4-15	3.55	3.82	3.82	3.27	3.68
Automotive HCCI Engine Research	Richard Steeper (Sandia National Laboratories)	4-18	2.92	3.00	3.00	3.00	2.98
Large Eddy Simulation (LES) Applied to Low-Temperature and Diesel Engine Combustion Research	Joe Oefelein (Sandia National Laboratories)	4-21	3.45	3.45	3.45	3.18	3.42
Free-Piston Engine	Terry Johnson (Sandia National Laboratories)	4-24	2.17	2.00	2.00	2.17	2.06
Fuel Injection and Spray Research Using X-Ray Diagnostics	Christopher Powell (Argonne National Laboratory)	4-27	3.70	3.30	3.30	3.20	3.39
Use of Low Cetane Fuel to Enable Low Temperature Combustion	Steve Ciatti (Argonne National Laboratory)	4-30	2.91	3.27	3.27	2.82	3.13
Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines	Dan Flowers (Lawrence Livermore National Laboratory)	4-33	3.36	3.73	3.73	3.09	3.56
Chemical Kinetic Research on HCCI & Diesel Fuels	Bill Pitz (Lawrence Livermore National Laboratory)	4-36	3.73	3.45	3.45	3.45	3.52
2012 DOE Vehicle Technologies KIVA-Development	David Carrington (Los Alamos National Laboratory)	4-39	3.17	3.08	3.08	2.67	3.05
Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes	Stuart Daw (Oak Ridge National Laboratory)	4-42	3.46	3.23	3.23	3.00	3.26

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines	Scott Curran (Oak Ridge National Laboratory)	4-45	3.54	3.08	3.08	3.23	3.21
High Efficiency Engine Systems Development and Evaluation	Dean Edwards (Oak Ridge National Laboratory)	4-48	3.38	2.85	2.85	2.92	2.99
A University Consortium on Efficient and Clean High-Pressure, Lean Burn (HPLB) Engines	Margaret Wooldridge (University of Michigan)	4-51	3.08	3.17	3.17	3.00	3.13
Optimization of Advanced Diesel Engine Combustion Strategies	Rolf Reitz (University of Wisconsin)	4-53	3.82	3.55	3.55	3.09	3.56
Flex Fuel Optimized SI and HCCI Engine	Gouming Zhu (Michigan State University)	4-55	2.82	2.64	2.64	2.73	2.69
CLEERS Coordination & Joint Development of Benchmark Kinetics for LNT & SCR	Stuart Daw (Oak Ridge National Laboratory)	4-58	3.80	3.60	3.60	3.00	3.58
CLEERS Aftertreatment Modeling and Analysis	George Muntean (Pacific Northwest National Laboratory)	4-61	3.17	3.67	3.67	3.00	3.46
Development of Advanced Particulate Filters	Kyeong Lee (Argonne National Laboratory)	4-64	3.25	2.75	2.75	2.75	2.88
Combination and Integration of DPF-SCR Aftertreatment Technologies	Ken Rappe (Pacific Northwest National Laboratory)	4-66	3.00	3.17	3.17	3.00	3.10
Enhanced High Temperature Performance of NOx Storage/Reduction (NSR) Materials	Chuck Peden (Pacific Northwest National Laboratory)	4-69	3.50	3.00	3.00	3.00	3.13
Degradation Mechanisms of Urea Selective Catalytic Reduction Technology	Chuck Peden (Pacific Northwest National Laboratory)	4-71	3.50	3.60	3.60	3.33	3.54
Experimental Studies for DPF and SCR Model, Control System, and OBD Development for Engines Using Diesel and Biodiesel Fuels	John Johnson (Michigan Technological University)	4-73	3.40	3.67	3.67	3.20	3.54
Development of Optimal Catalyst Designs and Operating Strategies for Lean NOx Reduction in Coupled LNT-SCR Systems	Michael Harold (University of Houston)	4-75	3.33	3.67	3.67	3.00	3.50
Three-Dimensional Composite Nanostructures for Lean NOx Emission Control	Puxian Gao (University of Connecticut)	4-78	3.17	2.83	2.83	3.00	2.94
Cummins/ORNL-FEERC CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines	Bill Partridge (Oak Ridge National Laboratory)	4-81	3.50	3.40	3.40	3.00	3.38
Emissions Control for Lean Gasoline Engines	Todd Toops (Oak Ridge National Laboratory)	4-83	3.75	3.50	3.50	3.75	3.59
Advanced Boost System Development for Diesel HCCI/LTC Application	Harold Sun (Ford Motor Company)	4-85	3.50	3.17	3.17	2.67	3.19
Advanced Collaborative Emissions Study (ACES)	Dan Greenbaum (Health Effects Institute)	4-88	4.00	3.75	3.75	3.50	3.78
Thermoelectric HVAC and Thermal Comfort Enablers for Light-Duty Vehicle Applications	Clay Maranville (Ford Motor Company)	4-90	3.50	3.50	3.50	3.50	3.50
Energy Efficient HVAC System for Distributed Cooling/Heating with Thermoelectric Devices	Jeffrey Bozeman (General Motors Corporation)	4-93	3.50	3.00	3.00	3.50	3.19

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Neutron Imaging of Advanced Engine Technologies	Todd Toops (Oak Ridge National Laboratory)	4-96	3.50	3.50	3.50	3.33	3.48
Collaborative Combustion Research with BES	Steve Ciatti (Argonne National Laboratory)	4-99	3.20	3.10	3.10	3.10	3.13
Deactivation Mechanisms for selective catalytic reduction (SCR) of NOx with urea and development of HC Adsorber Materials	Chuck Peden (Pacific Northwest National Laboratory)	4-102	3.00	2.75	2.75	3.00	2.84
Fuel-Neutral Studies of Particulate Matter Transport Emissions	Mark Stewart (Pacific Northwest National Laboratory)	4-105	3.67	3.67	3.67	3.00	3.58
Cummins SuperTruck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks	David Koeberlein (Cummins)	4-107	4.00	3.38	3.38	3.75	3.58
SuperTruck - Improving Transportation Efficiency through Integrated Vehicle, Engine and Powertrain Research	Kevin Sisken (Detroit Diesel)	4-110	3.00	2.63	2.63	3.00	2.77
SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer	Dennis Jadin (Navistar International Corp.)	4-114	2.88	3.00	3.00	2.75	2.94
SuperTruck Initiative for Maximum Utilized Loading in the United States	Pascal Amar (Volvo Trucks)	4-118	3.25	2.75	2.75	3.13	2.92
ATP-LD; Cummins Next Generation Tier 2 Bin 2 Diesel Engine	Michael Ruth (Cummins)	4-121	3.40	3.40	3.40	3.40	3.40
A MultiAir / MultiFuel Approach to Enhancing Engine System Efficiency	Ron Reese (Chrysler LLC)	4-124	3.29	3.14	3.14	3.00	3.16
Lean Gasoline System Development for Fuel Efficient Small Car	Stuart Smith (General Motors)	4-127	3.33	3.17	3.17	3.00	3.19
Gasoline Ultra Fuel Efficient Vehicle	Keith Confer (Delphi Automotive Systems)	4-130	3.14	3.00	3.00	3.14	3.05
Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development	Corey Weaver (Ford Motor Company)	4-133	3.43	2.71	2.71	3.14	2.95
Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles	Hakan Yilmaz (Robert Bosch)	4-136	3.33	3.67	3.67	3.00	3.50
High Fidelity Modeling of Engine Combustion Systems	Sibendu Som (Argonne National Laboratory)	4-138	3.40	3.50	3.50	3.20	3.44
Advanced Numerics for High-Fidelity Combustion Simulation	Matthew McNenly (Lawrence Livermore National Laboratory)	4-140	3.20	3.30	3.30	3.20	3.26
CRADA with Cummins on Characterization and Reduction of Combustion Variations	Bill Partridge (Oak Ridge National Laboratory)	4-142	3.33	3.50	3.50	3.00	3.40
Mixed Oxide Catalysts for NO Oxidation	George Muntean (Pacific Northwest National Laboratory)	4-144	3.43	3.14	3.14	3.29	3.23
Robust Nitrogen Oxide/Ammonia Sensors for Vehicle On-board Emissions Control	Rangachary (Mukund) Mukundan (Los Alamos National Laboratory)	4-147	3.33	3.67	3.67	3.00	3.50

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Thermoelectric Waste Heat Recovery Program for Passenger Vehicles	John LaGrandeur (Amerigon)	4-150	3.50	3.50	3.50	3.50	3.50
Development of Cost-Competitive Advanced Thermoelectric Generators for Direct Conversion of Vehicle Waste Heat into Useful Electrical Power	Greg Meisner (General Motors)	4-153	3.50	3.50	3.50	3.25	3.47
Nanostructured High-Temperature Bulk Thermoelectric Energy Conversion for Efficient Automotive Waste Heat Recovery	Chris Taylor (GMZ Energy Inc.)	4-156	3.50	3.50	3.50	3.50	3.50
Overall Average			3.37	3.27	3.27	3.12	3.28

Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling: Mark Musculus (Sandia National Laboratories) – ace001



Reviewer Sample Size

This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

According to the first reviewer, the project supports DOE objectives, and this reviewer noted a focus on combustion and emissions for HD. According to the second reviewer, this work is key to gaining a fundamental understanding of the mechanisms of LTC and RCCI, which strongly supports the objective of petroleum displacement. The work increasingly considers some of the more complex fuel injection and combustion strategies, offering valuable insight into the mechanisms through which these strategies reduce fuel consumption and criteria emissions. The third reviewer asserted that the focus on improved fundamental understanding of the in-cylinder processes should help enable the development of engines with higher efficiencies that will be more fuel efficient and thus help to reduce fuel/petroleum requirements. The fourth reviewer emphasized that the project leverages exceptional experimental techniques to further understand the combustion and emission phenomena in diesel combustion, including the application of LTC modes. The same reviewer observed that the author gave a clear picture of the combustion process, covering first and second stages of ignition, and late cycle oxidation. The fifth reviewer commented that understanding fuel spray impacts on low temperature combustion is a crucial step toward developing improved engine behavior for lower fuel consumption and emissions. Another reviewer indicated that research to improve efficiency and expand usage of diesel engines will reduce fuel consumption. Furthermore, continued this reviewer, understanding in-cylinder processes, particularly LTC but also things like multiple injections for diffusion combustion, will help overcome issues emissions-fuel consumption tradeoffs in diesel engines. The seventh reviewer commented that the project supports increased engine efficiency. The eighth reviewer commented that the project provides fundamental understanding of LTC and RCCI combustion processes that could be important to industry in developing the next generation of engines that are focused on improving brake thermal efficiency of today's engines. In particular, added this reviewer, injection strategies and dual fuel strategies under investigation in this project can provide limits of what is possible within practical combustion devices. Per the ninth reviewer, the project aims to provide fundamental understanding of low-temperature combustion so engine design for high fuel efficiency and low pollutants can be accomplished. The final reviewer found that the project supports DOE objectives. This reviewer commented that this fundamental work is critical to extending the understanding and modeling of extending combustion ignition analysis to diesel LTC.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt that the focus on high fuel pressures were well aligned with the industry's current and mid-term direction. This reviewer suggested that, for pre-competitive research, identifying challenges and opportunities in medium and ultra-high pressure should be considered for investigation. This reviewer pointed out that parasitic with high pump pressures were of course undesirable in the systems perspective. According to this reviewer, more effort to use a representative combustion chamber needed for at least part of the work (optical limitations). A second reviewer stated that the PIs deserve much credit in addressing key technical areas, and suggested that more attention should be given to metal engine data with regard to multiple injection strategies because this effect may be highly geometry-dependent. The same reviewer felt that understanding representative geometry effects in a metal engine would also be critical to one day extending this work to light-duty applications. The third reviewer stated that the approach of coupling optical engine experiments with modeling was excellent. This reviewer added that actual use of diesel fuel in the optical engine (vs. the typical approach of using only clean model components) enhances direct applicability of results to real fuels. According to the fourth reviewer, the combination of experimental work and modeling to provide insight into sprays and combustion was good. The fifth reviewer commented that the suite of diagnostic techniques coupled with simple models gave a good understanding of combustion, which allowed the PI to develop conceptual models. This reviewer further noted that there was a question of what influence the simple geometry used for optical diagnostics had on the result; however, it eliminated many complications for optical diagnostics. The same reviewer went on to say that it would be useful to investigate the effect of real combustion system geometries on this picture. This reviewer noted that this was done somewhat with the conceptual model through collaboration with the light-duty lab, but doing so in the heavy-duty lab as well would be useful, particularly as post injection studies progress. The reviewer remarked that it sounded like there were possible avenues to add that capability and that the PI had considered it. Another reviewer also felt that the project covered possibly too much ground when it extended its work to RCCI and that it was unclear if the multi-fuel work should be treated here. The project explores the phenomena of post injections. This reviewer stated that the work seemed to be in a beginning stage and that the results published were rather narrow in scope (few operating conditions) and hard to interpret. The reviewer went on to say that this work should align better with practices present in industry. The reviewer also suggested that experiments should be closely coupled with real multi-cylinder engine data. The seventh reviewer stated that developing conceptual models for LTC was good. This reviewer stated that the project could improve its approach by continuing to add noise factors into the combustion process, and added liking the idea of testing a condition that marginally produced soot. This reviewer had concerns about real world implementation of LTC due to the influence of noise factors. The eighth reviewer stated that the approach was solid for studying combustion processes with LTC, but there did not appear to be much attention paid to the impact of this combustion mode on indicated thermal efficiency. This reviewer felt that it would be helpful to the engine research community if the indicated efficiency impact was included in future work efforts. Also, this reviewer continued, it would be helpful if there was additional focus on wall impingement effects. Lastly, this reviewer commented that the LTC conceptual model should start additional positive discussions and future research toward better understanding this combustion phenomenon for heavy-duty diesel applications. The final reviewer commented that the gaps in experimental knowledge as well as model deficiencies were understood well and work was focused on addressing critical gaps in knowledge and that the work was integrated well with modeling work being done at the University of Wisconsin.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer commented that commissioning of the new Delphi injection system was a key milestone for experiments. This reviewer felt that the diagnostic of close coupled post injections were insightful. reviewer recommended doing much more work in this area. A different reviewer commented that the work represented a very important step toward firmly establishing a connection between optical engines and modeling to heavy-duty engine development, through well-reasoned hypotheses and well-designed experiments. This reviewer felt that working through the next stage of understanding the role of heat transfer would be important going forward. The third reviewer observed important results obtained in better elucidating a number of aspects of the LTC process. The reviewer explained that using injectors that were closer to state-of-the-art injectors that were being used for multiple injections by the industry was also very good. According to the fourth reviewer, this project gives a clear picture of the LTC combustion process. Good progress has been made to integrate the new Delphi injector. This reviewer felt that the work on close coupled injections seemed to yield relatively limited results towards soot reduction. This reviewer also felt that the RCCI versus conventional study seemed rather incomplete and the heat transfer reported appeared limited to the in-cylinder. This reviewer recommended that the project should include other heat rejection sources (e.g., EGR stream). The fifth reviewer remarked excellent and extremely useful conceptual model of LTC. This reviewer stated that it was not clear what was accomplished in the past year versus previous years. This reviewer commented that the finding of increased entrainment and over-leaning at the end of injection was a breakthrough and has been invaluable to the understanding of HC emissions in LTC. It would be useful to understand the relative contribution of this mechanism versus other HC mechanisms in LTC. The sixth reviewer said that there was great work to date utilizing a combination of various optical techniques and the modeling capability of the University of Wisconsin in understanding RCCI combustion. This reviewer felt that such work was thought provoking and would lead toward future research at other institutions and industry partners that would explore other limits of these combustion processes from a production specification view point. The seventh reviewer summarized by stating that progress has been made to distill years of knowledge into a conceptual model of LTC. In addition, this reviewer indicated that progress has been made to upgrade capability in the fuel system and multiple injection area by procuring hardware and getting early results. The reviewer stated that conceptual model of LTC is compared and contrasted to conventional combustion. Additionally, this reviewer felt that behavior of spray is better understood, especially that of the liquid length and that End-of-Injection phenomena, with increased entrainment and mixing, has been predicted by various models. The reviewer also stated that large structures were predicted that promoted faster entrainment and that first stage ignition (with presence of formaldehyde) had been observed as predicted by kinetics model. The reviewer reported second stage ignition with the presence of OH; soot and PAH were also observed during second stage ignition and where equivalence ratio is around two. Additionally, this reviewer commented that CO and UHC were near the high mixing region at the end of injection near the injector, where phi was less than one. The same reviewer also stated that details of the conceptual model were in the PECS paper and that initial experiments with high speed movies have been conducted with post injections. This reviewer commented that the experiments complement RCCI work in University of Wisconsin have been conducted that show that auto ignition processes dominate rather than flame propagation. This reviewer also pointed out that the project also found that main efficiency benefit of RCCI is due to reduced heat transfer.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt there was extensive Advanced Engine Combustion (AEC) working group cooperation, and suggested that additional interactions with the light-duty industry may be helpful for further insight. A different reviewer commented that collaboration with other lab projects, academia and with industry is well-structured for the success of the project and felt that continued close collaboration with KIVA and LES modeling is showing great progress, but continued exploration in this area will be invaluable. A third reviewer mentioned that the project was a very well collaborated project and has interacted and received parts from Delphi and Cummins and interacted with the University of Wisconsin on modeling. The reviewer also stated that the project also had interactions with reps from OEMs and energy companies through semi-annual AEC memorandum of understanding meetings, but that it was not clear if there were interactions with those reps outside of those meetings. A fourth reviewer felt that the project has done well to incorporate the Delphi injector, being a modern and capable unit. This reviewer felt that there could be stronger collaboration with the chemical kineticists at this facility or at Lawrence Livermore National Laboratory. This reviewer also said the project should collaborate with a diesel engine manufacturer that could provide data to corroborate the optical results. The fifth reviewer noted good collaboration in the AEC MOU. The reviewer observed that the project is engaging industrial support to define project to look at post injection. The reviewer also stated that the collaboration with Paul Miles and Lyle Pickett was very useful for understanding how the conceptual model applied to various environments. This sixth reviewer stated that this effort has been an ongoing key AEC MOU project for many years and has included close collaboration in the past few years with the University of Wisconsin. The same reviewer noted that the PI mentioned a possible collaboration with Wayne State University that could be of value to future work and that this was a very well collaborated project. The seventh panelist noted a solid connection with University of Wisconsin existed where a lot of the pioneering work in low-temperature combustion work is being performed. The panelist felt that a wider relationship with partners in the engine combustion memorandum of understanding exists. This panelist went on to say that industry input is sought to become familiar with operating conditions and strategies with multiple injections. The final reviewer noted that the project was responsive to industrial partner's queries on continuing areas of research.

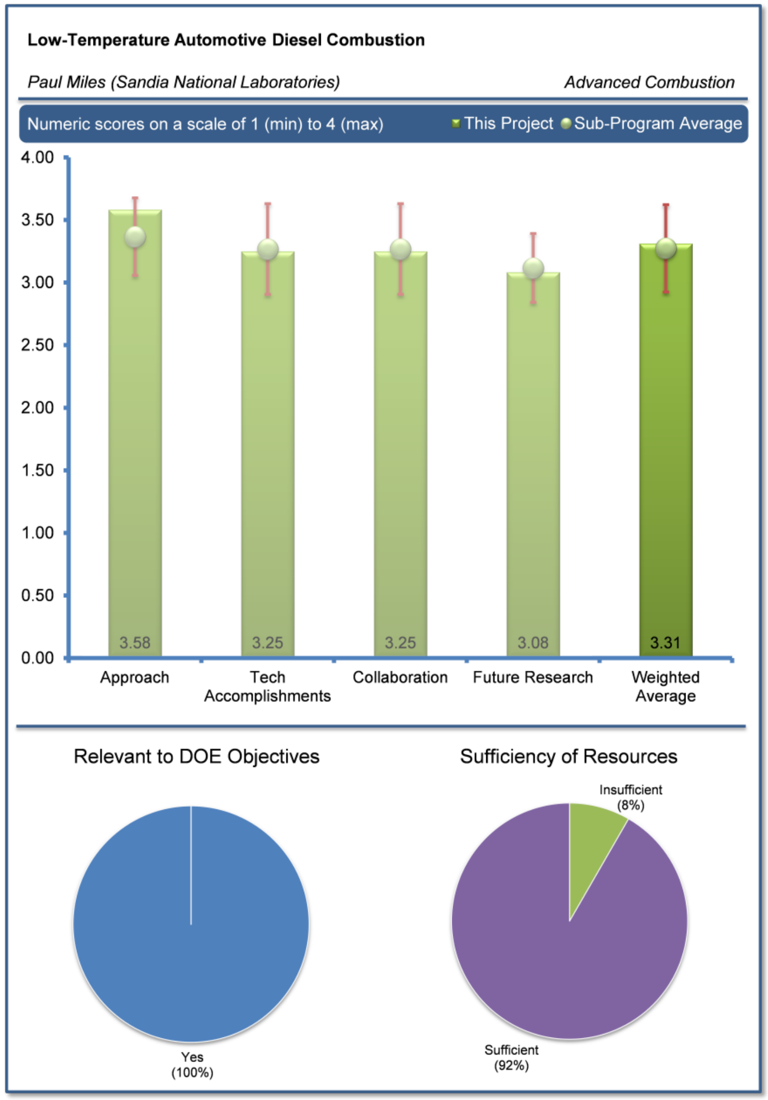
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted plans for combustion chamber design, LTC soot and PAH. The reviewer suggested more focus on in-cylinder heat transfer correlations and recommended coupling with real engine work. Another reviewer stated two areas where more progress was possible included the correlation with metal engine data to better understand the effects of heat transfer, as well as the effects of multiple injections, which tended to be highly geometry-dependent. The same reviewer also believed that more progress was possible in the fuel effects on RCCI area, including optically exploring the effect of low cetane number fuels and oxygenate fuels (e.g., alcohols) on pollutant formation (especially PM, but also CO and UHC). The third reviewer noted that the plans seemed well developed to build on progress and accomplish goals. The fourth reviewer felt that the author showed a rather comprehensive examination of the in-cylinder combustion and that the proposed work was adequate as it furthered the task at hand. The reviewer added that the project should align with testing in a modern diesel engine that could provide data to corroborate the optical results. The reviewer felt the question may be asked as to how the present study has impacted engine design of combustion development. A fifth reviewer felt that there was a need to solidify plans to look at post injection, but it sounded like the PI was engaging industry to help define the project well. A sixth reviewer noted excellent proposed future research but suggested that the project figure out how to extrapolate results to production type engines including piston design variations and also more representative injection rate profiles as related to current and future heavy-duty engines. Another reviewer cautioned that proposed measurements of heat transfer would have to be done carefully going forward, because of the uncertainties in making such measurements in an optical engine. The reviewer went on to say that multiple injection schemes have to be carefully tied in to industry practice so that it is relevant. This reviewer added that since the combustion geometry significantly affects efficacy of multiple injection, the optical engine geometry would have to be mimicked as closely as possible to realistic engine geometry. Per the final reviewer, modeling LTC soot and PAH formation would be an area of useful future research.

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

Reviewers had mixed responses regarding the sufficiency of project resources. Three reviewers felt that resources were insufficient. One reviewer noted that resources were sufficient to achieve project objectives. Another reviewer indicated that it was a well-funded project, while a different reviewer recommended expanding the work scope for more fuel sensitivity. The final reviewer stated that very good progress had been made with the current level of resources and that there was no indication that that should not continue to be the case.

Low-Temperature Automotive Diesel Combustion: Paul Miles (Sandia National Laboratories) – ace002



Reviewer Sample Size

This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer stated that a better understanding of in cylinder conditions (such as equivalence ratio distribution), combustion, and emissions formation processes should enable development of better designed, more fuel efficient engines which use less fuel/petroleum. A second reviewer pointed out that improved understanding of diesel combustion will potentially expand the use of clean light-duty diesel technology, which will help reduce fuel consumption. The reviewer elaborated by saying that enhancing models that are used to design engines would have an impact on the efficiency and emissions of future engines. The third reviewer simply stated that the project supported engine development for high efficiency and clean emissions and that the project was well established and organized. A fourth reviewer simply stated that there was a light-duty-focus using a 1.9L GM engine with optical access. The fifth panelist commented that this was another fundamental project that could aid engine developers in developing the next generation of small bore diesel engines through improved understanding of injection rate, bowl design, and swirl on engine performance. The sixth reviewer added that this project addressed the lack of fundamental knowledge of combustion and lack of combustion models in light-duty diesel engines. The final reviewer commented that diesels do reduce fuel consumption, so, in this respect, this project supported the objective. Yet this reviewer wondered why the focus was on CIDI in light-duty engines, since the reduced GHG emissions come at fairly significant cost in the light-duty sector. As a result, this reviewer said that very few in the industry, with the possible exception of Volkswagen, were forecasting a diesel revolution in light-duty vehicles in North America in the next 15-20 years, particularly under the constraints of California LEV3/T2B2. Moreover, this reviewer felt that the project should evaluate whether it is in the United States' interest to promote significant use of diesel fuel in the light duty sector as a national strategy.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer summarized that the focus was on real combustion chamber geometry and at least two to three geometries would be beneficial, budget and time permitting. Another reviewer stated that this project was focused with strong contributions between optical engines at Sandia National Laboratories and metal engines as University of Wisconsin-Madison and Oak Ridge National Lab. A third reviewer stated that the optical engine, in collaboration with CFD modeling, was an effective means for gaining an understanding of the basic effects of geometry and charge motion in light-duty diesels. However, this reviewer stated that the load limitations of the optical engines prevented an understanding of those areas of the engine load-speed range that posed the greatest challenge to meeting T2B2 emissions in diesels. According to a fourth reviewer, use of optical engine with clean model fuel having similar heat release rates as real diesel is a good approach for viewing/determining evolution of in-cylinder equivalence ratio as function of position and time. To this reviewer, it was also very good that the platform is a production model that others are also using. Another reviewer felt noted close ties exist to the modeling work at the University of Wisconsin. According to this reviewer, this ensures that models get the benefit of the latest findings from experiments. A sixth reviewer commented that it is important to understand mixing processes, and the data sets will be useful to help validate CFD models.This reviewer felt that it would be useful to more clearly define what would be learned from the experiments beyond validation data, such as what barrier was being overcome. The reviewer went on to say that future work seemed to be more focused on that through the study of multiple injection in LTC. The reviewer also felt that it was not clear how collaboration with CFD and metal engine studies were being leveraged to further understand this dataset. A reviewer stated that light-duty LTC needed to carefully address the emissions attribute, as LEV III/Tier 3 emissions would be difficult, even with a spark ignition engine with three-way catalysis. The reviewer went on to say that the project should consider how to develop rough guidelines on engine out emissions supporting low emissions. This reviewer observed that validating model predictions with experimentation was good. The reviewer also asked how the grid coarseness was established without experimental results. The final reviewer pointed out that much work has focused on developing advanced optical techniques for measuring equivalence ration and local mixing rate, and that this was great work. The reviewer added that it would be helpful if this effort also considered multi-zone analysis in addition to CFD, including a couple of piston design changes, and more of a discussion on indicated thermal efficiency impact of using LTC in small bore diesel engines.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer felt that the background slide on the image processing technique was useful. The same reviewer further remarked that the swirl and injection comparison was insightful and that more of these types of studies were needed. The reviewer went on to say that understanding physics was a goal, but design sensitivity assessment was equally important to progress. The second reviewer observed very good progress in determining equivalence ratio distributions. Although progress in identifying discrepancies between measured and simulation of UHC/CO sources and improved soot models was listed, this reviewer noted a lack of time devoted to discussing this progress. A third reviewer commented that this project gave impressive visualizations of the fuel distribution in the cylinder during the combustion process and felt that the author captured key points during the combustion process. The reviewer detailed that the work captured various contributions such as injection pressure and swirl, and related their impact primarily in the over-mixing phenomena. The reviewer noted that the project did not give any updates or references to the work at ORNL, specific to contributing transient, aftertreatment, and controls work. The expert also added that the project was framed within the relevance to improve fuel economy and emissions, but no mention was made on these quantities, and the reviewer felt that it would be good to incorporate these performance numbers. A fourth reviewer observed excellent datasets investigating not only the equivalence ratio field, but also the influence of swirl, injection pressure, and etc., with good interpretation of the data. This reviewer felt that the data set will be very useful for model validation. The fifth reviewer stated that there were great in-cylinder pictures that showed the mixture. The sixth reviewer felt that there was outstanding progress in toulene LIF imaging work and that the project would greatly increase understanding of mixing of the fuel jets under swirling conditions. The reviewer also observed the Coanda effect and pointed out that asymmetries from jet to jet and swirl center asymmetry suggesting full chamber modeling rather than sector mesh modeling would be needed. The seventh panelists wondered if the geometric effects identified in the study could be varied in a more controlled manner to demonstrate the parametric influences more clearly and perhaps identify some benefit. The panelist elaborated by saying that using the optical engine to further explore the effects of geometry experimentally would be an interesting contribution for light-duty diesels, and that the focus on light load in the optical engine limited the spray duration and penetration to a fairly small range. This led the panelist to again wonder if some effects of longer spray duration could be explored, which might be representative of what would be seen at a higher load. The eighth reviewer stated that documenting the Coanda effect is interesting and wondered if a similar mechanism would be at play in a GDI engine relating to HC emissions. Another reviewer felt that given the discrepancy between the experimental results and the model results, there needed to be some explanation for the difference or a plan to improve the model.

The final reviewer observed that great progress was made, overall, in more accurately measuring local equivalence ratio in a light-duty diesel that would lead to additional productive research on understanding LTC combustion in spray-wall interaction environments. This reviewer pointed out that there was no discussion on the impact of LTC on indicated thermal efficiency and that this discussion needed to occur in the future based on lab measurements and possibly zero-dimensional engine simulations. Also, according to this reviewer, it was not clear if the swirl could be decoupled enough from the optical engine bowl design to provide enough qualitative information to engine designers–time would tell if this was or was not the case. The same commenter added that including various piston bowl geometry (especially squish area) would aid in sorting out this situation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the level of collaboration in this area was appropriate for the success of this project. The collaboration with modeling was especially critical. The second reviewer noted good collaboration with the University of Wisconsin, GM, and Ford, as well as engagement with industrial partners at semi-annual AEC memorandum of understanding meetings. The third reviewer specified that the project has a good partnership with UWM but that the work appeared to be mainly focused on providing benchmarks for the simulation. It was unclear to this reviewer, however, whether the simulation was providing any significant value to the work yet. A different reviewer also pointed out that collaborations exist with many organizations in the MOU and that monthly teleconferences took place with GM and Ford. The fifth expert noted that this effort has been a key AEC MOU project for years and well connected with various industry partners and historically the University of Wisconsin. The final respondent noted excellent collaboration with the modeling community, industry, metal engine research on the same engine, and other optical engine research and spray facilities, which help develop a complete picture. However, this respondent indicated that it was unclear how the metal engine studies were being leveraged. The reviewer went on to say that there was some exploration of model agreement against the data set, but that it was not clear that there was a plan to improve the models based on the measurements.

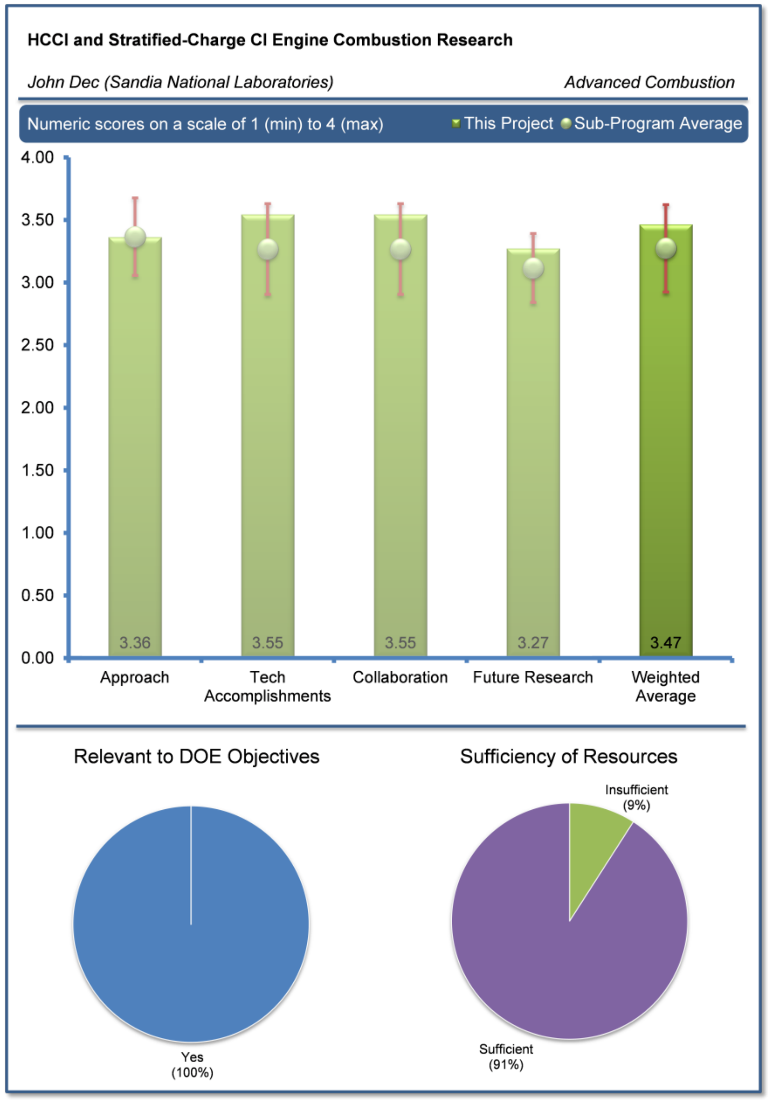
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One of the reviewers stated that further application of this diagnostic was an excellent endeavor and that it was critical to use it, not only to create a unique data set, but also to address key barriers for LTC. The second reviewer recommended that more vertical plane work, combined with combustion chamber sensitivity (squish height, bowl/squish geometry) would be helpful. A third reviewer said that vertical plane imaging should complement the information obtained so far especially the interaction between the radial outward squish flow and HC and CO emissions. The fourth panelist stated that given that this project was directed toward light-duty engines, at least some of the focus should be redirected toward fundamental understanding of SIDI combustion, rather than CIDI. The reviewer went on to say that some valuable work remained in the basic understanding of mixture prep in spray- and wall-guided direct injection gasoline systems. The fifth commenter strongly suggested better quantification of the injection rate profile as soon as possible to aid in better understanding optical engine measurements and also in the associated CFD analysis. The reviewer felt the transient nature of the injection event might have a stronger impact on LTC combustion behavior than what appeared to be the case today. Another reviewer simply stated that current plans looked like it would build on previous results and advance goals. The seventh commenter noted that several extensions to the work were provided, nevertheless, this work should be kept in sight of engine efficiency and emission improvements. The eighth reviewer felt that a plan to improve the model to match experimental results was needed. The last reviewer said there was limited detail on future research.

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

One reviewer found that resources were insufficient. The remaining reviewers found that resources were sufficient. One reviewer noted that the resources were sufficient to achieve the objectives of the optical engine study. The second reviewer indicated that good progress with existing resources had been made, thus there was no indication that changes were needed. One reviewer stated that it was not clear what new work more funding would allow. The final reviewer remarked that this was a well funded project.

HCCI and Stratified-Charge CI Engine Combustion Research: John Dec (Sandia National Laboratories) – ace004



Reviewer Sample Size

This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer summarized that the project contributed to reducing fuel consumption of internal combustion engines. The second reviewer noted that the project boosted HCCI at high loads. A third reviewer added that HCCI supported the DOE objective for petroleum displacement through reasonably high efficiency, with the potential for low emissions. A fourth reviewer said HCCI provided an avenue to clean efficient lean gasoline combustion, which was a high risk technology for gas engines, and that the project was looking at expanding the load limit of HCCI, which was a key barrier. The fifth reviewer said that this was an excellent experimental project addressing the continual push toward advanced combustion modes for driving up indicated thermal efficiency. A sixth reviewer elaborated that the difficulty was if this could ever be implemented given the control complexity and fuel sensitivity. The last reviewer pointed out that the project aims to understand and remove barriers in gasoline low temperature combustion, which include efficiency of HCCI and the application of HCCI to higher engine loads.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer simply stated that the objectives and several partners (e.g. LLNL, University of Michigan) were clearly indicated, but little or no information was given regarding the outcome from this collaboration. For example, this reviewer wondered what information was transferred to the kinetic modeling group from LLNL. Also, the reviewer wondered how this information was used by LLNL to refine its models. The second reviewer described the approach as very sound and outstanding. The third reviewer said that extending the load range, looking at representative future fuels and examining the NVH/efficiency tradeoffs were important for advancing HCCI. Yet, the reviewer believed that these do not represent the chief obstacles to high-load HCCI engine development. The reviewer went on to say that turbomachinery development, cold start emissions, low-temperature aftertreatment and transient control may be more important areas to explore going forward. The fourth reviewer stated that isolating aspects of HCCI to understand their effect was a good approach. However, continued this reviewer, the noise constraints and metrics may need to be reevaluated, there did not appear to be a consensus on what metric should be used, and at least one of the light-duty OEMs did not seem to agree with the limit that was being applied. The fifth reviewer said that there was an excellent combination of optical engine, metal engine, chemical kinetics modeling, and CFD analysis approach. The reviewer acknowledged and expressed thanks that this project was one of the few fundamental engine research projects explicitly addressing the impact of various engine boundary conditions on indicated thermal efficiency (such as fueling rate, speed, fuel type, intake conditions). A sixth reviewer wondered how the results were constrained with boost, inlet temperature and ringing index limits. The final reviewer had concerns about how this approach would be used in a production engine; primarily the controls aspect. The reviewer also wondered what the key roadblocks were and if there was work in place to address these roadblocks.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer felt that there was good progress showing higher thermal efficiency at high load HCCI using partial fuel stratification and the parameters that influence efficiency and that there was a useful investigation of the influence of various parameters on thermal stratification. The second reviewer said that accomplishments directly addressed the limited load range barrier to practical implementation of HCCI. A third reviewer stated that the new focus now on boosted HCCI and SCCI was appropriate and in keeping with the megatrend of boosting. The new work on looking at ethanol content (E0, E10, E20) and its effect on increasing load capability with HCCI was particularly relevant and interesting. The same reviewer also felt that the new work on supporting the kinetic modeling work at LLNL would also go a long way in understanding HCCI combustion. This expert also said that determining the effects of main operating variables on efficiency was very practical. The fourth reviewer wondered if this efficiency and emissions were good enough to compete with that of a T2B2 modern gasoline engine. The reviewer said that now that the project has shifted attention to boosted operation, some attention needed to be given to reducing PMEP with real boost systems. The reviewer pointed out that 48% indicated efficiency looked impressive with free boost, but this likely implied mid-30’s actual efficiency, which was not significantly better than a projected MY 2020 high-BMEP boosted gasoline engine; besides that, the reviewer said, the HCCI engine would be more expensive and larger. The reviewer provided an example of comparing a 2.4L HCCI/boosted with a 1.3L SI/boosted engine and asked where HCCI offered real-world efficiency and emissions benefit for a relevant torque/power level. This reviewer felt that this should be where this technology was focused, which may lead back to studying light load. A fifth reviewer stated that the work demonstrated 47-48% indicated thermal efficiencies and that these appeared to be very similar or even lower than conventional diesel combustion engines. This reviewer went on to say that naturally, the benefits resided in cleaner engine out NO_x and soot emissions but stated that efficiency was very important. The same reviewer also said that the author clearly showed the impact of highly premixed combustion and that efficiency closely tracked the combustion phasing. This emphasized the overall importance of phasing, possibly overshadowing other effects. The reviewer also felt that the fuel strategy (increased stratification) results were unclear. The results were insightful from the limiting of rates of heat release, according to this reviewer, but it was unclear what the combustion phasing impact was since it seemed it had not been kept constant. The same reviewer suggested that a comparison of pressure traces would be useful. Lastly, this reviewer was not sure if the study had significantly improved the fundamental understanding of HCCI/SCCI. The sixth reviewer summarized the project by saying that a large of amount of experimental data had resulted from this project which was very helpful in sorting out combustion variances between ethanol and gasoline under advanced combustion modes such as HCCI and PCCI. The only questioned whether the PI could accurately determine the indicated thermal efficiency to sort 0.2 to 0.5 percentage point variations based on combustion phasing.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the collaboration and connection with the industry and academia remained outstanding. However, the reviewer would have liked to see collaboration with turbomachinery and aftertreatment suppliers. The second reviewer went into more detail by saying that there was good collaboration with GM, LLNL and various universities, but that a closer connection to other industry partners would be helpful, and it was important to agree on what the acceptable combustion noise level was. Additionally, this reviewer remarked that providing data to LLNL to validate the project gasoline surrogate mechanism was very useful. However, the reviewer felt that collaboration with metal engine work at Argonne National Laboratory would be useful. The third reviewer noted that the project was another ongoing key AEC MOU project with close collaboration with various industry partners, a couple of Universities, and another national lab. The fourth reviewer noted that there was AEC cooperation, and the fifth reviewer observed the project has a good collaborative team. The final reviewer noted detailed collaboration with GM ad that several other collaborations existed.

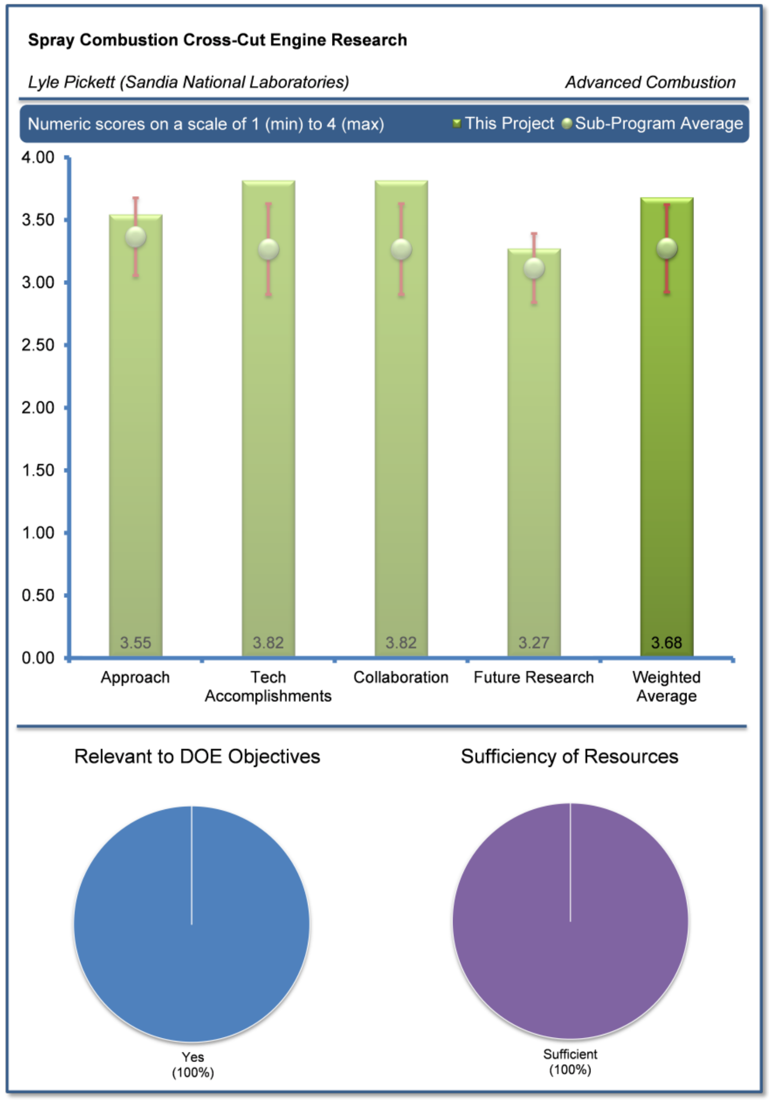
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One expert said that it was useful to look at different fuels, particularly the use of ethanol as an octane enhancer (including the influence this would have on HCCI), and felt that it would be important to understand the tradeoff between noise and efficiency. The second reviewer recommended some key areas for consideration: cold start and transition to HCCI from spark ignition (if needed); optimizing tradeoffs of efficiency and potential aftertreatment performance; and stability margins during transients. The present focus on efficiency, steady state combustion performance and emissions, and NVH already appeared to be more- or less adequate. The third expert noted SA-HCCI work. A fourth reviewer felt that the overall the project had excellent proposed future research, and suggested the exploration of piston design changes on thermal stratification. This reviewer felt that this detail could be important in the design of future pistons for engines that utilize these combustion strategies. A fifth reviewer felt that the increase of compression ratio or the sensitivity to it would be a good next step. This reviewer also wondered what the advantages were for SNL to install spark ignition. Additionally, the reviewer felt it was unclear what the support activity was that was taking place on the HCCI modeling. The sixth reviewer said that given the variability of fuel in the marketplace, it would be useful to consider this as a noise parameter rather than a control parameter. For example, the reviewer said the combustion seemed to be quite sensitive to ethanol content, but commercial fuel ethanol content as permitted to vary from the nominal ethanol content. The reviewer asked what could be done to evaluate the impact on combustion control given that commercialization of this concept would have to be robust to variations in fuel. A seventh commenter also liked the addition of SA-HCCI and real world fuels, but said that the project could address controls approach and challenges. The final reviewer reiterated that the project was going to look at spark-assisted HCCI and pointed out that this was a very geometry dependent concept. The reviewer was concerned for the ability to have a geometry that would aid partial fuel stratification, which would be a component that controls the flame propagation during the initial portion of combustion.

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

Only two reviewers provided comments, with one stating that the resources appeared to be sufficient to achieve the project objectives and the second simply stating that the project was well funded.

Spray Combustion Cross-Cut Engine Research: Lyle Pickett (Sandia National Laboratories) – ace005



Reviewer Sample Size

This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer felt that this work represented a key fundamental study to improve the efficiency of heavy-duty engines. The second reviewer said that direct injection is the linkage to efficiency of the future. A third reviewer stated that the project contributed to reducing fuel consumption of internal combustion engines. A fourth reviewer noted that good predictive spray models were critical for improving the design of engine systems and improving engine efficiency leading to improved fuel economy and thus lower requirements for petroleum. The fifth commenters stated that improving spray models was an important step toward improving combustion for improved engine efficiency. The sixth respondent indicated that the research will improve fuel spray modeling and that it supports engine efficiency improvements. Another reviewer said that this project aimed to provide an understanding of direct-injection fuel sprays. The reviewer felt that the shortcomings in modeling of sprays were a key barrier to understanding conventional as well as low temperature combustion. The final reviewer commented that this project indirectly addressed DOE needs by hopefully leading toward an improvement of today's spray models that was critical in evaluating advanced combustion modes, but that this project eventually needed to link fuel spray formation to indicated thermal efficiency at some point in the future.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that the liquid penetration distance focus was well placed. The second reviewer said that the project had a good approach of using optical diagnostics to view sprays and then develop and fine tune models. A third reviewer felt this project leveraged a wide range of partners with very capable facilities and that a worthy effort was made to coordinate these activities. The fourth reviewer said that the project produced some of the best fuel spray pictures the reviewer had seen and that it was great to see the results at temperature. A fifth reviewer commended the project by saying that the project had completed excellent work in deciphering issues with measuring evaporation rate (liquid length) depending on the technique and experimental apparatus. Also, the reviewer felt that the project did excellent work in pulling together various spray experts around the world in sharing data, comparing ideas, and also modeling sprays. The only suggestion from this reviewer was to more widely vary the spray boundary conditions, e.g., pressure and temperature and injection rate profile, and also to figure out how to link various spray formation processes on indicated thermal efficiency. The sixth expert felt that multiple organizations conducting similar analysis/measurements to gauge repeatability and establish common techniques were good. A seventh reviewer felt that the work, in collaboration with computational efforts and optical engines, represented an important piece toward gaining a fundamental understanding of combustion in heavy-duty engines. This reviewer stated that it was especially important going forward was the contribution to the evolution of near-field spray development, particularly at elevated temperature and pressure. Finally, the last reviewer said that experiments in a constant volume chamber had limitations as far as applicability to an engine because it did not have the correct flow and ambient conditions. However, it provided a first, idealistic view of spray structure.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that the collaborative study of many different aspects of spray development was invaluable. The reviewer recommended that extending this work to include gasoline sprays would be important for light-duty engines as well. The second reviewer said that there was interesting results on what happens at injector startup and excellent progress in coordinating Engine Combustion Network efforts to cross compare and calibrate/align results across the various facilities doing spray modeling work. A third reviewer liked that the project had results at realistic cylinder-like conditions. The fourth reviewer stated that the work is excellent and has brought new understanding on how to measure liquid length and correlate measurements to spray models. The reviewer felt that the PI had spent much time and effort to bring together the various spray research facilities around the world in order to commonize experiments; the reviewer felt that this should also be considered a technical accomplishment. A fifth reviewer said that high speed microscopy movies have shown increased features and phenomena of the spray in the near-injector region. The reviewer felt that these new insights into the atomization process would be very valuable in guiding the modeling efforts. The sixth expert remarked that repeated measurements at multiple facilities to understand repeatability and understanding measurement sensitivities to noise and control factors were good. The same reviewer asked how these observed differences in spray structure translated to differences in combustion and how to go about answering this question. The seventh reviewer summarized that the project sought to study the complex interactions between sprays, mixing and chemistry and that the work aimed at improving engine designs by providing more predictive, cost effective modeling. The work presented gave a very well organized description of the injection event. The reviewer felt that this included the beginning stages of the injection event, the discovery of vapor injection leading liquid injection, and the discovery of gas entrainment in the sac during first needle movement. The reviewer summarized that the work scope focused on spray, liquid-phase penetration, and spray structures. The reviewer then pointed out that what was unclear however was the impact that these had on overall the predictive modeling. The reviewer then wondered what the impact was on the emissions (NO_x, soot, HC) and performance (combustion, cycle efficiency). It was also not clear to this reviewer what came out of this collaboration and what was being transferred into modeling packages such as KIVA or commercial codes. The reviewer also asked what benchmarks had been made to demonstrate the effectiveness of this work, and queried the before and after performance of the models. The final reviewer questioned why there were no cursory investigations with closely spaced split injections, and gasoline-like fuels.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the Engine Collaboration Network (ECN) collaboration was exceptional and highlighted its alignment on hardware (e.g., Spray A). This was reiterated by two other reviewers, one who said that ECN was a good example of collaboration, and the other remarking that the engine combustion network was an excellent vehicle for collaboration. The fourth reviewer noted that excellent ties existed with the modeling community as well as industry through the AEC and ECN networks. Another reviewer said that the collaboration with other labs, academia and industry remained outstanding, and that future collaboration on gasoline sprays would only improve the usefulness of this work. A sixth reviewer went into more detail by saying that the ECN appeared to be providing an excellent mechanism for mostly universities and national labs to share results and collaborate. The reviewer also noted that a couple of industrial companies also appeared to participate and interactions with industry apparently also occur at the semi-annual AEC memorandum of understanding meetings. A seventh reviewer said that this work was needed with different nozzle hole geometries, primarily Kf and amount of nozzle honing. Both of these have effects on engine emissions and performance and it must be due to the effect on the spray. The reviewer felt that this work would lead to guidance on how to set up the spray model differently in a CFD run for different nozzle holes, and specifically pointed out that this was needed in the industry. The reviewer elaborated by saying that today a difference in emissions was seen, but that it was not known how to change the spray setup to get these differences. The eighth reviewer pointed out that this project was another key AEC memorandum of understanding project that has included much interaction from the industry over the years and that the combustion network that included global research partners at various institutions such as Pennsylvania State, ANL, Cambridge University, University of Wisconsin, CMT, and Caterpillar. The final reviewer suggested that the project could have a larger collaboration with partners that could exercise a real world evaluation of the outcome of these activities. The reviewer went on to say that one or several industrial partners could be engaged and supported to see how the present work could translate into successful implementation of improved models, validated by testing and added that many industrial entities performed extensive modeling exercises that were experimentally validated.

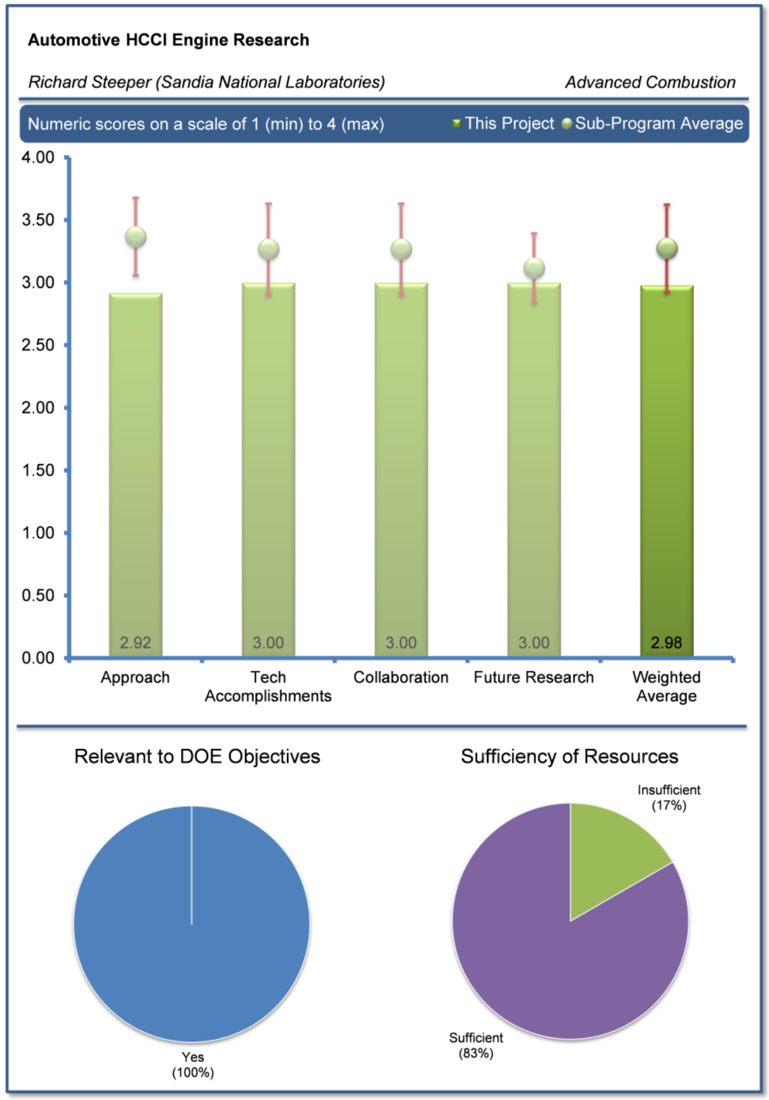
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that the project was well-planned and offered no specific recommendations. The second reviewer suggested that the project needed to greatly accelerate gasoline injection diagnostics. Another reviewer indicated that it is good to include gasoline injectors. The fourth reviewer's suggestion was to also investigate various injection rate profiles as part of future experimental and modeling activities. Otherwise, this reviewer felt that the future work plan is logical. A fifth reviewer commented that measurements of liquid volume fraction would be very valuable in validating models and that what was uncertain was if measurements could be made closer to the injector. This reviewer pointed out that some of the X-ray diagnostic work done by Professor Jerry Faeth at University of Michigan should be reviewed to see if any knowledge already gained for the near-injector, dense spray region under low-temperature ambient conditions was applicable to the current work. The reviewer added that, in the diesel area, the modelers should be allowed to catch up the data and insights already obtained. On the other hand, this reviewer said that gasoline injector and spray work should be accelerated to start getting results because the potential for impacting the passenger-car fleet and reducing petroleum usage was greater. The sixth commenter said that the physics of the phenomena was well represented and that the level of detail on the phenomena described would need to be further generalized so that it could or would be applicable to more universal conditions, other sets of hardware, wider rates of injections, and temperatures and pressures at which the fuel is injected. The reviewer added that the work continued into direct-injection gasoline, but encouraged the authors to ensure the work done is leveraged onto modeling tools. Similarly the seventh reviewer noted that the project did not have too much time to go into much detail on future work, but information on plans in the slide deck seemed reasonable. The final reviewer said that the project needed a roadmap to determine how these observations could be translated into engine attributes.

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

Of the two reviewers providing comments, both agreed that resources were sufficient for this project and one said the resources seemed sufficient for continued progress.

Automotive HCCI Engine Research: Richard Steeper (Sandia National Laboratories) – ace006



Reviewer Sample Size

This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One of the reviewers said that HCCI combustion has the potential to significantly improve light-load efficiency in light-duty engines, while another agreed that it had potential for lower emissions and improved efficiency which would lower demand for petroleum. The third reviewer simply stated that the project contributed to reducing fuel consumption of internal combustion engines. The fourth reviewer indicated that the project aimed to improve understanding of automotive HCCI engine combustion for higher fuel efficiency. A fifth reviewer recognized that HCCI was one possible path to improving gasoline engine efficiency, enhancing the load range was critical to implementation, but there were also many other technical barriers. This reviewer also said that it was not clear what influence NVO would have on efficiency. The reviewer continued that fundamentally, it should be bad for efficiency, so it was not clear that this path would yield a solution that would improve fuel consumption. The sixth reviewer said the project directly addressed DOE goals for improving gasoline engine thermal efficiency by exploring the control and use of HCCI to improve part-load indicated efficiency and thus improved composite drive cycle fuel consumption. A seventh felt that the HCCI barriers remained significant (noise, ringing intensity, controls) and that unless progress could adequately remove barriers for light-duty applications, the reviewer suggested placing funding elsewhere in the combustion portfolio. The final reviewer stated that improved efficiency was the goal but felt that what was missing was a mathematical calculation predicting how much efficiency gain was planned to be achieved. Without this, the reviewer did not know if it was worth pursuing.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer said this project sought to explore fundamental knowledge of engine combustion, looking into fuel injection, evaporation, mixing, heat transfer and thermal stratification; and that it targeted 25% gasoline fuel economy improvement and Tier II, Bin 2 emissions with less than 1% thermal efficiency penalty. The reviewer went on to say that the work was approached via experiments in an optical engine equipped and configured for automotive HCCI combustion strategies, diagnostics to acquire in-cylinder measurements of fundamental physical processes and computer models to guide and interpret engine experiments. The second reviewer felt that the acetylene seeding experiments were useful, but that there was not enough emphasis on realistic constraints on pressure rise rate. The reviewer also felt that more results on ISFC (efficiency) were needed in the material. A third reviewer said that the approach of coupling optical engine experiments with modeling was good and appropriate. One key question from the reviewer was whether the use of NVO in HCCI would be a key enabler to advancing the commercialization of high efficiency and clean combustion processes. The fourth reviewer noted that the project uses optical engine experiments to increase insights and knowledge. The fifth expert said that the approach to date has been logical and appeared to address some of the key issues with NVO approaches on gasoline HCCI, though pressure rise rate effects were not discussed in much detail. Also, the reviewer did not see a discussion on the impact of various HCCI control strategies on indicated thermal efficiency. The reviewer felt that it would be helpful to see a quantitative discussion of this subject matter in the future. A sixth observer commented that the experimental study had so far focused on a narrow range of conditions; the reviewer would have liked to understand the limitations of deploying this strategy over a wider range of operating conditions and questioned what the potential to extend this approach to higher loads was. The reviewer also asked if the range was too limited to achieve the overall targets for engine efficiency outlined in the advanced combustion roadmap, while achieving Tier2/Bin2 emissions. The reviewer wondered if a metal engine would be useful for mapping out the potential for this approach. A seventh reviewer stated that the project focused on NVO looking at different methods of NVO injection and that fundamentally NVO should be bad for efficiency, so it was not clear that this path would yield a solution that would improve fuel consumption. The reviewer said that it sounded like low load limits for HCCI was potentially the main barrier being investigated, but that it would be useful to create a clearer picture of what barrier was being overcome. The final reviewer said that it was difficult to determine if NVO was a viable path to production-capable HCCI engines.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that there were very interesting results and comparison of early NVO and late NVO in HCCI. The same reviewer also felt that there were interesting results with the acetylene seeding experiments. Similarly, the second reviewer stated that the Chemkin versus Experimental for C_2H_2 seeding was highly significant for insight. The third reviewer stated that understanding differences in early and late NVO injection was beneficial if NVO was employed and went on to say that this was a fundamental study, that it was important to reform fuel rather than fully consume it during NVO and identification of C_2H_2 as an important species. The reviewer felt that the connection to the model and leverage of the model would be useful. The fourth panelist felt that this was very good work to date in addressing the impact of fuel injection timing during NVO on heat release rate and piston fuel film formation. The reviewer suggested that it would have been nice to see more attention paid to the effect on indicated thermal efficiency using the various NVO injection strategies. A fifth commenter pointed out that last year's focus was on using TDL to identify other species during NVO and wanted to know if this work succeeded, and if it had been reported. The commenter stated that comparing with last year's work suggested relatively little progress in the past year. The sixth reviewer noted that the project focused on NVO to extend low load operation, but wondered why the authors were focusing on just NVO. The reviewer asked if this was the key and only enabler to promote HCCI load extension and asked what other mechanisms had been considered. This reviewer went on to say that large NVO gives off poor efficiency, and asked what efficiencies were being run in this work. Detailed images of combustion were shown, but the reviewer wanted to know how insightful it really was. The reviewer wondered why there were no correlations to engine out emissions of NO_x, HCs, and/or soot, and pointed out that the authors spoke of contributing to very stringent emissions and fuel efficiency standards, but no reference was made in their work to these. The reviewer also noted that the introduction of acetylene arises from apparent chemical effects of late NVO injection on main combustion phasing and that the imaging experiments show NVO fueling linked to rich flames. The reviewer then stated that since acetylene is a known product of rich flames and a known ignition enhancer, the project hypothesized its role as a reformed NVO product that can help control main combustion. The reviewer then pointed out that this was corroborated in the project's extensive experiment, but that the authors did not communicate the significance or practicality of this information for the HCCI application. A final reviewer noted that early and late NVO fuel injection strategies have been investigated, the effect of which has been simulated with acetylene seeding experiments. This reviewer reported that similar effects were observed, suggesting that late NVO fueling produces species that enhance ignition. The reviewer also wondered regarding the observed increased peak apparent heat release rate for the seeded cases, particularly, how the project was sure that all of that could not be attributed to the participation of the seed acetylene in the combustion process, providing a kick in the peak burning rate, per abrupt drop off in C_2H_2 profile in Slide 13.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer felt that the collaboration with industry and academia was good and that continuing to pursue new collaboration with the industry to help refocus the objectives would be helpful. The second reviewer said it looked like there were good interactions with OEMs (GM and Ford) and LLNL and that those main interactions with energy companies mainly appeared to be through the semi-annual AEC memorandum of understanding meetings. Similarly, a third reviewer stated that the main collaboration was through the AEC, however there were additional collaborations with universities and engagement with light-duty OEMs. The fourth reviewer noted that collaborations with the modeling community and input from industry were frequent. The final reviewer said that the presentation reserved a minimum discussion to the modeling work from LLNL and University of Wisconsin and that no details were given to the interaction with the OEM partners.

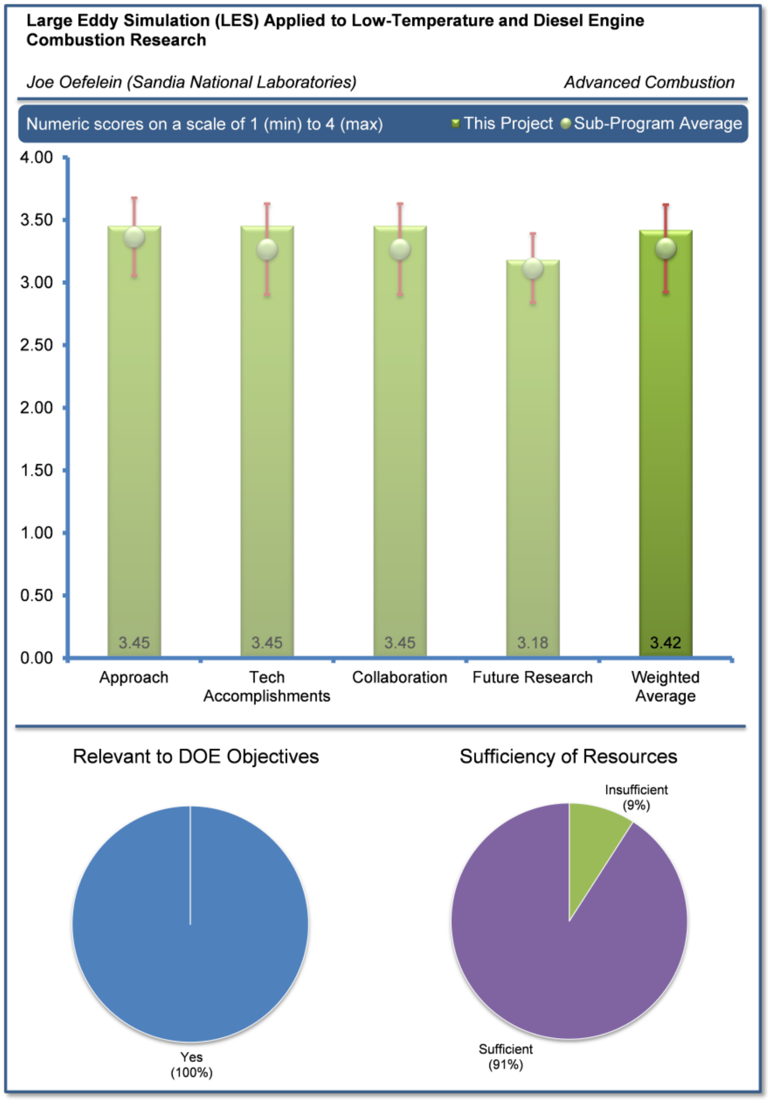
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that, overall, the project had a very logical approach to continue pushing the understanding of use NVO approaches for gasoline HCCI as a means to improve part load engine efficiency, and recommended that it would be helpful to also include attention on the impact of indicated thermal efficiency as part of the future experimental and modeling activities. The second reviewer suggested refocusing research on dilute, spark ignition research areas. The third reviewer said that understanding the effects of various fuels on kinetics may be important and that adding an oxygenate component (given certainty of E10) may affect the C_2H_2 mechanism. A different reviewer said that the presenter did not have enough time to discuss future plans, but that from the slides, the plans appeared to be reasonable. Another expert said that it was not clear how useful this work was to further promote the implementation of HCCI, but that the authors linked this work with the overall goals of efficiency and emissions targets cited in their opening slides. Another reviewer said that leveraging the model to understand what species would be useful, but that it was not clear how one would be able to control which species were generated. The reviewer also indicated that looking at fuel effects on this process would be helpful and asked if ethanol content or other gasoline properties altered the effect. The same reviewer remarked that focusing solely on NVO without having a clear path to improving efficiency with it suggested that the PI should potentially expand research to other techniques to expand the HCCI operation regime. One expert simply felt that a path to viable mass produced NVO HCCI engines was not clear. The final reviewer asked if it was necessary to quantify mass and duration of piston-top fuel films associated with late NVO fueling. Eventually, the reviewer wondered if the project could anticipate that depositing fuel on piston surfaces had to be avoided due to soot, piston deposit formation, or other reasons.

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

One reviewer felt that there was no evidence that the resources were not sufficient, while another said that funding was adequate. A third reviewer felt that upgrading the hardware to the new optical engine head would be important for future work.

Large Eddy Simulation (LES) Applied to Low-Temperature and Diesel Engine Combustion Research: Joe Oefelein (Sandia National Laboratories) – ace007



Reviewer Sample Size

This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer identified the project as a fundamental high pressure liquid injection process. The second reviewer noted that the development of affordable predictive tools was important for advancing the development of high efficiency, clean combustion engines which would rely less on petroleum. The third reviewer agreed that the project contributed to reducing fuel consumption of internal combustion engines. The fourth reviewer said that improved engine models would help contribute to improved engine efficiency. A fifth reviewer noted that this modeling effort was being well leveraged to compliment both optical studies and less rigorous CFD. This reviewer felt that the efforts would enhance understanding, and ultimately allow improvement of measurements and models which would be used to increase engine efficiency through combustion system design. Another panelist said this was a very fundamental spray model development project whose projected positive results would occur a few years from now. The panelist went on to say that the question of supercritical spray behavior modeling could be valuable to engine designers in future toward addressing both conventional and non-conventional combustion models by linking spray formation to heat release, PM formation, and NO_x formation. The final commenter said that this project was highly fundamental in nature, used very expensive and powerful computers that typical industry would not have access to, and that in the long run, it provided a pathway to accurately model complex spray and combustion phenomena.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that the Rayleigh vs. Large Eddy Simulation (LES) comparisons were interesting, but thought that more examples of specific applications would be useful. Similarly the second reviewer thought that the approach of coupling LES simulations with actual experimental results was very good. A third reviewer summarized that the approach sought to bridge the gap between basic and applied research, focusing on coupling of LES to key target experiments (at SNL). The reviewer went on to say that the models worked toward predictions at engine conditions of high-pressure, low-temperature, multiphase flow and combustion. A different panelist noted that the project used high fidelity models to provide information to validate more efficient models and that it could inform everyone about what physics to focus on when improving efficient models. The panelist went on to say that working with the ECN was a great use of these tools, because there was critical mass in that area and that these tools could have maximum impact with minimal resources. The fifth reviewer specifically commented that there was good collaboration with using Lyle Pickett's test results, which led the reviewer to ask whether the project could predict results for Picket's future case. Another reviewer said that the physics retained in this work was comprehensive and that the conservation equations were fully coupled, with detailed transport and chemistry. The reviewer remarked that this project was conducted on a computer platform that was unique in its power and capability. The final reviewer said that the approach was logical, but suggested the exploration of more experimental validation as mentioned below.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One panelist felt that this project was challenging current modeling practices for high pressure sprays and to date had shown some evidence of the importance of supercritical behavior of spray mixing layer formation. The panelist felt that accomplishments were slow to date, but that this work was important for future use in modeling next generation direct injection combustion systems. A second reviewer also opined that beginning to understand and sort critical noise and control factors with respect to sprays was great progress. The third reviewer felt that the full field thermodynamic analysis was impressive and recommended additional comparisons at various pressures, etc. to see effects (a sensitivity study). A fourth reviewer observed good progress in developing LES simulations that matched fairly well with Pickett's optical spray experiments. A different panelist pointed out that while LES models were still impractical for engine development because of computation time, it provided an important benchmark to evaluate the faster RANS approach. Therefore, the panelist felt this was valuable work to show simulation potential. A sixth reviewer summarized the project by saying that the project used the model to inform ECN experiments, providing a new understanding of diesel sprays where the spray does not actually have droplets, and helped identify what was different about the cases where droplets were identified and ones where it was not. The seventh reviewer stated that some good speed up improvements had been shown and that the work was key to guiding industry combustion CFD engineers in how to correctly set up their fuel spray models for different operating conditions, which had always been a challenge. The eighth reviewer noted that the experiments of Lyle Pickett at SNL were being modeled and that supercritical conditions had been identified under some engine conditions. This reviewer felt that this had been a significant step in understanding fuel injection and mixing. The final reviewer summarized that the project described injection of fuel under subcritical and supercritical cylinder pressures and pointed out that the latter showed turbulent diffusion dominating mixing prior to atomization. This led the reviewer to look for more information regarding if this detail was significant and to what extent. The same reviewer also said that the presentation stated the capability of real-fluid models to capture the behavior of multi-phase mixtures at high-pressure supercritical conditions, but noted that these details were not captured in traditional models. This led the reviewer to wonder if these more refined features were significant in the modeling of ICEs, and how it was significant. The reviewer also wanted to know if the colleagues in the applied teams had been able to asses these new features in the engine models. Lastly, the reviewer wanted to know how consistent the results were. This reviewer pointed out that the author showed two fairly wide temperatures of 440 K and 900 K. The reviewer would like to know what the case was for mid and even higher ranges.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer felt that significant collaboration existed but that a few examples of benefits would be useful. The second reviewer noted that it looked like there was close collaboration with Sandia National Laboratories experimentalists (Lyle Pickett and soon John Dec) as well as with others at University of Wisconsin, Pennsylvania State University, University of Michigan and the ECN. However, this reviewer indicated that there was no real mention of direct collaboration with industry, although maybe the industry did not have as sophisticated modeling tools. The third reviewer noted that there was good collaboration with a few universities and some connection to the combustion network but thought that it would be beneficial to see an engine development company more involved in this project. The fourth panelist noted that the project was well connected to the ECN. A fifth reviewer noted that the alignment with Lyle Pickett's work and ECN was good. Another reviewer reiterated great collaboration with ECN. The final panelist thought the work team appeared to be very extensive, but suggested that highlights from key contributors and examples of benefits would have been useful.

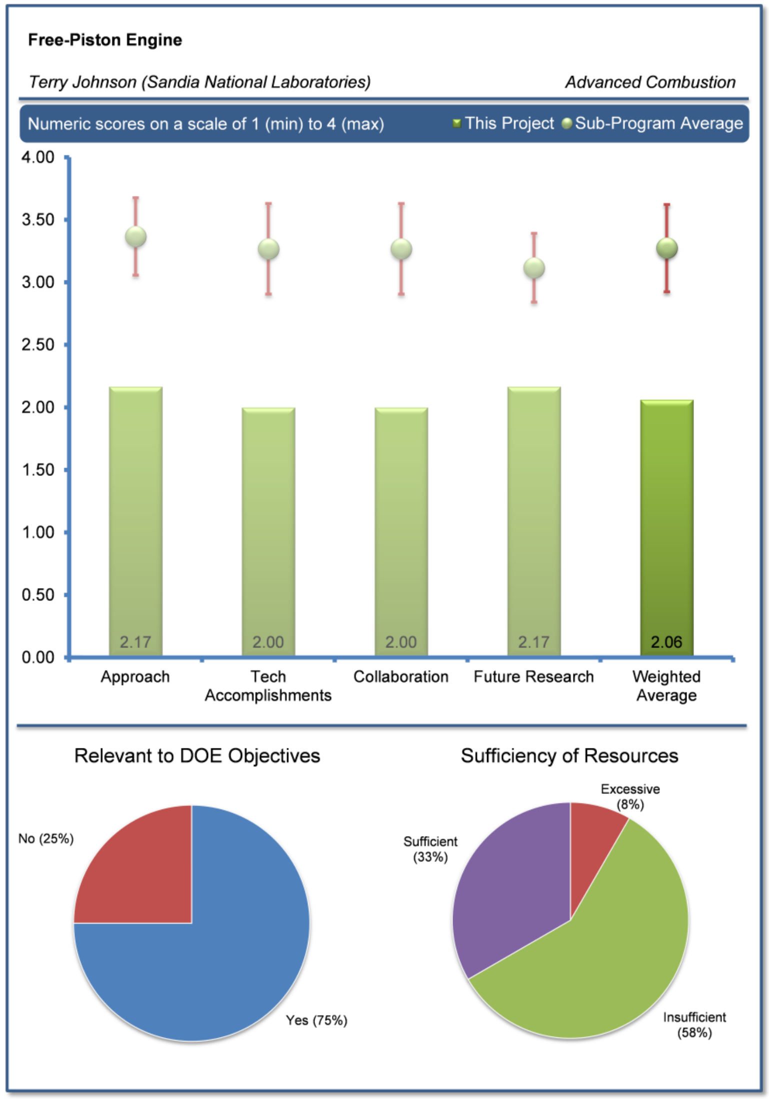
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer felt that the plans to continue the focus on spray modeling and also extending work to attempt to match John Dec's HCCI experimental results should yield useful results and advance the state of simulation technology. A second reviewer summarized that there was a plan to build on the ECN collaboration and suggested that it would be useful to clarify what specific problems would be the focus of future work and to define a path to improve efficient RANS models used for engine design. The third reviewer stated that the work appeared to be well coordinated with that of Lyle Pickett, and soon onto the work of John Dec. The reviewer felt that it appeared there was a need to close the loop to validate these results beyond the visual assessment, such as in the chemistry and ultimately the effectiveness on real environments. In other words, the reviewer wanted to know how the added modeling fidelity contributed to the combustion modeling process. A fourth expert simply stated that the project needed a clearer path on how this fundamental research cascaded to production engines. Another panelist felt that the computational aspects of this work are outstanding in addressing the historical question concerning supercritical spray behavior. Nevertheless, according to this reviewer, there was a real need for more experimental work to further validate any proposed new spray model. The reviewer suggested that three to five additional experiments be designed to address the research question including sprays that have projected large portions in the supercritical regime versus very little supercritical regime. Also, this panelist suggested that exploring the effect of injection rate profile could be valuable in addressing this question given its impact on the spray formation process. The final reviewer felt that the approach should be applied more to spray characteristics at common gasoline direct-injection engine operating conditions.

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

One reviewer commented that the resources seemed sufficient. The second reviewer stated that the project was well-funded for a project strictly focused on computations.

Free-Piston Engine: Terry Johnson (Sandia National Laboratories) – ace008



Reviewer Sample Size

This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first panelist simply stated that the development of engine systems with higher efficiencies would decrease the requirements for petroleum and that this engine was portrayed as being capable of using alternative fuels. The second reviewer acknowledged that the project was looking at creating an engine that obtained high thermal efficiency via high compression ratio. A third commenter felt that the project aimed to obtain very high efficiency via direct conversion of a high-efficiency engine output to electricity. The fourth reviewer found it very hard to imagine that this technology would ultimately have much impact on petroleum displacement. This reviewer thought for certain that there were better (more efficient and cleaner) ways to convert hydrogen. A different expert said that it was not obvious why a free piston engine would be more efficient than a conventional engine. The expert stated that there might be a friction benefit by elimination of the crank shaft, but the pistons in the project engine were very long and may offset this improvement in friction. The expert also pointed out that the same combustion barriers were still present in the opposed free piston, and that no work had been done to investigate these. The sixth reviewer said that if the project worked, that it would support overall DOE objectives. Similarly, a seventh reviewer asserted that it would address objectives if actual combustion and efficiency were to be demonstrated. The eighth reviewer commented that this high risk project if successful could show the impact of high compression ratio combustion on indicated thermal efficiency improvements versus today’s engines. The final reviewer stated that the project may need to be reviewed as to its readiness to provide realistic input to the DOE goals.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt that focus was needed on initial engine operation and that complimentary mechanical opposed piston engine operation would be useful. A second reviewer stated that the concept of conducting research on alternative engine designs was very good and useful. The third reviewer said that the project failed to provide a means to discern the potential benefits of the technology, if it were to exist. This reviewer indicated that there did not appear to be a clear means for separating out the heat loss, friction, and linear generator losses in such a way as to permit the results to be interpreted in more general fashion, such that the work might have longer-term reference value. A fourth reviewer stated that the goals and proposed roadmap to complete the project was unclear. The further remarked that opposed piston design was said to be simple and capable of high efficiency but that the concept appeared rather delicate as described (such as the startup procedure) and that there was no indication that this could translate to high efficiencies (either mentioned or referred to). The fifth expert noted that the project was creating a prototype;

however, it was not clear that the end result would provide something that was better efficiency. This reviewer pointed out that heat transfer from the various chambers increased blow-by, increased friction, and electric energy conversion efficiency were likely to erode the theoretical benefits. Following in the path of the other reviewers, the sixth panelist said that what was missing was a slide that showed how this device would actually lead to improved efficient engines, and that something that showed the thermodynamic calculations would be great. The seventh reviewer questioned the value of developing a free piston dynamometer to demonstrate combustion efficiency, and asked if there was a more cost-effective approach. One area of major concern for the eighth reviewer was lubrication with the engine concept. This reviewer felt that very little effort appeared to have been invested in addressing this key issue with free piston engines. The reviewer recommended that the PI should focus more energy on this issue. The final reviewer felt that in retrospect, this project was scoped poorly; and indicated that too much was taken on for the resources available.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that the target provided in 2011 was for a running engine and wondered if the exchange of the PI was perhaps a factor. This reviewer went on to say that the friction force model provided a good correlation with data and was useful for future work. The second reviewer specifically acknowledged the small budget, but still felt that the progress was too slow. This was reiterated by another reviewer who said that progress on this project has been slow over the years (but not necessarily attributable to those who were new to project and that fortunately the engine was now assembled and shakedown tests had been conducted. The fourth reviewer reiterated that the progress has been slow, but was finally close to producing data. The reviewer stated that the project still has not shown convincingly that it will overcome any of the technical barriers that it purports to address. A fifth expert commented that the author had made significant progress in the assembly of the engine and that the project had appeared to recuperate well from the loss of the previous PI, noting specifically that this included helium starts. This expert also pointed out that the time traces on the slides varied quite a bit, from milliseconds to seconds when describing the piston motion and asked if this was a typographical error. The expert noted that the project moves soon into motoring and combustion tests and that the work showed no estimates as to the target performance of the engine other than seeking to attain the Otto cycle efficiency. A thermodynamic and energy balance analysis would be useful. The expert wondered what issues were expected to be encountered as the project sought to run at higher compression ratios and what the implications were on emissions. A sixth reviewer noted that while the project has traditionally demonstrated slow progress, there has been better progress this year. A seventh reviewer indicated that there was good progress creating a prototype and that the project was starting to get some data. The eighth expected to see combustion results at this review. The final reviewer observed moderately slow progress this year and stated that according to last year’s presentation, this engine was supposed to have been subjected to combustion with some type of operable capability. The reviewer noted that it looked like funding was reduced and that it was not clear if this change caused the schedule to shift to the right, or if there were other issues.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer said that the GM/CRL and Matlab/Simulink work was of interest and wondered if any results would be available in 2013. The second reviewer acknowledged the collaborations with one OEM (GM), one university (University of Michigan), and one other national lab (LANL). The next reviewer said that to the extent that this project has long-term value for gaining an understanding of high compression ratio HCCI combustion, that the level of collaboration was appropriate. A fourth expert felt that the work team, especially the University of Michigan, could contribute more extensively especially in the area of cycle simulation and predicted engine efficiency. A fifth reviewer asked if there needed to be collaboration with someone on the electronics side. The sixth reviewer went into more detail by saying that it was not clear how involved GM was with the concept. Based on this involvement, the reviewer’s rating could change to good. This reviewer stated that it was important that GM ensures that the engine is properly tested and evaluated with good measurements to assess this engine concept’s validity toward 50% thermal efficiency. Finally, the last reviewer said that while there was good collaboration between the OEM and modeling partners, this project could have done with help from organizations that have some experience with free-piston engines and linear alternators. According to the reviewer, that would have left this project freer to focus on the issues and problems of marrying the two.

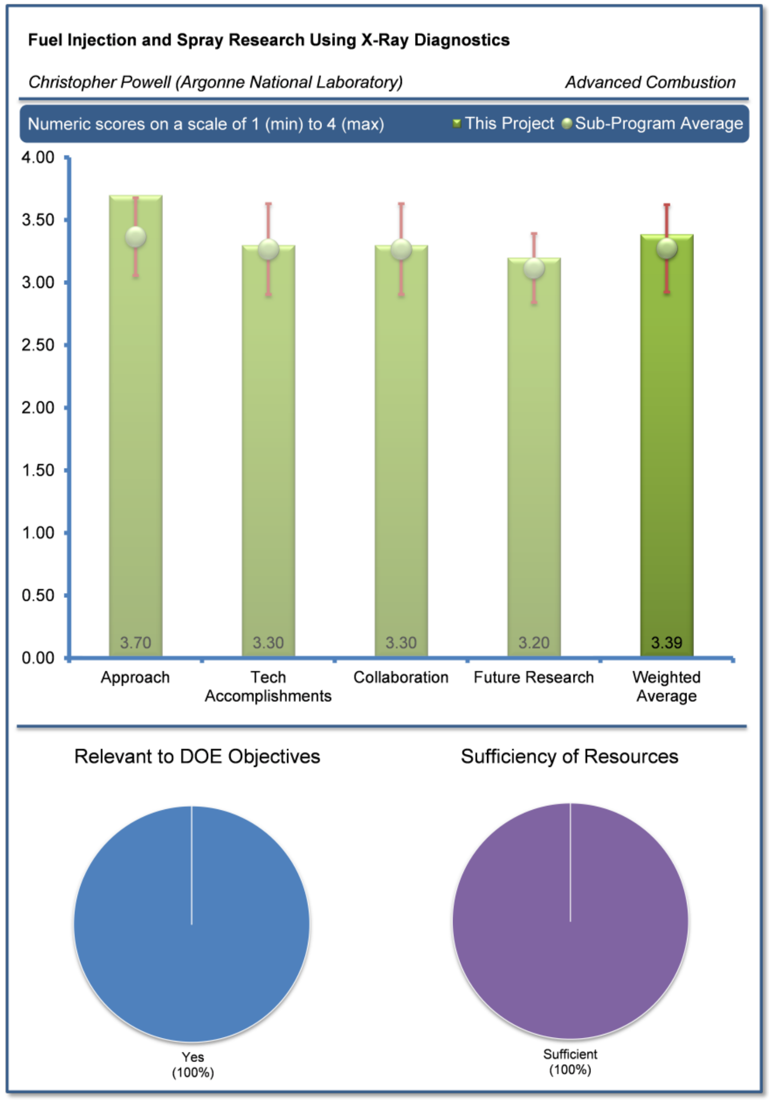
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first expert stated that given engine operation issues, plans to test different fuels at various compression ratios by year end seemed a bit too optimistic, but hopefully achievable. Another reviewer indicated that when looking at friction reduction, it would be important to understand whether these technologies are unique to the free piston engine or that their benefit was somehow more synergistic with that engine than standard engines. The third reviewer pointed out that the control of linear actuators was consuming all the resources, while significant combustion/efficiency challenges remained. A fourth reviewer questioned whether the project should start with H_2 combustion, as it raised the degree of difficulty on a project that was already in danger of providing very little progress. Also, the reviewer felt that it was unclear whether the models of the free-piston engine (FPE) were detailed enough to adequately interpret the data so as to understand the potential of this technology. The fifth reviewer said it appeared that the motoring and especially the combustion work was very aggressive as the authors sought to complete the work in the current academic year. A sixth reviewer said there was not enough time before the projects end to adequately investigate the combustion peculiarities of this engine. The next reviewer pointed out that there were many years of development on the engine and dynamometer, but only four to six months of combustion research were planned. This reviewer felt that this was very little return on investment with respect to combustion research. The eighth reviewer said that this engine needed to be assessed as soon as possible to evaluate the claims made by the original PI. Doing so, continued this reviewer, would determine the future of this ongoing project, which had significant technical challenges that have been discussed throughout the last three to five years. The final reviewer summarized by saying that it was unlikely that the list of future plans could be accomplished in the time available. The reviewer recommended that two or three key barriers to making this concept viable should be chosen and focused on as the project winded down. One example would be demonstrating the stability of the pistons.

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

One reviewer stated that initial engine firing experiments were absolutely needed in 2012 to continue funding research. The second reviewer felt that the resources were sufficient. The third reviewer was unsure that current plans could be achieved by year end. The same reviewer was also not sure though that it was worth putting additional resources into this project. This reviewer recommended that researchers who were fairly knowledgeable about free piston engines should provide recommendations on whether this project should be terminated or had enough potential to continue. A fourth reviewer pointed out that the project was high risk, though it had the potential to offer a new engine platform with unique characteristics. This reviewer went on to say that it was not clear however what guides the work, and what advantages were sought and expected with respect to current technologies. The reviewer felt that possibly more resources could help this team do a more complete job. The fifth reviewer opined that resources were excessive given the results. A different reviewer did not know if there was enough time to wrap up the project given the number of things left to do. The final reviewer said that there might not be enough funding to support a reasonable experimental assessment of the engine concept, which is a necessary step to close out this project.

Fuel Injection and Spray Research Using X-Ray Diagnostics: Christopher Powell (Argonne National Laboratory) – ace010



Reviewer Sample Size

This project was reviewed by ten reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer expressed that better understanding of fuel injection processes had the capability to reduce emissions and improve engine efficiency which would translate to reduced need for fuel/petroleum. The second reviewer acknowledged that fuel injection was a significant barrier to improving efficiency and emissions. A third reviewer noted that spray characterization and modeling were critical to developing efficient advanced combustion modes and that X-ray techniques added to the capability to compare models to experiment. The fourth expert said that understanding diesel fuel injection was important for diesel combustion modeling. The reviewer went on to say that diesel would reduce fuel consumption and increasing efficiency would depend on the tools used for design optimization. The fifth reviewer commented that fundamental knowledge of fuel sprays was needed to understand the effects on engine combustion. The sixth reviewer summarized by saying that this project supported spray targeting for advanced combustion modes where injection took place at mild pressures and temperatures in comparison to direct injection diesel engines. The reviewer said that the injection process is critical for enabling potential improved indicated thermal efficiency combustion modes such as LTC, PCCI, and HCCI which was clearly pointed out in other presentations. The final reviewer noted that the project aimed to improve engine efficiency by providing data and insight into the behavior of sprays and fuel injectors.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer felt that the reason for using x-ray versus visible light seemed reasonable. The second reviewer felt that the techniques were aimed precisely at overcoming barriers of existing methods. Similarly a third reviewer felt that this was a unique spray diagnostic technique providing quantitative measurement of the fuel location within the spray. The reviewer also liked the idea of leveraging various groups within ANL and thought that it was a good idea. A fourth expert commented that there was an excellent approach, including comparison with measurements from other labs, support of the ANL proposed spray break-up model, value added measurements of shock tube reaction rates, and assessment of nozzle design on near exit flow field behavior. The only suggestion provided by this reviewer was to work closer with other spray modelers beyond the current collaboration with ANL on developing a new spray break-up model. The reviewer mentioned that such data generated in this project could also lead to improvements in more traditional spray model approaches. A different reviewer said that the work appeared focused on spray characterization leveraging the x-ray capability of ANL and followed up by saying some work was being done in shock tubes but that the work here appeared to be less focused or mature. The final reviewer said that the project used unique APS X-ray light source to study problems of interest and that this could not be done anywhere else.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first expert noted that the gaseous jet diagnostics showing matching disks was very insightful and that there was improved productivity due to a dedicated x-ray lab. The second reviewer stated that ANL should be congratulated for this. The reviewer said that the project started work on Spray A of the ECN and that it was significant that nominally identical injectors produced very different sprays and noted that the elliptical shape of the spray has been correlated to the elliptical shape of the nozzle exit. The reviewer also felt that the validation of the KH-ACT model was very encouraging. Finally, this reviewer claimed that the imaging of a gaseous jet was remarkable and that the new work on cavitation in nozzles and shock-tube measurements was equally remarkable. The third reviewer said there were interesting comparative measurements demonstrating similarities and differences of nominally identical nozzles. The reviewer also noted the application of this technique to several areas for the first time (measurement of gaseous fuel jets, measurement of shock tube boundary layers). The fourth expert said that measurements of Spray A were very useful to the ECN community and that imaging of gas jet for natural gas injector was a new result and a very useful contribution. The reviewer did note that productivity has increased with the dedicated lab. A fifth reviewer found the results showing elliptical results from the fuel sprays to be fascinating and stated that the challenge now was to show how to incorporate this into engine modeling. The sixth reviewer said that there was good continued progress towards identifying contributors to spray geometry, but that the project needed to consider how these measured differences affect engine attributes. The seventh reviewer opined that there was very good experimental results to date and also in supporting a new spray break-up model development effort at ANL. The reviewer felt that one area of possible additional progress was supporting more traditional spray modeling efforts such as those at the University of Wisconsin or University of Michigan to name a couple. The eighth reviewer remarked that the x-ray images of the injector nozzle geometry were shown along with other images from various facilities and noted that the images showed a propensity for elliptical features on the nozzles under study. The reviewer thought it was hard to assess, however, the true implication of these features. This reviewer wondered how the eccentricities compared with production-like nozzles and if the authors had a sense of the variability found in the nozzle manufacturing. The same reviewer also wondered how much consistency was necessary and recommended that it would be useful to document these nozzles with standard deviations based on sufficient samples. The work, as observed by this reviewer, extended to gas injection and shock tube boundary layers. This reviewer noted that the presentation finally discussed nozzle cavitation and commented that the study had great potential but seemed to lack direction. The reviewer suggested that the project couple this work with production hardware with field data of wear, or a wider sample of hardware spanning nozzle geometries of size, consistency, and etc. that is tied to engine performance. The final reviewer said that there were some very nice results, but that it was not yet clear if the modeling methods were being improved significantly.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted that there was a good amount of collaboration with the industry (Delphi, Chrysler, Westport, and AFRL) and also with the Engine Combustion Network. This was reiterated by the second reviewer who noted good partners, especially partners from industry, which was seen as very valuable. The third reviewer said that there seemed to be an appropriate level of collaboration with other labs and industry. The next reviewer opined that there was a very good partnership with Delphi Diesel and the engine combustion network including a CRADA with an industry partner. The fifth reviewer noted good connection of spray and gas jet work to modeling activities, both internal and external and that the project would work on cavitation imaging and that connecting it to Som's modeling activity would be useful. The sixth reviewer commented on the collaboration by saying that the project was playing a key role using unique diagnostics to measure Spray A through nozzle imaging and spray measurements. The reviewer also noted that the project was coordinating the information to create a common geometry for everyone to use when modeling Spray A. The final reviewer felt that the collaboration was very good and that the collaboration with the European partner to do high resolution x-ray measurements was exciting. In addition, this reviewer indicated that the collaboration with KH-ACT modeling work at ANL and the Converge and KIVA codes at ERC was good.

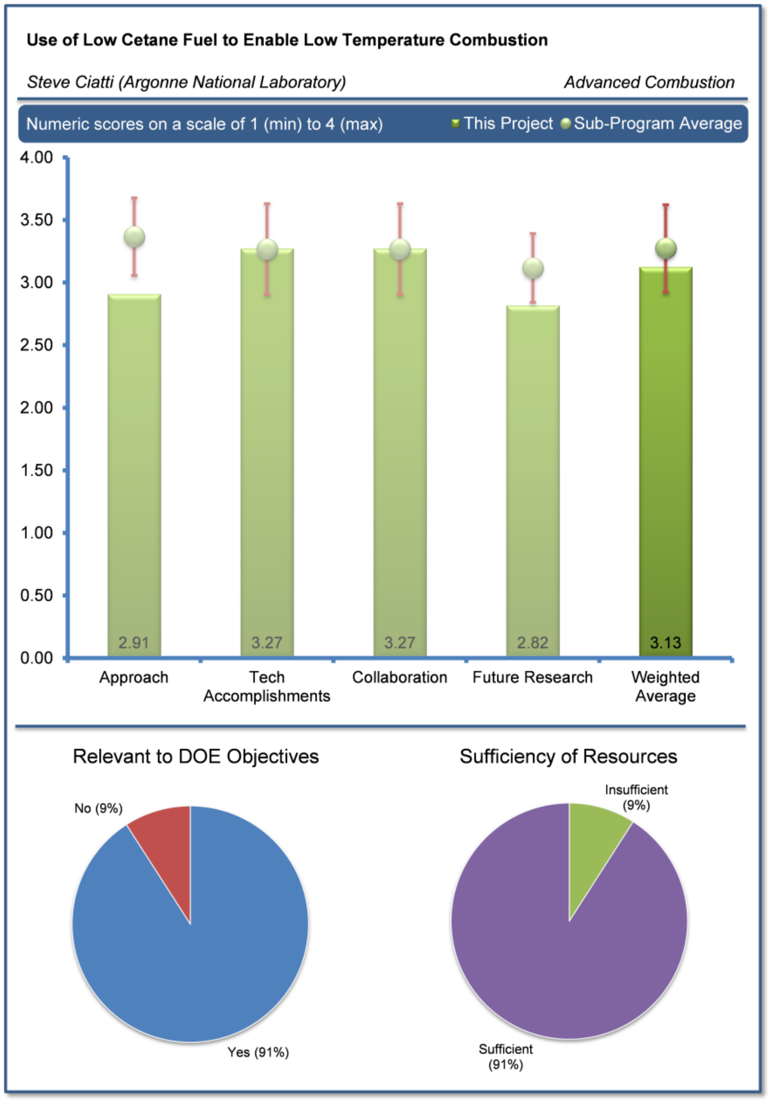
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer agreed that the planned future work was good. Nonetheless, the reviewer felt that the team should have greater interactions with engine hardware and engine performance information seeking to improve items such as spray atomization, nozzle flow efficiencies. The reviewer also pointed out that the work was yet to be either incorporated into some modeling platform or that this work needed to be reported. The reviewer wanted to know how the information provided helped improve the accuracy of these models. The second reviewer indicated that the plans for continued work seemed reasonable, and should build on current accomplishments. A third reviewer wanted to know if single shot images were possible. The fourth commenter felt that it was important to continue the contribution to the ECN and that further investigation of the nozzle geometry of Spray A and other sprays in the ECN was a great idea. The fifth panelist recommended closer work with other spray modelers than ANL who had a different perspective on spray modeling including more traditional approaches. The final reviewer reiterated that future plans were generally good; however, that more work was needed on gasoline direct-injection sprays and injectors.

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

One reviewer remarked that resources seemed sufficient. The second reviewer stated that the dedicated facility was greatly improving progress.

Use of Low Cetane Fuel to Enable Low Temperature Combustion: Steve Ciatti (Argonne National Laboratory) – ace011



Reviewer Sample Size

This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

As explained by one reviewer, this project supported DOE goals of improved engine thermal efficiency by exploring the use of low ignition quality fuels using flexible injection and lower levels of EGR as a means to enable LTC and PCCI use on future engines that theoretically could improve part to medium load fuel consumption. Another reviewer stated that high load LTC would possibly be an enabler for light-duty diesel or reduce diesel aftertreatment, which would reduce U.S. fuel consumption. The third reviewer said that RCCI was a potentially important technology for providing a cost-effective solution for both heavy-duty and light-duty engines. The fourth reviewer said that better understanding of improving and optimizing LTC had the capability to improve engine efficiency/fuel economy and thus lower fuel/petroleum needs. A different reviewer noted that the project aimed to achieve diesel-like fuel conversion efficiency with gasoline fuel, with lower emissions. A sixth panelist felt that the topic was relevant but that the work output and state of project (having begun in 2000) shown here appeared to be rather weak. Similarly, another reviewer stated that the project certainly addressed improved efficiency but the reviewer would have liked to see targets for efficiency and cost to comply with emissions. The final reviewer reiterated that the project tries to demonstrate improved efficiency.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer thought that it was great to see LTC work on multi-cylinder engines. The second panelist felt that the connection to cycle simulation was good. The panelist observed that the use of low cetane fuels provided benefits for LTC, but would likely have drawbacks in other areas. Thus, the panelist continued, while this may overcome some barriers, it introduced others. The panelist felt that a greater connection to similar research to use various techniques to better understand results would be useful. Specifically, the panelist pointed out that optical measurements by John Dec were not exactly the same, but wondered if there were ways to connect the work so that both PIs learned from each other. Lastly, this reviewer was glad to see noise metrics in the results. The third reviewer said that there was a very well thought out approach including supplemental CFD modeling for choosing triple injection fuel strategies. The reviewer stated that exploring variable injection pressure though future work more thoroughly addresses this opportunity. The fourth reviewer said that the project had a nice suite of tools in its approach, but needed to outline the primary roadblocks to achieving success with this technique. The reviewer wondered if there were speed/load regimes that would require a supporting combustion system (i.e., glow plug, spark ignition). A fifth reviewer commented that the NO_x/aftertreatment approach required more planning or communicating; the reviewer wanted to know what the plan was and what the likely challenges and system layout were. Similarly, the sixth reviewer felt that the goals of the program were not particularly clear. The reviewer went on to say that demonstrating efficiency over a broad operating range was important, but that it was difficult to determine whether appropriate operating constraints were applied. The expert believed that a two-fuel system would only be competitive if it offered reduced aftertreatment system complexity, so either engine-out NO_x should be at or below 0.2 g/bhp-hr, or the engine should be run at stoichiometric. The seventh reviewer reiterated that as others have shown previously, use of lower cetane, higher volatility fuel than diesel had potential to improve performance in compression ignition engines. Another reviewer opined that the work lacked a clear definition of targets for success. This reviewer inquired about the fuel efficiency and emissions levels the authors sought. The same reviewer also requested detail on the means to attain the targeted efficiency and emissions levels. The reviewer wanted to know what the expectation and contributions of each were to reach the goals as the authors introduce further technologies (GDI, VVA, endoscope, etc.). The final expert pointed out that this project was started in 2008, and that considering the time that has lapsed, that progress has been slow. The reviewer remarked that the approach seemed like a trial-and-error approach and that there was no unique diagnostic of capability being brought to bear on the problem. As such, it was more like a development project. The reviewer concluded by saying that the project claims to leveraging the ANL APS work (which incidentally is currently focused on diesel injectors) and the ANL RCM kinetics had yet to begin.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer said that most of the results seemed consistent, but no better than what others had already shown regarding use of gasoline-like low cetane number, high volatility fuels. The second reviewer said there was good work addressing low load operation at two bar BMEP and that high load LTC was achieved, but that there was a question of whether the level of NO_x (<1g/kWh) was low enough. Another reviewer felt that the accomplishments had been very good, though the issues with one cylinder having a lower compression ratio and with low load consistent cylinder-to-cylinder injection quantity seemed to slow progress a little bit. This reviewer also said that much work must be done to continue exploring injection and EGR strategies to enable LTC, PCCI, and or HCCI use at high indicated thermal efficiency. The fourth reviewer said that if this was a light-duty project, then the efficiency and emissions performance (and even the cost) should be compared against a modern turbocharged GDI engine. This reviewer also said that if the focus was on 2020 and beyond, then brake efficiency should not be a prime consideration, unless the project was intending to use an engine that was believed representative of MY 2020. The reviewer felt that more should be done with modeling to extrapolate performance to a modern engine platform, to project the technology potential. Also, this reviewer would like to see the effect of EGR on BSFC extended, to give 0.2 g/bhp-hr NO_x or lower. The reviewer asked to please consider light-duty vehicle test cycles, including FTP/HW/US06, when setting performance goals. A fifth reviewer said that a large part of the results presented appeared to be rather basic, including the effects of EGR on intake manifold temperatures, NO_x, and even HC and CO. The reviewer went on to say that the authors drew rather weak insights when the authors differentiated the effects of temperature and O_2 on NO_x, as the temperature and O_2 were simply tied together (no independent control over boost, cooling seems to take place). This reviewer also said the variability in cylinder-to-cylinder HRRs could only be understood fully by means of a more detailed analysis of cycle-to-cycle variation. To this reviewer, it was unclear why the modeling work did not correspond to the hardware tested (e.g. different compression ratios). The sixth reviewer was curious about variability, stating that experience with the CR effects indicated that variability could be a show stopper with this concept. The reviewer indicated that whenever the reviewer runs engines with reaction controlled ignition like this, a way to have some solid control of ignition timing always shows up as a need. Going into more detail, this reviewer stated that engines have to run in all ambient conditions: high and low temps, high and low altitudes, humidity, etc. The use of uncooled EGR was a good thought to help handle this, said the reviewer, but the reviewer wanted to know where the engine transitioned from cooled to uncooled. The seventh reviewer wondered what the chief control challenges with this technique were. The final panelist said that the BSFC comparison between gasoline LTC and conventional diesel was unclear, and the panelist pointed out that the y-axis of the graphs in Slides 8 and 9 should be plotted on an expanded scale to allow a clearer comparison. The reviewer also felt that gasoline BSFCs seemed higher than conventional diesel and that the total efficiencies in the tables in Slide 10 did not seem up to par for a conventional diesel. This reviewer also inquired about the engine-out-NO_x target for this project. The same reviewer further suggested that more NO_x emissions and smoke emissions should be presented to get a clearer picture of how work was progressing rather than making word statements.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One of the reviewers felt that the collaboration was good, but that the industry relationship perhaps suggested little more than hardware support and some technical input. The reviewer recommended that finding somebody more engaged in the project would help provide greater focus, particularly in the area of emissions and aftertreatment. Another reviewer reported a connection to industry through GM and added that there was excellent connection to the University of Wisconsin for CFD and BP for fuels. The third respondent also noted excellent collaboration with GM, a fuel supplier for various ignition quality fuels, and also a university for CFD support. The fourth reviewer stated that collaborations were very weak and that the approach mentioned the use of Autonomie, APS injector, and RMC, and wondered if these partnerships were realistic. A different reviewer observed some collaboration with industry (GM, BP, Drivven) and University of Wisconsin. The final reviewer suggested that more collaboration with others doing similar work (gasoline combustion in a diesel-like engine) may be warranted. Specifically, continued this reviewer, some of the work at SNL on partial fuel stratification and thermal stratification perhaps may be leveraged.

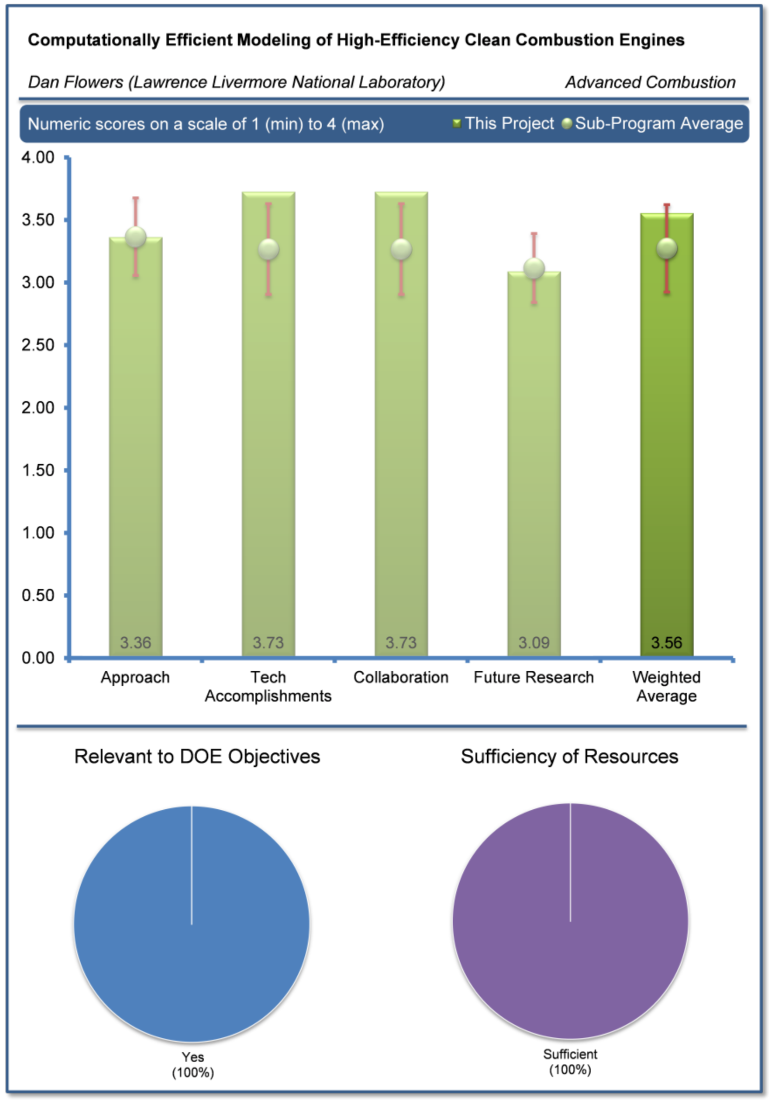
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commenter thought that this seemed to be the right work following on to the accomplishments. The second reviewer said the proposed research was well thought out, including the resolution of injector and cylinder four compression ratio issues. The third reviewer recommended considering an increased emphasis on narrow angle injector angle. A fourth reviewer highlighted that more focus needed to be applied to the goals of the program. Specifically, continued this reviewer, emissions goals did not appear to be consistent with Tier2/Bin5, and especially not Tier2/Bin2. Accordingly, the reviewer also said that despite being a multi-cylinder approach, the reviewer saw no apparent focus on cold start emissions. The reviewer noted that efficiency was adequate, but a comparison of PM emissions should be with GDI engines (since this is a light-duty application). Also, the reviewer said low FSN may not be an adequate measure of PM for a light-duty engine, particularly a LTC engine. The fifth reviewer said that looking at low load challenges of low cetane operation was a good idea, but that it would also be important to find out what could be gained with these fuels at high load and what impact it would have on cycle emissions. The reviewer also thought that the efforts to get cycle projections were key. The reviewer said that the light-duty target of the future was Bin 2. The sixth reviewer observed that the project seemed to be a repeat of tests that others have done (i.e., 70 RON fuel). Another reviewer commented that the data reporting in this project were below the standards expected from a DOE project and that the authors should try to have a more disciplined representation of the engine at each of these operating points. The reviewer also recommended that the effects of equivalence ratio, boost, fuel injection pressure, timing, and intake temperature should be reported. Overall the reviewer felt that there was a lack of direction both near and medium term. The reviewer said this was noted earlier in the mentioning of the use of rather sophisticated techniques without an expectation of the targets. The eighth commenter simply stated that there was little detail on future plans provided. The final reviewer felt that work should focus on multiple fuel injection strategies that created the right conditions for best LTC combustion based on the knowledge that was already out there at the University of Wisconsin, SNL and other places. The reviewer also thought that the design of experiments approach should be exercised to its fullest to minimize testing and trial and error.

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

One of the reviewers said that given the goals of the project, the resources were sufficient. However, the reviewer also said some resources may be needed to explore LTC aftertreatment. The second reviewer simply stated that resources seemed sufficient.

Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines: Dan Flowers (Lawrence Livermore National Laboratory) – ace012



Reviewer Sample Size

This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer simply summarized by saying that the project targets a fundamental study of combustion to enable high efficiency. The second reviewer thought that improved numerical modeling/simulations should enable greater success in understanding and optimizing high efficiency, clean combustion engine designs which, if successful, would reduce fuel/petroleum requirements. The third reviewer said that better and faster combustion models were needed to increase the progress toward engine efficiency. Providing more detail, another reviewer said improving chemistry models and solving them faster had a direct impact on improving engine modeling which would help the industry design better engines. The fifth reviewer noted that improving modeling tools of advanced combustion modes was needed to advanced research on those modes and design engines to take advantage of them. The sixth reviewer added that developing faster and better computer models would help the industry make more efficient engines. The final reviewer said that this project could supply tools that run at reasonable computing times with decent accuracy for engine developers considering homogeneous combustion modes for gasoline and diesel applications as a means to improve upon today's engines' thermal efficiencies at various operating conditions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One of the reviewers stated that the approach seemed good. Another reviewer said that there was a good focus on correlating the model with experiment and improving kinetic models. The third reviewer said that the application of a multi-zone model for coupling kinetics was a good solution for computational efficiency and that connecting it to CONVERGE was useful. The reviewer added that it was always useful to find areas to improve numerics to speed up results without compromising model fidelity. The fourth panelist_described this project as sharply focused on a broad area of combustion modeling and was showing great results at effectively getting some models out to industry use. The fifth reviewer said that the modeling approach was reasonable, but that validation was a concern. To this reviewer, there appeared to be some level of validation, but it was limited to few selected operating points. The reviewer said that more validation based on real engines was necessary for continual improvement in the clever multi-zone with chemical kinetics modeling approach. The final reviewer said that the approach described was confusing and wanted to know where the objectives were clearly defined to impact the attainment of precise improvements in light-duty and heavy-duty engines, and commented that the materials provided do not address the necessary approach to attain these. Furthermore, this same reviewer said that the presentation highlighted the use of PPC, HCCI, RCCI and LTC as strategies to meet emissions/efficiency targets, but wondered if this was even the case. The reviewer commented that heavy-duty engine manufacturers were relying on conventional combustion with more capable and more efficient injection, cooling, and air systems to attain the efficiency goals.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that very good progress had been made during the past year with the multi-zone work, and suggested that it would be helpful to see more comparison with a larger set of experimental data-and noted that validation was lacking a bit. Another reviewer indicated that the speed up in processing time with the multi-zone model results was very impressive and that it would result in a much wider use of these tools. The third reviewer noted significantly reduced computational time and said that one measure of success was that Convergent Sciences had licensed the LLNL multi-zone model and implemented in their CONVERGE software that is used by a number of OEMs. The reviewer added that the project also had integrated multi-zone model into GT Power for HCCI and PCCI applications and that using engine data to improve reaction mechanisms was very valuable. The fourth reviewer said that licensing of multi-zone chemistry model to Convergent Science had already had an impact on improving engine development in industry and that this was really great. The fifth reviewer said that four major tasks or milestones were reported on Slide 6, but that little evidence was given as to how successful these have been. The reviewer also noted that the author stated that predictions of their detailed chemical mechanisms matched the CONVERGE multi-zone simulations and wanted to know how many cases were examined. Also, the reviewer wanted to know what range of dilution levels and range of loads were used. This reviewer found it a bit surprising that no details were provided. The reviewer also noted that no discussion was provided as to why these multi-zone simulations were so good. The reviewer wanted to know then, if this meant that the author supported treating the multi-zone simulations as black box. The reviewer also commented that the speedup seemed to be well integrated with engine cycle simulations. The reviewer pointed out that the authors had incorporated advanced solvers into parallel CFD models (including multi-zone models). The reviewer also noted that the kinetic rates were revised for elevated pressures based on engine data as the authors performed a screening parameter exercise to highlight the most important ones. A sixth reviewer said that the project demonstrated substantial improvement in computational efficiency with good correlation to more computationally intensive models. The seventh expert said that there was apparently good correlation between experimentation and modeling, but wanted to know if there was a way to do a quantitative comparison rather than subjective comparison. Another reviewer felt that the project showed significant speed up using multi-zone model vs. solving chemical kinetics and that implementing advancements using CONVERGE was very useful.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that there were good partnerships with key institutions. Another reviewer identified the collaborations with a number of OEMs (Ford, GM, Bosch, Delphi, and Volvo) and cited other national labs (Sandia, ORNL). The reviewer added that this was a good sign that the industry valued the work. The third reviewer observed good collaboration with Sandia and indicated that that working with CONVERGE was useful because those tools were becoming more popular among OEMs. The fourth reviewer noted that a lot of collaborations were cited and that the collaboration with CONVERGE seemed to be rather useful to implement these new tools and mechanisms onto wide user interface tools. The fifth reviewer said that collaboration with research groups as well as the industry was exemplary. This reviewer felt that working with Convergent Sciences allowed the industry to rapidly utilize tools developed. In addition to great collaboration with the industry and working with CONVERGE, the sixth panelist cited that working with ERC-UW (KIVA), and GT-Power as the right level to get these tools into the hands of engineers. The final reviewer said that this project has historically strong collaborations with other national labs, universities, and certain industry partners. Furthermore, continued this reviewer, it appeared that much progress had been made in the last two years and that the multi-zone work in particular had drawn great interest from the research community due to its reduced computational time and apparent accuracy in comparison to CFD at select operating points.

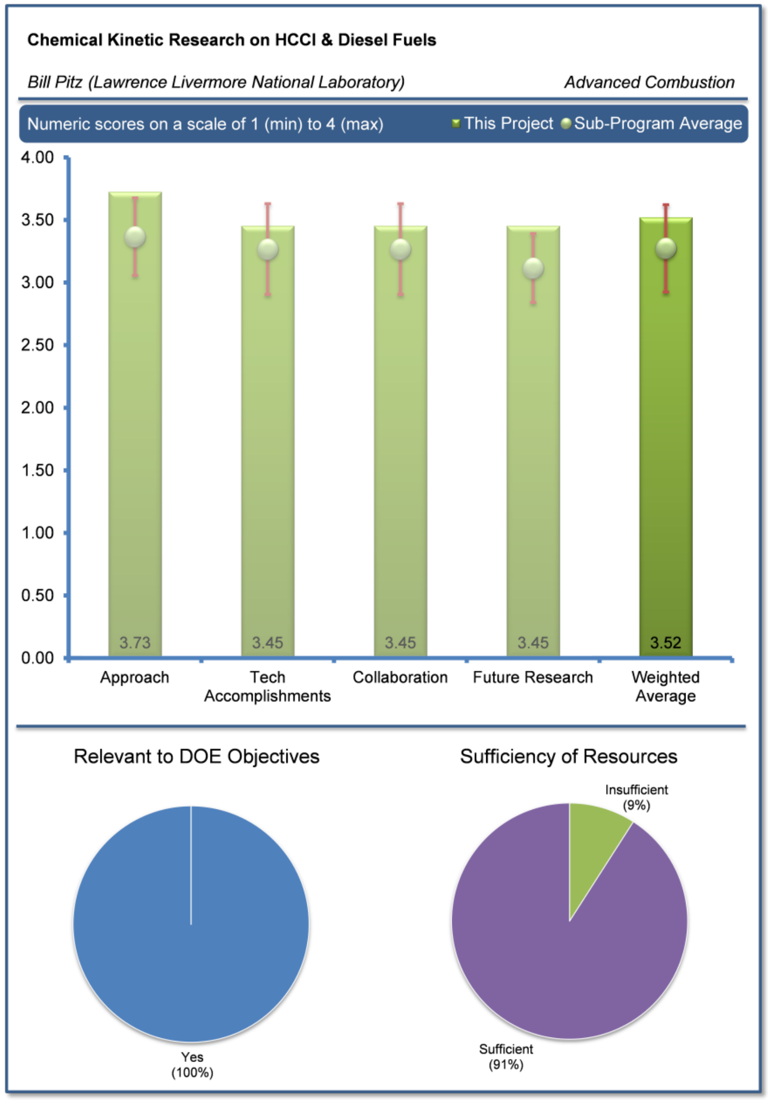
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that continuing to improve simulations and kinetics models and the goal of transferring models to industry/MOU partners was very worthwhile. The second reviewer said that it was good to continue with the present plan. Another reviewer remarked that further validation of the multi-zone model with additional test cases would be useful. A final reviewer commented that the computational aspects of the planned future work were reasonable, but that validation was really lacking in future plans.

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

One reviewer said that the resources seemed sufficient to maintain progress, while another reviewer felt that this was a well-funded modeling project.

Chemical Kinetic Research on HCCI & Diesel Fuels: Bill Pitz (Lawrence Livermore National Laboratory) – ace013



Reviewer Sample Size

This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer responses on this question were positive. An observer stated that the development of kinetic mechanisms was needed to model advanced clean efficient combustion modes, adding that the development of full kinetic schemes was the first step to creating and validating skeletal mechanisms that would be used in computational fluid dynamics (CFD) models used to design engine and research. A commenter noted that advanced low temperature combustion (LTC) concepts and highly dilute combustion processes both offer gains in fuel efficiency and that both need increased understanding and improved models of the combustion process. The commenter also said that this work was the only one of its kind that is relevant eventually to modeling chemical kinetic processes. A reviewer said that this was crucial work to improve combustion models to be able to predict engine behavior, and that this is an important tool for engine developers to improve engine efficiency. One evaluator said that improved chemical kinetic models were critical for improving and optimizing the performance of advanced combustion engines, which should improve efficiency and reduce fuel/petroleum demands. A reviewer said that the chemical kinetic models were needed as inputs to effective combustion models. A reviewer noted there was very high value for model development. One commenter stated that the project targeted a fundamental study of combustion to enable high efficiency. A commenter described this project as very fundamental in nature and supported advanced combustion strategy development at low temperature and high exhaust gas recirculation (EGR) boundary conditions that might enable higher part to medium load thermal efficiency in both diesel and gasoline engines or possibly some type of future hybrid gasoline-diesel engine. The reviewer added that such strategies would rely more on kinetics as a key controlling chemical process that would either yield controlled initial combustion rate with high thermal efficiency or high combustion rates which will limit the development of such combustion strategies. This reviewer ended by saying that better understanding of low temperature chemistry was critical toward finding the optimal control strategy.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer responses were generally good. One reviewer said that the approach of developing and validating mechanisms for fuel components, combining them for surrogate fuels, reducing the mechanisms for faster computational time, and validating versus engine results were excellent and critically needed. This evaluator stated that the objectives were clearly defined, and included continuing development of surrogate fuel mechanisms to improve engine models for homogenous charge compression engine (HCCI) and diesel engines. The reviewer added that reduced mechanisms were included. Another reviewer noted that real fuel surrogates were needed to identify which components were critical to accurately model the fuels. The commenter also said that creation of mechanisms for numerous components would have a large impact as other researchers would use them and combine them differently to model fuels. The reviewer added that continuing to build that palette was very important. A reviewer said that the approach was very logical and had no suggestions for improvement except to spend more time on validation. An expert said that surrogates were being developed for gasoline and models were being developed for larger alkyl aromatics.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer responses were generally good. One reviewer said that there was excellent progress in developing and validating the kinetic mechanisms for components that were more representative of components in real fuels (larger aromatics and naphthenes, more lightly branched aromatics). The reviewer added the project had developed correlation between gasoline surrogate AKI's to ignition delay times and sensitivity to slopes of NTC regions. An evaluator stated that the project had validated 3-methyl, 2-5-dimethyl alkane, and alkylated aromatics mechanisms by comparison to experimental data at engine-like pressures and temperatures and that increasing range of hydrocarbon species that are modeled will contribute to improved chemistry models. One commenter opined that progress looked good, but it was difficult to prioritize which molecules were most critical. A reviewer said that this project continued to add compounds to the palette and develop surrogates. A commenter said that the progress on modeling specific chemical reactions of interest was commendable; of special note was the excellent comparison between model and shock tube and rapid compression machine measurements of ignition delay time and temperature. One evaluator commented that the progress had been very good in developing gasoline surrogates, though it had been a little slower in generating improved diesel fuel surrogates. Overall, the reviewer continued, the output of this project has been very good. The reviewer suggested that more validation was necessary as commented in other portions of this evaluation which could accelerate the progress in meeting the objectives of this project.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The reviewers had mixed responses to this question. One reviewer mentioned that there were lots of interactions with universities and national labs to compare their experimental data to Lawrence Livermore National Laboratory (LLNL) model predictions. The reviewer added that industry collaborations seemed to mainly consist of involvement in Coordinating Research Council, advanced vehicle fuel lubricant (AVFL) and Fuels for Advanced Combustion Engines (FACE) projects and semi-annual AEC MOU meetings. The reviewer suggested making the mechanisms available on LLNL website. An evaluator commented that the principal investigators collaborated with many universities to get the data that they needed to support validation of their models. The reviewer continued by saying that the investigators also were very open with sharing those models with engine modelers, so that they could be used to improve engine simulations with chemical kinetics and also directly collaborate with engine modelers to help validate proposed mechanisms. The reviewer felt that the project had done a great job leveraging other funded research to get experimental data. A commenter stated that work was done in collaboration with multiple academic institutions and that modeling and experimental results were well leveraged and consolidated. The reviewer suggested that these could be more effective. The commenter went on to say that the work has characterized the ignition delays of surrogates such as n-heptane, gasoline-like fuels, with added compounds such as n-butyl benzene. The reviewer wondered, as these characterizations were made, what impact the work has made in modeling of combustion in engines. The reviewer was unclear if the authors of the research were tracking how these were being assimilated by the other PIs at the national laboratories. An evaluator said that very good collaboration existed with several organizations. A reviewer noted that this was an ongoing project that has shown tremendous collaboration throughout the years with other national laboratories such as the Sandia Combustion Research Facility, various universities such as Rensselaer Polytechnic Institute, and also with industry researchers who ultimately use developed chemical kinetic mechanisms for evaluating various combustion strategies in their applicable engine products. The reviewer emphasized that there had been great work over the years. A reviewer suggested that DOE should consider combining the three projects at LLNL with the objective of completing efficient combustion modeling that was fully integrated and correlated and that can be integrated into multi-cylinder engine models.

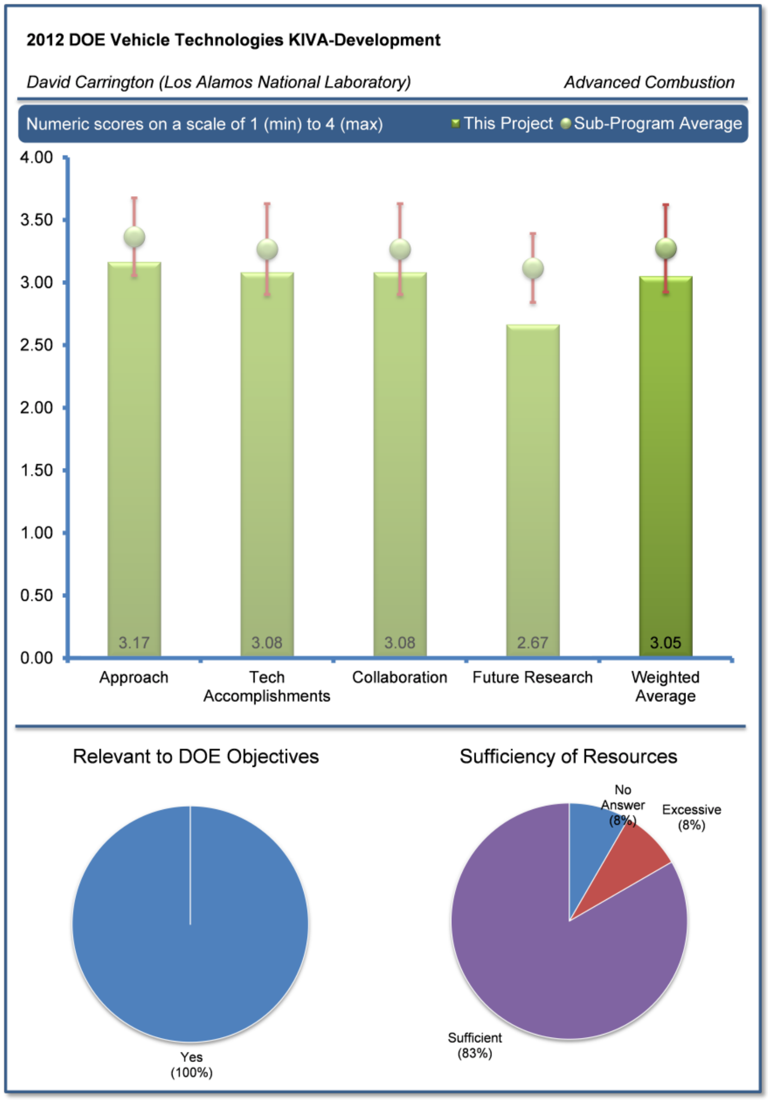
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer comments were generally positive. A commenter stated that extending mechanisms to larger alkanes and larger alkyl aromatics was very important to develop surrogates that were more representative of components in market diesel fuels. An expert stated that because of the good tie-in with engine experiments, the proposed future work was relevant and continues to get input from larger engine combustion and modeling community. A reviewer commented that the investigators continued to build up the palette of compounds. One evaluator said that the project was well-focused, e.g. larger alkyl aromatics, n-alkanes. Another reviewer said that, generally, the proposed future research was excellent. The reviewer suggested finding a way in the upcoming year to initiate more validation of the various mechanisms versus bomb or engine date. The reviewer added that although the latter is not pure due to its non-homogeneities, it is the real world device and could be valuable in assessing the predictability of the various mechanisms either from a bulk temp/pressure space or simulated (CFD) environment.

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

All but one of the reviewers responded that the resources were sufficient. One reviewer felt resources were insufficient. A reviewer said that the resources seemed sufficient, with no indication to the contrary. One evaluator said that it appeared that this project was sufficiently funded for completing the work included in the presentation, adding that additional validation would be very helpful to the industry, but who and how it was paid for was another story.

2012 DOE Vehicle Technologies KIVA-Development: David Carrington (Los Alamos National Laboratory) – ace014



Reviewer Sample Size

This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The comments were generally positive. A reviewer commented that this KIVA modeling/simulation work should speed up time to develop and deploy of advanced combustion engines, which would have lower emissions, better fuel economy which would reduce fuel/petroleum consumption. A separate reviewer said that KIVA has long been the standard for combustion modeling and needed to continue to evolve. One commenter noted that the KIVA code was widely used in the industry for modeling advanced high-efficiency engine development, adding that the list of licensees presented was impressive and proved the usefulness of the code. An evaluator noted that this project targeted development of robust and modular (highly desired characteristic) algorithms and easier and quicker grid generation to enable high efficiency. One reviewer said that this project was indirectly linked to meeting DOE petroleum displacement goals by eventually providing an upgrade combustion code for piston engines to engine developers/researchers for exploring advanced combustion strategies such as LTC, premixed charge compression engine (PCCI), or HCCI. An evaluator said that the development of modeling capability and flexibility was important for optimizing engines; however, with the emergence and popularity of commercial codes like CONVERGE, the role of next generation of KIVA for engine simulation was not well defined, which brought into question the potential for impact on the DOE goals. This evaluator suggested that it should be clearly communicated whether the finite element method (FEM) method provided a significant improvement over existing codes.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer responses were mixed. One reviewer said that the approach seemed reasonable. Another reviewer said the approach was outstanding. Another reviewer believed that the work was aimed at developing robust and accurate (more predictive was emphasized) numerical simulation codes, focusing on understanding the physics and optimized discretization of the problem. The commenter went on to say that the effort was accompanied by validation and verification. One commenter said the project aimed to reduce time for advanced combustion and engine development, without compromising accuracy. A reviewer stated that the upgrade of the KIVA code approach by the PI had been methodical and carefully considered during the last two years. The reviewer saw that one area of worry was validation against experimental data from an engine or bomb, adding that this was a key step in determining how well the new algorithms were working compared to the old algorithms. One evaluator said that the work was aimed at developing robust and accurate (more predictive is emphasized) numerical simulation codes, focusing on understanding the physics, and optimized discretization of the problem. This reviewer added that the effort was accompanied by validation and verification. Another commenter opined that, with robust and accurate commercial codes with fast grid generation available, the need for development of new software code architecture was not clear. The same reviewer suggested that the benefits of KIVA-4 beyond CONVERGE needed to be identified. This reviewer added that this should not just be a competitor code, but something that would ultimately find its way into codes like CONVERGE. The evaluator said that it would be useful to reviewers for the presentation to show the basic approach of model development and what the challenges were. The reviewer would have liked to be told how the projects approach changed over the years and why it was the same or if it had changed. The reviewer was uncertain what data was needed for model validation studies and suggested that more introduction content was needed in the presentation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer responses were mixed. One evaluator said that the quantity of licensees spoke volumes. Another evaluator said that it seemed like good progress, with accomplishments that included: more accurate prediction of combustion chamber wall temperatures; better injection spray model with finite elements; and significant number of KIVA licensees, which the evaluator believed demonstrated value to users. A reviewer said that it was important to have an open source tool that could be used at research institutions and at universities to train new researchers. Another reviewer stated that KIVA-4 was being extended in several ways, including a finite difference approach. The reviewer added that grid generation was also being sped up and spray modeling had been improved. One commenter noted that significant work had been done against the original objectives with validation against a wide variety of test conditions having been done. A reviewer said that the large number of licensees was good. One expert stated that this project was a good analog effort to the ANL project that was focused on a new break-up model development not using KIVA. The reviewer added that progress had been methodical during the last two years, carefully making sure all new algorithms were functioning properly with an overall code context. The reviewer believed that at some point, this new KIVA must be validated against engine or bomb data; and suggested using the x-ray data from Argonne National Laboratory (ANL) or engine/bomb, namely data from Sandia National Laboratories. One reviewer felt that the presenter spent too much time on approach at the expense of detailing the progress made. The reviewer also said that the project was developing fine element methods and conjugate heat transfer methods, but that the estimates of the wall temperatures were unclear. The reviewer wondered if the benchmark was done with engine data/measurements. The reviewer noted that developing work was tied with improved grid generation and that the authors were aware of the importance of rigorous benchmarking methods that were used.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

There were mixed responses to the question. A reviewer noted that the only collaborations mentioned were with co-developers at various universities and that there was no mention of interactions with industry users. A reviewer noted that there was a compact team established with clear responsibilities. Another reviewer referenced the collaboration with implementers. An evaluator said that collaborations with many universities existed. A separate reviewer noted that there was good leveraging of universities to accomplish the work, and that a number of licensees existed. One commenter noted that it was impressive to see the licensees as a testimony to the utility of KIVA. This reviewer would have liked to see closer cooperation with LLNL and other laboratories working on combustion modeling so that these developments could be integrated at the earliest opportunity. A commenter stated that there was reasonable collaboration among the PI and a handful of universities with expertise in advanced computational methods and combustion modeling--possibly that this was a good mix for now. The reviewer added that, at some point in time, this project needed collaboration with multiple experimentalists for validating the new KIVA.

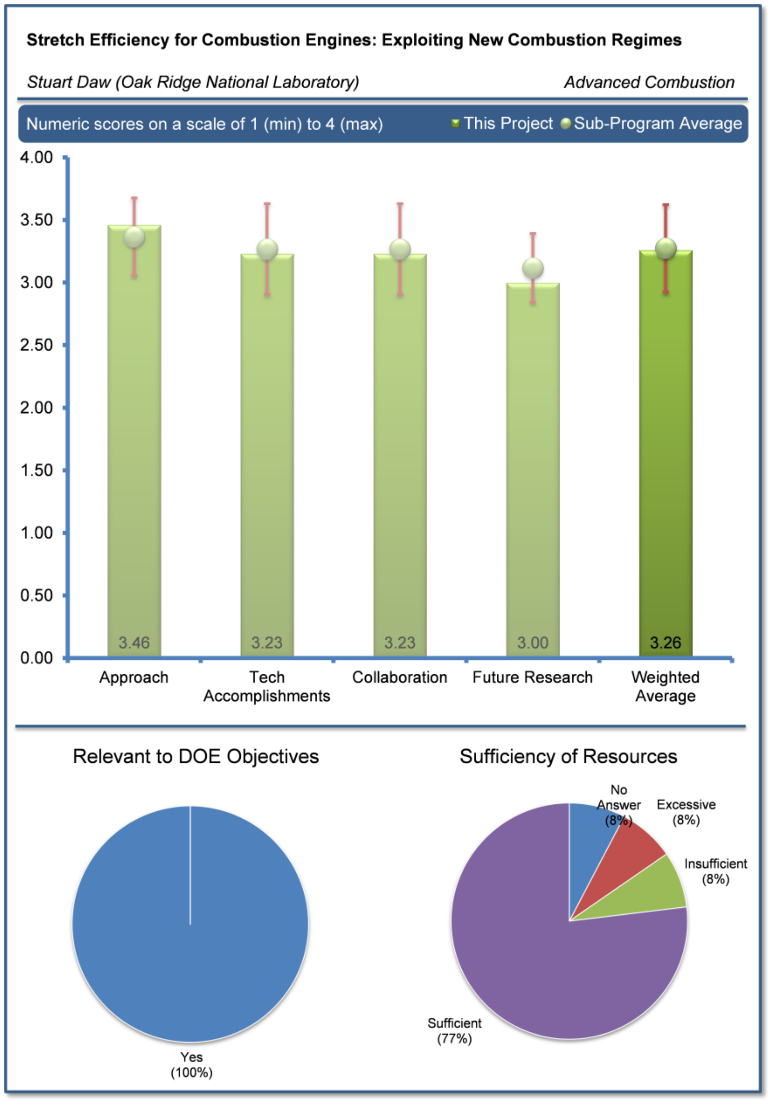
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One commenter stated that the project was well focused, and that continuous improvements were expected. The reviewer noted that the software appeared to be well accepted by many users. A reviewer said that it was important to identify what of this work was applicable to other CFD platforms and to define mechanisms to offer advancements into those commercial codes. A reviewer believed that the ANL Kelvin-Helmholtz-Aerodynamics Cavitation Turbulence (KH-ACT) model for spray breakup should be incorporated into KIVA. A commenter stated that future plans were not clearly spelled out in the presentation, but that the work seemed to be continuing on the stated goals. The reviewer suggested that the project needed to show why we needed to do this, and asked if no one in the CFD and finite element analysis (FEA) industry was doing this. One commenter said that, overall, the proposed future research was reasonable, though the PI should consider a significant validation effort for use in piston engines. The reviewer believed that validation against simple flames was not adequate enough. Another reviewer asked when this could be terminated. The same reviewer believed that this project was overlapping private industry work. This reviewer said that while there were a lot of licenses, it did not mean usage; and added that the reviewer had a license, but all the users do not want to use it. Instead, opined this reviewer, the users use a commercial code, because the users can get support when the users have a problem.

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

Nine reviewers indicated sufficient financial resources were available, while one reviewer indicated that financial resources were excessive. One reviewer commented that the resources seemed sufficient. Another reviewer who stated that resources were sufficient commented if this project cannot make a connection to improvement of commercial codes.

Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes: Stuart Daw (Oak Ridge National Laboratory) – ace015



Reviewer Sample Size

This project was reviewed by thirteen reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The comments were generally positive. A commenter said that it was excellent to see very advanced thinking, adding that this was needed as the limits of conventional engines were approached. An evaluator stated that finding ways to improve engine efficiency reduced demand for fuel/petroleum. A commenter said the project was working to increase internal combustion engine (ICE) efficiency via major combustion and architecture changes while seeking near 60% brake thermal efficiency (BTE). One of the reviewers commented that this project represented a critical long-term approach to explore the potential efficiency gains in ICEs, looking beyond near-term and mid-term technology advances. A reviewer said that this project directly supported the goals of higher efficiency. Another reviewer said that the project was pursuing high efficiency. One commenter stated that the project could achieve breakthrough improvements in engine efficiency by investigating some novel approaches, or, it could result in a mechanical curiosity producing some interesting chemistry results. The reviewer ended by saying that, in any case, something about engines would be learned and was therefore relevant.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer responses were somewhat mixed. A reviewer opined that these novel approaches with analysis and experimental results were exactly what should be done at national laboratories. An evaluator noted that this was a very inventive and creative approach to understanding the potential gains with waste heat recovery, continuing by saying that the models developed based on the data from prototype hardware perhaps would lead the way to understanding where next-generation improvements may lie. A separate reviewer commented that the project’s approach of taking a step back and thinking about fundamentals and designing experiments to improve fundamental understanding was useful. One expert stated that this was clearly a high risk, stretch objective type of project; the type of project the DOE should fund. One commenter said that, for this kind of work, the methods were well done. One reviewer listed the following attributes of the project: targeting theoretical and practical limits for engines; looking to promising advanced architectures; and relying on analysis-modeling with experiments and thermochemical recuperation (TCR), which required proper use of the syngas from the reformer. An evaluator greatly appreciated that this program was looking for potential gains in areas that were outside the box, and specifically noted that studying the potential for TCR is of high interest. The reviewer suggested that it would be good to add a couple areas of investigation in the future; specifically, it would be helpful to understand why TCR could be of benefit; if it was related to the rate of combustion, evaporation of the fuel, location of the combustion event, etc. The reviewer assumed the energy content of the fuel could not be changed (basic thermodynamics), but a good explanation for a logical reason of why it could be of benefit would be helpful. In addition, the reviewer added, some significant cycle simulation modeling (GT-Power, WAVE, etc.) of the six-stroke engine would also give good insight to the potential benefit/penalty of that effort, although certainly the impact of in-cylinder reforming would not be seen. The reviewer concluded by repeating that the project had an outstanding approach to investigating unique opportunities for fuel economy benefit. A commenter said that the potential of the ability to store energy through fuel reforming should be presented and the barriers to realizing this potential defined. The reviewer added that, it was not clear that onboard reforming would improve thermal efficiency, particularly in the context of a six-stroke cycle. One reviewer wondered if it would be a better approach to first complete a thermodynamic analysis of all possible architectures before, picking a couple of the most promising, and then conducting experiments to verify the analysis. Another evaluator would like to see more efficiency modeling results showing what could be expected if these different cycles had to be run on one cylinder, or have a cylinder run backwards.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Responses were mixed to this question. An evaluator said that the six--stroke hydraulic valve actuation (HVA) experiments with alternative fuels was an extremely well-targeted experiment. A commenter noted that, although the output was mainly theoretical with some experimental verification, that this was precisely what was needed. One expert said there had been good progress understanding the process for reforming. A reviewer said that the fabrication and testing of the prototype hardware represented an important accomplishment, adding that how this data would be characterized would be critical to establishing the long-range reference value of the work. An evaluator stated that it seemed like the researchers had made reasonable progress on exploring several thermocuperative reforming concepts theoretically and experimentally and also fuel properties such as molar expansion ratio. The reviewer added that there were interesting results on exhaust temperatures from combustion of iso-octane, ethanol, and methanol. One commenter noted that the first step to making a better engine was making a different engine, and that some different concepts were definitely being investigated. The reviewer added that it would be very interesting to see if the concepts turned out to be better. A reviewer listed the following project attributes: thermodynamic modeling study – showed that no one fuel was best, reforming experiments, one embodiment uses EGR + fuel, n-cylinder with dedicated EGR cylinder running rich, regenerative air preheating and TCR (RAPTR), experiments performed with a six-stroke cycle on a SCTE with variable valve actuation (VVA), suppression of exhaust temperatures seen with added fuel on off-stroke event. The reviewer was uncertain how the H_2 compared with dedicated EGR. The reviewer noted that no analyses was shown in this presentation for the merits of these concepts, suggesting that at least a first level analysis should be done to justify merits and direction. One evaluator commented that the discovery of the countering effect of fuel specific heat ratio on the Molar Expansion Ratio was very interesting and important. The reviewer suggested that the third bullet at the bottom of slide number 13 needed to be simplified. The reviewer wondered if the higher compression ratio enabled by H_2, in reality, would not result in an increase in NO_x. The commenter suggested that the fourth bullet on Slide 14 also needed further explanation, wondering if the 5% increase in efficiency was based on an analysis conducted by the Gas Technology Institute (GTI), and if so, what was that published work and could it be referenced. The same commenter noted that the injection of fuel into the recompressed exhaust gases experiment should be related to the negative-valve-overlap (NVO) experiments being done by Dick Steeper at SNL, where acetylene was being injected into the recompressed exhaust and effects in the main combustion were being observed. This reviewer noted that the SNL work was focused on HCCI combustion and wondered if these two projects could learn from each other.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

An evaluator noted a good-sized list of collaborators were named, which was composed of industry and universities. A separate reviewer stated that there was a good connection to other projects on efficiency as well as industry and university partners. One commenter stated that the level of collaboration was appropriate, given the long-range focus. The reviewer would have liked to see greater collaboration with system modeling, such that the experimental data may be used to project the ultimate potential for the technology. Another reviewer said that it would be good to open this up to a wider audience, suggesting that a symposium on TCR and very high efficiency concepts might be worthwhile. The reviewer added that it was good that this project was connected to the complete engine program. An evaluator suggested that discussions could be had with project ace006 for mutual benefit. A commenter urged the project to continue collaboration with Dean Edwards' project. A reviewer believed that this group would work with the other teams at ORNL on simulation and engine testing, but was not clear how some of the partners collaborated, such as Reaction Design, GTI or Cummins.

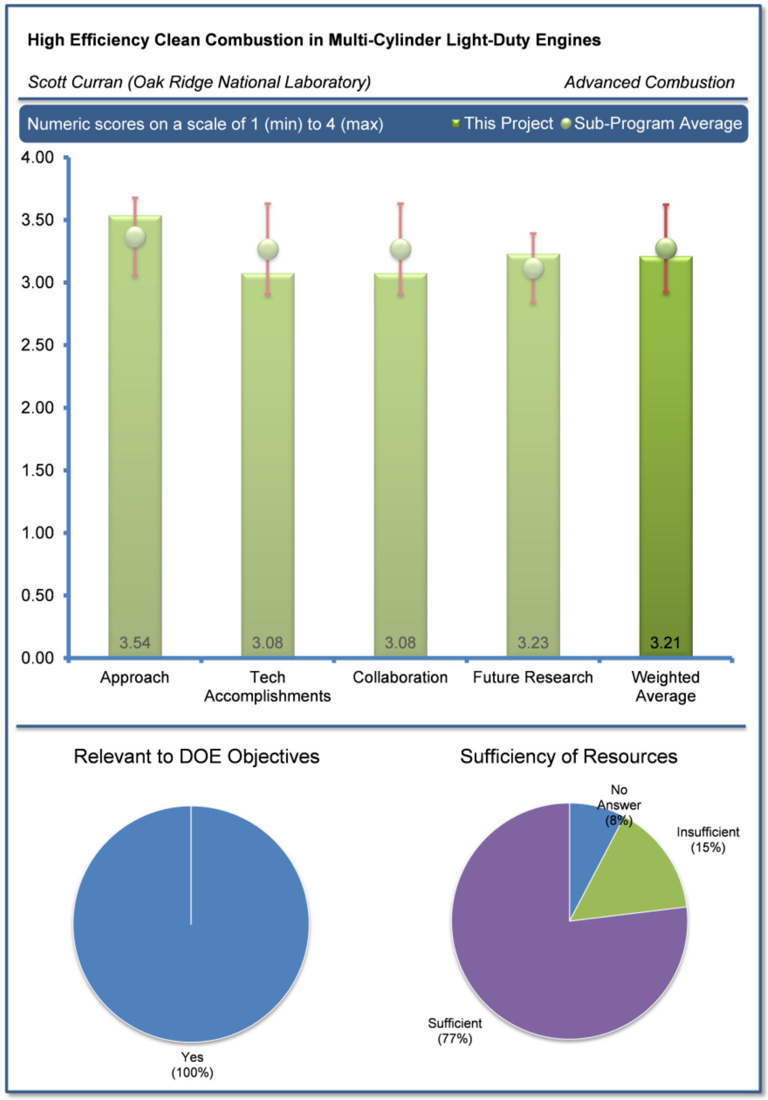
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer said that the plans seemed reasonable. A separate reviewer suggested that continued understanding of fuel effects may be useful. One reviewer agreed with the future plans, but cautioned that the hardware study should not distract from the overall goals of demonstrating the potential_of the technology. The commenter added that the project was focused on the long-term, and therefore the implementation of such a technology may ultimately be much different than it would be with today's hardware features and limitations. The reviewer continued by saying that the emphasis of the testing should be to validate system modeling, so that the results could be generally applied 10 years down the road. A reviewer asserted that the work needed to be focused more on how to accomplish its implementation. One commenter said that more upfront thermodynamic analyses should be done first. An evaluator suggested that there would be a benefit to modifying the plan moving forward to fundamentally explain and show why TCR had the potential to be of benefit as opposed to other alternative fuels.

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

Ten reviewers responded that the resources were sufficient; one felt the resources were excessive and another reviewer said the resources were insufficient. One reviewer commented that the resources were sufficient for this type of long-range development. Another reviewer said that the resources seemed sufficient to accomplish plans. A separate reviewer felt that the project needed more resources.

High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines: Scott Curran (Oak Ridge National Laboratory) – ace016



Reviewer Sample Size

This project was reviewed by thirteen reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

According to the first reviewer, reactivity controlled compression ignition (RCCI) represented a potentially important technology for light-duty engines. The second reviewer noted that this project had a direct impact on DOE's goals by addressing the promise of RCCI combustion for improving the gross and net thermal efficiency of CI engines through utilization of a multi-cylinder research engine. According to the third reviewer, advancing LTC was important for improving thermal efficiency while meeting emissions, and demonstration of those modes on a multi-cylinder engine was a key for demonstrating that DOE goals were being met. The fourth reviewer noted that expanding testing of advanced combustion technologies from single cylinder engines to multicylinder engines with aftertreatment systems enabled a more accurate assessment of potential benefits of these technologies to improve engine efficiencies and reduce fuel/petroleum requirements. The reviewer noted that the project also included biofuels in testing. The fifth reviewer noted that the project addressed barriers to meet engine efficiency goals, focused on RCCI on a multi-cylinder engine, and aimed to reduce emissions to T2B2 and improve efficiency. For the sixth reviewer, multi-cylinder assessment of LTC needed more emphasis to establish the real potential and issues. The final reviewer noted that the project was exploring higher efficiency operating conditions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed feedback on the project’s approach. The first reviewer noted a good approach with common speed and load points and fuel and strategy comparisons for alternative pistons. The second reviewer commented how the project was addressing practical implementation of HECC by using a systems approach was good, and the project directly addressed goals and roadblocks. The third reviewer noted an excellent approach of working with single cylinder researchers and modelers to extend work at ORNL to multicylinder engines. The fourth reviewer posited that the approach of multi-cylinder testing of proposed advanced concepts heretofore only demonstrated on single cylinder engines was a much needed one. This reviewer indicated that this project made a big step towards exposing real-world challenges. Another evaluator stated that this project was sharply focused on assessing RCCI combustion in comparison to conventional diesel combustion in a practical engine for ultimately showing the merits of advanced combustion modes on engine efficiency. This reviewer continued that the approach addressed key challenges with engine hardware associated with HECC over the years. Further, the reviewer indicated that it has included piston modifications when necessary, aftertreatment modifications when necessary, and development of flexible engine system for assessing various HECC approach. This reviewer commented that the project has a very good approach. The sixth reviewer observed that the project combined close coupled modeling and testing, and integrated aftertreatment to advanced combustion models. The seventh reviewer noted that the main focus appeared to be RCCI; however, regarding RCCI this reviewer had concerns about the combustion noise. The reviewer noted that coupling multi-cylinder engine data for engine mapping with full system models to project cycle emissions and fuel was sensible. The eighth reviewer perceived that targets were well established with a focus on real vehicle requirements. Still, it was unclear to this reviewer if the control could be accomplished in a real-world environment. The ninth reviewer commented that the project was focused appropriately on both the efficiency and emission, and aftertreatment issues. For this reviewer, still some work appeared to be needed in defining the goals for engine-out emissions, particularly NO_x. The final reviewer observed that the results were good on NO_x, efficiency and PM. The reviewer suggested that the project needed to explain further what would be done about the UHC and CO at these low exhaust temperatures. This reviewer perceived this as a significant barrier.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally saw good progress, and also offered suggestions. The first reviewer found that the initial results were very encouraging, and that the focus on emissions from LTC was long overdue. This reviewer felt the initial mapping to date was pointing toward good progress. The second reviewer commented that many issues have been identified and addressed. The third reviewer found that this project has yielded practical results and subsequently has explored engine system modifications for further understanding the validity of various HECC approaches. In particular, the contributions on understanding the limits of RCCI combustion in multi-cylinder engine have been of great value to the engine research community and future results with modified pistons should also be of great value. The fourth reviewer perceived that the project demonstrated that RCCI operation in multi-cylinder engine could cover most of the LD drive cycle with peak efficiency slightly higher than conventional diesel combustion. This reviewer indicated the project showed that NO_x emissions could meet Tier 2, Bin 5 NO_x levels without NO_x aftertreatment, but not Tier 2 Bin 2. HC and CO emissions were much higher in RCCI than conventional diesel combustion and HC emissions were different. The fifth reviewer noted that it was good work to map RCCI on the multi-cylinder engine; however, that the operating range demonstrated was fairly small and while it may benefit the FTP cycle, emissions on US06 would still be dominated by conventional combustion. The evaluator cautioned that the MPRR limited used was unrealistically high for the engine in this study, and noted that the maximum thermal efficiency was not increased beyond the stock engine. This evaluator continued that it was at lower load and ultra-low PM and NO_x emissions, but that the noise level was very high. This reviewer would like to know what would be the thermal efficiency and emissions if the MPRR were allowed to increase to 10 bar/deg. This reviewer noted that showing the thermal efficiency difference between diesel and RCCI was needed, and complimented that the project has done a good job in identifying potential barriers for RCCI based on multi-cylinder results, such as exhaust temperature. The sixth reviewer remarked that engine efficiency comparison to standard diesel engine looked like there was no advantage for RCCI. The reviewer suggested a need to compare to SI gasoline engines for efficiency comparison, or to show the emissions advantage of RCCI at the same time as efficiency. This reviewer noted that low maximum load was a severe limitation and would like to know what could be done to increase the maximum load. The seventh reviewer observed that the project began at single point optimization; extended to multiple speeds and loads; continued to introduce fuel effects; included modified RCCI piston with lower CR in its research; and that the work examined catalysts under RCCI conditions. This reviewer noted that the program captured clear boundaries with imposed MPR and CO ppm levels, and noted impressive BTE numbers, showing advantages over baseline, though results were shown without EGR. The reviewer indicated that the authors could do a better effort to explain the BTE changes, and noted that the reported differences may be due to a poor matching of the turbo system. Another reviewer commented that an expected increase in indicated and net thermal efficiencies due to decreased heat transfer with the lower CR modified RCCI piston did not result. The reviewer would like to know the explanation for that. This reviewer also indicated that for a load of 8.8 bar BMEP, Slides 10 and 11 showed a clear increase in brake thermal efficiency going from conventional diesel combustion to RCCI E85 or RCCI gasoline combustion. This reviewer felt that some of the benefits came from a reduction of ring friction due to the reduction in CR with the new RCCI piston. However, as this reviewer found, in Slide 12, for loads less than eight bar BMEP, there was no clear indication that RCCI combustion offered higher brake thermal efficiency. Further, this reviewer indicated that this was also seen in the BTE bar chart on Slide 14. The reviewer would like to know the reason for this result. This reviewer also stated that in this context, the sub bullet Higher BTE overall with RCCI in Slide 14 was confusing. This reviewer questioned whether the BTE with RCCI depended on the percentage of gasoline. This same reviewer also commented that the percentage of gasoline decreased with load according to Slide 16 and questioned whether this was the reason for the decreased RCCI BTE performance at lighter loads. The final reviewer would like to know how this technology behaved under cold start conditions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Responding reviewers remarked on the range of collaborators. The first reviewer remarked that a good team had been assembled. The second reviewer commented that there were good collaboration with the University of Wisconsin (UW) to implement RCCI and to investigate new combustion chamber, and that connection to CLEERS and others was useful for this project. The third reviewer noted that collaborators included several OEMs, including GM, Chrysler, MECA, Borg Warner; national laboratories; and universities. The fourth reviewer observed that very good collaboration with all relevant partners existed. The fifth reviewer commended that throughout the years, the various PIs' close work with GM, UW, and sub-system suppliers had been very good, with the only missing element being a stronger linkage with advanced combustion work at SNL. The sixth reviewer recommended that collaboration with ANL RCCI program should be included, and possibly with HCCI work at SNL (e.g., John Dec) in defining emissions targets for LTC aftertreatment systems. This reviewer suggested seeking deeper collaboration with OEMs where appropriate. The final reviewer questioned what the actual collaboration activity was.

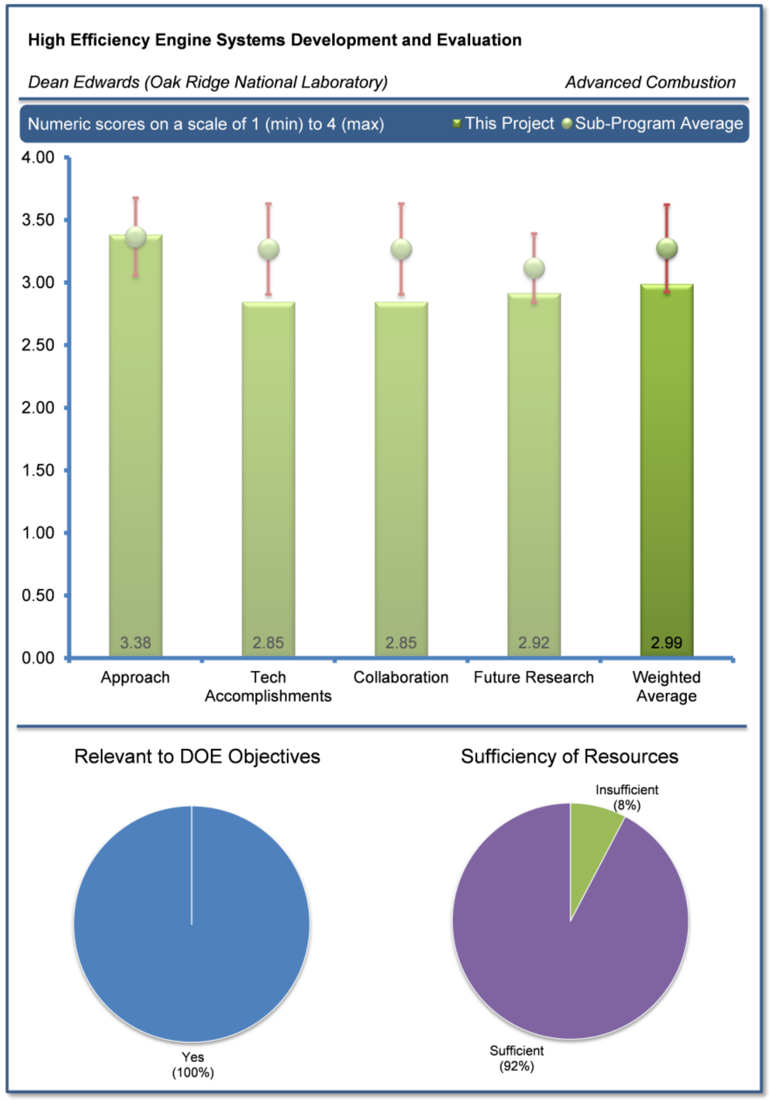
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

According to the first reviewer, the proposed future research was logical, and one possible consideration was to explore a means to utilize the large concentration of UHC in a positive manner or a means to reduce UHC with post injection or a non-standard valve timing strategy. This reviewer indicated, however, that these were just thoughts at this point in time. The second reviewer perceived that plans seemed reasonable. The third reviewer remarked that looking at the effect on aftertreatment and potential A/T solutions was important. According to the fourth reviewer, given the focus on emissions and aftertreatment for light-duty engines, next steps should include greater consideration of emissions test cycles, including more aggressive transient cycles such as the US06, as well as cold start emissions leading to catalyst light-off. Another reviewer suggested detailed FMEP breakdowns that account for injection pump and mechanical friction effects. The sixth reviewer observed that future hardware was delineated, including LP EGR, 2-stage TC. The seventh reviewer noted that future objectives were on target but would be difficult. The final reviewer thought that the project needed to explain if there was an answer needed for the UHC and CO. This reviewer would like to know if NO_x aftertreatment was still needed. If so, the reviewer wondered if diesel, gas, and DEF were needed.

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

One reviewer thought resources were insufficient. This reviewer noted that based on the hardware cost for this continual effort, this project could use a little more support for any additional subsystem needs. Ten reviewers thought that the funding was sufficient. According to one commenting reviewer, the resources appeared sufficient for the upcoming year, although the scope could be broadened to address more LTC aftertreatment challenges. Another reviewer remarked that the resources seemed sufficient.

High Efficiency Engine Systems Development and Evaluation: Dean Edwards (Oak Ridge National Laboratory) – ace017



Reviewer Sample Size

This project was reviewed by thirteen reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Most reviewers found that the project supported DOE's objectives. The first reviewer noted that this project held great importance for establishing future goals for the ACEC program. The second reviewer noted that the project directly addressed efficiency barriers. The third reviewer commented that the key project goal of determining maximum efficiency of ICEs and identifying methods for achievement would lead to higher fuel economy, reduced need for fuel and/or petroleum. The fourth reviewer saw excellent work to determine potential areas of improvement. Another reviewer perceived that this project had good relevance given that the goal was to quantify where there was potential to improve engine brake efficiency. The sixth reviewer thought the project was important work as part of the goal setting process to ensure that engine efficiency goals were meaningful and realistic. According to the seventh reviewer, the project addressed a comprehensive thermodynamic analysis to meet maximum engine efficiency goals. Another reviewer remarked that this was a good fundamental first and second law investigation of where engine efficiency loss came from and what actions could be used to improve it. According to the final reviewer, the project was working on higher efficiency.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers generally perceived that the approach had value, and also provided suggestions for future work. The first reviewer remarked that this study identified loss pathways via a second law of thermodynamics analysis. This person thought it would stand the test of time. The second reviewer noted that looking at fundamentals of combustion processes seemed reasonable. According to the third reviewer, the project sought to limit energy losses comprehensively, within the secondary constraints of cost and emissions. This reviewer saw the effort as analysis driven, specifically by the first and second laws of thermodynamics. The fourth reviewer noted the approach to understand loss mechanisms. The fifth reviewer thought that the approach was valuable in providing guidance to future programs; employing more detailed models of projected future engine geometries and features may affect the analysis, and should be incorporated. The sixth reviewer remarked that it was very important to analyze where gains could be made but that it was also necessary to set realistic targets based on technology to be utilized. For the seventh reviewer, leverage of a first and second law analysis was a good approach for a low-cost, up front investigation of various pathways to improve efficiency. The reviewer liked that the analysis was conducted at both a low load and peak efficiency point. The reviewer remarked that there may be a need for greater collaboration with the industry in order to solidify assumptions around how efficient waste heat recovery worked. The eighth reviewer complimented that this project did a good job of identifying potential loss reductions, but felt that the project did not get enough into the potential methods of recovering these losses. This reviewer understood that that was a much bigger job. Another reviewer liked the idea of using thermodynamics to isolate efficiency improvements. This person noted the need to apply some rigor to the inputting assumptions. The final reviewer commented that doing this type of analysis to isolate where the saved energy goes was definitely valuable and that engine modeling was a good starting point. This reviewer then indicated that at some point in the near future, it was possible that this approach should be opened up to understand what could be done to influence some of these tradeoffs. For example, this reviewer indicated, if the cylinder is insulated, most of the saved energy goes out of the exhaust instead of to piston work. This reviewer questioned whether modeling could be used to try and come up with strategies to alter the amount of energy that goes out of the exhaust instead of to piston work. Further, the reviewer explained that this was something to consider in the future that would separate this project from similar modeling efforts that were constantly being performed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

According to the first reviewer, the approach had been applied to two light-duty cases, one diesel and the other gasoline. This reviewer felt the results and conclusions looked very reasonable, and were pointing to areas of focus for increasing engine efficiency. The second reviewer remarked that it was very good to see a complete look at the entire system. According to the third reviewer, the presenter did a good job of showing the different results for the light load versus the full load cases, as this sometimes gets lost. The fourth reviewer was complimentary of the very nice summary of engine inefficiency sources. Parametric studies to understand sensitivity of assumptions was good. For the fifth reviewer, there has been some good progress made and this type of modeling was always interesting. The sixth reviewer thought that the project was on track for excellent results. This reviewer was awaiting assessment of multiple engines, including CDC, RCCI, and SI-dilute, at several conditions. This reviewer noted that the accounting in the turbo pumping and waste heat recovery losses might be presented in an alternate format. For example, that the engine system pumping losses should or could include pumping losses. This reviewer also emphasized boundaries. Another reviewer noted that the project identified some strategies to improve thermal efficiency. The eighth reviewer found that some of the findings seemed obvious, i.e., reduced friction and pumping losses, but that the project's efforts to determine the biggest impact areas for improvement of engine efficiency should be very beneficial. For the ninth reviewer, the modeling provided useful insight; however, it did not yet appear to incorporate important engine features and combustion strategies that may affect the outcome of the analysis. The final reviewer observed that the effort recognized this was a comprehensive approach; an adequate example was given dependency on Fuel-Air ratio and the distribution of energy in ideal expansion work, thermal exhaust, irreversibility. This reviewer commented that general guidelines were given regarding friction, maximize in-cylinder pressures, lean, full expansion, lower in-cylinder temperatures, and efficient WHR. The reviewer noted that advanced technologies or methods were presented, e.g., high efficiency turbomachinery, and heat loss mechanisms, and that the project focused on a light-duty diesel GM 1.9L. This reviewer commented that the stretch goals given, were maybe a bit optimistic, but a good start.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed responses regarding collaboration. The first reviewer noted that ACEC participation captured multiple labs and OEM partners. The second reviewer remarked that the closer collaboration with OEMs would be important to gaining access to improved models, which would ultimately aid in setting relevant technical performance goals. The third reviewer observed that the main collaboration appeared to be through the ACEC. This reviewer noted that engagement and discussion to get a consensus on what different technologies would offer in terms of energy extraction or to get ideas on possible avenues to explore would be useful. Another reviewer observed only a general description, extensive interaction with industry, university, and national laboratory partners. The project provided supporting analysis for understanding efficiency potential of ICEs to U.S. DRIVE and the ACEC Tech Team. The fifth reviewer commented that it would be good if this program could clearly partner with a couple of engine efficiency improvement programs to feed more data into the modeling effort. The sixth reviewer found it difficult to assess the degree of collaboration, although a statement was made of extensive interaction with industry, university, and national laboratory partners. This reviewer suggested that listing specific partner names would be helpful for reviewers to better assess the level of collaboration and coordination. The final reviewer remarked that there did not seem to be much collaboration in the program.

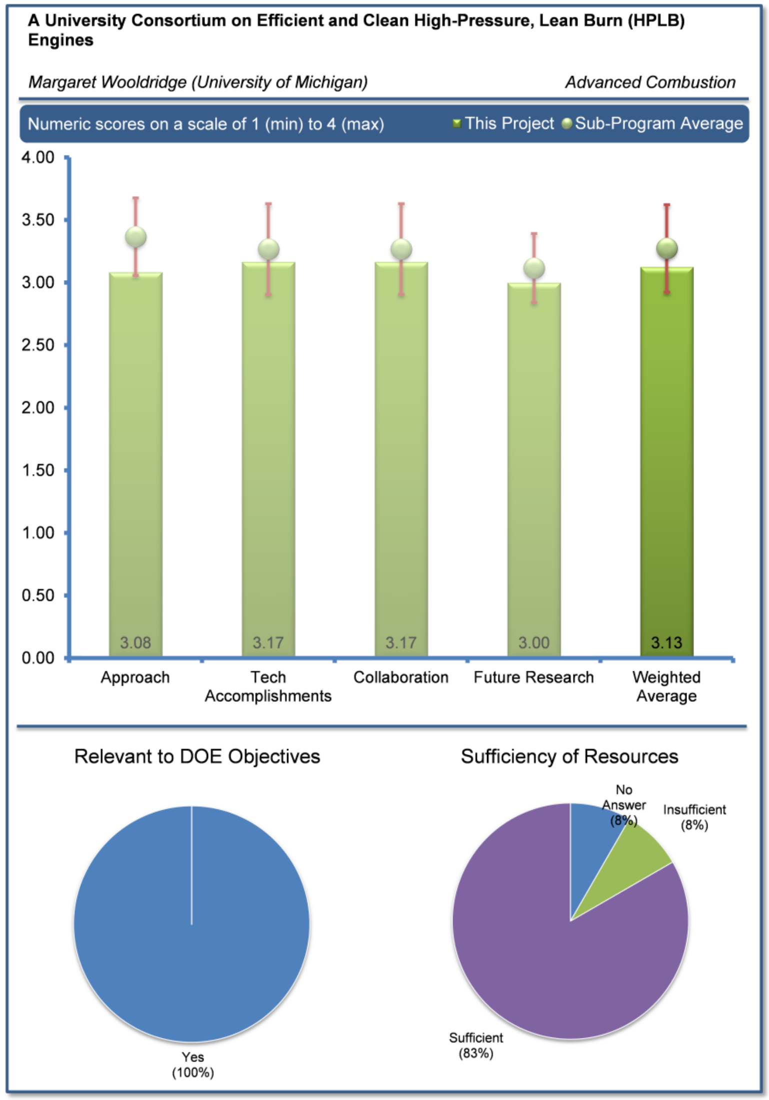
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

According to the first reviewer, the plans to continue this work seemed worthwhile. The second reviewer remarked that it included a good piece of work to set future directions. This reviewer suggested focusing on the RCCI work presented in ACE016 – multi-cylinder work. For a third reviewer, the future research goals were fairly broad and loosely defined. This reviewer felt further collaboration with industry would help to focus the work and make it more fruitful. The fourth reviewer suggested that brainstorming with a panel on ideas to explore for improved efficiency using this analysis might open possibilities. The final reviewer would like to see a proposal on how to firm-up the engineering assumptions on recovery and redistribution factors.

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

One reviewer perceived that resources were insufficient. This reviewer commented that more could be spent on identifying ways to use the lost energy and modeling those solutions. The remaining reviewers found that resources were sufficient. One commenting reviewer remarked that the resources were sufficient at this point, though more could be spent on obtaining improved model inputs. Another commenting reviewer noted that the resources were acceptable given that this was a modeling-only project. This reviewer stated that obviously resources would need to be reconfigured if any engine testing was to be done, although the engine data might be better done via collaboration with other programs that were currently looking at improved brake thermal efficiency.

A University Consortium on Efficient and Clean High-Pressure, Lean Burn (HPLB) Engines: Margaret Wooldridge (University of Michigan) – ace019



Reviewer Sample Size

This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that the project's focus was on improving fuel economy which if successful would lead to direct reduction in fuel/petroleum needs. The second reviewer commented that improving efficiency of gasoline engines was critical, because this was the technology that was likely to have the easiest path of penetration in the U.S. The third reviewer found that this project was clearly focused on methods to improve fuel economy of IC engines. The fourth reviewer commented good focus on improving engine efficiency. The fifth reviewer noted that the project was focusing on SACI, between SI and HCCI, and sought to demonstrate 45% peak efficiency. The final reviewer noted the pursuit of higher efficiency

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed responses. The first reviewer noted that the project possessed well-aligned objectives for dilute high pressure combustion. This reviewer observed a well-presented and organized plan by four tasks. The second reviewer noted that the project explored dilute, high pressure combustion and fuel properties. The project focused on analytical tools, stratification, multi-mode combustion, novel fuel properties. The third reviewer thought that including lean and dilute combustion in the portfolio was critical. This reviewer saw a good mix of modeling and experiment. The reviewer remarked that the connection between them through a final cycle projection was good, but that the connection between the various pieces of the project was not entirely clear. The reviewer commented that there was a lot of great work, but that connecting different research techniques to deepen the understanding would be useful. The fourth reviewer commented that clearly this program was going into good detail in a number of very interesting areas. This reviewer identified that one thing that might be missing was how the project down-selected to the single best approach (e.g., ESC), but perhaps that fell back to the industry partners. According to the fifth reviewer, various elements appeared to be disparate or non-integrated and did not necessarily support each other or have synergies that came together in order to achieve the program goal of improved fuel economy. Another reviewer commented good breadth, and considered the project very useful if eventually integrated. However, this reviewer did not see the vision to achieve that. The seventh reviewer noted that although there was a huge amount of work being done, it was not clear how it tied together. This reviewer also noted that it was not clear if there was any focus on shifting between operating modes. The eighth reviewer would like to know how the various aspects of this research were tied together. The ninth reviewer remarked that the approach seemed to have a shot-gun flavor to it; the link between the tasks on Slide 5 was not clear. The final reviewer questioned what NTC meant and pointed out that it was never documented in the presentation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer remarked that a huge amount of data and improved understanding has been accomplished. The second reviewer noticed good progress on a broad range of projects. The third reviewer found that there was clearly a lot of good technical progress in a variety of areas and noted that the combination of results from modeling, engine testing, optical testing, etc., helped build the fundamental understanding of some of these unique combustion modes. The fourth reviewer observed some good results in SACI mode. This reviewer desired that the project share more information on what conditions were needed and what conditions the project was running at. Another reviewer suggested considering the impact of aftertreatment on efficiency and drive cycle fuel economy. The sixth reviewer noted that the individual technical accomplishments were good. However, this reviewer felt it was unclear how it contributed towards a cohesive understanding of engine efficiency improvements. This reviewer noted that most of the numbers for fuel economy gains were from model estimates, which were nice to start out with but needed to be tempered with solid engine performance and emissions results. The seventh reviewer commented that GT Power results helped identify some efficiency targets, but the combustion model looked over-simplified, specifically with knock at high loads. In addition, this reviewer commented that FE modeling showed a large displacement HCCI engine (3.3L) with moderate economy. This reviewer suggested including the option of an advanced SI TC, or SACI engine with part load HCCI. This reviewer continued that fuel properties work with HCCI showed a fairly small window. The reviewer inquired whether the work could have also correlated with higher load or SI conditions. The eighth reviewer observed that Task 1 involved GT Power model completed on an engine with six case studies including combustion modes detailing increased efficiency, while Task 2 studied the benefits of stratification, including thermal and composition. This reviewer would like to know how Tasks 1 and 2 related to each other and inquired about what the implication of the model using H_2-air mixture was. In addition, this reviewer noted that stratification of RCM data was then presented with gasoline fuel. The reviewer observed that Task 3 focused on multi-mode, and Task 4 focused on fuel properties, specifically ethanol effects and octane number. This reviewer indicated that ignition studies attempted to understand prediction of emissions. This reviewer commented that in general, lots of work was completed, but it was unclear how Tasks 2-4 got incorporated into Task 1 in cycle simulation. The final reviewer remarked that some claimed accomplishments seemed known in the industry for some time, such as the desirability of engine downsizing and boosting.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally observed broad collaboration. The first reviewer noted wide participation. The second reviewer said broad collaboration with other universities, national laboratories and the industry. The third reviewer observed good collaboration with other universities and industrial partners. The reviewer stated that this program seemed to have a good team in place with a good variety of participants. The fourth reviewer noted that project collaboration was very broad and diverse. This reviewer noted that the level of integration or coordination was unclear. To this reviewer, it seemed like there were uncoordinated or minimally-coordinated individual efforts. The fifth reviewer noted that the collaboration between project partners, including UM, MIT, and UCB was not clear, and each seemed to have worked on their own areas. This reviewer noted that there was some apparent collaboration with the industry. According to the sixth reviewer, wide collaborations were shown, but it appeared that the integration of the many tasks could be better integrated or illustrated in the materials provided. The final reviewer suggested that links between all the partners should be clarified based on a clearer vision of the integrated approach.

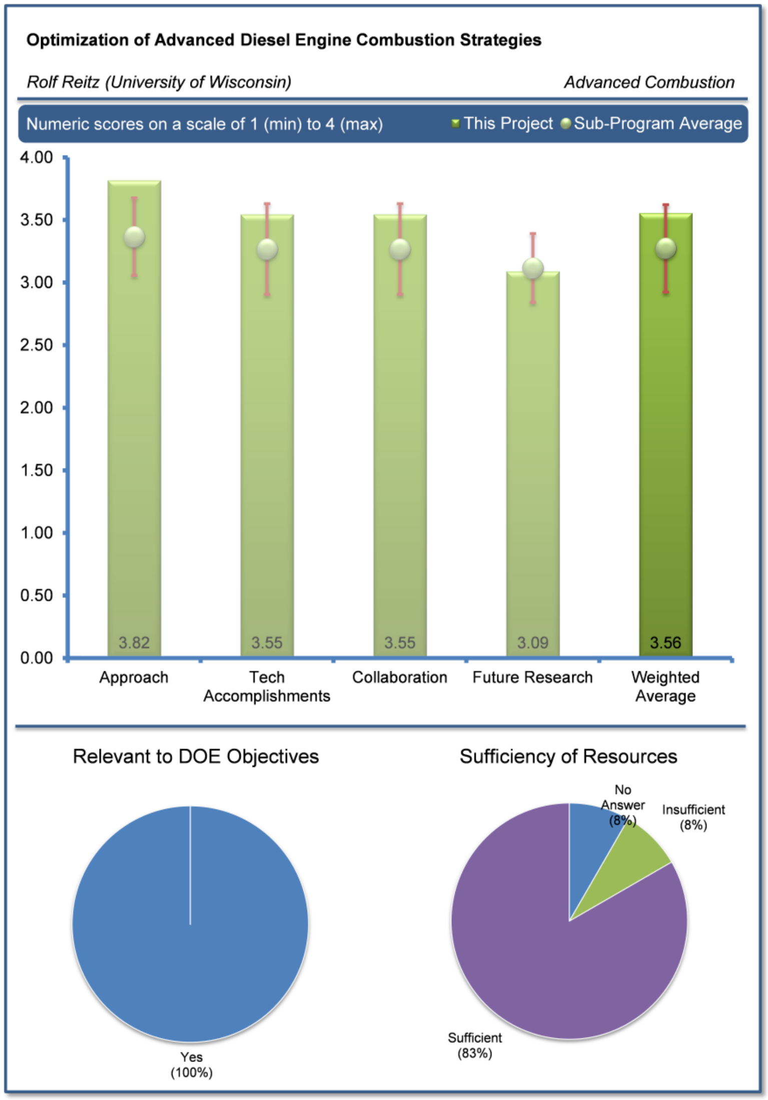
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Responding reviewers noted that the project was ending this year. The first reviewer believed that continuing this work was clearly warranted. The reviewer stated that it would help if the future areas to be studied were a bit clearer with some thought given to how these different combustion regimes could all come together. The second reviewer noted that work would be completed this year. The final reviewer commented that with the program ending this year, it was not clear how the work would be tied together.

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

One reviewer thought that resources were insufficient. The remaining reviewers found that resources were sufficient, with one reviewer commenting that it was not applicable because the program is ending this year.

Optimization of Advanced Diesel Engine Combustion Strategies: Rolf Reitz (University of Wisconsin) – ace020



Reviewer Sample Size

This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers generally found that the project supported DOE objectives. The first reviewer commented that reducing fuel consumption in-cylinder while also reducing the fueling penalty for aftertreatment systems was important for meeting the objective of petroleum displacement in both the heavy-duty and light-duty sectors. The second reviewer found that this pioneering work was excellent with real potential for improved efficiency. The third reviewer thought that this project was probably the best demonstrated engine efficiency of all the projects. The fourth reviewer stated that the focus on improving engine efficiency/fuel economy supported DOE goals of reduced petroleum usage. The final reviewer observed that the project focused on high efficiency engines.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Generally, reviewers perceived that the approach was effective. The first reviewer observed a very good approach of using metal and optical engine experiments, modeling and simulation, and surrogate fuels chemistry model development to accomplish goals. This reviewer noted that the project had an interesting approach of using both a more-reactive and less-reactive fuel. The key issue was whether the two fuel tanks could gain traction with OEMs and driving customers. The second reviewer commented that the experimental and computational efforts complemented those of key DOE laboratory programs, and continued to uniquely provide invaluable support. According to the third reviewer, the project developed methods to optimize in-cylinder combustion, and the project was very comprehensive while at the same time the team was notably innovative. Another reviewer commented that the approach continued to keep the scope of the project under control and limited to advanced engine combustion concepts; this helped to ensure efficient usage of resources and good progress. The fifth reviewer remarked that this program was clearly looking at a wide variety of engine systems in order to find potential improvement compared to today's engines. Some of these areas were more interesting and had more potential than others, but to this reviewer, to have the overall program look at a wide range of areas was outstanding. The sixth reviewer observed that the project had showed methods of how to make dual-fueled engines work. The final reviewer stated that although the work was very well done, that there needed to be more focus on gas pumping requirements and more realistic assessment of losses from GIE to BTE.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Many reviewers observed good progress. The first reviewer observed exceptional experimental and modeling coupling. The second reviewer commented that the program provided comprehensive support to many aspects of the DOE programs. The progress in each area was outstanding. The third reviewer noted that the project had made a number of significant accomplishments that provided potential options for achieving goals of improved fuel economy and lower emissions. Specific accomplishments the reviewer noted included the concept of changing fuel reactivity as driving conditions warranted, modeling work to identify optimal injection strategies, and development of surrogate for CRC FACE diesel fuel No.1. The fourth reviewer observed excellent progress and significant accomplishments in pushing the envelope and challenging engine developers around the world. Another reviewer noted that modeling and engine diagnostic work continued to focus on combustion issues raised and observed in metal engine. The sixth reviewer observed that Task 1 addressed optimization of combustion chamber and sprays with CFD with natural gas and gasoline mixed each with diesel, and that the work was accompanied with modeling combustion control and mode switching. This reviewer would like to know whether hardware was available to benchmark models, VVA, and multi-shot injections. The reviewer noted that the work also considered injection pressure and fuel strategies, and that experimental work extended to LD engines. The reviewer observed that Task 2 consisted of optical engine investigation of multiple fuels, and the work was accompanied by investigation of soot formation and impact of flame lift-off. This reviewer inquired whether the conditions were comparable to those of Task 1. The reviewer observed that Task 3 was considering multi-mode combustion and reduced mechanisms -- the work included spray and fuel film for SCR, turbulence mixing measurements, and the project executed crank angle measurements of species and temperature. The reviewer observed that Task 4 consisted of transient work. The final reviewer noted a large suite of research projects, but would have liked to know how the research projects tied together in a system to deliver efficiency for a LD or heavy-duty (HD) application.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers observed strong collaborations. The first reviewer noted that the level of collaboration was exemplary and unique. The second reviewer observed wide collaborations, and noted that the scope of work was very impressive. According to the third reviewer, it was good to have a strong industry consortium behind this work. The fourth reviewer noted that a large cross section of the industry had input into this program. The fifth reviewer observed collaborations with GM, Woodward, and ORNL, plus the DERC network. Another reviewer noted that the project showed some good results and shared these with others in the industry and in research. The final reviewer commented that while most of the work was being done by UW, the project obtained wide and solid input from the diesel engine consortium.

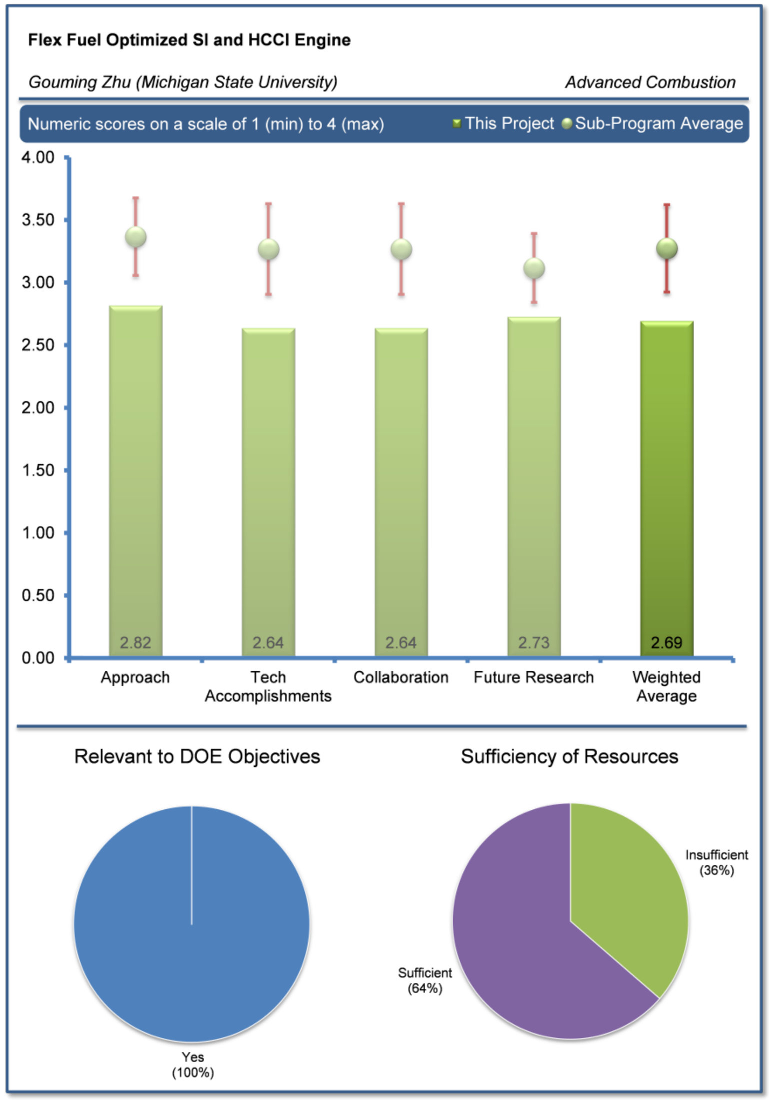
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers had mixed comments on the proposed future research. According to the first reviewer, DOE and UW deserved much credit in appropriately defining the scope of the cooperative efforts in so many areas. Each area was producing valuable results. The second reviewer thought that the plans seemed reasonable to achieve goals of the program, which is scheduled to end this year. The third reviewer remarked that no specific details were given. The fourth reviewer suggested that a multi-cylinder demonstration and an actual BTE versus GIE comparison were needed. The fifth reviewer suggested that the effect of heat transfer in a large-bore heavy duty engine versus a small-bore light duty engine should be presented at a future review so that reviewers may better understand the difference between the two. The final reviewer noted that the future plan of increasing the CR to 18.6 seemed to counter the surface/volume and friction trends. This reviewer inquired whether the project expected improvement on a brake basis.

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

One responding reviewer thought that the resources were insufficient. The remaining reviewers found that resources were sufficient. One reviewer commented that resources seemed sufficient to complete the program, which was scheduled to be completed by year end. According to this reviewer, this work was worth continuing, and the reviewer hoped that this work would receive a new phase of DOE funding.

Flex Fuel Optimized SI and HCCI Engine: Gouming Zhu (Michigan State University) – ace021



Reviewer Sample Size

This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to respond stated that Homogeneous Charge Compression Ignition (HCCI) combustion has the potential to provide significant gains in fuel efficiency; however controlling the combustion process is a big challenge. This person added that this project aims to provide knowledge and understanding of the control of Spark Ignition (SI) to HCCI combustion mode transition. Another reviewer believed that the development of a cost-effective HCCI/SI approach would be a valuable contribution to light-duty engine technology. The next reviewer to respond suggested that the project should demonstrate an SI and HCCI dual-mode combustion engine (multi-cylinder) that is commercially viable, for a blend of gasoline and E85. The next commenter stated that the transition from HCCI mode to SI mode will be necessary as long as HCCI BMEP is limited. Another commentator felt that both concepts, E-85 fuel and advanced combustion part-time HCCI engines, support the DOE goal of using less petroleum. The following commentator believed that the control of advanced combustion modes like HCCI is a significant barrier to implementation. These modes offer the potential to reduce fuel consumption, added the reviewer. Another reviewer agreed with the project as it addressed that another barrier to implementation includes cost effective controls for LTC. The last reviewer to respond felt that there still remains a lot of interest in HCCI engines and it is well known that HCCI can only be used at lower Brake Mean Effective Pressure (BMEP) levels. The reviewer added that a program is needed to study the transition effects between HCCI and other combustion modes.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commenter to respond stated that the developed transient control algorithm relies on the VVT system and that tests would be done in optical and metal engines. Another reviewer believed that the path for future control systems lies in model based control. Leverage of a HIL environment is an effective way to develop control strategies, added the reviewer. This person questioned whether the HCCI engine would be ready to execute transient maneuvers, as well as complete the task at hand. Another reviewer felt that the approach seemed reasonable. The next reviewer to respond believed that this project needed to work on demonstrating how some of the advanced combustion ideas would actually be used. Most of these combustion scheme ideas are neat, but lack the necessary controls concepts to really enable them to be used in the future, added the commenter. The following commentator liked this project. This person felt that, by using hardware in the modeling, the optical and multi-cylinder development effectively includes appropriate noise factors that demonstrate mode transitions. This person also added that, in regards to the execution, the project may have taken on too large a task in building up all of the various pieces (optical, multi-cylinder, controls hardware, controls software). The reviewer believed that with the large task at hand, the project may not be able to spend sufficient time addressing the key deliverable of a control strategy for SI and HCCI mode transitions. This person also questioned if the results were going to be combustion system specific and asked how the project would establish transparency or transportability to other architectures. The following commenter stated that it is difficult working with simulation without verification of a full HCCI engine. The next reviewer felt that it was unclear if the initial plan is to use pressure or ion sensing to feedback the SI to HCCI transitions. Another reviewer added that the approach to addressing the controls challenges seemed sound. The next commenter expressed the concern that excessive time spent on hardware development leads to insufficient time to address the core objectives of the program. This person added that more time would be needed to produce sufficient details on the nature of the combustion during the transients, such that the salient control issues could be identified and explored. Additionally, this reviewer added that it appeared that the present approach for the combustion mode transition would lead to significant emission concerns (especially HC), and yet this reviewer saw no solution proposed, such as air injection or some other approach. The last reviewer to respond said that it appeared that the approach was diluted from the stated goal of managing the transition to and from HCCI mode and conventional combustion. This person also thought that it appeared that this program had become the development of an HCCI engine and was not actually studying what was initially intended. This would indicate a poor initial assessment of available HCCI engines, added the reviewer. This person then explained that while managing the transition, a number of items should have been studied closely such as the torque resolved per firing event to detect torsional issues; the rates of pressure rise in-cylinder to check for potential mechanical issues; as well as the heat release data to evaluate the combustion performance during the transition. This reviewer was unsure why there was a need for an optical access engine since none of the items on the objectives during the transition required visual observation.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent observed that progress made to date included Task 1 – a finalized mode transition control which was validated with HIL; Task 2 – completed electrical VVT control, showing a 25 degree phasing within three engine cycles; and Task 3 – good progress appeared to be taking place with the metal engine build which included an engine controller. The reviewer added that, despite the delay, the hardware and controls were ready for an in depth development of the transition algorithms. With respect to the reviewer's opinion about the progress being made on Task 1, this person believed that it is necessary to detect knock if the author stated that the control relied on cylinder pressure feedback for the five-cycle transition. The reviewer stated that knock sensors were common in production engines and could respond on a 1-cycle base. The next reviewer to respond felt that the electric variable valve timing (VVT) performance was quite slow, even with low viscosity oil. This person wondered if it would be possible to obtain a faster unit. The reviewer also questioned what the tradeoff for controlled SI-HCCI transitions with VCT rate and accuracy would be. This reviewer added that a delta lambda value of 0.25 seemed like a very wide range and questioned what factors would prevent tighter control. Being mostly a control project, the hardware effort to launch a HCCI engine has apparently consumed a lot of time and resources. Another commenter stated that the slow progress may suggest that perhaps the scope was defined too broadly, since the basic nature of the combustion control has not been adequately explicated to make a significant contribution toward moving this technology closer to implementation. The following person listed the accomplishments to date as development of transition controller, method to regulate air/fuel ratio, construction and integration of an electrical VVT system to optical and muti-cylinder engines, and demonstration of the rich-to-lean SI transition in optical engine. With these accomplishments listed, this reviewer observed that the project team still needed to build a metal engine and test the control system with the very limited time the project had left. One commenter felt that the schedule seemed to be slipping. Another reviewer questioned whether there would be sufficient time spent on the actual combustion aspects of the project since there has been progress made in building the hardware. The following reviewer commented that the controls software seemed to have progressed well. This person also observed that this project is nearing the end of the project lifetime and was unsure if there would be a properly operating metal engine running so that the control system could be tested and validated and improved upon. The six-month extension to the project would certainly help in this area, added the commenter. Another reviewer added that there was good progress being made on building and developing an HCCI engine. Although the actual progress and data of managing the transition in and out of HCCI mode is somewhat lacking, the project has developed some interesting results, said the reviewer. The following commenter felt that there was good progress being made on the control strategy development and validation, but noticed that this was all on HIL simulation. This person also observed that progress was made on acquiring hardware, but the timeline required to complete demonstration may be difficult if the HCCI on the engine proves difficult to calibrate. The last reviewer to respond said that the theoretical results look positive but is unsure that the project will deliver a full engine.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed feedback and in particular had comments regarding the collaboration with Chrysler. The first reviewer observed that two of the several partners named in the presentation were Chrysler and Ricardo. Another expert stated that there was a partnership with Chrysler for system design and technology transfer, but that did not seem to be well thought out. It was unclear to this reviewer that Chrysler was committed to getting an HCCI engine to Michigan State in a timely fashion so that they can further develop and demonstrate their control strategy. The following commenter added that Chrysler was a later partner to the program. This person continued to explain that Chrysler is not known to have an HCCI engine program, and added that the expertise they could bring to this project was uncertain. Since this project was originally conceived as a controls project, this reviewer felt that attention should have been focused on having a partner or collaborator on the project that had the ability to either supply the HCCI engine hardware or the know-how. Another reviewer felt it appeared that the input from the Original Equipment Manufacturer (OEM) was not as valuable as it should have been, particularly in providing necessary hardware for the experimental work. Another reviewer to respond felt that the ability to get a HCCI metal multi-cylinder engine seemed to be limiting progress. A reviewer said that the work could use a bit more involvement from the industry. The final commentator felt that closer collaboration with an Original Equipment Manufacturer (OEM), beyond just supplying hardware, could have improved the approach.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers had mixed responses on proposed future research. The first reviewer stated that the upcoming task will include a move to start completing the metal engine work. The second reviewer expressed uncertainty whether the plans to complete the building of the metal engine, the integration of controls system, and the testing could be completed based on the current schedule. Another reviewer remarked that the plan looked good, but seemed late in the program. The fourth commenter stated that at this point in the project, time is the enemy, and explained that it appears the project objectives would not be met due to time constraints. Another reviewer added that there are significant concerns about whether it would be possible to calibrate the engine in SI and HCCI modes as well as develop a transient calibration where one could prove mode switching works. The final reviewer advised that the project should keep their focus on getting the metal HCCI engine operational as soon as possible. Then, the focus should be on understanding the issues involved in controlling the transition from SI combustion to HCCI combustion, which is the research issue in question and what is of value to industry.

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

Four reviewers felt that funding was insufficient, while seven reviewers felt that the project resources were sufficient. The first reviewer commented that more resources were needed and better hardware would be beneficial to the project team. The following reviewer thought that the current project suffers from inadequate recognition of the degree of difficulty in pursuing the approach taken. The final reviewer stated that the scope of this project was too large for the given funding level. The last commenter to respond assumed that a project extension to first-quarter 2013 was for a sufficient period of time to complete milestones.

CLEERS Coordination & Joint Development of Benchmark Kinetics for LNT & SCR: Stuart Daw (Oak Ridge National Laboratory) – ace022

Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to respond felt that this project is aligned well with DOE objectives. The effort strives to improve the long term performance of NO_x aftertreatment devices, added the reviewer. This person also believed that as the tradeoff between NO_x and fuel economy is critical, the project supports DOE goals of reduced petroleum displacement. The following commenter stated that the Cross-Cut Lean Exhaust Emissions Reduction Simulations (CLEERS) activities have been very successful for last several years in addressing a number of aftertreatment aspects for fuel efficient advanced combustion technologies. The following reviewer agreed that this work primarily focused on exhaust gas aftertreatment. This reviewer noted that required emission mandates have traditionally reduced fuel economy; however, as the understanding of aftertreatment technology has increased, the efficiency of the devices has increased significantly. This person continued that say that the work completed by Oak Ridge National Lab (ORNL) has increased the basic knowledge of actual production devices. The reviewer added that the CLEERS coordination is a model for bringing industry, national laboratories and academia together. This reviewer noted that the CLEERS workshop has at least one imitator in Europe, and since imitation is highest form of a compliment, to this reviewer that is a strong recommendation for the activity. The last reviewer to respond expressed that the major goal of any emissions control project is to minimize the use of energy to control criteria pollutants. This project provides focus for a wide range of technologies, so its benefit is spread over a set of engine families, added the reviewer. This person believes that the data and models are more likely to be used since they are wide-ranging results are readily available.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that CLEERS is the benchmark for collaborative research. The second commentator to respond stated that the results of this project would be very useful if the team used industrial application catalysts. Additionally the focus on N_2O is a look-ahead approach that gives the work long-term value, added the commentator. The following panelist felt that the approach of this project was unique from the point of view of building of an aftertreatment community. In contrast with the breadth of interaction in the Cooperative Research and Development Agreement (CRADA) or other two-partner projects, these projects bring together people in many ways, through the monthly web talks and through the databases that are available, expressed the commenter. One reviewer observed that CLEERS covered experimental simulation/modeling and made progress in forming diversified groups participation/contribution in lean exhaust emissions research areas. This person suggested changing the acronym not to limit on simulation; e.g. Cross-cut Lean Exhaust Emissions Reduction System or System technologies. The last commenter to respond said that the work appears to have good communication and collaboration activities. However, it was unclear to this reviewer how OEMs ultimately benefit from some of the work. For example, the hydrothermal aging study suggested that NO_x reduction was relatively robust to aging; that is a strong learning. But, it is not clear to this reviewer as to how the fundamental knowledge of NH_3 storage and its sensitivity to aging would lead to better robustness or better fuel economy. The reviewer felt that connection did not seem to get made.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer could clearly see a change in selectivity of Selective Catalytic Reduction (SCR) catalysts for NH_3 oxidation. This person mentioned that the Lean NO_x Trap (LNT) had focused on N_2O selectivity and that more nitrates stored lead to more N_2O. One reviewer felt that there was strong progress being made especially with respect to the hydrothermal aging study. The next reviewer suggested that the project should continue working on low temperature catalysis. The following commentator observed that ORNL coordinated the 15th CLEERS workshop well as usual, but suggested that they could have generated a more interesting discussion at the meeting if there were more invited talks from industry side (such as OEMs including heavy duty, catalyst suppliers, and etc.). CLEERS has made a good step on providing vehicle engine out data, added the reviewer. This person continued, saying that the recent BMW lean GDI vehicle data would help a wide range of research groups to better understand the real world conditions they are faced with. The reviewer added that, with regard to benchmarking exercise, the database needed some improvement with more frequent updates and well-defined conditions for all diesel oxidation catalyst (DOC), SCR, and LNT technologies. For oxidation catalysts, it would be difficult to standardize the performance level due to high platinum group metal (PGM) dependency on their performance, added the reviewer. This person then suggested that one possible option would be to have a normalized PGM activity database for oxidation catalysts. The last commentator felt that nothing in the work was earth-shattering. This person explained, unfortunately that it is not for lack of good investigative technique; it simply means that ORNL is validating prior aftertreatment studies.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally saw good collaboration. One reviewer felt that it was clear that there is good collaboration on this effort with a structured communication rhythm. Another commenter stated that ORNL interacts with both the domestic and international community and that the CLEERS workshop has become a high choice meeting for the international community. ORNL provides data to a wide range of institutions including national labs, industrial partners and both domestic and international academic institutions, added the reviewer. The following commentator mentioned that ORNL has been working with a wide range of groups including OEMs and other national labs. Although we are learning more interaction and technical information exchange between ORNL and Pacific Northwest National Laboratory (PNNL), this reviewer suggests that it would create more synergy if both labs work together on other components such as LNT and oxidation catalysts development. The final reviewer to respond believed that some of the key features of the this program include the collaboration between ORNL and PNNL, the collaboration with suppliers to provide catalysts, and the collaboration with universities and national labs in developing data and models that describe the various means of NO_x and particulate control in lean exhaust.

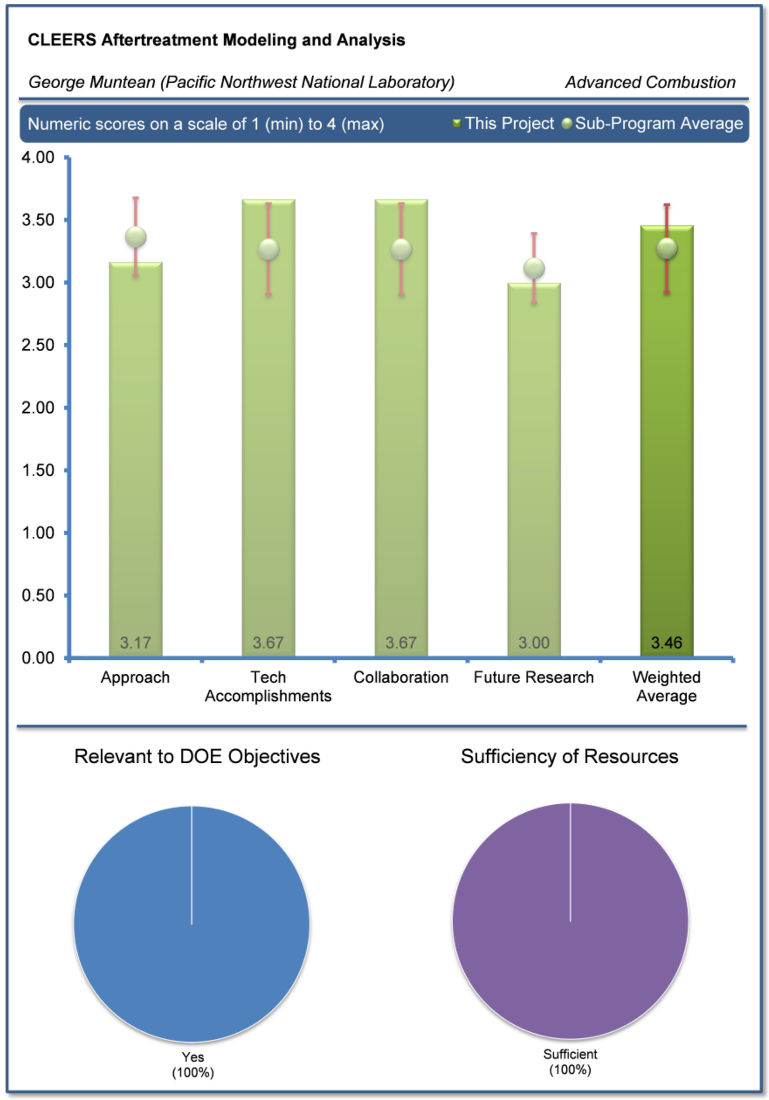
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer believed that there are many directions for this program to go. The following commenter mentioned that some of the future work had been covered and already reported by other groups such as PNNL. This person suggested that it would have been nice if the future direction was coordinated with PNNL at least under CLEERS coordination. ORNL has excellent resources in mechanistic study as well as integrated system research, while PNNL's strength lies in fundamental and material-based research, added the reviewer. Another reviewer stated that the project has developed an enhanced mechanism to share data and modeling information with the pre-propriety. This reviewer also stated that the presentation did not provide a clear reason for why the low temperature DOC surface modification should have been completed at the National Laboratories compared with having that work done at suppliers. The final reviewer to respond felt that the future work did not seem clear from the either communication or the presentation slide. This person suggested that they would have preferred to see more deliberate statements of future activities based upon what was learned.

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

Two of the five reviewers to respond felt that the project resources were sufficient in order to achieve the project milestones in a timely fashion. Three reviewers found resources to be insufficient, and two reviewers found resources to be sufficient. One reviewer commented that ORNL has been doing the CLEERS workshop and benchmarking exercise on top of technical research on LNT/SCR/OC. It seemed that more resources are needed to achieve a more frequent and systematic benchmarking study so that they can provide valuable up-to-date information to the CLEERS work groups and partners for advanced technology development, added the reviewer. A second reviewer observed that ORNL received most of the funding due to the level of accomplishment. This person suggested that increasing funding is not necessary. Another reviewer stated that the program seemed to be reasonably funded and resourced. The final commenter did not see a large need for further resources since doing so would create a major influx of work.

CLEERS Aftertreatment Modeling and Analysis: George Muntean (Pacific Northwest National Laboratory) – ace023



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer felt that there was a good alignment with the DOE goals of reduced petroleum usage. This person felt that the team clearly communicated that what was learned would be used to help develop aging parameters for model- based control in order to develop a clear linkage to overall engine operation and fuel consumption. The following commentator stated that, through CLEERS, this project helps ensure that new ultra-high efficiency engines continue to meet emission requirements. Collaborative development of models to support lean-burn engine aftertreatment designs is a cost-effective approach, especially since the models and the resulting data are being shared, added the reviewer. The next commenter to respond believed that the CLEERS activity has been well coordinated for the overall DOE objectives, and that this project is one of few sources that promote development of improved modeling tools for aftertreatment systems. A different reviewer stated that this project also related to low temperature activity of components, which may be of particular importance and concern as the team goes forward. The project will help maintain a better focus on projects that deal with future OEM needs by having this initial work validated through individual projects with OEMs (CRADAs), stated the reviewer. The commenter mentioned that the work covered includes a number of different components (SCR, LNT, and DPF) which have relevance to both diesel and lean gasoline strategies. The last reviewer to comment insisted that understanding how lean aftertreatment devices work is critical since they lead to higher fuel economy powertrains.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer remarked about the appropriate shift to investigation of NSR materials for use in lean-gasoline applications. This reviewer noted that close collaboration with industry, universities, and national laboratories strengthens the approach. Another reviewer stated that the technical approach seemed reasonable. The third reviewer stated that PNNL's approach on the CLEERS activities was good in a way that all projects were linked to CRADAs. This person continued, saying that this suggested that they had better approach to bring science to solutions to the table. The actual implication might be limited because most projects stay in the fundamental stage of research, added the reviewer. The commenter gave an example and said that PNNL developed unique kinetic models for SCR, but it was not clear how they were going to validate their model for real-world applications. Another example is that PNNL is very strong in material characterization and their approach is perfect for understanding the existing problems, but they are not clear on how to approach the solution, added the reviewer. The next commentator felt that the work was focused on characterizing the current state of the art components such as Cu-Chabazite (SCR), but also novel Mg and K-based LNT. Benchmarking Cu-CHA catalysts from suppliers other than BASF, added the reviewer, would also be desirable to benchmark technology and performance. This person felt that there may be more relevant alternatives to improve LNT performance other than K/Mg addition. The final commenter to respond felt that CLEERS was good for sharing of pre-competitive ideas and that industry involvement kept the focus more realistic. This person added that a barrier exists with proprietary data sharing, and that will always be an issue for a group like CLEERS. The apparent overlap with the industry makes CRADAs appear to be well managed, mentioned the commentator.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers had mixed responses. One respondent felt that good progress had been made in all three project areas (i.e., SCR, NSR, and DPF). Overall CLEERS data sharing through a public website is excellent, added the reviewer. Another reviewer stated that the project team continued with strong progress. The following commentator stated that the PNNL group had made great progress in the development of the SCR model, the state-of-art SCR thermal durability study, and its characterization. This person added that the NSR (LNT) and DPF work needed a little bit more improvement in their work scope. In the U.S. market, LNT does not seem to be a viable solution for lean-burn engine applications, not because of just high temperature performance, but because of low-temperature performance and its low sulfur-tolerance, observed the reviewer. The commenter suggested that for new NSR materials, all the requirements needed to be satisfied. The reviewer also recommended including NO_x reduction data from a commercially available LNT catalyst to compare to the newly developed NSR material. The next reviewer felt that it was difficult to gauge the technical accomplishments as the material was not appropriately timed and had to be rushed. This person also added that it was clear that the transient SCR model performed very well and seemed like it could be quite impactful to adoption from OEMs. The next reviewer stated that chabazites are now a known quantity and have been available to the automotive industry. This person was wondering what was next for this project team. The reviewer stated that the current work with K-based LNTs was interesting, but added that low temperature activity was lower than Ba. This person questioned whether the Ba formulations could be improved to offer even better low temperature behavior at the same time as destabilizing sulfur components so that De-Sox can proceed at a lower temperature. The reviewer suggested that this would improve performance and fuel economy. Fuel economy must be included in consideration of material more as well as progressively less exhaust energy, added the expert. The final reviewer added that Cu/CHA SCR is not new - it went into production in April 2010 on U.S. diesel trucks. This person found the characterization of existing catalysts not at all interesting. The reviewer added that improvement in understanding their behavior is only interesting if it will lead to improvements in performance and/or a reduction in cost. This reviewer felt that modeling flow reactor data is not so interesting. This reviewer suggested that applying the model to transient data and linking it to Autonomie would be very powerful.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that there was good partnering and communication for this project, and also observed many related projects, CRADAs, and collaborations on all three main areas of future emission control. The following commenter observed very strong collaboration with industry, university and national laboratory partners, domestically as well as internationally. Significant publications, presentations, and participation in relevant annual meetings and conferences occurred, added the reviewer. The next person to comment added that PNNL has been working with a wide range of groups including OEMs and other national labs. Although we are learning more interaction and technical information exchange between ORNL and PNNL, it would create more synergy if both labs worked together on other components such as LNT and Oxidation catalysts development, suggested the commenter. Another reviewer felt that the collaborative nature of CLEERS is what the group is all about and that it was especially evident during the annual workshops. The last reviewer to comment stated that partnerships are clear, but because there was a lot of material, it was unclear what role each partner played.

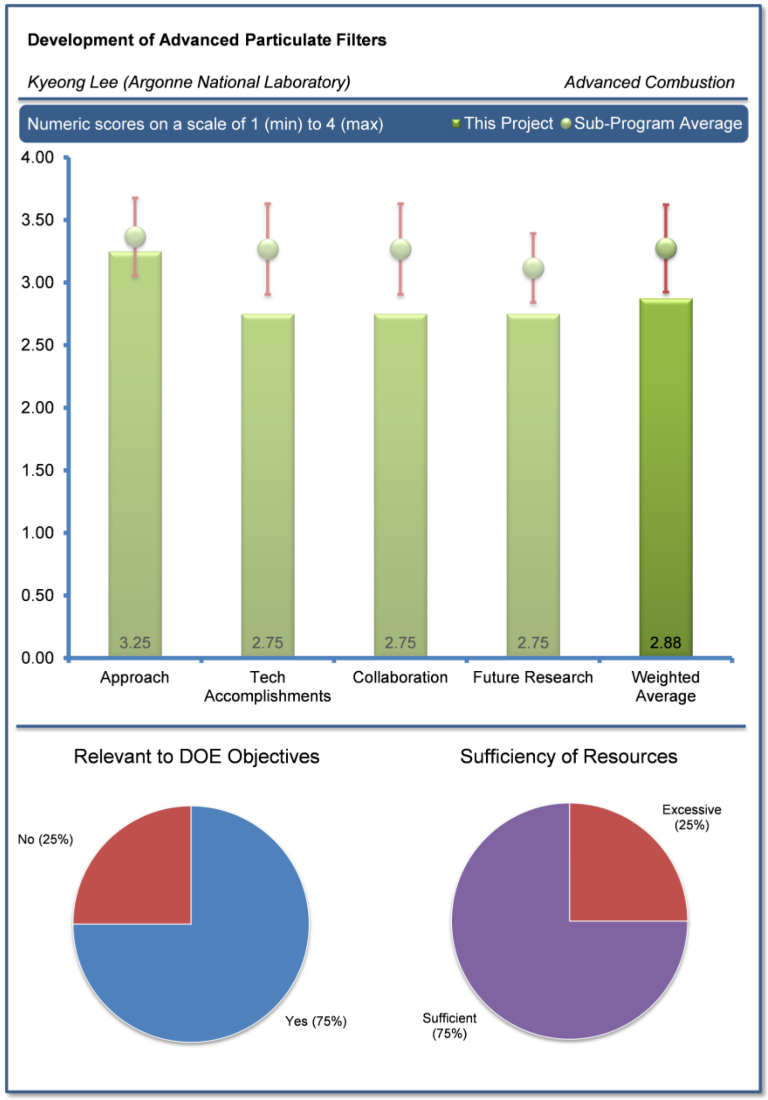
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer to respond felt that the future work appeared to logically build upon what was learned in the past. The second person to comment remarked that the focus of the project has appropriately shifted from DPF to SCR and that the development and validation of the SCR aging models was an appropriate future focus area along with the continued work in NSR catalysts and advanced DPF substrate characterizations. The following reviewer mentioned that the CLEERS projects use model catalysts unlike to CRADA, and added that it might have been difficult to work on state-of-art catalyst technologies. This person felt that it would be beneficial to understand state-of-art catalyst formulations that the aggressive benchmarking from in-house developments would provide. The catalyst technology moves quicker than we imagined, and to make the model usable in the industry, we should have a model updated more frequently and validated one step further from lab-scale reactors, added the reviewer. This person suggested that more interaction with engine dynamometer test capable partners should occur. This reviewer added that PNNL was very strong in fundamental research and hoped to see PNNL play a crucial role on the low-temperature aftertreatment technology development. The fourth reviewer to respond stated that the SCR work is of high value, although the direction into SAPO materials may not yield any benefits over the SSZ-13 type catalysts. DPF work is of higher value than LNT, believes the reviewer. This observer recommended a shift in future resources towards filters and soot control. LNT cost is the major barrier and it does not appear to be part of the work, observed the reviewer. The expert concluded by mentioning that K has issues with attacking cordierite substrates and could end up being a showstopper unless K mobility can be reduced. The last panelist to respond felt that most areas of the project were good. The expert added that the team needed to move forward with Chabazite alternatives and suggested that the project team look at improving Ba based LNTs for sulfur resistance. The reviewer concluded that there should be more DPF work, including compliant passive DPFs.

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

All six of the reviewers to respond felt that the project resources were sufficient. One of the reviewers felt that the program appeared to be adequately resourced. Another expert stated that this project was well-organized, had attainable objectives, and provided a good return on investment. The following reviewer said that PNNL seemed to have allocated the budget to individual projects in an appropriate way. The next reviewer said that the resource allocation, with a majority on SCR technology, seemed appropriate. This person added that the overall resource level seemed appropriate as well. The final respondent believed that the annual funding was consistent and commensurate with the importance of CLEERS work.

Development of Advanced Particulate Filters: Kyeong Lee (Argonne National Laboratory) – ace024



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to respond felt that this project appeared to have very clear goals regarding reduced fuel burn. This reviewer added that the additional backpressure of a DPF is a system penalty and regeneration strategies, with low temperature exhaust, could cause an additional loss of system efficiency. Another reviewer understood that a diesel particulate filter is very important in order to develop better regeneration strategies in fuel-efficient lean-burn engines. The commenter stated that regeneration requires extra fuel to burn off soot, and mentioned that the fuel penalty is closely linked to the regeneration strategy. The last reviewer to respond thought that the goals for this project definitely supported the overall DOE objectives of petroleum replacement within the strictures of emission standards. This expert questioned whether this work advanced the DOE objectives and asked if it ever repeated discoveries which had already been published in the open literature. This person also expressed that their view that this work makes no viable contribution to the DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had a range of responses. The first person to respond felt that this program appeared to be very well balanced and had a good technical approach. The reviewer added that the central focus was a GM engine which included a DPF bench top experiment, numerical modeling, and TGA analysis to provide a thorough understanding of what was happening. The next reviewer to respond felt that this group had a unique capability to image the behavior of soot accumulation and oxidation, which allowed a fully integrated approach in monitoring the behavior of soot on the filter under various conditions. Their numerical modeling strengthens the physical behavior of soot on the filter, added the expert. The following commenter stated that some of the data shown in the presentation revisited commonly known information. This person wondered why the oxidation effect of CO_2 would even be under discussion. The expert added that the results shown on Slides 8 and 9 did not seem to be worth the effort, and that for Slide 10, activation energies have been extensively studied by others and published. The reviewer noted that there is no comparison with the prior literature studies. The reviewer referenced that this complaint was made in prior years and has not been very well addressed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer felt that this program appeared to be very well aligned with OEM needs. This person added that the program also appeared to have provided fundamental data that showed the sensitivity of overall oxidation rates to exhaust gas constituents (i.e., O_2 and NO_2). This data can be used directly by OEMs to help develop a DPF and regenerative strategy, added the reviewer. The reviewer said that the program appears to provide fundamental insight, supported by optical measurements, as to the soot loading and oxidation process. This is clearly insightful and can help drive the design of better DPF substrates, added the reviewer. This person observed that the numerical modeling was well anchored to the data. This person claimed that this was also valuable to the engineering community. The commenter was encouraged to see that a PI can make a firm technical statement regarding the need for catalyzed DPF. Forming a technical opinion is not always easy based upon the fundamental nature of the data collected; however, it is very valuable to the OEMs, stated the reviewer. Another commenter said that they have not seen any new technical accomplishments compared to what was already in the literature. The following reviewer mentioned that soot oxidation enhancement by NO_2 is not new information. The expert added that the kinetic parameter comparison at various temperature regimes that resulted from this work was very useful information. The last reviewer wondered whether this approach and these conclusions could be applied to gasoline direct injection particulates.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer remarked that there seemed to be substantial industrial support for this work. Another person added that, although this research group listed a number of partners for this project, it was not clear what are their roles were on the project. This reviewer wondered how much ANL's approach was distinguished from the development of a kinetic model for DPFs done by PNNL. This person stated that it was clear that ANL had a unique capability for the DPF-related research and that there may be a great synergy for both PNNL and ANL if they could find a way to work together on the DPF-related projects. The following reviewer felt that the work being conducted through a CRADA made it difficult to judge collaborations and how the information is disseminated to OEMs outside of the CRADA. The final reviewer to respond stated that the slides spoke of collaboration, but the specific roles the collaborators were not covered, making it unclear as to whether this was a truly collaborative effort. The project very well may have been, but it was unclear to this reviewer.

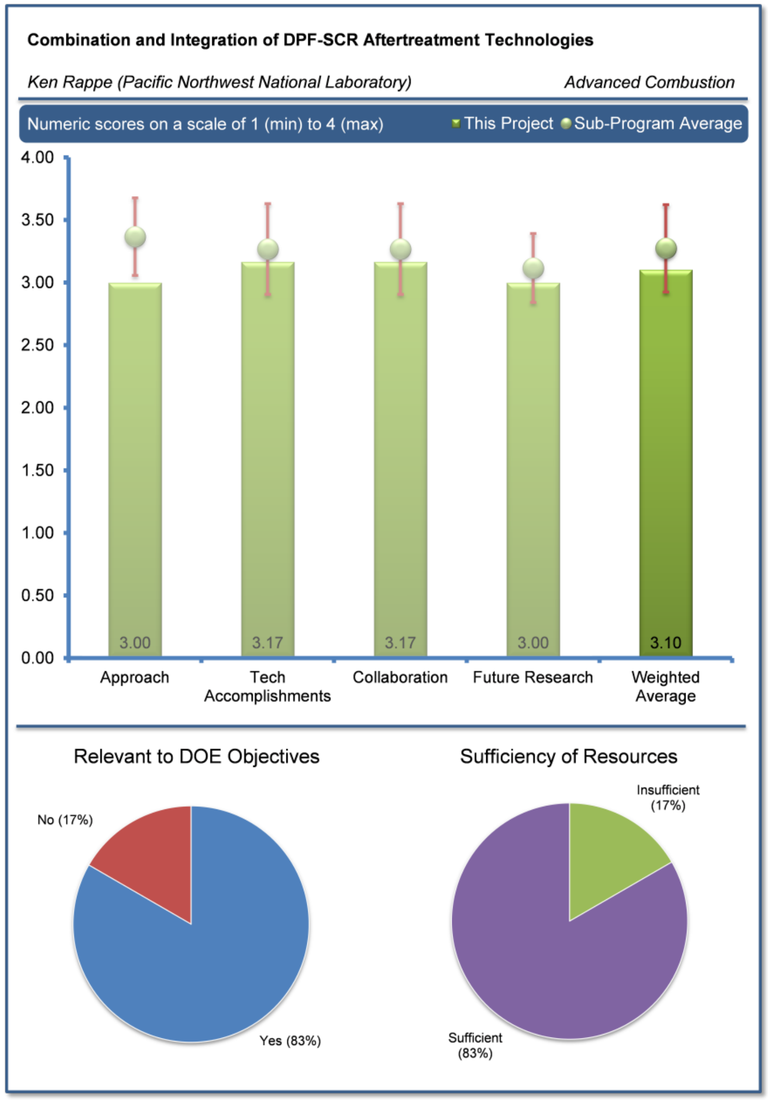
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the group's plan on a 2-way DPF was very appropriate as the next step. Another expert said that future work appeared to be laid out well and built upon past efforts. The last responder to comment said that there was no reason for this project to be continued.

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

Three of the four reviewers felt that the project resources were sufficient in order to achieve the project milestones in a timely fashion. One reviewer felt that the resources available were excessive. The first commenter felt that the budget ($250,000) seemed to be low based on the scope of project, but thought that the team delivered an excellent amount/quality of work. The next expert to respond stated that the accomplishments over a five-year period appeared to be very good and well-matched to the resources. One respondent believed that it was apparent that there was substantial industrial support for this program. The reviewer preferred for it to become 100%, and mentioned that the DOE should exit supporting this program.

Combination and Integration of DPF-SCR Aftertreatment Technologies: Ken Rappe (Pacific Northwest National Laboratory) – ace025



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to comment felt that this project was aligned with DOE goals. This person believed that the adoption of vehicles with lower emissions and lower fuel consumption was going to be well balanced by the overall system cost and complexity. As the program seeks to simplify the overall aftertreatment system via the combination of a DPF and SCR, it is well aligned with the DOE goals of petroleum displacement, added the reviewer. The following commenter felt that it was a good choice in using Urea for SCR and passive soot regeneration for improved fuel economy. This reviewer also felt that this enabled technology for use in LDD and HDD while meeting emissions and fuel economy standards. Another reviewer said that understanding diesel particulate filters is very important in order to develop better regeneration strategies in fuel-efficient lean-burn engines. The next reviewer to respond stated that by integrating DPF and SCR functionalities into a single device, the project has the potential to reduce the negative effects of aftertreatment on diesel engine efficiency. The last reviewer felt that the project did not really support the overall DOE objectives of petroleum displacement. This person added that the combination of SCR and filters, for a more compact aftertreatment system, would enable application in space-constrained applications and could improve fuel economy if the backpressure is less than the system with separate components. The expert stated that in order to get a high NO_x conversion, a relatively high washcoat would be needed to increase backpressure, thus reducing fuel economy. The SCR reaction will compete with passive soot oxidation through removal of NO_2 that may result in more forced regenerations and a lower fuel economy and will be application specific to understand if there are any advantages to DOE, added the reviewer.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers had mixed comments on the approach; some reviewers offered suggestions. The first reviewer felt that the technical approach was sound. This reviewer observed that it began with learning at the small scale and eventually pushed the technology to engine testing. The second reviewer mentioned that this is highly evolving field of work and the approach was appropriate as it was guided by the project partners, DAF and PACCAR. The third reviewer felt that the projected adequately addressed the technical barrier of pressure drop and mentioned that they used NO_2 as a soot oxidation pathway. There has been a lot of work in this area already, added the reviewer. The reviewer continued, mentioning that there is a need to be able to balance the SCR's need for NO_2 as well as a use for it for soot oxidation. The reviewer added that PI has not looked at biodiesel blends, which will be more important in future fuel stocks and the effect on a DPF/SCR component (during regeneration). Going forward, that will be a concern related to NO_2 oxidation, the reviewer added. The observer felt that due to the composition of biodiesel, there would be differences in the soot morphology and that it might be beneficial to know the NO_2/O_2 reaction pathways. The fourth reviewer believed that there have been a lot of interests to understand a c-DPF system in industry. The expert added that there is limited information on how the accumulated soot layer affects NO_x efficiency over SCR catalysts as well as pressure drop. Having a catalyst supplier (BASF) in the project approach is very good for ensuring that the catalyzed filter was prepared in very duplicable manner, added the commenter. The final reviewer to respond felt that the close cooperation with substrate and coating suppliers gave this project a higher value than in the past, but the goal of retaining passive soot oxidation may not be possible depending on the balance of NO_x versus soot control. Reliance on NO_2 can be expensive if a high Pt catalyst is needed upstream, and Cu itself is a poor NO oxidizer, mentioned the reviewer.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first responder felt that good progress had been made on the modeling of wall-scale transport effects. Another reviewer stated that the work was very interesting. The reviewer observed that important learning has been gained which suggests where the SCR should be physically located (upstream or downstream of the DPF), and that the overall catalyst amount would have significant impacts in the overall pressure drop of the system, which is one of the key barriers. It is unclear from this work whether milestones have been met on schedule, added the reviewer. The reviewer stated that, despite the actual milestones seeming reasonable, it appears that a significant amount of work must happen in the last part of this fiscal year. A third reviewer felt that the cost reduction opportunities were not adequately addressed. The fourth commenter believed that the project required more characterization of fuel blends to be useful for future vehicles and wondered how the project would benchmark BASF technology to other suppliers for reference. The next panelist felt that project focus was on the right things for HDD application, primarily the compromise between NO_x reduction and soot oxidation. The panelist added that the speed of progress has improved, but is still slow. The final reviewer observed that soot oxidation behavior as a function of SCR washcoating was not very clear, and mentioned that it would need a little bit more systematic study to look at the NO_2 effect. This reviewer noted, for example, that the NO_2 ratio was compared between 0.33 and 0.5 when there was 90 g/L of SCR washcoat. The reviewer stated that the team then compared 0.5 vs. 0.65 when the catalyst washcoat was 150 g/L (not 90 g/L). The reviewer wondered how the project can we be sure that there was no change in NO_2 effect between 90 and 150 g/L of SCR washcoat.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers observed good collaboration with a range of collaborators. The first commenter to respond felt that the work appeared to be very collaborative in nature in terms of OEM and substrate manufacturer and catalyst supplier organizations. Another expert felt that there was good collaboration with a truck and an engine manufacturer as well as a university and several industry aftertreatment partners. Collaboration roles are well defined and match partner core competencies, added the reviewer. Another reviewer reiterated that supplier involvement is critical to this project. The following commenter liked how the project partnered with experts in all areas; OEM, university, catalyst supplier, and filter supplier. This perfect team has a great potential to elucidate a lot of information on the evolving c-DPF technology, and their findings will make a big impact on the next generation SCR systems for both LD and HD applications, stated the commentator. The final reviewer to respond mentioned that this project would benefit from looking beyond current sources of material for newer innovations in filter material; however, even more recent innovations such as ACM filters have also been widely studied.

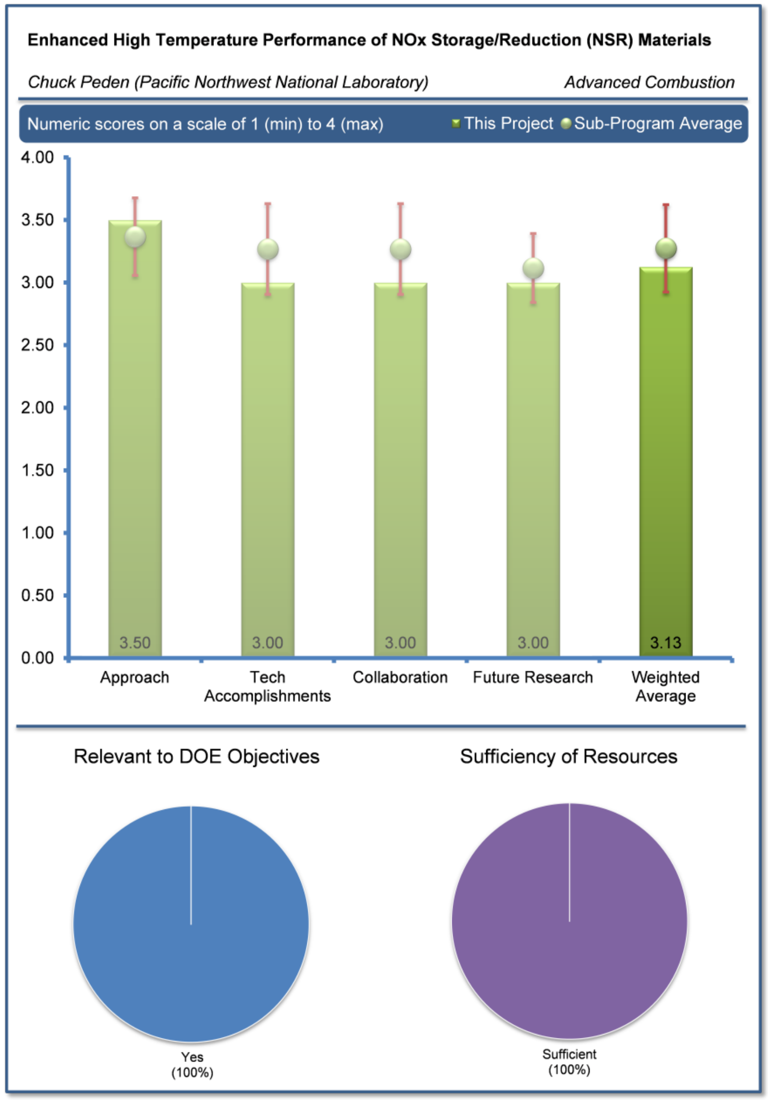
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer to comment felt that the PI is correctly widening substrate investigation beyond Corning cordierite, such as ACM, which has been investigated by Johnson Matthey and PNNL. The reviewer believed the results would be useful. The reviewer also mentioned that it would be of interest to find SCR formulation that are able to accommodate active components into the pore structure so that higher loaded formulations would not be needed. The second commenter to respond reiterated that many OEMs are interested in c-DPF for their lean-burn engines because the catalyzed filter provides a number of benefits; however there are unknown issues such as NO_x efficiency, pressure drop, and so on. This person added that this project has a right direction and scope of the research to contribute to improving the c-DPF technology, and with success their findings will make a big impact on the next generation SCR systems for both LD and HD applications. A third reviewer observed that appropriate future work included passive and active soot oxidation in full-scale engine tests. Another reviewer felt that a 650°C aging temperature seemed low for a system that would have to eventually be regenerated in an active manner. This person also felt that the reducing aftertreatment cost reductions were not clearly addressed, especially in light of tuning an upstream DOC for higher NO_2. The reviewer concluded that backpressure reduction is needed and was not properly addressed.

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

One reviewer felt that the budget seemed to be insufficient. Five reviewers felt that the project resources were sufficient. A respondent agreed that the overall funding seemed appropriate with the 50:50 cost share. This reviewer observed that the project team received $3.2 million over four years, with $875,000 received from DOE in each of the past three years, meaning that $725,000 from DOE is left in the last (fourth) year. The reviewer stated that this is consistent with full-scale engine testing starting now. The second reviewer to respond stated that just over half of the DOE funding share has been received over the first three out of four years of the project. The reviewer was unclear if that is the indication of progress or if it is in-line with anticipated project spending. The final reviewer to respond mentioned that the project ends in 2012 and was not sure on future funding. If so, the project should incorporate looking at biodiesel blends as well, added the expert.

Enhanced High Temperature Performance of NO_x Storage/Reduction (NSR) Materials: Chuck Peden (Pacific Northwest National Laboratory) – ace026



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer mentioned that high temperature lean NO_x aftertreatment will enable light-duty lean-burn engine technology to improve fuel economy. Another reviewer stated that potassium-loaded NSR catalysts are being more extensively explored by catalyst suppliers. The reviewer added that future catalyst will most likely be a combination Ba-K catalyst. This work isolates the response of the potassium with both an alumina support and magnesium aluminate support, mentioned the reviewer. This person also added that these technology improvements can make NSR catalysts more commonly used on a production vehicle. The final reviewer to respond stated that the focus of this program is on mitigation of NO_x emissions, not on petroleum displacement. Specifically, the objective is to evaluate the performance and stability of NSR catalysts for high temperature operation and minimize the amount of precious metals without compromising performance and stability, added the reviewer.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commentator to respond stated that PNNL is primarily characterizing the performance of NSR catalysts with a focus on different supports on activity and the deactivation mechanisms relevant at high temperatures. This person observed that Cummins will provide performance testing of NO_x systems; yet representative results were not included in this presentation. The panelist added that Johnson Matthey is synthesizing the catalysts and characterizing them in engine dynamometer tests. Results from Johnson Matthey testing's were not included, yet should be in future presentations to at least compare to the model systems studied at PNNL ($K/Pt/Al_2O_3$ and $K/Pt/MgAlO_x$), suggested the reviewer. The expert mentioned that the characterization work done at PNNL and their approach for assessing the role of the support and aging on the model catalysts is reasonable. Interestingly, as the authors noted, the results were not entirely intuitive (such as the high NO_x uptake in the aged and reduced 10K-Pt-MG30 sample) and should be further explored, added the commenter. The following reviewer noticed that the approach leverages a wide range of prior work from PNNL. Nothing new was introduced in this project, added the expert. The reviewer mentioned that this was not necessarily a negative thing since it was evident that a clear indication that potassium is a viable NO_x storage material. Unfortunately, no results on sulfur poisoning were presented, mentioned the expert. This person also added that potassium is known to be very sensitive to sulfur. The last reviewer stated that the effects of high temperatures on precious metals had been looked at by others, and questioned why the team is repeating this. The expert understood that new storage materials were going to be researched, but mentioned that PGM is not new. The reviewer suggested trying to make sure that the PGM experiments are related to the new storage elements.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer found that the activity of the 10% potassium-supported catalyst to be quite unexpected. The expert believed that this has the potential of being a major technological accomplishment and hopes that it is supported by future work. The reviewer added that the poor NO_x uptake after aging was not a good sign for this to be a major technological accomplishment. The magnesium-supported activity does give some added hope that this is a viable technology, added the expert. The following reviewer noted interesting observations on the performance of Al_2O_3 and $MgAl_2O_4$ supported catalysts (as noted their high NO_x uptake), yet the reason for the high activity following aging and reduction for the NG supports was not apparent. The expert also stated that the improved stability with the MG samples was also demonstrated in the TEM images. The final reviewer was unsure how higher K loadings would help the technology and wanted to understand it better. The reviewer also expressed concern that K has been shown to migrate into cordierite at high temperatures, 650°C and up. This would be a problem when DPF regeneration or $DeSO_x$ is performed, added the reviewer. This person also mentioned that K has been shown to be more difficult to desulfate, and further reported 700°C and up to really get it reduced.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers had mixed feedback on collaboration. One reviewer felt that the collaborations and interactions with others on this project were very strong and well thought out. Another reviewer felt that PNNL had done a nice job characterizing the model catalysts. The expert added that the technical contributions of the other partners was not really discussed or highlighted in this talk and that it would have been nice to learn more about the performance of the Johnson Matthey catalyst. The expert thought that this could have been done without revealing any proprietary information on its composition or synthesis technique. The last reviewer to respond felt that this presentation showed very little collaborative activity.

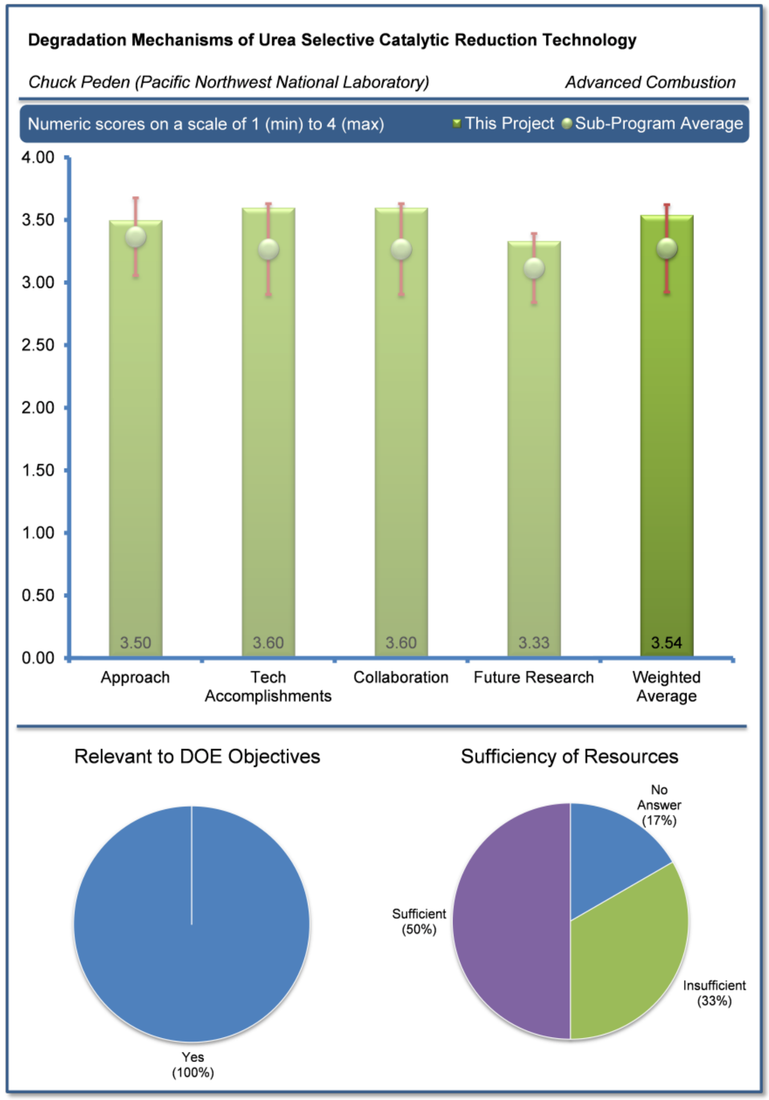
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer remarked that continuing the evaluation of this discovery is a primary focus of future plans. This reviewer strongly agreed with this approach. A second reviewer to comment suggested that as emission regulations come down, it would important to make sure that low temperature catalyst performance is also enhanced. The expert stated that the experiments seem to start at 250°C, and suggested that it would be nice to see how these new catalysts perform at lower temperatures. Testing down to as low as 150 °C would be good, added the reviewer. The last reviewer to respond mentioned that this program ends in September 2012. According to this expert, a preliminary list of future work activities was presented, including further characterization of the MG and alumina supports and continued characterization of the Johnson Matthey catalysts. This seemed reasonable to this reviewer, but the project would need a more detailed plan if funding for three additional years is requested.

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

All six of the reviewers to respond felt that the project resources were sufficient. The first reviewer to respond believed that the funding appeared to be sufficient. A second reviewer said that it appeared that the resources are adequate. The third expert mentioned that this work was supported through a CRADA and also through the CLEERS program. This reviewer stated that the reviewer was not involved in the CLEERS program and suggested that it would have been nice to know what fundamental work was being done in the CLEERS program and how it compliments this work.

Degradation Mechanisms of Urea Selective Catalytic Reduction Technology: Chuck Peden (Pacific Northwest National Laboratory) – ace027



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer agreed that the project supports the overall DOE objectives, and that the PI's work with GM on a diesel urea SCR system is relevant and important to the industry as a way of achieving emissions standards without sacrificing a significant fuel penalty. A second commenter stated that the focus of this program was on understanding the deactivation mechanisms responsible for urea SCR and DOC catalysts and to validate a rapid laboratory aging protocol for assessing the deactivation of the catalysts used to mimic real-world vehicle test data. This person also mentioned that the focus has been on characterization of the catalysts' performance, not directly on emissions reduction. The next reviewer agreed that this project supported the overall DOE objective of petroleum displacement through a better understanding of deactivation mechanisms in commercial SCR and DOC catalysts, enabling compliance of high-efficiency lean-burn engines with emissions standards over the vehicle life. The last reviewer to respond stated that lean aftertreatment enables higher efficiency lean burn engines, which is a reason why catalyst durability is crucial.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent felt that this was a highly focused project with well-established and achievable results, and that the team has very good direction and management. The following commentator stated that the project is utilizing PNNL's core capabilities in catalysis expertise and IIC testing facilities. This reviewer noted good delineation of tasks between PNNL and GM leveraging each other's expertise. This project helped GM commercialize DOC/SCR system in 2011, added the reviewer. Another commentator explained that PNNL is working with GM to characterize their DOC and urea SCR catalysts in an effort to better understand the deactivation mechanisms and validate the rapid aging lab tests to ensure that these can be used to accurately assess the catalysts' long-term performance in a vehicle environment. This expert added that PNNL has applied their suite of tools to support catalyst characterization and aims to help better understand the deactivation mechanisms for loss of catalyst activity to extend the lifetimes of the catalysts tested (and provided by GM). A different reviewer stated that DOC testing for HC activity was done with only propylene. The activity would be better tested with a broader spectrum of HC that are present in diesel exhaust, reiterated the reviewer. This person continued, stating that the light off characteristics will change, that DOC is an exotherm generator and that the testing did not include that condition which further stresses the catalyst. The last commentator felt that the close collaboration with OEMs helped to properly scope project and develop relevant objectives.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer said that the project had been completed within the given DOE budget, on schedule, and had achieved its three main objectives. Another expert reiterated that many aspects of the objectives were achieved for this project. The reviewer stated that both the correlation of lab aging with vehicle aging for the SCR and the characterization of the aging mechanism are technically important topics. This person suggested that it would be interesting to know more on the abrupt deactivation mechanism for the SCR as seen in XRD. With respect to the DOC, progress was made on the deactivation mechanism defined by bench and analytical work, added the reviewer. This person mentioned that some elements, though, were not investigated due to time. The reviewer explained that the Pt/Pd particle structure, and surface versus bulk composition, would have been of interest to know in terms of activity and performance. The next reviewer to respond noted that PNNL had applied their suite of catalyst characterization tools to better understand the deactivation mechanisms for SCR and DOC catalysts. The results for SCR catalysts highlighted the importance of agglomeration of the catalyst particles, while sintering and soot accumulation were shown to be issues with DOC catalysts, added the reviewer. This person also suggested that it would be useful to have more information on the catalyst (primary particle size) without infringing on proprietary information. The reviewer also suggested that it would be useful to know more about the 135,000 mile vehicle test protocol since there would be a lot of variability depending on the test procedure. Another reviewer thought that it was very nice work to see the chabazite zeolite falling apart and that the project had enough data to get a NTE temperature. The last respondent to comment thought that there was good understanding of the dominant aging mechanism of diesel catalysts – time at temperature. Testing in a reactor gives some indication of aging level, but the definitive test would be on vehicle, added the expert.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers cited good collaboration, particularly with GM and PNNL. The first reviewer agreed that close cooperation between PNNL and GM was evident. Another respondent observed that there was very good collaboration between PNNL, Cummins, and GM. This person believed that the project was well-structured to achieve SCR aging results that were useful for vehicle applications. The expert added that there was a very good comparison between laboratory bench work and vehicle aging to achieve correlation of SCR performance, as well as for the DOC that GM is now using as a lab aging protocol to represent vehicle in-use data. The reviewer noted that goals were well-defined and achievable within the timeframe. The third reviewer commented that there has been good collaboration with GM throughout the project. The final reviewer reiterated that PNNL appeared to have a good relationship with GM and is essentially subsidizing their research and development with DOE funding.

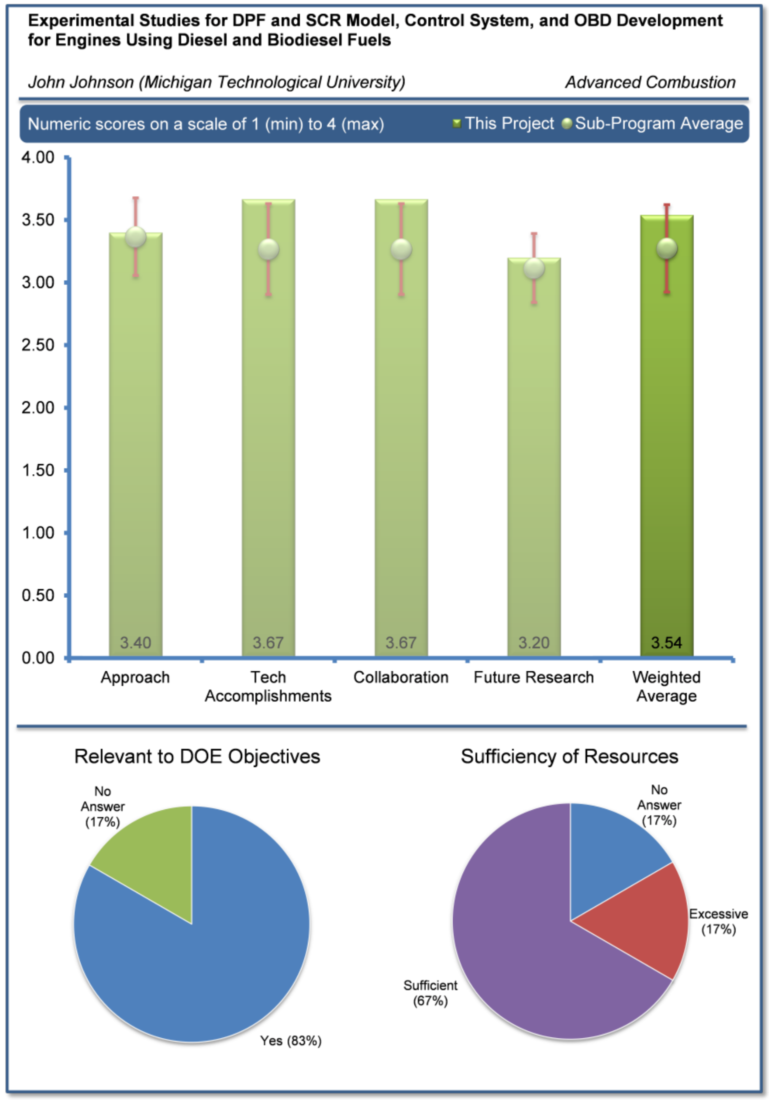
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer stated that the project is completed. The expert added that some ideas were proposed for a new project, such as chemical poisoning effects, and that vehicle level results with aged catalysts is needed. Another commentator mentioned that the PIs have achieved the main objective of this work and that there was no extension of work required. An aging protocol was developed as a result of this work and the mechanism by which the SCR and DOC deactivate as a function of time, added the reviewer. The last reviewer to comment said that no future research was proposed as project has been completed.

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

Two reviewers found that resources are insufficient. Three reviewers felt that the project resources were sufficient. The first reviewer remarked that the lack of time and funds required a highly focused project because funding was lower than what should have been allocated. A large amount of data was obtained for the time and resources allocated to this project, added the reviewer. This person concluded by saying that this project was a very good return on investment. A second reviewer felt that the resources seemed sufficient. The following expert stated that the project was successfully completed with allocated funding.

Experimental Studies for DPF and SCR Model, Control System, and OBD Development for Engines Using Diesel and Biodiesel Fuels: John Johnson (Michigan Technological University) – ace028



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the overall objective was to develop aftertreatment technologies for emissions reduction while minimizing the penalty associated with using these systems. This expert observed that the objective-specific approaches that had been detailed in the presentation included: the kinetic studies on the oxidation rate as a function of the operating parameters; the acquisition of test data for different operating conditions; the performing of reactor studies in well controlled conditions to evaluate storage in SCR samples; and the development and calibration tuning for the associated models. This person continued to explain that the emphasis of this project was the development of control strategies for these aftertreatment devices. Another reviewer stated that this project was working on new models for SCR and DPF for controls with and without biodiesel fuels, which was believed to help develop technology faster. The expert added that diesels would provide improvements in fuel economy and CO_2 emissions. The third respondent to comment stated that the program intended to develop a computer model and control scheme that incorporated feedback from various transducers and submodels to be able to determine the state of an integrated aftertreatment system, thereby optimizing the fuel dosing for DPF regeneration. This reviewer believed that, if the scheme works as intended, the project may potentially reduce fuel consumption in engines used for transportation applications. This person explained that additional benefits may accrue by reducing inefficiencies resulting from high backpressures from loaded DPFs. The final respondent that commented believed that the approach to developing the control strategy with all the hardware in the loop was great. This person added that this would directly connect the basic simulation work with the integrated control system, making the project unique and very worthwhile.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One commentator felt that this was a uniquely integrated project. The reviewer was impressed that the PIs were able to coordinate all the pieces of this project and make them fit together and that the project could not have been done better. Another reviewer said that project appeared to be well organized and had a good suite of collaborators. This person also added that the cycle-based transient dynamometer testing was good. The following commentator stated that a detailed approach (task-level) was presented, and that overall, the program is rather comprehensive – detailed tasks had been reviewed and provided for a well-integrated/comprehensive program. The reviewer was interested in learning more about the models (or optimized model) and their ability to deal with transients (work planned for this year). The next reviewer to responded thought that the overall impression of the proposed effort was that it was an engineering approach of optimizing the performance of a system by developing submodels for the components. There was no specific novelty to this approach other than the fact that it paved the way for developing control strategies for optimal performance given the fact that various sensors are still under development, added the reviewer. The last commenter to respond wondered if this work enables the aftertreatment architecture to change. This person also asked whether the SCR could be placed in front of the DPF to better represent light-duty systems for faster NO_x light-off. Finally, this reviewer also asked whether the model could be used to construct any type of aftertreatment system and still produce good data.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One of the reviewers stated that the significant accomplishments to date were focused on kinetic studies and the development and calibration of reduced order models with experimental test data. The following reviewer found the progress in stated technical tasks to be adequate. The expert pointed out that it was yet to be demonstrated that this approach had made any progress towards achieving the DOE goal of reduced fuel consumption. Another commentator thought the estimators seemed successful. The next reviewer to comment thought that none of the individual accomplishments were especially noteworthy; however, the ability to make advances as needed was quite impressive. The final commenter to respond stated that the current work was using a Fe Zeolite model calibrated using ORNL reactor data to a Cu Zeolite model using engine data. This person questioned if vanadium could be added to the model.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers generally saw good collaboration. The first reviewer felt that there was very good collaboration. This expert wondered if the project has approached any other sensor companies. The following reviewer felt that the integration of the various parties to this project showed a very high degree of collaboration, as well as the fact that John Deere was now beginning to integrate the control system into a prototype system. The next commentator to respond thought that the partnerships seemed well-structured and thought out with involvement from industry, OEMs, academia, and government labs. The last reviewer to comment stated that the net outcome of this effort was that a number of candidate PM sensors get to be evaluated. However, the engagement of the rest of the team members is small, according to this reviewer

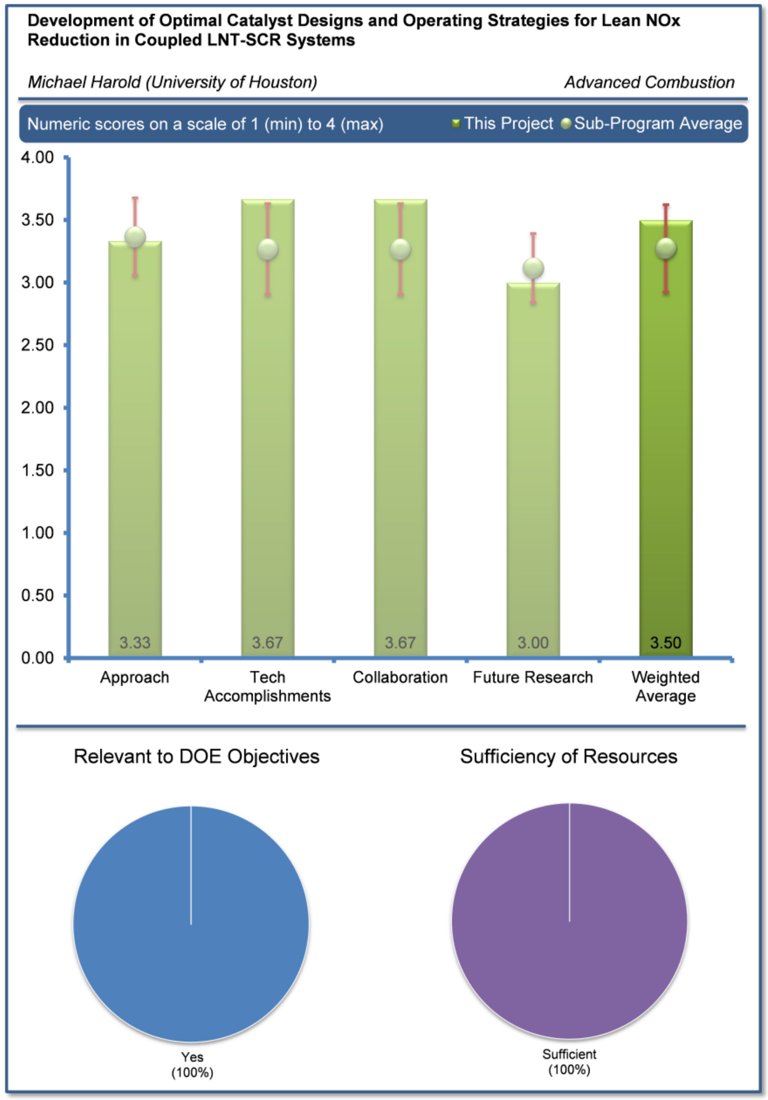
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One of the reviewers felt that this project was on track to finish on time. This person added that, occasionally, the milestones have been adjusted to be achievable. That certainly is a measure of a successful project, added the expert. The second reviewer to respond said that, while the tasks recanted in the presentation are appreciable, it would be advisable to direct those efforts to result in an integrated model that would help reduce fuel consumption in an engine. The following commentator stated that a detailed task-level plan forward was highlighted, as was seen by this reviewer as comprehensive. The reviewer was interested in learning more about transient response of the models. The last reviewer to comment wondered what the plan was to help reduce NH_3 slip in the model. This expert also wondered how the project was planning to account for drop to idle DPF regeneration in the model.

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

Four of the five reviewers to respond felt that the project resources were sufficient. One reviewer felt that the resources available were excessive. One reviewer thought that this group appeared to be meeting all their milestones. The expert added that they could not see them adding much to their plan without causing chaos. This person mentioned that it seemed there were sufficient resources to accomplish their goals and that no additional resources, in any area, were needed at this point. The following reviewer thought that this is a rather large program with the lion’s share going to Michigan Tech. The next commenter to respond saw no issues with the current resources. The last reviewer to comment found the funds allocated to be excessive when considering the magnitude and extent of the testing and modeling work that was involved.

Development of Optimal Catalyst Designs and Operating Strategies for Lean NO_x Reduction in Coupled LNT-SCR Systems: Michael Harold (University of Houston) – ace029



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to respond stated that this project was relevant to future diesel or lean-burn engines. The expert added that the main concern was how much fuel economy would be saved using LNT technology in front of an SCR to generate NH_3. This person also stated that the deSO_x of the LNT would also impact fuel economy and CO_2 emissions. The following commentator agreed that the project supported DOE objectives, adding that, for light duty vehicles, achieving NO_x emissions standards for lean applications without Urea by employing passive HC regeneration appeared to be a viable pathway. This person felt that an important feature would be to achieve this performance with as little impact on fuel economy as possible. This is an enabling technology to achieve both future emissions and fuel economy standards without the introduction of a second onboard fuel, remarked the commenter. A third reviewer stated that the overall objective of this program was to develop a LNT/SCR system to reduce NO_x emissions in diesel and lean burn gasoline engines without the need for urea based systems. An additional expert agreed that this project supported the overall DOE objectives of petroleum displacement by the development of LNT/SCR for enabling high-efficiency lean burn gasoline vehicles. Another reviewer commented that this project intended to develop a close-coupled LNT/SCR aftertreatment system that could be an enabler for lean-burn gasoline engines that have substantially higher efficiencies as compared to the traditional stoichiometric engines. The final reviewer to respond added that lean NO_x aftertreatment enables higher fuel economy powertrains.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer to comment felt that the research team had clearly identified the technical issues and pursued a research effort with a clearly identified pathway. Another commentator believed that the team’s approach combined focused experiments that were complemented by models tuned through simulation of experiments to identify optimal LNT/SCR design and operating strategies. The following reviewer added that the approach was very sound and was relevant to the automotive industry. This person mentioned that there were multiple combinations reported in the community now involving the arrangement of the LNT and SCR components to achieve the required emissions results. The expert suggested that the PI should investigate the impact of LNT deSO_x temperatures on those LNT/SCR combinations where the two components are in close contact. Having a HC trap so close to an SCR layer may damage the activity of the SCR from experiencing high temperatures, added the reviewer. This expert stated that novel Ba based LNT formulations that lower the desulfation temperature would be of interest. This person believed that the investigation of N_2O production by the LNT was very timely since it was a growing concern in the CLEERS community. The next reviewer to comment stated that the approach aimed to understand the mechanisms for NO_x reduction in LNT/SCR catalysts thru experiment and tuned reactor modeling and then optimize the catalyst and that efforts to extend or at least understand the operation at low temperatures and minimize the amount of PGM have been highlighted as principal objectives and challenges. The following expert to comment stated that the application of LNT and SCR have significant barriers including sulfur storage and thermal stability during $deSO_x$. This reviewer noted clearly that the SCR must also survive, but that it was unclear to this reviewer if ZSM-5 is capable of surviving deSOx conditions. The expert also mentioned that ZSM-5 may also suffer from HC storage in diesel exhaust and could cause damage from the resulting exotherm if it was the top layer of the catalyst and that it was not clear if the layering or zoning approach of LNT and SCR would result in an overall cost savings over LNT. Cost is a major barrier to the use of LNT, mentioned the expert. The last reviewer to respond stated that LNT-SCR systems would work, however, the PGM cost would be a concern. The expert also suggested that they would like to see some details with PGM levels that would be used to meet lower emissions standards.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally saw good progress; some also offered suggestions. One reviewer stated that good progress had been made on several different tasks and that there was a significant technology transfer through publications, presentations and lectures. The second commentator stated that showing the importance of where and how large the Pt particles are was important in ammonia generation. The expert explained that larger particles further apart reduces LNT conversion, but makes more NH_3 for SCR catalyst. This expert further reported that higher dispersion closer together makes more N_2, but leaves less NH_3. The third expert to comment felt that there was very good progress in understanding NH_3 generation mechanisms involving Pt loading and dispersion. The reviewer observed that the team surveyed a wide variety of SCR catalysts for downstream NO_x control while also investigating LNT catalysts. This person added that the results on lean rich control strategies were very good. The fourth commentator observed that the technical work had led to a greater understanding of how LNT and SCR can work together. Cost may still be a major issue to the implementation of this technology, especially with multiple washcoat layers, added the reviewer. This person also felt that the durability was also a major concern and not clearly addressed, most notably the effect of $deSO_x$. The fifth expert to respond thought this was a very productive research group. This person added that both modeling and experimental data was obtained for the LNT validation. The expert observed that the tuning of the model showed very good agreement with one another. For the SCR, a dual layer and dual-zone catalyst systems were also explored in an effort broaden the operating range of the catalyst, added the expert. For the LNT/SCR catalyst work, interesting results were obtained using ceria (suppressing Pt migration from the SCR layer to the LNT layer). This reviewer did not completely understand the physics for why this occurred, and felt that it seemed to be a promising approach as it may enable more NO_x storage at lower temperatures. The sixth reviewer felt that the progress on individual technical goals was outstanding. The expert suggested that, after the individual issues are adequately addressed, efforts ought to be directed in determining the system overall performance. These are however scheduled for the coming year, mentioned the reviewer. The last reviewer to comment felt that the rich cycling of the LNT only contained H_2, which was unrealistic with a real engine. H_2 only will enhance low temperature performance of the LNT, but when CO is added it inhibits the low temperature performance, stated the expert. This person suggested that additional exhaust gas constituents should be added to make it more realistic.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first commentator to respond said that there was excellent coordination and collaboration with four other partners in this project to achieve meaningful results. This person observed that there was very good use of facilities and assets. The following reviewer stated that there was very good collaboration with the University of Kentucky (UK), ORNL, BASF and Ford, leveraging each partners core capabilities. The next expert agreed and stated that the researchers have adequately leveraged the technical expertise developed in-house and elsewhere. The next reviewer said that it seemed like a complementary group of academics, researchers at DOE labs and industry. This person added that DOE labs performed primarily characterization and experimental measurements, the academics performed both modeling and experiments, BASF provided the catalysts and related expertise, and that Ford provided the application and integration of the technology pending successful results from the study. The final commenter to respond stated that the numerous partners appeared to be well-managed and include university, national lab, supplier and industry. The reviewer commented clear separation of tasks and responsibility. The last reviewer to respond saw no issues with the collaboration.

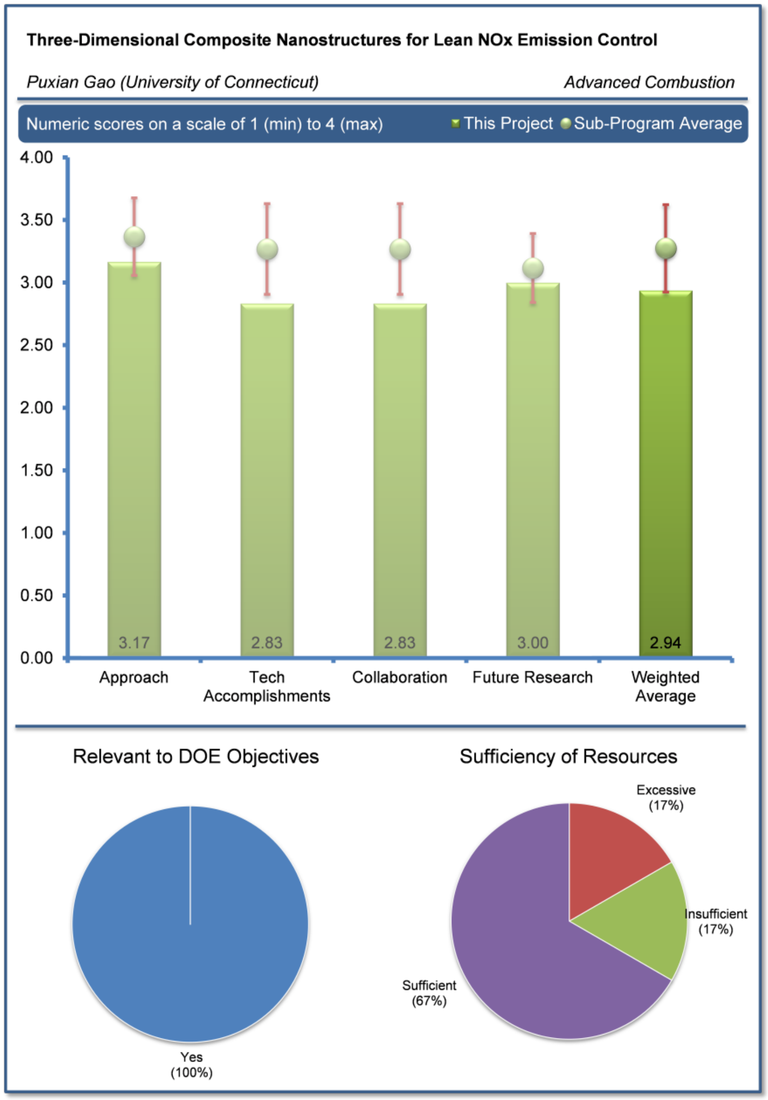
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first expert to comment felt that the project was nearly complete. Another reviewer added that the project was very good. The following commenter noticed that, according to the schedule in the presentation, a significant number of activities remain to be completed and added that the project seemed on track for completion by the end of FY 2012. Another reviewer suggested adding some characterization work on the effect of regeneration of the LNT to understand the effect on the downstream SCR. The last reviewer to respond felt that there was a need to look at HC mixtures in the feedstock. This person suggested that biofuels should be considered in future work. The expert added that higher temperatures should be looked at for aging the SCR if the LNT was going to be used to generate heat for a downstream DPF regeneration.

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

All six reviewers to respond felt that the project resources were sufficient. One reviewer felt that this project was an appropriate R&D topic and was well organized and showed a good use of resources. The second reviewer to respond felt that this project was a good return on investment. Even if this effort was not to result in a successful product, the knowledge base developed is invaluable; however, the progress trajectory indicates substantial progress, added the commenter. The third commentator to respond felt that the project appeared to be coming in right on budget and complimented the project, indicating that a good job was done. The fourth reviewer said they saw no issues with the project. The fifth expert stated that this project had a significant budget but included work from five different partners. The last reviewer to respond added that this project is roughly $2.2 million, $687,000 of which is going to Mike Harold group and partners. This reviewer wondered if the difference is distributed among the other partners, and would like to know how so. This was unclear to the reviewer. This reviewer trusts that the level of effort of the other partners would be commensurate with their activities and contribution to the program.

Three-Dimensional Composite Nanostructures for Lean NO_x Emission Control: Puxian Gao (University of Connecticut) – ace030



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer to respond stated that the technology pursued here, if successful, could be an enabler for lean-burn gasoline engines that potentially have 20-30% more efficiency as compared to the traditional gasoline engine. This expert added that, as a result, the effort pursued here confirms to the overall DOE goals of energy and fuel savings. The second reviewer to respond stated that the goal of this project was to reduce the cost of the aftertreatment system by reducing or eliminating the precious metal in the catalytic converter. The next commentator mentioned that new catalyst development for low-temperature lean NO_x control was crucial to meet future emission targets with advanced combustion system for high efficiency. The next reviewer added that lean NO_x control is very important and by reducing the usage of Pt-group metal catalysts, these technologies are enabled for the long term. The final commentator to respond reiterated that the overall goal of the program was to develop new catalysts for NO_x reduction with small Pt loadings (synthesis, characterization and testing) and assess their thermal stability. This expert added that the program included a modeling effort using DFT to understand catalyst behavior. This person mentioned that this work relates to undesirable emissions reduction, but was not directly related to petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One commentator explained that the effort pursued here evaluated the feasibility of 3D nanostructures for surface enhancement and thereby improving the performance of LNTs. This being a novel technology, the effort is more exploratory; however, the novel materials were tested per the traditional yardsticks for catalyst materials (hydrothermal stability, NO_x conversion efficiency, sulfur poisoning, etc.), added the reviewer. The second respondent to comment added that this approach used nanostructure synthesis techniques to discover a new catalytic active material, which could reduce NO_x to N_2 under automotive conditions. This expert added that this active material has to survive high temperature, sulfur poisoning and have a sufficiently high conversion activity. The reviewer thought that the PI was creatively using nano synthesis techniques to investigate these types of materials and mentioned that it appeared so far that none of the metal oxides or the perovskites were catalytically active. The reviewer added that it seemed as if the project had evolved into an attempt to generate highly dispersed platinum in a highly exposed structure. Effectively this is what the catalyst suppliers have tried to do since the early 1970s. The reviewer was not aware if this approach duplicated any approaches that were employed by the suppliers and consequently believed that gave it high value. The reactor data ostensibly looked better than what was shared last year; however, there is still some question whether the reactor studies are fully vetted, mentioned the reviewer. This person suggested a more experienced reactor professional be brought in to evaluate the reactor setup and perhaps help educate both the PI and his students on the pitfalls that can occur in reactor measurements. The next reviewer reiterated that the approach had been to synthesize nanowire catalyst arrays using vapor phase and liquid phase techniques (sol-gel and sputtering); to characterize the catalysts using transmission electron microscopy (TEM), x-ray diffraction (XRD), etc.; and to evaluate their activity, stability, and ability to be regenerated. This reviewer stated that representative images of nano-array catalysts were shown, observing that they had a high surface area; albeit the surface area was not quantified. In terms of thermal stability, images of the catalyst were shown before hydrothermal treatment showing what appeared to be a loss of surface area after treatment, added the expert. The reviewer continued, suggesting that it would be useful to show the degradation of the catalyst activity before and after treatment and/or as a function of time for a prescribed set of reactor parameters. The reviewer also added that Sol-gel processed catalysts were shown to be more active than sputtered catalysts, yet no explanation was given about why or how these catalysts are more/less active. This expert felt that, regarding the modeling work, focusing on O coverage on the catalyst was a step in the right direction. The reviewer suggested that it would be helpful to model the work that was more closely/directly tied to the high surface area catalysts developed in the program and create a direct comparison between modeling and experimental results. Another reviewer felt that the approach was on target and addressed important aspects of development/optimization of these types of catalysts. This expert wondered whether it would be good to consider adding catalyst evaluation beyond bench level and asked how the catalyst would respond/survive with real engine-out exhaust. The last reviewer to respond stated that the University of Connecticut research group had a unique approach in nanostructured material synthesis for thermally stable automotive catalysts. The expert added that their approach included synthesis, characterization, and evaluation of new types of oxide-based catalysts. In concluding, the expert noticed that they did not make an effort in benchmarking commercial catalysts in their experimental design, which according to the reviewer is the most important step in developing new materials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers saw good progress, and also offered suggestions. The first reviewer to respond said that it appeared to be on track and addressed barriers to this technology. This person added that the catalyst was still active after hydrothermal stability with same conversion efficiency and that LSCO reduces light-off temperature. CO conversion efficiency is still low compared to addition of Pt, but directionally is a big improvement, added the reviewer. The following commentator added that the project had produced a nanowire material which is hydrothermally stable at 500°C in steam and that this was a worthwhile accomplishment. The expert suggested that it would be helpful if the hydrothermal aging was done at temperatures around 700-800 °C, adding that this would be a more challenging condition. The low-temperature CO light-off is encouraging. If low temperature CO light-off that can be retained over a long aging cycle, this would be a good accomplishment, stated the reviewer. This person felt that it seemed as if the material had a decent sulfur tolerance but added there was activity loss with increasing sulfur poisoning. The reviewer suggested that it would be helpful if the possibility of de-sulfurization could be explored. The following reviewer stated that novel surface modifications (3-D growth of nanostructures) on typical catalyst substrates were demonstrated. The expert continued, saying that after platinum deposition, the performance of these materials for use as lean NO_x traps were evaluated. In such an evaluation, the traditional measures of performance are NO_x conversion efficiency, hydrothermal stability, sulfur poisoning, etc.; all of which were used for this performance evaluation, mentioned the reviewer. This reviewer concluded with the observation that the scope of this effort, while supportive of DOE goals, did not include performance testing using real engine exhaust. The next commentator observed that this research group achieved a very unique nanostructured (nanowire) metal oxide support material in monolithic substrates, but felt that the project failed to report basic bulk properties of the newly designed material such as the Brunauer, Emmett, and Teller (BET) surface area. Having thermally stable high surface area support in automotive catalysis is important as the surface area determines the dispersion (surface density) of Pt particles, added the expert. This person continued to explain that the researchers employed 500°C for their hydrothermal durability test, and mentioned that in the real world application, the catalyst had to be stable after hydrothermal aging at 700°C or higher. This reviewer observed that in their activity measurement, the catalyst showed 16% of NO to NO_2 conversion over ZnO/LSCO at room temperature, and that it decreases to roughly 13% at 200°C. For the case of Pt/LSCO/ZnO/CH, this reviewer reported that the catalyst showed 30% of conversion at 25°C, and then decreased to 20% at 200°C. At roughly 450°C, continued the same reviewer, it showed about 55% conversion, which was higher than its equilibrium level (X_{eq}NO to NO_2 equals 35%). The expert felt that the new material had shown some interesting behavior and believed that the results needed major revision. The reviewer strongly recommended the PI to read others' published work. The last commentator to respond suggested that the team continue to pursue means to lower the catalysis temperature.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer felt that the technical expertise of the partnering institutions was leveraged adequately. The second commenter to respond added that the collaboration seemed reasonable but the commenter was not clear on how everyone was contributing. The next reviewer believed that there was a good list of collaborators, but added that the talk did not give any evidence that there was much direct interaction with the collaborators. This person encouraged establishing collaborations with other OEMs in order to guide and scope future research. The following expert stated that the DOE partner, Brookhaven National Laboratory (BNL), provided synchrotron facilities for characterization of the catalysts, yet it was not clear to the reviewer what technical contributions all of the partners had made to the program. This expert added that HRI provided the samples and substrates, United Technologies Research Center (UTRC) provided the characterization facilities, and that Corning provided the catalysts. This person suggested that adding a more detailed slide showing the role and responsibilities of each partner would be helpful. The last reviewer to respond noted that there were many collaboration partners listed in the presentation, and felt that it was hard to understand why there were such poor experimental conditions (e.g., aging conditions, activity measurements, etc.). For example, the Umicore catalyst should have provided a typical aging requirement for real world automotive applications, added the reviewer.

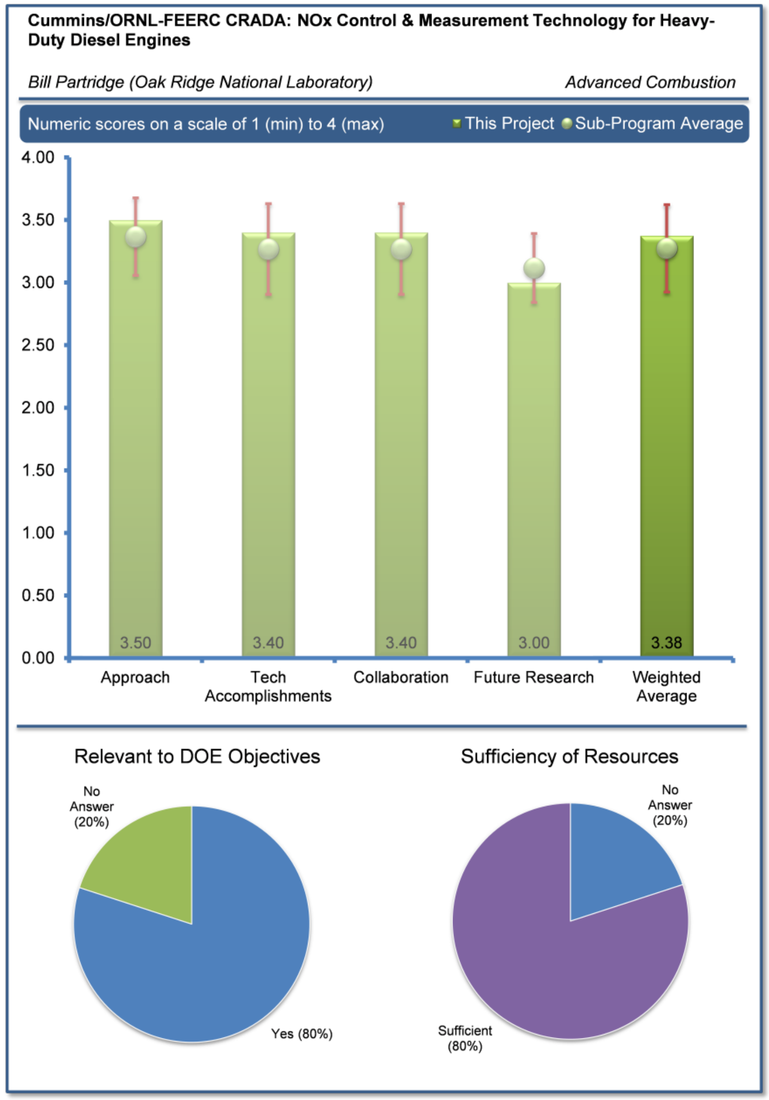
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer to comment felt that continuing the 3-D nano-wire development work seemed to be quite worthwhile. The expert continued stating that the PI has been quite responsive to the AMR reviewer comments. This person added that the DFT Monte Carlo simulations did not seem to add anything to the project, and was unsure why it was continuing. The second reviewer to comment suggested that, while the proposed future research was adequate, it would be beneficial if the following two could be evaluated: determine the performance of these surfaces in real engine exhaust, and long-term stability of the performance of these modified substrate materials. The following reviewer stated that future work included continuation of the MO doping study on nanowire arrays and evaluating their performance for NO_x storage/ reduction, S poisoning and PM filtering. If this reviewer could make a suggestion, the reviewer would suggest that the modeling work should be more closely tied to the experimental program and that ideally the model would be used to eventually guide experimental work such as dopant selection, etc. Another reviewer felt that the investigation of other deactivation such as sulfur poisoning is very appropriate in the development of automotive catalysts. This person felt that it was hard to understand what the theoretical calculations could provide in terms of the oxygen dynamics and suggest that a more detailed plan needs to be provided. The last reviewer to respond felt that some of the future plans read as if they were the same as what was just done. The expert added that it was hard to tell with any detail as to what was next and why.

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

Four of the six reviewers to respond felt that the project resources were sufficient. One reviewer felt that the resources available were excessive. One reviewer thought that the project needed a more traditional automotive catalyst evaluation partner to ensure that the reactor work is correct and effective. Another reviewer observed that the project received roughly $1.5 million for three and a half years.

Cummins/ORNL-FEERC CRADA: NO_x Control & Measurement Technology for Heavy-Duty Diesel Engines: Bill Partridge (Oak Ridge National Laboratory) – ace032



Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that this work was one of few projects that were investigating state-of-the-art NH_3-SCR catalysts and supported the DOE objectives very well. The second reviewer to respond stated that the talk explained that the effort was trying to align with time-accurate assessment of the state of the catalyst at a local level. This increased understanding would enable better catalyst control and have the potential for lower cost, lower emissions, lower and fuel burn vehicles to get adopted, added the reviewer. The last commenter to respond stated that the work from this group was known to produce first class instrumentation for the evaluation of the effectiveness of catalytic converters.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first commenter to respond felt that the technical approach was reasonable. The expert added that there was a good balance of work between Oak Ridge developing catalyst knowledge and assessment and diagnostic tools with the OEM performing the system integration. The following expert stated that this project was focusing on transient (dynamic) SCR performance from one of new SCR technologies, and mentioned that the results would provide information for the development of aftertreatment system control strategy. The last reviewer to respond felt that there were a number of ways to characterize the spatial status of the SCR catalyst, and that this was one of them. It contributes to the overall understanding of the SCR process and is not overwhelmingly new or special, added the reviewer.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers generally observed good progress. The first expert to respond saw strong technical accomplishments in the project. The reviewer found the data regarding the axial location of catalyst activity as a function of temperature to be very interesting and relevant to understanding the instantaneous state of the catalyst. The concept of total/dynamic/unused capacity is a powerful one and can be leveraged for catalyst control, added the reviewer. The following commentator mentioned that the ORNL team employed the popular four-step protocol to measure multiple features of the state-of-the-art Cu-based SCR technologies. The expert also stated that the features included NO_x conversion, NH_3 oxidation, and NH_3 storage capacity. Currently, there are two types of Cu-SCR being used in production; SSZ-13 and SAPO-34, added the reviewer. This person also stated that the Cummins commercial SCR catalyst is SAPO-34 catalyst, and mentioned that it is known to behave much differently from SSZ-13 Cu-SCR catalysts especially for high-temperature performance and NH_3 storage capacity wise. The team has made very good progress toward objectives, added the commentator. The following reviewer expressed that the spatial measurements from this group have been groundbreaking. This person added that this is an extension of that good work and that it was evolutionary, not revolutionary. The final reviewer to respond observed that the project used SpaciMS to see how conversions occur as a function of temperature. The expert did not see ammonia oxidation. The reviewer commented that in the place that the entire NO is removed, it is called SCR zone. Further, this reviewer remarked that total capacity equals dynamic capacity. The reviewer concluded by stating that conversion inflection is not a well-defined concept in this talk.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One expert felt that the collaborative efforts were strong. This person added that they need to be done in a way that the parts of the program connect between Chalmers, Milano, and Prague, in particular, to comment on similar issues. The second reviewer reiterated that the ORNL researchers have teamed up with world leading research groups in aftertreatment technologies such as Chalmers University and Politechnico Di Milano. It is well coordinated; however it would have been perfect if the team partnered with a catalyst supplier who may be more familiar with the intrinsic properties of the SCR technology, suggested the commentator. According to the third reviewer, there seems to be several partners working on this effort; however, the actual role of each partner relative to the work that was presented was not very clear. The fourth expert found that the collaborations do not seem to be well coordinated. This reviewer believed that the collaborating groups were good. This person added that they believed this will be a positive; however, they did not see anything earth shattering here. The fifth reviewer to respond encouraged further collaboration with other OEMs to guide and scope any future research.

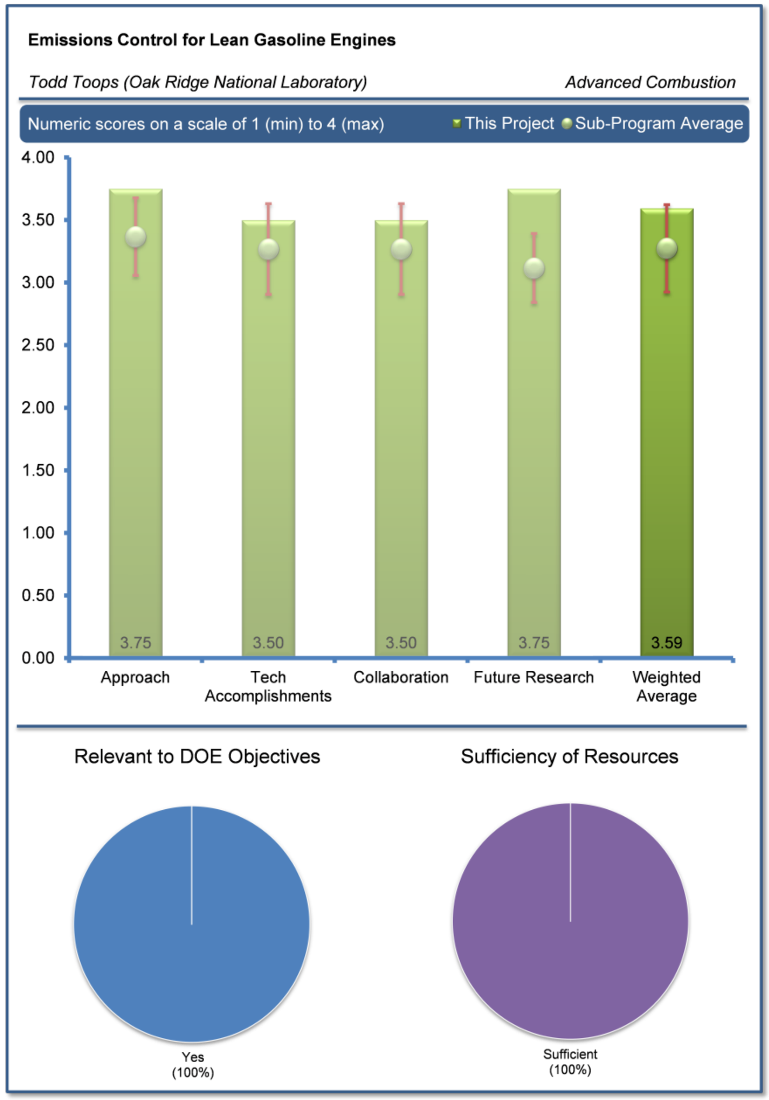
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commentator to respond stated that the future work appeared to logically build up on what was learned in the past. Another reviewer said that this work is on track and observed nothing unusual. The third reviewer mentioned that, unlike SSZ-13, it is known that SAPO-34 suffers from low-temperature deactivation. The expert suggested that the unique NH_3 storage behavior needs to be looked into as well as how its capacity changes as a function of aging conditions. The expert mentioned that the SCR technology moves quicker than we would imagine, and that the current Cummins commercial SCR catalyst may not be the same for the next generation SCR technology; therefore, it would be nice to have catalyst suppliers involved and be advised from them in terms of future directions, suggested the reviewer.

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

All four of the reviewers to respond felt that the project resources were sufficient. One reviewer mentioned that this project would be finishing in about four months and that the funding was appropriate. Another reviewer stated that the budget seemed to be well allocated for this CRADA.

Emissions Control for Lean Gasoline Engines: Todd Toops (Oak Ridge National Laboratory) – ace033



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Four reviewers commented. All agreed, some emphatically, that this project supported DOE's overall objective. One said that this work fully supported the overall DOE objectives of technology development for highly efficient, lean-burn engines and aftertreatment system. Another said that this program was extremely relevant to DOE goals. A strong case was made that lean-burn gasoline was an enabler for petroleum displacement, but that U.S. emissions compliance was currently a barrier. The last two reviewers said that lean emission control could result in significant fuel savings from gasoline vehicles and that the project was especially supportive of DOE objectives in light of the new focus on lean and dilute gasoline combustion.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The approach to the project work was approved by all reviewers. According to one reviewer, this project directly addressed the state-of-the-art in lean-burn gasoline aftertreatment technology that had been in commercial use in the European market and evaluated its performance for U.S. passenger car application. With this approach, continued this reviewer, the project would provide the technology gap of the lean NO_x trap (LNT)-based aftertreatment system and suggest the elements for which focus would be needed to improve its performance for future emission- compliant systems. Finally, another reviewer affirmed that the project was tackling the cost issue head on as cost was the most significant barrier to enabling lean emission controls. The third reviewer generally approved the approach of using vehicles and bench testing, but questioned the ability to develop an aftermarket set of controls (Drivven, Inc.) that would also capture other necessary attributes such as drive-ability. The last reviewer said that the technical approach seemed very sound and noted that lean-burn engines have been obtained from OEM and were being fully characterized. The reviewer concluded by mentioning that several different implementations with respect to aftertreatment were being considered and evaluated.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers indicated their approval of the technical accomplishments and in some cases offered suggestions for continuing research. One reviewer said that the biggest step the ORNL team had made was the full control of the BMW engine hardware and controller so that the engine could operate in various modes. This was critical for aftertreatment control with multiple aftertreatment devices, especially for the passive ammonia (NH_3) selective catalytic reduction (SCR) system. In parallel, the researchers carried out catalyst evaluations in lab-scale reactors under various engine-out exhaust conditions given by actual engine dynamometer results. This parallel approach helped researchers understand the system and technical barriers, and the quick turnaround feedback from lab reactors provided the next step in engine dynamometer tests. Another reviewer highlighted the nice understanding of catalyst behaviors achieved so far. The reviewer also thought that the reactor studies were nice, but cautioned that the vehicle work would be essential to this project. The third reviewer wondered how the impact of transients on the performance of the aftertreatment system could be assessed. The last reviewer noted strong technical accomplishments, and pointed out that engines were obtained and data collected on the impact on emissions of lean/rich durations.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers gave the project strong marks in this category. One person observed great partners covering the gamut of OEM, catalyst supplier, university, and a national lab and affirmed that the collaboration appeared to be well-coordinated. The second project evaluator concurred, saying that the program appeared to have a series of partners with active collaborations apparently supported by structured communication (monthly telephone conversations, visiting grad student, etc.). The third person urged for continued OEM collaboration to scope and guide the research. Finally, the fourth reviewer said that although the level of the participation could vary, this project formed a good team that included OEM, catalyst supplier, and universities. However, this reviewer went on that it would have been better if the team included an institution specializing in catalyst characterization. The reviewer noted that the nature of this catalyst work demanded an understanding of why the catalyst behaved differently under differing conditions, aging levels, platinum group metal (PGM) level, and oxygen storage capacity (OSC). Therefore, some basic material characterization would aid in the understanding of the system.

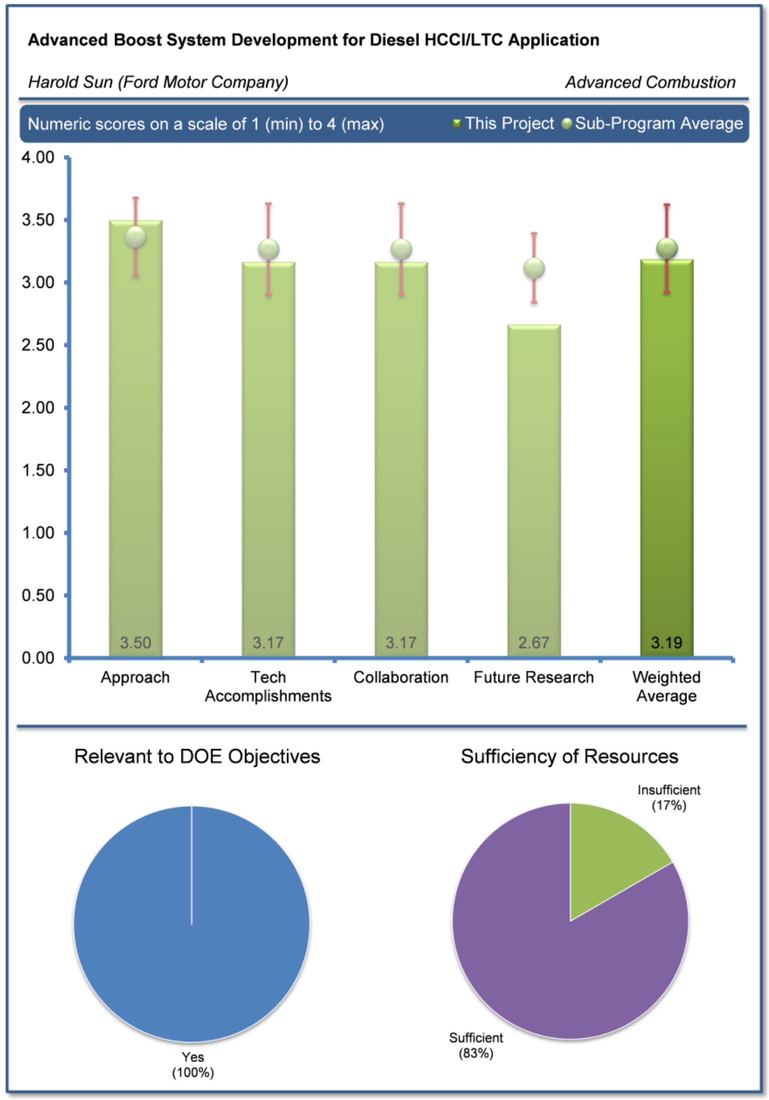
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Three reviewers endorsed the future research plans of this project. One described the future work as being very well planned, but suggested that something the project team might want to consider was investigating the effect of sulfur on NH_3 generation over three-way catalysts and lean NO_x traps. Another reviewer recommended setting a platinum equivalence goal to allow comparisons to stoichiometric gasoline three-way catalyst systems to know what the gap was. The last reviewer said that the future work appeared to build in a logical way from past technical work and findings.

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

All reviewers deemed resources to be sufficient. Only one offered further comment, saying that the budget seemed to be well-arranged for FY 2012.

Advanced Boost System Development for Diesel HCCI/LTC Application: Harold Sun (Ford Motor Company) – ace037



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Five reviewers were in general agreement that the focus of this project was relevant to DOE petroleum displacement objectives, albeit indirectly in most cases. One reviewer said better turbocharging would improve fuel economy, though it was not a very large impact by itself. It was a necessary enabler for high-dilution combustion systems which could yield larger gains. The second person concurred, calling boosting equipment a critical enabler for prime paths for engine efficiency like boosting and downsizing. The technology was also critical for more advanced, high-efficiency combustion methods like PPC and RCCI. This reviewer found that it was surprising that there was not more DOE investment overall in air-handling technology. The third reviewer predicted that surprisingly large improvements in turbocharger efficiency achieved in this project should yield useful improvements in many engines. Another reviewer concurred in the assessments of the first two, saying that new turbo technology was needed for low-temperature combustion (LTC) regimes that were needed to meet the DOE objectives. As the available energy in the exhaust is reduced with LTC, the demands placed on the turbocharger system change dramatically. This advanced boosting system addressed this specific barrier, targeting a 15-20% extension of the operating range of the turbo. In a similar vein, the last reviewer described this project as addressing turbocharger systems which were an important engine component to enable boost and achieve higher fuel efficiency and thus petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

General approval of the work approach was expressed by all reviewers. One said that the approach focused on broad-range turbocharger improvements coupled with on-engine test and demonstration was a good way to target this development program. The reviewer indicated that it would be nice to see something that indicated how this program could integrate with some of the DOE programs (ORNL HECC, ANL LTC, SNL HCCI, etc.), as those programs could make use of similar turbocharging technology. Citing a comprehensive team of OEM, turbo suppliers, universities and others, the second reviewer termed the approach well-focused. If there was a shortcoming, this reviewer said, it may be that the improvement goals were too conservative. The reviewer suggested focusing on longer-range engine plans. In the view of another reviewer, the project represented a nice combination of analytical and experimental work and good leveraging of an expert supplier and academia to support the work. A reviewer termed the approach integrated, using extensive simulation, followed up with experimental validation. This reviewer, while declining to comment on the arbitrary surface and ruled surface impeller designs as being outside of the reviewer's expertise, called the active casing treatment logical and innovative. Offering no specific comment on the merits of the approach, the last reviewer described it as attempting to optimize the turbocharger component of the engine to achieve greater fuel efficiency while still managing emissions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers praised the project's technical accomplishments. One noted that achieving significant gains in turbo efficiency was challenging, in view of which the demonstrated improvements were impressive. The new technologies that had been introduced through this program were working well to achieve the project objectives. The project had demonstrated and validated improved operation, in the view of another reviewer, who cited the innovation of active casing treatment in particular. This reviewer believed that the technology appeared to be transferrable to other engines, a step that might be facilitated with three turbo manufacturers on team. This reviewer was unclear on what outcomes were achieved by NREC and Wayne State. The third reviewer commenting said simply excellent progress, although somewhat longer timing than planned. Echoing the comment of the second reviewer, another reviewer singled out the active turbo casing treatment as a very innovative concept to open/close surge/choke slots and noted the excellent results of its use. The medium-duty (MD) performance, this reviewer continued, met or exceeded the goals of a 30% range improvement and a 3% improvement in brake-specific fuel consumption (BSFC). Engine demonstration of the MD turbo was completed, but the LD (light-duty) remained to be completed. The final reviewer said that the authors did an excellent job of optimizing the turbocharger component. This reviewer continued that reductions in fuel consumption were measured and NO_x and PM (particulate matter, or smoke) emissions were comparable between old and new turbo design. The reviewer suggested that it would be nice to observe the fuel economy benefit from a vehicle with an engine using this technology. This reviewer also noted the very nice technical work describing shock wave changes from impeller design. Attention was called however, to the fact that with the new DOE goal of Tier 2 Bin 2 emissions, that the Tier 2 Bin 5 emissions goal of this project lagged current goals. The reviewer added that more NO_x and PM emission reductions were needed.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

While generally approving the degree of collaboration in the project, reviewers offered two specific qualifications to their remarks. The first reviewer's comment was typical: It appeared the collaborations were working well. However, it was difficult to tell how much each partner was bringing to the program based on the presentation. Likewise, the second reviewer's comment was that the team was comprehensive, but that the contributions of NREC and Wayne State were not conspicuous in the presentation. The reviewer offered that the inclusion of three turbo companies was a very positive feature of project. Unqualified approval was expressed by the third reviewer, who said that the combination of consultants and academics with significant internal work was very strong. The fourth reviewer returned to the qualified approval theme in noting that the turbo suppliers chose not to have their names publicized. This reviewer would have considered rating this higher, suspecting that these suppliers were probably contributing heavily to the success of this project. However, since the presenter was unable to elaborate on their involvement, the reviewer did not feel justified in assuming that the success had been because of good collaboration. The last reviewer deemed the collaboration with Wayne State University to have been fruitful and supportive of the project design objectives.

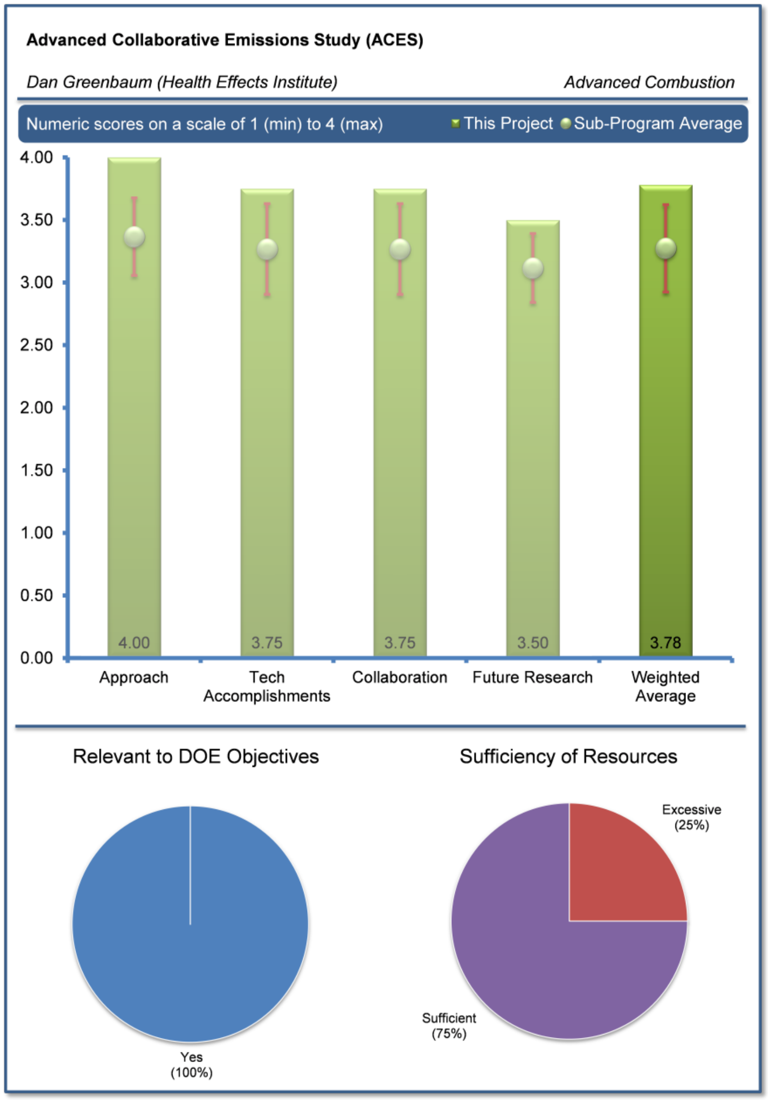
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers' comments on the proposed future project work were positive; two reviewers recommended that consideration be given in that work to specific questions. One reviewer thought that the proposed work looked like it would permit achievement of the final project goals, but remarked that there did not appear to be any significant barriers remaining in the program. The second reviewer observed a good plan to finish the program. The third applauded the planned Tier 2 Bin 5 goal engine demonstration, calling it good, but wished to see some effort put into determining if this design was manufactureable, or into identifying obstacles to commercialization of the concept. Another reviewer also suggested that such a revision to the planned future work, recommending that it consider the overall manufacturability and cost of new configuration and confirming that the casing treatment was not susceptible to fouling in low-pressure (LP) exhaust gas recirculation (EGR) systems. The last reviewer wondered if sufficient time would be available for the completion of this project, as it appeared to have lagged from the original schedule.

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

All six reviewers considered project resources sufficient; three submitted further comments. Two noted the delay that had occurred in the project schedule. One said that while there seemed to have been sufficient resources through the program, the time delay was due to product plan changes in Ford and not any lack of funding. The second agreed, noting that the time delay, caused by a change in engine platform, was significant, but that it did not appear that more funds would have prevented the delay. The reviewer remarked that the team deserved credit for seeing the project through to completion with the no-cost extension. The third reviewer felt that the overall funding had been modest over a long period. With the project now complete, this reviewer felt further comments were not very relevant.

Advanced Collaborative Emissions Study (ACES): Dan Greenbaum (Health Effects Institute) – ace044



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

While all four reviewers expressed approval of the project, one reviewer addressed this question directly, saying that this project supported the overall DOE objectives of petroleum displacement indirectly, as it investigated potential negative health impacts associated with the new generation of efficient, heavy-duty diesel engine technologies with modern aftertreatment solutions. Other reviewers' comments were more generally addressed to the importance of such work as this project advanced in areas other than petroleum displacement. One such reviewer opined that quantifying the health effects of particulate emissions and NO_x exposure was important to identifying the necessity of more stringent emission standards. The other two comments were in a similar vein, one reviewer noted that particulates created as a by-product of diesel and lean gasoline combustion processes had been a health concern for some time. Much progress had been made in reducing these emission products to levels below current standards. This project was a very good verification study validating the progress in aftertreatment technology which should influence the setting of standards by regulatory agencies. The final comment was that it was important to make sure future engine efficiencies did not cause health issues and this study confirmed it.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers clearly endorsed the technical approach to this project's work. One evaluator noted that the approach was an ongoing project whose approach has been vetted over the years and could think of no better way to determine these effects. The second person called it a very good approach, building on previous phases of work with 2007 diesel engine technology. The third agreed, saying that the experiments were thought out and executed very well and gave a good understanding of how newer diesel engine technologies performed with respect to tailpipe emissions as related to health issues. Calling lifetime studies very important to understanding the cumulative effects of exposure on human health, the fourth reviewer said that this work strongly supported the position that new diesel aftertreatment technology was capable of significantly reducing particulate and NO_x to levels considered not carcinogenic to human health.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers praised the technical accomplishments of this project and appeared to consider them quite significant. One reviewer expressed the belief that this project had very effectively shown that the mandated level of particulate emissions was so small as to have a negligible effect compared to other environmental sources of pollution. Another reviewer lauded very good lifetime studies of HDD (heavy-duty diesels) noting the implications of the work for light-duty diesels (LDD). In this reviewer's opinion, it appeared these LDDs would not be sources of named carcinogens, and that as of now, no studies were planned for LDDs on this scale, as these were considered too expensive. Good progress had been made to date, in the view of the third commenter, who felt that the work would potentially have large implications for how the health impacts of emissions from the new diesel engines were viewed worldwide. The last comment expressed the reviewer's belief that the health effects shown with newer diesel technologies was some great work which proved that newer diesel engine technologies did not impact health issues.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers rated the collaboration and coordination exhibited in this project was good to excellent. While noting that the majority of the work was done in-house, one reviewer praised the advisory board as first rate and, assuming that the board had had an effect on the oversight of the project, judged the coordination with other institutions to be very high. The second reviewer cited the good coordination of assets and collaboration with testing labs, while another praised excellent collaboration with relevant stakeholders including the U.S. Environmental Protection Agency (EPA), Engine Manufacturers Association (EMA), the Coordinating Research Council (CRC), the California Air Resources Board (CARB) and the American Petroleum Institute (API). Finally, the fourth reviewer cited good collaboration with the heavy-duty engine manufacturers and others involved.

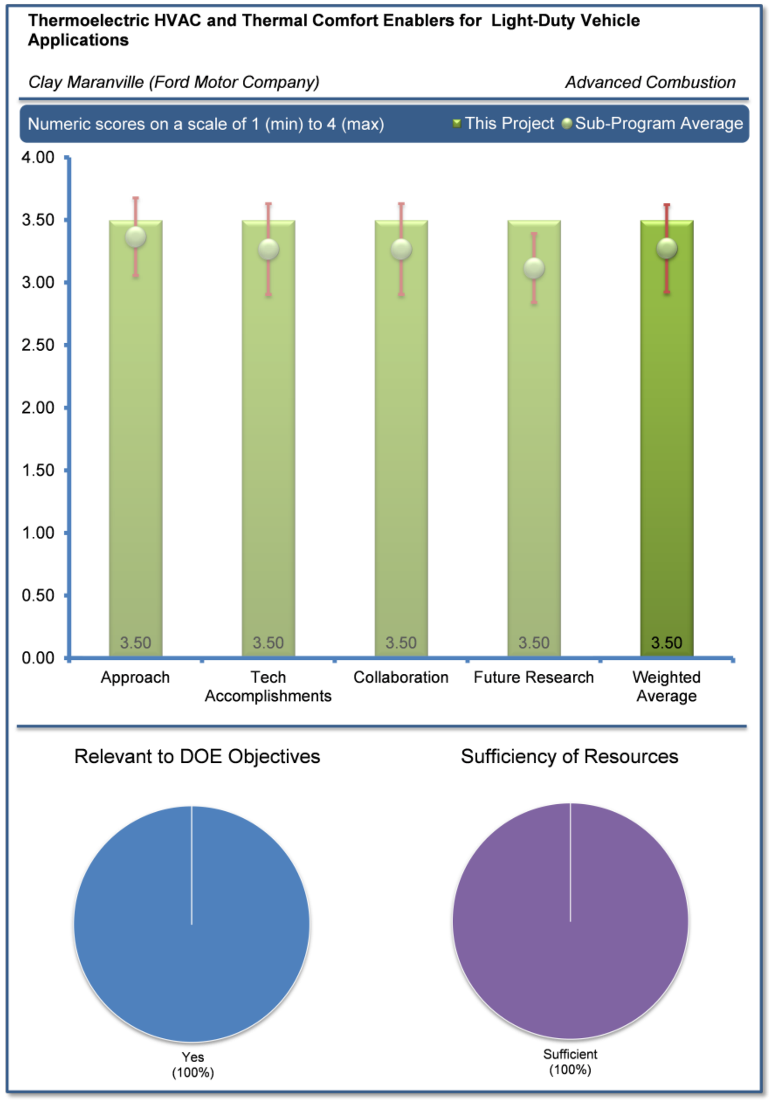
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer (of four) said that the proposed future research followed a proven approach that was implemented for 2007 engine emissions exposure. The second gave the authors of this report major credit for completing a phase of a project and knowing when enough was enough, i.e., for indicating that the project - no longer saw a need to do very expensive testing. A key result of near-future work, the third reviewer predicted, would most likely show that the new-technology diesel engines were not the source of human carcinogens (NO_2 or particles). This was extremely important evidence to communicate to regulatory agencies, the reviewer said. Noting that the project work was complete except for final reports, the fourth reviewer expressed a desire to see light-duty diesel engine testing in the future with different aftertreatment systems.

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

Three reviewers deemed resources to have been sufficient. One termed them excessive. Two of the three reviewers offered brief comments that simply affirmed their assessments of resource sufficiency. One noted that health impacts studies of this type were very expensive and therefore co-funding from partners was very beneficial. The dissenting reviewer acknowledged that while multi-year project, lifetime studies were very expensive to conduct, it was nevertheless unclear whether the testing conducted required the degree of funding used or if less testing could have achieved the objective.

Thermoelectric HVAC and Thermal Comfort Enablers for Light-Duty Vehicle Applications: Clay Maranville (Ford Motor Company) – ace047



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers were unanimous in the view that this project supported the DOE petroleum displacement goals. Two reviewers offered succinct comments to that effect, one saying yes, thermoelectric (TE) devices had many advantages over traditional heating and cooling options. The key was the materials and engineering design. This project was addressing these issues. The other agreed that this project did support the DOE mission to improve fuel efficiency by the integration of TE into an automotive platform. The other two reviewers commented at greater length. One explained that the project aimed to develop TE heating, ventilation and air-conditioning (HVAC) modules to reduce the load on the alternator, and thus improve fuel efficiency. In this respect the project was consistent with the DOE goals. The goal of this program was to reduce by 30% the fuel used to maintain HVAC systems. Finally, the fourth reviewer said that the program run by Ford offered one path to reduced fuel usage and petroleum displacement by developing alternative automotive cooling technology. If successful, there were two major ways fuel consumption would be reduced. First, this reviewer explained, vapor compression cooling systems on current cars can be removed, reducing the belt-drive mechanical load on the engine. Secondly, continued this reviewer, the zonal climate control eliminated the waste inherent in cooling sections of the cabin that do not contribute to passenger comfort. The effort by Ford appeared to be an excellent program with significant merit.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Here again, one reviewer commented directly and briefly on the merits of the work approach, saying that the project had been well-designed and that the technical approaches were aimed at solving the critical issues for the scale-up of thermoelectric devices. The approach consisted of the following: system design; CAE, thermal comfort models and control strategy; TE materials and device design; and prototype build and testing. TE device development includes impurity doping of commercial BiTe to improve ZT and thermal interface materials [Ohio State University (OSU)]. Work appeared promising but was still in development. OSU investigators are experts in the field. The comfort models and optimization appeared to have made some progress with simulations and mannequin data and identifying some promising architectures. The final system design, including heat exchangers, prototype build and test appeared all to be left for the last year. The third reviewer noted that much of the effort concerned modeling to predict system performance, which was good. More on this, the reviewer said, especially to draw a link between system components and fuel efficiency would be extremely valuable. The reviewer noted that the project included bench evaluation testing and materials development with an academic partner. The PI was coordinating a range of tasks including test protocols, CAE and comfort models to determine optimal heating and cooling node locations, and validating performance in a demonstration vehicle. The fourth reviewer noted Ford's development of a mannequin-based test bed that provided very useful raw data upon which an effective solution could be designed and engineered. While much of the presentation did not provide hard numerical benchmarks (most of the plots had no labeled axes), it was explained that the design of the system was so complex over a given real-world drive cycle that hard numerical figures could be somewhat misleading. While COP (coefficient of performance) values are informative and valuable for design, in an actual car the delta-T may change significantly over the course of driving (through a tunnel, in the shade of a tree, in hot sunlight, etc.). This reviewer confirmed understanding that the numerical benchmarks, while having been met in a lab, do not necessarily translate to real-world automotive comfort. Acknowledging that the term, passenger comfort, was almost impossible to quantify, this reviewer considered that it was clear from the plots that comfort would easily be achieved.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Two reviewers offered concise comments, both favorable, on the project's technical accomplishments and progress. One said Ford and their teaming partners had achieved significant progress and appeared on track to succeed in meeting all of the objectives. The COP metric appeared already to be in-hand in their lab tests. The other reviewer noted that the overall technical approaches were targeting the most difficult issues. On the materials side, however, it was unclear to this person how the ZT improvement was made and the quantitative values were hard to judge without the vertical scale. The third reviewer's comments were notably more detailed, citing specific technical improvements, but without rating their significance. The reviewer noted that the project was roughly two-thirds of the way into its three-year program, with the major barriers appearing to be the cost of the system relative to its performance, scaling it up from the lab and the challenge of packaging the TE system in the allowable design space. Specific goals included reducing compressor energy demand by the third and achieving a high COP for the TE device. Accomplishments included: TE device design, comfort modeling, control of HVAC (multiple points) in a transient environment, and advanced TE development. No component fabrication, cost analysis or systems testing had been done yet; these were slated for the next year. TE device accomplishments included design of liquid side heat exchanger (HX); optimization of fins on the HX air side; and a 25% improvement in p-type TE. Comfort models and matching performance of distributed systems to the overall HVAC system had been performed. Differentials between the two had been small. Model integration work with NREL has used mannequin testing (both virtual and physical) and feedback between the two. The reviewer felt that the presentation did not address how close an approach to the desired metrics was achieved; the approach appeared to be based on trying to effect improvements at different levels with the hope that performance gains relative to cost could be justified. However, at this stage it appeared to be a desired goal, and that no data in this regard were presented. Thus, it was difficult for the reviewer to assess if any of the gains at individual level would translate to a meaningful gain in the system performance. The last reviewer felt that the PI appeared to have met the Phase 2 Go/No-Go decision points for chamber testing, prototype evaluation, packaging studies, etc. This reviewer reported the following accomplishments: development of an apparatus to evaluate thermal properties using IR cameras and thermistors to quantify heat flux through the samples; modeling to determine an optimal TE element size and required number of elements; and fin optimization studies and dielectric system selection, all for TE device optimization. The same reviewer also pointed out that a liquid heat exchanger has also been designed and fabricated (though the details seemed a bit vague as described in the presentation). The reviewer summarized that the materials development effort resulted in a 25% increase of ZT over commercially available Bi_2Te_3 (the long-term use of this material is a bit uncertain), but explained that the lack of numbers on the ZT plot was curious.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers entered clear and succinct comments expressing their estimation of the degree of collaboration and coordination evident in the project, and two commented at much greater length and with less directness. The first reviewer called the collaborative effort good, with academic and industrial partners for testing and evaluation. The reviewer pointed out that the team included Ford as the prime contractor, Visteon, NREL, Amerigon, ZT plus and OSU. The second person said that this project had assembled an excellent team to complete the material and device development tasks. The third reviewer's comments, while more detailed, made clear a positive view of the value of project collaborators' capabilities. The reviewer noted that Ford had teamed with leading institutions and smaller thermoelectric specialty companies with unique capabilities for success. For example, BSST/Amerigon was already the world's largest suppliers for thermoelectric sub-assemblies for automobiles and they were already a DOE performer and well-suited for full production. The Ohio State partner was well-regarded as a world leader in developing new research and approaches to independently improve the dimensionless thermoelectric figure of merit. The comments of the fourth reviewer, for all their length, pertained more to technical accomplishments and planned future work. The reviewer listed the project collaborators and the areas of their respective contributions, noting Ohio State University (improved BiTe and others), Visteon (HVAC), Amerigon (TE materials), ZT plus (scaling TE) and NREL (systems integration), but offered no assessment of the degree or effectiveness of their collaboration in the project. Progress in the materials development, comfort modeling and systems integration were presented. However, this reviewer went on, that there still seemed to be issues to be addressed e.g., n-type TE doping optimization, systems control and design, discrepancy between virtual and physical mannequin data, etc. Scale-up issues were not clearly addressed.

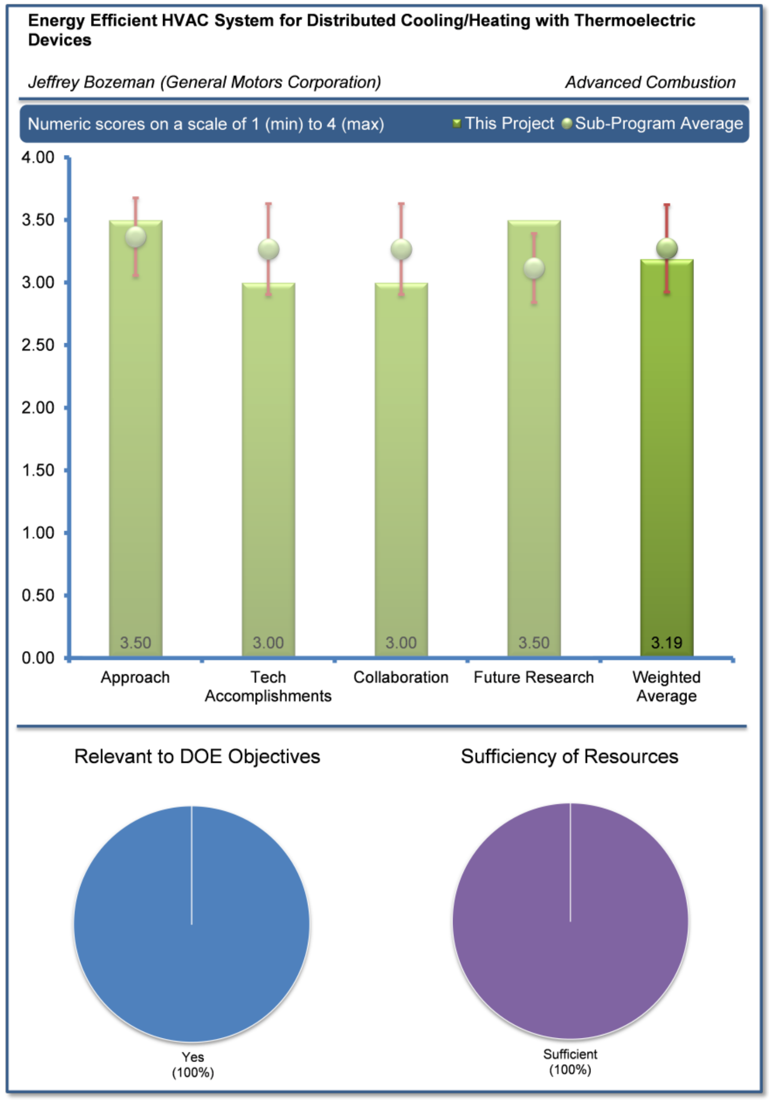
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer commented that future plans appeared to be well-aligned with DOE objectives of reducing overall demand by developing technologies that did not require petroleum-based fuels. This reviewer explained that thermoelectric cooling was purely electrically driven refrigeration that reduced mechanical load on the belt-driven engine, and would improve fuel efficiency. Noting that the system design, prototype build and testing were all still pending, another reviewer expressed the view that a lot of work had been left for the final year of the project. The third reviewer listed the remaining activities: a proof-of-principle TE unit design, build, test and model. This reviewer also noted that a thermal comfort model would be used in a sensitivity study and that additional work on system component design would be included, with a test vehicle delivered to DOE in 2013. This reviewer strongly recommended that the system-level model be expanded to allow linking the results to fuel economy. It was unclear, in this reviewer’s opinion, if this could be done with the model as it currently existed, as it would require considering aspects related to effects that play into engine load: alternator, aerodynamic drag, rolling and component friction, etc. If this could be done, the results would help guide where future resources should be directed. For example, it would make little sense to study a problem with little promise for impact on fuel economy if that sub-problem were predicted to have little or no influence on fuel economy.

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

All four reviewers found the project resources to be sufficient. Two people provided additional comments. One evaluator termed the budget expenditures to be commensurate with the industrial nature of this project. The project costs were comparatively high but that was the nature of Ford's budget structure. This reviewer expressed hope that Ford was investing significantly in this technology, which at present seemed to be about 50% of total costs. Eventually, Ford would need to be weaned off this government subsidy and develop TE systems to the point where they were self-sustaining to the company's product line. The other reviewer discerned no requests for more funding, and since the contractor was engaged in a funds-match with DOE, saw neither a need for additional funding nor excessive funding.

Energy Efficient HVAC System for Distributed Cooling/Heating with Thermoelectric Devices: Jeffrey Bozeman (General Motors) – ace048



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer asserted that the project supports the main goal was reducing energy usage by 30% and it supported the overall DOE objectives for petroleum displacement. In the view of the second reviewer, the General Motors (GM) program was well-aligned with the overall DOE objective for new technologies to reduce fuel demand and cut overall petroleum usage. Eliminating the conventional belt-driven air-conditioning compressor's mechanical load on the engine would improve overall fuel efficiency. Also, for future all-electric vehicles, thermoelectric cooling would be the method of choice because it was an all solid-state electrical cooling technology. The third reviewer who commented said the project appeared to focus on an improved HVAC system to improve fuel efficiency, with emphasis on comfort modeling, and system design and integration. The TE work, however, was not a big focus for this project. The one-third energy savings could apparently be achieved through an optimized distributed HVAC systems modeling. This was where the focus of the work had been, and this was supportive of the DOE goals. The last reviewer concurred, saying that the primary goal of the project was to reduce the energy used for vehicle heating and cooling, with a secondary goal of developing a new TE material for engine waste heat; thus these broad objectives were relevant to DOE's objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer opinions on the approach to the project work were mixed; some reviewers approved of some aspects while others elicited suggestions for improvement. Fairly typical were the comments of a reviewer who described the project as comprising a number of tasks, including developing a thermal comfort model for distributed heating and cooling; an exploratory effort concerning development of prototype HVAC components (based on bench and demonstration vehicles); integration of HVAC components into a demo vehicle, and developing a new TE generator. The comfort modeling effort, the reviewer said, was important, and other components of the DOE program were pursuing apparently similar efforts, suggesting that DOE might better coordinate overlapping system-level model development (e.g., Ford's apparently similar effort). Better coordination among overlapping tasks would be preferred. The second reviewer described that the GM project was focused on overall system design and integration of TE materials into the vehicles, calling the selected vehicle platforms and technical approaches well-planned. The zonal control and design were based on the low efficiency of thermoelectric devices. The reviewer cautioned that if it was unable to replace the current air-conditioning (A/C) system, addition of TE cooling/heating may not be cost-effective, especially in extremely hot or cold climates. The third reviewer observed that GM's effort had approached the work by designing a mannequin test bed to qualitatively and semi-quantitatively analyze the cooling performance of their designed system. While passenger comfort appeared to be an impossible-to-define quantity, their mannequin test bed could give important design and performance testing. The last commenter was similar and stated that the overall approach appeared to design a distributed HVAC system and to optimize the system design with a thermal comfort model to seek COP improvements to achieve the desired fuel efficiency gains. The TE elements would provide the distributed heating/cooling units. The system design and comfort model with a specific TE selected have been implemented for a chosen vehicle to demonstrate COP and performance gains, this reviewer said, but offered no explicit assessment of the merits of the approach.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers were prone to enumerating project accomplishments without offering explicit opinions on their value. One reviewer noted the primary project goals of a 30% reduction of fuel use attributable to HVAC (DOE goal) and the development of TE with high COPs. Milestones cited included the development of a passenger comfort model (UCB), control systems to integrate control of TE components (Intrepid), and comfort system installation (Faurecia). This reviewer reported that the five project tasks included the following: applied research on thermal comfort model; prototype HVAC components; COP evaluation; integration into vehicle and testing; and TE research and integration. The reviewer observed that the chosen vehicle was a Buick LaCrosse with a belt-driven compressor, adding that it is desired to equip it with an electrically-driven compressor. The project focus, the reviewer said, appeared to be much more on HVAC and comfort modeling and that it was not clear what improvements to the TE system design would be developed and implemented. The technical accomplishments cited by the reviewer included improvements in thermal comfort model subject to tunnel test data and PC-based CAE tool with virtual mannequins that was used to understand physiological impacts of HVAC design. The emphasis was on understanding the effects of different parameters on skin temperatures. Marlow's TE heat exchanger (a dense plate-fin design) showed a COP of 1.7. Overall, the effort showed progress on several fronts, but that work on a commercial system remained. The second reviewer commented in a like vein, observing that accomplishments were reported for the comfort model, identification of a final set of HVAC locations, initial design concept of a fin and plate heat exchanger, incorporation of recently published data about sweat distribution on human body into the physiology portion of the comfort model, specify control strategy, development of waste heat recovery modules. However, this reviewer offered no assessment of the significance or value of these accomplishments. The third reviewer said that the hard metrics that have been laid out by DOE to the contractor seemed to include common thermodynamic quantities including the COP (coefficient of performance), and GM appeared to be capable of meeting that metric. The reviewer asserted that their mannequin system was providing excellent feedback data. The last reviewer explicitly addressed potential improvements to the work approach, noting that while it had made significant progress in overcoming the identified barriers, several areas needed more attention. The first area was materials and device reliability because TE coolers could fail under thermal-mechanical cycling, so it was important to identify the design limitations on temperatures and stress levels and obtain data on the performance of the TE devices. The second area was high-performance materials because the HVAC application demanded the best-performing TE materials. The cost associated with performance must be understood and a pathway to reduce cost after the demonstration phase must be identified.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

In the view of one expert, this project had assembled an excellent team to focus on the research tasks. In the opinion of another, collaborations appeared extensive, including nine partners from the industry, national laboratories, and academia. However, this reviewer felt that the coordination of such a large team was not especially well-described in the presentation. A similar comment was submitted by the third reviewer who saw no mention of what the actual activities and accomplishments of the teaming partners were. For example, UNLV was specified by name, but it was unclear to the reviewer what would not have happened had the university not been part of the program. UNLV was identified as providing materials modeling support, but the reviewer did not recall seeing any materials modeling results. The last reviewer's comment partially echoed this observation, and this reviewer acknowledged that partners included UC Berkeley on thermal comfort modeling, and Delphi Systems and UNLV on TE materials where Delphi was doing the TE component design. The reviewer added that Marlow was responsible for TE module development, but to this reviewer, it was not clear that all partners had been actively engaged, with GM and Berkeley playing major roles.

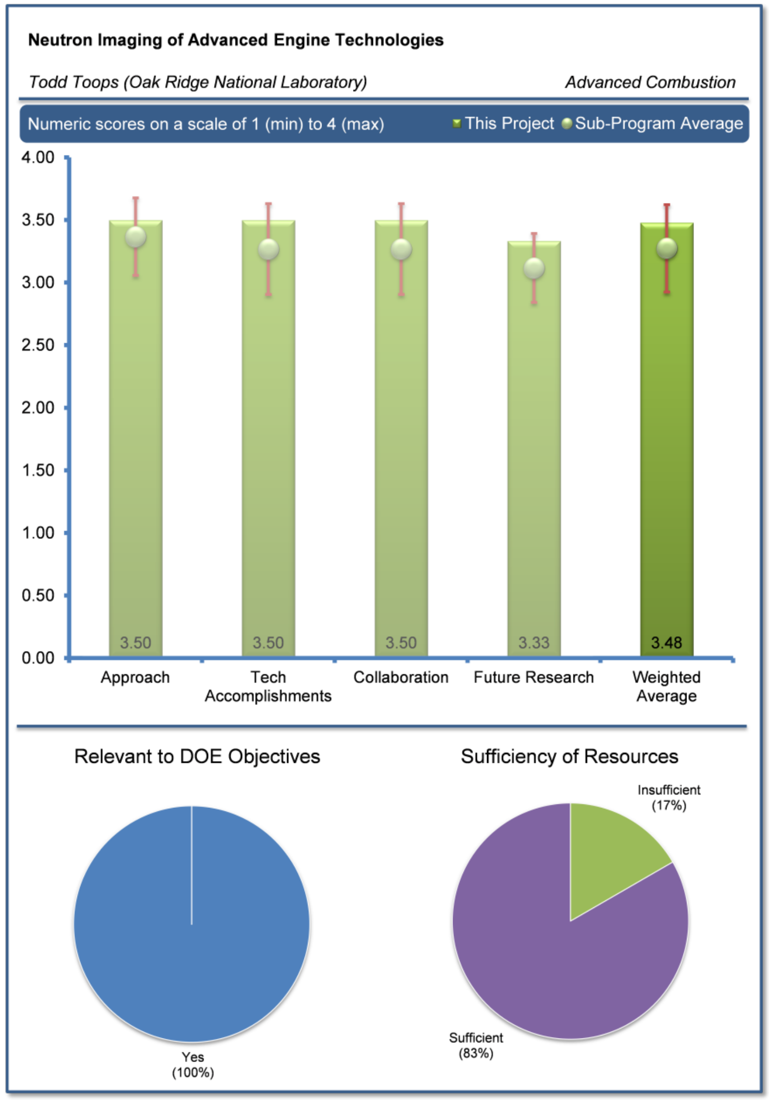
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer termed the proposed future work clear and very promising in completing the project. The second reviewer felt GM to be well-positioned to succeed on this program and to have excellent plans. While believing success to be extremely likely, however, this reviewer would have liked to have a risk analysis, and to know if there were mitigation plans in case problems arose. The third reviewer noted that future work included completion of Phase 2 tasks, climatic tunnel testing (including Go/No-Go points), a look back at liquid cooling, testing and evaluation of final components, and vehicle integration (for Phase 3). This reviewer speculated that a greater degree of specificity in the future tasks might better crystallize the team's way forward. The last reviewer cited a number of remaining future efforts including vehicle build and instrumentation; commercializing and testing new components, and vehicle level testing.

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

Four reviewers agreed that the project resources were sufficient. Three people provided supplementary comments. One said that based on information in the presentation, it seemed difficult to determine if the resources were adequate or inadequate. Accordingly, this reviewer indicated a belief that resources were sufficient (rather than excessive or insufficient), and encouraged the contractor to have that direct conversation with DOE. Another reviewer said that the project had been using the appropriate resources and reaching stated milestones timely. Finally, the third reviewer termed resources commensurate with the industrial scale of the project and said that the funding appeared adequate.

Neutron Imaging of Advanced Engine Technologies: Todd Toops (Oak Ridge National Laboratory) – ace052



Reviewer Sample Size

This project was reviewed by twelve reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Five of the eight reviewer comments addressed this question directly or by implication. The most directly relevant comment was that some aspects of this project directly supported petroleum displacement, such as its focus on improving diesel particulate filter (DPF) regeneration to minimize fuel consumption. Another reviewer said that, although not directly related to efficiency, the technique showed promise to help with problems that restricted engine advancements. The third offered a comment in a similar vein, saying that the project contributed to a better understanding of aftertreatment devices, which was important so that high-efficiency engines can still meet emissions requirements. The fourth comment was that the project was developing a new technique for looking at diesel technologies to understand and improve them. This would potentially translate into higher-efficiency diesel engines. The project contributed to a fundamental understanding of devices needed for high-efficiency engines, said the fifth reviewer. The remaining three comments described the project's aims but offered no opinion on its relevance to DOE goals. One person commented that the project concerned non-destructive and non-invasive imaging techniques to study DPFs, EGR coolers, and diesel fuel injections. The second evaluator offered essentially the same information, and stated that the project included non-destructive imaging of EGR coolers, DPFs, injectors. The last reviewer echoed the preceding two people's comments, describing the project focus as a unique, nondestructive and powerful technique for evaluating and diagnosing the performance of a number of advanced engine sub-systems like particulate filters, EGR cooler fouling or fuel injector performance.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Three of the five submitted reviewer comments expressed keen interest in the work that was the focus of this project and generally approved the approach to its development. One reviewer thought that the project had some great potential uses and that the approach to developing the tool and selecting applications for it was appropriate. In addition to the tool itself, the reviewer was gratified that the visualization tools were also being developed because that would make this a complete package. Another reviewer urged continued development of the usefulness of the technique, including quantitative metrics. The non-destructive technique was very valuable, in the estimation of this reviewer. The third agreed, saying that it appeared that neutron imaging was a potentially useful tool, providing a non-destructive technique for evaluating components such as filters. The fourth termed it a unique non-destructive technique to understand soot deposition on a DPF to enhance modeling and understanding of durability issues. The last of the five commenters simply stated provide a complete analysis of hardware performance without destroying them.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Nine reviewers commented on the accomplishments and progress achieved in this project, with generally very positive opinions. One person called the progress on this program outstanding and described that this tool was being applied to areas that were of direct interest to a wide cross- section of the diesel industry, and that the progress and demonstration were going extremely well. The second reviewer said that the work done so far to demonstrate the usefulness, as well as the limitations, of the technique was exactly what was needed to understand its power. The results presented left no doubt to this reviewer as to the power of the technique. The improvement in resolution, the generation of quantitative results and the animations all constituted very good progress, in the view of the third reviewer. There had been good progress developing the technique for both DPFs and injectors, said another, who cited interesting results on partial DPF regeneration and interpretation of the results. One reviewer termed the presentation an excellent demonstration of neutron imaging's potential. This reviewer felt that it would be good to focus on injection, since DPF regeneration had been largely solved with minimal fuel use in most engines using selective catalytic reduction (SCR) for NO_x control and DPF regeneration was not required in low-temperature combustion (LTC) engines. Another reviewer noted that the project met the first milestone – demonstrating that filter images could be obtained which distinguish between particles and walls – and was on target to meet the second milestone. Also speaking to the quality of the images obtained, another evaluator spoke of incredible pictures of the soot loading in a DPF and averred that there was nothing else like it. The next step, in this reviewer's opinion, would be to learn if it was possible to get down to the individual DPF cell wall and show the pores and the soot in them. This would be helpful in understanding the newer, higher-porosity DPF materials that were entering the market. Another reviewer cited the project's improved visualization tools and its identification of particular loading images such as tomography profiles on actual DPF units. The project also investigated how particulate profiles changed during regeneration and provided insightful comments on packing densities as the initial loading changed. The tool seemed an excellent technique to leverage for filter performance and future developments, the reviewer said, urging that work begin on injectors. The last reviewer asked what subsequent learning resulted from DPF imaging (injection strategy versus efficiency, and etc.).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers were explicit in their positive assessment of collaboration in this project. One observed that there were a number of collaborators and that the interaction appeared to be quite fruitful. The second agreed, noting several key collaborations existed that have enabled the successful evaluation of the technique to date. Other reviewers (two) noted that samples had been obtained from several OEMs and that the researchers were working with several universities. The last reviewer cited complete sample from DOE's Office of Basic Energy Sciences (BES), academic institutions and industry.

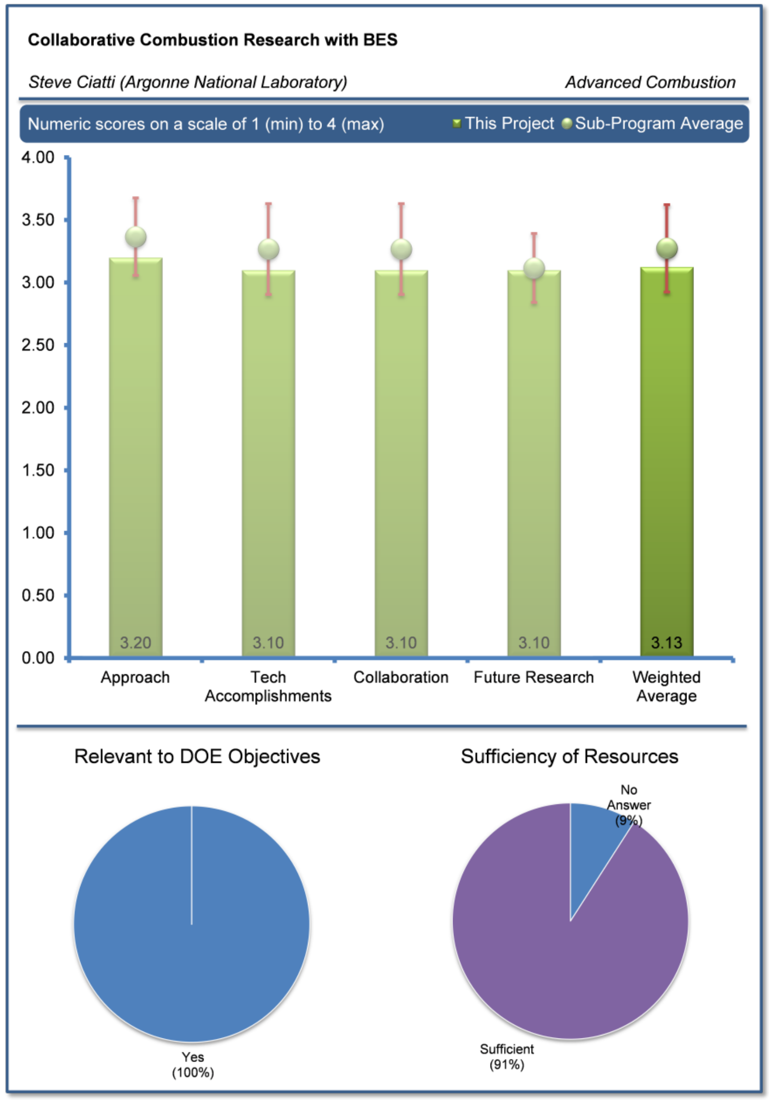
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The plan to develop visualization tools is excellent, said one reviewer, and will help make the data that much more understandable. This person added that there are certainly a number of items that could be studied in DPFs and injectors and those plans of study should be considered carefully, but that was outside the current project's scope, which appeared to be the development and demonstration of the imaging tool. Said the second reviewer, this was a powerful technique, and one of the next areas it should be applied to was visualizing flow and cavitation inside the nozzle of high-pressure, direct-injection fuel injectors. The third reviewer commented that the injector tests would be interesting. Speaking more generally, another reviewer said it would be exciting to see further results from this unique approach. The plan was deemed reasonable by one reviewer and the fifth observed that the research team would continue to use this unique approach on DPFs, incorporating ash-laden and catalyzed samples, and on injectors.

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

Comments were received by twelve reviewers, of which 10 deemed resources to be sufficient, and the remaining two reviewers dissented and termed them insufficient. Only one of the latter offered further comment, expressing the belief that more could be done with more funding.

Collaborative Combustion Research with BES: Steve Ciatti (Argonne National Laboratory) – ace054



Reviewer Sample Size

This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

While only one of the five reviewers who commented spoke directly to this question, all seemed generally to consider the research worth pursuing. The one directly relevant comment was that, in general, fundamental combustion data from rapid compression machines (RCMs) should help to optimize high-efficiency, advanced combustion systems that should reduce fuel/petroleum usage. The second reviewer said that the project supported the DOE objectives through improved understanding of chemical mechanisms of autoignition. A similar comment from another reviewer was that to realize control of LTC, there was a need for better understanding of fuel combustion characteristics. The fourth reviewer agreed, saying that getting data on a rapid compression machine was a key component of kinetic mechanisms validation. These mechanisms were used in detailed computational fluid dynamics (CFD) models used to optimize engines for higher efficiency and low emissions. The last reviewer called this important collaborative combustion research with the BES office which addressed fundamental knowledge of advanced engine combustion regimes. The same reviewer further observed that this research supported the development of chemical mechanisms. This reviewer, however, was unsure if this work was unique or how it compared with other facilities.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

There was a distinct division of opinion on this question among the seven reviewers, with some deeming it useful and complementary to similar work being pursued elsewhere and others suspecting it to be unnecessarily duplicative. Typical of the former was the reviewer who called this project a great application of experimental tools (RCM) to develop an improved fuel property database. Another said that the project provided complementary capability to other organizations doing similar work with capability to support testing of high boiling-point fuels and high pressures. Yet the third reviewer appeared to agree, noting that the team was providing a new RMC. It appeared that it would coordinate with other teams from the DOE. Marking the transition between the differing opinions, one reviewer wondered how the approach complemented or replicated other work in the field. Two reviewers' comments expressed doubts about the uniqueness of the work. One evaluator observed that the installation and use of RCMs to study fuels ignition, including in the negative temperature coefficient (NTC) region, had been done by several other organizations (including University of Michigan, MIT, and Stanford University). Stanford had also developed the capability to volatilize/evaporate components in diesel fuel. So it was important not to reinvent the wheel, both in terms of setting up instrumentation capabilities and with regard to the fuels studied. Quite a bit of work had been done on fuels and fuel components by others. The next reviewer clearly agreed with this assessment, saying that this program seemed very much like the other rapid compression testing devices, so it was not clear what was unique about this. The reviewer added that it seemed the desire was to fill some gaps in the data, but it was not clear that this was what was actually being done. The reviewer also thought that there should be more priority given to testing with gasoline and diesel, as the other fuels are largely just a science project. The final comment suggested a modification to the approach, the reviewer opining that the obstacles to obtaining useful data from the RCM appeared to have been adequately addressed. The reviewer concluded by stating that a more focused approach to addressing specific issues was needed, otherwise, this would become a solution in search of a problem.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Three reviewers cited good progress and expressed general approval of the accomplishments in this project to date. One said that there had been good progress getting the experiments set up and validated and in starting to get results to help generate data to validate Lawrence Livermore National Laboratory's (LLNL) surrogate models. It looked to this person that there was a lot of detailed work developing the RCM. The second commenter noted many good results with fuel data and in advancing RCM techniques. In the opinion of the third reviewer, development of the RCM had scientific value, provided that sufficient collaboration existed to fully interpret the data generated. The progress and improvements with the RCM to date demonstrated that it could in the future be a productive apparatus for improving the understanding of certain aspects of chemical kinetics. Another reviewer agreed that clearly there was progress made and data were taken. This reviewer expressed full understanding that there were challenges with the hardware and sampling system, but still felt that the actual amount of data taken was small. The fifth reviewer observed that there seemed to be significant scatter in the RCM data taken so far and asked what steps could be taken to reduce the scatter and experimental uncertainty in the data. The last two reviewers recounted the specific accomplishments described in the presentation. One expert noted that the research team had tested iso-octane and a four-component surrogate in the newly constructed RCM hardware; tested a very rapid sampling valve which was unsuccessful and had been replaced with a sample dump tank. The evaluator described that the researchers had helped develop high-aerosol fuel adaptation for an RCM and that the work shifted to control-oriented models for chemical ignition prediction and aimed to evaluate existing ignition delay correlations on a homogeneous-charge compression-ignition (HCCI) engine platform. The last reviewer simply observed that the team had finished setup of the RCM and had started to take data with it.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Three out of four reviewers specifically mentioned project collaboration with academia and two of them drew attention to collaboration with a national laboratory. One commenter said that the main collaborators included universities (Akron, Marquette, and Wisconsin) and LLNL. The second respondent cited extensive interactions with LLNL and three universities who were each providing separate assistance on analysis and experimental techniques. The third person praised the good connection to other universities doing similar work as well as LLNL and others who would use the data to validate kinetic mechanisms. The last reviewer endorsed the collaboration with Lawrence Livermore Laboratory, but also called for greater collaboration with other national labs, particularly LLNL and Sandia National Laboratories (SNL), so that these results could be used most effectively for modeling purposes.

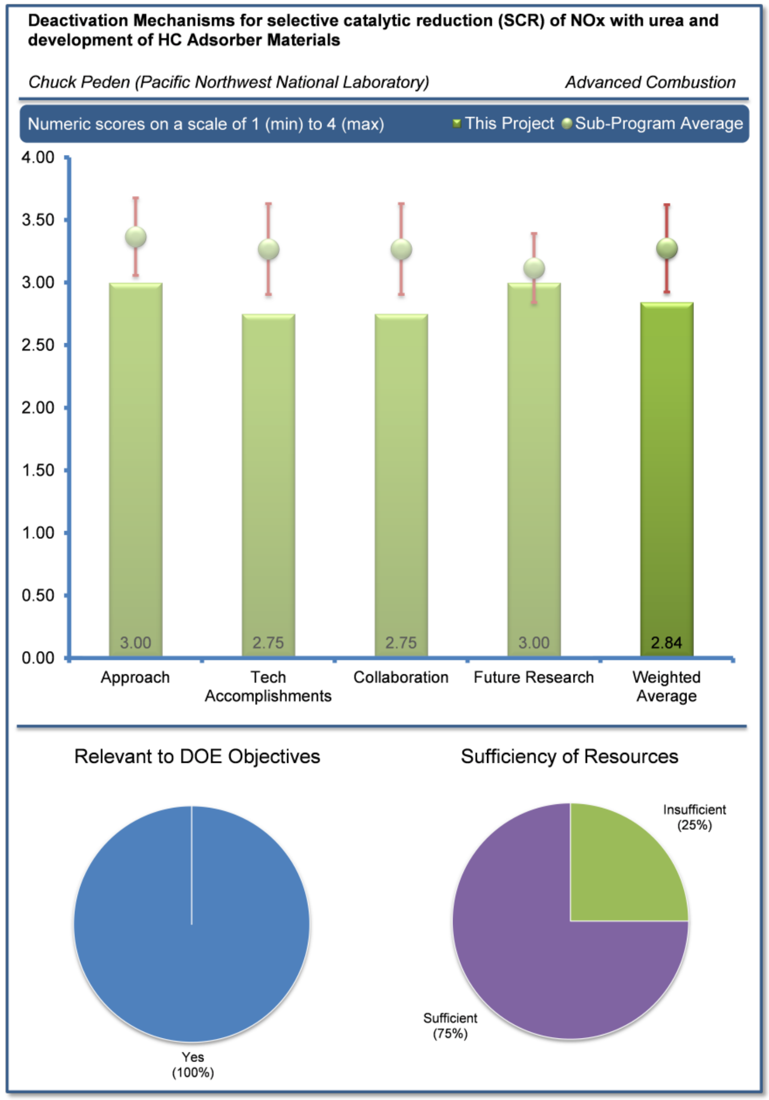
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers offered clear suggestions for the direction of future research. One said that the project team's plans seemed reasonable, but again, the project needed to ensure the focus was on fuel formulations and components that have not already been tested by others (unless this is absolutely necessary for calibrating equipment). In the view of the second commenter, the plan needed to show clearly how studying these various alternative fuels helped build a better database, as that was somewhat lacking. What exactly would it help calibrate, and equally, why was low priority being given to the fuels that engines actually burn, as this was what was most often required in real-life models against engine testing. The third reviewer felt that the emphasis should be on integrating this work with modeling efforts, to provide feedback into the test program. Another reviewer said that the proposed candidates for future work supported future development and refinement of diesel and biodiesel surrogates. The last reviewer again cited the proposed future work mentioned in the presentation, and described that the team would do the following: continue to improve the RCM, seeking to extend its operating regime (not specified); expand the fuel matrix including real gasoline, a diesel surrogate based on n-dodecane and m-xylene, and a biodiesel surrogate based on methyl decanoate; and continue the development of aerosol fueling capability.

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

All ten reviewers termed project resources sufficient. Only two offered amplifying comments, one saying resources appeared sufficient to support a fundamental study of this type, the other merely affirming that resources seemed sufficient.

Deactivation Mechanisms for selective catalytic reduction (SCR) of NOx with urea and development of HC Adsorber Materials: Chuck Peden (Pacific Northwest National Laboratory) – ace055



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All four reviewers appeared to believe that this project was well worth pursuing but only one explicitly addressed its relevance to petroleum displacement. Two others did so by implication. The first person said that SCR and hydrocarbon (HC) traps were key technologies to facilitate fuel economy improvement in internal combustion engines, and that this project addressed challenging aspects of protocols for rapid aging of SCR and the performance of HC adsorber materials. The second reviewer agreed, noting that both SCR and HC adsorber catalysts would help reduce emissions and SCR would enable lean-burn engines. The third reviewer observed a very relevant program, adoption of high-efficiency diesel engines relied on robust, cost-effective NO_x aftertreatment devices, and that the deactivation and poisoning of these devices is critical to successful implementation of these devices in the marketplace. The last reviewer pronounced both aspects of this project as relevant to reducing the life-cycle costs of clean, high-efficiency vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One reviewer felt that the technical approach seemed sound, with the OEM providing new and aged catalysts while PNNL did the detailed characterization. This reviewer noted that the project consisted of two phases (i.e., SCR aging and HC adsorber performance assessment). The second reviewer described the approaches to both phases effective. This reviewer described that in the SCR aging portion of the work, the approach successfully identified and addressed the key technical barriers of sulfur poisoning and deactivation mechanisms, using appropriate methods to assess these losses. In the HC adsorber performance assessment portion of the work, performance parameters were well established and technical barriers effectively identified. Technical barriers for HC adsorber performance relative to zeolite type (variations in pore size and shape, acidity, and Si/Al ratios), the effects of added metals and/or other exchangeable cations were the main targets along with deactivation methods. The third reviewer cautioned that the project work was outside his areas of expertise and noted that reporting two different projects in a single presentation somewhat complicated evaluation of the projects. The reviewer nonetheless observed that understanding aging mechanisms helped designers avoid and/or mitigate those mechanisms and realistic aging protocols substantially lower total testing time and cost. The reviewer noted that the team was also investigating fundamental understanding of HC trap mechanisms. The final reviewer offered the comment that the experimental feed gas used in the HC adsorber work seemed to be well-designed and asked if the research team had thought about aging catalysts to full useful life (FUL) on the vehicle instead of just to 50,000 miles.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

All four reviewers were impressed by the technical accomplishments and progress achieved in this project and were intrigued by some of the same findings. One person cited the recognition that sulfur trioxide (SO_3) had a greater effect on catalyst poisoning than the more abundant sulfur dioxide (SO_2) was a significant result, showing the importance of developing system-level understanding. The second reviewer agreed, saying that there had been good progress and technical accomplishments in both phases of the project. The SCR aging portion accomplishments, this reviewer said, were handled thoroughly with very clear, strong results concerning the effects of sulfur poisoning. Echoing the first reviewer's comment about the relative effects of SO_3 and SO_2, this reviewer further noted items including the ability to remove SO_3 with catalyst heating strategies, the greater activity loss at the front of the catalyst, and the source of activity loss and its probable causes. The more complex and interesting aspect, the reviewer felt, and which is critical to the dissemination of this work to other manufacturers, is the specific methods and degree to which this research allowed the SCR aging process to be reduced. The presenter, however, identified this as work done by Ford, which unfortunately limited the universal value of the work. The published work showed the protocol recommendations; however, the presented work and questions did not address this point. The reviewer thought the HC adsorber portion of the project also showed significant accomplishment, with the establishment of clear assessment parameters, set-up of the reactor and initial tests of ethanol adsorption and desorption. Agreeing with these comments, the third reviewer said that progress on the SCR work was very good and wished to see more progress on the HC adsorber work in the future. The fourth reviewer cited strong technical accomplishments overall. The same reviewer opined that understanding the mechanism of sulfur poisoning was important and the studies on SO_2 versus SO_3 seemed critical given the diesel oxidation catalyst (DOC). It was unclear to this person why these sulfur oxides effects were not shown. Secondly, it was very interesting to this reviewer that the aged SCR was largely deactivated in the front end due to changes in the copper, and not so much due to carbon or phosphorus. However, the reviewer acknowledged that there did not appear to be any insight offered as to why the copper aged differently at the front of the substrate than at the rear, which led to the reviewer asking what the root cause may be.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Two reviewers lauded collaboration on this project. One called it good collaboration, calling Ford Motor Company a strong partner, with clear, published results. While observing that this project appeared to have fewer partners than other programs, the second reviewer also noted that, unlike some of the other programs, the collaboration seemed very deep and well-coordinated. The two other reviewers joined in making the observation that there was not a catalyst company involved in this work. The reviewer felt this would help to resolve any issues found and implement in future technologies, so suggested working with a catalyst manufacturer in the future. Seconding this, the other reviewer suggested that a catalyst supplier could be a worthwhile addition to the team. That reviewer also noted the presence on the team of a major automotive OEM (Ford).

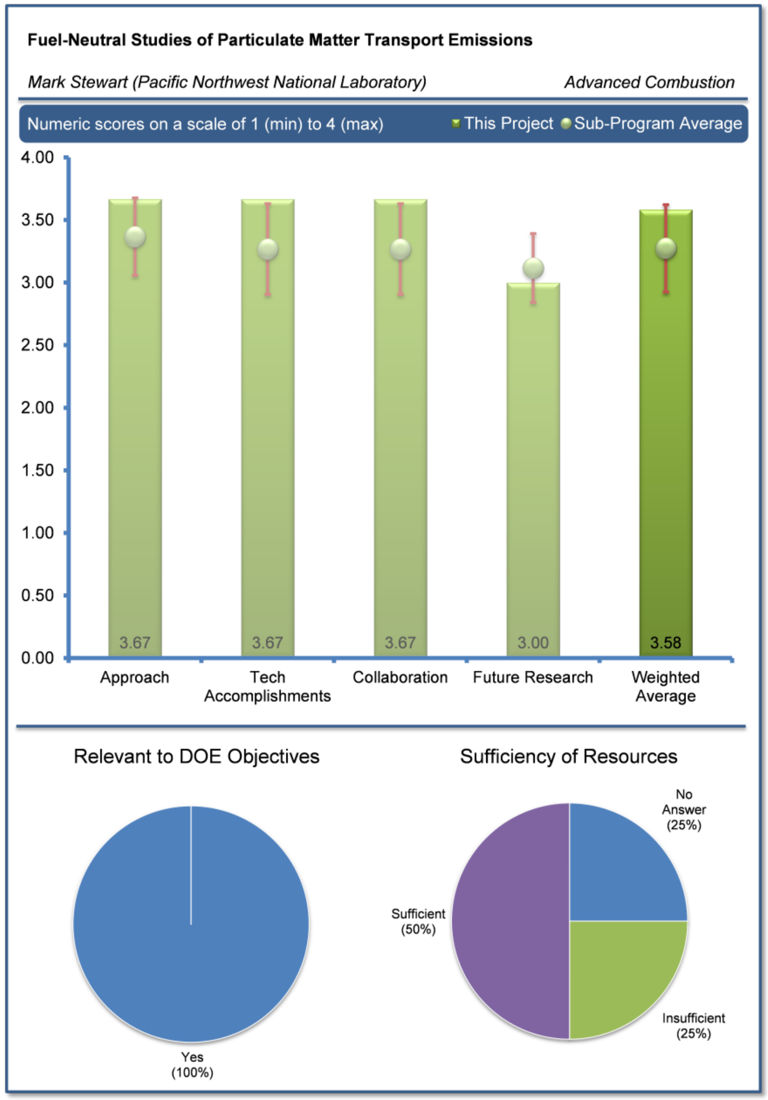
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Future activities appeared reasonable, given that the projects were nearing completion, said one reviewer. The second deemed the proposed future work good to fair both phases of the project, especially the SCR aging work, as it was sound and nearly complete, with models being evaluated against actual dynamometer test results. The HC adsorber had limited/fair plans for future work, with the claim of limited funding. For HC trap, the specific focus was limited to studies aimed at identifying ways to improve ethanol retention (and the potential for metals and exchangeable cations zeolite pore structure). The final reviewer commented that the HC-trap future plans seemed a little unclear and lacking specificity. The reviewer also wondered what exactly the deliverables were.

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

Three respondents deemed resources to be sufficient, while another respondent found resources to be insufficient. One respondent said the SCR catalyst work was done well with a limited budget. The HC trap work was by researchers to be underfunded in light of the large array of work ahead. The reviewer felt that this claim was not well substantiated and required additional support, which the reviewer anticipated. Another respondent felt that not enough resources had come from the PNNL side and questioned whether resources were sufficient to complete the work in the time left for the project.

Fuel-Neutral Studies of Particulate Matter Transport Emissions: Mark Stewart (Pacific Northwest National Laboratory) – ace056



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All three reviewers appeared to consider this work important, but the only reviewer who explicitly addressed the matter of petroleum displacement noted that its focus was not directly on displacing petroleum, although a few ethanol fuel blends were tested to get a sense of the differences in soot morphology. The reviewer went on to describe the project as focusing on particulate emissions (particle size distribution, aggregate shape, average particle size, etc.) from next-generation engines. Particulates produced using a few different fuel blends (e.g., E20) and engine operating conditions were considered to get a sense of primary particle sizes, fractal dimensions, size of agglomerates, etc. Modeling efforts for filtration were also conducted and select results were reported. The second reviewer speculated that the project's relevance could increase pending California Air Resources Board LEV III and EPA Tier 3 emissions regulations and a potential move to regulation of particulate emissions by particle number versus the current particulate mass regulation. The reviewer also mentioned that the focus on gasoline direct injection (GDI) was important for U.S. market versus diesel particulates. The final reviewer commented that this work was an extensive effort to characterize soot from gasoline-fueled engines. The reviewer reported that there was substantial concern that filtration would be needed for high-efficiency gasoline engines. Since gasoline engines made up a very large proportion of the consumer vehicle fleet, resolution of the need for filtration and definition of the filtration characteristics was a very large barrier to future gasoline engine development.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Calling it a coordinated approach of measurement and modeling, one reviewer said the approach appeared to utilize all tools to evaluate the character of gasoline soot. In addition, it was evaluating the soot emissions from all three types of future consumer gasoline engines. Another person urged the project team to consider adding engine temperature (especially combustion chamber temperature) to the test plan, pointing out that most particulate matter (PM) was generated during the first 500 seconds of engine operation on a GDI engine. The third reviewer observed that the work focus to date had been on spark-ignition, direct-injection (SIDI) engines, on the assumption that those would play an important role in efficiency improvement; a recent focus on gasoline direct-injection compression-ignition (GDICI) and reactivity-controlled, compression-ignition (RCCI) engines had followed suit. This reviewer called for additional justification in the form of evidence to suggest that these new engines would displace current internal combustion (IC) engines. The reviewer added that the presentation had been gratifyingly informative concerning the soot/particle characterization and unit collector modeling, and that it would be helpful to strengthen the tie between the experimental characterization work and modeling work. The reviewer concluded by mentioning that the characterization work provided some sense about the average particle size, and perhaps could be used to guide the filtration design work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Noting that the number density, volatile fraction and morphology of the soot particles were examined, a reviewer called this the most comprehensive study presently available. Another person described the project as significant work on characterizing primary particle size and morphology of soot agglomerates for SIDI operation and praised it as nice work, overall. Improvements suggested by this reviewer included the development of a comprehensive understanding for a broader range of operating conditions and closer tie between the characterization work and modeling effort. The reviewer further noted that tunneling electron microscopy (TEM) of particulates for gasoline and diesel had been done, that gas could be more reactive and that ethanol blends produced far fewer particulates. Other project findings mentioned by this reviewer included that the shape and number of particles changed depending on fuel-air ratio, rich or lean, and that the data were providing a better fit to models.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Observing that the direct funding for this project was relatively low, one reviewer said that the investigators have nonetheless very effectively leveraged results from several very well-respected research institutions to gather a comprehensive view of the gasoline soot. The combination of OEMs, university, and national laboratories was good in the view of the second reviewer. The final comment was that the primary collaboration was really between PNNL and the University of Wisconsin (UW). The reviewer did acknowledge that Pennsylvania State University provided analysis and imaging of the particulates and GM seemed to have provided financial support for the UW engine research.

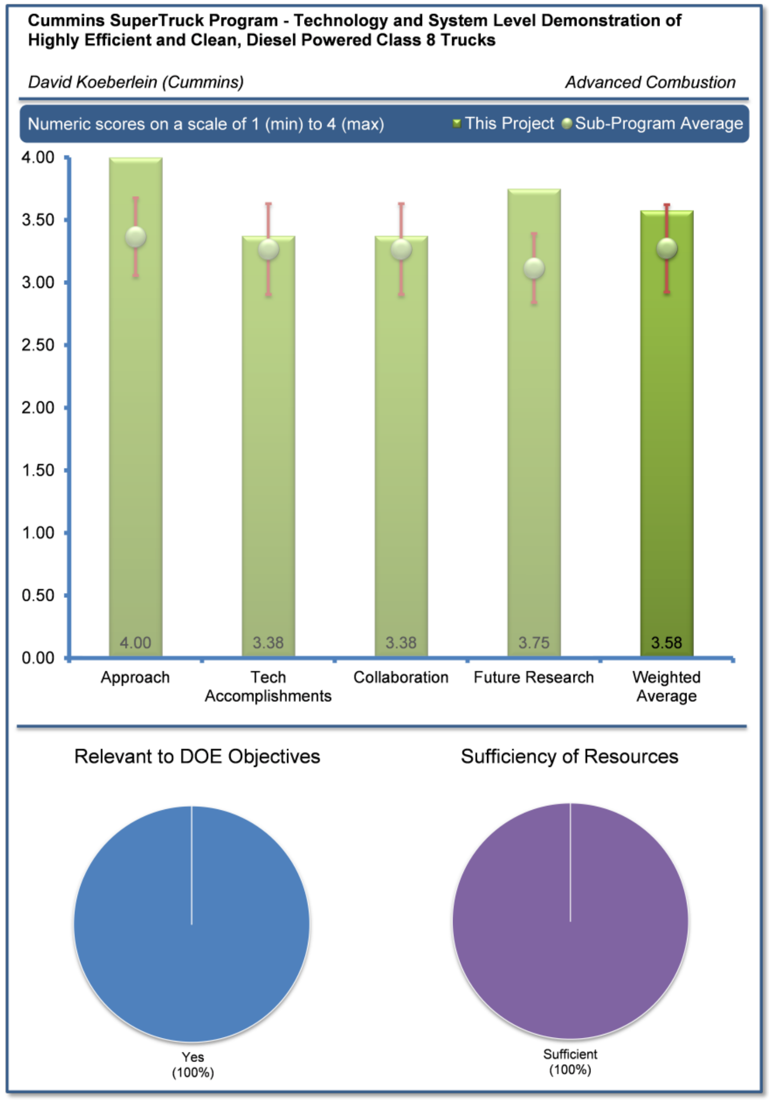
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Both reviewers commenting offered suggestions for future research in this project. One observed that the current future plans did not seem to emphasize the filtration efficiency for these gasoline-generated particles using the innovative, membrane-coated soot filters. Noting that it may simply have been unclear from the slide if these membrane-coated filters were being evaluated or if the end of funding in 2012 precluded a more extensive study of these filters, the reviewer expressed a strong desire to see these filters included in the future of this work. The second reviewer's suggestion was that the results be extended to a broader range of operating conditions and that a more fundamental understanding be developed of how the particle size/morphology depended on engine type/fuel type/operating conditions.

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

The one reviewer (of three commenting) who deemed project resources to be insufficient, noted that this work was apparently scheduled to end in FY 2012, a fact the reviewer deplored, saying that the work was sorely needed to allow engine manufacturers the technology to control soot from gasoline-fueled vehicles. The only comment made by either of the reviewers who considered resources to be sufficient was that the resources seemed sufficient.

Cummins Super Truck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks: David Koeberlein (Cummins) – ace057



Reviewer Sample Size

This project was reviewed by eight reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

While not all eight reviewers directed their comments explicitly to the matter of petroleum displacement, most did so at least indirectly and all seemed to agree on the merits of the project. One reviewer said this project supported DOE objectives for petroleum displacement because it targeted one of the highest fuel-use segments (Class 8 Tractors) and provided potential for near-term reductions in fuel use in these applications. Two other reviewers commented, respectively, that major efficiency improvements in highway trucks would reduce energy use significantly, and that the project objectives were clearly in line with energy reduction and security. The fourth commenter noted that the objective and goals of the SuperTruck program were formulated to reduce petroleum consumption in the medium- and heavy-duty truck market. This reviewer was inclined to classify not using petroleum as equivalent to displacing it, and perhaps even better, because petroleum not used was an increment of carbon not emitted into the atmosphere The fifth reviewer praised the very solid presentation overall and deemed the project to support the overall objectives of petroleum displacement, but felt it might be extended. Stating that Cummins was the only company that has not considered downsizing as the project approached the efficiency goals, the reviewer expressed the opinion that if Cummins could meet the goals with technology that was excellent, but Cummins could then exceed the goal with additional, simpler strategies such as downsizing. One reviewer called engine thermal efficiency improvement the most critical element of this program in meeting the overall DOE objectives. Another evaluator said that the value was an approach which used an untested technology; in this case it was the solid oxide fuel cell. The last reviewer noted that the project met the American Recovery and Reinvestment Act (ARRA) and DOE Vehicle Technologies Multi-Year Program Plan goals.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

All reviewers endorsed the work approach, with several noting its sharp focus and its concentration on engine and powertrain optimization. One reviewer noted that this project had demonstrated 49.3% engine efficiency, which the reviewer believed was the best demonstrated to date. In the view of another reviewer, Cummins had done a good job identifying and categorizing the different losses of the engine and powertrain. Because of their business, their emphasis was on improving the efficiency of the engine and powertrain system. The reviewer felt that the project team’s estimates of the potential improvements achievable by addressing each of these losses are reasonable, but unfortunately, because of the nature of the program, technical details of the approaches being used were not presented. The commenter added that the review must accept that the researchers are competent and doing good work. The reviewer felt that the approach that the researchers were following was sound and that the presenter did a nice job reporting on their answer to the question of whether a non-EGR engine with increased aftertreatment or one using EGR and less intense aftertreatment gave a preferred answer. The researchers were staying with EGR. Downspeeding and higher BMEP will play an important role in the project work. It is an integrated effort with collaboration among many participants. The third reviewer called the project sharply focused indeed, well integrated and covered the bases. This appeared to be a solid analytical and experimental technology selection program, said one reviewer. Although the presentation was very short and thus could not say too much, some data was shown to indicate real work and solid results. The overall approach was very strong (as expected) on engine approaches, observed another reviewer, who also noted that there was good definition of barriers and approach, and authoritative descriptions. The approach to EGR and brake thermal efficiency (BTE) was logical and analytical. The approach seemed a very strong and engine-centered one, which was expected. The reviewer commented that these contributions would make the whole SuperTruck program of DOE more productive. Partially echoing these comments, a reviewer described the work as highly focused on technical barriers for engine/powertrain efficiency: EGR, automatic transmission, waste heat recovery, downspeeding, friction, combustion chamber design, and fuel injectors. The project was very sharply focused on goals with reasonable technology decisions, another reviewer said, calling it the best of the program. The last reviewer noted that the program included many advanced technologies that could mitigate the overall program risks and that the road map was very well-defined.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One reviewer commented that this project showed outstanding performance for the very challenging goal of 50% brake thermal efficiency (BTE). The project was currently at 49.3% and had well integrated engine systems which had potential for near-term production, including an integrated waste heat recovery (WHR) system. According to the principal investigator (PI), the map at which the high efficiency could be achieved had been significantly widened, which was excellent. The research team had exceeded the freight efficiency goal of 50% by 10% (i.e., reached 60%). This assessment was largely echoed by the second reviewer who called the presented results impressive, noting that the team claimed a demonstrated 49.3% BTE in 2012 and expressed confidence that by addressing the remaining issues, such as a compression ratio (CR) increase, combustion chamber shape optimization and specific injector calibration, the 50% BTE would be achieved. The same reviewer indicated that the researchers would not pursue hybridization. The project anticipated including waste heat recovery, which the researchers felt they were uniquely qualified to do, and would enable meeting the ultimate target of 55% BTE. Two other reviewers commented on similar lines. One person said that the small amount of data shown indicated very solid progress toward these very difficult goals and was impressed by test results from the waste heat recovery (WHR) system. The second commenter noted the very impressive progress at 49.3% BTE now, and called this result the best of the four programs. This reviewer praised the description of gains achieved, predicting that the team would exceed goals and be well on the way to 55% total. The reviewer welcomed the open presentation the research team made welcome. A reviewer noted that the project was on target and ahead of schedule in some aspects, another that the team seemed to be doing well with emissions, but observed that because there was very little discussion of the solid oxide fuel cell (SOFC) it was difficult to know where that was in development. Yet another reviewer called attention to the demonstration of 49.3% BTE with engine, aftertreatment (AT), waste heat recovery (WHR) (analysis shows optimization would move it to just over the 50% mark), reduction in pumping and friction losses. Finally, the last of the eight reviewers seconded several colleagues' comments, and called the demonstration of an interim milestone for 50% BTE an amazing accomplishment.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Some evaluators offered suggestions for additional collaboration or changes to the relationships among them, but reviewers were united in their approval of the collaboration and coordination within the sizable group of cooperating companies and institutions. One reviewer said that through Cummins Inc. and Peterbilt Motors, many different organizations were included in the work. From the information presented, it appeared that the project had a good collaborative effort. Another person agreed substantially, noting a nice list of who was doing what and a good set of collaborators. Cummins had a history of working well with long-term collaborators, including suppliers and universities, and this program built on that. The third reviewer's comment was similar, noting a nice breakout of collaborators, with clear definition of engine and vehicle partners. The challenge, this reviewer said, would be integration rather than throwing it over the fence. Also, there was a risk that full optimization of the interplay between the engine and vehicle might not be realized. That was not altogether bad, as more would be required from each, and integration could be learned from others. The project was quite engine-centered, but there was very impressive collaboration with right team members. The fourth reviewer also noted the long list of supplier, university, national lab and OEM contributors. The project's bottom-line results were well integrated and appeared commercially productive, substantiated effective integration of suppliers', universities', and lab's efforts. The project team, in the words of the fifth reviewer, was solid, diversified and integrated. This reviewer, however, regarded the SOFC auxiliary power unit (APU) as a weak part of the plan and recommended that the team pursue other options as soon as possible, considering integrated options in contrast to a separate APU. The collaborations were well described, said a reviewer, noting that the work with Purdue University seemed to be very mature. Acknowledging the participation of Modine, VanDyne, ONRL, and Purdue University, another reviewer opined that more university involvement would be an improvement. The last reviewer offered the following comment: actively involve partners into the program with tangible deliverables.

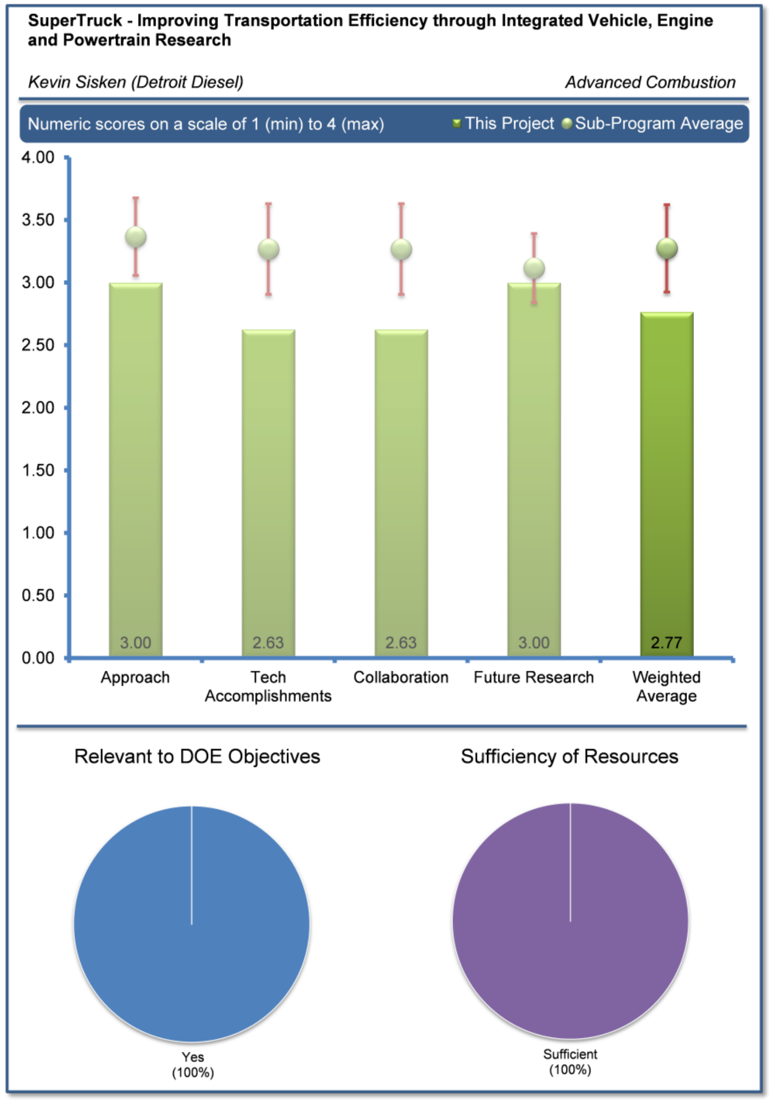
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

All reviewers voiced strong endorsement of the proposed future work. One said that the road map which was laid out and their current accomplishments led one to believe that the project would be successful. In a similar vein, another reviewer described future plans as well laid out and would likely be achieved ahead of schedule. Reiterating gratitude for the team's open presentation, the reviewer said future programs were right in line with what should be done. The third reviewer saw a solid plan to integrate the selected technologies and looked forward to seeing the results next time. The fourth reviewer noted clearly presented next steps which included the final integration and vehicle demonstration of developed technology. Very good, the reviewer added; the project was on target, on plan. The project seemed to be on track, said a fifth person, it was reported in a manner that provided confidence that the project would achieve or exceed their objective. The future work was very well-defined toward the final program goals, according to the sixth of the eight reviewers. Future work was actually excellent, said another reviewer, who referred to an earlier comment urging a revised approach to the APU development and an end to work on the solid oxide fuel cell APU. The future work seemed to be pretty standard milestone description, said the last reviewer, finding nothing exciting there.

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

The eight reviewers all termed project resources sufficient. Four offered supplementary comments, one noting that to achieve such significant goals in a short time required large-scale funding. Cummins and other manufacturers were supporting essentially matching funds, so the research was highly likely to yield productive, real-world results in future designs. Foreseeing that the project team would likely exceed its goals, another reviewer concluded that resources were certainly adequate. This seemed like a good investment and well worth the expenditure, the reviewer said. The third reviewer termed resources solid funding for this major program. The last reviewer said simply that the funding resources seemed to be sufficient.

Supertruck - Improving Transportation Efficiency through Integrated Vehicle, Engine and Powertrain Research: Kevin Sisken (Detroit Diesel) – ace058



Reviewer Sample Size

This project was reviewed by eight reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Five of the six reviewers who offered comments stated explicitly that this project supported DOE's goals. One said it supported DOE objectives for petroleum displacement because it targeted one of the highest fuel-use segments (Class 8 tractors) and provided potential for near-term reductions in fuel use in these applications. Three others weighed in with similar observations, one saying that major efficiency gains in highway trucks would make a big impact on energy use. Certainly this project was in line with meeting DOE's goal of reducing fuel consumption and energy security, another affirmed. The third of these reviewers said that improving engine thermal efficiency was one of the most effective ways to support overall DOE objectives. The fifth reviewer observed that the objective and goals of the Super Truck program were formulated to reduce petroleum consumption in the medium- and heavy-duty truck market. Not using petroleum, in the judgment of this reviewer, was equivalent to displacing it, and perhaps even better, because petroleum not used was an increment of carbon not emitted into the atmosphere. The last reviewer did not directly address the subject of DOE's overarching goal, but praised Detroit Diesel for doing a great job of analyzing the various contributions to fuel economy for heavy-duty trucks.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers were generally quite positive in their assessments of the approach to the work of this project, although some discerned specific weaknesses and offered suggestions for addressing them. The first reviewer observed that the research team was going step by step through each of the possible engine systems and making state-of-the-art technology improvements. The reviewer stated that their approach was the interactive one which was most likely to be successful. The reviewer concluded by mentioning that the project had not identified any technology as being infeasible. The second reviewer was among those who approved the work approach but saw a shortcoming in it. The reviewer called it a good program, predicted that it would be successful, and described that the researchers were pursuing downsizing with an increased CR. The project team, continued the same reviewer, was also aggressively pursuing reduced friction and gas exchange improvements. The reviewer agreed that all of these would give improvements. This person felt that one of the unique aspects of the project team's program was the real-time engine control using global positioning system (GPS) information which would interface with the hybrid powertrain. This was really good, the reviewer said, foreseeing that it would lead to significant reductions in fuel consumption. However, the reviewer saw no efforts in combustion improvement and felt that an important component of improvement was not being addressed. Expressing confidence that the research team would meet the 50% BTE goal, the reviewer added that the project would have been rated outstanding if combustion improvement were also being sought. The third reviewer thought the approach seemed quite good, noting that the presentation covered only the powertrain and not the vehicle part, so the reviewer had to assume that the two lined up well. The commenter stated that powertrain part shown here was good. It would be easier to judge more completely if more detail were presented, but the short presentation probably precluded that, concluded this reviewer. Another evaluator asserted that the researchers had a good approach, who noted that the work was focused on technical barriers to engine/powertrain efficiency, listing EGR decrease, waste heat recovery, engine downsizing, higher compression ratio, reduced friction and parasitic loads. A weakness this reviewer felt was not well addressed was the increased NO_x production in the base engine and the assumption that aftertreatment could take it up without penalty. The fifth reviewer approved the good step-by-step plan to reach 50% BTE and the logic of the order in which subsequent steps would be taken, noting that modeling suggested engine downsizing, followed by work on EGR, then air handling, and finally adding compression ratio and parasitics reduction later. The reviewer agreed that waste heat recovery (WHR) was logically approached last. However, the reviewer stated that counting on a new lubricating oil for most parasitics reduction seemed expensive and risky, but made sense if it was valid for others. It was reasonable, the reviewer felt, to wait in the wings to see how others progressed on WHR. Some unique features of the project seemed risky to this reviewer (fluid). Other aspects of the work seemed incremental to the work of others. This reviewer pointed out that predictive controls were a major contribution and seemed unique and valuable. Achieving 48% BTE from the engine seemed reasonable and the 2% balance from others was expected. However, this reviewer found that the project’s movement toward 55% BTE seemed poorly thought out and wanted to have more information, questioning whether these technologies lined up with 55%. The sixth reviewer said it would be challenging to achieve 50% thermal efficiency from the current 46% in two years. The reviewer asserted that the program should have more options or technology road maps at this stage to show various technology potential to achieve the 50% BTE goal. The last two reviewers’ comments were remarkably similar. One commenter observed that integration of the building blocks was planned for late in the program, and added that some level of integration testing, virtually or in the dynamometer lab, should be ongoing. Separate engine and vehicle development, the last reviewer said, seemed likely to lead to challenges and that better integration here would be warranted.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Four of the eight reviewers who provided comments on this project spoke positively of its accomplishments and progress, although some expressed reservations regarding some aspects of the work. One person said that progress was good; 46% BTE had been demonstrated, and the project’s road map to getting to 50% was credible. According to the project road map, the researchers will use WHR to get to 50%. From the presented information, there was reason to be confident that the researchers would succeed. Another agreed substantially, saying the evidence so far indicated the researchers would be successful. This reviewer cited waste heat recovery and route prediction as the most challenging aspects of the proposed work. Solid progress on several difficult technologies was the assessment of the third reviewer, who was pleased to see some real data even in such a short presentation. The fourth reviewer complimented a good description of accomplishments, citing impressive progress on aftertreatment, air handling, engine mapping and firming calibration and predictive capabilities which were described as unique. Achieving 46.2%, this reviewer said, was well on the path. The project represented very impressive work on all aspects of the program. Subsequent reviewers, while generally positive in their estimation of the project’s progress, also noted potential shortcomings. One said good performance for the very challenging goal of 50% brake thermal efficiency noting that the team’s results currently stood at 46.2%, with plans to optimize a prototype waste heat recovery system and other components. The reviewer noted that a weakness appeared to be the level of productive hardware and claimed thermal efficiency performance gains at the expense of NO_x, which may not be realizable in production, as SCR system cost or performance penalty may offset such gains. Another possible weakness cited by this reviewer was that the milestone of 50% freight efficiency was not addressed in this presentation, being deferred by PI to another presentation on the project. A reviewer expressed the view that 46% thermal efficiency was low at this stage of the project, considering the program road map and the limited time remaining. More detailed commentary on aspects of the project was offered by a reviewer who cited specific slides in the presentation. With respect to Slide 5, the reviewer said much of the reported testing (done and planned) could be avoided if high-fidelity simulation was used. This would save much money and time; ditto for Slide 6. Obviously, the reviewer opined, reduced engine size would reduce its motoring parasitics. Further, higher BMEP at road load would compromise any hoped-for improvements in fired engine parasitic losses, and would have additional deleterious effects. This was engine-engineering ABCs, had been researched for decades and had been the subject of many Ph.D. theses. The engine tests in Slide 11 confirmed what had been known all along. Although currently and historically fashionable, engine downsizing may not be desirable. The reviewer discerned a bright spot in the Detroit program in its controls approach. Returning to the presentation, the reviewer cited Slide 11, saying it repeated tried-and-true pursuits and testing, and gets the same results. The MIT consortium was approved by the reviewer, but also called a rehash of similar work there over the last 40 years. The reviewer said a search of the literature of a decade starting in the late 1970's would surface work similar, albeit even more sophisticated, to the ongoing engine parasitic reduction pursuits at Detroit Diesel and elsewhere. This reviewer referenced work done at MIT, UM, Georgia Tech, and by Japanese researchers. The documents of the DOE's ECUT program of this period would yield similar results. The last reviewer cited the considerable amount of controls work (i.e., neural network to calibrate) yielded the accomplishment of good predictions for transient events, and reported that the 46% goal was met.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewers' comments on this aspect of the work indicated general approval of the breadth of the collaboration, but expressed reservations concerning the actual degree of involvement. One reviewer said that the project's collaborative effort was good. The project worked with two national labs, one university, and a company and it appeared the effort was coordinated and each participant had specific tasks. Another felt the researchers were working with their collaborators in a supplier mode, which appeared to be working. However, there was not much evidence of feedback from the suppliers having an appreciable effect on the project trajectory. This reviewer speculated that this impression may have resulted from the brevity (20 minutes) of the presentation. The third reviewer said that there seemed to be a good team, although most of the work appeared to be in house. Perhaps, the reviewer speculated, there were a number of suppliers involved who were not documented here. The next reviewer sounded a contrary note, sensing weak collaboration, but allowing that this might be an incorrect impression. It seemed to this person that Daimler was doing everything. Others had a small role, but this was not all that bad, except that it did not permit for widespread dissemination of knowledge acquired with public money. Internal coordination toward meeting the goal was nonetheless expected to be excellent. The fifth reviewer noted a fair list of collaborating partners – MIT, national labs, and DOE – but felt that, for commercial production systems, there seemed to be a weakness in that only limited production supplier organizations had been identified. The Principal Investigator (PI) asked the audience to recognize the inherent support of the German parent company, but no material support was substantiated. The PI also pointed to the strong attention to detail in the use of funds. The complicated master powertrain controller system was developed by parent company Daimler Trucks AG, based in Stuttgart, Germany. The following reviewer echoed this observation, calling the collaboration a bit parochial. Limited partnership with ORNL on WHR and with Atkinson on controls was cited, but the reviewer agreed that the involvement in the project of Stuttgart should have been explained and details provided as to what was being done there versus here in the United States. The last two reviewers' comments were brief, one noting the collaboration of Oak Ridge National Laboratory (ORNL), MIT and Atkinson but wished for more university involvement. The other said simply that various partners seemed to be involved in this program.

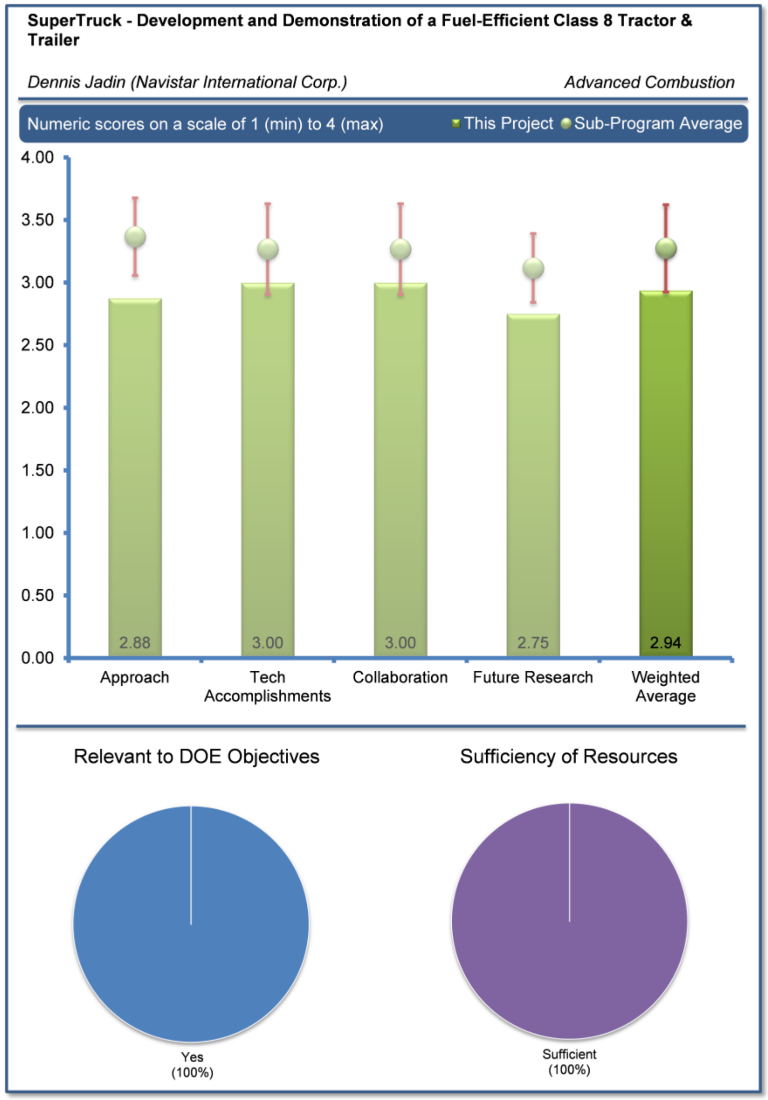
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers expressed general confidence in the proposed future research, but noted the challenging nature of the work remaining to be done and the relatively short time that remains in which to accomplish it. One thought there seemed to be a solid plan, assuming the powertrain/vehicle interfacing was done as well as the part presented here. Another reviewer noted that the team was close to meeting the project target and has stayed pretty much on trajectory. Another expressed a high level of confidence that the project would achieve 48% engine-out and get at least 25 from WHR. The reviewer noted that there had been no comment on a proposed pathway to 55% BTE. The approach to laying out a trajectory to achieving 55% BTE was not very well-defined in the opinion of one reviewer, who interpreted the approach as being: the project would achieve 50% and then see where improvements could be made to reach 55%. The fifth reviewer noted a good understanding of future obstacles and the approach that was laid out. This reviewer felt that there was some room available for misses, but not much. The project was well laid-out and the work seemed to be focused on high-risk areas. More thought should be given to the 55% BTE goal and the long-term roadmap, but tools were in place. The sixth reviewer noted that the project was now in its second year and weaknesses identified so far were that the SCR system was not capable and the waste heat recovery system was still in optimization. Thus, there was the risk that many additional gains were planned to be achieved by complex and time-consuming friction reduction and combustion development. The seventh reviewer briefly sounded the same cautionary note, saying that the technology menu seemed to be thin considering the aggressive goals and the current achievement of 46.2% BTE. The final reviewer simply referred to comments made in the previous section, in which criticisms were directed at specific slides in this presentation.

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

The eight reviewers unanimously agreed that resources were sufficient in this project. Five of the reviewers offered further comments. One said that the mix of DOE funds and industrial funds was not quite clear from the presentation, which left the reviewer with the impression that DDC's investment greatly exceeded the DOE investment, leading the reviewer to conclude that resources were sufficient. The second reviewer saw solid funding for a major program. Funding seemed about right and goals were being met, said a third evaluator. Non-project help from Stuttgart assures success and adequate resources. The fourth reviewer noted that to achieve such significant goals in a short time required large-scale funding. Detroit Diesel was on track, but there were some concerns about production-ready subsystems and components from the project based on their current maturity of development. The last reviewer identified the uniqueness of the project as the support of people and resources (especially for WHR) and predictive controls.

Supertruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer: Dennis Jadin (Navistar International Corp.) – ace059



Reviewer Sample Size

This project was reviewed by eight reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Five of the six commenting reviewers agreed that this project supported the DOE objective of petroleum displacement. The sixth did not address that question explicitly, but observed that the value of these competitive projects was that each had a different focus. This project, as far as the reviewer could determine, emphasized reactivity-controlled, compression-ignition (RCCI) combustion technology. The first of the other five reviewers said the objective and goals of the SuperTruck program were formulated to reduce petroleum consumption in the medium- and heavy-duty truck market. Not using petroleum was equivalent, in this reviewer's opinion, to displacing it, and perhaps even better, because petroleum not used was an increment of carbon not emitted into the atmosphere. The second of the five said major improvement in truck efficiency would save significant energy use. Another concurred that the DOE Program goals were right in line with this project. This project, in the view of another reviewer, supported DOE objectives for petroleum displacement because it targeted one of the highest fuel-use segments (Class 8 tractors) and provided potential for near-term reductions in fuel use in these applications. The last reviewer observed that engine thermal efficiency improvement undertaken in the program was one of the key deliverables of the DOE program.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most reviewers seemed to be in two minds concerning the approach to this work. The reviewers recognized and applauded its uniqueness, but foresaw critical technical challenges to be overcome. One said that using an advanced engine technology was definitely an alternative, but was not convinced that the computational fluid dynamics (CFD) calculations provided value. This reviewer strongly approved the payback analysis and cited the planned reduction of the waste heat recovery complexity as a potentially significant accomplishment if the BTE goal could be reached without it. The reviewer said that most of the SuperTruck projects presented to that point had seemed to be throwing everything at the ultimate objective. This project showed a rational evaluation. The second reviewer noted that Navistar was not as far into their program as two of the other teams, said the project seemed to be pursuing an approach of minimizing the need for sophisticated aftertreatment systems that minimized engine-out NO_x emissions so that the project could minimize NO_x aftertreatment system complexity. The reviewer felt that a persuasive technical foundation for this approach had not been presented, but considered the approach unique. Other teams, the reviewer said, were looking for synergistic combinations of combustion modifications and aftertreatment system performance, that was, employing much more of a systems optimization approach and wondered if Navistar had assessed the trade-offs of letting the in-cylinder emissions increase and relying on the capabilities of the improved aftertreatment systems. As they stated, it was a system challenge. They are placing tremendous emphasis on improved combustion, which is good, but may be over- constraining themselves with simplified aftertreatment. The third reviewer was less concerned about such considerations, calling the program plan excellent, pragmatic and realistic. On a peripheral matter, the reviewer noted that for the second year, the presenter was shown as Dennis Jadin, while in fact the person who led the engine sub-program was William de Ojeda. This should be corrected, the reviewer said, ethically and professionally. Dennis was the SuperTruck program manager, but did not need to have his name on the engine section; see the similar presentations of others. This reviewer made three additional minor observations, calling the presentation style excellent, citing Slide 8 as an exemplary tech program tracking chart and urging all SuperTruck contractors and others to construct their program reporting in like fashion. The reviewer praised the presentation as having substance and value, which was good for DOE and its stakeholders. Another reviewer, while citing the difficulty of judging well on such a short presentation, said a strong set of technologies had been considered by the project team. It was unclear to this reviewer exactly how the set was defined and how the downselection was being done. It appeared, the reviewer said, that Navistar was relying more on advanced combustion concepts than other SuperTruck teams. These were very sensitive to fuel properties and would require sophisticated systems to control combustion in the presence of fuel variability. The reviewer surmised that while this may be included it was not mentioned in this presentation. The fourth reviewer called new approaches to the overall DOE program a good idea and agreed that keeping $deNO_x$ on the table but moving to low-NO_x, high-efficiency engines was challenging but pushed the envelope. The reviewer cited a nice approach to components and payback period, and expressed hope that the new program shifts would pay off. RCCI seemed a very high risk, the reviewer felt, for a minimal return and the approach to achieving 55% BTE seemed weak. In a similar vein, the fifth reviewer commented that the plan's strength was that it included virtually all important elements which could be listed to reach the goal of 50% BTE and the path toward 55% BTE, including waste heat recovery, combustion and friction reduction. Additionally, the approach considered the value equation through payback analysis and presented this, which was a great benchmark. The weakness, on the other hand, seemed to be the plan to incorporate every possible option and potential pathway (e.g., the addition of RCCI, PCCI). This posed complexity risk and the possibility the system would become unwieldy and difficult to manage to successful completion as focus and resources became scattered. The next reviewer also discerned technical risk in the approach, noting that the main plan was hybridization, which was risky. This reviewer noted that Navistar was the first company to mention the true sticking point of any new technology (i.e., customer acceptance) and bestowed kudos to Navistar for realizing that it did not matter how great the engine was if no one would buy it. The reviewer also cited the best matching between in-cylinder combustion and aftertreatment and observed that the plan did not relax engine-out emissions to improve efficiency. The reviewer observed only mention of cost/payback consideration. The reviewer indicated that last year's reviewer comments on payback were taken, and then further reported re-evaluation and down-selection to derive an updated plan. However, continued this reviewer, the plan for RCCI seemed unreasonable. The same reviewer pointed out that the efficiency numbers quoted come from a single point, and for a technology that was notoriously hard to control; this seemed very unrealistic, opined this reviewer. The last reviewer found it unclear whether the baseline engine was based on an SCR solution or EGR solution. It would be extremely challenging to achieve the program 50% BTE goal with the EGR solution approach while maintaining 2010 emissions levels, in this reviewer's opinion. Integrated aftertreatment and engine should be one of the critical areas for improvement. Slide 7 failed to mention any contribution from the aftertreatment system.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer comments again reflected the tension between recognition of high technical risk and the possibility of significant payoffs from the incorporation of uncommercialized technologies. One reviewer said that the work the project team had done so far was very good and explained that the project team was earlier into the program than two of the other teams. Therefore, observed this reviewer, much of the project work was still at the component, bench, and simulation level. The evaluation work the researchers did on WHR systems was good. The project was pushing technical boundaries with their injection systems and working with Bosch in a nice collaboration. The project's demonstration of 46.5% BTE on the dynamometer resulting from improved combustion and turbocompounding was good. The researchers were pursuing exciting new technologies like RCCI, the reviewer noted, which was anticipated to be challenging for them to achieve the load and speed range of their applications, but indeed they were pushing the envelope. The second reviewer was of like mind, noting good performance for the very challenging goal of 50%

brake thermal efficiency. Current result was 46.5% BTE and the research team had begun to integrate engine systems with the potential for near-term production, including a waste heat recovery system. One reviewer described that a weakness and risk was that progress had been slower than planned and the team had taken on a long list of technologies. The project's accomplishments were limited, but were progressing, said the third reviewer, who expressed appreciation for the open descriptions, and noted that the parasitics had been met. BTE seemed behind but was nonetheless on track at 46%. Variable valve actuation (VVA) seemed integral but was slow. Air handling progress was good. The fourth reviewer felt that the fuel reactivity studies of this program complemented the Sandia National Laboratories (SNL), UWM, and ORNL work. It had the potential to produce higher-value, disruptive technology results and was worthy of DOE support via the SuperTruck program or separately. The reviewer mused about a team led by competent engine representatives (ORNL or Navistar) spearheading such a relatively large program, and involving SNL, Argonne National Laboratory (ANL) and UWM, but did not recommend any of those three organizations to lead such a team. The reviewer asserted that the controls piece was critical, but there was not much reporting on it. The same reviewer also mentioned that Navistar could benefit from an increased focus on controls. This was especially critical in probing the VVA and fuel reactivity areas; otherwise, a great discovery (or discoveries) may be missed. The Detroit Diesel controls part of the SuperTruck may provide a clue. ORNL, but not other laboratories, have some competence in this area too. So does UWM, focused here on combustion. This project had a lower demonstrated engine efficiency than the other programs, a reviewer noted, finding it hard to separate what analytical from experimental data in some of the slides. The reviewer said it appeared individual parts had been tested and the benefits combined analytically to predict future program results. Other teams seemed to have more of their systems put together with actual test data to support their status. The last two reviewers noted, respectively, that this team had hit 45% BTE with engine alone, without compounding and friction numbers, and that jumping from the current 46.5% BTE to 50% in two year is a big step, especially while maintaining 2010 emissions at 0.2 g/bhp-hr NO_x level.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer comments continued to be equivocal in this section of the review. One reviewer said that the project had identified and established collaborations with good partners: Bosch, Federal Mogul, and ANL. The second reviewer expressed that the project team apparently was working with Argonne, but that it did not seem to be an intensive collaboration and that very few other collaborations were mentioned. Work within the partnership was needed and going well, said the third reviewer; all parties seemed committed and coordinated. This reviewer observed a well-managed project. The next reviewer noted little mention of collaboration other than a listing of a small number of partners on an early slide. This reviewer found it unclear what the collaborators were doing, for instance, whether Bosch was a development partner in control and combustion, or just providing fuel system parts. The ANL/Wisconsin collaboration was not defined, the reviewer said, presuming it to be related to RCCI, but left wondering what that effort was doing, what part Navistar was counting on, and who was doing what. The fifth reviewer cited as a strength of the project the engagement of some suppliers (Bosch, Federal Mogul, Behr), and one national laboratory. With the long list of technologies to model, integrate, and test, the reviewer said, the weakness was a short list of collaborators. Additional suppliers and universities might strengthen the team's ability to deliver all of what was promised. It may be that there were other collaborators, but these were not mentioned in the presentation. The sixth reviewer also noted the collaboration of Behr, Federal Mogul (friction), Bosch (high pressure injection), ANL, and the Engine Research (ERC). The last collaborator, in spite of its co-location and association with the University of Wisconsin, was not a true university partner, in this reviewer's opinion. Another reviewer said a good team of collaborators was on board, and felt that close (or closer) involvement by Navistar and perhaps UW-M, in the ongoing testing at ANL was warranted. This should cover hands-on involvement in the execution of the test plan, quality of data acquisition, raw data processing, etc. The last reviewer said it seemed that all key partners were involved in the program.

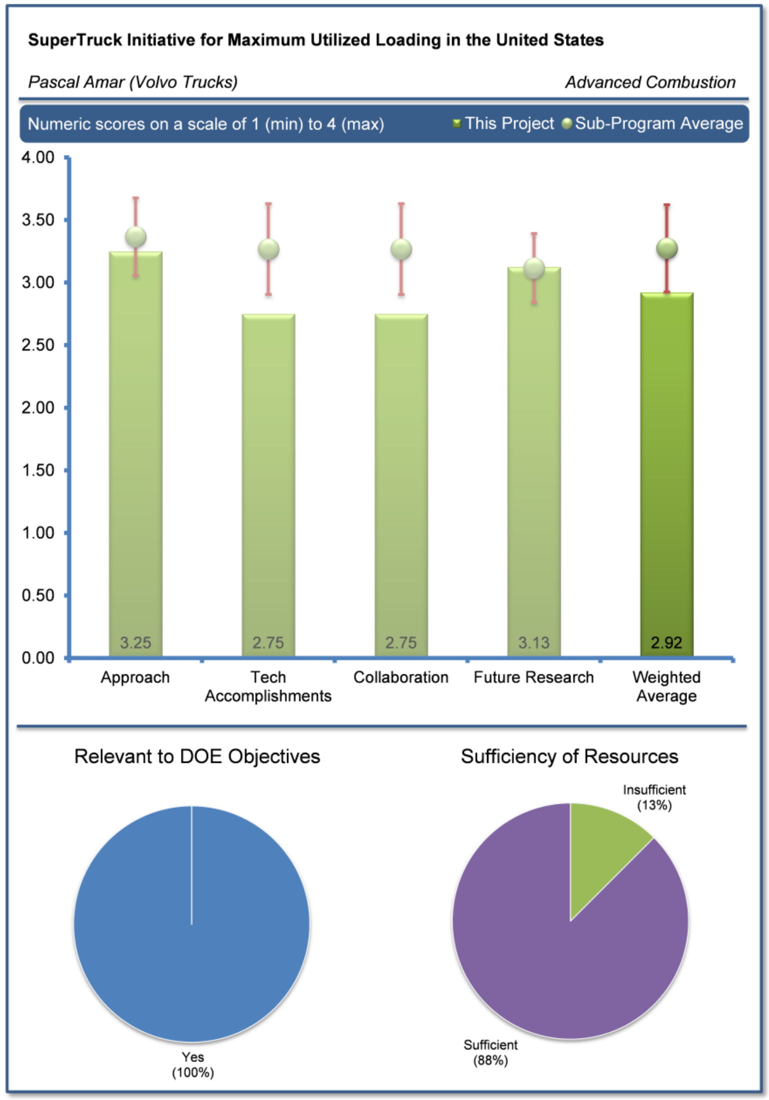
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers continued to be in two minds about the proposed future direction of this research. One found the description of the future work to be somewhat limited, consisting mostly of milestones. While expressing hope that the team would meet their efficiency targets, the reviewer felt that the future plans did not show a clear path to success. The second reviewer's assessment was that the team had over-constrained themselves by imposing the limit of a simple aftertreatment system. This reviewer suggested the team at least analyze the efficiency gains that would result from assuming aftertreatment capabilities equal to those of in-use systems and determining what the optimal engine performance would be if that level of emissions were allowed to leave the cylinder to be handled by the aftertreatment system. This reviewer, too, found the proposed trajectory to reach 55% BTE target to be unclear. In the opinion of the third reviewer, the future plans were not explicitly identified. The reviewer was left in doubt as to how the combustion system would be selected, whether there would be aftertreatment and, if so, what kind would be used. VVA was to be added, but no strategy of analysis was presented to say what that term meant in practice or what basis there was for expecting the results shown in the plan. Weaknesses in the proposed work were being addressed, one reviewer said, and while there were many challenges, the plan seemed doable. However there was a big gap in the approach to 55% BTE. The strength was a solid plan of attack, said the fifth reviewer. There were separate efforts planned for engine friction reduction, the prototype Rankine cycle WHR system and PCCI/RCCI engines. The weakness lied in the timing delays and the risk that the already large scope may continue to grow and become untenable or result in further delays and cost overruns. A reviewer suggested that further serious consideration be given to whether RCCI was a viable technology. Another was unconvinced of how dual-fuel engines could help the program achieve the 55% goal in a multi-cylinder configuration, considering this concept suffered from a huge pumping loss and substantial pressure rise during initial heat release.

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

All eight reviewers deemed project resources to be sufficient. Five of them offered further comment. Again, said one, it was difficult to extract how the funds were directed; however, Navistar has billed DOE for about $13 million so far, or about three times what DDC billed. Conceding that knowing how to judge was difficult or impossible, the reviewer ventured that Navistar may not be as far along as DDC. The second reviewer said simply that this was well funded for a major project. The third comment was that project funding may be a little low given the challenges, but project was well-managed. To achieve such significant goals in a short time, said the fourth reviewer, required large-scale funding. Due to fund matching requirements and the structure of the project for specific goals, Navistar research was highly likely to yield some productive, real-world results in future designs. Commercialization of new combustion regimes may put pressure on the budget and it surely would on the timing of the work. The last reviewer commented that resources may not be sufficient if the program was focusing on a baseline engine with an in-cylinder EGR solution.

SuperTruck Initiative for Maximum Utilized Loading in the United States: Pascal Amar (Volvo) – ace060



Reviewer Sample Size

This project was reviewed by eight reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

With the exception of one reviewer who did not address the question directly, the reviewers were in agreement that this project supported the DOE objective. One said that the objective and goals of the SuperTruck program were formulated to reduce petroleum consumption in the medium- and heavy-duty truck market. Not using petroleum was equivalent to displacing it, and perhaps better, because petroleum not used was an increment of carbon not emitted to the atmosphere. The second agreed that major improvement in highway truck efficiency would impact energy use strongly. Likewise, the third stated that clearly, improving freight fuel efficiency was in the best interests of the nation's energy strategy. The technologies listed had a good chance of attaining the stated goals of 50% and then 55% BTE. The fourth reviewer concurred, saying that this project supported DOE objectives for petroleum displacement because it targeted one of the highest fuel-use segments (Class 8 tractors) and provided potential for near-term reductions in fuel use in these applications. This project addressed the objective of petroleum displacement by increasing energy efficiency through lightweighting and systems integration (including aftertreatment and WHR). It supported petroleum displacement through improved efficiency was the conclusion of one reviewer. Another considered that improving thermal efficiency was one of the key overall DOE objectives. The last reviewer remarked that this was part of the heavy-duty improvement in fuel economy, but saw nothing unique about this project and found it interesting that the PI did not choose to make the presentation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewers were hampered somewhat in their evaluation of the work approach in this project by the fact that it was recently begun. One reviewer noted the fact, remarking that Volvo was still very early into their program, so the presentation mostly focused on explaining their capabilities and articulating their approach to achieving the goals. The project had a very balanced and comprehensive plan. As expected, their plan addresses both engine and vehicle improvements and their road map carried to 55% BTE. The second reviewer concurred, saying that the plan appeared to be methodical and systematic. The reviewer would have rated the project higher if more substantive information had been provided to justify an outstanding rating. The third reviewer found it hard to judge based on such a short presentation and with so little actual technical content. This reviewer felt that the presentation implicitly asked reviewers to assume the research team really had useful technologies that ought to work. The next reviewer thought it was unclear that the combustion simulation would add much to the field, given the other models out there. However, if it was a specific tool for the project, this was acceptable. The reviewer also liked the idea of staged development on individual technologies, starting with the 50% BTE goal, and then refining it for 55%. The chassis design approach was valid, the reviewer said, and thought the integrated approach of all aspects of the truck a key attribute. The use of accepted technologies and approaches to achieve the objective improvements was deemed to be a strength of the approach by a reviewer. For the 50% BTE target, the approach was typical, i.e., assess waste heat recovery, combustion, air handling, aftertreatment, driveline in a test cell. For 55% BTE, evaluate PCCI and RCCI, alternative cycles, simulation tool, fuels optimization, demonstrate in simulation and single-cylinder scoping. A weakness of the approach was that the modeling and single-cylinder work for advanced combustion modes (PCCI and RCCI) was not on the critical path and there was no mention of the value proposition for technologies (payback and cost per percent of improvement). The sixth reviewer termed the approach logical, and stated that using the second objective to drive the first seemed well thought out to actually accomplish the goals of the first objective. The approach was unique in that it built an entire system, not just engines and thus resulted in an integrated product. But in the view of the seventh reviewer, the road map was not very well-defined, with different technologies. At this stage, the incremental efficiency improvements based on some of the key technologies should be analytically defined. The reviewer felt that Slide 10 (i.e., Strategy for 50% BTE Powertrain Demonstration) was confusing. It showed that combustion had the greatest impact on BTE improvement, higher than WHR. The final reviewer reiterated an earlier comment, finding nothing special in this project compared with the competitors. There was no clear indication that the CFD work was bringing much to the table.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

In this category, too, reviewers noted the difficulty of rating a project's progress and accomplishment so soon after its inception. Because the project was so early into the program, one reviewer said, it was difficult to rate progress. The researchers had a believable plan in place, the reviewer acknowledged and after viewing the presentation felt that their chances of success were high. The project was already demonstrating efficiency improvement in their early tests. The second reviewer said that the project could have been rated higher if more substantive information had been provided to justify such a rating. This reviewer complimented the presentation style, saying it got the message across with ease. Slide 5 and similar ones gave a top view of the program and allowed reasonable tracking of it, continued the same reviewer, who also suggested that listing the acronyms would have been helpful. This reviewer also mentioned that some slides presented good information, though these were scarce, while other slides were merely a weather report and should offer more substance in the future. The reviewer found it hard to see how $4-5 million had been effectively utilized to result in technical accomplishments and progress. The next reviewer to comment also found it hard to judge, since no data were presented in any quantitative way to allow a judgment. A graph showed apparent progress but it did not seem connected to presented data. The fourth reviewer, on the other hand, saw impressive progress toward 2016, given the limited time in play. The project was now in a stabilization period for debugging and would enter another rapid growth period. This reviewer did not see much on WHR except sweet spots, or much data on other sub-projects, and so found it difficult to assess progress. The reviewer deemed 45% BTE to be about right for this stage of the project. Rating the strengths and weaknesses of the project, the fifth reviewer noted in the first category the fact that engines had been built and tested with prototype combustion, air handling, fuel injection, and EATS as an integrated unit. Among the weaknesses, the reviewer included a lack of clarity in the presentation materials as to actual BTE achievement. A 10% increment over a baseline value was all that was shown, the reviewer said, implying a masking of results to date. Results may be better than indicated, but little data about hardware results was presented. The fact that the PI did not attend the review to present such a large-budget project also was a concern to this reviewer. The sixth reviewer discerned excellent progress, the team meeting all goals, and on track to meet the next set. The seventh reviewer found that Slide 18 (i.e., Milestone Update) was vague and lacked any tangible number. It was hard to believe, this reviewer said, that the next goal could immediately jump to 55% BTE without any intermediate milestones. The last reviewer failed to note anything special from the presentation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Most reviewers commented positively on the selection of collaborating institutions in this project, although there were some reservations expressed concerning the amount of work done by the principal contractor. For example, one reviewer saw indications of collaborations with Ricardo and Penn State; however, this reviewer said, this seemed to be an in-house Volvo activity. The second reviewer commented simply that the researchers had established a good team of principal and collaborative participants. The third reviewer agreed in part, saying that it was a good team of collaborators but also limited because much of the teaming was an in-house work. The reviewer asked what the level of effort distribution among teams and collaborators was. It seemed that small pieces (WHR and combustion studies) were thrown over the wall to Ricardo and PSU. The reviewer wanted to know in the future if there was more and what portions of the work were done in the United States and what was done in Sweden. In the view of the third commenter, there appeared to be a good set of suppliers and co-researchers, but without more information on who was doing what and how decisions were made, it was hard to judge fully. The fourth reviewer expressed approval of the idea of bringing some new partners into the fold, citing UCLA, Penn State University, and Grote. These were good organizations, the reviewer said, and it was good for DOE to develop multiple sites of expertise and it appeared that the parties were working together. Citing as project strengths the university partners in the California system and Pennsylvania State, another reviewer went on to identify a weakness in the limited supplier involvement in combustion and hardware integration. Ricardo was an excellent engineering systems partner, but had not been a viable production supplier. Production-level collaboration was relatively weak for such a large project (on the Rankine cycle WHR system, etc.). If it was desired to keep suppliers confidential, the reviewer said, more results and accomplishments were needed to compensate for the omission of supplier collaborators. Some collaboration existed, said another reviewer, citing Ricardo and two university partners with fairly specific roles that coordinate into overall project. Partners did not seem to be full participants, but did seem to be well-coordinated. The final reviewer comment was that all key partners seemed to have been involved.

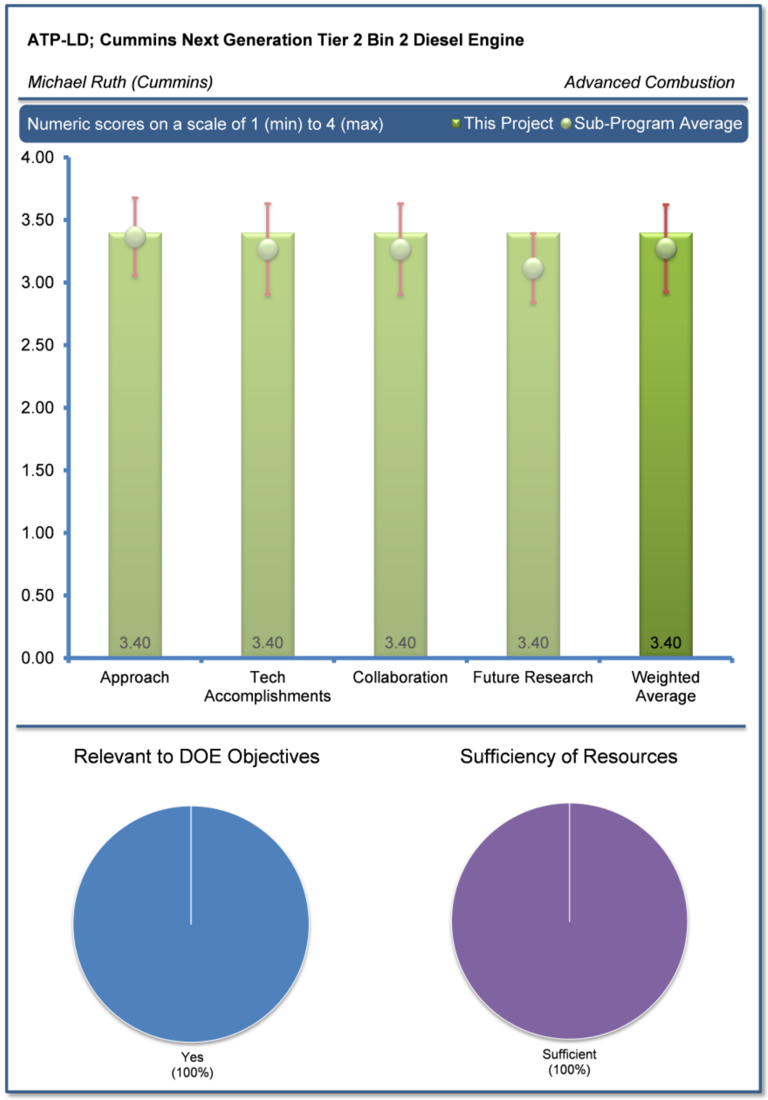
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer opinions on this question were mixed. One reviewer felt that this project seemed to be far behind the curve compared to the competitors and saw no clear indication of a way to catch up. On the other hand, the second reviewer, who found this category difficult to rate, nonetheless expressed intuitive confidence that the project team would succeed. The project team has done a nice job partitioning where gains would come from as the project moves forward and have identified the challenges that must be met. Downsizing and downspeeding would be major components of future improvement, and the researchers have the entire vehicle to work with. This reviewer thought that the project team had a clear focus on where their effort needed to be focused and hoped this would hold true as the project progressed in the program. The list of proposed future tasks was very good, according to a reviewer, but more substance would have to have been presented to score the project higher. Also noting that little detail had been provided, another reviewer still felt there was a solid plan to carry forward. The project was entering a critical timeframe of optimization and testing, in the opinion of one reviewer, something entirely reasonable and expected. The sixth reviewer said that the plans for the future were good and followed the general schedule which was provided. The seventh reviewer noted an excellent plan/pathway to an integrated solution. The final reviewer, however, considered the statement on the future work vague and said more detailed future technologies should be described.

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

All but one of the eight reviewers termed project resources sufficient. The dissenting opinion held them to be insufficient. Four supplementary comments were provided by members of the seven-reviewer majority. One person merely noted that this was a large program with significant funding while another reviewer pointed out that it appeared to be well-staffed and progress was being made and that the right parties were in place. To achieve such significant goals in a short time, the third reviewer observed, required large-scale funding and that Volvo was matching funds and many of the technologies fit in the advanced technology portfolio plan for a Class 8 truck manufacturer. The same reviewer observed nothing special here. The reviewer who thought resources insufficient noted that the project had started late with the half the funding compared to other competitors. The goals were too aggressive, this reviewer felt, for the time frame mentioned.

ATP-LD; Cummins Next Generation Tier 2 Bin 2 Diesel Engine: Michael Ruth (Cummins) – ace061



Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The five reviewers who addressed this question largely agreed that the project supported DOE's petroleum displacement goal. One reviewer, noting that the project targeted a 40% increase in fuel economy for the half-ton pick-up truck, observed that such vehicles enjoyed a large market share and account for a significant share of fleet fuel consumption. This made them the most logical target for getting significant fuel economy gains. The second reviewer's comment was similar. A large improvement in light-duty and medium-duty (LD/MD) truck applications would lead directly to fuel savings, opined this reviewer. The same reviewer explained that the program was designed to contain costs and meet other program requirements increased the likelihood of increased diesel use in North America. Likewise, the third reviewer noted that a fuel economy increase in light trucks and SUVs of 40% would reduce U.S. oil consumption by 1.5 million barrels a day (bbl/day). The fourth reviewer's comment was more general, namely that improving engine thermal efficiency and vehicle fuel economy was the key to the overall DOE program objective. The last reviewer did not make the connection between project goals and the DOE objective, merely observing that the project entailed engine design to achieve 40% FE benefit with Tier 2, Bin 2 vehicle standards.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Most of the comments indicated approval of the project work approach. One reviewer called it a very strong approach based on extensive previous work. According to this reviewer, the project team was apparently employing mixed-mode combustion with HCCI, but not full time. This reviewer noted a stretch SCR NO_x conversion target had been set and a good selection of collaboration partners were contributing important parts of the approach. This reviewer also indicated that Cummins has a good history of working on projects with DOE and collaborators and leveraging the results; this skill showed in this program. The second reviewer identified project strengths as the choice of an aluminum diesel engine, PCCI combustion, passive NO_x adsorber, and direct ammonia injection systems. Although technically challenging, this reviewer felt these represented an excellent approach to achieving aggressive goals. A very logical approach, said the third reviewer, with excellent leveraging of previous DOE-funded work. A reviewer observed that the team did not appear to be developing any breakthrough technologies, but were implementing all logical technologies for achieving good fuel economy on a light-duty truck. This reviewer said some of the engineering steps would be challenging, but appeared achievable. Finally, the fifth reviewer agreed that the goal of a 40% improvement over baseline seemed to be aggressive with the approach taken. The reviewer felt the technology road map seemed to rely more on aftertreatment improvement and a new engine design with a focus more on weight reduction. This reviewer was unsure how much fuel economy would improve with a 140 pound weight reduction.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewers' remarks on the project's technical accomplishments were generally positive, although some reviewers tempered their comments by noting the brevity of the presentation and its consequent lack of detail. One reviewer noted very nice results so far. In spite of its brevity, this reviewer believed this presentation managed to communicate a picture of major progress in basic engine design. In addition, this reviewer noted that the difficult tasks were clearly identified and good progress has been made against them. The NH_3 supply seemed to work well, this reviewer said, and asked if there had been an initial effort to determine whether the California Air Resources Board (CARB) and EPA would approve the system. The reviewer called the cold NO_x trap innovative and expressed the desire to hear more about it in the future. The strength of this project, in the view of another reviewer, was having an operating engine with aluminum block and very good initial results for emissions and the potential to achieve 40% fuel economy improvement. This was seen by this reviewer as an extremely challenging task which has been achieved in a very timely manner. According to this reviewer, the weakness was the limited discussion of power targets relating to vehicle performance and cost/value estimates. The performance metric presented for the cylinder block material was a good start, but standard torque and power curves (power and torque versus RPM) would be more appropriate, in this reviewer's opinion. The third reviewer considered that accomplishments appeared to be in line with overall program timing, but found it difficult to track specific progress on hardware given the minimal detail provided. This reviewer indicated there was good progress on the aftertreatment side and an impressive weight reduction, though this was unsurprising given the change from traditional cast iron to aluminum. The fourth reviewer said that the project had already demonstrated the capacity to exceed projections and expressed very positive feelings about the likelihood of its achieving project objectives. The last reviewer discerned more progress on aftertreatment improvement and tailpipe emissions, but less on fuel economy. Still though, the reviewer said, the overall progress is outstanding.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Again citing the shortage of detailed information in some cases, reviewers approved the degree of collaboration and the selection of partners. One reviewer said collaboration appeared to be very good, though there was not much detail on how integrated the partners were into the day-to-day program work, but the project was addressing challenges through good partnerships. The second reviewer observed that there was apparently good collaboration with suppliers like Johnson Matthey, customer Nissan, and others, but found it hard to fully evaluate the collaboration after such a short presentation. The third reviewer felt the strength of the project was having a good lineup of partners for emission work and engine design: Johnson Matthey, Nissan, and Rose-Hulman for controls, as well as a national lab for materials. This reviewer felt the results show apparent synergy, but a weakness may be controls and power, as limited discussion in these areas may show a need for additional university or engineering consulting. The last point was also mentioned in the comment of a reviewer who noted project partners Nissan, Johnson Matthey, Rose-Hulman and ORNL, but felt more university involvement seemed warranted. The final reviewer's comment was that it seemed the program involved all key partners.

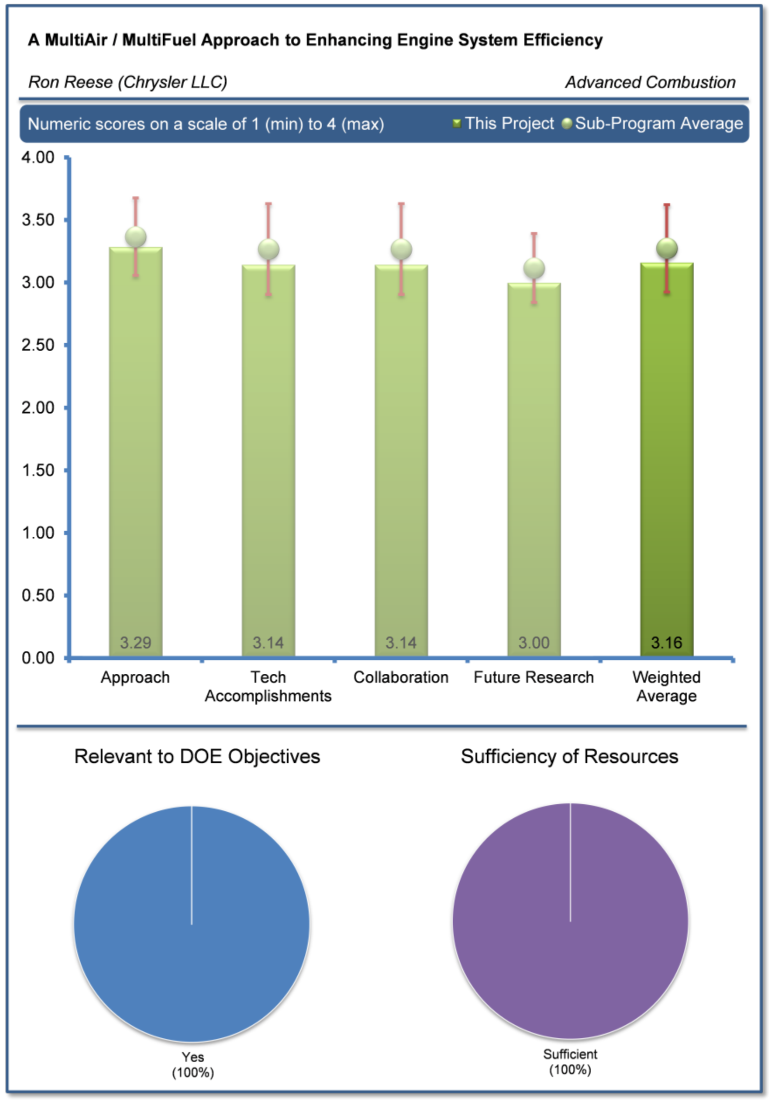
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The proposed future work plans met with the reviewers' approval. One called them appropriate for a development program. Another noted that the open issues seemed to have been clearly identified with good work plans aimed at resolving them. The third reviewer noted the strength of the plans in getting to vehicle testing in 2012, indicating that this was the most effective way to compare performance when making powertrain size reductions, transmission changes and aftertreatment system changes. According to this reviewer, there was no mention of value analysis, however. Detailed costs were not necessary, but some idea of potential relative to the baseline was worth considering for this reviewer. At a minimum, this reviewer continued, it should demonstrate that this was a better choice over a hybrid or other options. The project appeared on track to exceed targets, said a reviewer. Another noted that focus appeared to be more on aftertreatment improvement and the bet was put on the forthcoming new engine for achievement of the final goal, but that significant development was still needed on the engine, which would take time and resources to accomplish. This reviewer also noted that it appeared achieving the aggressive fuel economy goals while maintaining Tier 2 Bin 2 emissions was a high-risk undertaking.

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

All five reviewers deemed project resources to be sufficient. One observed further that resources appeared to be appropriately deployed for the program. The second reviewer called this a well-funded project with a large team doing a lot of work. A high level of funding is justified for this aggressive goal, said the third reviewer, however, this architecture must continue to be evaluated as a top contender for best value for achieving fuel economy benefit.

A MultiAir / MultiFuel Approach to Enhancing Engine System Efficiency: Ron Reese (Chrysler) – ace062



Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer stated that the targeted 25% improvement in fuel economy was a significant improvement and well aligned with DOE's goals. The second reviewer mentioned that the research supported efficiency improvements in main-stream engines and vehicles. The third commenter indicated large gains in fuel efficiency at moderate cost would have a large leverage on the LD vehicle fleet. The fourth reviewer noted clear support objectives with goals to demonstrate a 25% improvement in combined City FTP and highway fuel economy for a minivan, meet Tier2 Bin 2 emissions, and accelerate the development of highly efficient engine and powertrain systems. The final reviewer explained that this project addressed the fuel efficiency challenges of larger SUVs (minivan to be specific) which were driven by a large portion of the U.S. population. Even small improvements in the fuel economy of these vehicles would achieve significant petroleum displacement/ reduction.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer stated that the stoichiometric approach made excellent sense for more rapid deployment to the market. This reviewer felt the overall program plan was very good, with suitable decision points for revisiting hardware designs. The second reviewer reported that there were many ideas and technologies stacked up here, with a number of engine approaches built on HEDGE. This reviewer noted that the engine appeared to be expected to bring 45% of the 25% improvement, which was (only) 11.25% net improvement from quite a bit of added engine content. The reviewer noted that the comprehensive team was good. The same reviewer suggested to keep the baseline engine performance documented so that the improvement was clear in the future. The third respondent observed a good approach, but pointed out that many technologies were selected with apparently little or no previous data to assure that it would work. This reviewer noted that although the selected system seemed reasonable, several key improvements were needed. The reviewer questioned if the CARB/EPA agreed to dual fuel systems, and reported that stoichiometric operation avoided the need for lean NO_x aftertreatment. The fourth respondent expressed that the strengths were the consideration of list of technologies which had been vetted to prioritize and provide an incremental benefit. This reviewer indicated that the weakness was the potential cost of some technologies, such as crankshaft balancing scheme and that the performance of the downsized engine must be identified in part to ensure value. The fifth reviewer described that the approach encompassed many aspects of the engine system, which was good as multiple fuel efficiency improvements could be additive to achieve impact. The same reviewer described the balance of engine and system R&D and collaboration matrix as good. The dual approach of DMP and multiple sparks was logical as the DMP approach may have market challenges, according to this reviewer.

This reviewer inquired about the value of the DMP if it was only used at high loads. The commenter noted that multiple spark locations were of potential interest in enabling advanced combustion, and that this project was uniquely addressing that approach. The sixth reviewer indicated that the approach was to downsize and boost, but was not considering stoichiometric approach. The reviewer stated that this is really confusing because that seemed like low-hanging fruit. The reviewer appreciated the distinction between RCCI and Dual Fuel (HEDGE) – and noted that this puts Chrysler way ahead of HD companies that have more fanciful ideas. Also, the reviewer appreciated that Chrysler appropriately credited development partners (SwRI). The seventh reviewer felt that the use of stoichiometric combustion and TWC was safe but not terribly innovative. The reviewer commented that it was good to see dual fuel (DMP) considered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commenter indicated that the parallel ignition system approach was very good; that it would permit both low-risk/moderate reward and high-risk/high reward paths. According to this reviewer, it appeared that good progress had been made on many fronts to develop advanced technology components and integrate them all into operating engines. The second reviewer agreed with good progress on building and installing research engines and computational tools. This reviewer stated that progress was evident in the remainder of controls and vehicle systems. The third reviewer explained that there seemed to be good progress, although it was hard to judge due to the short presentation time and the blinded results plots. The reviewer questioned if the damper system actually had been able to remove lug limit issues. The fourth reviewer noted that the strengths were available prototype engines with consideration for multiple fueling schemes and thorough modeling assessment, MATLAB Simulink models and GTPower models of control system and EGR, as well as control architecture definition. The reviewer added that the data on dual fuel and single fuel indicating some progress was also very good. The fifth respondent observed that the benefits from the system components make sense; crankshaft damping and nine-speed transmission were good and when added together provided significant fuel savings. The progress on DMP and the multiple spark approaches were good according to this reviewer; however, it was unclear whether the DMP approach would be worth it as operation was limited; only high loads and multimode control may be problematic. This reviewer felt the multiple spark approach was showing good fuel efficiency and stability. The final reviewer stated that the project was behind schedule already--no cost extension and that there were go/no-go plans set for June for major decisions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first commenter felt it was unclear if the supplier partners were true partners or simply component/technology suppliers. The reviewer felt that the work with OSU was promising and a good use of the capabilities of the university. In addition, the reviewer added that the fundamental work at ANL looked promising for providing some more fundamental insight into the combustion systems, especially the dual-fuel system. The second reviewer observed a well-defined team roles and listed suppliers, universities, and national labs. The third commenter reported a limited selection of partners, but that the partners seemed to be solid. Historically, explained this commenter, DOE supported engine testing at ORNL and basic combustion research at SNL; ANL seemed to be getting into the business but the reviewer was not sure if these would have been the reviewer's first choice. The reviewer noted that the project team does have good strength in injector spray research. The fourth respondent noted that the strength was a good mix of suppliers that could implement the technology, national labs, and universities. The reviewer suggested a potential need to add support or split activity for dual fuel concept with base engine platform. The fifth respondent noted good collaboration with Delphi on the ion sense technology. The reviewer also stated that it was not clear what the magnitude of the impact would be, but it was apparent that the technology has been characterized well. It was also not clear to this reviewer what was being learned from the modeling efforts. The final respondent listed ANL, Bosch, and OSU, and stated that more university involvement was warranted.

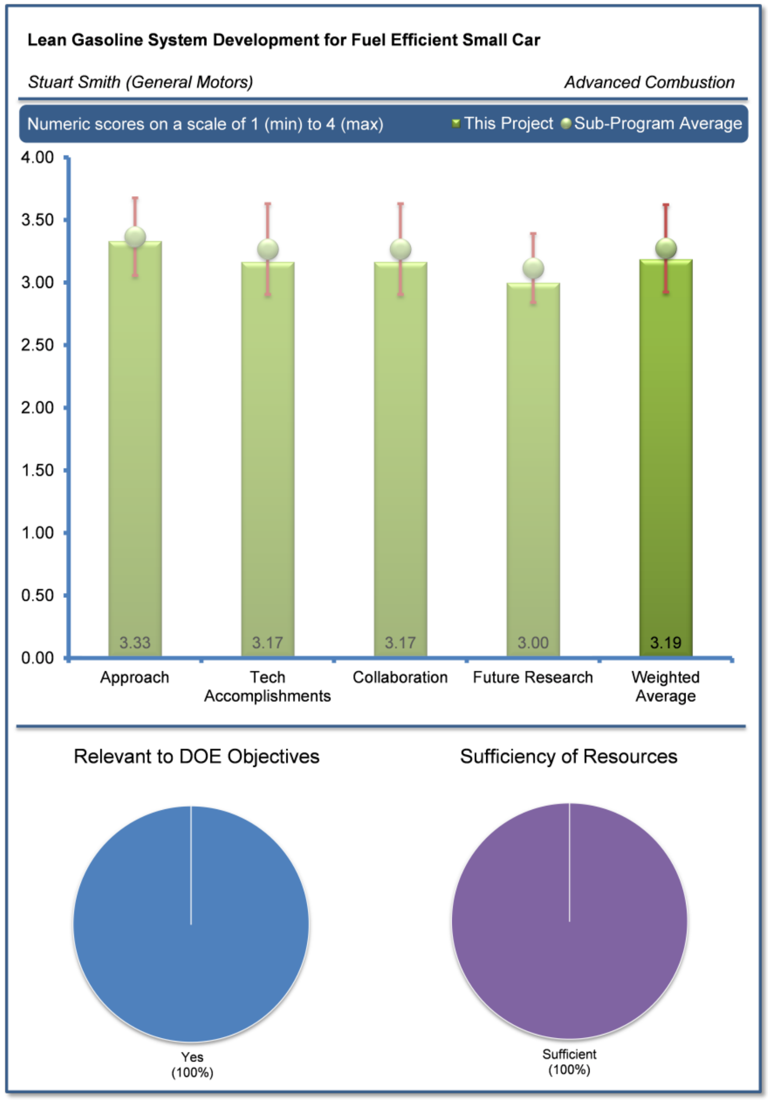
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the remaining work was significant, but all appeared achievable based on the results to date and the overall program scope. The second commenter acknowledged that the plans as presented were acceptable, but were not very detailed, and that calibration was expected to be big challenge. The third commenter observed a solid plan and noted that the down-select of ignition concept would be very important. The fourth commenter described that the strength was zeroing in and prioritization of a path with milestone decisions for effective results. The reviewer pointed out that a weakness in the presented material was the lack of detail in the timeline, and consideration of value analysis for concepts. The reviewer indicated that it appeared that there were still too many options to engineer and integrate that were not part of the critical path to meet the near-term production objectives. The reviewer added that the dual fuel concept may be extra credit at this time. The final respondent indicated that it was a good idea to move to down-select between DMP and multiple spark approaches at this point.

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

All of the commenters agreed that resources were sufficient. The first respondent stated that the funding supported a significant program with lots of work and real stretch in the technologies chosen. The second reviewer reported that a high level of funding was justified for this aggressive goal with continued diligence to consider technologies that have good value and could be implemented in the near-term of three to five years. This reviewer further remarked to scope for funding and timing. The third commenter indicated that the largest budget of all projects was reviewed in this session, and that it was good to see a 50/50 cost-share.

Lean Gasoline System Development for Fuel Efficient Small Car: Stuart Smith (General Motors) – ace063



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer stated that the project targeted development of a more efficient engine applicable to a multitude of future vehicle platforms. The reviewer applauded tackling lean-burn as a possible leap in technology. The second commenter indicated that major improvements in fuel economy would impact the U.S. LD fleet fuel use in an important way. The third reviewer noted that the target of 25% improvement in fuel economy for LDVs is in line with DOE's objectives. The fourth respondent reported a clear support of objectives with a goal to demonstrate a 25% improvement in combined City FTP and highway fuel economy in a mid-sized sedan, meet Tier2 Bin 2 emissions, and accelerate the development of highly efficient engine and powertrain systems. The fifth respondent described that this project addressed improving the fuel efficiency of the passenger car market in the United States. The reviewer concluded that the technological approach being pursued is widely applicable to that market and therefore has potential for high impact.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent affirmed a well-defined combustion and emission control approach on relatively high-risk approach with higher efficiency return. The second reviewer stated that a variety of technologies were considered. The reviewer noted that not much evidence of why concepts were chosen or an analysis to assure concepts worked together was provided (at least in this presentation). A lot of effort had been expended on the wrong engine - naturally aspirated and different displacement. There was a lot of published data that showed boosting changes in the cylinder environment strongly, so the solutions developed at naturally-aspirated conditions may not be right for the boosted concept. The third reviewer stated that the approach was sound, employing a combination of technologies to reach the 25% fuel economy improvement. This reviewer indicated that the combustion and aftertreatment approaches were using a balanced combination of CFD simulation and laboratory validation to develop the dilute combustion and aftertreatment systems. The fourth respondent indicated that the strengths of approach were a clear critical path and limited the number of technical risks. The reviewer added that the start/stop is becoming mature, downsizing strategy with turbo was mainstream, and advanced dilute combustion was also moderate risk. Lean, dilute aftertreatment was most significant risk in approach, according to this reviewer. This reviewer also noted a simplified approach for other elements frees bandwidth to be considered, and that an additional strength was the clear timing plan. The reviewer identified that a weakness was consideration for driver response with a downsized engine. According to this reviewer, this was a historical issue which needed to be clearly placed on a technical challenge list and addressed. The fifth reviewer remarked that the approach was good as progress could be achieved in phases as the engine becomes downsized and that the technological approaches of interest were added to the system. This reviewer went on to note that the approach built on existing engine technology and transitioned well to the newer technology. The reviewer concluded that it was good to see nice attention to the emission challenges via passive SCR.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One respondent emphasized good progress on controls, combustion/ignition, and aftertreatment. This reviewer felt there was a lot of work remaining for one more year. The second reviewer indicated that some good results were shown, but that it was hard to judge well on such short presentations. Another reviewer remarked that much of the data shown for the naturally aspirated engine may not be relevant to the boosted engine. This reviewer indicated that the lean aftertreatment would be challenging; not much was shown to assure that it has worked so far. The third respondent criticized that the technology demonstrated in Phase 1 needed improvement at higher load conditions, and that the needed improvement appeared to come from the stratified/boosted operation. The reviewer observed good progress and noted that the chart on Page 10 in the handout was in error. This reviewer indicated that the closely spaced injections have increased the range of lean operation. This reviewer noted that the higher ignition energy improvement in EGR limits looked very good, but questioned if the level of energy that was used to demonstrate this was feasible. The third respondent also commented that it was unclear as to whether adequate progress was made with the aftertreatment development. The commenter said that the obstacles were clearly identified, but asked if the move to active SCR, with passive at light loads was possible (i.e., what the low temperature efficiency was, if there were long-term efficiency concerns). The fourth reviewer reported that the strengths were the demonstrated fuel economy benefits at steady state of 10-20% and the preliminary results on the novel aftertreatment system called passive SCR, which produced ammonia. The same reviewer added that the active SCR backup was a strength that eliminated technical risk. The reviewer identified that a weakness was that no cycle fuel economy numbers were provided or projections/data for vehicle performance expectation and cost risk of poor consumer acceptance of active SCR system for lean operation. The reviewer added that a value analysis was needed for the technologies to insure a proper path. The final commenter felt that at this stage in the project, positive results were being shown for both fuel efficiency and emissions. The reviewer commended good attention to the driving map and identification of opportunities for fuel savings (by load/speed). The reviewer concluded that the Phase 2 findings of 90% lean operation capability over the FTP and highway cycles showed good promise for high impact

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer felt that this part of presentation could have used more detail on exactly what the other team members had contributed. The second reviewer observed that solid suppliers were chosen for interaction. This reviewer felt that it was not clear how much was in-house versus suppliers. The third respondent observed that these collaborations were better than what GM had typically shown in previous DOE projects. The reviewer observed well-regarded partners in their areas of expertise. The reviewer also commented that it would have been helpful if the presentation could have made it more clear what the level of involvement that each had. The fourth reviewer noted that the strength was a good core team for combustion: Ricardo Fuel System and Bosch and Umicore for aftertreatment. The reviewer then pointed out that the project's weakness was that a high risk passive SCR system optimization may need additional support and benefit from national lab involvement or consideration of other suppliers to develop solutions. The final respondent mentioned good collaboration with suppliers, but no mention was made of university or national laboratory collaboration. The final reviewer asked if the project would benefit from collaboration with universities and/or national laboratories.

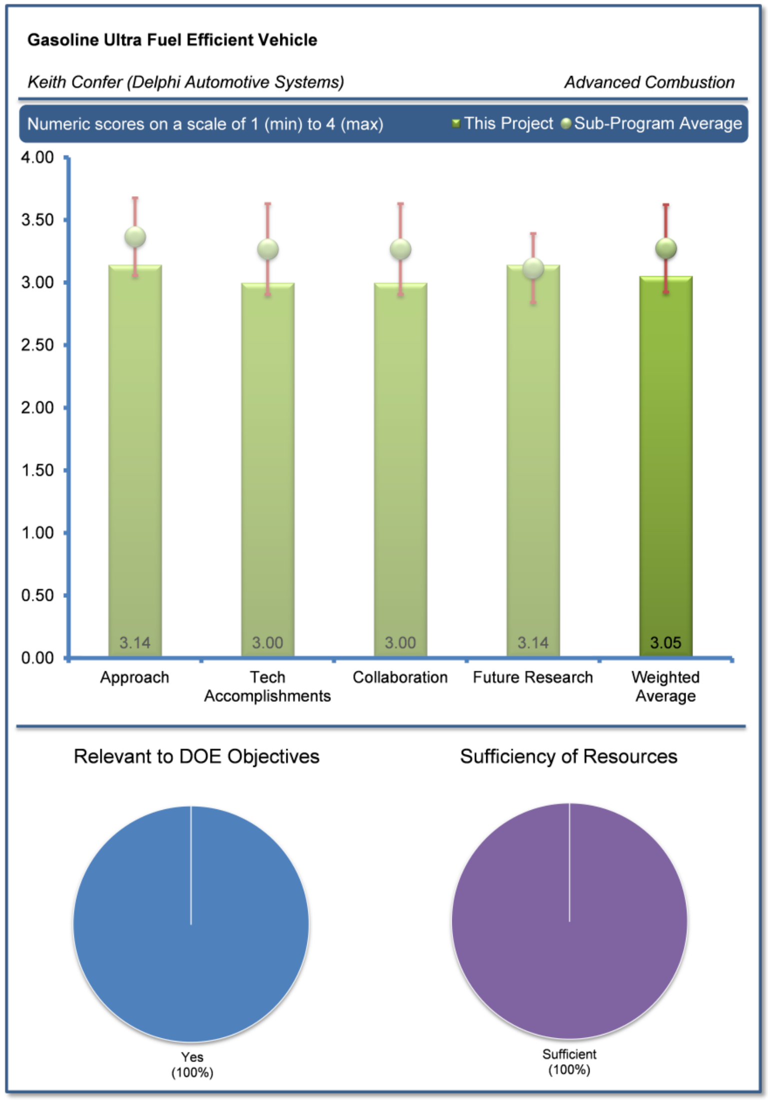
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer emphasized that the future project path was acceptable and noted that hopefully there would be enough time for good vehicle calibration. The second commenter felt that the aftertreatment development needed to be integral with engine development and calibration. The reviewer added that development needed to move to the boosted engine and review system impacts. The third commenter stated that future activities looked good. The fourth respondent asserted that the strength was that the future work followed the strong plan with achievements shown already. According to this reviewer, a weakness was that the communicated level of detail in the future work relative to technical challenges and risks could be improved (for example, how to address the consideration and the combination SCR active and passive system did not appear to be the most cost-effective solution and that the data was not provided). The reviewer added that it may be worthwhile to consider focusing on a decision gate to use SCR passive only or SCR active only but not both, unless the cost/value data can support both systems. The fifth respondent highlighted that it would be interesting to see performance once moved to a 1.4-liter system.

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

There was unanimous agreement from the reviewers that resources were sufficient. The first respondent commented that the program was well-funded and supported large efforts. The second respondent indicated a good level of funding for an aggressive goal. The third reviewer felt that it was good to see a 50/50 cost share. The final respondent stated that the resources seemed barely sufficient for a lean-burn system and full vehicle demonstration.

Gasoline Ultra Fuel Efficient Vehicle: Keith Confer (Delphi Automotive Systems) – ace064



Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first respondent stated that the fuel economy improvement target was appropriate for supporting DOE objectives. The second commenter mentioned that it investigated a wide range of technologies to improve vehicle fuel economy, with major focus on a most-of-the-time lean-burn engine. The third reviewer noted that large fuel economy gains in LD vehicles would save lots of petroleum. The fourth respondent indicated that the project aimed to demonstrate a 30% improvement in fuel economy from a current baseline vehicle, and that this would reduce greenhouse gas emissions and reduce consumption of petroleum in the U.S. proportionally. The fifth reviewer mentioned that this project addressed improving the fuel efficiency of gasoline-powered passenger cars which dominates the U.S. LDV fleet; so, it does support DOE objectives of petroleum displacement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent reported that the vehicle-level tasks were interesting, but were not particularly advanced technologies. To this reviewer, many of the tasks appeared to be minor refinements on already deployed technologies. On the other hand, this reviewer noted, the advanced combustion tasks appeared to be too much of a stretch for successful vehicle implementation in the timeline of the program. The second reviewer mentioned that the kitchen sink approach to friction reduction was fair for a demonstration, but that the features like roller bearings on crankshafts was an old idea and had been historically rejected for cost and durability issues. This reviewer asked what was new this time, and indicated that the engine valve control did not appear to be stretch technology. This reviewer noted that the GDCI approach was good in pushing technology forward, but the reviewers were not shown efficiency and emissions comparisons with DI diesel or GDI. Thus, this reviewed posited that the GDCI apparently needed SI for starting. In addition, this reviewer felt it was unrealistic to assume that the engine would not need aftertreatment. The reviewer noted being surprised that DOE did not challenge that more in the award process. The third commenter observed a good set of candidate technologies and aggressive combustion and engine design goals. This reviewer added that there was a nice set of loss reduction technologies to be evaluated. The fourth respondent stated that a suite of technologies was being employed to reach the targeted fuel economy improvement, and that these were aimed at parasitic (friction) losses, thermal losses, and advanced combustion. The reviewer stated that this project was certainly exploring all of the possible technologies currently available and that it looked like a nice combination of simulation and testing on a single-cylinder optical engine and multiple-cylinder engines. The reviewer indicated that all of this sounded good, but the reviewer criticized how the down-select process would happen from

Phase I to Phase II for all of the features. In addition, the reviewer asked what the evaluation criteria would be for the Go/No-Go phase review process. The fifth reviewer indicated that the approach of GDICI technology was good. The focus on injector technology was very relevant to this approach, according to this reviewer. The reviewer suggested that while the PM measurements were a valuable part of the approach, further demonstration of transient emissions relative to regulation drive cycles should be considered. The sixth respondent felt that the goal of no aftertreatment was probably overly optimistic. The last reviewer noted that the project stopped its original HCCI plan based on mid-term results and indicated that this showed excellent judgment and use of tax payer dollars. This reviewer also observed a 2011 Hyundai Sonata 2.0 L Theta turbo, an 80% new engine, and detailed that GDCI as best of diesel and SI. Referencing GDCI, the reviewer reported the following: high-CR and late multiple injections; gasoline vaporizes and mixes easily at low temperature (mixed enough); and gasoline PCCI (centralized mounted injector, pushing injection pressures down, multiple late injections, continually variable valve train, no classic knock, and diesel type piston).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One respondent felt that it was unclear that a fully calibrated PPC engine could be developed and installed in the vehicle in time for the end of the project. The reviewer felt the Phase 1 progress was good, though there was much lower uncertainty in the success of those technologies. The reviewer expressed concern about the parallel single-cylinder and multi-cylinder development, as changes in the combustion system may require changes in the boosting and other systems for best performance. Aftertreatment concerns also appeared significant with the current combustion approach, according to this reviewer. The second commenter noted that there was a nice achievement in completing the low-parasitics vehicle and was looking forward to the results. The reviewer observed lots of iterations and improvements on fuel injector designs, but that one would think that exercising models would have been sufficient without so many design and build iterations. The reviewer appreciated realistic conclusions on HCCI. The reviewer also noted that it was a little surprising that there was no multi-cylinder data. The reviewer added that there was also no substantive discussion of boosting system requirements. The third commenter remarked that the new engine design and features seemed to be making good progress and noted that a lot of work has been done. This reviewer felt that the presentation was too short to fully present the work done. The fourth commenter pointed out that the demonstrations were on schedule. The reviewer stated that very good progress was shown on extending the operating range of the GDCI mode of operation. The reviewer added that good progress was shown on simulations of spray and combustion, as well as the fuel injector configuration tests to select the best performer. This reviewer applauded the team for evaluating the particle emissions size and distribution. The reviewer noted that this would be an important consideration in the future, and seemed to be overlooked by a lot of the projects. The fifth respondent described that this project showed some excellent technical progress; in particular, the demonstration of lower PM emissions with (injector E) technology was a dramatic improvement in regard to PM emissions from DI gasoline engines. Furthermore, this reviewer indicated fuel efficiency and NO_x emissions were also significantly improved. The last respondent commented on plans for robust controls concerning sensing and changing timing. This reviewer noted a lot of faith was put in fuel injection.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer reported that there appeared to be a good partnership with other OEM/supplier/R&D entities. The second respondent affirmed that the team was complete with the exception of an aftertreatment technology organization. The third reviewer indicated that major suppliers, OEM, and academia were nicely integrated. The fourth commenter said there were good partnerships developed between academia and the industry. This reviewer assumed that the Hyundai participation was strictly from the North American center. The fifth respondent observed that the partners identified were HATCI, WERC, and Wayne State University; however, that it was unclear what benefits were being attained from these partners in general. The reviewer asserted that perhaps HATCI's benefits would be realized later in the project in vehicle phases. This reviewer questioned whether Wayne State University would model newer combustion techniques if its HCCI modeling work was completed. The reviewer noted that it would be good to see publications coming out of this project and that it was an important aspect of giving back to the public information related to technical accomplishments of this cost-shared program with U.S. taxpayer support. The final respondent noted WERC and HATCHI. This commenter emphasized that university involvement would be very beneficial and noted that WERC was a spin-off consulting group, and not a university partner.

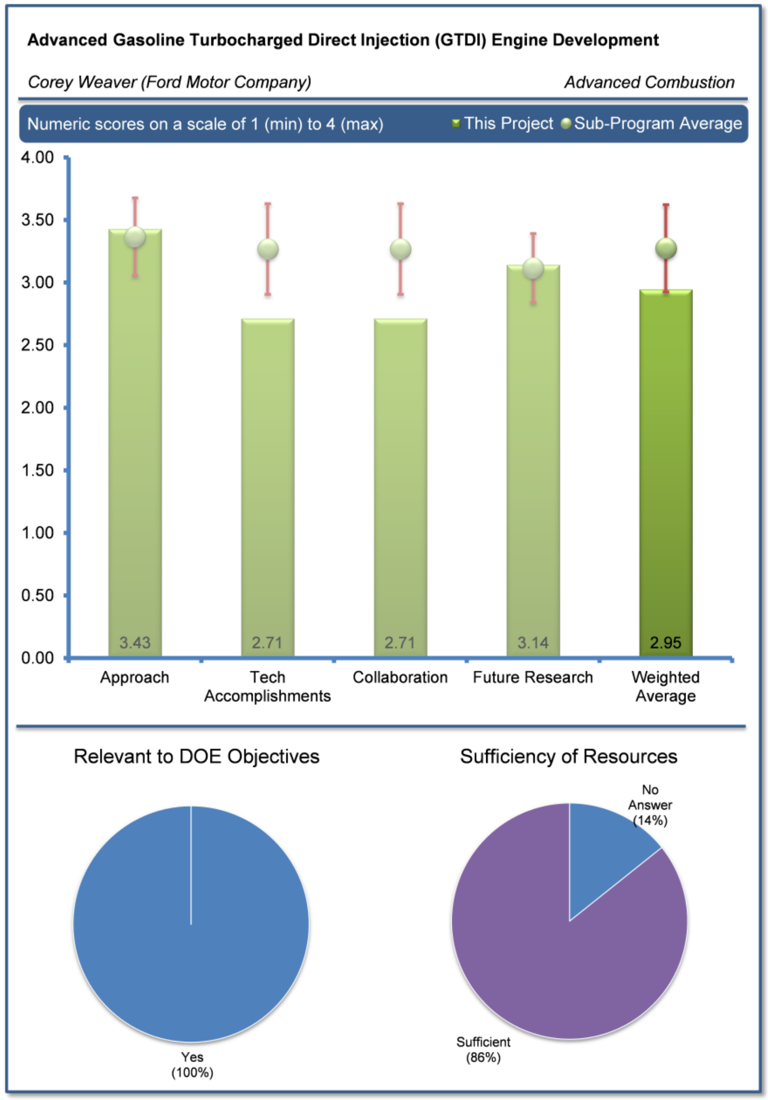
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first respondent pointed out that the plans were good, but remained skeptical about the chances for success. The second reviewer noted that simulation was in future plans, but thought that would have been greater as a part of early work. The third commenter indicated this was a solid plan to continue moving forward. The fourth reviewer reported that future work appeared to be on target to reach the fuel economy goal. The reviewer noted that not much detail was given, just mostly general statements with regard to carrying out the Phase 2 plans. The reviewer added that the simulation appeared to play a larger role in Phase 2 than it did in Phase 1, which should help guide the project's decision making process. This reviewer questioned if enough attention was being put into model validation with the single-cylinder optical engine. The reviewer noted that maybe this did occur, but that there was not enough time to highlight this effort for the presentation. The fifth commenter stated that the authors had a logical path forward and were adjusting their vehicle plans accordingly.

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

All of the reviewers indicated that there were sufficient resources. The first respondent reported that this was a well-funded program supported by a large team working on difficult technical problems. The second respondent expressed that the progress appeared to be appropriate at the current funding level.

Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development: Corey Weaver (Ford Motor Company) – ace065



Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first respondent noted that the goal of 25% fuel economy improvement fit with DOE goals. The second respondent affirmed that the project intended to achieve a greater than 25% gain in fuel efficiency of vehicles using main-stream engines (not niche technology). The third reviewer indicated that a larger fuel economy improvement for LD vehicles would save a lot of petroleum. The fourth commenter reinforced that the project aimed to demonstrate a 25% improvement in fuel economy from a current baseline vehicle, and that this would reduce greenhouse gas emissions and reduce consumption of petroleum in the U.S. proportionally. Another commenter agreed that this project addressed gasoline light-duty vehicle fuel economy improvement and, thereby, addressed DOE objectives of petroleum displacement for the U.S. fleet (which is dominated in LDVs by gasoline engines).

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One respondent observed a good, progressive program plan with a suitable path from easy-to-implement technologies to higher-risk, higher-reward solutions. The reviewer would have liked to see more detail on how the different technologies would cascade to the MCE and vehicle timelines. The second reviewer affirmed a comprehensive approach of medium-to-high risk technologies, including stretching the current EcoBoost system to higher levels and also looking at lean-burn. The reviewer noted the excellent grasp of benefits and challenges of each step. The reviewer described use of a full VVA system to explore valve timing space as nice. The third respondent mentioned that a solid approach based from EcoBoost with added features for fuel economy improvement, but that nothing in the presentation addressed why lean versus stoichiometric; aftertreatment gets much harder, and what the benefit was. The fourth respondent criticized that the approach section of the presentation was lacking in details, but did become apparent through the accomplishments. This reviewer indicated that the combustion development use of simulation (MESIM) was a good approach, as well as the usage of a single-cylinder engine for initial program guidance. This reviewer further noted that the other components that appeared to be key elements of the overall approach included EGR, a composite intake air intercooler, electronic controlled variable valve timing, pendulum damper/active engine mounts, and aftertreatment. According to this reviewer, the use of the MTU combustion vessel to understand the limits of operation was excellent. The fifth respondent noted that the approach by the authors was solid. The commenter remarked that the approach builds on the Ford EcoBoost product family and thus leads to an achievable technology introduction to marketplace pathway. The commenter noted that the approach is to achieve fuel economy gains via various aspects of the engine system, and that the work is appropriately addressing many potential opportunities in the system. Another reviewer noted EcoBoost GTDI and listed moderate downsizing, advanced dilute combustion with cooled EGR and advanced ignition, advanced lean combustion, and advanced aftertreatment.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

One commenter noted a lot of progress on the design and specification tasks. This reviewer emphasized the need to see data from the experimental hardware. The second commenter observed good progress in modeling, single-cylinder work, ignition studies, and multi-cylinder design. The reviewer noted that not much data was shown for SCE work. This reviewer stated that 12 engines and 5 vehicles were being built; with only 18 months left in the contract, the project appeared a bit behind schedule. The third reviewer acknowledged that nice results were shown and that it was hard to say too much in such a short presentation, but what was shown was quite good. The fourth reviewer reported that the accomplishments seemed to be on schedule, according to the timeline provided. This reviewer felt that it did appear that the multi-cylinder engine dynamometer tests may be a bit behind, but did not appear that it would cause significant problems. This reviewer expressed concern that the modeling effort did not continue during the multi-cylinder testing. The reviewer added that if the simulation had been adequately validated with the single-cylinder engine data, that it should be useful to continue to provide guidance and insight on the advanced combustion during multi-cylinder tests. This reviewer noted great use of the MTU combustion vessel. Another respondent felt that this project showed good technical progress in the areas of micro stratified charge, low P EGR, Electric tiVCT, and engine design. However, the reviewer added that more specific information on the different benefits that these technologies gave for various drive cycles was needed. Also, the reviewer noted that the combined drive cycle performance benefits were of interest. The reviewer concluded that it was good to see the approaches being pursued to address the emission control challenges (TWC, LNT+SCR, and etc.).

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer highlighted the interesting advanced research at MTU, but felt that it was unclear how those results would feed into the overall program. The second reviewer stated that the project consisted of a small team. The reviewer added that it seemed an ignition system supplier would be needed. The third commenter observed that the presentation did not highlight a lot of collaboration; however, Ford is a large company and can contain much of this work in-house to their benefit, and thus the reviewer did not see this as a problem. The fourth commenter liked the MTU work and interaction, although MTU seemed to be the only organization in collaboration. This reviewer questioned whether the program would benefit from additional partners like an aftertreatment supplier or fuel injection company. The fifth reviewer said that while there did not appear to be a large number of collaborations, the work with MTU did seem to be benefiting the project by providing fundamental insight into the ignition and combustion processes. The last reviewer noticed very little collaboration, but that it was not really needed with an OEM that had all resources in-house. The reviewer concluded that this was somewhat a meaningless criterion for this type of project.

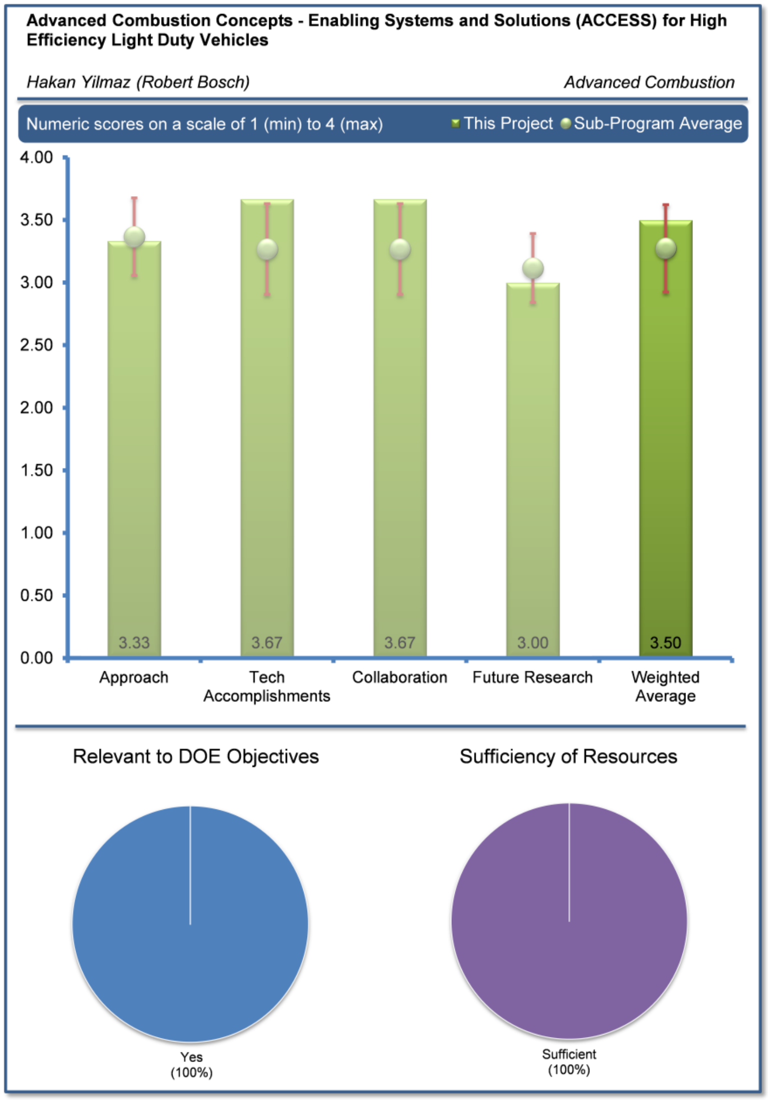
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commenter said that the program plans were suitable. The second reviewer observed lots of work left including the MC engines and vehicle calibration, with integration of aftertreatment. This reviewer questioned the integration of the new ignition system. The reviewer noted that this appeared to be a good project overall, and that it was likely to succeed and be commercialized. The third reviewer noted a solid plan to complete the program. Another reviewer stated that the proposed future research looked okay and added that there was not a lot of detail, but that the project seemed to be on target. The final reviewer pointed out that a logical path forward on the project was apparent. The reviewer added that it should be interesting to observe the combination of the engine technologies shown on the vehicle.

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

All of the reviewers were in agreement and indicated there were sufficient resources. The first respondent stated that the speaker had no respect for the other presenters, reviewers, or audience by going far over his allotted time. The reviewer suggested that the presenter prepare a more appropriate presentation length next year. The second reviewer observed a well-funded program with a large effort making good progress. The third reviewer commented on the overall presentation and that the presenter went way over time. The final respondent felt this was the largest budget of projects reviewed in this session and that it was good to see a 50/50 cost share.

Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles: Hakan Yilmaz (Robert Bosch) – ace066



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer indicated that a 25% FE improvement target was suitable. The second commenter reported an aggressive engine development program for higher efficiency and greater than 25% reduction in fuel consumption. The third reviewer reported that the project aimed to demonstrate a 25% improvement in fuel economy from a current baseline vehicle. The reviewer noted that this would reduce greenhouse gas emissions and reduce consumption of petroleum in the U.S. proportionally. The fourth reviewer affirmed that this project addressed DOE goals for energy security and petroleum usage reduction by pursuing advanced combustion concepts that could greatly improve the fuel efficiency of the LDV U.S. fleet.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent said that HCCI would be challenging to implement, but in the context of a multi-mode approach that it would be interesting to see how it turns out. The second respondent reported that the engine development program had a number of innovations and was generally aggressive on combustion and air handling. The reviewer added that it stays with stoichiometric operation and three-way catalyst for most of the operation that lowered risk. The reviewer noted that this program did not include vehicle improvements and questioned vehicle validation. The third respondent stated that the team had taken on a very comprehensive hardware arrangement that would provide many options for future direction. The reviewer indicated that the capability for multi-mode combustion flexibility looked like it had a high probability of success. In addition, this reviewer noted that the system would be capable of multi-fuel operation towards the end of the program, which would provide a good demonstration of the robustness of the approach. Another reviewer reported that the approach for this project was nice in that it combined expertise from a team of universities and industry companies into one common platform for fuel economy improvement and low emissions. This reviewer felt the coordination of all of the activities appeared solid, and the incorporation of various engine components looked thorough. Furthermore, this reviewer continued, the production-suitable (relatively) high capability ECU was a nice aspect of the project especially considering the multitude of controls and sensors that the project addressed. The final respondent pointed out somewhat vague responses regarding questions about aftertreatment plans.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent observed that there were clearly many engines and experiments running. The reviewer noted that it appeared that modeling results were providing useful guidance to hardware design and calibration. The second reviewer observed much progress on simulation and engine experiments running at multiple sites. This reviewer also mentioned that the progress was evident on HCCI controls theory and application. The reviewer noted a good list of publications. The third commenter reported that the engine demonstration of 33% fuel economy improvement with a downsized HCCI engine was significant. This reviewer questioned if a valid comparison was really being made here. The third commenter also questioned if targets had been achieved, or if the HCCI Prototype 1 engine was not a viable solution for production (i.e., controls and transitions) because this was steady state data. The reviewer added that this did not come across clearly in the presentation. This reviewer stated that the combustion modeling effort looked very good, and the use of model-based HCCI control looked to be making significant progress. The fourth respondent observed that the fundamentals of combustion had been studied, and multiple injector technologies had been evaluated. This respondent indicated that boosting with a supercharger and turbocharger demonstrated excellent reductions in BSFC with reasonably low NO_x emissions. This reviewer also felt the controls work was excellent and was extensive (covering cycle-to-cycle variations as well). Further implementation of the engine in transient drive cycles was needed and was of interest, according to this reviewer.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first respondent reported that there was an excellent collaborative program with clear definition of roles and with clear technology transfer between the partners. The second reviewer said that the exceptionally strong team seemed well-coordinated. The reviewer noted Bosch representation at most team member sites to assist with hardware and experiments. The third commenter felt that this team had a good mixture of industry and academia members with an excellent definition of their individual roles. This commenter also noted that the vehicle platform to be used and the exact U.S. OEM (one or multiple) support role were not apparent. The team members looked to be well qualified to take on the approach of using extensive feedback and controls of the HCCI mode and transitions, according to this reviewer. Another respondent indicated that there was excellent collaboration in the project and that the various entities appeared to be operating in a nice team atmosphere. The final reviewer noted a very large international team.

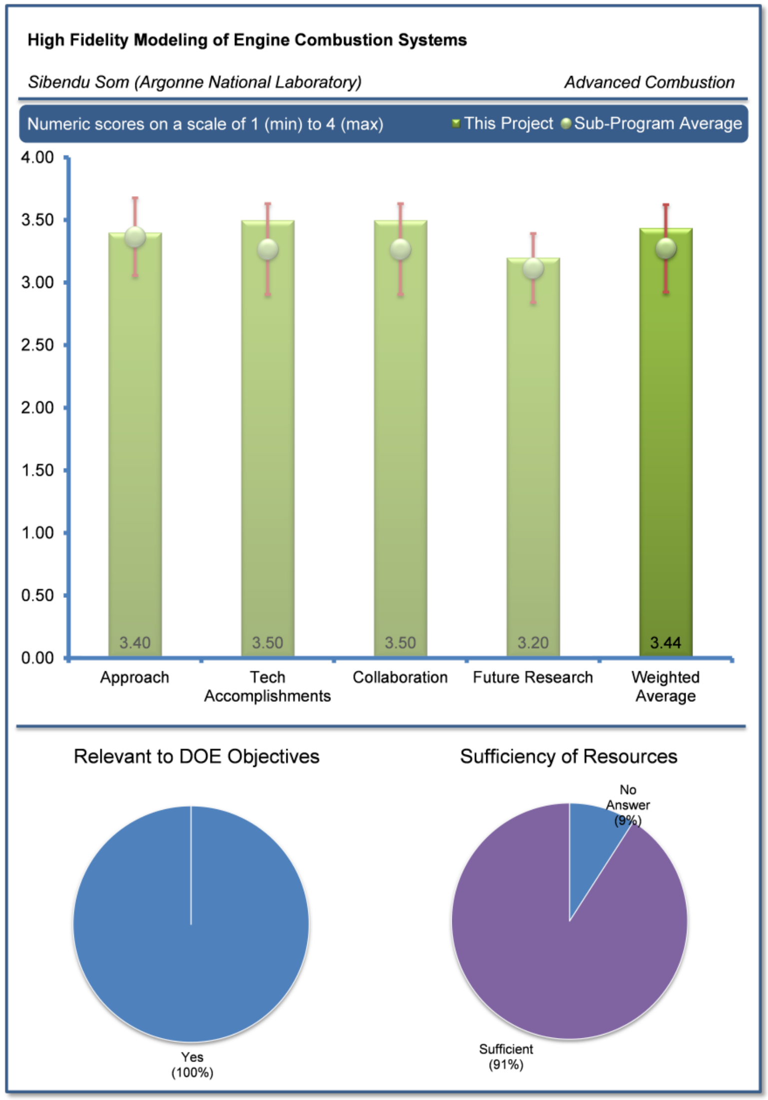
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer said that the ongoing plans looked good for completing the project on time. The second commenter reported that the future tasks were well-defined for each team member. The third reviewer asserted that everything looked to be on target and looked forward to next year's progress. The final reviewer pointed out that while there was not a lot of detail on the future work, the plan would importantly include evaluation of multi-mode combustion and controls.

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

All of the respondents indicated sufficient resources. The first reviewer stated that no apparent lack of resources could be seen. Another reviewer commented on the very large budget. This reviewer offered that it was good to see a 50/50 cost share.

High Fidelity Modeling of Engine Combustion Systems: Sibendu Som (Argonne National Laboratory) – ace075



Reviewer Sample Size

This project was reviewed by eleven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted the improved predictive capability of spray and combustion models. The second commenter explained that better simulation and predictive capabilities of fuel spray and combustion should enable the development of engines with lower emissions and better fuel economy which would result in lower requirements for fuel/petroleum. The third reviewer indicated good fundamental work on spray to support improved combustion models. The fourth reviewer emphasized that the linking of spray and combustion simulation with reduced processing time was significant in advancing combustion development. The fifth reviewer affirmed that improving spray modeling was important for predictive simulation tools that would be used to design future engines with greater efficiency and lower emissions. The sixth respondent pointed out that this fundamental spray modeling project was indirectly related to DOE goals by enabling a more precise tool for modeling the break-up process, which ultimately impacted spray formation, ignition delay, and the heat release profile that collectively impacts indicated thermal efficiency.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

One respondent reported that the approach was focused on several important tasks in fuel spray and combustion modeling. The second respondent commented that the project had just begun. The reviewer indicated that the project would develop spray models particularly looking at the nozzle cavitation and focus on *n*-dodecane + m-xylene as a suitable diesel surrogate since it better mimicked diesel cetane characteristics. This reviewer questioned the number of cases studied. The third commenter noted that a clear focus on barriers and methods to improve. The fourth reviewer felt it was not clear what the benefit of dynamic coupling of nozzle flow and spray modeling was beyond the static coupling. To this reviewer, there was some question whether there was a sufficient plan to get nozzle geometry. This commenter questioned if the use of *n*-dodecane and m-xylene was enough to capture cetane effects of very diverse fuels in the United States. The fifth respondent questioned if there were synergies with Joe Oefelein's work. The sixth respondent reported that this project could be improved by more validation, since, to date, there has been a little bit of validation, but nothing extensive enough to conclude that the proposed break-up model is a big improvement over existing models. This reviewer felt the same statement could be made for the dodecane diesel fuel surrogate work. The final reviewer explained that this project if focused on understanding and modeling spray atomization and characteristics was a very critical industry need. This reviewer indicated this project aimed to develop spray breakup and spray combustion models that were closer to commercial viability and that could be used by the industry to affect engine design.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first respondent felt that the KH-ACT (Kelvin-Helmholtz-Aerodynamics Cavitation Turbulence) model seemed to do better job of matching x-ray data than the original KH model. The reviewer added that there was also better agreement with lift-off lengths and ignition delay. This reviewer mentioned the successful reduction of the *n*-dodecane mechanism which reduced computational time. The second reviewer noted that the work was developing the KH-ACT breakup model focused on aerodynamics, cavitation, and turbulence, and that the x-ray data was used to validate data. This reviewer noted the simulation of the impact of conicity to limit cavitation, and to identify interesting definitions for ignition delay and flame lift-off length. The third commenter noted that the project was just starting but that the plan looked good. The fourth reviewer reported that the results from the KH-ACT model were very encouraging for qualitatively capturing the effect of internal nozzle flow. The fifth commenter acknowledged very good work proposing and developing what appeared to be an improved break-up model near the injector nozzle orifice. Nevertheless, according to this reviewer, more validation was necessary covering a wider variety of boundary conditions including injection velocity, cylinder pressure/temperature, and nozzle design. The reviewer commented that the initial results were promising for this break-up model and also in reducing a possible diesel fuel surrogate fuel for ignition delay modeling. Another respondent indicated that very good progress had been made in model comparison to experimental data.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

The first reviewer noted good collaboration – including ECN. The second commenter reported a number of collaborations with industry (Convergent and Caterpillar, with Cummins pending); national labs (SNL and LLNL); and universities (University of Connecticut). The third commenter mentioned that the team was rather complete. This reviewer stated that it would be very helpful to partner with an industrial pattern as the one mentioned here to have direct data and realistic conditions to relate to. The fourth reviewer noted that the connection to the ECN was important and added that playing a leadership role in the Spray A modeling for ECN. According to this reviewer, Argonne National Laboratory is the main group who is connected to CONVERGE, which is becoming more popular among OEMs. The reviewer noted that collaboration with OEMs was likely a direct result. The fifth respondent mentioned that this project included good collaboration between the PI, a university, other national labs, and two HD engine development partners. The last respondent stated that very good collaboration existed with several partners. The reviewer added that the possibility of immediately using the model results by industry was greater.

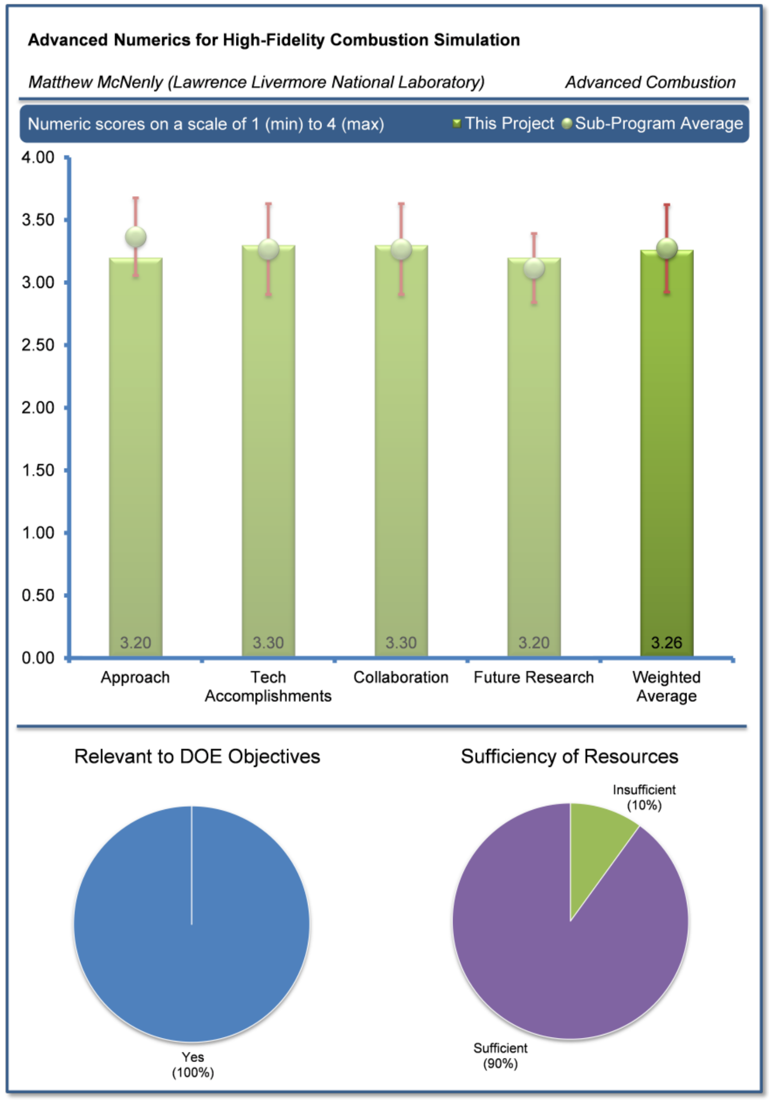
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One respondent reported that plans to continue work on nozzle simulation, further mechanism reduction and development of diesel surrogate model, and improving efficiency and scalability of models would build on and add to current accomplishments. The second respondent suggested that the project defined early on the scope of injector nozzle geometry selection. The reviewer noted that this work was necessary to ensure the results were broad enough to have a reliable model that as valid across a range of geometries. The third respondent felt that it would be important to determine how critical the dynamic coupling was relative to static coupling. The fourth respondent found that this was a good plan overall for future research. This reviewer suggested more validation with wide varying spray boundary conditions and also suggested a closer partnership with the two industry partners to aid in the validation of both the spray model and reduced diesel fuel chemical kinetics surrogate. Another reviewer observed that so far only diesel spray was being studied. This commenter suggested that gasoline sprays should be included.

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

All of the reviewers who responded indicated sufficient resources. One respondent said that resources seemed sufficient. Another respondent stated that the project appeared funded well enough especially given its computational focus. The reviewer added that any additional funding should be used for experimental validation.

Advanced Numerics for High-Fidelity Combustion Simulation: Matthew McNenly (LLNL) – ace076



Reviewer Sample Size

This project was reviewed by ten reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first respondent noted that the reduction of computational costs to solve detail kinetics in an effort to improve modeling of combustion for supporting design of high efficiency engines would accelerate research. The second commenter indicated that improving computational speed was necessary to allow accelerated development of highly efficient combustion processes. Another reviewer mentioned that CFD tools were essential for combustion system optimization and combustion research, both of which were critical components to increasing efficiency of engines. The reviewer added that increased modeling efficiency without sacrificing fidelity would be essential as models continue to increase in complexity through the use of chemical kinetics and more complex turbulence models. The final respondent emphasized that this project was linked to project ACE012 and was evaluated with the same grading as that project. The reviewer added that it was too difficult to discern the difference between these two projects and that this same grading approach seemed reasonable. This reviewer stated that this project could supply tools that run at reasonable computing times with decent accuracy for engine developers considering homogeneous combustion modes for gasoline and diesel applications as a means to improve upon today's engines thermal efficiencies at various operating conditions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first reviewer reported that this project has done a good job at identifying the key components that are limiting speed of kinetics modeling and addressing them. While other projects focused on creating models that are faster, this reviewer felt this project recognized that the mathematics and computer architecture may not be optimized for engine problems, and then set out to improve them. Another reviewer felt that the modeling approach was reasonable, but that validation was a concern. The reviewer noted that there appeared to be some level of validation, but it was limited to a few selected operating points. The reviewer added that more validation based on real engines was necessary for continual improvement in the clever multi-zone with chemical kinetics modeling approach. The third reviewer observed that this project bridged the gap between the detailed fundamental chemical kinetic mechanisms and the need for combustion software to model engine combustion by reducing computation cost. Therefore, this reviewer noted that it made use of recent advances in computers and computing methods. The fourth reviewer stated that the team decided to work on new algorithms to speed up CFD calculations (new chemistry integrators, new thermochemistry software and solvers) and that the methods were beyond the expertise of the fourth reviewer and could not be judged.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first commenter stated that this was interesting work on implicit methods to integrate time scales over an engine cycle. This evaluator stated that this work looked into the physical meaning of the Jacobian matrix of the system's set of differential equations to improve the solver proposed here. The second reviewer remarked that the speed of computation without loss of accuracy was quite impressive. The third respondent felt that the improvement in chemistry computation speed was great, and licensing to commercial codes like Converge would have a large impact on industry. Another reviewer noted that the speed up achieved relative to previous computations was very impressive. The reviewer noted that it was now to a point where others could start using it to speed up computations. The fifth respondent affirmed that the reduction in computational times without a loss in accuracy was impressive. At this rate, the reviewer indicated, there is hope that complicated chemistry modeling could be used for the analysis of engine performance data in the not too distant future. The final reviewer noted that there was good progress during the past year with the multi-zone work and that it would be helpful to see more comparison with a larger set of experimental data; also validation was lacking a bit.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

One reviewer reported extensive interactions with the industry, national labs and universities. Another commenter mentioned that the suite of LLNL projects on combustion simulation had potential to deliver huge gains for modeling combustion. Although there was good collaboration, the reviewer suggested that it would be even better if these were all managed under a single lead to manage resources and priorities. The third reviewer indicated that the plan was to make the new solvers available to the combustion modeling community. In the future, this reviewer noted, it would be important to consider how to provide improvements to the combustion modeling community quickly to maximize the impact of this excellent work. Another commenter reported that this project had strong collaboration historically with other national labs, universities, and certain industry partners. According to this reviewer, it appeared that much progress has been made in the last two years and the multi-zone work in particular has drawn great interest from the research community due to its reduced computational time and apparent accuracy in comparison to CFD at select operating points. The fourth reviewer noted that very good collaboration existed with Convergent Science, GT-Power, Volvo, etc.

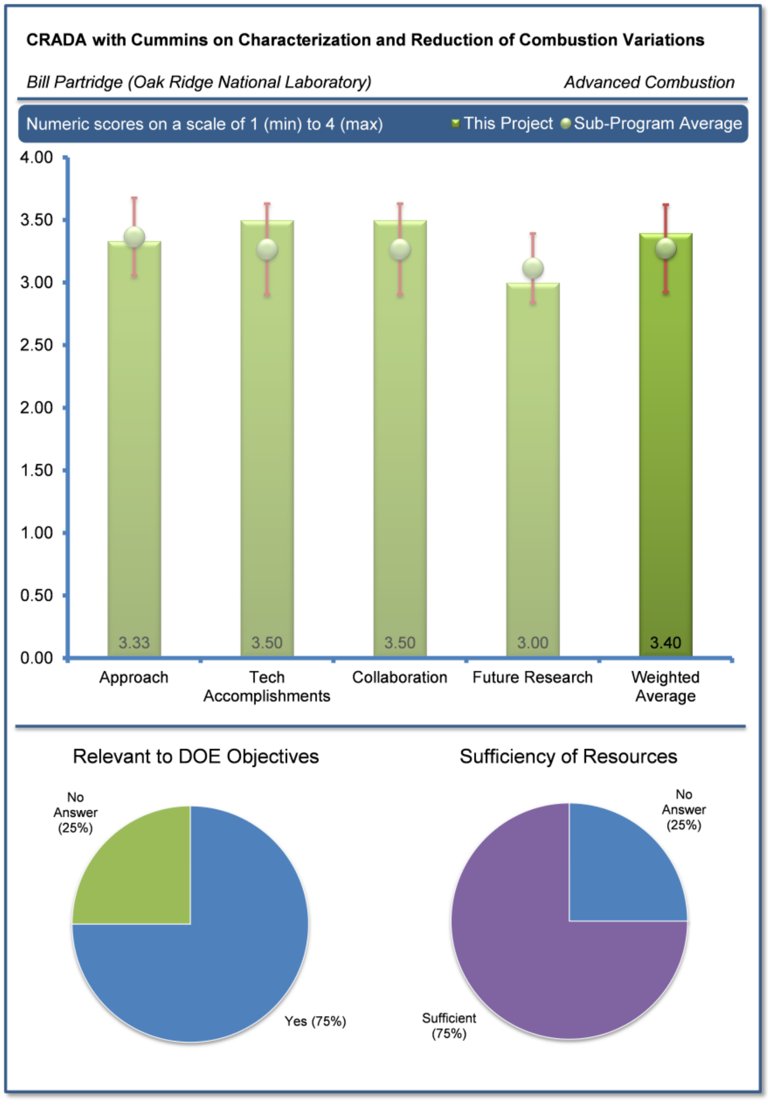
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first respondent suggested that the project continue to explore strategies for improving efficiency of CFD and chemical simulations. The second reviewer remarked that high fidelity combustion simulation on a desktop PC was a worthy goal. Another reviewer acknowledged that the computational aspects of the planned future work were reasonable, but that validation was really lacking in future plans.

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

The majority of reviewers indicated sufficient resources. One respondent noted this was an adequately funded modeling project. Another commenter stated that this project could do with more funding which could accelerate the development of computer codes that were within the reach of the industry.

CRADA with Cummins on Characterization and Reduction of Combustion Variations: Bill Partridge (Oak Ridge National Laboratory) – ace077



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The reviewers were in agreement that this effort supported petroleum displacement objectives. The first respondent remarked that reducing cylinder-to-cylinder mixing variations had always been recognized as necessary to improve both fuel economy and reduce emissions. This reviewer indicated that this instrumental design provided the measurement technology to be able to accomplish this. The second reviewer stated that broadly, the program aimed to develop advanced diagnostics for improved engine design (controls, etc.) for improved efficiency and reduced emissions. As noted by this reviewer, in the past year, the focus had been on the effect of EGR uniformity. Further, this reviewed stated that a new probe for single point measurements was developed and preliminary data was acquired on a representative Cummins engine showing that the EGR fraction varied as a function of spatial location (highest near the wall and lower away from the manifold wall). This reviewer felt these results provided additional information that a single line of sight measurement could not provide. This reviewer acknowledged that this was all very nice experimental work. In general, however, this reviewer indicated it would be helpful to better understand how the data would be used and specifically understand the correlation between the EGR uniformity and the combustion figures-of-merit.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

There was general consensus regarding the approach. The first reviewer noted that it was a really cool approach to getting in cylinder gas distributions. Another reviewer stated that addressing multi-cylinder robustness issues (cylinder-to-cylinder effects) was good. The final respondent reported interesting results, overall. This reviewer noted that the correlation between the EGR results and the actual combustion performance was not discussed. According to this reviewer, if the sensitivity of the combustion process was shown to be highly dependent on the EGR fraction, it would be a strong case for demonstrating the need for high resolution single point measurements using the new probe and the proposed development of laser-based techniques for even higher accuracy measurements (future plans). The reviewer added that it was not clear that such high accuracy measurements were needed. In addition, the commenter added that there needed to be a stronger tie between the EGR fraction and combustion performance and emissions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

There were mixed results regarding the project's technical accomplishments and progress. The first reviewer indicated that this was a difficult experimental technique, but that the project seemed to have been quite successful. Another reviewer noted the ability to measure EGR variations across a region of the engine. The reviewer added that now there was a design for a system that could use single point access and that it could run for hours to a day. According to this reviewer, the data can be translated and in one case showed large variation in what went into the cylinder, depending on which cylinder it was relative to EGR input. This reviewer noted that one can see variations in the five millisecond time scale. The third reviewer reported that the value of this project was clearly the diagnostic tools development. The reviewer observed that hardware development (i.e., mixer design) is engine dependent and was not so interesting. This reviewer also reported application to LD gasoline engines as the project team begins to employ cooled EGR. The final commenter emphasized that the key technical accomplishment was to develop a new single point, faster response probe for EGR measurements showing that the EGR fraction was not spatially/temporally uniform. The same commenter recommended clarifying the importance of this effect to further justify the need for high accuracy single point measurements.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

There was general consensus among reviewers concerning collaboration and coordination efforts. The first respondent noted that there appeared to be a strong relationship to Cummins. There was not clear indication that this device had been used yet at Cummins. The second reviewer reported strong collaboration with Cummins, as Cummins is the partner in this CRADA and no others. The reviewer noted that the work at Cummins was by ORNL people. The third commenter agreed that there were strong collaborations with Cummins.

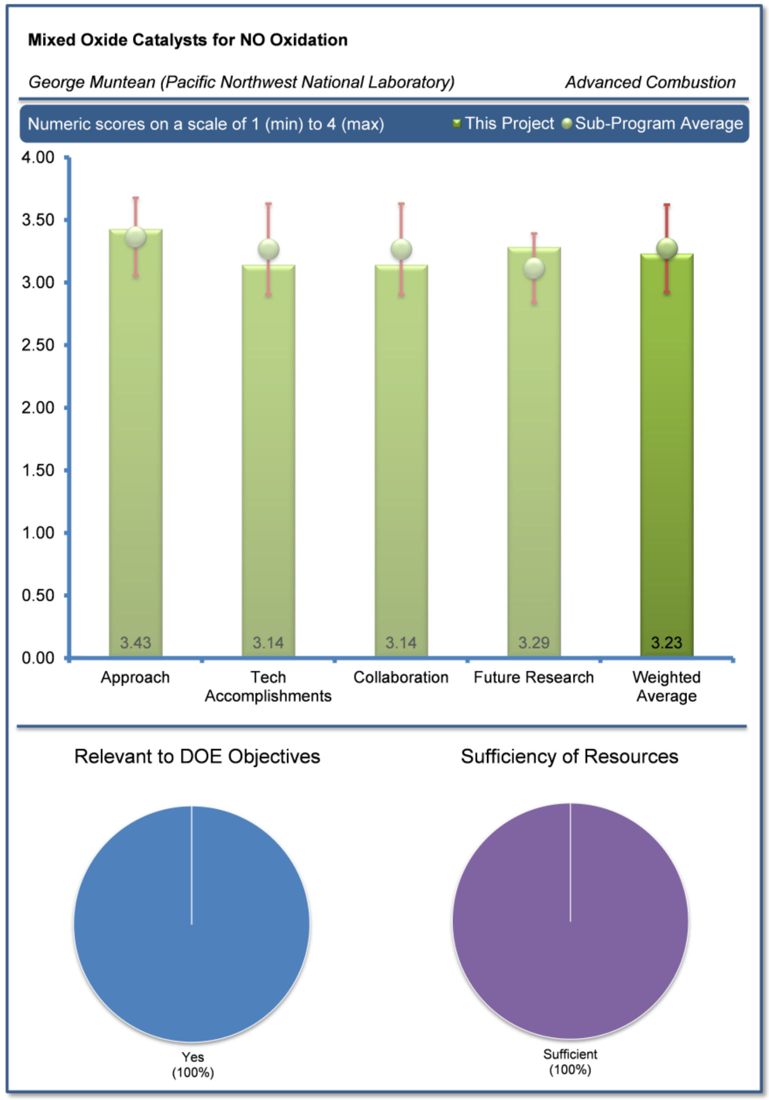
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first respondent noted that the proposed future research seemed to be reasonable. The second reviewer suggested tying the measurements to the combustion performance and emissions to further justify the need for high speed, single point EGR fraction/ species concentration measurements.

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

All of the reviewers indicated that resources were sufficient. One reviewer commented that there was no indication that this project was limited by funding.

Mixed Oxide Catalysts for NO Oxidation: George Muntean (Pacific Northwest National Laboratory) – ace078



Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

The first reviewer noted that the effective catalysts that require less or no platinum-group metals would help reduce the costs of clean high-efficiency vehicles. The second reviewer reported that understanding both the deactivation mechanisms that impacted the temperature window for SCR reduction performance, and the development of effective HC absorber materials that operate at lower temperature in the presence of water, were important enablers for advanced combustion technologies which left less exhaust energy available for emissions catalysts. According to this reviewer, these technologies, with lower PGM content, showed the potential to achieve mandated emissions standards while employing lean gasoline and diesel combustion strategies. The third respondent noted that reducing LNT costs was an important step to enabling high-efficiency lean-burn engines. Another reviewer affirmed that lean aftertreatment was an enabler for higher fuel economy. The fifth respondent agreed that this project supported the objective of petroleum reduction peripherally through potentially reducing aftertreatment costs for NO_x and offering solutions for low temperature combustion. Strategies for lean operation generally produced more NO_x and advanced combustion techniques like RCCI and PCCI have low exhaust temperatures. The final reviewer indicated that the work just recently began in late 2011 and noted that a clear path forward was outlined with a focus on better understanding of mixed metal oxide substrates and metal doping on NO oxidation. This reviewer noted that the program had both an experimental characterization assessment components with some preliminary work done to better understand NO oxidation on ceria by DFT.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The first respondent stated that the approach to address the project objectives was fairly sound, but that there appeared to be alternative materials that may be more effective at achieving the intended results. The reviewer noted that work done by others, including Honda, shows that yttria incorporation showed enhanced performance for CO and HC oxidation which could be extended to NO oxidation. The second commenter indicated that there was a clear delineation of tasks between partners. This reviewer identified that a specific focus was on replacing platinum in LNT to reduce cost fluctuations. Another respondent stated that lower cost catalysts were needed; platinum substitution with base metals was favorable for lower cost. In addition, this reviewer felt that the project may benefit from early catalyst supplier involvement. The fourth reviewer reported that the strength was the selection of most likely candidates to replace platinum in catalysts and sound analytical methods. A project weakness identified by the reviewer was that although candidate materials and processes were sound, the approach did not include an assessment of alternatives or state-of-the-art in the presentation. The fifth commenter indicated that the approach was well-defined. This reviewer noted that catalytic reaction and catalyst characterization tests had begun. This reviewer also indicated that interesting questions were raised pertaining to the underlying mechanism responsible for lower reduction temperatures for MnO_x with CeO_2, etc. The final commenter stated that the approach was reported as preparing and evaluating potential catalyst formulations. This reviewer questioned how PNNL and GM were selecting and refining the candidates and if it was because the PI worked with manganites in SOFCs as he mentioned during the Q&A. This reviewer felt that the audience questions and comments seemed to indicate a broad appreciation of the work; this reviewer noted that this work was outside the reviewer's areas of expertise, and suggested to evaluate comments accordingly.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

The first reviewer noted that some progress had been made, but that it was still early in the project. The reviewer pointed out the table on Slide 12 where the presenter said that the trend in lattice dimension is down, but what little trend there was not smooth. The second reviewer indicated that durability and sulfur tolerance were not well known and that the project should address durability as an important component to the work. The commenter noted that if the project cannot demonstrate hydrothermal or sulfur regeneration procedures, then this must be addressed. However, according to this reviewer addressing low temperature activity would be an important aspect of future aftertreatment solutions. Another commenter felt that the manganite materials were interesting because they may be more stable to reduction and sulfur-resistant. The reviewer added that the Science article did not use supported materials. The fourth commenter observed that this project had just started in the fourth quarter of 2011, therefore accomplishments were limited, but the approach seemed good. The fifth respondent warned that the test conditions so far seemed like ideal conditions and may not be indicative of vehicle operation. The reviewer added that aging was unclear and that it was also not clear if these materials would survive deSOx. Another respondent mentioned the limited results, but indicated that a project strength was a systematic completion of a plan. The reviewer commented that it was a good indication about the impact of Ceria and use of Mn. The final reviewer highlighted that a number of samples had been formulated by GM and characterizations studies at PNNL have begun. The reviewer added that the preliminary results obtained aimed at improved understanding of the reaction mechanism for NO oxidation on CeOx, MnO_x, and mixed metal oxides. The reviewer concluded that interesting questions were raised related to the importance of bulk versus surface effects on NO oxidation with the catalysts being evaluated.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

There were mixed results among the reviewers regarding the project's collaboration and coordination. The first reviewer stated that PNNL was working with a major automotive OEM (GM) and that a catalyst supplier could be a worthwhile addition to the team. The second commenter felt that GM and PNNL contributions were fairly clear and essential. However, the reviewer perceived that the contribution from Tianjin University was not clear. According to this reviewer, it appeared most of the work had been contributed by the national lab and GM directly. Another respondent also questioned how Tianjin was involved. The fourth reviewer acknowledged that the academic partner is Tianjin University, which has reportedly developed some interesting nanospehrical and hollow spherical catalyst materials, yet the contribution to the program was not clear from the presentation, so the reviewer asked for clarification on this point. The fifth reviewer indicated that CRADA with GM was leveraging partners' core capabilities and also hosting a Chinese student from a university that would be providing some new material samples for testing. The sixth respondent reported there was good collaboration with the industry. The final commenter stated for scope and level of funding was good. The reviewer also added that a strength of the collaboration was the connection to an OEM and a national lab. The reviewer concluded that a weakness was identification of catalyst supplier or consortium state-of-the-art.

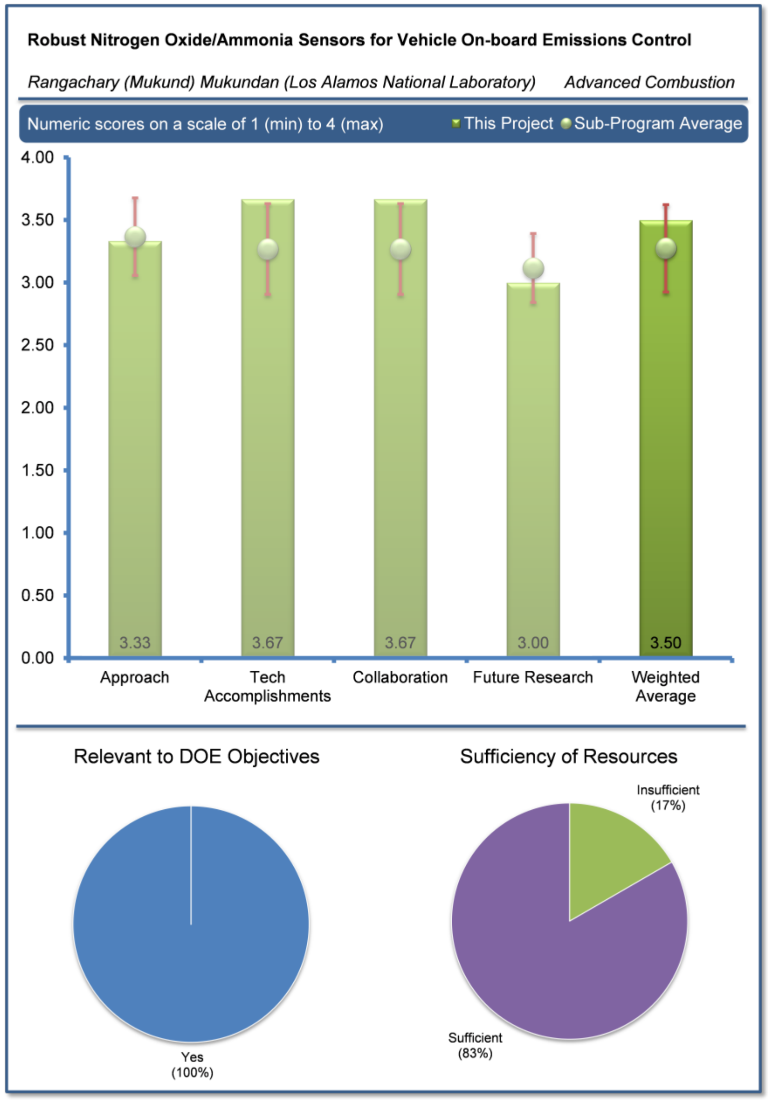
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first commenter reported that not much detail was given regarding future work. The reviewer noted that what was there appeared reasonable. The second reviewer stated that while this was a CRADA, benchmarking of results with other work in this area might benefit the project. In addition, this reviewer noted that the metrics did not seem to be clearly defined in the presentation. The third respondent affirmed that a strength of the proposed future research was to follow the plan. The reviewer noted that the project was just getting started. The fourth respondent noted that generally, there was good direction for future work, although the contribution of Tianjin University was not well understood. The final reviewer observed that catalyst characterization studies and DFT modeling were proposed. The reviewer added that it would be nice if the DFT calculations could provide new insight into NO oxidation on mixed metal oxides and guide the catalyst synthesis and characterization testing. The reviewer noted this was perhaps premature.

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

The reviewers all agreed that the resources were sufficient. One respondent reported that DOE funding was $150,000/year for three years with a 50/50 match from GM and that this funding level seemed reasonable for the level of effort discussed. A second reviewer agreed that the funding did not appear to be an issue for achieving the stated goals within the timeframe allotted. The third reviewer asserted that this was a relatively low budget project but seemed to be addressing an important need. The final respondent pointed out that there was a reasonable work scope considering the funding.

Robust Nitrogen Oxide/Ammonia Sensors for Vehicle On-board Emissions Control: Rangachary Mukundan (Los Alamos National Laboratory) – ace079



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewer feedback was positive in this section. The first respondent explained that a NO_x/NH_3 sensor would assist greatly in closed-loop control of urea SCR catalyst, thereby enabling the OEMs to meet emission standards with higher fuel efficiency. The second respondent agreed that the automotive grade sensors for NO_x and ammonia were important for emissions control compliance of high-efficiency engines. Another respondent asserted that these sensors were critical to enable the cost-effective use of emission control systems and to meet OBD requirements. Furthermore, this respondent explained that monitoring the state and activity of a LNT or SCR were essential to a viable NO_x reduction system. The fourth respondent commented that yes, this would enable a diesel or lean-burn engine technology into the market with a lower cost NO_x sensor for control. The fifth respondent remarked that NO_x and NH_3 sensors were essential for future OBD of a lean NO_x emission control system. The sixth respondent encouraged DOE to have more sensor projects in its research portfolio.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Comments received in this section were generally positive. One of the reviewers stated that focusing on a production-viable solution was good. Another reviewer expressed that this work represented a more novel approach to preserve the reactants until they reached the electrodes so that they have increased sensitivity. The third reviewer observed that this appeared to be an extension of previous work and further opined that the most appealing part of the approach was the attempt to use all of the manufacturing advances for oxygen sensors to make this NO_x/NH_3 sensor more cost efficient. The fourth reviewer offered that the approach seemed acceptable to try a dual sensor for NO_x and NH_3 because the current, commercial NO_x sensor had interference and could not differentiate. This reviewer pointed out that the reduction in platinum usage was attractive, but that the approach needed sharper focus on sensor durability and interferences in real exhaust gas. The fifth reviewer remarked that a very specific approach was presented and followed. The same reviewer suggested that testing in an actual engine exhaust environment would be interesting to see, especially due to the interference shown when multiple gases were present. Another reviewer explained that while this technology seemed to be good for both NO_x and NH_3 with the approach taken, it did not allow for NO and NO_2 measurements. This reviewer queried whether there could be a Phase 1 sensor that would just provide NO_x and NH_3, and a Phase 2 sensor that would provide the ability to measure NO and NO_2. The seventh reviewer reported that a two electrode system was done (i.e., one for NO and NO_2, and one for NH_3).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer feedback was generally mixed in this section. The first commenter noted that accomplishing a +/- 5 ppm for both NO_x and NH_3 on the same sensor is a substantial accomplishment. The second commenter opined that good progress had been made on testing in a laboratory setting with different gases to simulate the engine exhaust. This commenter also observed identification of a few issues that would hopefully be investigated in more detail during the proposed follow-on work with Caterpillar. The same commenter added that it had shown good promise to significantly reduce the cost, close to that of the conventional oxygen sensor, given its simplified design compared to the current commercial NO_x sensor technology. Another commenter described progress on the sensor so far as very good and indicated a desire to see results from a full exhaust gas feed. Also, this commenter noted that the stability of the sensor needed to be improved, but the commenter did not see a clear plan of how to do that. The fourth commenter expressed that using sensor material that was not reactive with the gases was useful for increasing the sensitivity of a NO_x detection device. This commenter further explained that diffusion through the porous layer was not reactive, therefore preserving a more accurate accounting of the exhaust feed. In order to meet future emissions standards, added this commenter, accurate detection of low concentrations of NO_x species would be required. However, the reviewer claimed that more work must be performed with more realistic gas feeds to determine the interaction and interferences of other interfering species. This commenter pointed out that distinguishing between NO and NO_2 could not be done without changing the bias on the sensor, but that the response time may be too long to be effective. The same commenter recognized that the measurement of NH_3 would require a separate sensor to also account for interferences with NO_x species. This fourth commenter noted that N_2O was also increasingly important, but not a part of this study, and inquired how this compared to competitive sensors (performance and cost). The fifth commenter stated that NO could not be separated from NO_2 and NH_3. The sixth commenter was unclear regarding the cost reductions achieved, and further remarked that new sensor durability under exhaust gas conditions like repeated filter regenerations were unknown and not presented.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Comments in this section were positive. One respondent described the collaboration with Caterpillar as promising. Another respondent indicated the interactions with industry sensor producers seemed to be very strong and greatly assisted this project. The third respondent recognized collaboration with ESL, who had expertise in sensor manufacturing for high volume production, which allowed better batch-to-batch reproducibility. This respondent highlighted the partnership with Custom Sensor Solutions (CSS) to stabilize the temperature, because temperature stabilization must be controlled tightly. The fourth respondent observed good collaboration with ESL and CSS for ensuring commercial manufacturability of a potential end product. The final respondent also saw good collaboration with ESL and CSS and inquired who the project team planned to work with to get the sensor to the market.

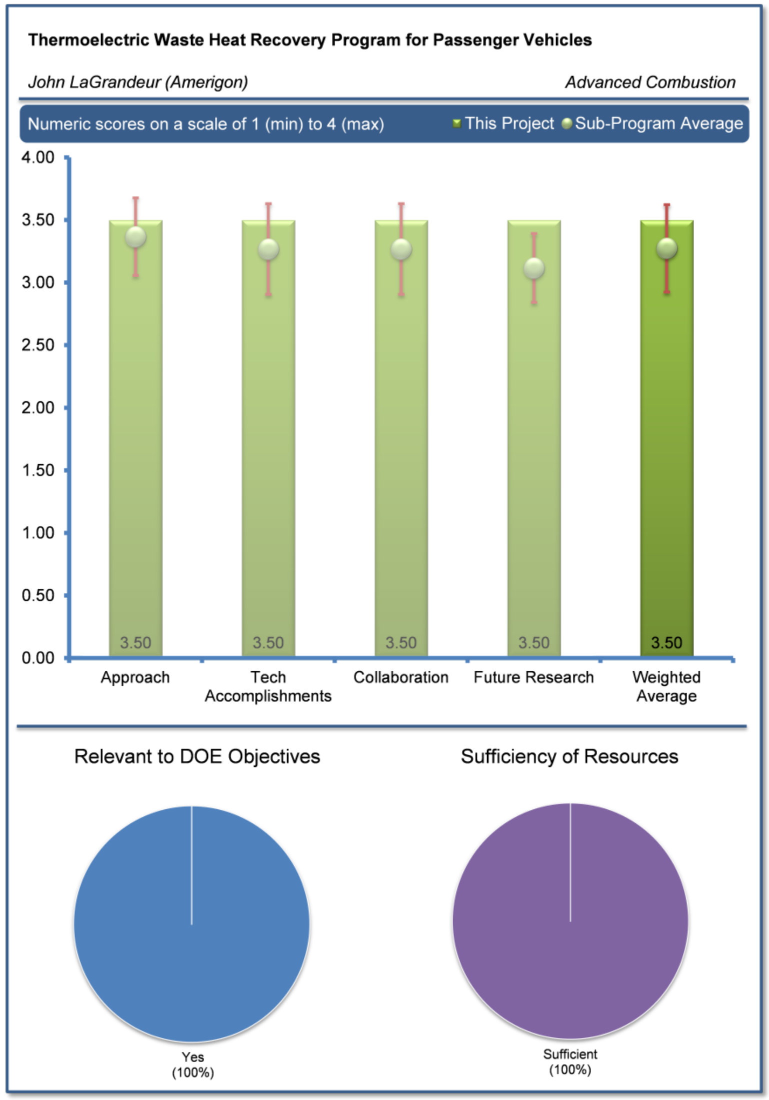
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback in this section was somewhat mixed. The first reviewer remarked that the plan going forward looked good with respect to multi-component gas feed and, eventually, engine testing, but pointed out that it was less clear how sensor stability was to be improved. The second reviewer observed this project was very near its end, but noted that future work had been proposed as part of a new project, which would evaluate the NO_x sensor in actual engine exhaust with Caterpillar. The next step when this project ends, as stated by the third reviewer, is to approve a project with Caterpillar to test a sensor at their facility under realistic conditions. However, this reviewer cautioned that interference problems with a mixture of interferents must be resolved. The same reviewer added that the ability to distinguish NO, NO_2, NH_3, and possibly N_2O was required. This reviewer further observed a new proposal to diagnosing the sensor for OBD. The fourth reviewer stated that the project was awaiting funding.

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

The respondents disagreed regarding the adequacy of project resources. Five respondents indicated that resources were sufficient, while another respondent reported that resources were insufficient. One respondent believed this project should be extended or have a carry-on version, while a second respondent observed that the project had progressed well with the given resources and was very near completion. The third respondent remarked that resources were appropriate, and the final respondent saw no issues with resources.

Thermoelectric Waste Heat Recovery Program for Passenger Vehicles: John LaGrandeur (Amerigon) – ace080



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Overall feedback in this section was positive. One evaluator indicated that development of low cost TE materials and engines was highly relevant to DOE's effort to integrate thermoelectrics in vehicle platforms, and further asserted that the target of achieving high efficiency with TEGs was very relevant. The second evaluator reported that the goal of this 2011 completed project was to achieve a 10% FE improvement, which supported the DOE objective of reducing petroleum consumption. Another evaluator agreed that the fuel economy improvement goal supported the DOE objective of petroleum displacement. The fourth evaluator described that the program run by Amerigon/BSST offered one path towards reduced fuel usage and improved petroleum displacement by developing alternative automotive cooling technology. If successful, continued this evaluator, there are two major ways fuel consumption would be reduced: compression cooling system on present cars can be removed such that the belt-driven mechanical load on the engine is reduced; and the zonal climate control does away with the waste of cooling sections of the cabin that do not contribute to passenger comfort. This evaluator concluded that the effort by Amerigon/BSST appeared to be an excellent program with significant merit.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Reviewer comments were positive in this section. The first reviewer opined that the Amerigon/BSST approach was the best in the business, and observed the project team adopted a novel device structure that seemed to solve critical issues in TE power generation, such as differential thermal expansion. In earlier work, explained this reviewer, the project team selected device materials that gave reasonable ZT, but gave the most impressive power output, overall. In subsequent work and with higher quality materials, this reviewer opined that these power output values should only be more attractive. The second reviewer remarked that this project has shown the complete process of materials selection, system design, and prototype demonstration of thermoelectric waste heat recovery. Furthermore, this reviewer pointed out that the approaches have been focused on solving the technical barriers. Another reviewer expressed that the task of addressing production costs and manufacturability of the cylindrical TEG developed in past years was relevant to commercial viability, and described the incorporation of half-Heusler materials as good. This reviewer also acknowledged that further development of the cylindrical TEG (e.g., better control of gas through the system to more precisely determine locations for the TEG) and developing strategies for improved manufacturing were appropriate. The same reviewer praised the project team's very good understanding of the challenges of the TEG design, and noted that design improvements would result in reduction of the overall, physical size. This reviewer concluded that integration of the TEG into Ford and BMW vehicles included developing better atmosphere control through installation of gas ports in the outer shell. The fourth reviewer reported that the phase five objective was to improve the design of the cylindrical TEG and integrate into the BMW and Ford vehicles, and further commented that the prototype was delivered and tested. This reviewer observed that the heat exchanger design was carefully optimized to control TE locations, hermetically sealed enclosure. In Phase 5, added the reviewer, stacked TE designs were made and tested.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Feedback was generally positive in this section. One of the respondents remarked that Amerigon/BSST showed the largest overall power output, and employed a novel cylindrical design. Additionally, continued this respondent, the materials choice (half-Heusler) and cylindrical design decisions had really paid off. This respondent further opined that the project team was currently leading the pack and was best-in-class. The second respondent observed that the team appeared to have completed the 2011 milestones, including TEG building and testing, dynamometer testing at NREL, delivery of a TEG to BMW and Ford, and completion of system evaluation in BMW and Ford vehicles. The same respondent further reported the following, completed activities: road tests were carried out and TEG power measured; dynamometer tests were carried out on BMW's six-cylinder engine; and independent confirmation of results was accomplished at NREL. Another respondent summarized that an actual prototype TE device was designed, built, and implemented on BMW and Ford automobiles. Further, this third respondent explained that TE material was half-Heusler, crossflow HX, hermetically sealed with stainless tubing to eliminate material degradation. This respondent remarked that the focus was on delivering the prototype and performance testing. Additionally, according to this reviewer pressure transducers monitored the pressure drop in the system, and the bypass valve allowed lower pressure drops to avoid engine performance degradation. Approximately 500 W on a 500ºC hot side was achieved in a test bench at Amerigon. The same respondent further described that the BMW test data showed 400-450 W of power at 120-150 km/hr, while Ford Lincoln data showed 250-300 W at about 65 mi/hr. Although this respondent commented that it was not clear what this translated to in terms of fuel efficiency and that work remained to be done to go to the next step, the project was one of the few ones, overall, with encouraging data. The fourth and final respondent stated that the technical accomplishments of the project were impressive, especially the demonstration of power output on Ford and BMW vehicles. However, this respondent noted a few issues remained to be resolved in the area of materials and module design. Referencing the materials area, this respondent pointed out that although half-Heusler was used in the final generator, it was stated that this was not going to be the final material of choice for TE devices. Based on a recent literature report, this respondent suggested that this decision seemed to require a second look. If the properties of the half-Huesler materials could be verified, the same respondent also recommended that it may be worth a second look because there had been a lot of experience built upon this material during the project. Referencing the module design, this final respondent observed that an inappropriate power form was identified in Slide 7. This respondent concluded with an inquiry regarding whether the requirement of serial and parallel combination of TE couples was going to complicate the heat exchanger design and how the new design was going to affect cost.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Reviewer comments in this section were positive. The first commenter indicated that Amerigon/BSST have partnered with well-respected experts in the field in academia, as well as in other small business and large business. This commenter further remarked that the project team had a good perspective – that teaming was the path towards successful completion of DOE goals. Another commenter observed that the collaboration between BSST, Ford, BMW, and other team members has been excellent. The third commenter stated that the collaboration with BMW and Ford was very good, and had been essential to the success of the TEG designed ultimately developed. The fourth commenter reported OEM partners were BMW and Ford, and noted that other partners included Faurecia and Visteon, California Institute of Technology (Caltech), Virginia Polytechnic Institute and State University, JPL, and NREL. This commenter explained that Faurecia provided input on the bypass valve and component design, whereas ZT Plus and Caltech provided support in material characterization.

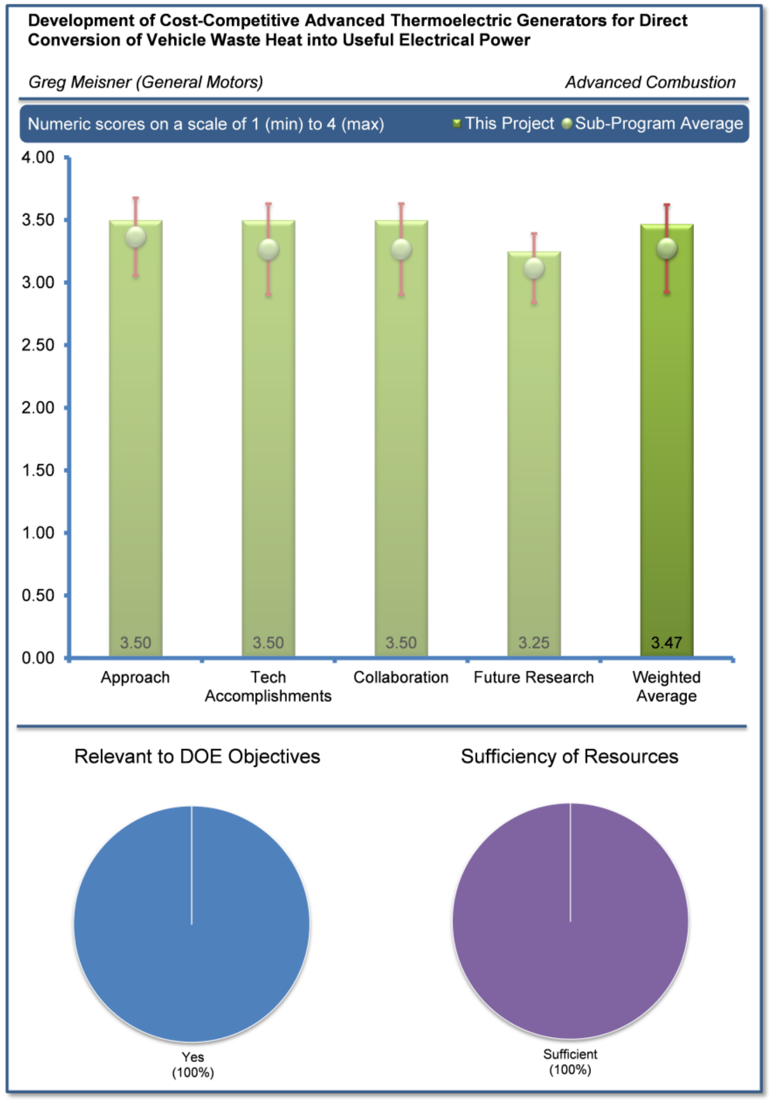
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments in this section were generally positive. One evaluator expressed that future research (in Waste Heat II) had been planned well, and that based on the experience in Waste Heat I, this team had very promising potential to succeed. The second evaluator stated that Amerigon/BSST have considered and rationalized plans to continue the project team's effort towards making DOE succeed in reducing fuel demand and using available fuel more smartly. Another evaluator reported that future work would include the following: a greater number of smaller TE devices; desired fuel efficiency gain was 5%; and economic analysis. This evaluator opined that it was not clear whether the project team would achieve the 5% improvements with the choices the project team has made in terms of the TEG, which was limited by what was available. The fourth evaluator commented that future work would follow the development of the TEG module, especially the cost of the TEG module. The evaluator noted that the PI mentioned a 5% efficiency gain as a target. It was suggested by this evaluator that details of a how-to-get-from-here-to-there strategy to achieve that benchmark would be very useful to know, as the answer would guide the allocation of the project team's budget. Furthermore, this reviewer encouraged the PI to provide some guidelines regarding the targets that should be emphasized in the project team's future work to achieve this goal.

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

The respondents agreed that the project resources were sufficient. One of the respondents offered that the resources appeared to be sufficient for the tasks that comprised the project. The second respondent observed this project had utilized sufficient resources from each collaborator, while the third respondent indicated that there was not enough information to determine adequacy of the resources.

Development of Cost-Competitive Advanced Thermoelectric Generators for Direct Conversion of Vehicle Waste Heat into Useful Electrical Power: Greg Meisner (General Motors) – ace081



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Comments in this section were positive. The first reviewer explained that integration of a TEG into a commercial vehicle would be a significant accomplishment consistent with DOE's goals of improving fuel economy (through waste heat recovery). Additionally, continued this reviewer, the goal of reducing fuel consumption via waste heat recovery was certainly relevant to DOE, and national interests. The second reviewer reported that the overall goal of the project was to design, incorporate, and test a TEG prototype on a vehicle to demonstrate fuel efficiency improvements by 5%. These project goals are consistent with the DOE requirements, opined this reviewer. The project goal is in good agreement with DOE objectives of petroleum displacement, agreed the third reviewer, who added that thermoelectric devices provide a good alternative to reduce energy and improve engine efficiency. The fourth reviewer expressed that the program run by GM offered one path towards reduced fuel usage and improved petroleum displacement by developing alternative automotive cooling technology. If successful, continued this reviewer, there were two major ways fuel consumption would be reduced. First, stated this reviewer, the compression cooling system on present cars could be removed such that the belt-driven mechanical load on the engine was reduced. Secondly, added the same reviewer, the zonal climate control does away with the waste of cooling sections of the cabin that do not contribute to passenger comfort. This reviewer concluded that the effort by GM appeared to be an excellent program with significant merit.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback in this section was mixed. One of the evaluators described that the completed project has gone through careful materials research and down-select process, system design, and prototype generator manufacturing and testing. Additionally, continued this evaluator, this exercise was the basis for future development of TE generators. This evaluator further opined that the focus on materials and system design was appropriate and effective. The second evaluator explained that the focus of the work had been on the TEG design, including materials development of skutterudites, heat exchanger design, implementation, and testing. A number of collaborators with GM as the lead were involved, observed this evaluator. The approach has been systematic, and the work has focused on scalability issues, according to this reviewer. However, this reviewer continued, the performance of bulk skutterudite materials has been a challenge, and the two-part design with two, different, TE materials has not been as successful. This evaluator concluded that the lessons learned would be transitioned to the next phase. The third evaluator acknowledged that there were strengths and weaknesses. This reviewer commented that one strength of the approach was the expertise of the PIs for accomplishing the objectives. The reviewer noted that the PIs had made good materials selection(s) and teamed with experts to make rapid progress. One weakness was in the device (and TEG) design, opined this evaluator. The merit of the planar design, stated this evaluator, was that significant pressure could be applied to make interface thermal resistance negligible. The same evaluator opined that one team member, Marlow, knew this and should be consulted about the magnitudes recommended for their modules. This evaluator inquired whether the exhaust flow through the TEG was serpentine, or laminar and straight. Unless it was a highly proprietary secret, this evaluator asserted that the project team should discuss topics similar to that because they give insight into the mechanical physics of the process. The final evaluator reported that the approach was outlined in 18 tasks ranging from materials integration into TEG components, modeling to compute performance, manufacturing TEG components and scale-up manufacturing processes, and carrying out a detailed production cost. This evaluator noted that the actual approach to achieve the target fuel economy improvement of 5% needed better definition in future work, and further encouraged the PI to provide a detailed roadmap that would also be helpful to the project team to allocate internal resources (e.g., there would be no point to direct resources to tasks that could be shown to have a minimal influence on fuel economy).

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Mixed comments were received in this section. One commenter opined that this project has made significant progress. Further, continued this commenter, the critical issues in materials and design have been identified and would need significant improvement in the next phase of the program. Referencing materials, this commenter offered that skutterudite was one of the most promising materials for TE generators. However, according to this reviewer, the performance had not been optimized especially in the p-type materials. This commenter asserted that material stability needed to be studied for long-term usage. Referencing system design, the same commenter expressed that it seemed the current design was not the best choice based on test results, and further noted that improvement in the design should include enough flexibility to accommodate potential issues in the generator. Referencing generator power, this first commenter acknowledged that the reason for very low power output was explained, but pointed out that there seemed to be a missing step in verifying the performance of skutterudite modules. This commenter concluded that if the performance of each module could be specified and verified, the final generator performance would be easier to predict. The second commenter observed that while a lot of work had gone into the design, material scalability, fabrication, and testing, the results in terms of power output were quite discouraging, with maximum output power in the range of 20-35 W. It appeared to this commenter that the design weakness with the use of Pb-Te, the two-part TEG, and the HX design could have been predicted and improved at the outset. This commenter described that the future work, which appeared to be focused on the lessons learned, was promising. The third commenter reported that accomplishments included development and testing of a TEG, a materials development effort concerning skutterudite materials, and incorporation of the materials into a TEG. This commenter described the TEG as a sort of flat structure that contrasted with the BSST design, and suggested that it would be useful to discuss why the design was to be preferred, or vice versa. The accomplishments also included testing and evaluation in a US06 drive cycle series of tests. The same commenter further pointed out that it would be interesting to re-evaluate the TEG design and performance limits benchmarked against the BSST design. This commenter expressed concern in the apparently low performing TEG design that the team had invested considerable resources to develop. At some point, stated this commenter, it would be necessary to have a Go/No-Go point to determine the extent to which further work on developing the project team's TEG module was warranted. The fourth and final commenter remarked that the output power seemed to be somewhat low considering the platform from which the project team was harnessing energy, and that it appeared that the PI was aware it was low. But at a minimum, opined this commenter, the project team should explain its results. The same commenter indicated that low power was acceptable if it was understood in sufficient detail to design a path towards higher output power. If the explanation was that the interface thermal resistance was a limiting factor, added this commenter, then that was valuable information to know for future demonstrations. The commenter expressed that the presentation would be improved if more mechanics, heat flows, and stresses of the TEG were described.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Positive comments were received in this section. The first respondent explained that this project has shown successful collaboration among team members and that the project has been very well coordinated. Another respondent observed that an excellent group of partners were involved, including Marlow and Purdue. The third respondent acknowledged an extensive collaboratory team, including groups at GM (R&D, Powertrain, and the Alternative Energy Center) as well as TE industries (Marlow), national laboratories (ORNL, BNL), and academia (e.g., Purdue, MSU). The fourth respondent indicated that the GM team had partnered with well-respected experts in the field. This respondent further noted that the Marlow staff members were leading experts, and that GM has had a long history of success with developing skutterudite materials for TEG applications.

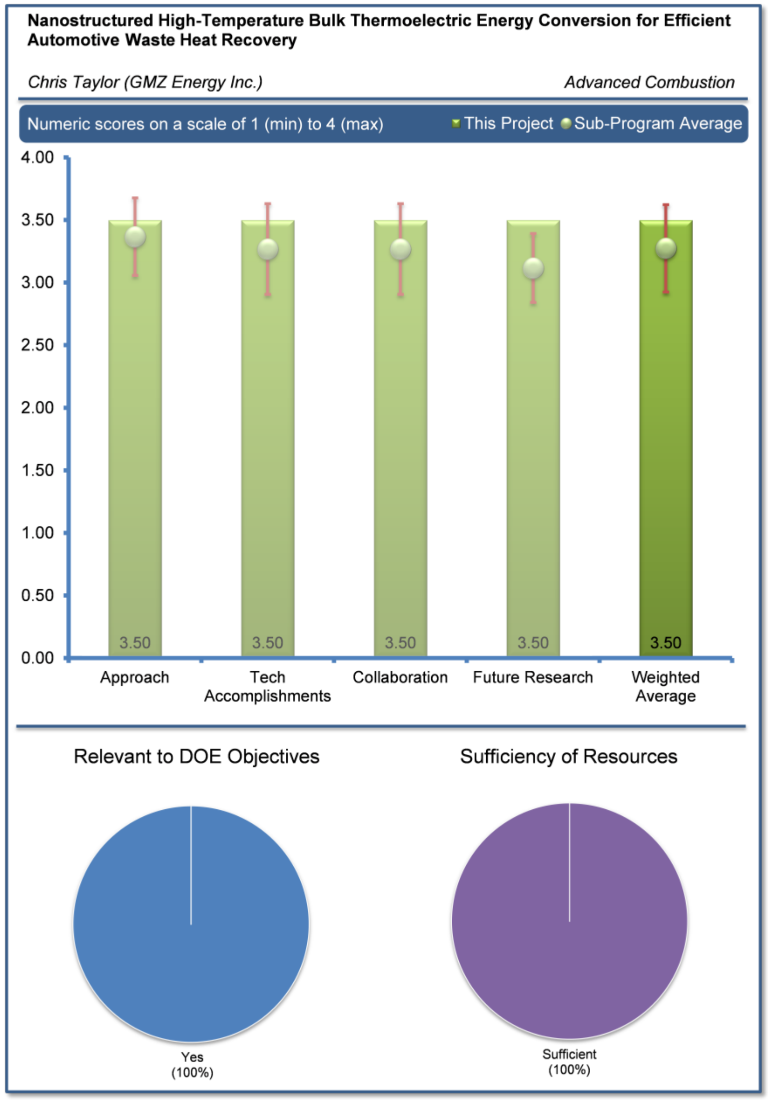
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Overall, reviewer comments were positive in this section. One evaluator opined that valuable lessons appeared to have been learned based on the TEG data generated and the vehicle tests, and that a rational path forward had been proposed. Another evaluator explained that the future plan laid out by GM included several thrusts, all of which seemed reasonable. First, continued this evaluator, the project team planned to down-select from two different TEG materials (i.e., skutterudite and bismuth telluride) to just one, which seemed like a simplification that helped both power conditioning and system design. Overall, concluded this evaluator, the project team should be able to significantly exceed the past accomplishments in the future. The third evaluator reported that future work would include continued evaluation in a demonstration vehicle, completion of TEG system analysis, and establishing design targets for the TEG subsystem and associated targets. This evaluator described the identification of issues that do not relate to the materials themselves (e.g., interfaces) as good. The fourth evaluator stated that the proposed research in Waste Heat II was focusing on the issue identified in a previous project. If successful, noted this evaluator, it would bring commercialization of TE generators in vehicles closer to reality.

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

The respondents agreed that project resources were sufficient. One respondent observed that the resources appeared to be adequate for the tasks proposed. A second respondent asserted that resources were being sufficiently utilized in this project, while a third respondent explained that there was not enough information to determine whether the resources were adequate or inadequate.

Nanostructured High-Temperature Bulk Thermoelectric Energy Conversion for Efficient Automotive Waste Heat Recovery: Chris Caylor (GMZ Energy Inc.) – ace082



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Positive comments were received in this section. The first evaluator stated this new project focused on the vehicle fuel economy improvement and fully supported the DOE objectives of petroleum displacement. Added a second evaluator, development of efficient and cost-effective materials was relevant to DOE's objectives as success in these efforts would improve the efficiency of TEGs and ultimately, fuel economy. Another evaluator reported that this project was focused on improved TE materials and an improved metallization system for a higher efficiency TEG, and was expected to contribute to improved fuel efficiency. The same evaluator noted that the project was in its early stages of research and is a partnership of GMZ, Boston College, and Bosch. The fourth and final evaluator explained that the program run by GMZ offered one path towards reduced fuel usage and improved petroleum displacement by developing alternative automotive cooling technology. If successful, continued this evaluator, there were two major ways fuel consumption would be reduced. First, this evaluator observed that the compression cooling system on present cars could be removed such that the belt-driven mechanical load on the engine was reduced. Secondly, the same evaluator remarked that the zonal climate control does away with the waste of cooling sections of the cabin that do not contribute to passenger comfort. This evaluator concluded that the effort by GMZ appeared to be an excellent program with significant merit.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

Feedback in this section was generally positive. One of the respondents indicated the technical approaches were appropriate and focused on the critical technical issues. The second respondent opined that GMZ had an excellent approach that leveraged low-risk half-Heusler materials with new, high-efficiency improvements. The project team, observed by this respondent, had selected low-cost variation of half-Heusler alloys for the hot-side stage, and nanostructured bismuth telluride as the colder-side stage. This respondent added that these were excellent choices and offered the overall DOE program an alternative to Skutterudites, which have significant challenges. The same respondent pointed out that the project team teamed with Bosch to help with integration and transition to automotive applications, and have noted the need for a compliant bus technology to mitigate the deleterious effects of differential thermal expansion. The work was new, concluded this respondent. Another respondent acknowledged that the project aimed to demonstrate a robust TEG device that would provide fuel efficiency gains. A system design was developed that combined half-Heusler and BiTe at the higher and lower temperature stages. Half-Heusler was chosen because of greater reliability. The focus of the proposal, reported this respondent, appeared to be on the nanostructured TE materials. The same respondent added that this work was based on earlier, published results from MIT and Boston College (GMZ is a spin-off company), while the other contribution of the work appeared on the contacts/metallization. This respondent also mentioned that plans for prototype build and testing were parts of future work. The fourth respondent observed the PI noted that the goal was to achieve a five percent fuel efficiency gain. This respondent asserted it was imperative that some sort of analysis be undertaken to assist with determining where resources should be targeted to reach this goal. Without doing this, cautioned this respondent, it could be like shooting in the dark to achieve this goal. The respondent encouraged the PI to develop some sort of system-level modeling to assist in targeting what needed further work to achieve this goal. The respondent also reported that the materials selected were half-Heusler (versus skutterudites), which the PI believes was a higher performance material. The focus on system design, contact metallization, joining, and mechanical strengths of joints, etc., was described by this respondent as appropriate. The same respondent summarized that the TEG design was a two-stage structure comprised of half-Heusler materials in the first stage and Bi_2Te_3 as the low temperature stage. This respondent opined that although the design seemed novel, it also seemed complicated. The respondent recommended that some indication of the difficulty of fabrication and integrity of the interfaces over time would be appropriate to provide in additional presentations. It was reported by the same respondent that the materials were nanostructured, and that the team appeared to have the capability to make these materials in large quantities. This respondent concluded that the Phase 1 effort would focus on TE device performance using a suite of sophisticated instrumentation for characterization.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

Reviewer comments were generally positive in this section. The first reviewer expressed that this team has shown significant progress and potential to be successful, given the very short duration of the project in FY 2011. Furthermore, continued this reviewer, the materials research based on prior GMZ work has laid a good foundation for the project. This reviewer concluded that it was good to see that this new project was able to use the lessons learned in other DOE projects to catch up quickly. The second reviewer pointed out that the project is relatively new (i.e., about four months along) and anticipated that accomplishments would be more forthcoming in next year's presentation. This reviewer remarked that the PIs have carried out some initial contact metallization studies that showed low contact resistance and good diffusion barriers, and pursued some initial modeling studies using ANSYS. The same reviewer reported that the team plans for a workshop at GMZ in May 2012 to share results among Bosch, GMZ, and BC, and observed that GMZ was building a system-level model of power generation using ANSYS that includes TE output and associated thermo-mechanical stresses. The reviewer further remarked that the team was developing a plan to merge the TE model with a model for the heat exchanger/system multi-scale model. The third reviewer highlighted that this program really had not kicked off, but indicated the project team was already hitting the ground running with some initial results. The fourth reviewer recounted that GMZ would look at both mechanical and thermal testing, and reported that progress included improvement in materials fabrication of half-Heusler, as well as improved contact metallization and power generation. Improved ZT of half-Heusler of both n-type and p-type to 0.6-0.8 has been shown. According to this reviewer, the investigators had also shown that reducing the Hafnium composition by a factor of three did not lead to a definable reduction in ZT. This reviewer also observed system design exploration and modeling with Bosch. Specific system improvements were not clear to this reviewer.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

Overall, positive feedback in this section was received. One of the evaluators highlighted that the project had assembled an excellent team to carry out the planned tasks. The second evaluator reported that the collaboration included GMZ as the lead, along with Robert Bosch, ORNL, and Boston College. Each component, observed this evaluator, brought excellent expertise in various disciplines, including prototype fabrication, heat exchangers, contacts and integration, materials characterization, and dynamometer testing. Another evaluator opined that the project team had assembled a good team with very high expertise in the relevant areas. This evaluator described Bosch as a known parts supplier and pointed out that MIT and Boston College were experts in TE materials. The same evaluator further noted that Chris Caylor was a nationally known expert in TE materials, devices, and sub-systems for integration. The fourth evaluator recounted that Gang Chen from MIT (consultant) and Zhifeng Ren from Boston College, along with Bosch and ORNL, were all collaborators with GMZ. It was not clear to this evaluator, however, whether scalability and vehicle integration/system design were properly represented.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Remarks in this section were generally positive. The first commenter explained that while most of the work on this program was to be performed in the future, the scope and perspective of the future plans appeared to be excellent. The commenter added that the project team appeared to have identified risk areas, and had planned for mitigation of those risks. If successful, continued this commenter, the half-Heusler approach could be a far more attractive alternative to skutterudite materials. Another commenter reported that most of the future work presented focused on the critical issue for thermoelectric generators. The third commenter stated that the future work, which in reality was the beginning work because the project was so new, included tasks associated with characterization of properties (i.e., ZT), mechanical testing, thermal cycle data, heat exchanger design, and system level modeling. The final commenter observed power generation and mechanical testing of half-Heuslers and bismuth telluride. This commenter also indicated that the project team would conduct planning on the heat exchanger design and system/vehicle model development. At this stage, concluded this commenter, it appeared that GMZ was more focused on the materials development, and in capitalizing on their improved performance.

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

The reviewers agreed that the project resources were sufficient. One reviewer described the budget allocated to the project as reasonable, and another reviewer remarked that the resources of each participant were being utilized sufficiently. The third reviewer noted that there was not enough information to know the adequacy of resources.

Section Acronyms

The following list of Acronyms cited within this section is provided as a reference for readers.

Acronym	Definition
3D	Three Dimensional
ACEC	Advanced Combustion and Emissions Control
AEC	Advanced Engine Combustion
AFRL	Air Force Research Laboratory
ANL	Argonne National Laboratory
API	American Petroleum Institute
APS	Advanced photon source
AVFL	Advanced vehicle fuel lubricant
BET	Brunauer, Emmett, and Teller
BMEP	Brake Mean Effective Pressure
BNL	Brookhaven National Laboratory
BSFC	Brake-specific fuel consumption
BTE	Brake Thermal Efficiency
CARB	California Air Resources Board
CE	Coulombic Efficiency
CFD	Computational Fluid Dynamics
CIDI	Compression-ignition Direct-injection
CLEERS	Cross-Cut Lean Exhaust Emissions Reduction Simulations
CO	Carbon Monoxide
CO2	Carbon Dioxide
COP	Coefficient of performance
CR	Coefficient of Rolling Resistance
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council
DERC	Diesel Engine Research Consortium
DOC	Diesel oxidation catalyst
DOE	Department of Energy
DPF	Diesel particulate filter
ECN	Engine Collaboration Network
EGR	Exhaust Gas Recirculation
EMA	Engine Manufacturers Association
EO	Engine Out
EPA	U.S. Environmental Protection Agency
ERC	Engine Research Center
FACE	Fuels for Advanced Combustion Engines
FE	Finite Element
FEA	Finite Element Analysis
FEM	Finite element method

Acronym	Definition
FMEP	Friction mean effective pressure
FPE	Free-piston engine
FY	Fiscal year
GDI	Gasoline Direct-injected
GM	General Motors Corporation
GMZ	GMZ Energy Inc.
GTI	Gas Technology Institute
H_2	Hydrogen
HC	Hydrocarbon
HCCI	Homogeneous Charge Compression Ignition
HD	Heavy-Duty
HDD	Heavy-duty diesel
HECC	High Efficiency Clean Combustion
HPLB	High-pressure, lean burn
HVAC	Heating, ventilation and air-conditioning
HX	Heat Exchanger
ICE	Internal Combustion Engine
K	Temperature in degrees Kelvin
K	Potassium
KH-ACT	Kelvin-Helmholtz-Aerodynamics Cavitation Turbulence model
LANL	Los Alamos National Laboratory
LD	Light-Duty
LDD	Light-duty diesel
LES	Large Eddy Simulation
LLNL	Lawrence Livermore National Laboratory
LNT	Lean NO_x Trap
LP	Low-pressure
LTC	Low Temperature Combustion
Mg	Magnesium
MIT	Massachusetts Institute of Technology
MOU	Memorandum of Understanding
NO_x	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
OEM	Original Equipment Manufacturer
OH	Hydroxide
ORNL	Oak Ridge National Laboratory
OSC	Oxygen storage capacity
OSU	Ohio State University
PACCAR	Commercial Vehicle Manufacturer (Kenworth, Peterbilt, DAF)
PAH	Polycyclic Aromatic Hydrocarbon
PCCI	Premixed Charge Compression Ignition

Acronym	Definition
PGM	Platinum group metal
PI	Principal Investigator
PM	Particulate Matter
PMEP	Pumping mean effective pressure
PNNL	Pacific Northwest National Laboratory
PPC	Partially Premixed Combustion
Pt	Platinum
RCCI	Reactivity Controlled Compression Ignition
RCM	Rapid compression machines
R&D	Research and development
SA	Spark assisted
SACI	Spark assisted compression ignition
SCCI	Stratified charge compression-ignition
SCR	Selective Catalytic Reduction
SEI	Solid Electrolyte Interface
SI	Spark-ignition
SIDI	Spark-ignition direct-injection
SNL	Sandia National Laboratory
TCR	Thermochemical Recuperation
TE	Thermoelectric
TEM	Transmission electron microscopy
TGA	Thermogravimetric analysis
UHC	Unburned hydrocarbons
UK	University of Kentucky
UM	University of Michigan
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability
UTRC	United Technologies Research Center
UW	University of Wisconsin
UWM	University of Wisconsin-Milwaukee
VCT	Variable camshaft timing
VTP	Vehicle Technologies Program
VVA	Variable Valve Actuation
VVT	Variable valve timing
WHR	Waste Heat Recovery
XRD	X-ray diffraction

THIS PAGE INTENTIONALLY LEFT BLANK