4. Advanced Combustion Engine Technologies

The Advanced Combustion Engine 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.

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses *(on a scale of 1 to 4)*. In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling	Musculus, Mark (Sandia National Laboratories)	4-5	3.89	3.78	4.00	3.67	3.82
Low-Temperature Automotive Diesel Combustion	Miles, Paul (Sandia National Laboratories)	4-8	3.30	3.40	3.70	3.10	3.38
HCCI and Stratified-Charge CI Engine Combustion Research	Dec, John (Sandia National Laboratories)	4-11	3.44	3.56	3.67	3.22	3.50
Low-Temperature Diesel Combustion Cross-Cut Research	Pickett, Lyle (Sandia National Laboratories)	4-14	3.40	3.40	3.90	3.20	3.44
Automotive HCCI Engine Research	Steeper, Richard (Sandia National Laboratories)	4-17	3.27	3.27	3.64	3.09	3.30
Large Eddy Simulation (LES) Applied to Low-Temperature and Diesel Engine Combustion Research	Oefelein, Joe (Sandia National Laboratories)	4-20	3.63	3.13	3.63	3.25	3.33
Free-Piston Engine	Van Blarigan, Peter (Sandia National Laboratories)	4-22	2.36	1.82	2.36	2.36	2.09
Optimization of Direct-Injection H2 Combustion Engine Performance, Efficiency, and Emissions	Wallner, Tom (Argonne National Laboratory)	4-25	3.29	3.71	3.14	2.86	3.43
Fuel Injection and Spray Research Using X-Ray Diagnostics	Powell, Christopher (Argonne National Laboratory)	4-27	3.42	3.17	3.00	3.08	3.20
Use of Low Cetane Fuel to Enable Low Temperature Combustion	Ciatti, Steve (Argonne National Laboratory)	4-31	3.23	3.15	3.08	3.23	3.17
Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines	Aceves, Salvador (Lawrence Livermore National Laboratory)	4-35	3.40	3.60	3.40	3.20	3.48
Chemical Kinetic Research on HCCI & Diesel Fuels	Pitz, Bill (Lawrence Livermore National Laboratory)	4-37	3.91	3.64	3.64	3.36	3.67
2011 DOE Vehicle Technologies KIVA-Development	Carrington, David (Los Alamos National Laboratory)	4-40	3.00	3.22	3.33	3.00	3.15
Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes	Daw, Stuart (Oak Ridge National Laboratory)	4-43	3.33	3.00	3.22	3.11	3.13

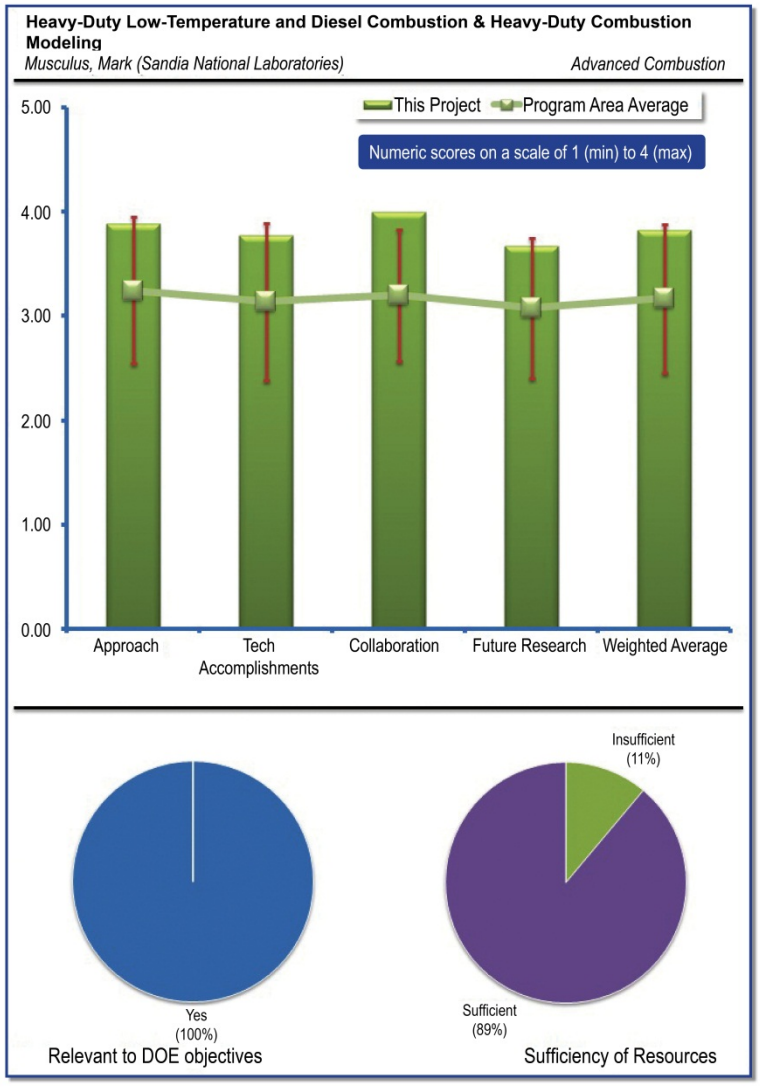
Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines	Curran, Scott (Oak Ridge National Laboratory)	4-46	3.38	3.50	3.25	3.00	3.38
High Efficiency Engine Systems Development and Evaluation	Briggs, Tom (Oak Ridge National Laboratory)	4-48	3.50	3.33	3.42	3.17	3.36
A University Consortium on Efficient and Clean High-Pressure, Lean Burn (HPLB) Engines	Assanis, Dennis (University of Michigan)	4-51	3.27	3.18	3.73	3.10	3.26
Optimization of Advanced Diesel Engine Combustion Strategies	Reitz, Rolf (University of Wisconsin)	4-54	3.83	3.75	3.67	3.50	3.73
Flex Fuel Optimized SI and HCCI Engine	Zhu, Gouming (Michigan State University)	4-56	3.00	2.64	2.55	2.91	2.75
CLEERS Coordination & Joint Development of Benchmark Kinetics for LNT & SCR	Daw, Stuart (Oak Ridge National Laboratory)	4-59	4.00	3.67	4.00	3.33	3.75
CLEERS Aftertreatment Modeling and Analysis	Lee, Jong (Pacific Northwest National Laboratory)	4-61	3.33	2.67	3.67	3.33	3.04
Development of Advanced Diesel Particulate Filtration (DPF) Systems	Lee, Kyeong (Argonne National Laboratory)	4-63	2.00	2.00	1.67	1.67	1.92
Combination and Integration of DPF-SCR Aftertreatment Technologies	Rappe, Ken (Pacific Northwest National Laboratory)	4-65	2.33	2.33	2.67	2.33	2.38
Enhanced High Temperature Performance of NOx Storage/Reduction (NSR) Materials	Peden, Chuck (Pacific Northwest National Laboratory)	4-67	3.33	3.33	3.00	3.00	3.25
Degradation Mechanisms of Urea Selective Catalytic Reduction Technology	Peden, Chuck (Pacific Northwest National Laboratory)	4-69	4.00	3.50	4.00	3.50	3.69
Experimental Studies for DPF and SCR Model, Control System, and OBD Development for Engines Using Diesel and Biodiesel Fuels	Johnson, John (Michigan Technological University)	4-71	3.67	3.67	3.33	3.00	3.54
Development of Optimal Catalyst Designs and Operating Strategies for Lean NOx Reduction in Coupled LNT-SCR Systems	Harold, Michael (University of Houston)	4-73	3.50	3.00	4.00	3.00	3.25
Three-Dimensional Composite Nanostructures for Lean NOx Emission Control	Gao, Puxian (University of Connecticut)	4-75	2.00	3.00	1.50	2.00	2.44
Efficient Emissions Control for Multi-Mode Lean DI Engines	Parks, Jim (Oak Ridge National Laboratory)	4-77	3.00	3.00	3.00	3.33	3.04
Cummins/ORNL-FEERC CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines	Partridge, Bill (Oak Ridge National Laboratory)	4-80	3.50	3.00	3.50	3.00	3.19
Emissions Control for Lean Gasoline Engines	Toops, Todd (Oak Ridge National Laboratory)	4-82	3.67	3.00	3.67	2.67	3.21
Development of Chemical Kinetic Models for Lean NOx Traps	Larson, Richard (Sandia National Laboratories)	4-84	3.00	3.50	2.50	3.00	3.19
Advanced Boost System Development for Diesel HCCI/LTC Application	Sun, Harold (Ford Motor Company)	4-86	3.33	3.33	3.33	3.33	3.33
Advanced Collaborative Emissions Study (ACES)	Greenbaum, Dan (Health Effects Institute)	4-88	4.00	3.00	3.50	3.00	3.31

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Measurement and Characterization of Unregulated Emissions from Advanced Technologies	Storey, John (Oak Ridge National Laboratory)	4-90	3.67	3.00	3.00	3.00	3.17
Collaborative Lubricating Oil Study on Emissions (CLOSE Project)	Lawson, Doug (National Renewable Energy Laboratory)	4-92	3.33	3.67	3.67	3.00	3.50
Thermoelectric HVAC for Light-Duty Vehicle Applications	Maranville, Clay (Ford Motor Company)	4-94	3.67	3.33	3.67	3.67	3.50
Improving Energy Efficiency by Developing Components for Distributed Cooling and Heating Based on Thermal Comfort Modeling	Meisner, Greg (General Motors)	4-96	3.00	3.00	3.33	3.33	3.08
Thermoelectric Conversion of Waste Heat to Electricity in an IC Engine Powered Vehicle	Schock, Harold (Michigan State University)	4-98	3.67	4.00	3.33	3.67	3.79
Develop Thermoelectric Technology for Automotive Waste Heat Recovery	Meisner, Greg (General Motors)	4-100	3.00	3.00	3.33	3.00	3.04
Automotive Waste Heat Conversion to Power Program	LaGrandeur, John (BSST LLC)	4-102	3.50	3.75	3.50	3.50	3.63
Neutron Imaging of Advanced Engine Technologies	Toops, Todd (Oak Ridge National Laboratory)	4-104	3.43	3.14	3.14	2.86	3.18
Expanding Robust HCCI Operation (Delphi CRADA)	Szybist, James (Oak Ridge National Laboratory)	4-106	2.78	2.78	2.56	2.78	2.75
Rapid Compression Machine - A Key Experimental Device to Effectively Collaborate with Basic Energy Sciences	Gupta, Sreenath (Argonne National Laboratory)	4-108	2.80	2.40	3.10	2.70	2.63
Deactivation Mechanisms for selective catalytic reduction (SCR) of NOx with urea and development of HC Adsorber Materials	Peden, Chuck (Pacific Northwest National Laboratory)	4-110	2.67	2.67	3.33	3.00	2.79
Fuel-Neutral Studies of Particulate Matter Transport Emissions	Stewart, Mark (Pacific Northwest National Laboratory)	4-112	3.50	3.00	3.50	3.50	3.25
Cummins SuperTruck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks	Stanton, Donald (Cummins)	4-114	3.33	3.33	3.00	3.33	3.29
Supertruck - Improving Transportation Efficiency through Integrated Vehicle, Engine and Powertrain Research	Sisken, Kevin (Detroit Diesel)	4-116	3.00	3.00	3.00	2.67	2.96
Supertruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer	Jadin, Dennis (Navistar International Corp.)	4-118	2.67	3.33	3.67	3.33	3.21
High Fuel Economy Heavy-Duty Truck Engine	Tai, Chun (Volvo)	4-120	3.20	3.20	3.20	3.40	3.23
ATP-LD; Cummins Next Generation Tier 2 Bin 2 Diesel Engine	Ruth, Michael (Cummins)	4-122	3.40	3.20	3.20	3.60	3.30
A MultiAir / MultiFuel Approach to Enhancing Engine System Efficiency	Reese, Ron (Chrysler LLC)	4-124	2.50	2.75	2.50	2.75	2.66
Lean Gasoline System Development for Fuel Efficient Small Car	Smith, Stuart (General Motors)	4-127	3.00	2.60	2.20	3.20	2.73

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Gasoline Ultra Fuel Efficient Vehicle	Confer, Keith (Delphi Automotive Systems)	4-130	3.00	3.00	3.33	3.00	3.04
Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development	Rinkevich, Dan (Ford Motor Company)	4-132	3.67	3.33	2.67	3.67	3.38
Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles	Yilmaz, Hakan (Robert Bosch)	4-134	3.00	3.00	4.00	3.00	3.13
Integration of Advanced Materials and Interfaces for Durable Thermoelectric Automobile Exhaust Waste Heat Harvesting Devices	*Ju, Yongho (University of California at Los Angeles)*	*4-135*	*3.50*	*3.50*	*3.00*	*3.00*	*3.38*
Thermoelectrics Partnership: High Performance Thermoelectric Waste Heat Recovery System Based on Zintl Phase Materials with Embedded Nanoparticles	*Shakouri, Ali (University of California at Santa Cruz)*	*4-137*	*3.50*	*3.00*	*3.50*	*3.00*	*3.19*
NSF/DOE Thermoelectric Partnership: Inorganic-Organic Hybrid Thermoelectrics	*Vaddiraju, Sreeram (Texas A&M University)*	*4-139*	*3.00*	*3.00*	*1.00*	*2.50*	*2.69*
An integrated approach towards efficient, scalable, and low cost thermoelectric waste heat recovery devices for vehicles	*Huxtable, Scott (VPI & SU)*	*4-141*	*3.00*	*2.50*	*2.50*	*3.00*	*2.69*
NSF/DOE Thermoelectric Partnership: High-Performance Thermoelectric Devices Based on Abundant Silicide Materials for Vehicle Waste Heat Recovery	*Shi, Li (University of Texas, Austin)*	*4-143*	*3.00*	*3.00*	*3.00*	*3.00*	*3.00*
Thermoelectrics for Automotive Waste Heat Recovery	*Xu, Xianfan (Purdue University)*	*4-145*	*3.00*	*3.00*	*3.50*	*3.50*	*3.13*
Overall Average			3.25	3.14	3.20	3.08	3.17

Note: Italics denote poster presentations.

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



Reviewer Sample Size

This project had a total of nine reviewers.

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

Reviewers generally felt the project was relevant since it strongly supports advanced combustion modes that may lead to higher efficiency and lower emissions. It was pointed out that low-temperature combustion (LTC), and specifically reactivity controlled compression ignition combustion (RCCI), shows good potential for significant improvements in fuel efficiency. One person noted that this supports efforts of dual fueled LTC combustion which the University of Wisconsin has demonstrated to be capable of higher efficiency at steady state operating points in their lab. That affirmed a comment by another reviewer that felt understanding of in-cylinder processes relating to RCCI combustion is still limited, so given the demonstrated efficiency of RCCI combustion by the University of Wisconsin and others, optical work in this area is very important and needed. Another reviewer stated that this provides in-cylinder understanding of high efficiency LTC concepts like RCCI for heavy duty applications. It was also noted by a reviewer that investigating behavior of sprays is key to high efficiency combustion modes. Another mentioned that this research is applicable to improving indicated specific fuel consumption (ISFC) of internal combustion (IC) engines through enabling non-standard combustion mode strategies that can simultaneously deliver very low engine out NOx and particulate matter (PM). A reviewer felt that this were revolutionary discoveries aimed at advancing combustion and emissions. A final reviewer asked if this research had light duty applications.

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 it had a good and pragmatic approach that includes modifying the tasks as new technologies (like RCCI) emerge. Two other reviewers felt it was a well-focused approach, with one going on to say that this was innovative and an example of what a national lab should be doing. A fourth commented that this world-leading research is well thought out to create genuine understanding in a way that is accessible to product designers. The fifth person remarked that this project is delivering fundamental knowledge to the community concerning the physics associated with flame propagation versus distributed ignition. This reviewer went on to state that it is a very outstanding effort focused on addressing the key physics associated with RCCI. Their only suggestion was to include metal engine work to address the impact of the various combustion mode strategies on ISFC. A sixth reviewer listed the key aspects of the project that included providing fundamental knowledge of flame behavior, probing effects of injection timing and various mixing approaches, providing data for evaluating models of combustion process, specifically providing an understanding of unburned hydrocarbons (UHC) and soot emissions, and using laser spark to improve understanding of flame propagation versus auto

ignition. This reviewer stated that although the optical engine conditions are not exactly the same as the University of Wisconsin, the approach will still provide insight into the RCCI process. A seventh reviewer was not sure the investigator could explain the post injection activities very well. In their opinion, it had more to do with switching to a lower cone angle spray which messed up the combustion. The last reviewer wanted to know what would be changed for light duty applications.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer felt very good progress in understanding these very complex systems. Another reviewer agreed, stating that excellent progress was made on a wide range of fronts with diagnostics, measurements and modeling described. A reviewer observed that the initial work has been promised toward building understanding on how to properly model RCCI, though it is obvious much work is still ahead of the PI. This person believes the only possible area of improvement could be in addressing the impact of RCCI control strategies on ISFC in a metal engine. Another person listed examples to demonstrate the good progress that has been made. This included; 1) post-injection lowers soot, 2) wide-angles reduced soot only in the squish region, but left soot unoxidized in bowl region, 3) narrow-angle injector investigated provided same soot reduction, although higher soot resulted because of impingement on bowl walls, 4) added gasoline direct injection (GDI) side-injector to engine for early-injection premixed charge, 5) investigated three diesel injection timings and looked at heat release rate differences, 6) RCCI combustion is mostly auto ignition; with some flame propagation, and 7) heat release is affected by reactivity gradients. High load soot vs. injector angle was the noted progress by another reviewer who also commented that some work towards understanding ISFC of various strategies would be useful, even on optical engine. This reviewer also pointed out that very insightful results were shown through the given first look at RCCI. Another reviewer also mentioned the first in-cylinder chemi-luminescence video of RCCI.

The final commenter provided specific feedback on slides from the presentation that are also applicable to other evaluation categories. For Slide 11, the GDI location and orientation in the combustion chamber influence the generated phenomena and thus the observed results. Putting it in place of the side-window may provide global misleading results, or directionally wrong findings. However, reported results under the stated objectives in Slide 7 are plausible, especially in the context of understanding BASIC combustion aspects which are not affected by temporal fuel-air mixing. On Slide 17, adding the plasma spark via a focused laser beam is a nice experimental tool. On Slide 19, the location of the GDI injector is a handicap to the experiment setup and will not give results that readily correlate to real-life. In reference to Slide 24, the investigator should continue close-coupled modeling and experimental work, with both feed-forward and feedback iterative process. The reviewer concluded by stating that it seems that the team is on the threshold of revolutionary discoveries, with promising real-life applications.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Overall, reviewers were please by the collaboration on this project, with one noting the investigator's work with the University of Wisconsin at Madison and industry. A second reviewer affirmed that this is a model for how to integrate government sponsored work, National Labs, academia, and industry. This person went on to say that there is a long history of excellent collaboration and this work is continuing that. A third person felt the researchers had no issues working with ideas and concepts generated elsewhere, since they currently host a graduate student from University of Wisconsin and work with Memorandum of Understanding (MOU) partners. Another reviewer stated that it looks like great information for the MOU and University of Wisconsin on RCCI that can be used to improve the modeling results. The fifth reviewer pointed out that this project has strong collaboration; it is coordinated with the Advanced Engine Combustion Working Group that is collection of various key industrial partners. Another agreed that there was a wide spectrum of collaborating institutions, although it was heavily slanted towards the University of Wisconsin for RCCI studies. Criticism from the seventh reviewer was that too many publications (and travel) distract from better value-added efforts. The last reviewer was glad to see this moving into new area (RCCI), and recognizes the significance of this new 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?

The proposed list of future work was fine according to the first commenter. One reviewer noted a solid approach to the issue, but would like to see more work to address off cycle conditions such as cold starting. Another remarked that the proposed research plan is fundamentally sound. However, this reviewer did have the suggestion to keep an eye on the impact of ISFC as a function of the various combustion strategies, even though it is difficult to understand this in an optical engine. Suggestions from another reviewer included in-cylinder mixing, multi injection, LTC, and polycyclic aromatic hydrocarbon (PAH). One person observed that the split between optical and metal engine experiments should be better delineated. This reviewer felt the shortcomings of measuring fuel consumption for the calculation of thermal efficiency should be resolved. The final reviewer proposed an approach for future research that included 2 parts. Part 1 establishes a corresponding metal research engine, preferably at University of Wisconsin at Madison to capitalize on their solid core competency, and introduce its test results into the effort. This makes the iterative research cycle described above a 3-segment loop. Part 2 establishes a corresponding multi-cylinder research engine, preferably at ORNL to capitalize on their solid core competency, and introduce its test results into the effort. This makes the iterative research cycle described above a 4-segment loop. This reviewer suggested that a robust multi-year program be developed along these lines with goals focused on short cycle-time and fairly robust development. The objectives could be defined so that progressively lower hanging fruits are harvested for the U.S. vehicle industry.

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

The one reviewer who felt resources were insufficient noted that no amount of funding is sufficient enough for such an excellent work. Eight reviewers stated that the resources were sufficient. Expanding on this one reviewer said there was a good balance between budget and tasks completed, although was curious to know if the time available on the optical engine and similar experimental apparatus was the limiting factor in the progress achieved per unit time. Another reviewer was not clear what additional funding would enable. Comments from two other reviewers asserted that the resources seem to be about right and that the funding level appears commensurate with this effort.

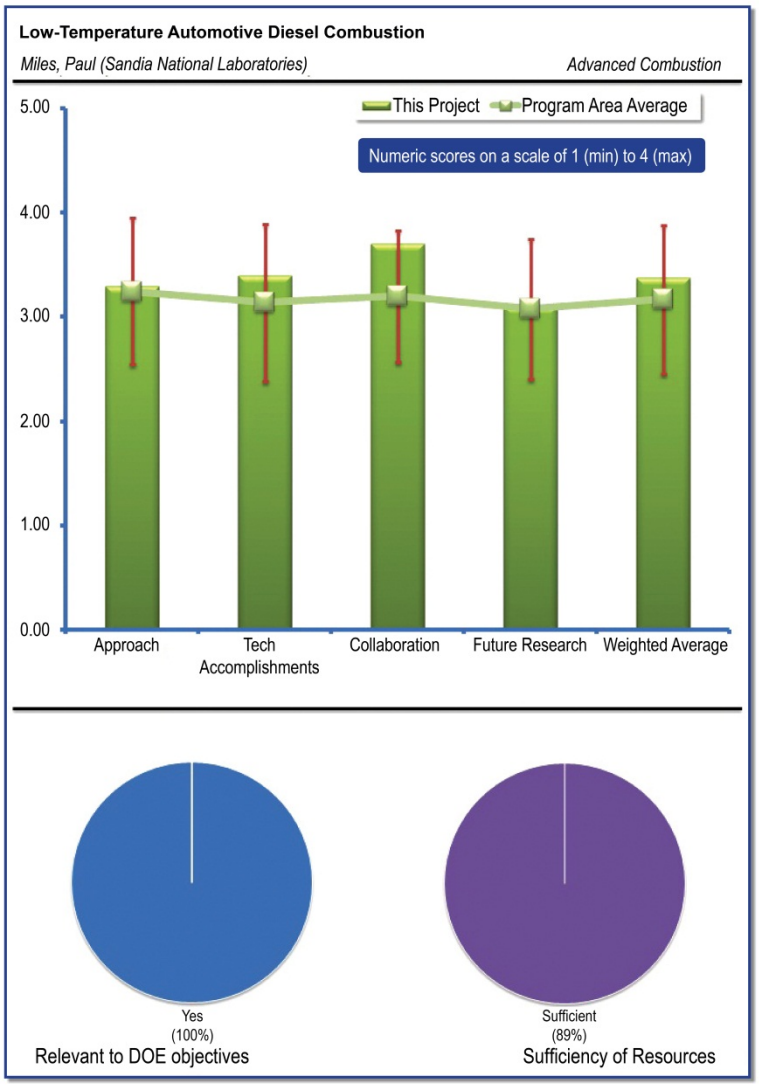
Low-Temperature Automotive Diesel Combustion: Miles, Paul (Sandia National Laboratories) – ace002

Reviewer Sample Size

This project had a total of ten reviewers.

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

The first reviewer felt this research was directly linked to efficiency and emissions targets, while another commented that it improves understanding of LTC to yield higher efficiency and reduce emissions. A third reviewer said that LTC might be a way to improve gasoline engine efficiency. The fourth reviewer acknowledged that the project's focus is on emissions of diesel combustion in automobiles which is more efficient than typical gasoline combustion in automobiles. Another pointed out that this is the light-duty compliment to Musculus (PI for ace001). A sixth reviewer mentioned that it provides fundamental understanding of light-duty diesel LTC combustion. Another person observed that a good portfolio of engine investigative studies which should lead to light-duty next generation engine fuel efficiency improvements. The last reviewer stated that it indirectly addresses DOE goals by studying the impact of ignition quality, evaporation, and turbulence on advanced combustion modes in compression ignition (CI) 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 reviewer expressed that the project has a good comprehensive approach to experimental investigations, modeling and visualization for light-duty (LD) engine studies. Another felt that this was top quality research with great tools and careful design of the experiments. A third reviewer remarked that close collaboration with the University of Wisconsin, Oak Ridge National Laboratory and General Motors, in addition to providing optical engine data to this group, results in a good approach. Overall, another commenter stated that it was a good approach, although much time was spent studying flow structures and showing that turbulence modeling in IC engines needs improvement especially during post injection mixing processes. This reviewer felt more time could have been spent investigating fuel property effects on RCCI/advanced combustion modes on ISFC, though this person did acknowledge that mixing is important. That reviewer also pointed out that this project should be closely collaborating with ACE001. The fifth reviewer noted that Slide 5 is a really good example of connecting fundamental research to industrial R&D; however, no reports or correlations were presented or alluded to. This person stated that the project improved in that some designed experiments (orthogonal fuel matrix) were used, but there seems to be too much emphasis on experimental testing vs. simulation. The last person inquired as to whether this approach parallels the proposed PRESICE model development and if there is a way to quantify the sensitivity of the various combustion system design parameters.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer pointed out a wide range of accomplishments, including good progress on UHC/carbon monoxide (CO) emissions in LTC, and modeling. Progress listed by another person included turbulence model assessment and in-cylinder flow characterization with particle image velocimetry (PIV). A third reviewer noted that the measurement of the in cylinder flow field is impressive and this shows the weakness of using a segment model for computational fluid dynamics (CFD) for this type of combustion work which is important to know. Another reviewer commented that last year's experimental (Sandia National Laboratories [SNL]) work plan (Slide 18 of the 2010 presentation) was only partially addressed, while the University of Wisconsin plan (Slide 19) seems to have been more thoroughly executed. This reviewer advised the investigator not to automatically assume that simulation has the error, when discrepancies arise between measured and simulated results. This forces-fit the experimental results into a new model formulation (e.g., Turbulence model shortcomings…). The new model with "variable constant" could very well fit the wrong experimental data. This reviewer also noted that Slide 11 may drive this point home since it shows about 50% variability across a wide range of experimental mean tangential velocity measurements vs. radius from the center of swirl structure. The reviewer concluded by stating that sometimes experimental data can be significantly more unreliable than simulation. A fifth reviewer acknowledged that good progress was made in understanding biodiesel wall impingement during PM regeneration, assessing the impact of ignition quality and evaporation on advanced combustion modes, and modeling post injection mixing. However, this person also said that it was not clear what the multi-cylinder engine (MCE) metal engine results were concerning the impact of advanced combustion modes on ISFC - possibly there was lack of time, but this is the main nugget for this project and should be closely collaborated with the key fundamental aspects of this project. Comments from a sixth reviewer pointed out that previously, discrepancies with model predictions of UHC and CO were observed. This person noted that it has been determined that fuel cetane number and ignition quality were quite influential, while fuel volatility was less effective. The reviewer went on to state that significant shortcomings in the renormalization group (RNG) models to predict turbulence levels have been observed. In addition, swirl center tilt and precession has been observed. This person concluded by remarking that work has shown that biofuel tends to wet the wall more at late injection timings. The last reviewer affirmed that the processes are becoming clearer thanks to work like this, but there remain many issues to worry about.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

A wide range of collaborators was noted by the reviewers. One reviewer mentioned the strong collaboration with the University of Wisconsin at Madison which was affirmed by another who felt the investigator did an excellent job of working with this university. Another commented that this is a model for collaboration between DOE, National Labs, academia, and industry. One reviewer acknowledged the close contact with members of MOU, collaboration with General Motors funded work at the University of Wisconsin, and the post doc at Sandia provided by General Motors. The good collaboration was pointed out by another reviewer who gave examples of Reitz doing simulations, Foster doing metal engine, leveraging funding by General Motors at the University of Wisconsin, as well as with the Diesel Engine Research Consortium (DERC). The remaining reviewer affirmed that there is close collaboration between the investigator, General Motors, and the University of Wisconsin. However, this person noted that Oak Ridge National Laboratory was named as a funded partner though no results were shown from the MCE.

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?

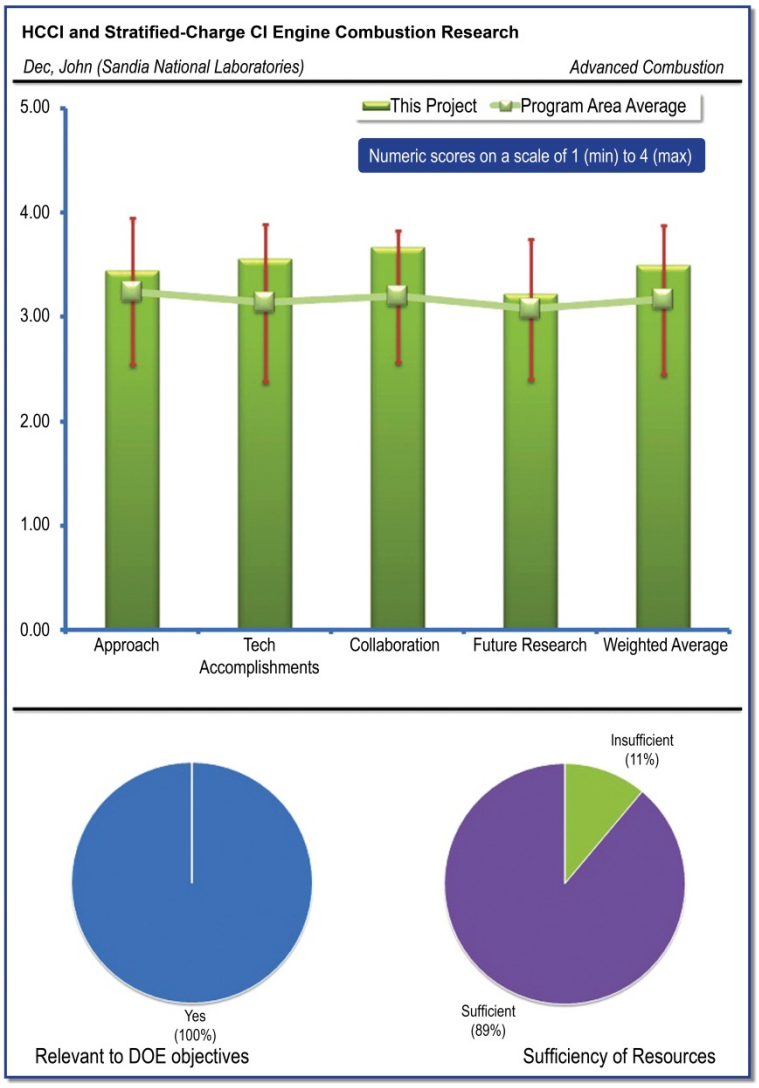
One researcher felt that the future plans listed were fine and anther suggested more of the same, but several others offered additional suggestions. One reviewer expressed interest in increasing the simulation effort by extrapolating the operational range and boundary conditions in the virtual lab. This person felt the researchers should share discoveries and results of this effort with the Advanced Engine Combustion MOU partners, ahead of trying to devise an experimental setup at SDL to validate it. Another researcher mentioned that for light-duty vehicles, cold start emissions are critical and some work is needed to ask how LTC can co-exist with light-duty cold start test requirements. This person went on to question whether LTC is worth the trip if you have to buy catalysts to meet cold emissions. One of the reviewers suggested trying to further improve predictive capability of models because it was not clear

what the approach is and still seems to rely heavily on empiricism. The final commenter suggested less of a focus on flow structures and more of a focus on the link between RCCI/advanced combustion mode fundamentals and the impact on ISFC.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All nine reviewers responded that the resources were sufficient for this project. Additional comments from the reviewers stated that results per unit budget seem on track, resources seem about the right level, and that it is great to see solid support from industry. One reviewer remarked that this is a WELL funded project and that it would be nice to see ORNL's contribution to this project given their portion was roughly 15% of the budget. A reviewer mentioned that resources are perhaps more-than-sufficient for SNL and is insufficient for UW. This person pointed out that the PI responded to a comment by a reviewer last year: “Too many publications can be a distraction” by providing rationale and justifying it to “transferring the knowledge gained.” This reviewer wants to again reiterate that criticism by expressing that too many publications distract from better value-added efforts, and consumes much time and budget. This also goes for travel to attend and presentations at too many conferences. The reviewer believes that transfer of knowledge gained is accomplished through the MOU membership, and in fact should be limited to it. This person feels the investigator should report an itemized list of the percent of the budget that is spent on publications and travel, which includes preparation time, write-up, response to reviews, etc. This reviewer concluded by questioning if the investigator would spend the same amount of time and resources if the funding source is a SNL-Laboratory Directed Research and Development (LDRD) project?

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



Reviewer Sample Size

This project had a total of nine reviewers.

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

This project was described by reviewers as providing fundamental understanding of controlling homogeneous charge compression ignition (HCCI) at higher loads, while another summarized it as the emission and efficiency impacts of light-duty HCCI. One reviewer felt the combination of premixed and injection controlled combustion offers a potentially large capacity for improvement in engine fuel efficiency. Additional comments from reviewers stated that this supports high efficiency HCCI combustion, is well aligned with HCCI/LTC interest, and is focused on key items noted of interest by DOE. One researcher observed that extending load range of HCCI directly addresses key barrier to implementation. The final reviewer remarked that this project provides insight into high efficiency LTC gasoline combustion like HCCI and partially stratified charge LTC 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?

Summarizing the approach, one reviewer mentioned that the investigator uses an optical engine for in-cylinder understanding, extending high load operating range of gasoline HCCI; which extends efficiency of HCCI and improves understanding. Another pointed out that this was a good combination of experimental methods and technologies aimed specifically at technical barriers. The third reviewer noted the fundamental understanding towards development of HCCI engine by industry through this project. One reviewer liked the ability to run optical and metal engine in the same lab, by the same PI. A fifth commented that as usual, the researcher carefully thought out experiments and used world class tools to improve understanding of the HCCI processes. Another reviewer felt that the strategy displayed in Slide 4 would be substantially improved if there are feed-forward and feedback continuous loops among the 4 outlined elements. The seventh observed that ringing metric may not be appropriate metric for combustion noise/vibration/harshness (NVH).

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

The first reviewer felt the researcher produced fascinating results, pointing out that the in-cylinder diagnostics combined with modeling make a very compelling case and help clarify these very complex situations. A second mentioned the excellent work on

gaining understanding of the effects of charge and temperature stratification, and remarked that the investigator is showing good progress on increasing the load range. A third reviewer also acknowledged that good progress has been made. This person went on to point out that in regards to thermal stratification, autoignition proceeded from hottest to coldest pockets and that thermal stratification of bulk gas is most critical for controlling high load HCCI. This reviewer questioned whether the researcher was investigating how cold gas from boundary layer mixes into bulk gas. In addition, this third reviewer had comments on the efficiency of boosted HCCI that included: partial fuel stratification increases high-load limit of boosted HCCI, autoignition proceeds from richer mixture to leaner mixture, and when boosted, mixture becomes much higher in phi sensitivity. This person concluded by stating that ethanol influences thermal stratification more and is also effective. The fourth commenter noted that the investigator had very interesting results, but felt that it will be difficult to take from lab controlled conditions into vehicle application. Another reviewer also acknowledged this by saying that it was a nice fundamental study, but this person would like to see the barriers identified (and addressed) that will allow this work to ultimately impact commercial product, because it was unclear how this will be done with respect to thermal stratification. The fifth reviewer recommended focusing on much reduced NVH limits (<3 bar/deg) for light duty. The sixth person was also concerned that this approach will be dominated by noise factors present in real world engines and expressed an interest in this being addressed. A seventh reviewer mentioned that the results shown starting on Slide 13 would be significantly enhanced if the testing was done via a statistically designed test matrix, instead of carrying out "systematic sweeps". This person felt the conclusions may be impacted by this. The last person expressed that there was very good progress in covering the spectrum of direct injection (DI) versus PM combustion regimes. However, this reviewer wanted to know how much further improvements can be expected in thermal efficiency as a result of the optimization of these two technologies and questioned whether engineering intuition would be able to tell us that the optimum solution lies somewhere in the middle of the range of fuel injected quantity that results in PM versus DI combustion.

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

One reviewer commented that there was good dissemination of results and collaboration with other institutions, while another specifically mentioned SNL Advanced Engine Combustion and Sjoberg. A third reviewer felt that the investigator established excellent, close working relationships and that the active support and involvement of industry is great. Another person commented on the researcher providing data directly to General Motors for in-house development of their codes to account for thermal stratification. The fifth reviewer acknowledged that the investigator provides data for modeling at Sandia (LES, Oefelein), provides understanding for work at General Motors, and complements work at the University of Wisconsin, while at the same time collaboration within the MOU and with several other collaborators exists.

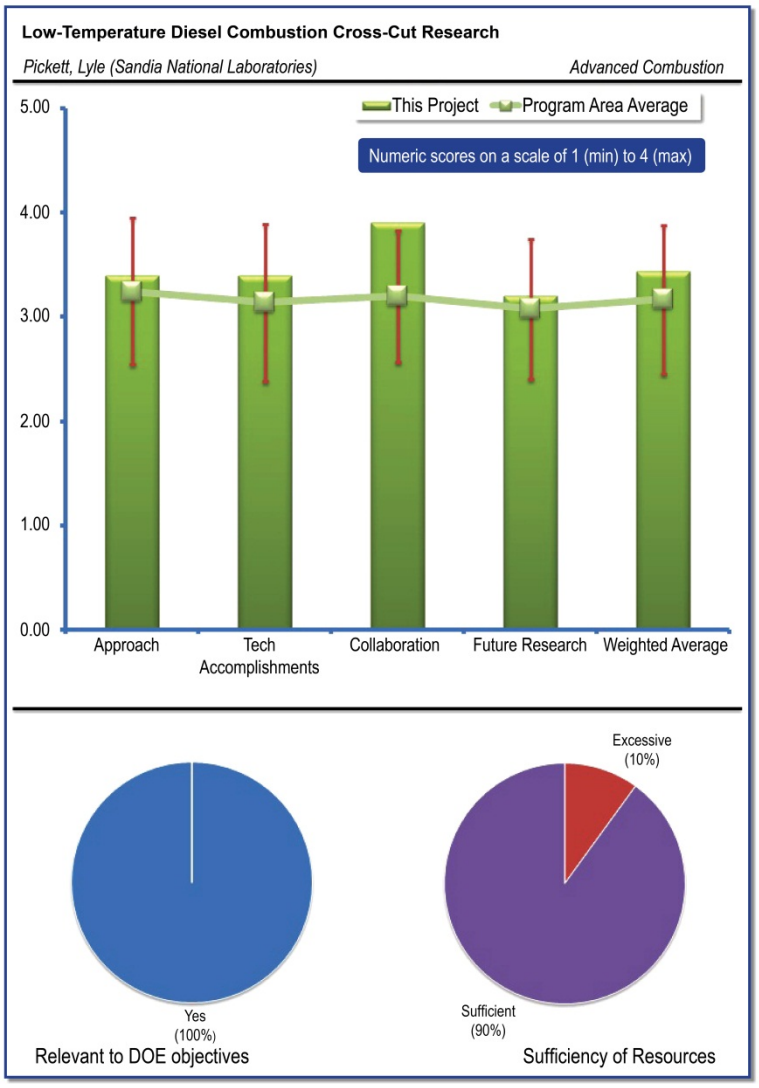
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

While one reviewer felt that the proposed work is relevant, the others included recommendations for improvement. One reviewer mentioned that more specific future tasks and plans would be more useful. This person stated that there are a number of issues in this area that demand attention, so perhaps a more systematic approach for covering the experimental domain required. Another commenter wanted the investigator to consider moving to either light or heavy duty architecture, because it was unclear how direct the findings translate to both. This person observed that 44% indicated thermal efficiency (ITE) at 14 bar indicated mean effective pressure (IMEP) with high rise rates and HCCI control issues, is not very high. This reviewer questioned that if real benefit is low NOx, are the data available? Another reviewer commented that the researcher had very good plans for further development; however, the light-duty/medium-duty systems have major cold start emission concerns and none of the HCCI research seems to address cold starting. This person pointed out that light-duty vehicles typically make 90% of total cycle emissions in the first 30 seconds or so. Feedback from the final reviewer was that the researcher may consider solving the global heat transfer equation of the combustion chamber. This reviewer went on to state that the boundary conditions (thermal properties, etc.) of the firedeck, piston top and bore/liner should be readily available, while General Motors or University of Michigan (UM) can do analyses in one-dimensional (1D), two-dimensional (2D), and/or full three-dimensional (3D), accurately and easily. A recommendation from this person was to superimpose the measured T-maps (e.g., slides 9 -12 in 2011 presentation) and explore further.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The one reviewer who asserted that the resources were insufficient recommended switching to a relevant light duty platform with rapid hardware commissioning in 2011. Eight reviewers decided that the resources for the project were sufficient. One of these gave an additional comment stating that the budget seems well-spent, while another remarked that it seems appropriate and that it is good to see industry's active support. One person responded that the resources were sufficient and generous.

Low-Temperature Diesel Combustion Cross-Cut Research: Pickett, Lyle (Sandia National Laboratories) –ace005



Reviewer Sample Size

This project had a total of ten reviewers.

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

One reviewer affirmed that this project supports DOE objectives by providing fundamental spray formation knowledge including evaporation and mixing effects on ignition and flame propagation. This person went on to explain that though this project does not directly support address the fuel consumption improvement goals of DOE it does provide a basis that can be used by others investigating RCCI and other combustion modes that do impact ISFC. A second reviewer pointed out that strong experimental and visualization techniques are required for the development of future high efficiency engines. Another stated that this project provides an understanding of fuel spray impact on combustion that should lead to better control and improved efficiency. The fourth commenter remarked that diesel, gasoline, and mixed fuel systems use DI and they depend critically on air-fuel mixing, so improved data and models are needed. Noted by another reviewer was that good models of sprays and mixing are keys to being able to model engines that use LTC concepts. A sixth reviewer commented that this work is improving the predictability of models, which should lead to an improved understanding of sprays and is important because in-cylinder injection is becoming more relevant for both diesel and gas. The final reviewer stated that the investigator focuses on understanding spray behavior relevant to 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?

One reviewer summarized the approach stating that the project provides fundamental understanding of fuel sprays; all high efficiency engines use direct injection, multiple injection, two-phase mixing, etc. This person went on to mention that the researcher provides data for modeling via the Engine Combustion Network (ECN), included gasoline sprays this year, uses laser ignition to differentiate autoignition and flame propagation, and that Schlieren and Mie scattering is conducted simultaneously. This reviewer concluded by noting the strong coupling between experiments and CFD modeling that has been established. Debating the addition of gasoline sprays, a second reviewer commented that the approach seems suitable, but there is a wide range of topics covered with both diesel and gasoline sprays. This person questioned the extent to which this is investigator-driven, rather than prescribed by the DOE. However, a third commenter felt that adding gasoline sprays to the portfolio of research is appropriate. A fourth reviewer remarked that the combustion network approach is outstanding toward ensuring that various partners are conducting experiments and analysis similar enough to collectively improve the fundamental understanding of spray formation processes - evaporation, mixing, and spray thermal stratification. Another person acknowledged that the investigator had produced good test data results for improving modeling capabilities. The sixth reviewer liked Slide 5, but asserted that the investigator should take it a few more steps down the research

development & demonstration (RD&D) path with others, especially the industrial partners. Explaining further this person suggested integrating with the work of others at SNL and beyond to make sense of all of these closely fitting pieces of a complex puzzle, which should include the applied research and advanced development domains. The seventh commenter felt that the modeling and observations in the project lead to questions that need to be explored more fully and that the investigator should compare results to conventional diesel type combustion to understand differences and reasons. The final reviewer acknowledged that this was solid work on detailing injection. However, this person also noted that autoignition and flame propagation seem to be somewhat different regime from HCCI/ premixed charge compression ignition (PCCI)/RCCI engines, so the investigator should be sure conditions are meaningful.

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

Good progress on a year-to-year basis was expressed by one reviewer. This was affirmed by a second person who identified specific areas of progress that included models of mixing have been validated with mixture fraction measurements, global penetration rate has been related to mixture distribution, and ignition of gasoline sprays in the constant-volume chamber has started. In addition, this reviewer noted that a 2-hole injector of an 8-hole injector is being studied, the investigator is using laser ignition to set baseline flame propagation behavior, and when ambient temp is raised, autoignition occurs 20-mm downstream which is followed by what looks like an autoignition flame. A third reviewer encouraged the investigator to stay with "Transition Combustion", even if tangible progress seems slow. Another person acknowledged the nice work, observing that ECN seems useful and good for reaching others. The fifth reviewer stated that this work was interesting, specifically noting that finding flame propagation after self-ignition is opposite of s/a HCCI. The last commenter remarked that to date, very good measurements of vapor concentrations and penetration have been produced from this effort. However, this person felt that it would have been helpful to see more results alluded to in Slide 14 such that the reviewer could have a better feel concerning progress made this past year. Although, the reviewer acknowledged that there is a limited time slot for the presentation.

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

A number of positive remarks about the Engine Combustion Network were given by the reviewers which included ECN is a nice initiative, excellent work with the ECN, ECN good example of collaboration, ECN and its web site deserve "4", ECN provides a great forum to collect information from a variety of researchers and make it available to the general community, and ECN is a powerful approach to collaborative. However, a few additional comments on the ECN from reviewers mentioned that the ECN is perhaps duplicative and that too much collaboration with outside organizations, especially on the global domain, for the sake of harmony and professional courtesy can be a deterrent. One reviewer suggested that perhaps the ECN scope should be expanded to gasoline injectors, while another requested that in future reviews, it would be nice to see how the ECN has positively advanced the state of the art in spray simulation by including a few specific examples. One reviewer remarked that the collaboration with the ECN and MOU partners is very good. Another affirmed this by stating that the project has excellent collaboration between many industry partners through the combustion network and Advanced Engine Combustion MOU. This person pointed out that the idea of using similar or exact hardware is a great approach that is only possible with real collaboration.

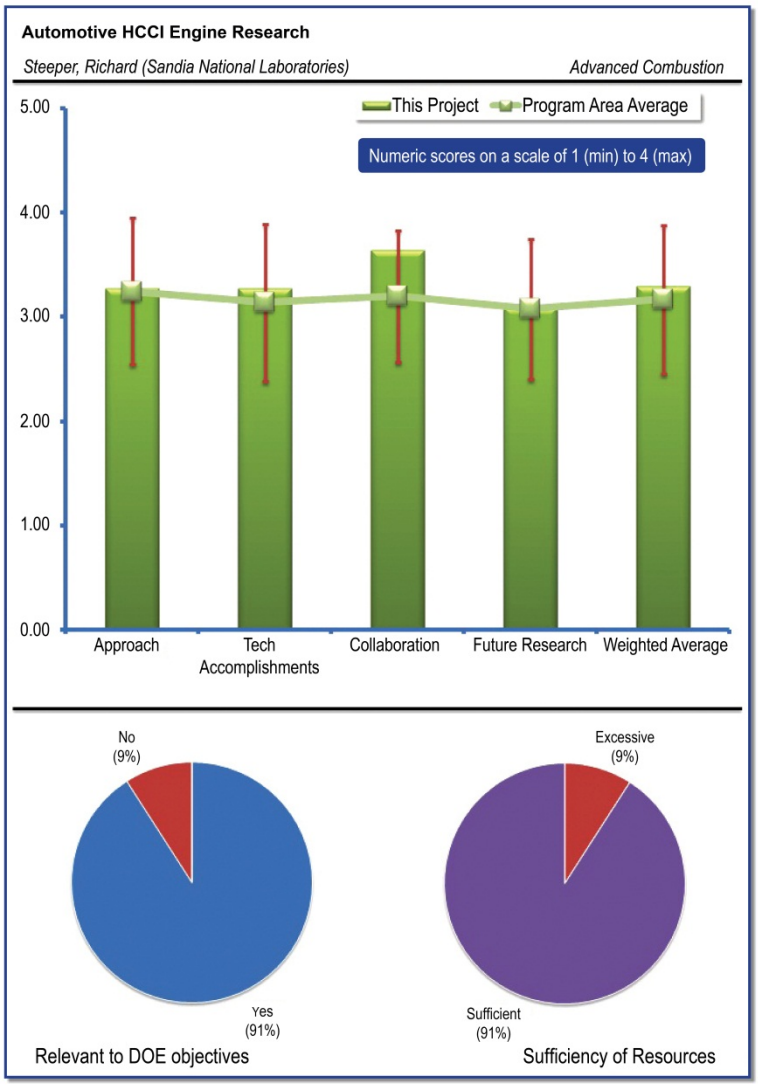
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer remarked that it was nice to see that gasoline sprays are now planned for evaluation. Another concurred, saying the gasoline work planned makes the balance between diesel and gasoline work better than in the past. A reviewer felt the PI has a very comprehensive parametric spray study planned for next year which will be of great value to the spray combustion community, although it might be too aggressive. However, another asserted that future progress is possible on a wide front, but needs to be well thought out, or will simply become reactive and scattered. The other reviewers stressed the importance of collaborating with other research areas stating that the investigator should compare results to work done on conventional and HCCI diesel and be clear on how this integrates into engine concepts like RCCI. Another reviewer reiterated this interest to see sprays (both in hardware, supply pressure, and flow rates) more indicative of RCCI combustion currently being studied by other researchers.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Nine of the ten reviewers responded that the resources for the project were sufficient. One of these commented that progress seems to match budget and vice versa. Another mentioned that it seems to be sufficient, but may perhaps be a bit high versus other efforts. The last reviewer asserted that the resources for the project were excessive, and went on further to state that there does not appear to be any funded partners, which leads to the question why this project has such a high funding level compared to other SNL projects. This person thought that the reason for this was that possibly part of the funding is/was invested in hardware.

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



Reviewer Sample Size

This project had a total of 11 reviewers.

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

Summarizing the research, one reviewer noted that this project is focused sharply on enabling advanced combustion models in gasoline engines that are necessary for efficient part load operation. In particular, this person explained that it explores the use of negative valve overlap (NVO) injection strategies for controlled phasing of the main heat release event. Directly addressing this question, one reviewer stated that the project supports the goal of achieving 25% fuel efficiency improvement through extending the HCCI operating range and that in combination with other technologies, this approach may enable that goal. Another pointed out that extending operation of HCCI to the light-duty automotive market application will likely result in fuel consumption reductions in that market. Disagreeing with these other reviewers one person was not too sure about the efficiency improvements of this method. Five other reviewers remarked on certain aspects of the research while not necessarily specifying the relationship to petroleum displacement. Their comments included: high Efficiency and low NOx operation of HCCI, work on NVO fueling can yield control of HCCI combustion, good study of issues of interest to HCCI combustion, understanding NVO fueling and its reactions with requests from industry, and addresses barriers for LTC combustion like gasoline HCCI while providing fundamental knowledge. The final reviewer said that the investigator uses the right words and terminology and that it seems that "the industrial partners" endorse it, so it has to be 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?

Most reviewers approved of the approach being used, but had mixed reactions related to the relevance and value to this research. One person noted that the optical engine is a good tool to visualize mixing and combustion during NVO operation and pointed out that relevant hardware and operating conditions are investigated, due to good interaction with OEM collaborators. This person also affirmed that state-of-the-art visualization techniques are applied and collaboration with modeling community is good. A second reviewer remarked that combustion control is a key barrier to HCCI combustion and that this work can lead to realistic ways to accomplish this, however with some loss of power density and efficiency. Two other reviewers stated that this is a well-defined problem being studied carefully and that it is an excellent combination of experimental, diagnostic and modeling. The fifth commenter mentioned the laser modulation for CO diagnostics and CFD modeling. A sixth reviewer felt that this project has a very good approach using optical engine, modeling, and zero-dimensional engine modeling to assess NVO injection strategies. This person's only suggestion is to explore heat transfer as a potential important phenomenon that could impact the main heat release event. This reviewer pointed out that the CFD analysis did show that heat transfer modeling was an issue during the power stroke which leads to

the possibility that the heat transfer during NVO and the compression stroke could be issues, too. The seventh person affirmed that the approach is outstanding, and the tools being developed (e.g., tunable diode laser [TDL]) are very useful for understanding the fundamentals. However, this commenter also remarked that the narrow focus on NVO to extend the useful range of HCCI may not offer significant incremental benefit over other engine technologies, yet introduces some additional aftertreatment and engine control complexity. The eighth reviewer said that it is not abundantly clear why NVO offers higher fuel efficiency possibilities than any other regime of operation of HCCI performance and that there needs to be better motivation other than being of relevance to a specific OEM. The last person questioned whether "riding the NVO horse" is a good investment of funding, talent and resources, or, if this research is too narrow of a focus in the bigger scheme of HCCI. This reviewer expressed that the reported experimental work is OK; however, it could be of little added value to the entire state-of-the-art knowledge database of HCCI combustion. This person pointed out that advancements in simulation, along with other programs' results from SNL and elsewhere, call for a revision or revamp of this program's activities and directions.

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

One reviewer felt a good range of achievements were made on a wide front, including both the experimental and diagnostic tool development. The second person agreed that there was good progress, complimenting the nice combination of experiment and modeling, while another commented on the impressive correlation between experiment and simulation. The fourth reviewer acknowledged that the CO absorption diagnostic work was progressing well and remarked on the CFD validation of results. Another person pointed out that the investigator has made significant progress this past year trying to understand NVO injection timing impacts on the main heat release event through the development and use of CO measurement techniques, optical engine experiments, and chemistry modeling. Good progress was also noted by the sixth reviewer who listed the following accomplishments by the researcher: probed reasons for early heat release during late NVO injection, seeded with candidate species to determine the role of intermediate species on affecting heat release, developed Tunable Diode Laser for in cylinder measurement of CO, and updated GT-POWER model. This person also noted that acetylene provides similar early heat release, acetylene (C2H2) is known as an ignition enhancer, and that the good agreement between KIVA model predictions and NVO heat release measurements is very encouraging. The seventh reviewer questioned the accomplishment noting that the fundamental understanding of the C2H2 mechanism is important to expanding the range of HCCI operation, but questioned specifically to what degree. This person pointed out that it appears, even if fully successful, this would offer only incremental efficiency gains relative to other technologies, particularly when the goal is to push the HCCI range to higher load where less marginal gain is offered. The last commenter stated they were hard pressed to find real original findings and discoveries, criticizing that slides 6-10 do not present new findings that could not be obtained via a competent simulation exercise and/or from literature. This person said that the methodology in slides 11-19, started in prior year, is "nice", but the researcher should assess its forward value to continue investing in its development.

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

Most reviewers were pleased with the collaborations on this project. One said it was a very good and comprehensive set of collaborators, while another remarked on the tight coordination with potential implementers. The third reviewer remarked that the collaboration with industry and the integration of the experiment with modeling is commendable. This person went on to point out that this will increase body of institutional knowledge in this area, and improve future in-cylinder combustion and cycle simulation modeling capabilities. Another commenter felt it was appropriate to have universities and OEMs as collaborators. This was affirmed by another reviewer who commented on the good collaboration that exists with Lawrence Livermore National laboratory (LLNL), University of Wisconsin, General Motors and Ford, and all the members of the MOU. The sixth person noted the good collaboration with General Motors and that Ford is starting to now get involved as well. The seventh reviewer remarked on the excellent collaboration among the PI, the University of Wisconsin, and LLNL utilizing the strengths of each organization in addition to technical input from General Motors and Ford. Another person acknowledged that the collaborators are well known and acclaimed, but felt that their respective roles do not match their capabilities, abilities, or reputation.

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?

Expressing their approval, one reviewer stated that the future plans as listed are fine, while another just said to keep going. A third person remarked that the combination of experiments, diagnostic developments and modeling is a powerful suite of tools, and wanted to know what overlap there is in the modeling area to other similar projects. Another commenter stated that overall, it was an outstanding plan, but suggested to consider running some hot motoring experiments to better understand heat transfer characteristics of the optical engine as referenced in the above approach section. The fifth reviewer observed that now with better understanding the influence of NVO injection on combustion, the effort should explore how robust of a combustion control parameter it is over a wider range of charge and coolant temperatures. This person noted that moving from isooctane to real gas is good and that General Motors sending new heads is a sign of active support. Another commenter mentioned that the quality of the work is outstanding, and the switch to a new test platform will only improve the relevance. This person believes that broadening the scope of the study to include other mixed-mode combustion regimes would be useful. It was also stated by this reviewer that the work presumes that extending HCCI is the best option, but perhaps other options should be considered that would be more consistent with the overall efficiency/emissions goals. The seventh reviewer also expressed that it was not clear if HCCI is relevant part load combustion mode is based on control and NVO status. The last person questioned whether upgrading the facility and engine hardware, even duplicating a setup that exists somewhere else at SNL, is a good stewardship for project budget. This reviewer also asked where this project would fall, if "industry partners" were forced to priority-rank all the funded programs at SNL.

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

Ten of the eleven reviewers responded that the resources for the project were sufficient. One person expanded to state that the budget and tasks show good agreement. Another felt that the cumulative benefits of this project to the overall program are perhaps broader than the scope suggests, and for that reason the level of funding is justified. One of these reviewers stated that the funding seems reasonable, though compared with other SNL combustion projects, it appears to be a little underfunded on an output versus funding ratio perspective. The eleventh reviewer asserted that the resources for the project were excessive. This person questioned whether this project would survive if the DOE funding to SNL is cut by X% next year, where "X" is 10, 20, or another percentage. This comment applies to this and all projects, not only at SNL, but also at all other national labs.

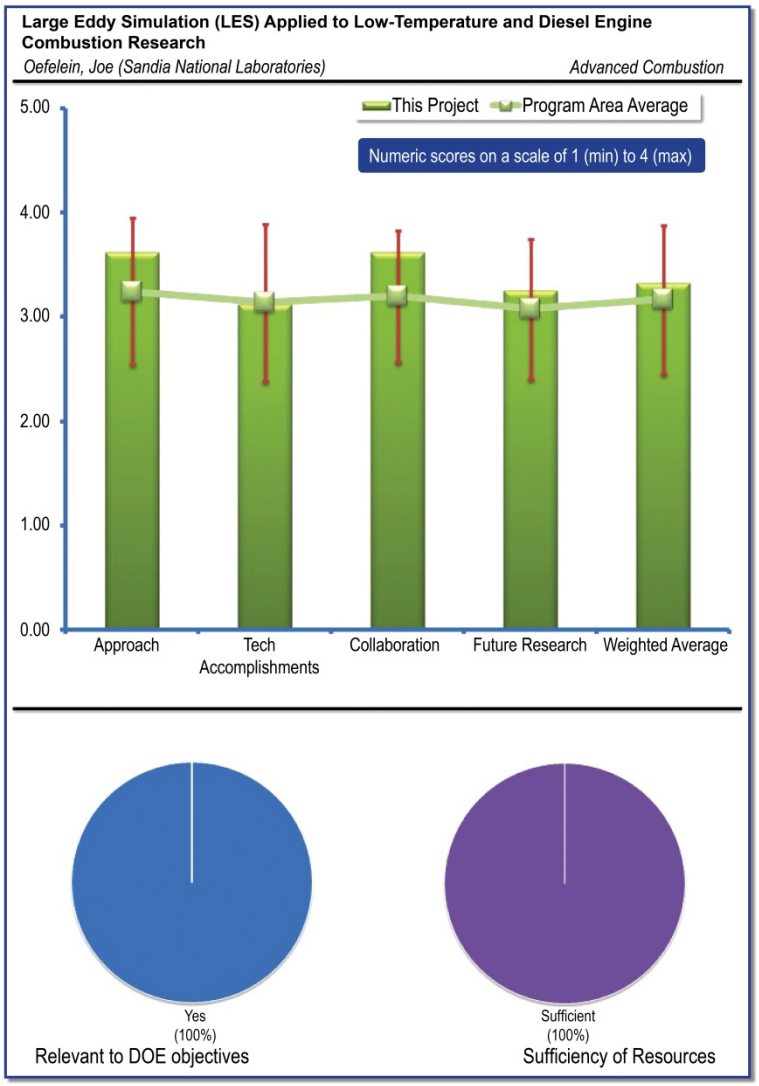
Large Eddy Simulation (LES) Applied to Low-Temperature and Diesel Engine Combustion Research: Oefelein, Joe (Sandia National Laboratories) – ace007

Reviewer Sample Size

This project had a total of eight reviewers.

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

This aspect was summarized by one reviewer, who stated advanced simulation is a critical complementing element of future test programs aimed at reducing fuel consumption. Most other reviewers affirmed this, with one reviewer noting that high fidelity modeling provides insight into highly efficient engine designs. A third person commented that the long term value for fundamental computations is good and that this will ultimately link well with other engine combustion work. Another concurred, mentioning that high performance computing is another important tool in engine development. The fifth commenter said that this leads to improvements in computer models to improve future engine designs. The last reviewer pointed out that this research is focused on understanding LTC combustion which is a barrier and is also on efficient and routine use of exascale computing.



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 this approach sets the ideal standard for CFD, to which other more available, affordable, and engineering-oriented approaches can be compared to. This person detailed components of the approach mentioning the access to advanced massively paralleled and newest DOE computers, as well as the Office of Sciences Supercomputers. Also pointed out was the solving of fully coupled equations (direct numerical simulation [DNS]), detailed thermodynamics, no tuned constants, eliminating constraints of computer capabilities on computational model performance, and connections to Jaguar. This commenter concluded by stating this work bridges basic and applied research. Another reviewer also acknowledged the strong link between basic and applied research and that the project was a good explanation of Jaguar computational resource. The third reviewer wanted to know how this work ties into the pending PRESICE modeling. Another person asserted that this project pushes forward the frontier of computations in a significant way and felt the use of DOE computational capabilities to approach the engine problem is unique. The fifth commenter thought the validation test cases where the efforts are being applied, though extremely challenging, are appropriate for future work. The reviewer pointed out that including additional work in kinetics of spark ignition and flame-front propagation in stratified charge engines, perhaps including mixed-mode combustion, would also be a useful validation case going forward. The last reviewer remarked that the approach is good, but noted that this project runs the risk of seeming to be a solution looking for a problem. This person pointed out that there are enough areas of interest to keep computational facilities busy indefinitely, and questioned how the topic areas are chosen.

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

One reviewer remarked that nice progress towards basic understanding of complex phenomena. Another person listed accomplishments that included completing large eddy simulation of transient jets and conducting computations of work at SNL with Pickett, Musculus and Dec. The third commenter stated that leveraging the available computational capability to further the understanding of fundamental, ongoing experimental programs will ultimately provide invaluable insight toward overcoming barriers. This person mentioned, for example, continuing to add critical features such as the state model in the spray simulation demonstrates continued good progress in the right direction. Other reviewers were more critical of the accomplishments with one saying that there was good continuing progress, but the direction of the calculations seems obscure. Another person concurred stating that the investigator showed some good things, but future is not all that clear on this project. The last reviewer was not clear on timeline and tasks for subset to full engine validation, because it was not explained what the success look like.

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

Most reviewers, such as the first reviewer, felt that there was good, wide-ranging collaborations with a range of institutions and investigators. Another commented that collaboration with key experimental investigators to provide data for the model evaluation is good. Two other reviewers pointed out that the work was directly coupled with BES and Office of Vehicle Technologies (OVT), and that there was nice linkage to BES, other researchers, and industry. Another commenter stated that the partnerships included are appropriate for the success of the project, although perhaps future collaboration on fundamental next-generation direct injection spark ignited (DISI) systems would be 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 remarked that computation is a powerful tool, but the direction needs to be more pro-active and not reactive. This person mentioned that we have been told for years that high-power computing will lead to better engine design, but we have yet to see any engine design outputs from studies like this. This reviewer concluded by explaining that steady combustion in an aerospace application is trivial compared to fully transient, unsteady combustion in a piston engine. The second commenter noted that validation with current homogeneous engine may be helpful and that building confidence of tool key to acceptance should be included in future studies. The third reviewer felt that the scope of the efforts is appropriate for this time. This person suggested that given the importance of advanced boosted DISI engine technology, especially stratified charge modes, in the next decade or so, perhaps some effort could be directed in this area. Another commenter acknowledged that we need to keep going on these fundamentals, because they will change the game somewhere in the future. A fifth person was not real sure where this is heading in the future and another reviewer commented that the specific future research was rather vague. The final reviewer stated that this was interesting and needed research, but for this approach to impact product, the time (and cost) of the approach needs to be significantly reduced.

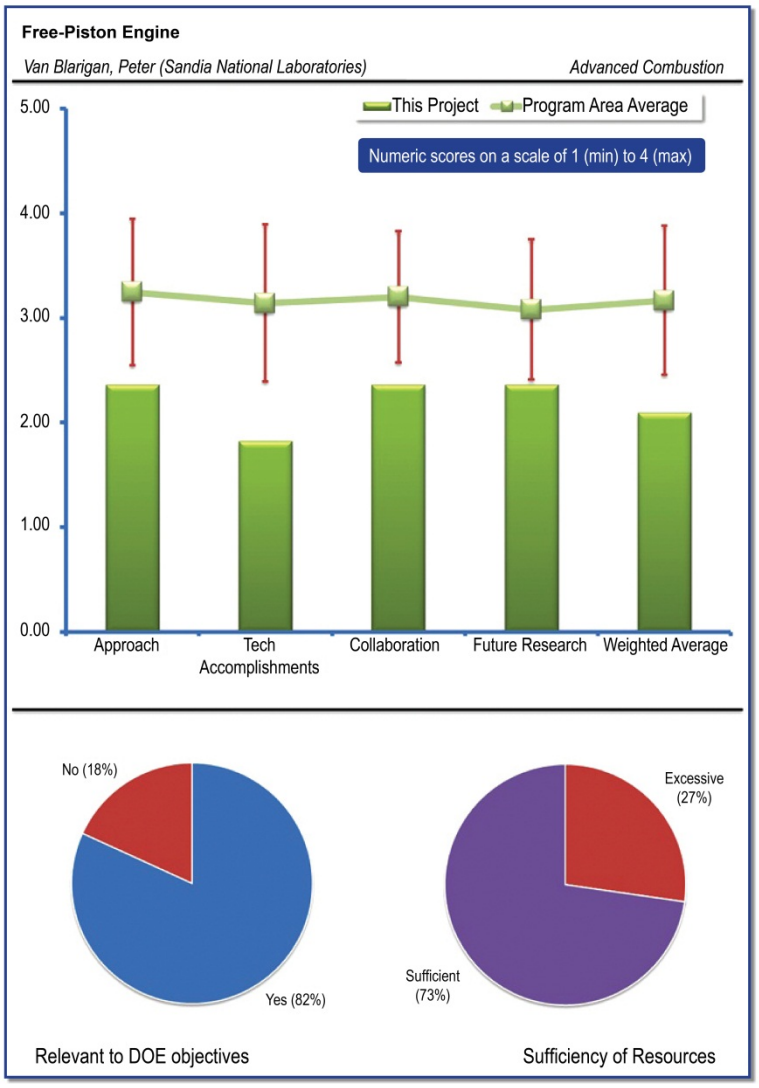
Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

All eight reviewers responded that the resources for the project were sufficient. One of these reviewers was not clear how additional funding would accelerate progress, one explained that the funding seems about right, and another felt that the budget seems appropriate. One reviewer mentioned that the expectations are high with this level of funding, so expanding the work in outside of just LTC/HCCI may provide a greater payback.

Free-Piston Engine: Van Blarigan, Peter (Sandia National Laboratories) - ace008

Reviewer Sample Size

This project had a total of eleven reviewers.



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

The reviewers provided mixed opinions on this work, with most acknowledging that the work is highly speculative in nature. One reviewer felt that it does have relevance for fuel efficiency improvements in automotive and stationary generation applications. Another said that it was interesting work with great potential but it has many issues to overcome. A third reviewer described this as a unique project with high potential and high risk that is looking for very high efficiency conversion from fuel to electrical energy. Expressed by another commenter, this project is a very long range concept but is estimated to have potential for high efficiency. However, other reviewers were not convinced of the benefits with one stating that it barely supports the DOE objectives because the concept is very high risk, but possibly has only medium reward for mobile applications. Another reviewer questioned if there was a practical use for this device. One person has been tracking this project for the last few years and feels that it does not really fit with the DOE objectives. Another commenter acknowledged that the project is relevant, but only if there is progress. One person pointed out that there was much interest to identify peak thermal efficiency results. The final reviewer asserted that to the extent that the Free-Piston Engine program can contribute to long-range understanding of the potential of novel technologies to reduce fuel consumption, it is a valuable 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?

The first reviewer remarked that the investigator used a nice systematic approach to the design and attempted to address design issues up front, although long term issues like lube and cooling are still pretty fuzzy. The second person noted that the researcher did a good job of trying to address the technical hurdles. A third reviewer mentioned that this provides a good research tool and prototype by studying free piston linear alternator and using high compression ratios of 20-40 with HCCI combustion. The approach is systematic, but progress is very slow was noted by a fourth person. Another commenter pointed out that the compression ratio tradeoff of efficiency with heat losses requires further work, and that single cycle experiments are interesting, but boundary conditions, such as temperatures, representative of sustained engine operation are needed. The sixth reviewer pointed out that it would have been better to use a mechanical coupling to focus on the combustion and indicated efficiency rather than mechanism and electrical coupling design. Another person felt that more effort should have been spent realistically assessing this concept's capability to meet ISFC targets before building hardware including air system, friction, linear motors, etc. While the eighth commenter thought this was a very interesting project, the design of the test apparatus adopts an inherently high risk approach to evaluating many complex elements simultaneously, rather than in a controlled, isolated manner. This person observed that beyond just the complexities of the linear engine/alternator

mechanism, it appears that many critical uncertainties remain in the air exchange, in the combustion process (highly dilute port fuel injected [PFI] CI at extreme compression ration [CR]), and in the heat transfer. Thus, this reviewer concluded that it may be difficult to interpret the results that may one day be obtained. The ninth commenter felt that the real question is whether this can move beyond academic interest to practical device. The final reviewer pointed out that the opposed piston, 2-stroke engine has been over-researched and over-developed for the last 70 years, after the German Junker engine of World War II and this research cycle tends to repeat every 10-20 years. This person remarked that hundreds of millions of dollars are spent, with claims of approaching a solution to its Achilles' heel, but that DOE is better off investing their funds in a better mouse trap. This reviewer acknowledges that a few private and venture-capital companies have sprung out, are making big noise recently on the merit of the opposed piston engine, and even one known truck-engine company announced partnership with one of them. However, this implies that this cycle is approaching its peak and this person expressed that if investors are ready to put their money into it, let them do so and use taxpayers money for something else pertinent to the national agenda.

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

Almost all reviewers mentioned that there has been very slow progress on this project. One person acknowledged that developing a new engine concept is a very time and budget consuming enterprise, but the progress on this project seems to be glacially slow. Another commenter noted that the funding of this project has been worthwhile; representing a long-term vision of "what could be", but the execution has not been on par with the vision. This person stated that fuel needs to be burned to advance the concept, and ultimately to decide whether to push forward with more work in this area (ideally) or to stop altogether. A reviewer pointed out that this project has been moving slowly for a few years, but consented that a significant amount of effort has been spent on hardware development. This person does not think the investigator was clear in explaining how the depth of the analysis has been, which makes it hard to truly assess the merits of this engine concept. This reviewer believes that this project has serious real world engine design challenges that will be difficult to overcome including cooling, tribological, scavenging, and charge preparation issues. Another commenter also expressed that progress has been very slow and gave an example of the project hiring a new person last December even though the original plan was to hire a person early in 2010. This person listed a few accomplishments including running the motor at operating compression ratio, with a bounce chamber, having a Helium starting system, and that the Data acquisition system is now functioning. One reviewer pointed out that the milestones of this complex project were shown, but the investigator did not show how those relate to past plans or what the future roadmap looks like. Being more critical, one reviewer stated that there was nothing of value to report as an accomplishment and that it is like a senior project hardware activity. Another reviewer stated that there has been quite some time invested without yet having a single fired stroke. This person expressed interest in seeing if the device is controllable under combustion, while another commenter agreed that is will be exciting to see if it runs.

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

The first reviewer felt that the collaboration with General Motors and University of Michigan for model validation, while needed, does not provide the kind of collaboration needed to address the hardware design, build, and test issues on this project. Another person also remarked that the General Motors and the University of Michigan collaboration seems token, and a bit out of date. Questioning whether this project is a part of the MOU's group projects, or sanctioned by it, the third commenter observed that General Motors and others are playing a supporting role and are not contributing to real R&D. Another reviewer also noted that the investigator is working with the University of Michigan on modeling this engine, though the contributions with General Motors are not obvious. This person was hopeful that the University of Michigan will aid in truly assessing the potential of this engine concept for delivering the claimed ISFC levels at the targeted very high compression ratios. The fifth commenter inquired as to whether the project was fully leveraging progress in power electronics world. One reviewer stated that it was good to see academic and industrial partners, while another mentioned that the collaboration on this project has been improved in the past couple of years, and is appropriate for this stage of development. This last reviewer felt that once data can be generated from the test article, further collaboration can be expected.

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 the list of future work as listed is fine; however, the traditional problem with this project is the extremely slow rate of progress. This person expects to see that the hiring of the new person last year will approximately double the rate of progress. Another commenter noted that much of the proposed work is not really value-added, but is only overcoming the challenges of getting the test apparatus functional. This person mentioned that once the engine is operational, it would be useful to see more specifics laid out describing what aspects of the proposed "combustion experiments" will be focused on. This reviewer also wanted to know how the instrumentation will be applied to evaluate all critical aspects of the engine performance, so that the most useful aspects of the results may be sorted out. A third person concurred that a lot depends on the results of the experiments. Another reviewer was glad to see progress toward combustion, but was concerned that there are still many detail issues to work out. The fifth reviewer asserted that is was critical to see it running in sustained operation, at any speed or load. Another reiterated this by expressing that the future research is okay provided it is executed and that it is important to see combustion data in 2012. The seventh person stated that we need to see data as soon as possible under realistic boundary conditions. Another reviewer felt that the proposed future research is good assuming fired results are available at the 2012 Annual Merit Review, but that if this did not happen, then it will be difficult to recommend further funding. The ninth commenter pointed out that progress is steady but very slow and that it seems as though more and more barriers to the operation of the prototype engine crop up. This person remarked that the engine has been on the verge of running for several years now, or so it seems. Another reviewer wanted to know if there is a calendar timeline that leads to expected results milestones and decision points, although this person felt that there was no need to continue this activity. The last commenter asserted that there are too many failure modes to count with this thing.

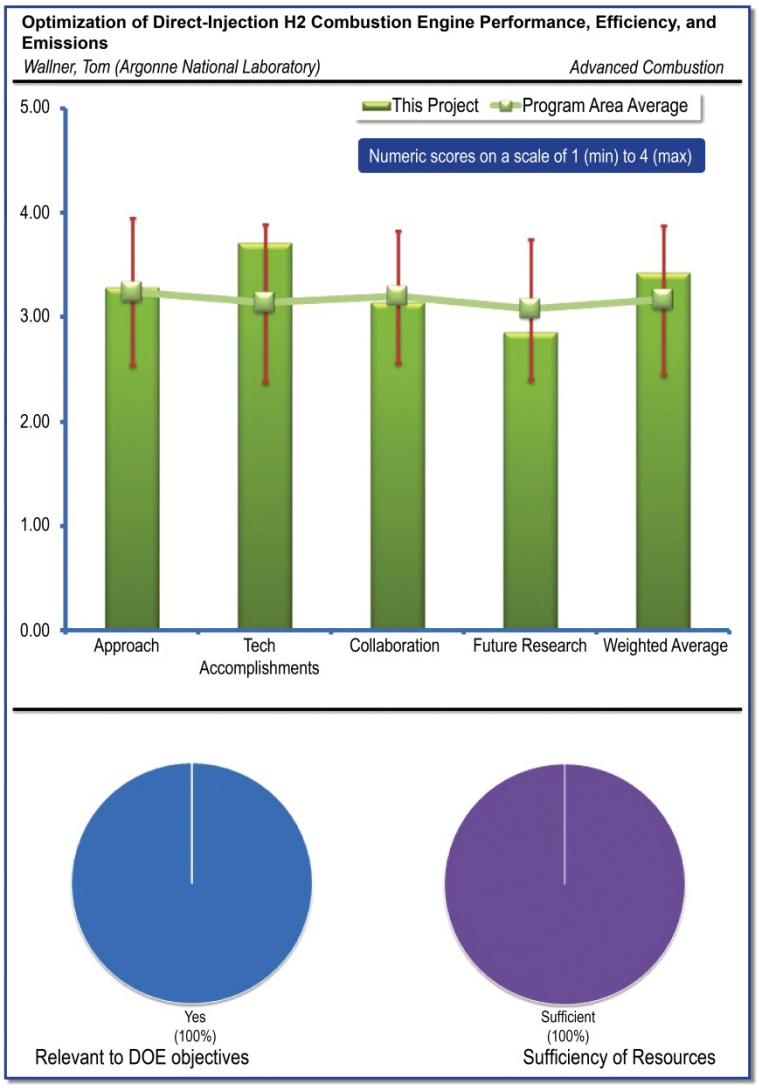
Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Eight of the reviewers responded that the resources for the project were sufficient. One of these went on to state that the level of funding for such a long-term project is appropriate, but expressed hope that this next year will show a stronger return on the many years invested. Another reviewer acknowledged that this project is a real long shot and would have suggested to not fund it so highly, except hardware tests do need funding. The last of these eight reviewers to provide additional comments stated that the funding is adequate for this project and pointed out that it appears to be spent more on hardware development which has allowed the progression of this project. The other three reviewers felt that the resources for the project were excessive. One of these reviewers suggested that future funding should be tied to milestones vs. realistic targets. Another commenter remarked that the resources were excessive given the progress. The last person questioned whether this project would survive if the DOE funding to SNL is cut by X% next year, where "X" is 10, 20, or ??%. This comment applies to this and all projects, not only at SNL, but also at all other national labs.

Optimization of Direct-Injection H2 Combustion Engine Performance, Efficiency, and Emissions: Wallner, Tom (Argonne National Laboratory) – ace009

Reviewer Sample Size

This project had a total of seven reviewers.



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

The first reviewer mentioned that hydrogen use could displace petroleum usage at the cost of electric power (presumably) for hydrogen production. A second person noted that hydrogen could be a replacement for some petroleum pointed out. Another reviewer concurred with that statement and also remarked that understanding efficiency potential of a hydrogen internal combustion engines (ICE) is a useful for comparison to a fuel cell. The fourth commenter observed that this project is targeted at fundamentals and delivering on 45% with hydrogen. Another person said that this was nice work for potential hydrogen applications, but also expressed that major hydrogen use is unlikely, but it is appropriate to be prepared. The final reviewer remarked that this project investigates hydrogen as a fuel to displace petroleum, but noted that the key issue for this project is Hydrogen fueling infrastructure, which is outside the control of this project. However, this person acknowledged that this project will provide data to a hydrogen IC engine if the infrastructure issues ever get resolved.

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 investigator had a very good approach that was systematic and wide in scope, while another mentioned that the work was well focused and very practical. The third commenter stated that this was solid work on a technology that might be useful if hydrogen fuel infrastructure should ever come about. Another person affirmed that the project provides early data to make decisions of pursuing Hydrogen as an IC engine fuel and that it explores the tradeoff between efficiency and NOx emissions. The last reviewer pointed out that the project is concluding, so this review will have less future impact than for continuing projects. This person pointed out that the words "optimization" and "optimized" are used liberally and that "Optimized engine" is a misnomer, even within the limited scope and activities of the project. It was asserted that the injection system is "upgraded" within Westport's capability, but hardly optimized by Bosch/Delphi/Denso standards. This reviewer observed that a few experimental efforts could have been avoided by having a highly competent combustion system expert group carry out these tests in the simulation lab.

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

The first reviewer stated that the investigator produced an excellent set of results using a very comprehensive study with very worthwhile conclusions showing the efficiency benefits of gaseous hydrogen usage. A second commenter noted that all key objectives were met, while another complemented the excellent work on the drive cycle analysis. The fourth person remarked that the good solid results that provide a base of quality data for future analyses and that the technology has been developed enough to form an opinion of capability. Another reviewer felt there was good progress and affirmed that goals for both efficiency and NOx were achieved. After 6+ years of work, the fifth commenter asserted that the project has extended the hydrogen internal combustion engine to DI system and that indirectly, it has established that the hydrogen ICE engine time has not arrived yet. Nevertheless, this person pointed out that the investigator showed the hydrogen ICE is more viable than the hydrogen fuel cell, so this may be a significant accomplishment in this context. The sixth commenter listed the accomplishments by the investigator, which included completed the development of an efficiency-optimized hydrogen combustion system; found that a longer stroke was more efficient; assessed three injector nozzle designs to show that the 5-hole and 13-hole sprays collapsed and injected down along the cylinder axis; completed a full mapping of the engine; reached DOE goals (45%) at peak efficiency and world wide mapping point (WWMP) with very low NOx emissions; and evaluated drive cycle fuel economy and emissions with the Autonomie tool kit.

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

One reviewer expressed that the close collaboration with industrial partners is one reason for the robustness of the results in this project. Another felt there were good collaborations with Ford and others. The third commenter questioned how much of the financial budget weight and the technical input have the international team partners contributed, aside from the nice collegial exchanges. The last reviewer mentioned that the single cylinder metal and optical engines at ANL and SNL, multi-cylinder experiments at the OEM, and support from modeling provide for a sound approach.

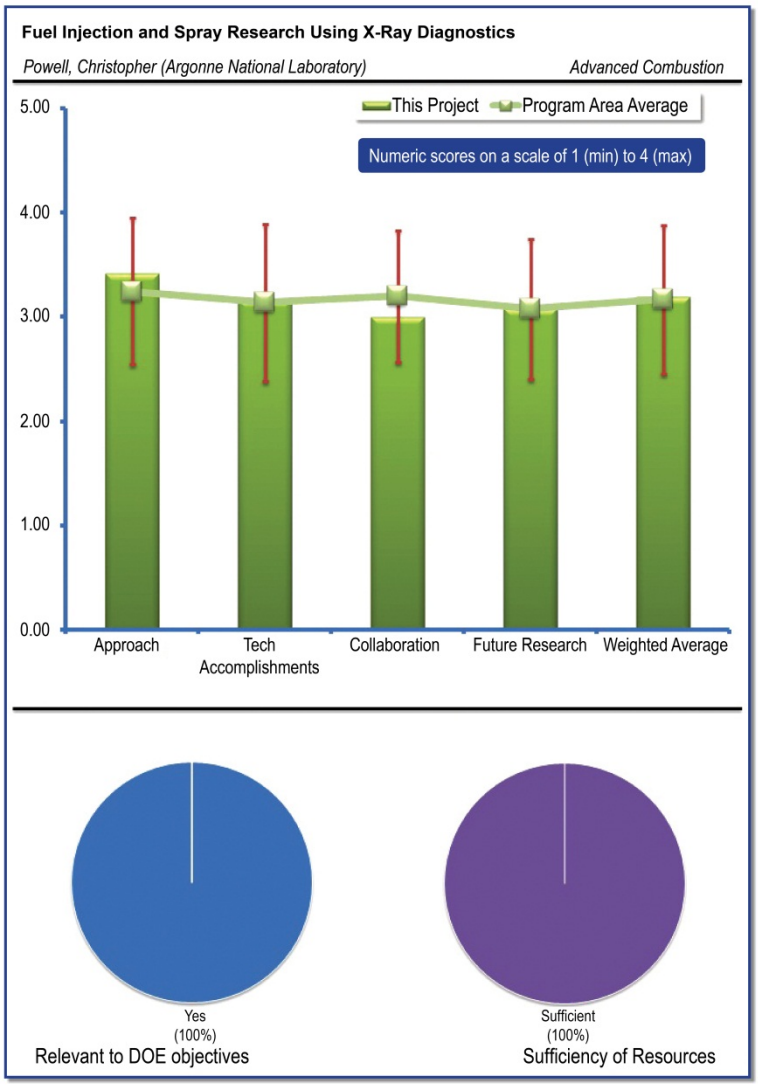
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer acknowledged that this was a good project, but felt it was appropriate to see the project wrapping up given that goals were achieved. A second person concurred that it was an appropriate plan to wrap up this investigation. Another commenter mentioned that one more iteration with an alternate nozzle design is planned as a wrap up of this project, but recommended that the project should be wrapped up following that and not allowed to languish on indefinitely. The fourth reviewer felt that the program could achieve more, possibly commercialization, if pursued. The last commenter suggested spending more time on the documentation and the final report, instead of going on to carry more "optimization." This person recommended that the investigator avoid presenting the findings as globally applicable to DI, hydrogen ICE engines and instead, make it clear that the findings apply only within a limited set of hardware and experimental schemes. A final comment by this reviewer was to include TNO's and other work, which is referenced in the investigator's response to other reviewers of prior years, in the final report.

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

All seven reviewers responded that the resources for the project were sufficient. One reviewer stated that it was good enough to conclude the final year of the program, while another said that it seems sufficient to bring the project to an end.

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



Reviewer Sample Size

This project had a total of 12 reviewers.

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

The first reviewer stated that this project indirectly supports the overall DOE objectives of petroleum displacement by providing a tool to assess spray formation processes, including break-up and mixing phenomena for exploring engine spray formation processes in high efficiency, and DI engines using advanced combustion strategies. Another reviewer came to a similar conclusion, assuming that more fundamental knowledge of fuel spray characteristics will lead to more efficient combustion which would reduce fuel consumption and thus reduce dependence on combustion. The third commenter affirmed that fuel injection is a critical process in any engine system, and a better understanding or ability to simulate fuel injection and spray formation can support improved and advanced combustion. Two other reviewers concurred with this mentioning that this project provides insight in fuel injection behavior and that injection is critical to diesel, gasoline DI, HCCI, RCCI. A sixth person asserted that this was good work in understanding fuel injection with better resolution, while another commenter remarked that this investigation has the potential to provide fundamental understanding of fuel sprays. The final reviewer commented that detailed in-situ studies of injector operation and spray behavior are an important new diagnostic tool.

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 approach is systematic and well thought out. Another stated that X-ray absorption sounds like a good approach to study multiple injection events which is difficult for other approaches. Two other reviewers concurred, mentioning that this is a unique tool for close in analysis and that the technique shows good promise. The fourth commenter noted that the investigator makes use of unique diagnostic capability with X-rays and that it would be interesting to see several types of injector designs (solenoid, indirect Piezo, direct Piezo) to quantify injection near opening and closing events. Another reviewer pointed out that the high energy X-ray system at ANL is a useful tool, but past work on this subject required a very high level of dopant, making some of the physical characteristics of the fuel somewhat unrealistic. Nonetheless, this person acknowledged that this program at ANL has provided some valuable information on the behavior of injectors. The sixth commenter remarked that with X-ray diagnostics of fuel sprays, the X-rays scatter far less than visible light with some being absorbed, but the investigator should get a good quantitative idea of where the fuel is located in the spray. This person believes the approach should aim to provide specific information of interest to modelers of sprays and that in this next year, by providing spray and needle motion data to the Engine Combustion Network, this goal should be realized. However, this reviewer asserted that a closer tie should be established with the spray and engine modeling work at the University of Wisconsin. The seventh commenter stated that having a dedicated X-ray beam lab allows more focused studying of

fuel property effects on sprays, and another person recognized that this project has unique capabilities unavailable elsewhere. The last reviewer observed that the years of DOE investing are starting to pay-off with this project and yield interesting information concerning near field spray formation processes. This person noted that the investigator has upgraded the chamber for 100°C operating temperature; however, this is still too low for many diesel-like operating conditions and possibly more focus should be on gasoline DI where combustion chamber mean temperature during injection is much lower than diesel engines.

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

The first reviewer felt the investigator was making good, steady progress in an interesting field. Another commenter noted that being able to study pure fuels and multiple spray events are major accomplishments. A third reviewer pointed out the nice alignment of x-ray diagnostic with low cetane test plan. The fourth reviewer said that the researcher presented some interesting and useful results, but that it would be useful to extend the view to evaluate greater distance from nozzle. Another person remarked on the nice data so far, but questioned how it connects in detail to the modelers. The sixth commenter said that the X-ray movies of injector pintle are interesting; however, the investigator needs to show correlation to a combustion metric to make it more valuable. A seventh person expressed that it was nice to see dedicated lab and expected to see more volume of results in coming years with more collaborations. The eighth reviewer also mentioned that now the VT beamline has dedicated lab space which will expand experimental capacity and the resolution and need for dopants has been eliminated, which are major enhancements to this approach that eliminate weaknesses and concerns raised in past reviews. This reviewer also commented on the expanded consideration of spray phenomena to include multiple injections, as well as supporting other DOE projects at ANL, through extensive studies of low cetane fuel combustion, and at SNL-L, through the Engine Combustion Network. Still, this reviewer pointed out that the investigator cannot perform evaporating studies on conventional fuels and is limited to 100C. The ninth reviewer stated that given the limitations on the spray chamber boundary conditions, the generated data have been informative for near injector hole break-up studies at very low temperatures. However, this person pointed out that much work still lies ahead of the researcher to truly investigate real world sprays, though as noted above, the most applicable application is gasoline DI where bulk cylinder temperatures are moderate in comparison to diesel engines. A tenth commenter felt there was slow progress, since many spray phenomena and characteristics could be studied, but were not. It was acknowledged that perhaps the limited beam-time has been the issue as it was in the past. Now with dedicated lab between Basic Sciences and VT, this person was hoping to see more time for experiments, which should spawn more collaborations. This commenter also remarked that the upgraded optics for finer resolution was sorely needed which will hopefully provide more near-injector data for spray atomization models, and that the higher x-ray flux should permit study of pure fuels without additive. This tenth reviewer observed that multiple injection events were imaged, but there was no effect on penetration of second spray or spray angle of second spray. It was questioned whether this could be because the downstream distance investigated was terminated at 12-mm. This person pointed out that typical distances in engine combustion chambers is larger than this distance and that larger downstream distance should be investigated. This researcher concluded by commenting on the contributing to ECN of needle motion. The eleventh reviewer recommended ensuring the validity of the measurements and, more importantly, its reduction to quantitative values which needs to be through independent means or measurements. This person acknowledged that this may be a challenging task, as new discoveries may have to be pursued; however, fuel injection equipment (FIE) companies, especially Bosch (Germany and Austria) have the know-how to help out. It was pointed out that because this would be exposing their "treasure chest", ANL must ensure strict confidentiality and security of information gained, so that the FIE company may open up. This commenter also stated that the "Excellent reproducibility" is good, but wanted to know what exactly the investigator was measuring, and if it is qualitative distribution or indeed quantitative measurement (Example: What EXACTLY are the "parcels?"). Additional thoughts from this person included use a statistically valid experiment, instead of running arbitrary sweeps and individual test points; do not use injector current as an indication of actual fuel injection event reference (quantity and timing). Hopefully, your Bosch and /or Delphi collaborators should be able to explain this to you, and provide further information regarding for example hydraulic and inertia lags, electric and physical damping, etc. Errors can be quite significant and has led to costly mistakes in the R&D arena! Continued this reviewer, two "identical" injectors, fed by the same injector current, will yield two different fuel injection events into the combustion space. The variability may not be too significant for commercial use, and is in fact dealt with through calibration techniques and injection system controls. On the other hand, such variability could be significant for the ANL R&D efforts, and could mask the discovery of important findings when you are using such sophisticated methodologies. This reviewer also referenced Slide 12: the 3-hole injector will not

give similar results as a 7-hole injector, unless other parameters are rationally adjusted. The simple change in the exit flow area (restriction) changes the nature of fluid flow, under both static and dynamic conditions. Perhaps a starting point is to use dimensionless numbers of fluid and heat transfer flow (Reynolds, Prandtl, Nusselt, etc.) as an initial boundary condition, then change quickly to turbulent and cavitating flow assimilation? This will give results that are directionally more representative of the General Motors 1.9L engine and other experimental lab systems.

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

The first reviewer felt that the good OEM interaction should lead to important results for fundamental injector design. The second commenter mentioned the links to General Motors through engines, the Sandia Engine Combustion Network and other researchers at ANL, while another also pointed out the support of the ECN. The fourth reviewer remarked that the primary collaboration seems to be via the Engine Combustion Network where members use similar injectors and common injection conditions, and with colleagues at ANL. This person noted that it sounded like collaborations with industry are to be initiated. The fifth commenter affirmed the excellent payback on collaboration with the SNL team and pointed out that ANL and SNL should chart up a more cohesive, 2-part team, with full/complete feedback loops. This person also suggested adding the Combustion MOU group of SNL as a formal partner and not over-spending or getting over involved in the ECN activities. Another reviewer stated that this project has outstanding collaboration with the investigator participating as an SNL engine combustion network partner while working with three fuel injector suppliers. The seventh commenter acknowledged the solid interaction with several suppliers, but others did not seem to be represented, perhaps because they were not as obvious. The last reviewer felt that collaborations could be significantly improved. This person asserted that the recent connections with the ECN and the University of Wisconsin are a step in the right direction and that these connections should be exercised diligently.

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?

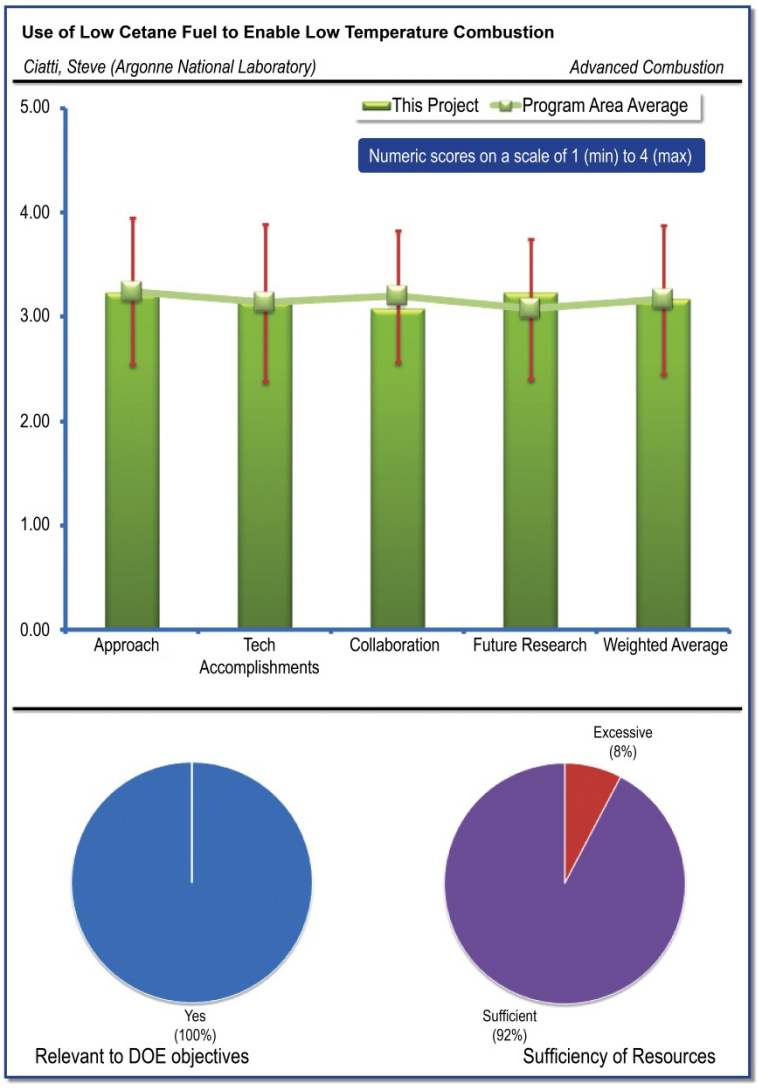
The first reviewer remarked that the valuable work should continue and another mentioned that the proposed plan seems reasonable. The third commenter said that it was a nice broad plan for work on 1.9L, Delphi, Westport, etc., while another reviewer commented that the cavitation study should prove very interesting. The fifth reviewer pointed out that improved beam characteristics should only improve the results of the spray and mechanical operation of the injectors and that there should be greater interaction with spray modelers now that the experimental results have reached this level of sophistication. Another person noted that spray penetration, wall wetting, and piston wetting are very important for gasoline DI smoke/PM mitigation when combustion chamber temperatures are cold (perhaps during the first 200-300 seconds of the FTP cycle on a light-duty vehicle), and that it would be good to consider research in this area. The seventh commenter felt the investigator should not just duplicate what have been done before with Bosch on the Delphi HW and should instead explore new issues and new frontiers. This person's advice was to discourage "general users" applications, at least for few years down the road, so that the high value tasks relevant to the OVT charter can be addressed, which include diesel and gasoline-related injection and combustion issues. Another reviewer stated that in looking to continue the General Motors engine measurements, the researcher should consider cavitation phenomena and develop collaborations with Delphi, Chrysler, and Westport. This person felt that it would be very helpful to expand the cell capabilities to study evaporating sprays with practical fuels. The ninth commenter asserted that it would be good to see more gasoline work in the future. A different reviewer concurred with this, recommending that the investigator focus more on gasoline or gaseous fuels due the chamber temperature limitation of 100ºC, since this type of limit makes it very difficult to properly simulate realistic diesel bulk temperatures during the injection event. The final reviewer said the future steps as outlined in this report are all good and that hopefully a large portion of them can be completed at the next report period.

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

All twelve reviewers responded that the resources for the project are sufficient. Additional comments from reviewers stated that the budget seems sufficient or that there was no evidence that it is not sufficient. Another person remarked that the resources were at least sufficient, noting that the dollar value seems large but is perhaps justified by work volume. Not sure about funding, a fourth reviewer expressed that the funding level is quite high in comparison to other projects though only six weeks out of year are spent performing

experiments. This person mentioned that possibly renting space at (Advanced Photon Source) APS is expensive, which was also asserted by a different commenter that assumed access constraints to APS remain. The sixth reviewer observed that the funding has been stable, which has permitted significant improvements of the facility and thereby the approach. The last commenter suggested establishing a "productivity measure" that would be a (robust) metric on the use of the new dedicated facility, including both time-on and output in terms of data analysis and conclusions. This person asserted that the investigator should not add new technical staff and manpower, and instead do more with the current expert staff and support personnel. This reviewer questioned whether the new DOE APS upgrade (ca. 2015) will put the facility out of commission, and if so, how long would the estimated time off be. This person concluded by pointing out that if this time off will be few weeks or months, it might be better or wiser to hold off on this "upgrade" until some useful utilization and more harvesting of results from the latest upgrade and the current beamline is garnered?

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



Reviewer Sample Size

This project had a total of 13 reviewers.

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

One reviewer noted that the project's goal of improving engine efficiency via advanced combustion, if successful, would improve fuel economy and reduce fuel consumption, reducing amount of petroleum needed. Another person stated that the project represents a potentially attractive commercial pathway for achieving reduction in fuel consumption. The third commenter pointed out that avoiding soot and NOx emissions through the control of fuel stratification to enable high efficiency combustion can reduce the efficiency burden from very low engine emissions, thereby providing a path to clean combustion technology with a lower fuel economy penalty. Another reviewer remarked that the use of gasoline (as opposed to diesel) in high efficiency engine operations will reduce overall petroleum usage. The fifth reviewer affirmed that this is a very good experimental project studying the possibility of operating a high efficiency, compression ignition engine on gasoline. This person noted that much work is still ahead of the PI, but acknowledged that the initial results are promising. Another commenter felt that this is very useful work to extract higher efficiency using alternatives to gasoline. The seventh commenter said that the investigator aims to further improve thermal efficiency with diesel architectures using gasoline-like fuels, while another person mentioned that this project is the evaluation of gasoline-based LTC strategies. The last reviewer observed that the researcher is investigating advanced high efficiency LTC combustion by using gasoline in a diesel engine.

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 this was a good systematic approach to a worthwhile project. Another concurred that the approach seems reasonable and is similar to others using gasoline-type fuels in CI engines. The third commenter felt that studying the impact of low cetane fuel properties to enhance and extend LTC is a well-focused research project. A different person affirmed that the investigator was doing excellent work with sound results and that it is very useful to see DOE's approach to testing. The fifth reviewer commented that the approach is very well structured for achieving the targets laid out; however, it is somewhat unclear what the emissions goals are for this project. This person observed that the engine-out emissions seem to float around non-specific targets and that perhaps this can be better defined. This reviewer would also like to see PM measurements included as part of this study. A different commenter remarked that the approach was reasonable, but more thought is needed for low load and cold start conditions. The seventh reviewer pointed out that the researcher was combining in-cylinder visualization with advanced combustion studies in a sophisticated production engine system (a light duty diesel engine operating on gasoline). This person noted that the investigator was combining

modeling with partners, as well as performing spray imaging at ANL-APS and engine studies to understand the phenomena occurring with different fuels and injection strategies. It was also observed that the project is using a low cetane/high volatility fuel (low cetane gasoline with lubricity additive), and using injection parameters to study combustion phasing. The eighth commenter suggested to avoid soot and NOx by early injection, before start of combustion. A different reviewer felt that the project slightly improved over prior reporting period and used statistical design of experiments in part of the testing. The researchers involved in this work are urged by this person to compare their approach to that of ACE019's (Assanis, et al.) as an example. This is not to see if there is a duplication of efforts, but to devise a similar systematic R&D approach in order to uncover the underlying phenomena and apply them to real life. This reviewer pointed out that there are other programs that are presented at the Annual Merit Review, which include total, multi-cylinder engine hardware, and this program will benefit from studying the pros and cons of these. The tenth commenter urged the investigator to consider plotting experimental results in a traditional "response plot" fashion versus the control factors to clearly show the effects. This person mentioned that the inability to run low loads is problematic and that it is unlikely that gasoline below 91 research octane number (RON) is going to be readily available. Another reviewer remarked that the general approach has been good as an initial investigation, though it would have been highly beneficial to have taken PM exhaust measurements. The modeling work and eventual experimental work at the University of Wisconsin should be very insightful during the next years. Lastly, this person felt that the investigator's approach of further studying EGR rate and injection timing changes on the chosen load points will be very helpful. The final commenter stated that low Cetane fuels (like gasoline) provide longer ignition delay, which promotes more mixing and lower soot and injection ends before combustion. The investigator should maintain partial stratification of fuel air and EGR. This person observed that the project has migrated from a controls focused project to one that seeks to develop base combustion strategies. In Slide 5, the statement saying this project is different from other LTC projects because it uses little to no EGR does not make sense. This reviewer pointed out that in most of the data presented in this report, the gasoline LTC cases use more EGR than the base conventional diesel case, therefore, it was questioned as to what significance is the fact that no EGR is used for the 2 bar case.

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

Many reviewers noted that the investigator was making good progress and included remarks such as: good progress with useful results, good work as far as it goes, and very good progress on an interesting approach to using gasoline fuels rather than conventional diesel fuels. Another commenter agreed that it seems like good progress and good results at intermediate to high speeds and low, but pointed out that the challenge is at low speed, low load. A different reviewer said that there was good progress, but it was not clear from the presentation what the potential efficiency improvements are. One reviewer expressed that it was a nice presentation of alternative injection strategies. Another reviewer pointed out that the initial experimental portion of this project has been very insightful in assessing the capability of operating a high compression ratio engine on gasoline. This commenter mentioned that the investigator showed good work developing injection strategies that enable pretty good initial operation on gasoline, although there is much work is ahead for the researcher. A different reviewer affirmed that the accomplishments are good from a fuel consumption standpoint, but the emissions targets need to be more of a constraining factor. This person felt that adding the collaboration with modeling groups at the University of Wisconsin is very positive, as is broader collaboration with other groups at ANL and SNL. One commenter listed the project’s technical achievements, which included demonstrating low NOx and output as high as 16 bar brake mean effective pressure (BMEP) and >30% brake thermal efficiency (BTE), able to vary injection timing, boost and EGR levels with current setup, demonstrated significant capability to operate under the gasoline LTC operation and working toward maintaining diesel brake specific fuel consumption (BSFC) but low engine out NOx, while keeping CO and HC penalty as low as possible.

Another reviewer asked about the logic behind the selected values of injection strategies of Slide 10, since it is very hard to establish phenomenological conclusions from this work. This person also questioned what the fundamentals are (physics, thermodynamics, combustion, kinetics, etc.) that guide the approach, design of the tests, parameters and their values, etc. It was remarked that it is not enough to simply state "by fluid mechanics", because no state-of-the-art fluid mechanics knowledge or tools are sufficient enough to simply guide in the set-up of the prescribed tests. This reviewer pointed out that a much simpler approach might have been adopted, and in such case the fidelity with real-life system may not exist. It was acknowledged that using a statistically designed experiment is encouraging; however, further quantitative trends and conclusions from post-processing the data shown in Slide 28 are absent. This person concluded by asking if the analysis was aborted prematurely, or if it was just not reported at the Annual Merit Review. The final commenter suggested that key parameters like BSFC should be presented in tabular format so that precise differences between

baselines and gasoline LTC combustion can be properly made. It seems from Slide 8 that there has been an increase in BSFC going from conventional diesel to gasoline LTC. This person stated that if this increase in equal to or greater that the fuel penalty for NOx aftertreatment in a conventional diesel, then there would be no profit in gasoline LTC. Smoke and/or particulates are a critical variable in any combustion mode and should be measured on this project in order to get a complete picture of the value of gasoline LTC. It was observed that at the 1,500 revolutions per minute (RPM) 2 bar point there is a significant increase in HC and CO emissions for gasoline LTC, and the reviewer wanted to know what the plan is to investigate other strategies to lower HC emissions at this point. A measure of knock or ringing index should be included in all the experimental work so that these constraints are not being violated. This person also criticized that on the summary Slide 8, a vague statement is made that greater than 30% BTE is achieved at most operating points, but in the body of the report not a single plot or table of BTE is presented to substantiate this claim. This reviewer concluded by stating that either BSFC or BTE should be used consistently and in light of others reporting BTE's in the high 30%'s, it was questions as to what this project is investigating to achieve higher BTE's.

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

The first reviewer felt that there was good interaction with industrial partners and cross-industry groups. Another listed the close collaboration with General Motors and with the University of Wisconsin, while British Petroleum is supplying fuels. This reviewer mentioned that the University of Wisconsin Engine Research Center is simulating some of the experimental studies from this program and the comparisons looks quite good. A third commenter acknowledged the excellent collaboration between the investigator, General Motors, and the University of Wisconsin Engine Research Center. This person observed that General Motors is actively engaged in this project and the University of Wisconsin is and will be providing additional analytical and experimental support of this effort. A different reviewer noted the increased dialog with Sandia. The fifth reviewer stated that the industry coordination is appropriate for a project of this nature, although perhaps the input of a heavy duty engine manufacturer would be useful. This person went on to point out that linking this work with modeling and more fundamental combustion studies is important to the success. Other reviewers were less supportive of the collaborations, with one remarking that the partners are somewhat limited to one OEM and one energy company plus the University Wisconsin. This was reiterated by another that asserted there was good collaboration, but with a somewhat limited range of partners. The eighth commenter gave the suggestion to improve the core competency and the quality of contributions of the collaborators. The last reviewer felt that this project seems to be conducted in somewhat of a vacuum and that a more specific tie should be sought with the modeling work at University of Wisconsin. This person expressed that the investigation should try and relate this work to John Dec's work on partial fuel stratification, which also uses gasoline, but uses alternate methods to achieve ignition of low-cetane fuels.

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?

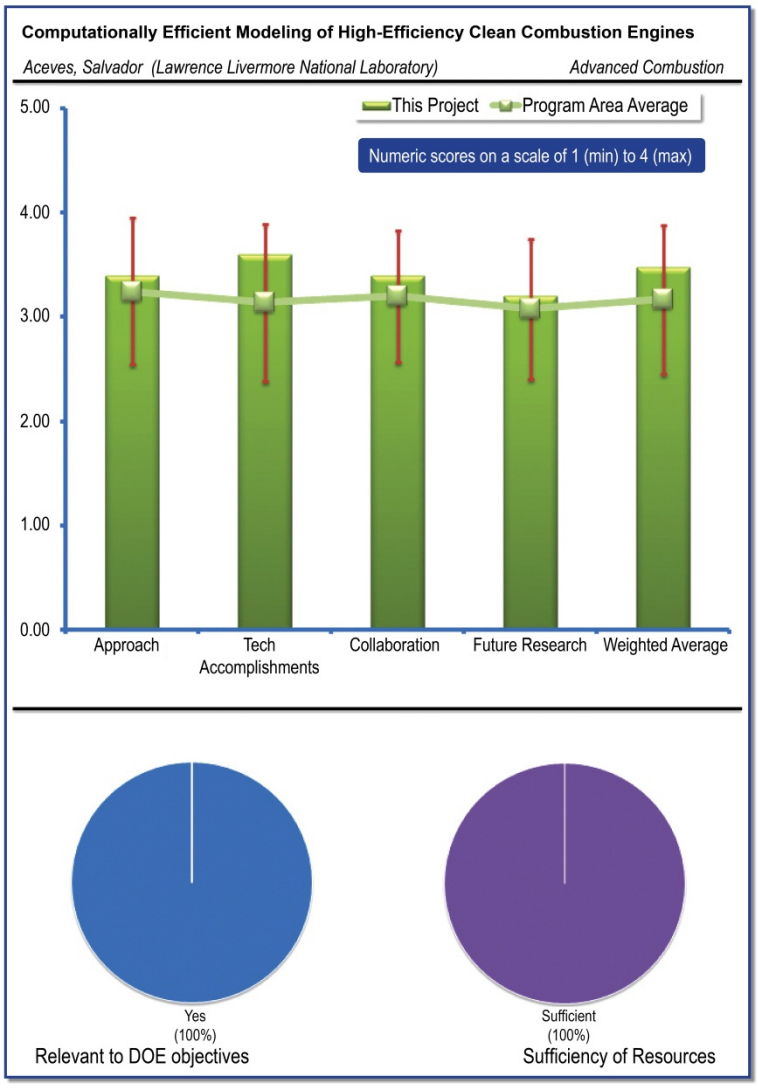
One reviewer stated that the plans seem reasonable and build on results to date. Another reviewer felt there was good use of experimental design and a systematic approach to an interesting area of research. A different commenter said the plans look good, but advised the investigator to consider higher injection pressure as well. The only suggestion by the fourth reviewer is to add PM/smoke as an additional measurement. Another reviewer remarked that the test plan is mapped out well; however, the ultimate success of this depends also on how the challenges of achieving idle, low load and transient operation are addressed. This person also asserted that some attention must be given to cold starting with this approach. The sixth commenter reiterated the investigator's proposed work, which includes: expanding the database of experiments, operate with fuels for advanced combustion engines, perform in-cylinder measurements, and continue APS x-ray imaging of spray. This person suggested that the researcher should emphasize PM and particle sizing measurements to see what amount and type of particles may be emitted by this combustion process, and also speciate the HC emissions to see what type of HC's are being emitted. Another reviewer felt that the investigator should focus on meeting remainder of experimental metric (CR, Injectors, Strategies, EGR etc.), and also mentioned that smoke/soot measurements would be valuable. The eighth commenter questioned why the researcher was going back to a parametric sweep, after having tried the statistical DOE approach. A different person commented that much more effort is needed to understand how the investigator addresses the full range of operation. This person pointed out that light loads have to be run, and questioned how that would be done. It was also asked whether a dual fuel RCCI approach needed. This reviewer mentioned that most emission comes from cold start for LD vehicles, so the

investigator wanted to know how the project will do the start and runs. The last reviewer also picked up on this point, asking how the investigator planned to address idle and cold start, given the ignition / combustion difficulties at light loads. This person said that if there is no clear plan for this, then the project would be more relevant if even lower cetane fuel was used (i.e. 91 RON) and an electrical ignition source was added.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Twelve of the thirteen reviewers for this project responded that the resources for this project were sufficient. One explained that stable funding is keeping progress on this program quite robust and that future funding should be kept at this level to maintain progress. Another commented that the resources are sufficient to achieve the future milestones. A different reviewer stated that there was no evidence that resources are not sufficient. A reviewer also asserted that the project appears adequately funded to support the investigator and the University of Wisconsin. One of these reviewers remarked that the resources might be excessive unless solutions are proposed for light load and cold starting. This person mentioned that otherwise, the researcher may have perhaps not proven that this concept will work in real systems. The one differing opinion regarding the level of resources for the project came from the thirteenth reviewer, who stated the funding was excessive.

Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines: Aceves, Salvador (Lawrence Livermore National Laboratory) –ace012



Reviewer Sample Size

This project had a total of ten reviewers.

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

The first reviewer pointed out that high efficiency clean combustion engines can be enabled by predictive simulation, and therefore this work is directly responsive to the objective of lowering fuel use and displacing petroleum. This person also mentioned that this work is directly responsive to the grand challenge from the Basic Research Needs Workshop on 21st century transportation fuels. Another commenter remarked that the development of tractable combustion models should enable optimization and/or design of engines with higher fuel efficiency, which should reduce fuel/petroleum requirements. The third reviewer asserted that simulation of high efficiency engine combustion is a potentially important tool for the engine design community. A different person concurred with this statement by also noting the improved simulation tools for high efficiency engines. The fifth commenter mentioned that this directly supports future simulation capabilities and leverages a U.S. competitive advantage in supercomputing. Another person said that bringing simulation tools to a usable state within industry is quite relevant and needed. The last reviewer summarized that the project addresses mixing and combustion processes for various advanced LTC and high efficiency clean combustion concepts.

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?

Some reviewers were positive about the approach, stating that the project well defined and that there was great basic scientific contribution. Others, however, disagreed with one reviewer remarking that the approach remains piecemeal and not necessarily well-motivated, while another mentioned that it was unclear what the path to implementation for industry was for all this. This reviewer did acknowledge that there was some mention of work with convergent Science, which is good. One reviewer pointed out that the investigator should consider high fidelity combustion kinetics and fluid dynamics to achieve predictive capability. This person pointed out that this requires reduction of the computational expensive of simulating complex combustion phenomena involved in high efficiency clean combustion regimes. The last reviewer commented on the project, noting that it models chemical kinetics and fluid mechanics of combustion processes in engines with a focus on being computationally effective. This reviewer also stated that the investigator is applying the numerical tools to high efficiency clean combustion and reducing computational expense to make them accessible to engineering workstations.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer felt there was amazing progress and that it is encouraging to see these improvements rapidly moving toward customer usability. The second commenter mentioned four major areas of advances by the investigator which included numerics, computing architecture, improving sub-models in KIVA platform for large-scale CFD, and detailed comparison with experiments. This person observed that the researcher was looking for 1000-fold speed improvements by numerics and the use of graphic processing units for simplified and faster parallel computations by tailoring the algorithms to use these fast and inexpensive processors. Another reviewer also commented on those accomplishments by listing the improved the numerical stability and improved computation architectures that can now get 1000X speedup. A different reviewer concurred that progress on reducing computing time seems very good. The fifth commenter remarked that the 11x improvement sounds good and pointed out that the investigator mentioned it is possible to do better, but did not explain how. Another expressed that it was an important approach, but that the accomplishments are not necessarily well-linked to the stated program goals. The seventh person suggested that it would be beneficial for the reviewers if the investigator showed a few simple case studies, along with any improvement over time with validation. The last commenter criticized that the researcher was not clear how results will be disseminated.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer felt that there was good coordination with industry and other academic institutions, which was reiterated by another person who observed that there was extensive collaboration with industry, labs and universities. A third commenter also mentioned that the collaboration is quite extensive with several National labs and universities. A different person remarked that is was good to see linkage to private industry, as way to quickly deploy the results to industry. The sixth reviewer criticized the coordination with industry, noting that collaborations mostly seem to be with national labs and universities. This person pointed out that the primary industry collaboration listed was through the Advanced Engine Combustion MOU, and it was not clear if sufficient "collaboration" comes through the 2 presentations per year at this forum. The seventh commenter asserted that the investigator should converge licensing and interactions. The last reviewer expressed that many groups are depending on this work.

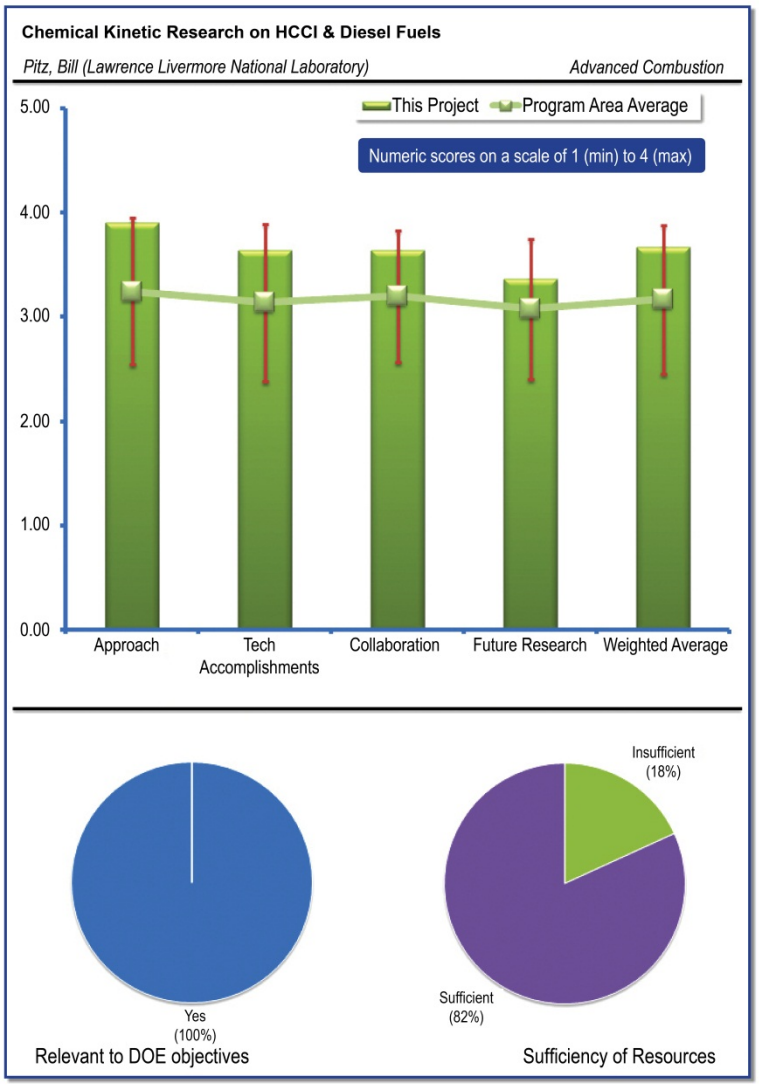
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer stated that there was a good outlook for this project if it can truly deliver on its stated goals of bringing engine simulation to the desktop environment. Another person also mentioned the project's intent to achieve large scale parallel computation on a desktop computing platform and felt that this is a laudable goal which may enable broader implementation of computational design of advanced engines. The third commenter acknowledged that the continued narrow focus on numerics and computation speed efforts are appropriate. A different reviewer noted that the proposed plans seem reasonable, while another said to keep up the good work. The last person remarked that it was unclear what the future plan of these codes for graphic processing units is. It was not clear to this reviewer whether they work on future computer hardware, or if any of the software people are planning to pick this up and produce codes for industry.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All ten reviewers responded that the resources for this project are sufficient. One went on to mention that the effort seems to be suitable. Another commenter pointed out that this project's stable funding is key to maintaining progress over the long term and suggested to maintain this funding level to ensure continued progress.

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



Reviewer Sample Size

This project had a total of 11 reviewers.

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

One person summarized the general consensus of the reviewers by stating that this project indirectly supports the overall DOE objectives of petroleum displacement. This person explained that this is a very fundamental fuel chemistry project that is critical toward the continual development and refinement of kinetics models that are important for the simulation and assessment of advanced combustion modes in compression ignition engine. An additional comment from another commenter was that the reduced mechanism chemistries and reaction kinetics parameters are an important requirement for the fundamental modeling of high efficiency engines. A different reviewer stated that understanding the chemical kinetics of combustion is even more important in advanced combustion and for unconventional fuels to achieve truly predictive simulation capabilities. The fourth person asserted that the development of fundamental kinetic models should help improve engine optimization and design and thus fuel efficiency. Another commenter mentioned that this project provides an understanding of chemical kinetics in the combustion processes, which are key to understanding advanced LTC and highly dilute combustion concepts. A different reviewer pointed out that kinetic combustion models are needed to fully model combustion, while appropriate models are also needed to simulate complex fuels. The seventh commenter remarked that this was solid work leading the world in fuel chemistry and is fundamentally needed for many modeling purposes. Another person affirmed that this is important work for chemical reaction models, while others reiterated that chemical kinetic models for combustion and emissions are very important and required.

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 approach of mechanism development has proven to be very effective to support simulation, because the kinetic models are continually being updated and validated. This person pointed out that the network of connections to the fundamental and applied combustion communities provides a technically rigorous and rapidly responding basis for mechanism development. Another commenter felt that this was an excellent approach to modeling, reducing models, and comparison to experimental results, and a third concurred that this was great work. The fourth person remarked that the approach has been logical throughout the years, explaining that the investigator has developed the basic building blocks for continually refining ignition chemistry in CI engines through careful additional of chosen specie classes that are deemed important in the various ignition stage processes. A different reviewer asserted that the focus on filling gaps in kinetic data/models that exist from key components in real fuels, such as methylalkanes and larger (C8) aromatics, is very relevant as well as validation against existing experimental data.

Another complimented the investigator on using several different types of machines to get the data needed to confirm the chemical kinetics models. The seventh reviewer mentioned that the approach is systematic and well-thought out, although the choice of iso-alkanes as the "next" functional group to study is not well explained. Another person was also critical on the investigator's priorities of fuels and requested more detail of reasons behind path chosen for research. This person questioned whether there were voids in the fuels database and suggested that the investigator determine which ones matter and why. The last reviewer summarized the approach mentioning that the investigator develops models of chemical kinetics of gasoline, diesel and advanced HCCI fuels, determines reduced models for efficient combustive flow simulation (CFS) models, uses the models to simulate advanced combustion concepts, and develops surrogates for gasoline.

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

One reviewer noted that there were several significant accomplishments, particularly in modeling chemical reactions, that have been made this year and that the extent of progress is commendable. Another person concurred that the progress seems good. The third commenter mentioned that significant results were reported with substantial improvement in model efficiency. Another reviewer felt that there was good progress in reducing the computational burden of first-principles combustion modeling. A reviewer asserted that the investigator has made really good progress toward more realistic fuel models. The sixth commenter acknowledged that the developments of this project are very valuable for achieving the goal of predictive simulation of engine combustion for current and future fuels. Specifically, this person pointed out that the investigator added mechanisms for methyl alkanes and substituted aromatics, and developed a new methodology for matching gasoline surrogate properties to real fuels through the negative temperature coefficient (NTC) behavior. The researcher also developed a new method for mechanism reduction based on functional groups in the molecules being simulated. This person concluded that the experimental comparisons of the new mechanisms look good for ignition behavior and for flame speeds in most cases. The seventh reviewer remarked that the posting of mechanisms on website useful and recognized the accomplishment of validating 2-methyl alkane mechanism. The last commenter said that each year this project continues to develop mechanisms that allow experimentalists to evaluate against their appropriate experiments and help the community decide which mechanisms are best. This person added that this is an evolving project and can really use additional experimental support for test/evaluation/validation of proposed new mechanisms.

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

Reviewers generally saw strong collaboration. The first reviewer acknowledged that the investigator has established a wide range of collaborations resulting in a good leveraging of effort to obtain new and extended results. Another person pointed out the collaboration with many groups through application of the models to prediction of experimental results and for validation and improvement of the kinetic mechanisms. This person also noted that the investigator participates in the DOE and industry supported working groups. The third commenter remarked that the experimental efforts with the University of California at San Diego and others are beneficial. A different reviewer asserted that there seems to be good collaboration and exchange of information with Sandia and some universities. This person observed that direct collaboration with industry seems to mainly consist of participation in some Coordinating Research Council activities such as Advanced Vehicle/Fuel/Lubricants Committee (AVFL-18) and any input obtained during presentations at semi-annual Advanced Engine Combustion MOU HCCI meetings. The fifth commenter felt that there is strong collaboration with SNL, Universities, and the combustion network in reducing and experimentally evaluating portions of the various developed kinetic mechanisms. Another person listed the researcher's coordination efforts that included MOU group of collaborators, John Dec at Sandia, various university collaborations, and the Fuels for Advanced Combustion Engines Group. The last reviewer noted that this work is used by most serious researchers in the field.

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?

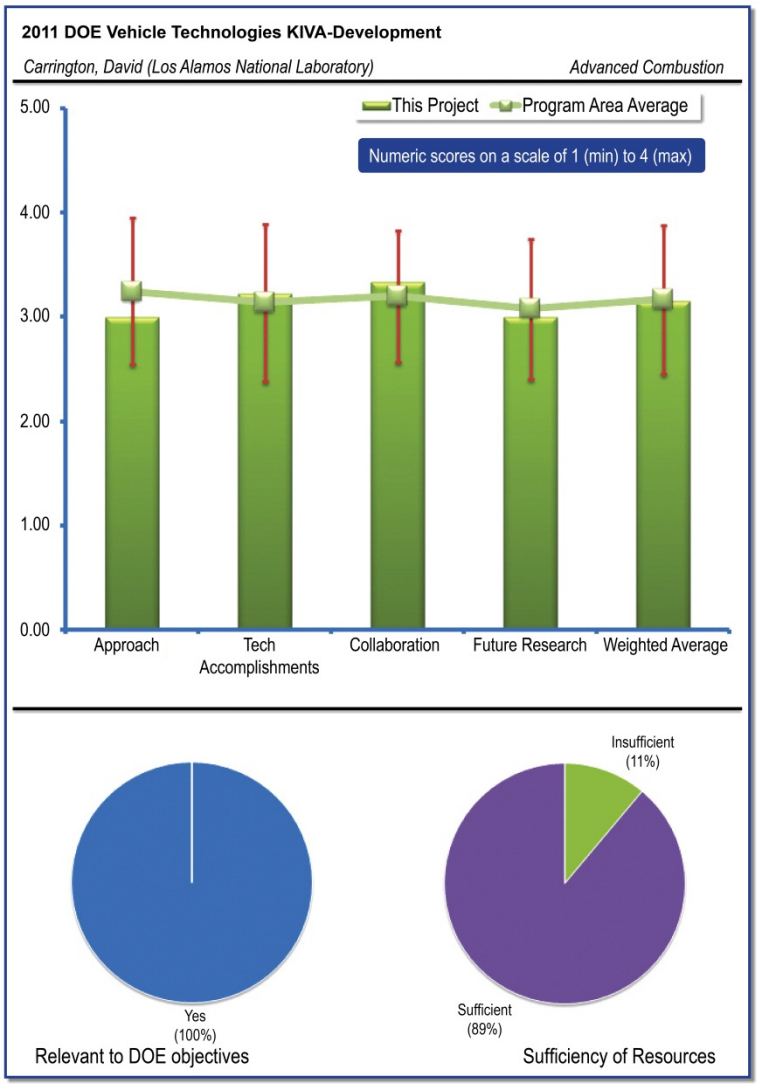
Listing the researcher's proposed work to perform validations on additional alkane structures, improve gasoline surrogates, and continue the functional group - mechanism reduction effort, the first reviewer felt that these efforts will continue to advance the ability to achieve predictive simulation of engine combustion. Another commenter concurred that the plans to validate mechanisms for the 2-

and 3-methyl alkanes and development of an improved gasoline surrogate are very worthwhile and build on accomplishments already made. A third person encouraged the investigator to continue the good progress. A recommendation from a different reviewer is to find partners to increase the current experimental efforts that further refine the proposed mechanisms. This person acknowledged that this is a challenge, but notes that it is a critical building block for engine developers. The fifth commenter would like a clearer picture of what is all in diesel fuel and gasoline relative to the fuels the investigator is doing reactions for and requested to know whether the project is 50% done, 10% done, etc. The last reviewer criticized that the motivation for next functional group to study is lacking.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers responded that the resources for the project were insufficient. One of these reviewers remarked that this work seems to yield a lot of knowledge for the small amount spent on it suggested to spend more to learn more faster. The other reviewer stated that this project needs additional experimental support to accelerate refinement of the proposed mechanisms such that engine developers will see a bigger benefit sooner versus later. Nine reviewers felt that the resources for the project were sufficient. One reviewer added that the funding seems to be about right. Another person requested to know from the investigator how more funding would be used, while at the same time asked what could be cut with less funding. A different commenter acknowledged that this was great work and questioned whether the scope or rate of progress be significantly increased if the budget were increased. Another reviewer pointed out that funding has been stable and increased slightly in 2011. This person felt that this is very good news given how important this work is to the entire engine/combustion community and also asserted that this program is a good candidate for additional funds because the impact is so great.

2011 DOE Vehicle Technologies KIVA-Development: Carrington, David (Los Alamos National Laboratory) – ace014



Reviewer Sample Size

This project had a total of nine reviewers.

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

The first reviewer stated that KIVA is a powerful tool for simulation of diesel combustion and contributes to diesel engine development. Responding directly to this question, which others only alluded to in their answers, this reviewer pointed out that higher efficiency engines can lead to petroleum displacement and that this tool can also shorten the design cycle. Another concurred, mentioning that KIVA is a powerful tool for engine simulation with upgrades and validation being helpful for improved predictive capability. A different commenter affirmed that KIVA is a needed tool and should be supported. This reviewer said that although it may not be widely used at the OEM level, KIVA is "required" at the university level as a way to empower students and professors to push the state of the art and improve the code. The fourth reviewer noted that the investigator seeks to improve understanding of combustion processes by modeling the spray, fuel-air mixing, fluid mechanics and chemical processes in the combustion process. This person went on to assert that the KIVA code is fairly widely used in the combustion community and applied to present and future combustion concepts. Another commenter expressed that KIVA has become the de-facto engine simulation code for CFD and chemical kinetics but it still requires significant effort to produce useful results for engine design. The sixth person pointed out that improved, faster, and easier to use combustion CFD methods are important to create better engine designs. The last reviewer appeared to reiterate the general opinion of the group by stating that KIVA is THE tool for engine simulations.

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 approach seemed to be a bit ad-hoc or scattershot, although perhaps it is just not well-motivated. Another mentioned that it was difficult to assess/see the results and impact, so this person suggested that the investigator provide more examples. A different commenter stated that the researcher needs to incorporate engine related validation of model accuracy. Another reviewer recommended researching new numerical and grid methods and new algorithms for flexibility, adaptability, and stability. The last commenter noted that the investigator is building from the current KIVA platform by improving algorithms, adding capacity to simulate cylinder heat transfer, and improving grid generation. It was pointed out that the researcher used several improvement methodologies, the understanding of which is beyond the ability of this reviewer. This reviewer summarized that the efforts focus on improving accuracy and robustness of the algorithms, which are backed up by validation and verification. Many of the abbreviations and terminology were not recognized by the final respondent. As a result, this reviewer acknowledged that offered the presentation could not be followed well. Finally, this respondent offered no criticism.

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

The first person affirmed that the investigator made good progress, but the direct application to engine simulation should be better enunciated. This commenter explained that the driven cavity flow, or flow over a backward facing step, is interesting from a computational fluid dynamics point of view, but not for engine designers and simulators. The second reviewer pointed out the addition of conjugate heat transfer proper step in making model more predictive, even though results are similar to baseline condition. This person also observed that the researcher effectively removed some of the tuning parameters and replaced them with physical inputs. Another commenter acknowledged that the investigator developed an hp-adaptive (higher-order polynomial approximation) process which provides more accurate and robust turbulent reactive flow modeling. This reviewer observed the following: a new algorithm characteristic-based split (CBS)-FEM method to replace the KIVA-4 advective approach was developed, which is very diffusive; concluded that some finite-element methods are better for fluid mechanics formulations compared to finite volume methods; and improved wall heat transfer under PCCI conditions with wall impingement. The fourth reviewer noted the improved algorithms in KIVA and continuing efforts on validation, as well as added conjugate heat transfer feature to improve consideration of wall film efforts to better simulate partially premixed combustion and improved adaptive meshing, which will shorten computation times and improve accuracy. This person suggested that for future Annual Merit Review presentations the presenter should include less of the fine detail and jargon in the main body of the talk, and leave much of that for the technical backup. Instead, it would be more effective to boil down the motivation and the approaches to levels that the non-numerical analysis members of the audience can better appreciate the motivation, approach and accomplishments. This point was reiterated by another reviewer who stated that it was very difficult to follow the presentation if not fully steeped in the detailed computational methods, so it would be better to include more practical impacts and results. Many of the abbreviations and terminology were not recognized by the final respondent. As a result, this reviewer acknowledged that offered the presentation could not be followed well. Finally, this respondent offered no criticism.

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

The first reviewer observed a good array of collaborators, which shows that this is considered to be an important research area. Another commenter pointed out that this project included many collaborators, particularly at the University level, which more Vehicle Technology program projects should include. This person felt that this project is a model for broad university collaboration and an example of a program with more than just the University of Wisconsin and University of Michigan as university collaborators. Suggested to maintain working group, host workshops and support the code for thousands of users. A different reviewer specifically pointed out the Iowa State collaboration. The fourth commenter remarked that there seems to be good connection between this group developing the model framework and the community of KIVA users. Another reviewer acknowledged the collaborations with principal investigators at four universities, and a vast KIVA user community (thousands of users) that exists. This person suggested that a running tally of KIVA licenses and users should be presented every year so it is possible to get an idea of how widely the code is being used. The sixth commenter questioned why the University of Wisconsin was not a collaborator given their wide use of KIVA. This person also inquired as to whether any industrial users would be willing to become a collaborator. Many of the abbreviations and terminology were not recognized by the final respondent. As a result, this reviewer acknowledged that offered the presentation could not be followed well. Finally, this respondent offered no criticism.

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 choice of emphasis of future work is not well motivated. This person pointed out that much work needs to be done, and then questioned where the time and effort should be spent and why. Another commenter asserted that a focus on reducing empiricism is a must and that it would be useful to see a list of all the assumed inputs and what is planned to replace them with physical quantities. A different reviewer commented on improving methodology for simulating moving boundaries to improve consideration of valve motion. This person mentioned that efforts will continue to increase robustness, permit simulations with higher resolution, and apply overset parts/grids. Many of the abbreviations and terminology were not recognized by the final respondent. As a result, this reviewer acknowledged that offered the presentation could not be followed well. Finally, this respondent offered no criticism.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer that felt the resources for the project are insufficient. This person pointed out that it was only partial funding in 2011, which is an impediment to successful collaboration and progress with this important tool. It was recommended that this project receive more funding if at all possible. The remaining eight reviewers responded that the resources for this project are sufficient. One of these reviewers said that the funding seems sufficient, but acknowledged that they are not an expert in this area. A different commenter wanted to know how many others are involved in the day to day KIVA development other than PI. Another reviewer questioned how this competes with commercial codes and how is it advancing the science over what is commercially available.

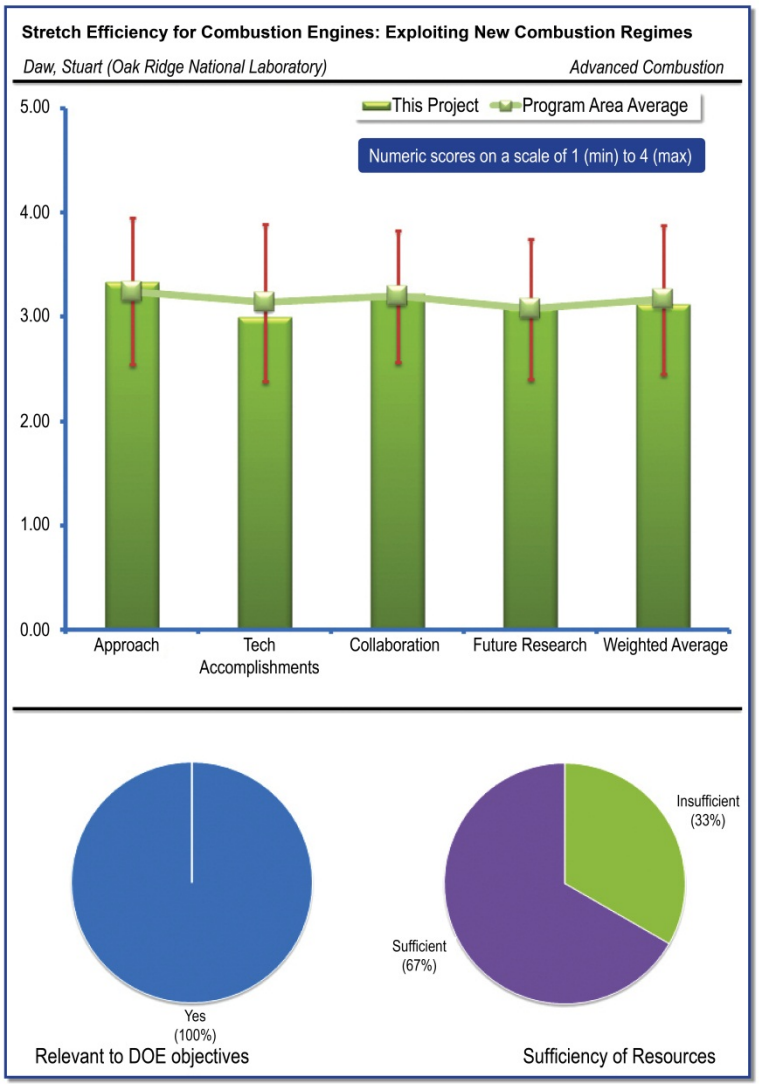
Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes: Daw, Stuart (ORNL) – ace015

Reviewer Sample Size

This project had a total of nine reviewers.

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

The first reviewer stated that this project provides one of the strongest bases for data-driven decision-making that will guide future work on efficiency improvements. Another person affirmed that this project directly addresses DOE efficiency goals for ICE technology. It was pointed out by a different commenter that though to date this is a theoretical study, it is valuable in exploring the thermodynamic limits of what is possible concerning maximum possible engine efficiency. The fourth reviewer mentioned that this project probes potential for achieving maximum theoretical efficiencies in engines, and another said this effort is key to stretch efficiency objectives. A fifth commenter noted that it is always useful to determine what are feasible targets for long range efficiency objectives, because this can set limits on objectives. A different person felt this was an interesting analysis of possible future directions. The last reviewer was pleased to see that this work was performed by the national labs, where a very advanced conceptual study of this kind should be conducted.



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 mentioned that the approach is fundamental and from a first-principles point of view, which is appropriate in this context. A second commenter remarked that the researcher has been methodically investigating the thermodynamic limit of peak engine efficiency through conducting workshops, seeking the counsel of various university experts, and investigating practical issues with theoretically pushing engine efficiency limits to 60% or higher. This person's only suggestion is to also include lean burn in future analysis in addition to stoichiometric. A different reviewer stated that this is an invaluable exercise in "blue sky" thinking and that this will eventually lead to more practical approaches to achieving next-level ICE efficiency gains. The fourth person affirmed that this is clearly out of the box thinking. However, this person felt that the investigator needs to consider the engine out emissions and also the energy available for operating emission control devices such as lean NOx traps and 3-way catalysts. Another reviewer also applauded the out-of-the box thinking. This person acknowledged that the thermodynamic analysis is thorough; however pumping and friction should be included in the analysis. Stating that maximum fuel efficiencies of 50-60% can be achieved, a sixth commenter remarked that this study focuses on why today's engines do not meet these theoretical efficiencies and pointed at ways in which to increase the efficiency of today's engines. This person commented that the approach is sound and involves consulting with experts, conducting colloquia, conducting analysis and modeling (I and II Law analysis), and considers heat and mass transfer along with chemical kinetics. A different reviewer said that the investigator used an excellent survey of experts in the field to further look at

new methods to approach maximum efficiency. An eighth person concurred that there was a nice combination of expert consultation and analysis. The last commenter felt that more description into brainstorming process would be helpful.

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

The first commenter felt there was good progress, but commented that areas of emphasis should be better motivated and explained. Another reviewer stated that the engine platforms and cycles considered are appropriate for the initial phase of study; however elements of this may be more appropriate for heavy duty engines. This person also mentioned that perhaps boost systems should be included to address potential power density loss in some advanced cycles. A different commenter remarked that is was good to see real thought on stretch goals but asserted that the researcher still has to put this in context of power density and packaging for mobile equipment. Solid progress was expressed by the fourth person. The fifth reviewer pointed out that this project has been a high output versus funding type of project that is exploring the limits on engine efficiency. This person suggested that it would be very helpful to include lean burn in any analysis and experimental efforts. The last commenter highlighted the investigator's progress on studying Thermochemical recuperation to capture waste exhaust heat to reform HC fuel into a syngas mixture which can be added back into the chamber to modify the combustion process and make it more efficient. It was also noted that gains in efficiency that could be made have been quantified. This reviewer pointed out that one finding that the investigator should capture is molar expansion pressure rise, since energy has to be captured in pressure form for it to be useable, and ultimately that is what moves the piston. This person also acknowledged that several publications have resulted from this work, chemical looping has been studied and the regenerative air preheating and thermochemical recuperation (RAPTR) and variable valve actuation (VVA) experiments continued.

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

One reviewer noted that the investigator has included the input from many engineers in universities, Industry, and the government, while at the same time chairing workshops that included the aforementioned partners. Another commenter also affirmed that collaboration exists with several universities and industries, involved in analytical and experimental aspects of the study. One reviewer stated that the collaboration on the project is outstanding for a forward-looking project such as this. A different reviewer acknowledged the investigator's good use of external experts, but felt that the range of these could be expanded. The last commenter observed that the collaboration is probably as much as the researcher can get out of other groups.

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 suggested that future research should include alternative combustion cycles and not be limited to traditional piston motion. This person pointed out that if the intent is to see how far engine efficiency can be pushed, the investigator should not impose artificial limitations just because that is the way that engines have always been designed. Along these same lines, another commenter said that it would probably be useful to reconvene another expert seminar to look at new concepts. The third reviewer was unclear how relevant RAPTR is, and mentioned that the investigator should have more examples with correlations. A different commenter stated that the proposed research for the time and funding proposed is reasonable. This person noted that the focus of the work is almost exclusively on thermodynamic efficiency, and then questioned whether there is sufficient means in the testing proposed to differentiate the thermodynamic from the mechanical efficiency to fully evaluate the potential benefits. A fifth reviewer expressed that the investigator needs to account for mechanical efficiency and power density in the analysis. This person also pointed out that it would also be helpful to differentiate between light duty and heavy duty. The researcher commented that marine engines are in the 50%+ BTE range, which is true, but those are very low speed with big bore, and are more representative of heavy duty rather than light duty. This person advised the investigator to avoid the misconception that 60% BTE is likely or practical for a light duty application. The sixth commenter said that the proposed experimental work with more real world engine process analysis is a logical approach to further explore more practical efficiency limits of engines. This person suggested including lean burn in future work. Another reviewer asserted that the VVA experiments should be the main focus, since that could be a practical pathway to embody Thermochemical recuperation. The last reviewer commented that this is interesting work and worth doing.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Six of the reviewers responded that the resources for the project were sufficient. One added that the investigator should potentially collaborate with engine development activity. Another affirmed that the funding seems appropriate assuming it includes adequate proportions for experimental work with the VVA engine and the RAPTR device. Three other commenting reviewers felt that the resources were insufficient. One of these reviewers expressed that the level of funding is not adequate to support a significant amount of experimental effort. This reviewer pointed out that the return may be longer-term, but additional funding would be worthwhile. The second of these reviewers felt this would be worth more effort, while the last stated that it is a pretty small effort but perhaps appropriate for a low level program.

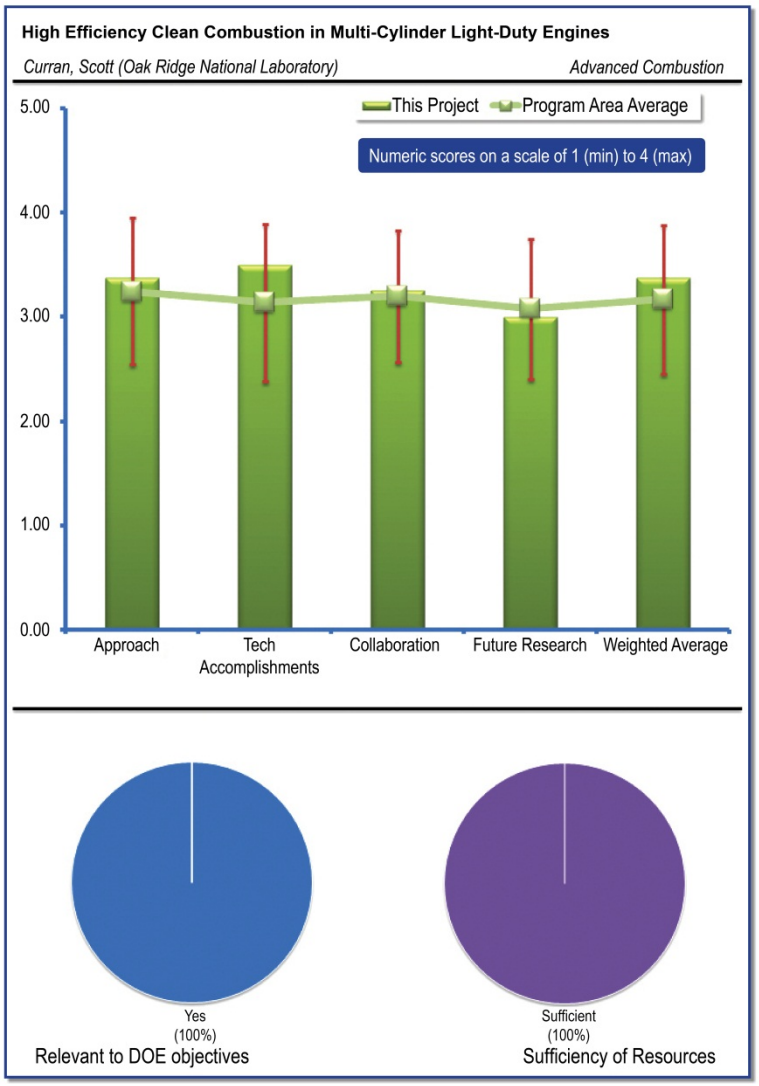
High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines: Curran, Scott (Oak Ridge National Laboratory) – ace016

Reviewer Sample Size

This project had a total of eight reviewers.

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

One commenter asserted that achieving clean combustion with diesel equivalent efficiencies is consistent with DOE objectives. Another person stated that improving engine efficiency is a key requirement for the future. A reviewer noted that RCCI related high efficiency research is very relevant, while a different reviewer reiterated this same point by expressing that there is a definitely a need for RCCI evaluation on multi-cylinder complete engine. Another commenter acknowledged that this is a very good approach for achieving low fuel consumption, but pointed out that a combustion system of this nature is probably lower priority for light duty. The last person observed that this project seeks to demonstrate the potential of advanced high efficiency diesel and gasoline combustion concepts in a multi-cylinder setting.



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 the approach is well thought out and comprehensive. Another stated that the comparison of RCCI to conventional Diesel is useful, while a third reviewer noted that fuel neutrality is an important piece. The fourth commenter remarked that the investigator had a good approach of combining modeling and "real" engine experiments to test feasibility of implementing advanced combustion on production-like engine hardware. A different reviewer concurred that it was great to have full engine RCCI data and that it will be interesting to see how this can be optimized. The sixth reviewer observed that this project was a good complement to RCCI research happening elsewhere. This person also affirmed that the production-like approach is important for understanding new roadblocks preventing mass implementation. A different commenter acknowledged that the approach taken to achieve low fuel consumption with appropriate emissions targets is very strong. However, this person pointed that the bar for light duty is set very high for achieving this with reasonable cost, reliability, NVH, and ease of refueling, in addition to other critical factors. Contrary to the other reviewers that felt the project was utilizing a “real” world model, this seventh person commented that if the goal is to make something commercially attractive for light duty, the project must in some way deal with issues such as eliminating the need for direct cylinder pressure sensing, mitigating the consumption of the secondary fuel and moderating the rate of heat release in the cylinder. The last reviewer highlighted aspects of the project’s approach that aimed to evaluate proposed advanced combustion concepts in multi-cylinder production-type engines to expose practical issues and evaluate the state of technology

readiness. Noting that experimentation is the focus of this project, this person said that combustion modeling, dynamic modeling, engine-system modeling, and vehicle system modeling are used to understand the results.

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

One commenter expressed that the experimental work is doing an excellent job of staying in front of the modeling work and expanding the useful range of RCCI combustion. This person also pointed out that exploring the emissions profile will be an important step to addressing the aftertreatment requirements that, by first indications, may potentially be quite unique. Another reviewer affirmed that the investigator was producing good progress and interesting results on testing of RCCI concept. A different person also acknowledged the project's robust results, but noted that the proper context of these forms of combustion should be described. This person explained that the correct new view of the gasoline-diesel spark ignition (SI)-LTC domain is more likely 2- or 3- dimensional, with fuel type, ignition type, and level of mixing as being the proper axes. One commenter stated that the overlay of PFI stoic Atkinson at 2000 RPM, 6 bar BMEP would be useful, and that this could potentially match Diesel BSFC. Another reviewer asserted that there were excellent results, but would like to see a direct comparison to indicated single cylinder efficiency at similar operating points with breakdown of differences. The last reviewer listed the investigator's progress, which included installing a diesel engine for the diesel work and a gasoline 2.0-liter LNF engine for the gasoline work. This reviewer noted that the multi-cylinder experiment is running points that the University of Wisconsin has run and modeled on the single cylinder. Also, FTP simulation points have been run by the investigator and RCCI operation has been demonstrated. This commenter observed the addition of ethanol permits operation with no EGR at higher loads. At the 2,000 rpm and 6 bar BMEP point, RCCI experiments were conducted to see if the University of Wisconsin's predicted BTE improvements of about 10% can be achieved. This person noted that no improvement in BTE is seen, but said that the researcher offered reasons for this that included the lack of multiple injection (fuel system goes unstable when attempting to inject small quantities of fuel) and high combustion instability for RCCI.

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

Reviewers provided a range of responses about collaborations. A commenter felt there was good collaboration with OEMs, suppliers and universities. Another person concurred that there was excellent collaboration exists with the University of Wisconsin, Bosch, Borg Warner, and the University of Michigan. A different reviewer questioned the level of collaboration provided by these partners. This person remarked that it was not clear if these were true collaborations, and hoped that it was not just a case of obtaining equipment from the OEM's and modeling data from the universities. The last commenter acknowledged that the level of collaboration is good, but pointed out that the project could really benefit from more collaboration with industry, particularly on the fuel injection strategies for extending RCCI.

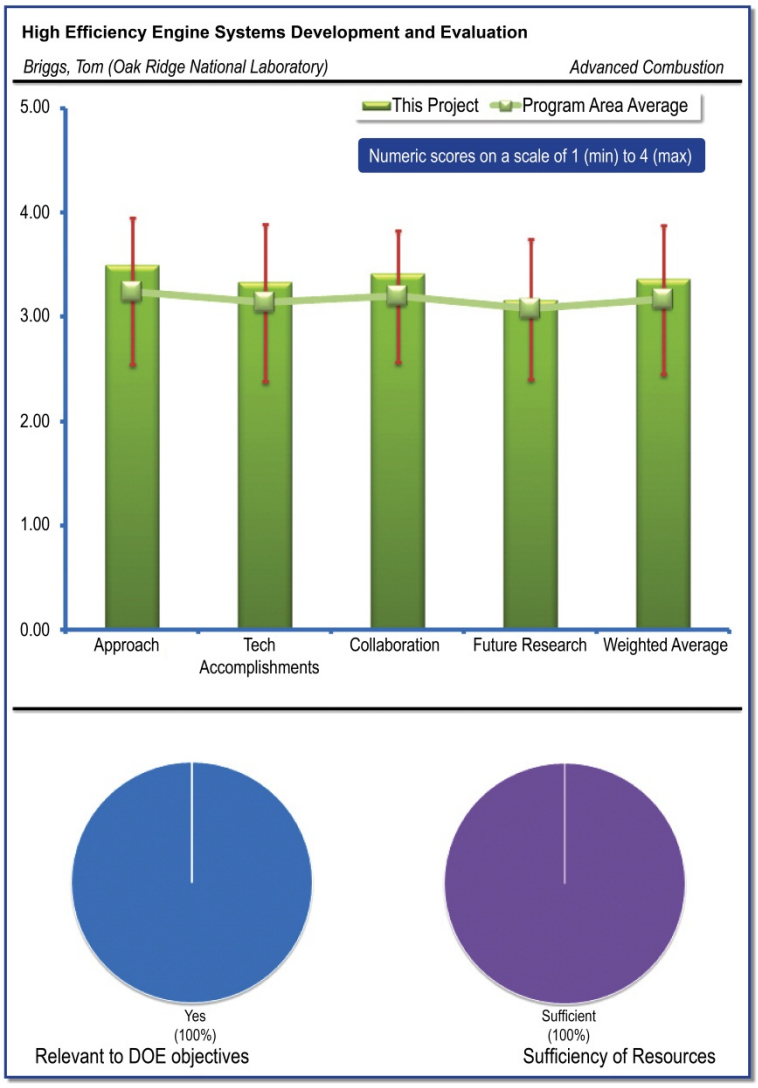
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the elements addressed are appropriate for achieving RCCI in a light-duty engine, but critical areas for commercialization in the light duty fleet must be identified and addressed. This person felt that input from OEMs would be very valuable. The fifth person commented that the plans seem reasonable. The third commenter strongly encouraged more research into the combustion stability issues for feedback control systems, while a fourth said that it would be useful to add transient development. A different reviewer criticized the research direction by questioning if it is driven by the hardware available rather than the other way around. The final reviewer pointed out that the investigators plans are to continue to demonstrate RCCI and high-dilution stoichiometric gasoline combustion by addressing the new barriers (fuel-system limitations, high coefficient of variation [COV], etc.) that have been unearthed. This person also reiterated the researcher's plan for FTP steady-state point emissions evaluation and fuel effects on RCCI combustion.

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

All seven reviewers responded that the resources for the project are sufficient. One reviewer commented that the level of funding is sufficient for the project goals at this time.

High Efficiency Engine Systems Development and Evaluation: Briggs, Tom (Oak Ridge National Laboratory) – ace017



Reviewer Sample Size

This project had a total of 12 reviewers.

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

Comments were generally positive in this section. One reviewer said the project is an excellent example of a sound application of fundamental principles to guide technology selection in order to meet stretch efficiency targets. A second commenter noted direct demonstration of higher fuel economy, while another said the project directly supports DOE's goal of demonstrating 45% BTE by 2010. Similarly, another respondent said this project directly addresses the DOE goal by demonstrating key engine technologies in a more realistic, multicylinder setting. This reviewer added it directly supports efficiency goals, performance milestones, and Advanced Combustion and Emissions Control (ACEC) goal setting. Another reviewer commented that this is directly addressing DOE objectives through optimization of a metal engine for both part- and full-load thermal efficiency while meeting Tier 2 bin 5 emission standards and forecasting vehicle-level fuel economy performance through vehicle modeling efforts. One commenter said investigating the maximum potential of the efficiency of an engine-vehicle system is an important step in determining the petroleum reduction that can be achieved and at what cost of system complexity. Another said success in improving engine efficiency would result in improved fuel efficiency/economy and thus reduce fuel and petroleum requirements per vehicle. One person noted peak efficiency demonstration on diesel architecture, while another said hardware demonstration of DOE efficiency goals. One final reviewer said waste heat recovery offers potential for fuel savings.

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 were generally positive in this section. One reviewer said the good selection of a wide-range map is useful to demonstrate trends versus single points. Another said excellent use of thermodynamic analysis to guide the selection of technology and to help create a stationary target, and a basis for comparing benefits. A third respondent said good approach of using modeling and experiments to determine and improve efficiencies at road-load conditions relevant to actual engine platforms. Another reviewer said very well planned project approach, including engine experiments for developing portions of the engine map, engine system modeling for assessing first- and second-law energy distribution and losses, vehicle modeling for assessing near real world behavior of the high efficiency clean combustion (HECC) engine, and bottoming cycle modeling for assessing potential engine efficiency gains. This approach allows for a high output-to-funding ratio from an engine and vehicle system perspective. One reviewer said the investigations and demonstrations are conducted on a multicylinder basis with practical intake and exhaust systems, fuel systems (including turbo charging), etc. This person added that experiments are supported by GT-POWER modeling and second-law analysis

is also conducted. Another commenter said nice lab demonstration of theoretical possibilities. This reviewer would also like to see more consideration of powertrain matching issues: downsize/down-speed opportunities to get closer to the actual peak efficiency. Another reviewer likes the analytical approach of looking at availability and finding all the sources where one can get energy. However, this reviewer adds, the organic Rankine cycle (ORC) system is not very practical at the low loads. One person said good work, but this looks like a very expensive system for the road load output. Another respondent said the second-law analysis is appropriate. It is difficult to interpret the energy breakdown to see the remaining opportunity. The ORC approach may lend itself to heavy-duty (HD) applications. The LD cycle will have limited opportunity. One final reviewer said one of the fundamental problems of waste heat recovery (WHR) as implemented here is that the ORC system has its highest energy recovery (and hence contributes most to the overall system efficiency) when the engine load is highest. However, this leads to significantly lower recovery at low road loads, where the engine efficiency needs to be boosted most. This reviewer added that this is not addressed in this project.

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

Comments were mixed in this section. One reviewer noted that the group had achieved the milestone of 45% BTE, while another commented good results and added that the project should focus design and analysis on road load cycle. A third commenter said nice work in the lab and models. Another person said good results with what the researcher has done. The presentation showed all the faults along with all the benefits: a good, balanced story. One respondent noted that the DOE and ACEC goal of 45% peak brake thermal efficiency was met. This was obtained by adding an Organic Rankine Cycle for converting exhaust energy into electric energy through a turbine/generator. This reviewer added that several models of alternate configurations have been completed, and noted simulated UDDS and US06 cycle performance. Another person said that this is a great project that explores what might be possible for HECC light-duty diesels for increasing engine thermal efficiency and vehicle fuel economy while meeting Tier 2 bin 5. In particular, it points towards the limit of WHR toward improving engine efficiency and vehicle fuel economy, and also the limit of turbo-compounding on improving light-duty engine thermal efficiency. One reviewer asked if there is a means to assess the impact on aftertreatment temperatures. Another commented: 45% BTE demonstrated at 2250 RPM, 18 bar BMEP. This person added that it may be useful to compare to other production diesels (advertised), as well as lower CR to minimize friction; a graphic to emphasize the very small net yield status from ORC would be useful. One respondent said the demonstration of the WHR is impressive, yet does not include a few key elements; the global warming potential (GWP) of the ORC working fluid (R245fa) is very high, and an alternative would be needed to satisfy GHG emissions targets. Energy storage would also need to be addressed to determine the true incremental benefit. Another commented that the system is oversized – we know how ORC systems work, and that they do work, but sizing is critical. This was not performed here. One final reviewer likes this project, in that it is the only one which has provided multi-cylinder data demonstrating the 45% BTE goal; however, the rate of progress this year seems to have slowed significantly, and does not reflect the funding level.

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

Comments were generally positive in this section. One reviewer said that the collaboration for a project at this stage of development is outstanding, and is promising for the future success. Another said good collaboration and consulting relationships exist with key suppliers like Barber-Nichols, Borg Warner, GT-POWER, and Cummins. A third reviewer commented that this project has included partnering with a turbo manufacturer and an engine OEM interested in the bottoming cycle of this effort and another OEM provided engine set-up support. One person noted that there seems to be collaboration with ACEC Technology team plus interactions (but not necessarily complete collaboration) with several companies on specific components. Another reviewer suggested that it would be nice to have closer industrial support at the system level.

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 were mixed in this section. The first reviewer said this seems to be appropriate and build on previous work. Another commented that the proposed future research focus includes air system options that enable RCCI and highly premixed combustion, the exploration of RCCI and highly premixed combustion in light duty diesels, and second-law analysis. Based on other presentations and

other work sponsored by DOE, this is a sound plan that can further peel back the possibility of using these advanced combustion modes for improving real world type light duty diesel engine efficiency versus single cylinder engines. A third reviewer indicated that logical evaluations of RCCI and PCCI advanced combustion concepts are planned, adding that this will provide valuable, and more real-world, demonstrations of these advanced concepts on a multicylinder platform. Planned second-law analysis will help ACEC in its engine-efficiency goal-setting objectives. One respondent said the area of concentration is of critical importance to the development of efficient, turbocharged/downsized engine platforms. This person asked, to what extent can low heat rejection concepts and variable exhaust valve timing be combined with the test engine to improve the performance of future prototype exhaust energy recovery systems? Another respondent said good work planned, but suggested the researcher please consider downsize/downspeed opportunities while considering transient drive requirements. One person felt that it was not clear if the series sequential boost system will help peak efficiency region with typical match; what are the plans to size components to optimize the system in this area? One commenter queried whether we need yet another demonstration of WHR through ORC. This person added we know that it works, but sizing and duty-cycle-specific implementation is the most important unknown (unless the project goal is to develop new hardware for LD applications, which it does not seem to be). Another person said it is not clear that working with LTC makes sense, adding that this will only lower exhaust temperature. It is better to focus on optimizing for conventional diesel. One respondent said that the future plans lack detail, while one final commenter indicated a lot of nice words, but not a lot of substance.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All twelve respondents said sufficient. One reviewer said about right, while another said funding in the last two years seems commensurate with this effort and appears to have tracked the experimental portions of this effort. A third respondent said this project needs to be re-evaluated to determine whether we need yet another demonstration of what we already know; namely, that there is a large amount of waste heat in the exhaust, EGR, and coolant of any engine, but it is extremely difficult to recover under partial-load conditions. Another reviewer said the funding is sufficient for the present stage of the project, but clearly more resources could be justified for future work. One final respondent said hopefully the progress picks up to match the funding.

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

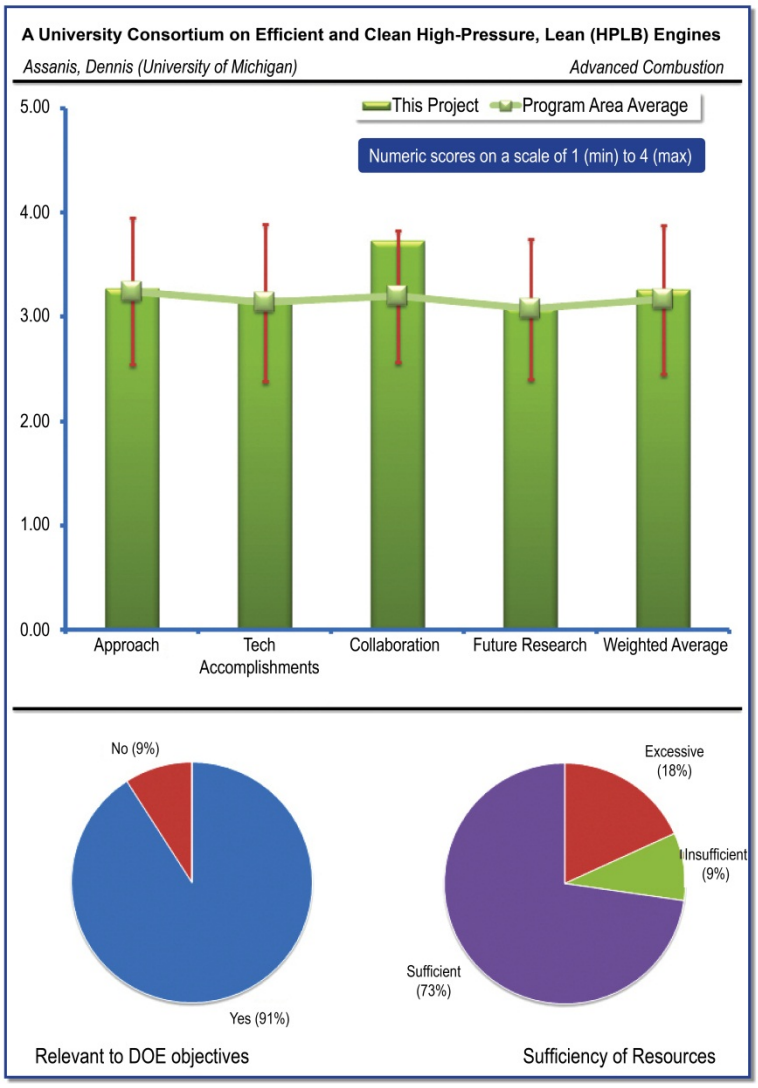
Reviewer Sample Size

This project had a total of 11 reviewers.

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

Comments were generally positive in this section. One reviewer said high-efficiency LD engines will facilitate petroleum reduction once implemented, while another said advanced high-efficiency clean combustion can directly lead to the displacement of petroleum. A third respondent agreed, stating that success in improving engine efficiency would reduce fuel and thus petroleum consumption. One person said the project investigates advanced light-duty gasoline combustion concepts with an aim to improve understanding. Another reviewer indicated significant study to pull many aspects of combustion together. One final reviewer was less favorable, stating the work seems redundant to other work and without a clearly defined path to a specific goal.

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 tended to be positive in this section, though a few reviewers did express some suggestions and reservations. One person said nice modeling plus experimental approach, while another reviewer noted a good combination of engine experiments, simulation, and modeling. A third respondent indicated a great use of many tools and capabilities available within different facilities. Another reviewer stated the group is targeting improvements in light duty gasoline engines to achieve 45% peak engine efficiency. This reviewer added that, to achieve this, they are exploring lean burn, high pressure, multi-mode combustion, enabled by sophisticated engine configuration and control. They are linking simulation and experimental studies at various scales (rapid compression machine [RCM] and engine). One reviewer observed an impressive array of research, but added it was unclear how it ties together or complements each other. One person emphasized the systematic and integrated approach, adding solid competency is exhibited in the approach, and in the results. Multi-faceted approach, covering the bases, and capitalizing on individual entities' core strength. This is perhaps one of the most proficient and well-rounded combustion and engine programs under the OVT umbrella, which should advance the state-of-the-art of the technology and bear good fruits! Another respondent remarked the approach seems to be a wide range of sub-tasks that are loosely linked to the project goal – we understand that spark-assisted compression ignition has the potential to improve fuel efficiency through extending the lean limit, but why the development of the microwave ignition device? What about laser-based ignition, or more conventional approaches? The reviewer added this project seems to be a catch-all project funding interesting sub-tasks that the PIs were interested in pursuing anyway. One reviewer commented the approach seems to include everything but the kitchen sink. There are various combustion strategies from HCCI, spark assisted compression ignition (SACI), and high-dilution stoichiometric SI, at various physical locations like UM, Massachusetts Institute of Technology (MIT), University of

California-Berkeley, and various labs within UM, such as the optical engine, diesel engine, fully flexible valve actuation (FFVA) camless engine, and the rapid compression facility (RCF) are being engaged in what seems like a shot-gun approach. There does not seem evident a master integration of all the work going on. This reviewer added the concern is that at the end of the day we have elements and subsets of various combustion issues that do not integrate well to meet the objectives of demonstrating a high-efficiency gasoline engine that meets the objectives. The final respondent felt the basic analysis to support the project is flawed because of the erroneous assumptions of combustion phasing and burn rate being constant. Task 1, though the basic combustion tenet of the project, completely ignores the realities of combustion; it is completely unreasonable to assume a CA50 of 10 degrees can be achieved at 12:1 CR, phi=1, and 3 bar inlet pressure.

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

Comments were mixed in this section. One reviewer indicated the program seems on track, while another commented numerous accomplishments within the individual facilities, labs, and institutions have been accomplished. A third reviewer said the program advanced the understanding of the HPLB technology on many fronts, and also advanced experimental and simulation techniques, acquired new findings, and identified logical next steps. This reviewer also noted the excellent managerial skills of the PI, as he navigates multi-institutions and complex work tasks, then weave them into a cohesive fabric. Clear presentation and well laid out graphs. Another respondent noted thermodynamic analyses have been completed that confirm the benefits of high pressure and lean burn, setting potential targets to achieve experimentally. The program incorporated GT-POWER analyses in vehicle cycle calculations to show overall potential gains of 50% with dilution, boosting, and downsizing. There has been continued progress on the use of stratification and SACI (multi-mode) combustion. Also, the program is investigating novel spark strategies to extend the lean limit. One reviewer asked how SACI compares to HCCI and lean-SI for NVH and ISFC. Another reviewer commented the technical accomplishments seem scattered and diffuse. Will they be brought together in the final half of the project? Another person agreed, stating many good results, but that it was difficult to see how it will tie together. One respondent commented that the project could benefit from some clear goals. One final reviewer indicated stratified HCCI seems like a poor choice of words. How does this compare or compliment other similar efforts in this area? For the RCM work, what octane and how do its results compare to other published work? Regarding the NOx standard… which one? Please specify next time. This reviewer felt it was not clear how SACI combustion was achieved. What was the charge air temperature, and is it reasonable? This reviewer added that it was not clear what the new and novel contribution was regarding the flame speed correlate.

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

Comments were generally positive in this section. One person noted it was great to see such wide collaboration, while another said excellent collaboration. A third reviewer said there is strong industry and national lab involvement and support for the program, noting the consortium with MIT and University of California-Berkeley to broaden experimental facilities capabilities. An impressive overall team. Another respondent remarked the consortium enables collaborations of the three universities with each other and with several energy companies and automakers. One reviewer said good collaboration, although to date each institution seems to be following its own path. Presumably these disparate results will be brought together at the end. Another person simply said see prior comments. One final reviewer noted the collaboration is extensive; however, the integration of knowledge gained is a concern.

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 a number of comments and suggestions in this section. One person commented the planned work will advance all the program goals, adding that, for each task, the future work is well thought out and should continue to advance the knowledge base. Another reviewer stated the plans seem appropriate. One respondent emphasized the need for a strong focus on task 1 to create the design for utilizing results and various mechanisms. Another stated that, in order for each facility and lab to better contribute, a common pathway to achieving the objectives should be clearly communicated. A fifth reviewer indicated expanding the range of test fuels will be critical work. Another person indicated the program should (1) keep the overall system demonstration in focus, and develop a clear pathway and its associated validation plan, and (2) develop a combined (simulation plus testing) process of elimination

to narrow down the variables and parameters, in order to converge on item (1). One reviewer remarked that it needs to be described how all of these disparate sub-tasks will be drawn together to reach the final goals. One final reviewer asked how the program will choose and organize tasks towards the 45% BTE goal. This reviewer said it was not clear. This person added that HCCI and SACI ~ 6 bar net mean effective pressure (NMEP is far below the identified 12-18 bar BMEP region shown for peak BTE.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Eight reviewers said sufficient, two said excessive, and one said insufficient. The first reviewer said good investment! The other respondent said the funding is only partial in the current fiscal year. This makes progress on programs very difficult and is incompatible with graduate student-focused research. This reviewer added DOE should not do this to university programs.

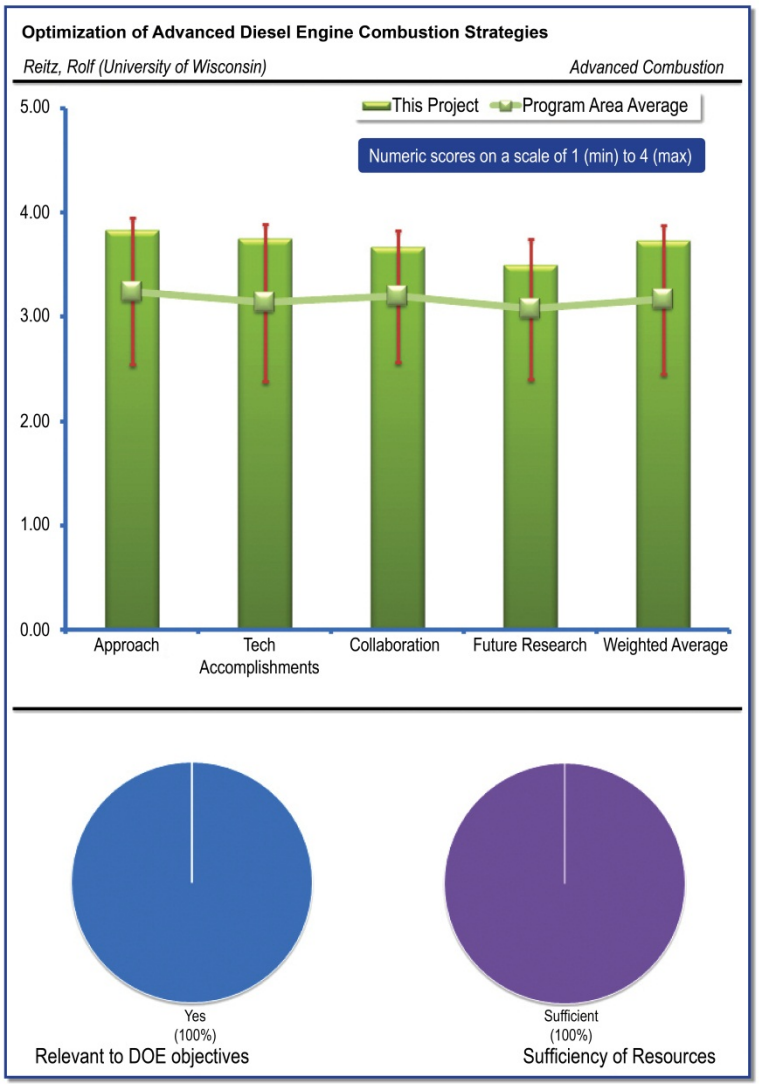
Optimization of Advanced Diesel Engine Combustion Strategies: Reitz, Rolf (University of Wisconsin) – ace020

Reviewer Sample Size

This project had a total of 12 reviewers.

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

Comments were generally positive in this section. One reviewer indicated improved fuel efficiency is a requirement for the future, and added that this project has the potential for significant reductions in fuel usage. Another reviewer indicated top quality work directly demonstrating high efficiency in IC engines. A third respondent said achieving practical 55% BTE HD engines will lead to significant fuel savings and the potential to displace petroleum. Another reviewer agreed, saying the focus is on improving engine and fuel efficiency where success would translate into lower fuel and thus petroleum consumption. Another person remarked leading work in RCCI combustion is very useful to explore potential efficiency benefits. The final reviewer indicated the program addresses the challenges of increasing diesel engine efficiency via LTC while minimizing emissions.



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 tended to be positive in this section. One reviewer commented the approach is comprehensive but seems to be well-arranged and justified. Another person said excellent approach of investigating engine design, fuel properties, and operation strategies and using analytical, modeling, and experimental tools. A third reviewer said pioneering work on high-efficiency engines, adding that a broad range of tools and methods is used effectively. One person, similarly, noted an excellent mix of simulation models and experimental results leading to model improvements and good test results. Another reviewer very much applauds the mixed simulation and experimental approach. One respondent noted the program is combining simulating and experimental studies in advanced combustion, considering PCCI and dual fuel combustion operation, and includes combustion and in-cylinder visualization, coupled to predictive modeling. Another person remarked use high-fidelity computing and engine experiments to design a new engine combustion system based on PCCI and RCCI combustion concepts. One reviewer felt there needs to be more focus on achieving brake efficiency, and **added that the focus on gross indicated efficiency obscures the problems with gas management at high** EGR rates. The final reviewer noted the comprehensive suite of research, but added that it was unclear how it ties together to deliver DOE objectives.

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

Comments were generally positive in this section. One reviewer said very good progress in a number of different areas, while another stated very good results demonstrated. Another simply wrote great work. A fourth reviewer noted a wide range of achievements, where the most important is the improvement of brake thermal efficiency through the judicious use of dual fuel reactivity controlled combustion. Another respondent said very good progress, too numerous to comment on here, has been made towards objectives. One person felt the work with RCCI dual fuels is of great interest to industry. One reviewer noted the work includes hardware studies, fundamental experimental and numerical methods development, and a broad scale of studies. This program has already demonstrated significant accomplishments, with the results from the "RCCI" combustion having created worldwide interest in this process and its potential. Rarely does an engine and fuels research project stimulate such interest. This reviewer added this is a credit to the innovative and comprehensive approach of the investigators. Another respondent said excellent work on striving to meet emissions regulations engine out with novel approaches, and added that it is difficult to get a final picture of what is all needed on a final multicylinder engine to achieve all this. One final reviewer noted the interesting explanation as to the rationale behind the two diesel injections on the RCCI engine (first injection in the squish region, second one in the piston bowl).

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

Comments were generally positive in this section. One reviewer noted the wide range of collaborations, including OEMs, suppliers, and national labs. This reviewer also indicated very good technology transfer activities. A second reviewer commented strong industrial involvement and support, while a third remarked a good example of how to do it. Another respondent said good collaboration exists with Sandia, GM, and the 24-member DERC consortium. One final reviewer indicated the primary, most frequent collaboration appears to be with Sandia and GM, adding that collaboration with members of the UW DERC were also mentioned, although at least the formal interactions are much less frequent.

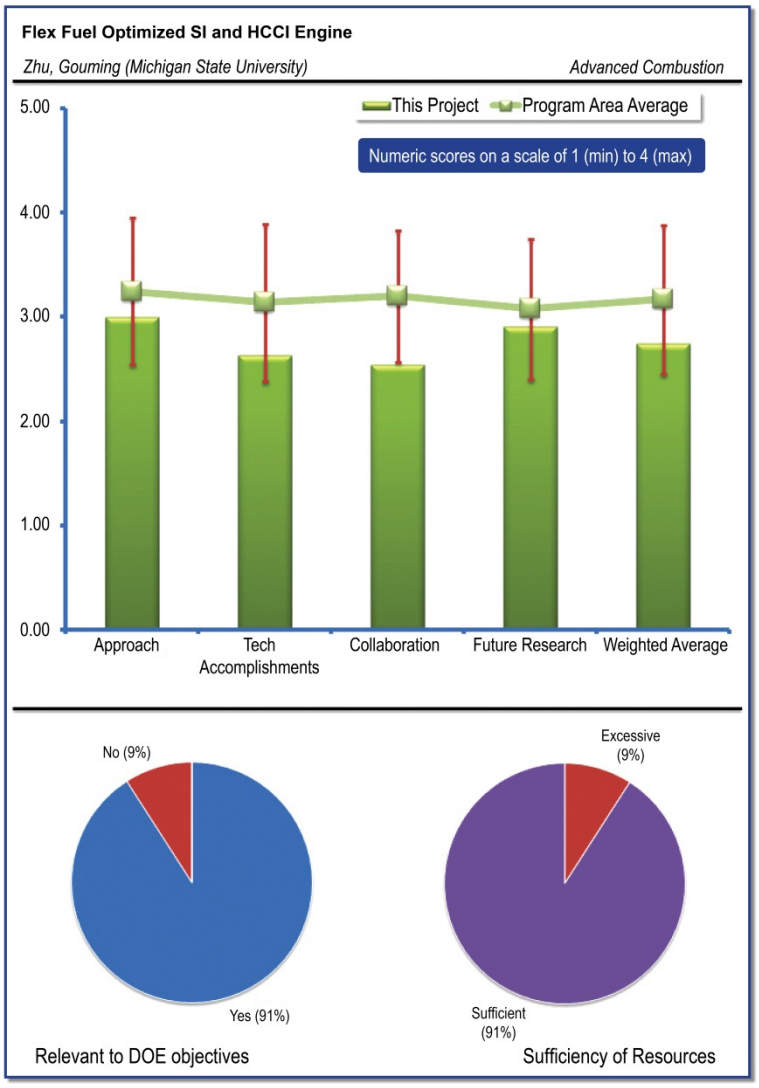
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments and suggestions were generally positive in this section. One reviewer said plans look good, while another commented the plans proposed for each task build on past progress and remain focused on meeting objectives. A third reviewer noted an ambitious set of goals, although a large amount has already been achieved. This reviewer added the control of RCCI under transient operation will be a substantial task. A fourth respondent indicated future research will expand the range of operation of these advanced combustion modes and continue kinetic mechanism and simulation capabilities. This reviewer added that significant observations should arise from the planned work on all the tasks. One reviewer indicated that many results are presented on a gross peak efficiency basis. Changes in efficiency are shown for variables that impact mechanical efficiency (such as fuel pressure and real boosting systems), but with no accounting for the parasitic load. This reviewer added it would be nice to include in the analysis, and provide an estimated BTE with the list of assumptions. Another reviewer noted the focus on transient is important. Also, the future research needs more focus on complete engine development and evaluation. One final reviewer would like to see some thought toward total vehicle operation including cold starts. How will you meet emissions in LD cycles where cold start makes most of the emissions? How do you run engine idle and other very light mode conditions?

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

All twelve reviewers said sufficient. One reviewer indicated solid funding for a major project, while the other respondent in this section said the funding is stable and sufficient to support a strong program.

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



Reviewer Sample Size

This project had a total of eleven reviewers.

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

Comments were slightly mixed in this section, but generally positive. The first person indicated the objective to enable advanced SI and HCCI combustion can provide increased efficiency and use of E85 can displace petroleum directly. Another reviewer said the program is developing a method to transition from SI to HCCI, which is a more efficient mode of operation. A third person commented the controls for LTC are important for transitioning LTC from research to production environment. Another reviewer said the group looks at some practical aspects of mixed mode systems. One person remarked the research addresses barriers for HCCI by developing model-based controls for controlling mode transitions between SI and HCCI combustion modes, while another said control strategies are needed for transient operation between SI and HCCI modes to allow effective operation. One reviewer said exact relevance of this project is obscure. Another commented not specifically mentioned, and added that presumably the answer is yes if one realized outcome of successful development of their transition control schemes between SI and HCCI is fuel economy improvement and/or enables use of higher concentration ethanol blends. The final reviewer did not know, and added that this project is focusing on transitioning between SI and HCCI combustion. This reviewer felt there was no discussion on target efficiency or vehicle fuel economy gains, and asked if this is the big picture or if the use of E85 in SI engines is.

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 were mixed in this section. One person said the combination of modeling and optical and metal engine tests seems appropriate, while another indicated good work with practical hardware. A third reviewer commented demonstrating a dual mode SI and HCCI combustion operations scheme for a blend of gasoline and E85 is a sharply focused research area that is needed for flex-fuel vehicles (FFVs). Another commenter said good combination of modeling and experimental, and added that the group needs to be sure the results are not engine specific and can be applied generically. One respondent stated the group is using simulation and engine/valve control to achieve robust control of a SI-HCCI combustion engine, including operation on E85, and includes metal and single-cylinder engine approaches, including optical access engine. Another reviewer stated very large-scale project. How to scale back in hardware commissioning is difficult? One person said solid approach. Perhaps it was done but not presented how you came to select the combination of hardware and strategy – is it optimal? Another reviewer felt the goals are worthy but the approach is diffuse, and asked why a new controller (hardware) needed to be developed when off-the-shelf items are available. One reviewer remarked this project does not seem to have a pathway to first of all design and fabricate an HCCI engine. This reviewer added that the real-time control system and hybrid combustion model to study SI to HCCI combustion mode transitions seems to have progressed ahead of the

base HCCI engine. The final reviewer noted the PI appears to have put a lot of faith in the ability of GT-POWER to model combustion well under SI and HCCI conditions. This reviewer's experience has been that such zero-dimensional models are highly empirical and yield accurate or inaccurate results based on the engine and various boundary conditions. This reviewer is not confident in this approach until the PI generates real world data. Otherwise, the general approach seems reasonable from a controls perspective.

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

Reviewers expressed a number of reservations in this section. One commenter stated solid accomplishment to get this much working, but added there is still some way to go. The second reviewer thinks the control strategy is the useful part of this. Another reviewer was wondering if there was research into prior art of doing these transitions, and asked if some engines are doing this today. A fourth reviewer commented the simulation task is developing a combustion model and validating against GT-POWER, and the model will be used in hardware in the loop (HIL) for model-based control development. The model validation was successful. The group completed optical engine development, and completed an injector spray bench. They are continuing to work on engine system development, but completed development of the electrical cam phasing system and made progress on the engine controller interface. The group also performed simulations on transitions from SI to HCCI mode operations to determine control response requirements. Another reviewer commented the bulk of the technical accomplishments are in the future, and added that the PI still has to commission a new engine that can handle such mode transition combustion excursions. It appears much effort was spent just studying control laws and simulating what might be possible from a transition control perspective. One person felt the progress is very slow and a lot of effort has been expended on engine hardware that has taken too much time to develop and perfect. Another commenter said good results from modeling but very little experimental. It seems a challenge to complete this essential work within budget and timeline. This reviewer added that it is not clear that emissions during the transition phase can be ignored. One final reviewer indicated a 2-step valve and electrical cam-phasing has been installed on the Chrysler engine, and an optical engine has been fabricated. This reviewer's concern is meeting deadlines for experimental objectives, i.e., demonstrating model evaluation on the Chrysler engine and the single cylinder optical engine operation, etc. It seems like the base engine for HCCI operation has to be developed from scratch for both gasoline and E85 operation. This reviewer added that it seems like at the moment there is no HCCI engine to calibrate and validate all the model and control system development work.

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

Comments were similar in this section, focusing on the partnership with Chrysler. One reviewer noted the significant involvement of Chrysler, with hardware support, while another commented on the close partnership with one OEM. A third reviewer said this project is strongly partnered with a light duty vehicle OEM. Are there any other partners that could aid the PI in better understanding how combustion transitions from SI to HCCI? One person commented small group of collaborators, while another noted there appears to be the single collaborator of Chrysler (i.e., collaborations, especially with industry, are somewhat less than other programs). One final reviewer remarked the only partner is Chrysler, who is supplying engine hardware for a basic homogenous-charge engine. It seems like work has to start fresh to convert this engine to operate properly in the HCCI mode over a typical operating range. So far, no work has been reported on this front, but the control system has progressed well along. It seems like the cart is before the horse.

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?

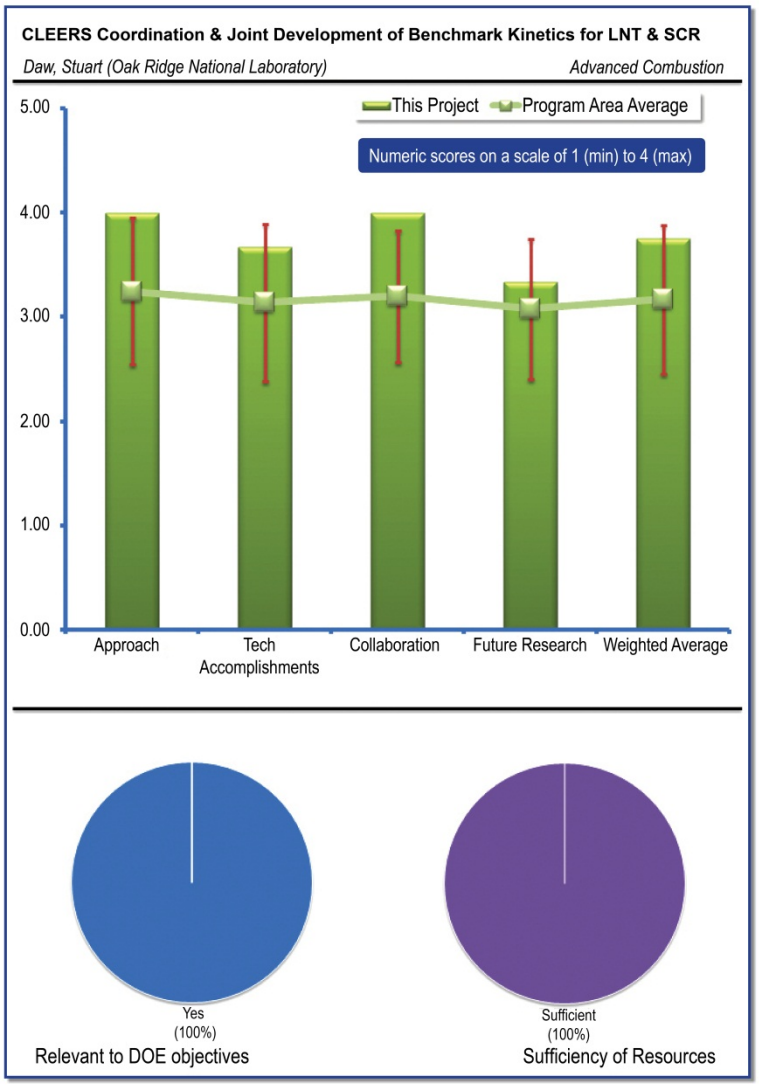
Reviewers offered a number of suggestions in this section. One reviewer said good plan, but a lot to do yet. Another commented that much work needs to be done to make this expenditure worthwhile. A third reviewer said to complete engine control integration and validate the engine control strategy in the single-cylinder engine and then in the multi-cylinder engine. Another person indicated it seems to be useful work planned. However, for LD systems this reviewer thinks the group needs to address cold start issues and overall emission control needs. How much HCCI will you be able to run? If practical constraints and cold start force aftertreatment and conventional combustion, do you gain enough to be worthwhile? A fifth reviewer said definitely need to get some data from the engine to validate models. One person commented, overall, a good approach, and added that this next year might call for some possible multi-dimensional combustion mode transition modeling to aid the PI in understanding the physics of how to most optimally

transition from SI to HCCI combustion modes. One final reviewer suggested partnerships with institutions that have the know-how to design and fabricate a state-of-the-art HCCI engine should be pursued to speed up the project instead of reinventing the wheel.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Ten reviewers said sufficient, while one said excessive. Comments were mixed in this section. One reviewer noted a large budget compared to the results achieved to date, while a second said the resources seem appropriate. The final reviewer remarked the funding level is sufficient, but the large dip in FY11 is problematic. This reviewer added that this creates significant difficulties with graduate student-based research, and DOE should insulate its university programs from these funding fluctuations.

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



Reviewer Sample Size

This project had a total of three reviewers.

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

Comments were generally positive in this section. One reviewer commented aftertreatment technology is a key enabler for many combustion strategies that offer the potential for enhanced fuel economy, adding that fundamentals associated with their application are key to the development of improved performance and durability, as well as laying the groundwork for their cost reduction. A second reviewer said developing reactor protocols for the LNT and SCR catalysts is a major contribution to the industry. This is clearly pre-competitive and allows the industrial participants to be able to concur on the correct measurement conditions that are necessary to use to develop reaction kinetics for these production catalysts. One final reviewer stated that particularly the SCR aftertreatment system can allow the engine to run with better fuel economy, where it makes more NOx. The activity of an excellent SCR catalyst is needed to make this possible, so this research is very relevant for NOx. This final reviewer added that the unique distribution of results via the cross-cut lean exhaust emission reduction simulation (CLEERS) conference and the web seminars is an excellent way to let many know what is going on in new areas and then make use of them.

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 were generally positive in this section. One person remarked the CLEERS program serves as an excellent forum for drawing specialists in the aftertreatment area together to share knowledge related to catalyst mechanisms for reaction and deactivation. This knowledge, in turn, provides the basis for the development of robust kinetic models. Key to the development of these models is the availability of suitable kinetic data covering the relevant chemical processes. Each of these activities is addressed well in this program. Additionally, the CLEERS group itself queries its stakeholders on a regular basis to help ensure that the approaches and directions are consistent with industry needs. A second reviewer stated the workshops and focus group calls provide an outstanding method for the competitive companies to discuss pre-competitive issues. This reviewer added that developing reactor protocols is an activity that would not be undertaken by the industrial partners. These protocols have been used by industry to evaluate catalysts of interest to them. These protocols are in use to develop kinetics for aftertreatment emissions predictions. This reviewer commented that it is hard to believe that this crucial work would be done under any other forum. One final respondent agreed, noting that the range of techniques used is extensive and difficult to improve upon. One method that is not too common, but useful, is SSITKA, or Steady

State Isotopic Transient Kinetic Analysis. It can provide information on how the coverage of an adsorbed reactant changes in steady-state conditions.

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

One respondent observed the accomplishments and progress appear to be in line with the project plans, while a second person stated that the technical results on how ammonia and nitrous oxide (N_2O) are involved in the reaction are very interesting and new. They are representative of the interesting results. One final respondent noted the LNT reactor data made available from ORNL has been used by more than two groups to develop catalyst kinetics. This reviewer added that an SCR protocol is in the development phase. PNNL has begun to develop kinetics from this protocol and has presented a first-pass kinetic mechanism for NOx reduction. It is not clear if this protocol is sufficient, however, since modeling is going on in parallel with the protocol development. It seems clear that a refined protocol will be developed.

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

Comments were generally positive in this section. One person commented the actual interactions in the programs are excellent, and the distribution of information via CLEERS is really important and valued by those who use these materials forums. A second person noted the university and academic lab participation is excellent. The focus of many of the current DOE aftertreatment CRADAs suggests that industrial partners are finding value in the CLEERS work and developing their own related programs as a result. One final reviewer noted that a typical focus group conference call with have more than 40 participants. This reviewer highlighted the fact that so many industrial professionals take time out of a typically busy day to participate in a technical phone discussion, adding that is a high indication of strong collaboration. This reviewer lastly noted the coordination with a number of other institutions to promote the modeling.

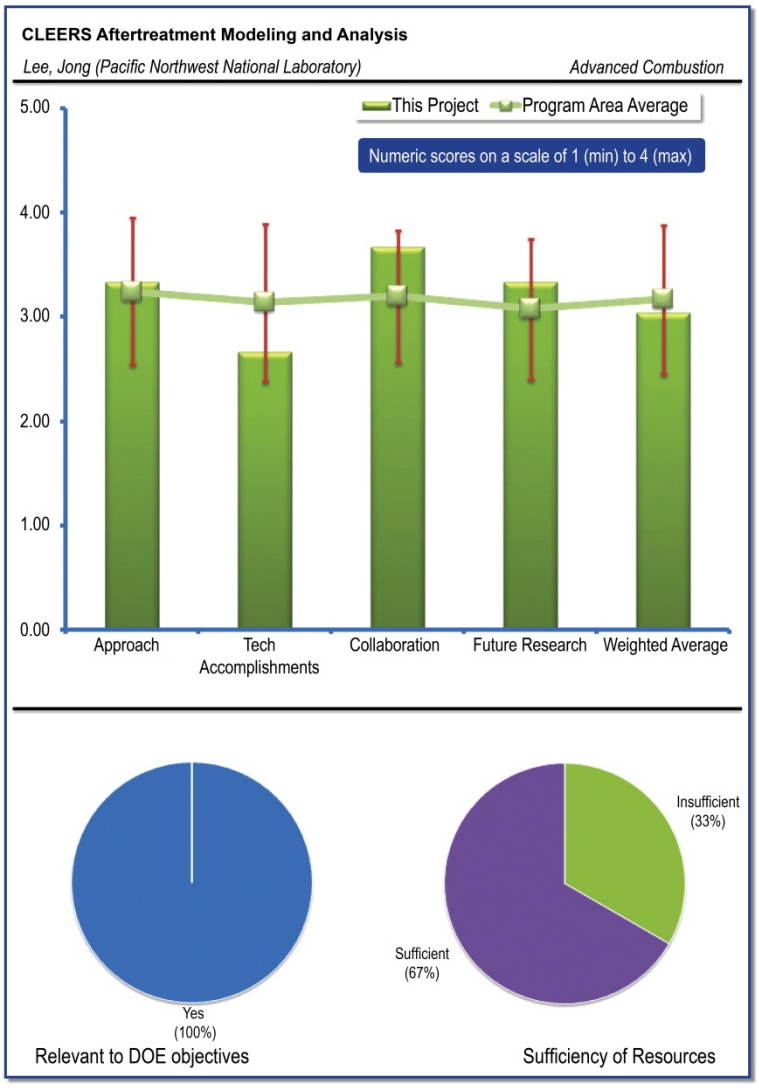
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments were somewhat mixed in this section. One reviewer commented that future work with the inclusion of aging and sulfur effects seems very appropriate. A second respondent, in contrast, noted very unclear discussion on what is being planned for the SCR fouling. Actually, this reviewer added, there was no clear definition of what fouling was viewed to be, and no procedure was identified to do either the aging or the fouling. This reviewer does, however, believe evaluating the kinetics of properly aged SCR catalysts is an important step in the modeling of these components. One final reviewer made a number of comments. This person said there is a perception that many DOE-funded programs are developing models of their own. Are they reinventing the wheel or building off existing work? If the former, are their ways we can transition to the latter? If the latter, perhaps we need to document this better to ensure that the value of funding this area is not underestimated. This reviewer also noted that an additional area where CLEERS might coordinate relates to broader utilization of the models for research guidance. Would there be value in brainstorming amongst the group on how different models might be "interrogated" to provide research guidance, either for formulation or application development? Lastly, this reviewer requested, with regard to experiments on hydrothermally aged SCR samples, please make sure that the aging requirements of the industrial stakeholders is adequately surveyed to ensure that the chosen aging is broadly accepted.

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

All three respondents said sufficient. The lone respondent here stated the funding allows quite a range of useful projects. There are certainly projects that could be added; however, this reviewer does not believe that ORNL has the staff to take on more projects. This reviewer added that future funding cuts could put in jeopardy this very useful program.

CLEERS Aftertreatment Modeling and Analysis: Lee, Jong (Pacific Northwest National Laboratory) – ace023



Reviewer Sample Size

This project had a total of three reviewers.

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

One reviewer remarked the project covers lean-burn aftertreatment technologies (DOC, LNT, SCR, filters), while another noted that the SCR portion of catalyst deactivation is a current need for industry. One final respondent commented the modeling serves as a basis for quickly optimizing and controlling systems for peak performance and minimum fuel penalty. Improved deNOx performance translates into lower fuel consumption with engine calibrations. This reviewer added that analytical work provides the tools for evaluating materials and developing fundamental understanding.

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 were mixed in this section. One respondent noted that the work is reaching a conclusion and is addressing the proposed goals. A second reviewer commented the group is using a state-of-the-art analytical and experimental technique to understand the base performance of several catalysts, and is evolving from current, base materials as well as new, experimental types (k-$MgAl_2O_4$). This reviewer is a little concerned about the universality of a detailed model developed on one catalyst or catalyst family. Can these models be applied to other catalysts? How can the models be made more flexible and universal? This reviewer added obtaining the catalysts ought not to be a barrier. They are available as replacement parts or might be obtained from the OEM. Fe-zinc (Z) are not the same. The final respondent said recognizing that it is often difficult for a national lab to keep up with proprietary developments in industry, it is good to see that PNNL is open to receiving new technology from an OEM (i.e., the state-of-the-art Cu/zeolite catalyst Cu/chabazite [CHA]). Use collaborations to stay relevant. This reviewer added that it is not clear who is leveraging CLEERS models. There are a lot of models out there. This reviewer thought there were more CLEERS activities than the PNNL CRADAs.

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

Comments were generally positive in this section. One person remarked the experimental and analytical results are quite impressive and will serve as a strong basis for developing models. This person likes the use of a wide variety of catalysts as a way of understanding the fundamentals. The competitive adsorption results on zeolite are very impressive and show the potential for the approach. The metrics of interest are a good indicator of utility. A second reviewer commented nice, careful work on most key issues. The LNT work was repeated later in a CRADA presentation and no modeling was included here. This second reviewer would

like to see more on diesel particulate filters (DPF) and DOC. One final reviewer commented this is mostly a characterization study and further observed that work is needed, though it will not address creating better SCR technologies.

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

Comments were generally positive in this section. One reviewer commented excellent collaborations with multiple industry partners and other national labs, while a second said PNNL is working well with GM from what this reviewer can see. The final respondent said fantastic assortment of fundamental, integrator, and industry partners. No gaps. There is not much information given on the sharing of data and level of collaboration, but there was some mention of conference papers for getting the data out to industry.

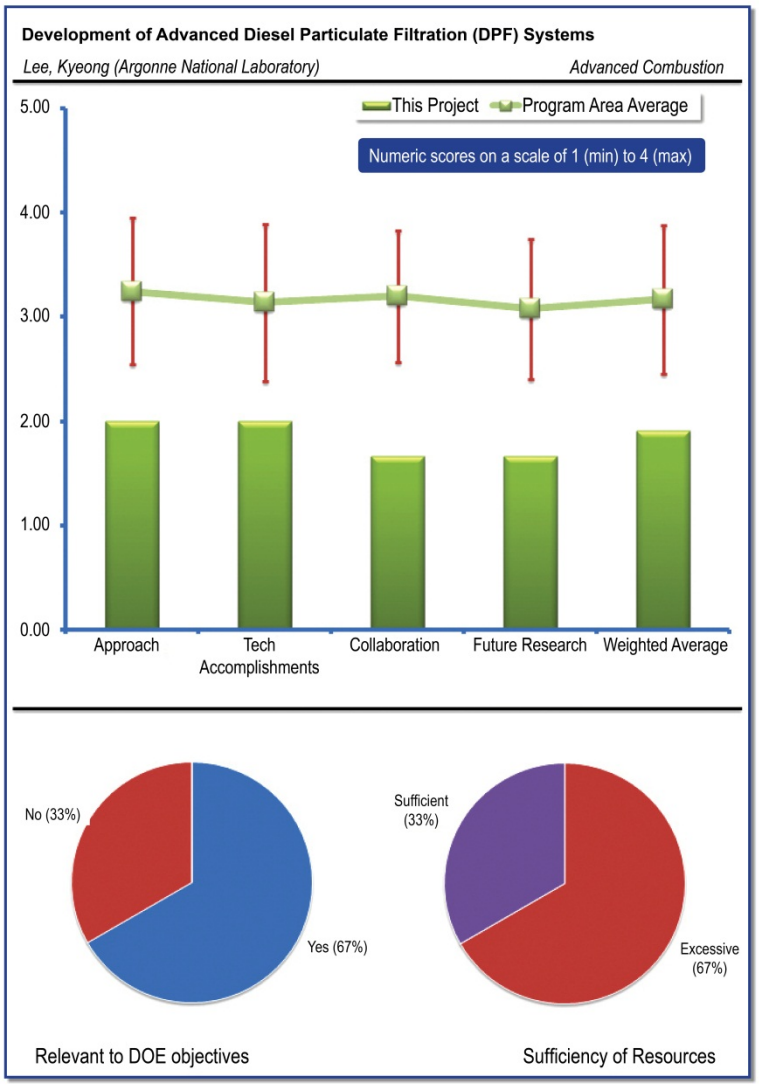
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said the systems approach is being followed and clearly defined roles are set. A second commenter stated the modeling work on SCR is very important to meet the high-performance demands of SCR to deliver fuel-consumption gains. This work should be accelerated. High-temperature (HT)LNT work is important for lean-gasoline applications that are coming later in the decade. This is important. This reviewer suggested de-emphasizing the DPF work, adding that the calibrations are going to low PM and high NOx. DPF performance with soot (regeneration, etc.) will become less important for fuel-consumption benefits. The final reviewer made a number of comments. This respondent said modeling Fe/zeolite is not interesting to U.S. OEMs, as mentioned by reviewers last year. Keep the prime work focused on Cu/CHA. Also of interest are materials that do not adsorb ammonia, i.e., modified zirconias (Rhodia, Umicore). This reviewer felt the fundamental work proposed on K LNTs will be very beneficial to understand the migration into substrates. The group needs to include substrate study in the next steps. This person added that a DPF model based on pore structure would be very beneficial to predict full-size filter behavior on materials/structures that do not exist yet and to determine how to integrate catalytic coatings. This final reviewer also asked about DOCs.

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

Two reviewers said sufficient, while one said insufficient. The lone respondent here commented the funding seems about right, but it may be a little light given the core nature of the project and the scope. However, this reviewer added, the results are impressive. Would more money give faster results?

Development of Advanced Diesel Particulate Filtration (DPF) Systems: Lee, Kyeong (Argonne National Laboratories) – ace024



Reviewer Sample Size

This project had a total of three reviewers.

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

One reviewer said lowering the backpressure of soot filters and enhancing their regeneration strategies will reduce the energy consumption associated with vehicle operation. A second respondent commented understanding and reducing back pressure in DPFs as a function of soot loading would be important for petroleum displacement in diesel engines using diesel and biodiesel fuels. The final reviewer believed that cordierite filtration is in general sufficient, but does not see this work providing any improvement in diesel filtration technology.

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 offered a number of comments and suggestions in this section. The first person felt the oxidation activation energy work was not particularly useful, adding there is really very little helpful information in the variation in the activation energies. This reviewer added the continuing work on the segmentally blocked channel approach still gives physically unreasonable results; there must be an experimental issue that is causing this. A second reviewer commented the general approach is appropriate, but has not yet covered some key systems. This reviewer added it is important to know the actual soot loading on the DPF, and that is not being measured. This is a key measurement needed to make sense of the "improved DPF" whose back pressure levels off for high times of soot loading. The final reviewer remarked that it is not clear how a number of activities will contribute significantly to meeting the objectives of this program, and went on to offer a number of specific comments. (1) Regarding the characterization of pore size with catalyst coating, the effect of washcoat loading on flow restriction is well known, and state-of-the-art coatings are minimized to lower their impact on flow restriction. This reviewer asks how this characterization contributes to a control strategy. (2) The PI has apparently resolved some of the variance in activation energy values obtained under helium (He) vs. nitrogen (N_2) or Argonne (Ar). It is not clear, however, how resolution of this disparity contributes significantly to addressing real world regeneration control problems. (3) Explanations associated with the observed advantages of the modified filter plugging strategy are inadequate. Pressure drop results are counter-intuitive. It appears that the filter model was developed without making soot loading measurements, which is problematic. How this design will contribute to enhanced regeneration control and filter survivability is unclear. If advantages in pressure drop are only observed at high filter loadings and the soot loading on the reduced filtration surface is actually increased (for example, a thicker soot cake in the downstream section relative to a conventional filter), then exothermic generation and associated filter melting would actually appear to be more likely. (4) Lastly, this reviewer asked how another TEM image analysis of soot contributes to the development of the enhanced control strategy targeted in this program.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Comments were somewhat negative in this section. One reviewer sees nothing particularly new accomplished in this project. A second respondent stated it is not clear how all of the completed activities contribute to the development of an enhanced control strategy. What is the approach for accomplishing this? What will differentiate this control strategy from others? One final reviewer commented the actual results show a leveling off of back pressure as the time of soot exposure increases, which presumably means more soot is present. So these results were not explained, even though the results are counterintuitive, since if soot is being collected, it would make sense that the DPF will plug at some point.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Respondents generally expressed uncertainty in this section. One reviewer said it is not apparent how the activities in this program are coordinated with the work carried out by others. Measurements appear to be repeated (soot characterization and activation energy measurement) rather than built upon. A second person commented it is not clear what in this project interests Corning. Corning's interest was not made particularly clear during the talk. One wonders if they were most interested in the pore size measurements. One final reviewer added that collaborators were not emphasized, so this is hard to evaluate. This reviewer added it does not appear that there has been much interaction with a company that would have provided guidance on how to proceed.

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 were generally negative in this section. One person noted, again, it is not clear how this work contributes to enhanced filter operations. A second reviewer commented that continuing in the direction shown by the past two years of reviews does not seem to have any value. One final person pointed out that, before proceeding with regeneration studies and some of the other work for the future, the grams/liter of soot in the brick needs to be determined. This reviewer added that only then can a better understanding of a near leveling off in back pressure be explained.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers said excessive, while one said sufficient. Comments were generally negative in this section. One reviewer remarked that there is no apparent payback for the money spent on this project. Another commented this program seems to have received a great deal of funding with little potential for capturing significant value and addressing the outlined barriers. This final reviewer assumed the resources are sufficient, unless there is no way to measure the soot loading available in the lab.

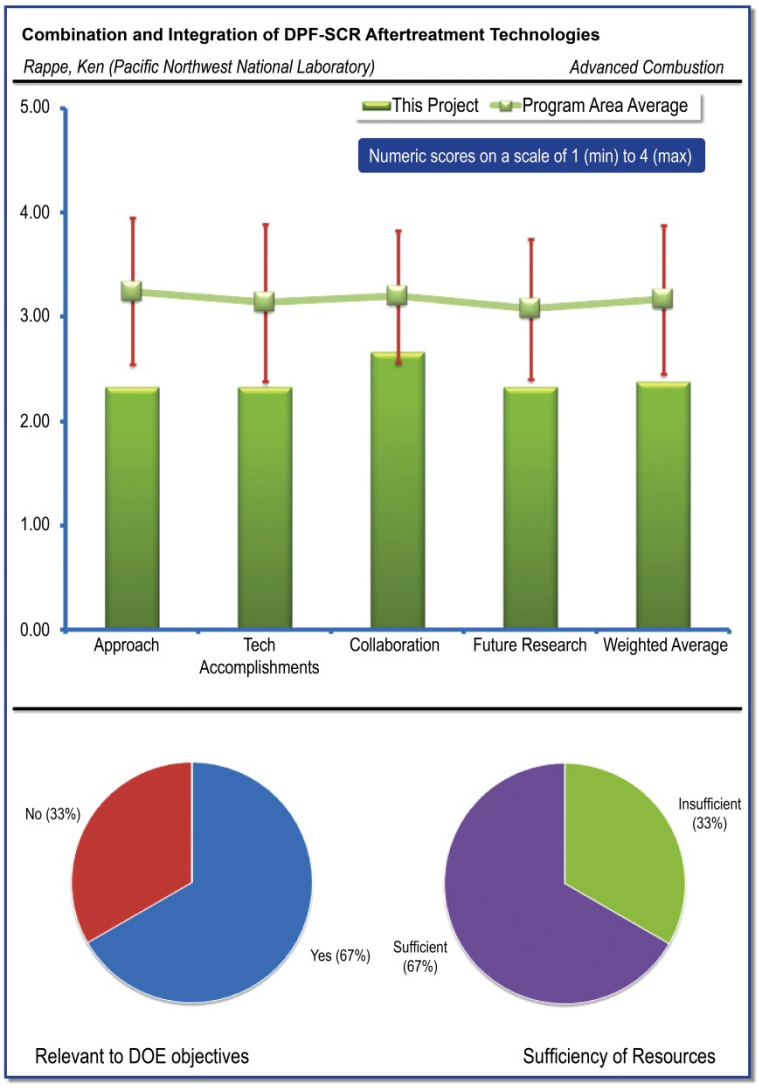
Combination and Integration of DPF-SCR Aftertreatment Technologies: Rappe, Ken (Pacific Northwest National Laboratory) – ace025

Reviewer Sample Size

This project had a total of three reviewers.

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

Comments were mixed in this section. One reviewer stated the topic is of relevance for potential cost savings in diesel aftertreatment. Another respondent said integrated DPF+SCR systems allow more SCR catalyst to be utilized on a vehicle within the same space. This results in higher deNOx performance and, the reviewer emphasized, thus lower fuel consumption through a higher NOx engine calibration. The final reviewer remarked that integrating SCR and filter functions will not necessarily result in less fuel usage. SCR filters have higher backpressure than conventional filters, with a lower safe soot limit resulting in more frequent regenerations. This reviewer added that, to meet the NOx target, another SCR brick is often required. The only possible way it could save fuel is if the original filter was located far downstream and by combining the SCR and filter, the location may be moved upstream, closer to the engine for less heat loss. This person added that this is usually not the case for heavy-duty systems.



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 offered a number of comments and suggestions in this section. One person said the evaluation of samples is behind schedule due to scaled-up catalyst creation. A second reviewer commented that, in essence, it appears the vendor simply provided DPFs with three or four levels of SCR catalyst and the investigators are testing various features. This person added that fundamental properties need to be linked to coating quality to help direct what type of coating quality is desired. The investigators are beginning to investigate fundamental properties, and this can add to the understanding of what a good coating is. The final respondent indicated the approach is centered on good SCR and should include good filtration function: testing full-size filters for maximum soot loading and regeneration behavior, as well as performance on certification cycles. This reviewer added that only then can the system be determined – is another SCR catalyst still needed, is a slip catalyst for ammonia (NH_3), CO and HC needed, etc. Finally, an assessment of the calibration impacts is needed – different regeneration frequency, temperature limitations, regeneration emission penalty, etc. This reviewer noted this was alluded to in the presentation, but no well-defined test plan was indicated. The regeneration frequency, temperature and duration will also determine the aging of the entire catalyst system.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Reviewers indicated some reservations in this section. One person noted the work is at a stop while the next set of samples to evaluate is being developed; not clear if this situation will be resolved. A second reviewer commented the results so far address critical aspects such as backpressure and coating limitations; they do not address regeneration behavior, duration, frequency, and aging. The final respondent remarked there does not appear to be anything profound here compared to what is now coming in the literature. This project is 60% complete, so the next 40% needs to focus on gaps and value (see future direction). A valuable contribution would be to tie performance to coating quality. This reviewer added that, fundamentally, there are gaps on the soot/catalyst interaction (NO_2 behavior, NH_3 behavior, the effect on NO recycling in passive regeneration, ash behavior, etc.).

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One person commented the right partners are here (research, catalyzer, OEM), but added it appears that the coating vendor is not doing much. It would be very useful to get different types of coating to tie performance to coating quality. A second reviewer commented that PACCAR seems to be still involved with the project, adding that a washcoater came on board, but there's been limited progress. The final reviewer commented that supplier involvement is essential and the interaction here seems good because it is resulting in valid samples to test. The interaction with the University of Utrecht appears to be rather informal and the objectives they have are probably not essential to the project; however, the speaker noted that they are not receiving any direct funding from DOE, so the loose relationship is understandable. That said, their work could be leveraged better to have more impact on the program objectives.

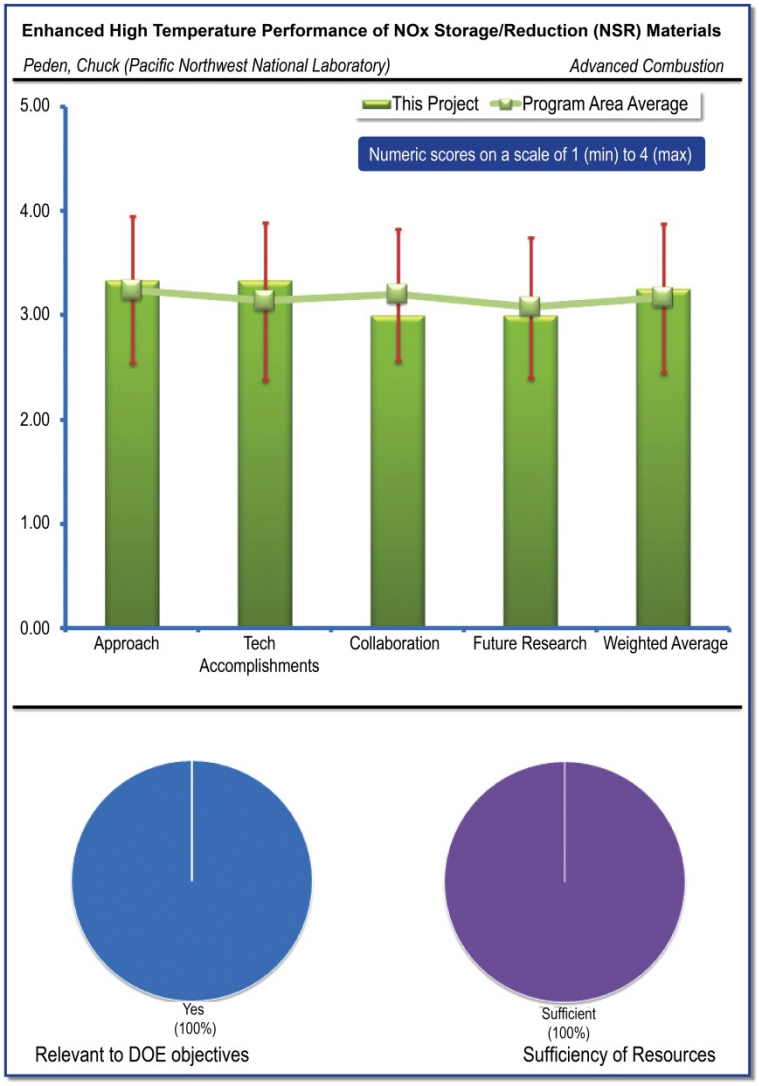
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One respondent stated that continuing with last year's proposed work is the next step. A second reviewer would like to see more on regeneration behavior of the integrated SCR filter and how the SCR filter fits into an emission control system. The final respondent indicated, looking at the nature of the experiments and work, it is critical to develop a usable and consistent coating method. This reviewer added the team needs to get this sorted as soon as possible to begin delivering valuable, usable fundamental information. Perhaps the team ought to determine the best type of coating: lining the pores versus the membrane. It seems best to this reviewer to promote the membrane approach rather than coating the pores, but then back pressure through the membrane will be very high. This will need to be resolved, and might be a very valuable contribution.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers said sufficient, while one said insufficient. The first respondent said sufficient, but the team needs to work more efficiently going forward to provide meaningful data (see previous comment). The other person to comment here indicated the funding level seems low for being able to really prove if the SCR filter is going to be viable in a diesel exhaust system.

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



Reviewer Sample Size

This project had a total of three reviewers.

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

One person stated better high-temperature performance for an LNT will be especially helpful, especially for lean gasoline applications. This work helps move along the high-temperature functionality of the LNT for practical applications. The other respondent said that, although SCR has become the aftertreatment solution of choice for HD diesel, advantages in low-temperature performance of NOx storage catalysts have resulted in their selection for many Euro 5/6 passenger car applications. They are of interest for lean DISI as well. This reviewer added that both of these represent opportunities for reduction in petroleum use in the transportation sector.

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 offered a number of observations in this section. One person indicated the methods and their application seem well designed. A second reviewer said that effectively PNNL is leveraging a long history of evaluating catalytic materials, adding that this work becomes outstanding because the work is able to compare work that is done under other projects. As long as the research group continues to be effective, it justifies very good ratings. In addition, this reviewer noted the utilization of high-temperature LNT catalysts is an important addition to the aftertreatment tool box. The extensive capabilities of this laboratory allow PNNL to synthesize similar catalysts to what is believed the suppliers have provided and can use that information to usefully evaluate the properties of potassium storage materials. The final reviewer said broadening the operating window to include higher temperatures is an important objective. It is well known that potassium (K)-based storage materials can accomplish this. Unfortunately, this reviewer added, desulfation and K-migration issues are also well known with these materials. PNNL has all the right tools to study catalysts; however, is an investigation of sulfation/desulfation the best approach? Do we need to step back a little further and investigate more closely how the storage components interact with the support oxide and the related interaction of the storage component with NOx to yield high temperature storage? Could this understanding lead us to new materials? This reviewer went on to ask if enhancing the thermal stability to accommodate higher temperature deSOx is really desirable. Doesn't this mean that more energy would be expended to accomplish the desulfation? Doesn't higher temperature translate into more precious-group metals (PGM) sintering, which drives the use of higher PGM loadings, or sacrifices low temperature performance?

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Comments were generally positive in this section. One reviewer stated the study of the John Marvin Inc. (JMI) and PNNL materials showed interesting effects on performance from the analyses done. We look forward to the data on desulfation at different temperatures on the PNNL materials to see if it matches the behavior in the JMI material. A second respondent said this is a nice evaluation of a supplier-provided high-temperature LNT. It is very helpful to see a relevant set of experiments on this catalyst. Generally the work attacks the relevant issues. The comparison to the potassium MgAl2O3 support is interesting. However, this reviewer added, the effect of oxygen storage is not evaluated and that is an important facet. The final reviewer remarked that some different materials have been prepared and relative NOx performances and thermal durabilities have been studied. The direction of upcoming surface characterizations is key. In related presentations this reviewer believes to have seen images suggesting that K might be present in different arrangements after different conditioning treatments. These are observations which should be extended upon.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One commenter acknowledged this research group is well connected to researchers who have characterized existing LNT formulations, studied the mechanisms of their deactivation, and are developing kinetic models consistent with these observations. It appears to this reviewer, however, that their existing catalyst supplier is providing very limited access and understanding of details related to their "advanced" formulation, and quite probably limited direction in the material discovery process that is central to meeting the objectives of this program. The other respondent commented that most of the work was done at PNNL, adding there seems to be little input from the partners; however, the work is good and the suppliers are providing prototype catalysts and allowing presentation of some of the results. This person added that the government supplier relationship is always a difficult balancing act between proprietary issues and the need for enhanced evaluation of new formulations. The fact that Johnson Matthey has shared this formulation is a good measure of their trust for the PNNL staff and their valuation of the PNNL work.

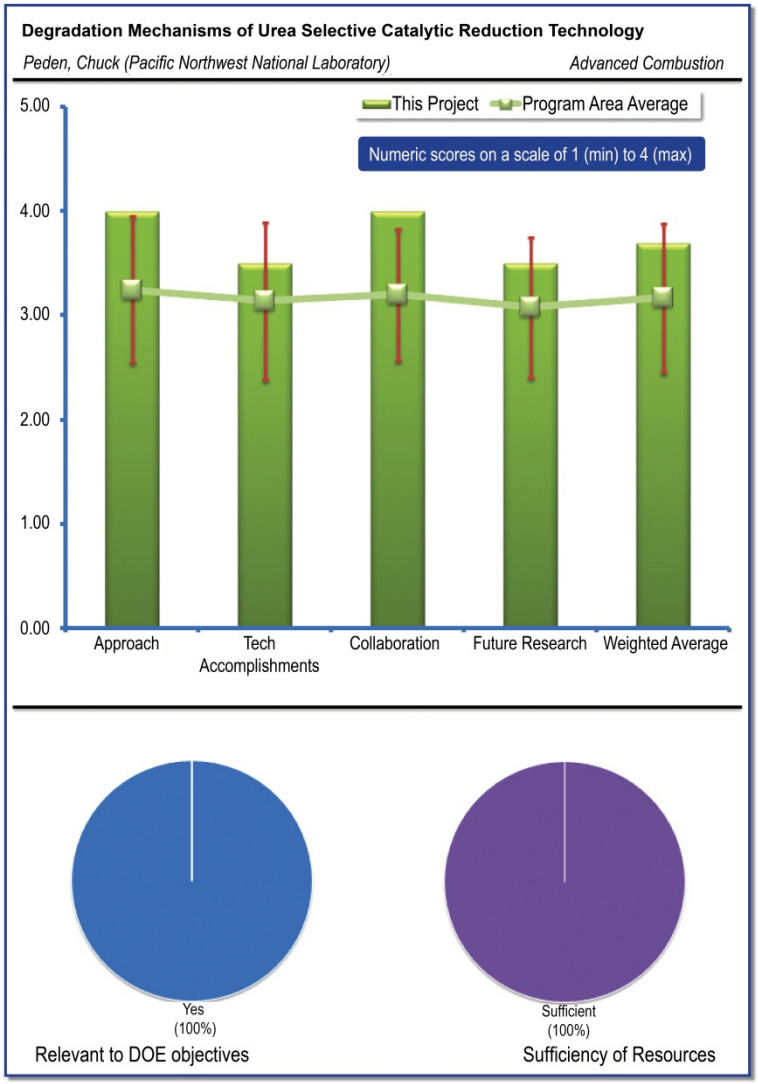
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One person noted that, under the section on characterization of the Johnson Matthey (JM)-supplied NSR, seeing the statement "determination of optimum conditions" causes it to sound like developmental work, not pre-competitive. This reviewer asks if this is appropriate for DOE funding. The other respondent wishes there were a mixed potassium/barium system in the future plans. This reviewer suspected that will be the NSR of the future, especially for gasoline applications. So far there is little information on the effect of the interaction between the two storage compounds. In addition, this reviewer added, the lack of oxygen storage is worrisome, but not a no-go issue.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All three reviewers said sufficient. The lone respondent commented the instrumental leverage of the national lab is extremely crucial to being able to successfully accomplish this project.

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



Reviewer Sample Size

This project had a total of two reviewers.

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

One person indicated SCR is a lean emission control technology that enables higher fuel economy than other lean NOx options, adding that understanding the DOC is important for overall system function. The other respondent emphasized the need to have durable catalysts to provide acceptable performance for the full useful life of the vehicle. Air quality is the priority. If there is degradation, this reviewer added, the system will need to be run in a less efficient manner. This project quantifies degradation.

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 thinks the approaches are spot-on: analyze road samples and run fundamental studies on lab samples, and then correlate results. The other reviewer said the approach seems sound, and would like to see details of the vehicle aging in the future.

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

One person commented they have found critical thermal aging mechanisms of DOC and SCR catalysts that should lead to lab agings that represent these mechanisms to the level of a vehicle-aged sample (to be determined). The other respondent noted the project is 80% complete. The DOC aging study results shown are so-so. The carbon impact is important understanding. What is the effect? Is it blocking or chemical? The PGM aging is less so. Quantification is good, but this reviewer is not sure this adds much to the understanding. What else besides thermal impacts can impact PGM growth and reaction? Sulfur aided? Maybe much can be gained by a quantification of chemistry to grain size, and this person encouraged trying to add insight into the relationship. This reviewer thinks the SCR XRD results are exciting and valuable, adding that correlation of the XRD parameters to performance could yield valuable test protocols.

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

One reviewer noted the government-industry cooperation seems impressive, highlighted the guidance, samples, etc. from industry and the quantification and analyses from the government. This reviewer added: good. The other respondent commented this is a 1:1 CRADA and the meeting frequency seems about right (audio every 2 months). This person also noted that there are no other institutions 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?

The first reviewer commented the plans seem reasonable, adding that the real value is on developing a protocol that can be fast and effective. The group seems to have some of the essentials here for that: XRD vs. performance, for example, on both DOC and SCR. The group has little time left and should make sure it spends it on tying everything together into a valuable package. Tests should be focused on filling in gaps, not on new testing, samples, etc. How do poisons tie into XRD results, for example? This reviewer warned about being careful not to get too diluted. The other respondent emphasized the need to understand chemical poisoning effects, if any, from the analysis of the vehicle-aged catalyst. This reviewer added that then these impacts may be incorporated in the lab-aging proposal.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Both reviewers said sufficient. One reviewer said the funding level appears to be sufficient to meet goals, while the other respondent similarly commented there seems to be enough resources to complete the study. This second reviewer emphasized the focus needs to be on wrapping this up and making sure loose ends are tied, as is not sure there is enough left to enter new testing.

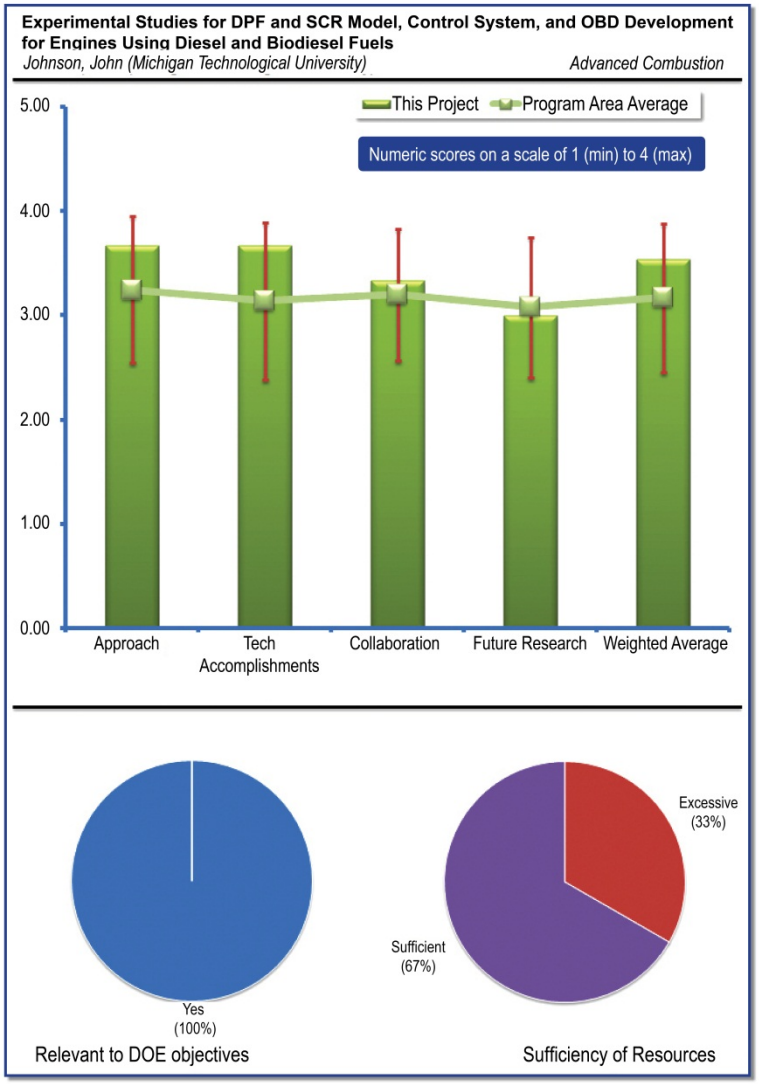
Experimental Studies for DPF and SCR Model, Control System, and OBD Development for Engines Using Diesel and Biodiesel Fuels: Johnson, John (Michigan Technological University) – ace028

Reviewer Sample Size

This project had a total of three reviewers.

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

One reviewer said optimization of aftertreatment system controls and OBD are important to the HD industry and directly impact combustion and fuel economy. The second person noted the OBD focus as part of the project is important to have long-term durability of the aftertreatment. Modeling could optimize the injection of fuels and enhance fuel economy. The final respondent indicated coupling the modeling with control strategy development is difficult and important to the ultimate application of one of these SCR-DPF combination devices. This reviewer added that one might wonder if this work should be done at the engine manufacturers. However, they do seem to be intimately involved in the project. Consequently, this might be viewed as the most cost-efficient way to develop a control strategy for this device for the industry.



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 were generally positive in this section, with a few suggestions. One reviewer commented that estimators are dependent on getting lots of data now at a lot of places, and coordination is key to this approach. The second respondent said this industry-integrated project seems to be a very effective way in which to accomplish the integrated system. This reviewer emphasized the integration of the aftertreatment modeling with the control strategy/sensor development and the full experimental application. This has all the pieces, and it should be very effective. This is one of the few projects that includes an approach to sensor inclusion and evaluation, and, as such, it deserves high marks.

The final respondent remarked that the approach appears generally sound; however, it seems like leaving maldistribution effects for NH_3 storage and soot loading to the end of the program could be a problem. If this reviewer understands correctly, 1D models are being used to fit the real-world data and drive development of the estimator. On the other hand, if there are maldistributions, are not parameters being adjusted to compensate, which will then have to be corrected once maldistribution effects are characterized?

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

One reviewer remarked this project is moving along well, adding that it is interesting that several of the elements of the project are moving along in parallel. The evidence seems to be that all the pieces are coming together. Other than the sensor work, this reviewer added, much of this is similar to the work being done in the rest of the technical community. The major accomplishment to this point is all the elements seem to progressing successfully and appear to be integrating. Individual accomplishments seem to be evolutionary. The other respondent in this section noted the results on the contribution of back-diffusion to passive filter regeneration are interesting; however, the fact that the highest relative contributing effects are being observed at the highest temperatures and exhaust flow rates may suggest that there is another mechanism that has been overlooked. This reviewer added that the progress on active filter regeneration appears to be behind schedule. During this short review, little was shared on the strategies and success/failure of associated PM sensors. Because this general area is of high interest to upcoming OBD requirements, this reviewer hopes this is only a reflection of the limited time for presentation.

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

One respondent noted the large team of folks from many places, while another stated this project is so integrated and cannot imagine that the integration could be much better in today's proprietary environment. The final respondent noted that 1-D models are being developed as a first step in the development of the estimator. This reviewer asked how these models relate to those developed previously by other DOE-funded programs. Are we reinventing the wheel?

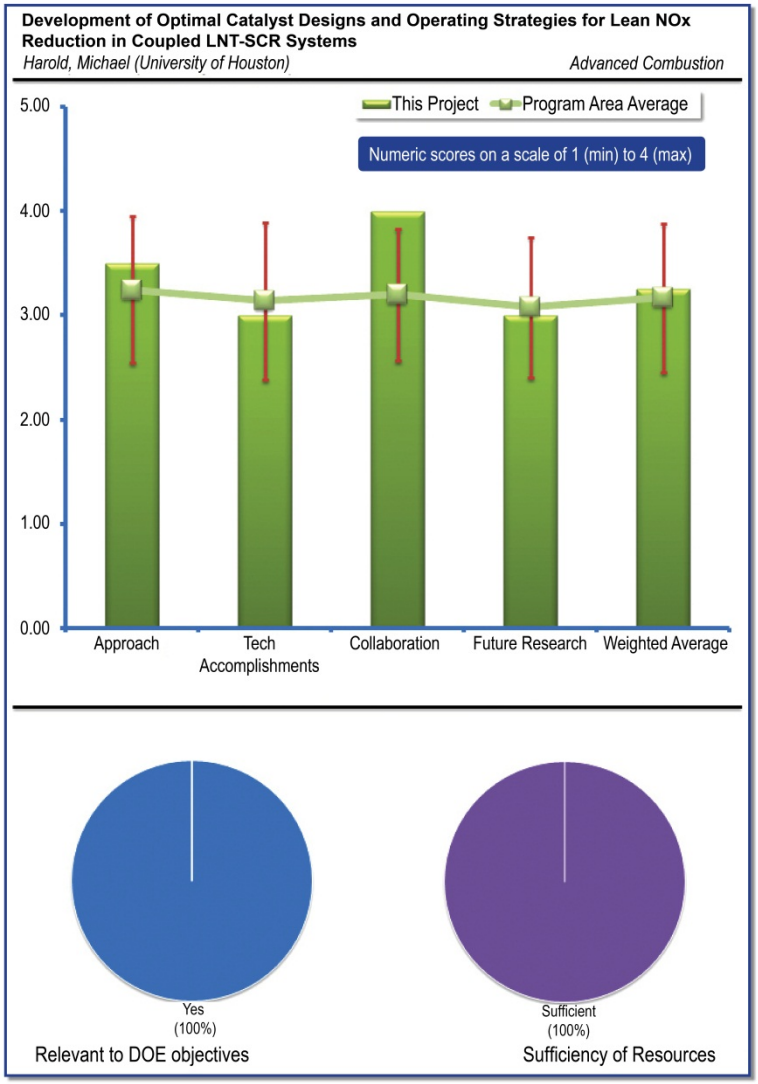
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers expressed some reservations in this section. One commented the project seems to be coming together on time, but added that if something does not fit it could have problems. That will be the major challenge for the research team. The reviewers were not given backup plans if one or more of the tasks is not successful or falls significantly behind. This reviewer suspects that there is some backup plans in consideration, but it could be a big enough problem that it should have been included in the review. A second reviewer indicated there is still a great deal to accomplish. Is it possible to do it all? If not, which objectives will be given highest priority? The final respondents felt that the inclusion of so many estimators and getting them to come to fruition together seems challenging; independent estimators would at least not depend on all the others working.

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

Two reviewers said sufficient, while one said excessive. One reviewer commented the resources seem to be sufficient and everything seems to be getting done. The other respondent remarked that, with the widespread commercialization of filter + SCR systems in 2010, future projects need to strive to address precompetitive technical challenges. This reviewer added that it seems like this program provides an excellent learning experience for students, but may not contribute as much to technology advancement as the equivalent money spent elsewhere could.

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



Reviewer Sample Size

This project had a total of two reviewers.

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

The first reviewer commented that the project concerns lean NOx control for higher fuel efficiency at lower cost. The other respondent said lean burn, dilute (EGR) gasoline engines are emerging as the most efficient. OEMs are projecting application by decade's end. Engine-out NOx emissions are nominally Tier 2 Bin 5 (0.3 g/kWh). Nominally 70-80% deNOx is needed to meet State of California Low-Emission Vehicle III (LEVIII) requirements. This work could provide an attractive deNOx option for these engines, allowing them to focus on even higher fuel economy.

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 person said the design is very well thought-out. There is a fundamental understanding of each unit operation and modeling, and then using that understanding to determine the best configuration. Hypotheses, results, explanation, confirmation, retest: classic. The other respondent said the approach includes link of rxr tests/modeling to vehicle testing. However, this reviewer added, it was not clear what vehicle would be tested.

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

One reviewer was glad to see someone finally study in detail the sandwich and layered LNT SCR approaches. The other person commented that the results more than half-way through are quite interesting. There are new findings (impact of HCs on deNOx in SCR), and NH_3 drivers in LNT. This reviewer added that the base understanding is being developed to begin optimizing the system.

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

The first respondent noted good collaboration with multiple research groups, leveraging their strengths. The second commented that, by all indications, this is a well-managed project. Coordinated and meaningful contributions are coming from all partners. Strengths of each are being utilized. It is well done, this reviewer concluded.

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 the SpaciMS work on layered or zone coated samples might be very interesting. It might be interesting to look at LNT-SCR mixtures, understanding problems with PGM migration. The other respondent was unconvinced that Fe/zeolite is appropriate for this system, and added that Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS) studies should help elucidate the non-NH_3 mechanism.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Both reviewers said sufficient. The lone respondent said the project is large and well managed, adding that resources are large, but adequate.

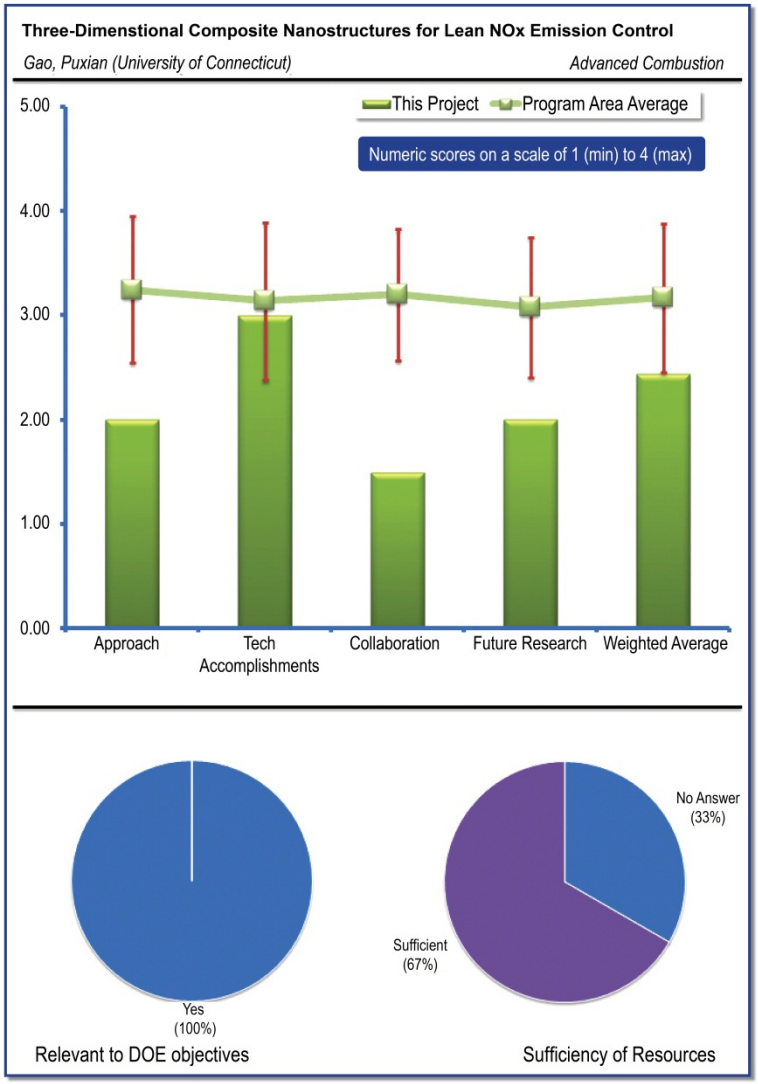
Three-Dimensional Composite Nanostructures for Lean NOx Emission Control: Gao, Puxian (University of Connecticut) – ace030

Reviewer Sample Size

This project had a total of three reviewers.

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

One reviewer said that this is extremely advanced catalyst/material science being directed toward an area where breakthrough technology is required. It needs to be recognized that it is high risk. The other person commented that reducing the PGM content of aftertreatment catalysts is an enabler for future high fuel economy engines. So far these materials seem to be using the same amount of PGM loadings that are commonly used in production. This is a highly speculative project, and as such it still has potential to make a significant breakthrough. However, this second reviewer cannot find much evidence in the presentation that any NOx reduction measurements have been accomplished. This work cheerfully discusses a range of microsynthesis, but there is still very little evidence that this microsynthesis has any impact whatsoever.



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 novel material and structure for an emission catalyst. Alternative support oxides may be required to enhance thermal durability and sulfur tolerance. It is critical to assess whether the type of surface area associated with this type of catalyst architecture adds value. Simple reactor experiments demonstrating activity of base concepts should be pushed forward quickly. Hydrothermal stability is more important than simple thermal stability. Also, it is not clear to this reviewer if the atomistic modeling will add value. This reviewer may become a believer if initial catalytic results are encouraging and these models are proven to point in the direction of improved materials. The second commenter noted that the synthesis work appears to be outstanding; however, the definition of the NOx reactions to be treated is not discussed and seems to be very poorly understood. Even though emission testing is listed as an accomplishment, as best as this reviewer can determine the work has only shown simple CO oxidation, and no NOx testing has yet been attempted. This should not be considered as an accomplishment at this point. Additionally, many of the perovskite materials that are considered in this project are very sulfur sensitive. However, there has been no sulfur poisoning testing. The rationale given for sulfur resistance could be correct; however, there was no evidence given that the "sacrificial" theory of the nanowires was not justified with any additional evidence. This reviewer is extremely uncomfortable with density functional theory (DFT) as the justification of catalytic activity. This is insufficient because it is based on an idealized structure, which is probably not realistic. Also, the DFT calculations are based on an assumption of a particular reaction mechanism/pathway. The reviewer adds that that is just not sufficient.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Reviewers expressed some concern in this section. The first said that a range of materials has been generated, and added that activity tests are desperately needed to help establish project credibility. A second respondent commented the synthesis work appears to be quite creative; however, the funding and goal for this project is NOx reduction or oxidation (the PI is not at all clear about this focus). Consequently, this reviewer thinks the progress must be viewed as very weak. The final reviewer said the project team has prepared and tested as materials the titanium dioxide (TiO2)-coated material and some with metal. They have Brunauer-Emmett-Teller (BET) numbers, but have not demonstrated why this would be any better than other options.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One person said Honda seems to be the major consumer contact, and some materials have been provided by Honda; however, there is very minimal evidence that Honda is an active participant in this project. A second respondent stated this appears to be a fairly isolated research program. Although there is some industrial sponsorship, the PI is encouraged to seek support and direction from an emissions catalyst company. The final reviewer said it is not clear how much interaction and guidance is being received from the OEM and other suppliers to help focus what measurements to make.

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 commented that reaction tests need to be given highest priority. The other respondent noted that there was no clear indication of the specific catalytic process that each of the coatings was made to enhance, adding that no sulfur testing seems to be in the plan. Emission testing seems to at least be in progress, but did not seem to be an aggressive part of the program. This reviewer added that there seems to be an excessive focus on thermal stability at the detriment of a number of other gateway barriers.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said resources appear to be sufficient to establish and achieve the current objectives, while another reviewer was not sure. The final respondent said this is a high risk project. This reviewer does not believe that this project can be accomplished with less funding, but cannot justify additional funds at this point with the relatively low promise so far demonstrated. This person added that the focus should be adjusted to provide better evidence that this approach has promise. If better promise is not shown in the next year, this reviewer would recommend termination of the project.

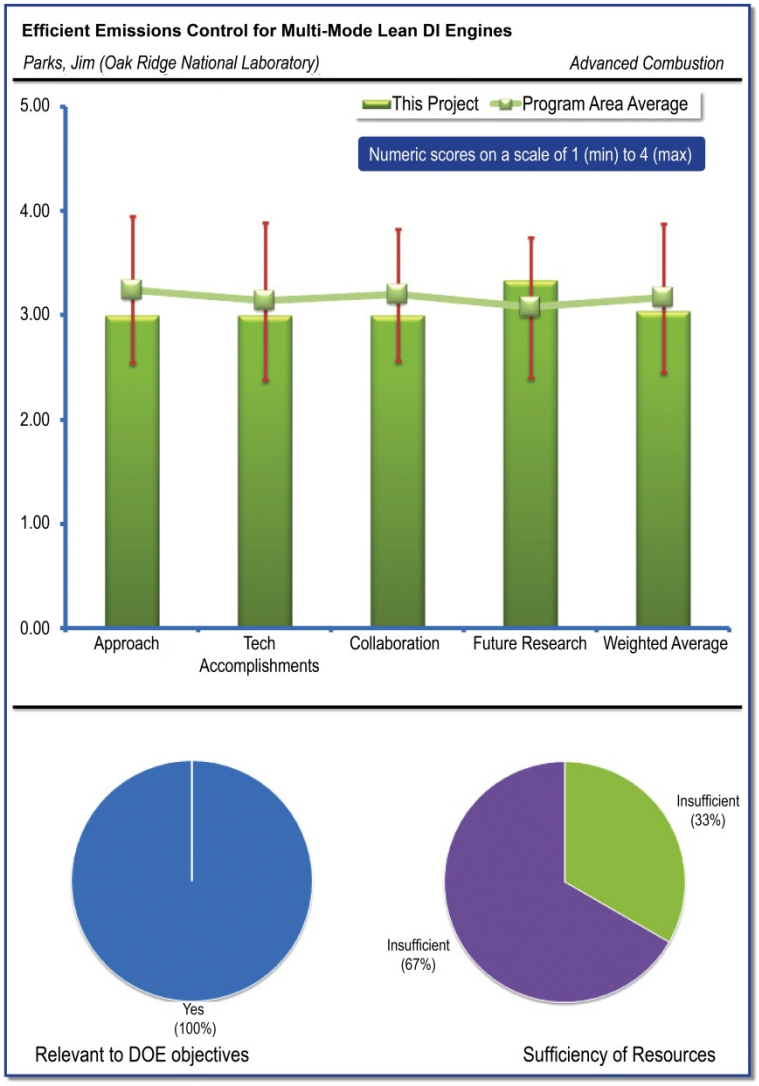
Efficient Emissions Control for Multi-Mode Lean DI Engines: Parks, Jim (Oak Ridge National Laboratory) – ace031

Reviewer Sample Size

This project had a total of three reviewers.

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

Comments were generally positive in this section. One reviewer commented on the engine combustion modes to enable higher efficiency and lean aftertreatment, thus saving fuel. A second reviewer remarked that advanced combustion modes can deliver higher combustion efficiency and unique emissions issues, adding that this kind of fundamental and practical understanding will advance these kinds of engines, leading to lower cost of high-efficiency platforms. This reviewer added it is very important to take the fundamental work to the next step to begin showing practical application and solving unknown fundamental problems; excellent! The final respondent similarly commented this project supports the necessary emission offsets that may be required for implementation of RCCI and PCCI technologies, which are purported to significantly improve thermal efficiency and fuel economy of diesel- and dual-fueled applications.



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 offered a number of comments in this section. The first respondent noted the excellent example of taking fundamental work (RCCI) into a practical application, coupled with advancing further, pointed fundamental understanding. This reviewer added that the engine is a good choice. The combustion modes seem well understood (very important to get a good representation), and this reviewer noted the very solid base understanding of these issues by the investigators. A second reviewer felt it was good to include DOC and SCR technologies in the study on new combustion modes, and would like to see DPF included and system interactions – but perhaps this requires more funding. The final reviewer said technical barriers are addressed well for the scope of this project, which is focused on exhaust aftertreatment. As a standalone project, this reviewer added, it could be rated at least 3-4; however, the basic work that is being done on PCCI and RCCI technology is not yet producing significant gains in thermal efficiency or fuel economy, so the work being done here to take care of the increases in HC to achieve the reductions in NOx may not be the final direction that is needed. (RCCI: 10x engine out (EO) HC increase, 10x EO NOx decrease; PCCI: 2x HC increase, with 1/4 NOx of baseline).

This final reviewer also added that it was not made clear that, once the RCCI and PCCI activities were successful at producing significant improvements in BSFC or Thermal Efficiency (today's data: RCCI with 1.5% improvement in BTE and 10x degraded HC performance, and PCCI with "comparable Brake Thermal Efficiency to conventional diesel with reduced NOx emissions" and 2x

increase in EO HC), the emissions to be corrected would in fact be what is being used to evaluate aftertreatment technologies. This reviewer said demonstrated, and asked if the 10x HC increases will be the real problem to be solved.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Comments were generally positive in this section. The first reviewer said excellent characterization of PM/particulate number (PN) from the three engines, and added it might be interesting to see composition work to better quantify particulates (ash differences?). This reviewer added good start on Nanostellar catalyst work. It looks like the group is on the right path. It would be good to have some fundamental characterization to gain understanding and improve performance. This reviewer also noted the very impressive and important new results on HC adsorption on zeolites. Speciation, distribution, and oxidation behavior on zeolite are all valuable fundamental findings. A second reviewer commented that, considering the base work to improve fuel economy is not fully complete and the premise "RCCI is fuel-efficient with emissions that can largely be controlled with DOC alone, thus reducing the fuel penalty and cost of the after treatment system" was not demonstrated, significant progress has been demonstrated in aftertreatment development for the RCCI case. The final respondent noted the project is serving an important purpose in bridging the gap between engine and reactor. It is nice to see a relevant SCR catalyst being utilized. This final reviewer suggested more on filters and system interactions/approaches.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers were generally positive in this section, while offering some suggestions. The first person said the collaboration with ORNL and University of Wisconsin (well known for leadership in RCCI work) is a great asset. Catalyst suppliers are being leveraged. This reviewer added that CLEERS is a strong resource for crosscut activities and can provide additional confirmation that the assumptions for the PCCI and RCCI base engines and fuel savings assumptions/results are on track. A second respondent indicated the GM collaboration is important to make sure the engine modes are representative and adding credibility; this seems accomplished. ORNL has enough experience on what the practical issues are, but GM also seems to feed into this. Perhaps lacking might be some feedback into the more fundamental investigations from the national labs or universities. However, this does not seem to be a major issue. The final reviewer expressed a need for a better DOC benchmark than the model DOC. This reviewer suggested a current production catalyst on medium-duty trucks, and that the group solicit Manufacturers of Emissions Control Association (MECA) and U.S. OEMs for samples. This reviewer noted good collaboration with other groups to leverage their knowledge and maximize the use of the funding.

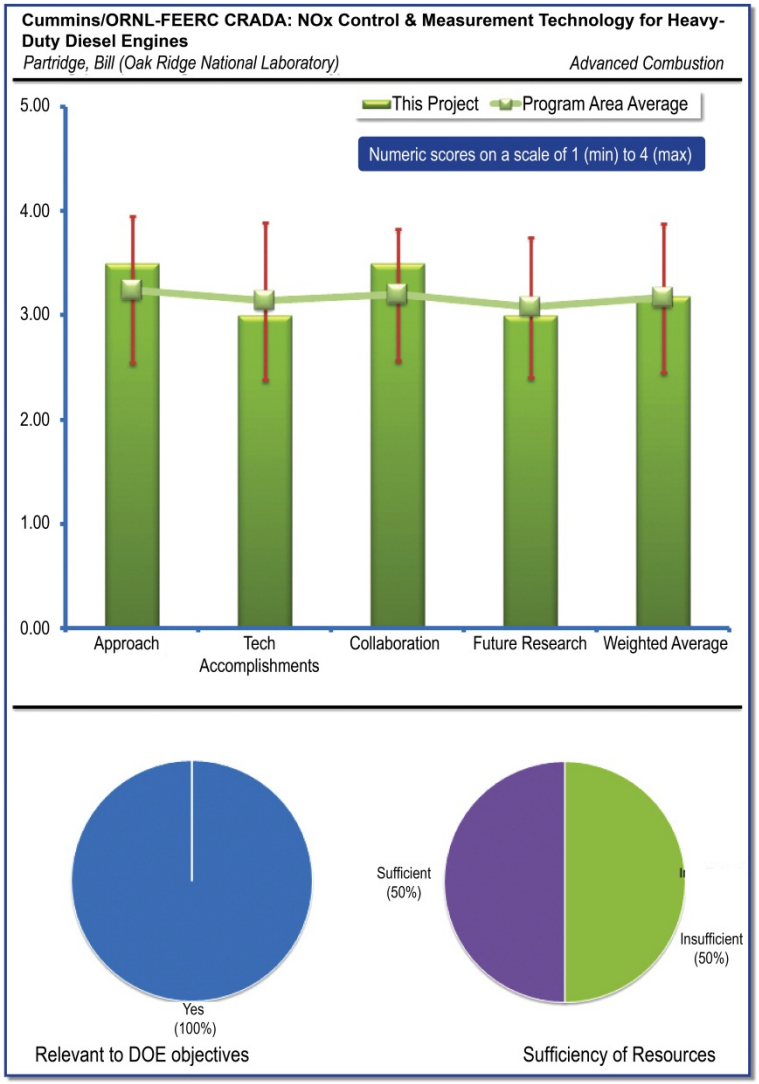
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Reviewers offered a number of comments in this section. The first person remarked HC speciation and coking behavior on zeolite SCR catalysts is extremely important; consider zeolite in DOC as well. Another respondent said that, although controls work is being done on the "combustion side" of this project, it is clear that there will be a need for future controls-level and modeling work for the aftertreatment side for NH_3 generation. The final respondent said further evaluation of DOC under different modes is important. It might be interesting to couple this with a more fundamental understanding/confirmation of the mechanisms, and perhaps more speciation/performance coupling should be considered (what about heavy HCs; higher-CO modes?). This reviewer noted it is critical to look at the HC adsorption on zeolites and the effect of the exotherm on durability. This reviewer's guess: CuZ will show very different effects. This is at the heart of HC adsorption issues on zeolites. Regarding the DPF directions: the group is spot-on on DPF implications from advanced-combustion modes. Low-temperature (LT) PM needs active regeneration, and this is no longer needed here. DPF implications are significant. Also important: ash. This is an emerging issue, and one needs to be ahead of the health authorities on it. This final reviewer asked if there are differences in ash emissions and composition with different combustion modes. What about some insights into ash distribution on DPF? Impacts of low soot on filtration efficiency?

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers said sufficient, while one said insufficient. One reviewer said the funding is appropriate for the aftertreatment technology studies. The other respondent asked: $200K per year on such critical work? This reviewer noted the group is delivering incredible value and has to ask: what could be done by doubling the funding? Excellent track record, key results, good understanding of weeding out the next level of problem solving. This reviewer concluded: go for it!

Cummins/ORNL- Fuels, Engines, and Emissions Research Center (FEERC) CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines: Partridge, Bill (Oak Ridge National Laboratory) – ace032



Reviewer Sample Size

This project had a total of two reviewers.

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

The first reviewer said correlating the catalyst performance with the engine variations is very necessary to assist the OEM electronic control unit (ECU) developers in producing the optimal engine control strategy. The other respondent commented that the diagnosis of emission control systems is in its infancy with new challenges still arising (NO_2, PM, etc.). Inefficiencies in combustion control and aftertreatment system diagnosis drive the utilization of larger and more complicated systems, which in turn drives up the cost of emission compliance. This ultimately limits diesel penetration into the North American marketplace.

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 said this program illustrates excellent utilization of DOE money and national lab expertise: let industry identify difficult technical problems that appear to require special tools to better understand the fundamentals, then let the national lab develop/provide the tools, techniques, and analysis to address the problem. The other reviewer commented that overall the SCR catalyst evaluation studies are great. The hallmark of this work over the years has been the instrumental development and measurements. This report has continued that consistent series of successes. The reviewer adds that perhaps his or her only discomfort is that the work is such a mélange of technologies that a focused approach is difficult to identify. However, the success of this group in getting these approaches into common use in the technical community allows them a significant measure of leeway.

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

The first respondent commented that the tool/technique for estimating intake EGR-mixing is envisioned, design validated, and readied for real world assessment. Bravo! The other reviewer indicated that there is such a mixture of projects presented here that a clear definition of accomplishments is hard. (1) SCR work: there are very good indications of spatial information on the ammonia storage; however, with no accompanying modeling information, it is difficult to see where it fits with the work of the Trinconi group or the Koltsakis group. This reviewer had a mixed response here. (2) CO_2 fast measurement: this could be a game changer for determining the response of CO_2 to changes in engine operating conditions. Very good response here. (3) LNT measurement: there is not enough

information to make a judgment. This is continuing work, but it is not obvious where it fits with the CLEERS LNT measurements. Is it part of them?

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The lone respondent said the collaborations are outstanding. It is very clear that the work is recognized as enabling, and multiple partners are willing to work on these measurements. This reviewer wishes they would get more reports on the partners' work to see how much of an impact it has. This reviewer especially likes the number of visitors that the group brings in, adding that this makes the collaborations work especially well.

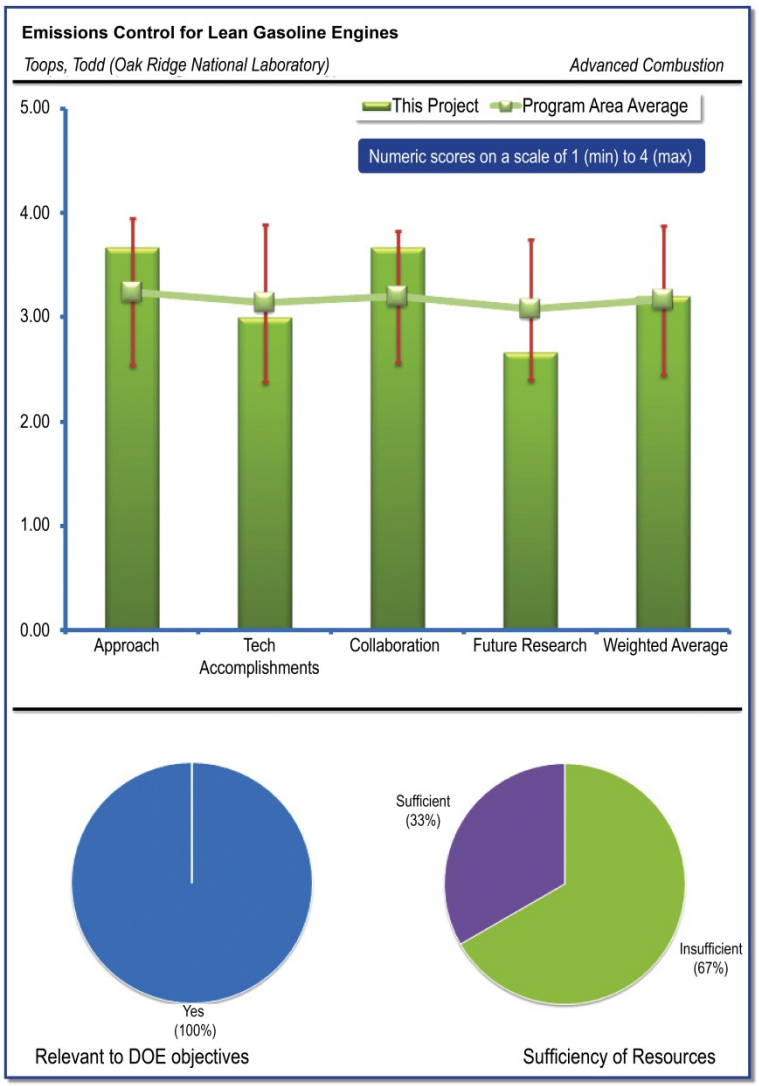
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first commenter mentioned that "Self-Diagnosing" SmartCatalyst is a big challenge, which will take time. It has a much higher risk for failure. The approach appears sound. Many people seem confused by name. This reviewer added that sharing more on the approach and plans for the development of fiber sensors would be useful. The second reviewer said, based on past history, most of these future plans will work out; HOWEVER, they are awfully vague and make it hard to judge. For the control work, how is this going to be implemented? Is there an active partner to use the control work? Is it Cummins? With the communication limits on the CRADAs, it is difficult to tell. When is the Fuel-in-oil work going to be declared a success and fully transferred? Is there a clear way to share the combustion variation information with the technical community? Very weak on the mid-infrared (IR) laser and the fiber based ammonia plans. Very hard to judge.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer said sufficient, while the other said insufficient. The lone respondent said their resource ranking is not a funding comment. This reviewer wishes that there was more engine modeling attached to this project to evaluate the measurements. It is not clear that the resource is being effectively developed.

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



Reviewer Sample Size

This project had a total of three reviewers.

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

One reviewer commented aftertreatment that enables lean burn gasoline. A second person said successful Lean NOx Trap technology (efficient, low fuel consumption regeneration, cost effective, and durable) may enable 5-15% fuel economy savings on gasoline engines. Three way catalysts have the limitation that they are not able to operate efficiently in lean exhaust stream. Optimization of LNT technology through improved technology, modeling to minimize regeneration fueling, and product durability are needed.

A third reviewer said Toyota, Nissan, Ford, and Mercedes have all publicly put lean GDI on their long-term technology roadmaps. Toyota showed 48% BTE at an operating point, while emitting only 0.3 g/kWh NOx (Bin 5 levels). This reviewer added that 70-80% deNOx will be needed to capture these very impressive results in a practical application. Dilute (EGR) and lean gasoline will be the future ICE in the U.S. to a large degree in the 2016 to 2025 timeframe.

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 the project is taking fundamental understanding to the next step (engine), with inputs from a catalyzer and OEM, with loop-back into the fundamental understanding; generous public disclosure of results: beautiful. This reviewer added good engine choice, and commented it would be nice to bring the engine to a lean limit with and without EGR to better represent future direction, but the project has a good base engine. Another commenter stated best approach slide of any emission control project presented so far. Great way to see the link from fundamental catalysis to on-engine studies. It would be nice if a U.S. OEM engine were used. This reviewer went on to suggest that perhaps there could be a link to a U.S. industry project currently developing lean burn engines, adding that these engines will not be available for a while, though. The final reviewer noted the study and modeling of 3-way catalyst and LNT exhaust to optimize performance, as well as the evaluation of industry-supplied catalysts to improve performance.

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

One person felt that the characterization of engine operation and performance is good. It improves community understanding of base lean-burn engines today. The result on rich gas composition from a TWC is interesting. Good investigation. Bench work on NOx storage characteristics is very well designed and analyzed. Good correlations and descriptions/analyses. Nice, new understanding, at

least regarding public domain. Valuable to get out and communicate. This reviewer added that Ceria impacts are well-known, but perhaps not well documented elsewhere. Marginal benefit to community understanding. However, calcium impacts are new, interesting, and important. This reviewer wants more! A second reviewer said particulates should be measured; this was alluded to but not presented. The final commenter said modeling of single case LNT TWC configuration has been achieved and shared. Literature-based numbers have been quoted for fuel economy; however, no significant benefits for fuel economy were made or claimed for this study currently or in the future plans. As an enabling technology for lean combustion, some clear path to demonstrate actual fuel-economy impact is recommended.

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

One reviewer said the research has got it all, and everyone seems to be involved: ORNL facilities and practical-fundamental ties; GM on the engine results and pertinence (hats off to them in choosing a competitor's engine); Umicore involvement is obvious and significant, important; fundamental loopback is also there. This reviewer did not see too many results, but the impact is there; project seems quite well managed. Another reviewer noted the coordination with CLEERS, Umicore, and loosely with GM, and added that communication about details of direct benefits from CLEERS participation is recommended. One final reviewer encouraged more interaction with catalyst suppliers.

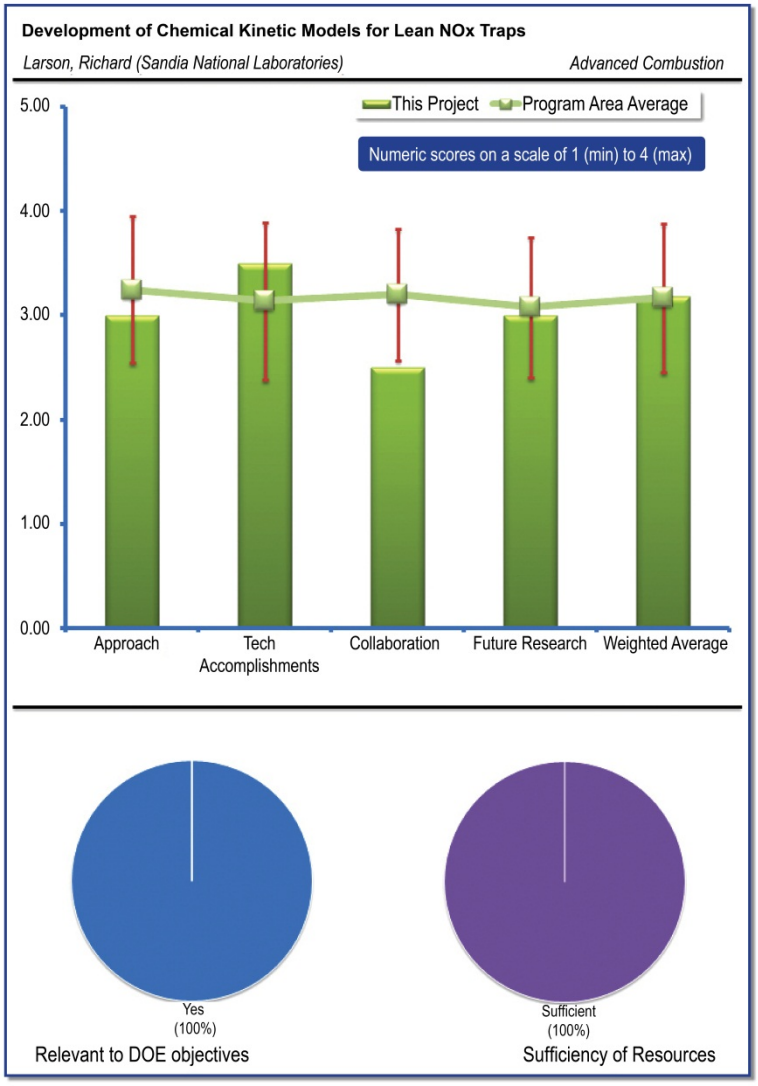
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the plan for future work is building on past work. Specific goals showing the fuel economy improvement that is planned for this project and the approach to get there are possible improvements. This reviewer added that systematically evaluating, modeling, and sharing data through CLEERS on aftertreatment material technologies is an excellent approach that can multiply outputs of research. A second respondent suggested the investigator consider moving into extra lean (lambda 1.6, maybe? find lean limit, even go with a strong spark). Add EGR to maybe 10-25%. These are the future engines. Maybe this is next proposal/program. Regarding the sulfur and calcium work: craving fundamental understanding on calcium effects. Regarding the Ceria work: the researcher may want to pull back on this. Oxygen effects and others are well-understood. This is the base LNT. The reviewer suggested the investigator broaden out into other oxygen-storage materials, if he still wants to go down this path. The heated microscope is interesting and a good example of using new, fundamental tools. The final reviewer commented on the need to leverage industry projects on lean burn gasoline and get a new engine aimed at U.S. emission standards. Continue to share engine data back to CLEERS. Also, try urea SCR approach. Medium-duty diesel trucks are already using it, and its applicability to lean gasoline has been shown by other groups. This reviewer added that urea SCR would allow for even greater fuel savings.

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

Two reviewers said insufficient, while one said sufficient. The first reviewer said $200K is delivering quite a bit here. This seems so small given the scope and parties involved. Engine work alone will eat this up. What happens if you add more? This is a very critical and important area – lean gasoline – and is clearly underwhelmed here. One reviewer commented that the resources are sufficient for the size and scope of this project, while another said the project appears to be making good use of the funding available, adding that more funding would allow for more technical progress.

Development of Chemical Kinetic Models for Lean NOx Traps: Larson, Richard (Sandia National Laboratories) – ace035



Reviewer Sample Size

This project had a total of two reviewers.

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

The first person commented that making the connection between the microkinetic model (of which this work is a good example) and the global reaction kinetics that are a commonly used approach in industry is important. This work provides a basis for validating and evaluating the global models. The other respondent said LNTs are being applied widely in Europe to meet Euro 6 LD emission requirements. Lean DISI engines represent a potential next step in furthering the efficiency of gasoline engines; however, without advancements in LNT technology that increase their efficiency and lower their cost, this may not occur.

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 said that the development of the model appears to be progressing well, with new attributes being incorporated to enhance applicability. This person added that the coordination with CLEERS data acquisition is good. The other reviewer commented there is rarely a comparison of this work to a global mechanism; consequently, there is no way at present to evaluate the short comings of the typical global reaction mechanism. This persona added that a comparison of this work to the predictions of Kocii (Catalysis Today (2009)) would be most informative and would be a more extensive justification of the funds invested in this project.

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

The first reviewer is extremely impressed with the agreement between the experiments and the sulfur poisoning models, noting that this comparison has been viewed as a significant barrier. However, the extension to a global sulfur poisoning mechanism is not obvious. The other commented noted steady progress in key areas that do not seem to be addressed in other LNT simulations (i.e. sulfation/desulfation).

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

One reviewer noted close collaboration with ORNL to obtain critical test data. The other respondent commented that, at this point, there is no clear connection to GM and the modeling, adding that more detail on that would have been helpful. The connection with

ORNL is good; however, it appears from this presentation to be almost one way (i.e., from ORNL to SNL). This reviewer noted it would have been very helpful to have SNL indicate how they have modified any experimental approach used by ORNL.

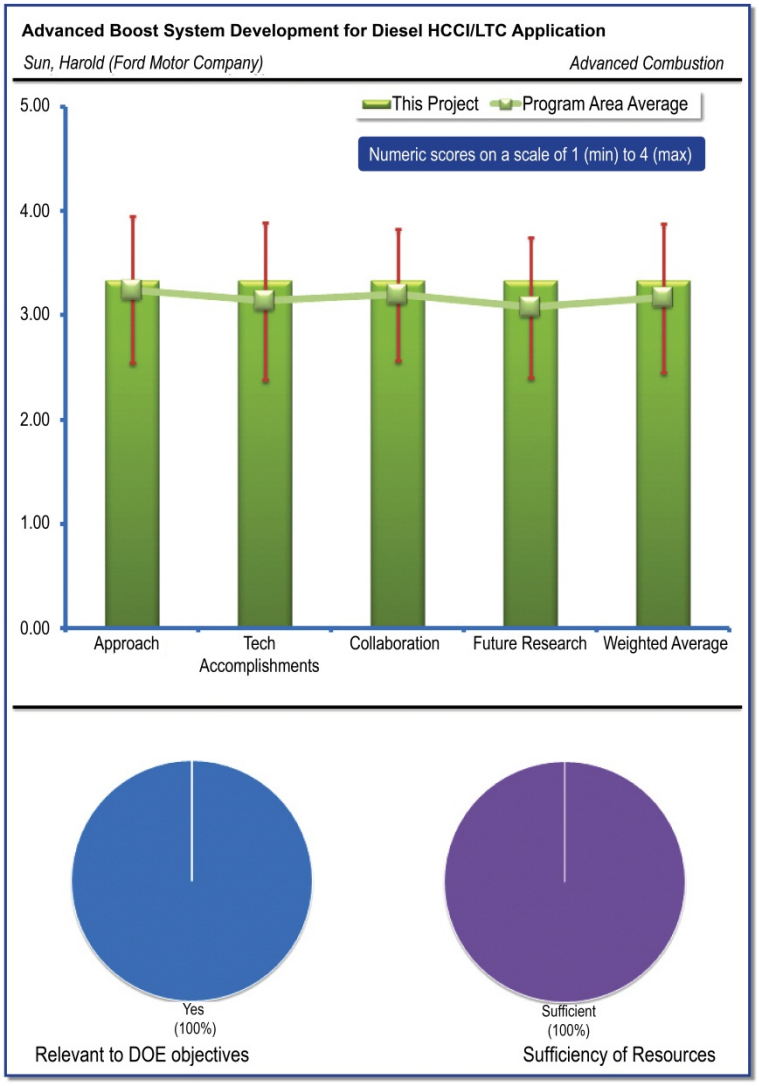
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer said it appears that the model has advanced sufficiently so that it should begin to be used as a tool for providing research guidance for catalyst development. Brainstorming with stakeholders to address the potential (and direction) of this path is recommended. The other commenter felt the whole issue between isothermal and adiabatic is like the 800-pound gorilla hanging around on the outside of the presentation. It would seem to be that a few evaluations with adiabatic conditions and isothermal conditions would indicate how big a deal the effect is. This reviewer is guessing that nothing in the trapping and release mechanism has a major effect on the thermodynamics. However, the CO energy release does have a major effect on the temperature of the catalyst wall and at this point we have no inkling at all as to how big an effect that is. A low level sensitivity analysis would be extremely helpful.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Both reviewers said sufficient. The lone respondent said the resources seem to be sufficient, especially since the work is so leveraged with the experimental work from ORNL.

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



Reviewer Sample Size

This project had a total of three reviewers.

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

One reviewer said this contributes to a higher efficiency engine, while another said good explanation provided to describe the need for turbocharger redesign due to the effects of heavy EGR. One final commenter said improved boost systems are critical enablers for high efficiency combustion operation. Objectives are right on target. Air handling will make or break the implementation of many of these combustion modes. With that said, this reviewer is not sure Ford is the appropriate place for this 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?

One reviewer said good work on a fundamental component. A second stated optimize compressor, diffuser, and mixed flow turbine; well-defined approach and milestones; the approach progression seems logical; and significant modeling is well done. This reviewer added that this is the best approach for cost effective development of turbomachinery. Hardware often behaves much differently than turbomachinery simulations when exposed to multi-cylinder engine variations. Modeling gives excellent guidance though. One final reviewer said the translation of technology from "large" turbo development to "small" turbo development does present some risks that this team may not be able to overcome in the timeframe/budget remaining. This was acknowledged in the presentation that innovations were needed to be successful.

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

Comments were mixed in this section. One person noted surprisingly large improvements have been shown on engines. A second reviewer commented on something that was not in the presentation: bearing change - journal to ball provided 2-3% improvement. This person added that thrust bearing problems were highlighted, but noted that it was unclear how the bearing design change and the failure to the thrust surface were related, if at all. Other accomplishments seem to be reasonable for the size of the program. One final reviewer commented that the project is one year behind schedule at the moment. This reviewer does not believe that this impacts the requested funding from DOE. This reviewer also noted the following: bench and engine evaluations of turbomachinery; nice progress toward project targets; dynamometer results actually exceeded targets. Characterization on dynamometer is very important and supported simulation and bench findings with more applicable data. Engine tests did result in bearing failure on turbomachinery. Will the technology findings from this study be transferable to other engine platforms?

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer said the project seems to have suppliers closely integrated. Another person said appropriate team with sufficient detail on partner contributions to evaluate, and added thanks and also a good plan for technology transfer beyond Ford. The final respondent noted Concepts NREC, Wayne State University, and turbo suppliers (unnamed??). This reviewer could not really tell who was doing what, other than Slide 17. This may be better than a "fair," but this reviewer could not conclude that from the presentation.

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 said the extension to LD is important, while another commented good plan to finish up the program and demonstrate program goals on an LTC engine by September 2011. A final reviewer said future work looks reasonable, adding that transient calibration on engine dynamometer will be very important. Any plans for vehicle testing? Plans to demonstrate expansion of advanced combustion? More specifically, will you demonstrate expanded, dilute operation as a result of improved turbomachinery technology?

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

All three respondents said sufficient. One commenter said the resources seem appropriate, while the other respondent said the project is finishing in September 2011 and the budget appears somewhat under spent. This may be because over half the total project funding came in FY11, so the final six months should have a lot of activity to complete the demonstration.

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

Reviewer Sample Size

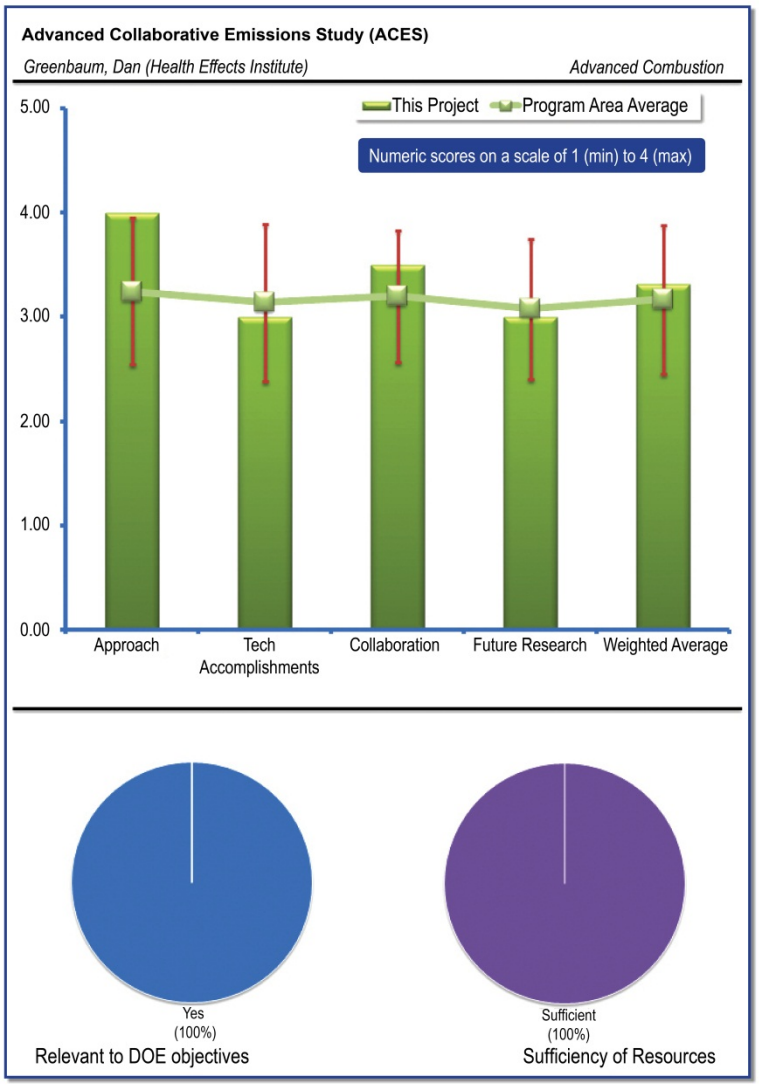
This project had a total of two reviewers.

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

Reviewers felt that careful characterization of the health effects of particulate matter is crucial to the suitable selection of particulate emission standards for both diesel and DI gasoline engines. They stated that this most recent study seems to indicate that the most recent standards are sufficient for health safety.

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 deemed this a reasonable way in which to directly evaluate the effect of diesel effluent on mammals. It was agreed that by directly running the emission into the atmosphere that the test animals breathe seems to be the most appropriate method.



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

Reviewers agreed that the accomplishments appear quite sufficient. However, since the authors have not yet gotten closure on the results, a better rating for technical accomplishment is not yet appropriate. The emphasis in the presentation on getting the entire dataset peer reviewed before finalization is comforting. It was felt that the accomplishments will be very effectively propagated given the partners involved with this work. The final reviewer stated that the phase three health effects study has been slow starting, but it appears to be on track and progressing on schedule now.

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

The first reviewer stated that the list of advisors is quite impressive and it was assumed that range of advisors are effective in disseminating the results of this study to the rest of the professional community.

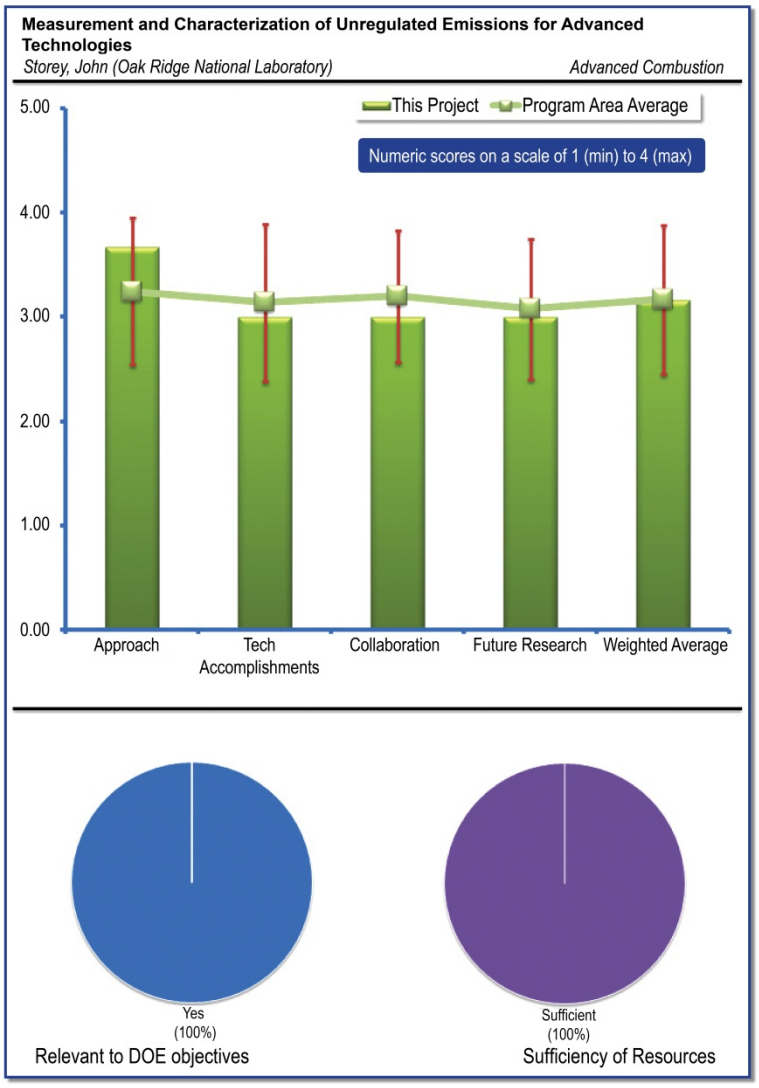
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The reviewers were unable to tell from the presentation what specifically is in the future for this project. It was questioned if it is simply final data analysis or if there is another step planned for this project.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer felt that nothing has been skipped in this project due to funding limitations.

Measurement and Characterization of Unregulated Emissions from Advanced Technologies: Storey, John (Oak Ridge National Laboratory) – ace045



Reviewer Sample Size

This project had a total of three reviewers.

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

The first reviewer acknowledged that particulate emissions from lean gasoline engines need to be characterized and evaluated to determine if aftertreatment will be necessary for their control. This work provides a basis for that determination. Another reviewer pointed out that the results from this appear to be quite similar to the results of Mark Stewart of PNNL. The final reviewer said that moving into ethanol is a major strategic public policy direction to displace petroleum. We need to know the characteristics of the emissions with the most toxicity (PM, PN).

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?

Overall, it was felt that this project is a very nice monotonic comparison of the gasoline, E10 and E20 is helpful in giving us an indication of how those effects will scale with additional blended alcohol. Reviewers stated that the strong focus on the driving cycles is great and that the effect of transients on particulate formation in diesels is well known and expanding that knowledge to gasoline engines is absolutely necessary. The final reviewer pointed out that the project is focused on fundamental characterization of particulate emissions on ethanol and GDI which is right in line with the future directions in gasoline.

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

The first reviewer believed that using production engines for this study is a great benefit. Since they are production vehicles, a clear indication of the future issues can be determined. Unfortunately, they are basically all European cycle engines and there are US DISI engines in production! Another reviewer was very impressed with the work covering the range of issues and felt that it was properly analyzed, compared, and spot on regarding objectives. The third reviewer stated that the work adds substantially to the knowledge database and will serve as the basis for further work.

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

The first reviewer was extremely uncomfortable that there was no interaction on this work with the similar work at PNNL. It was thought that some of the results are very similar and it would have been a good approach to have clearly separated out the areas that each would study. The final reviewer stated that although the work is heavily focused on ORNL, it meets the collaborative promises of the proposal. It was assumed there was little guidance from GM and Coordinating Research Council (CRC).

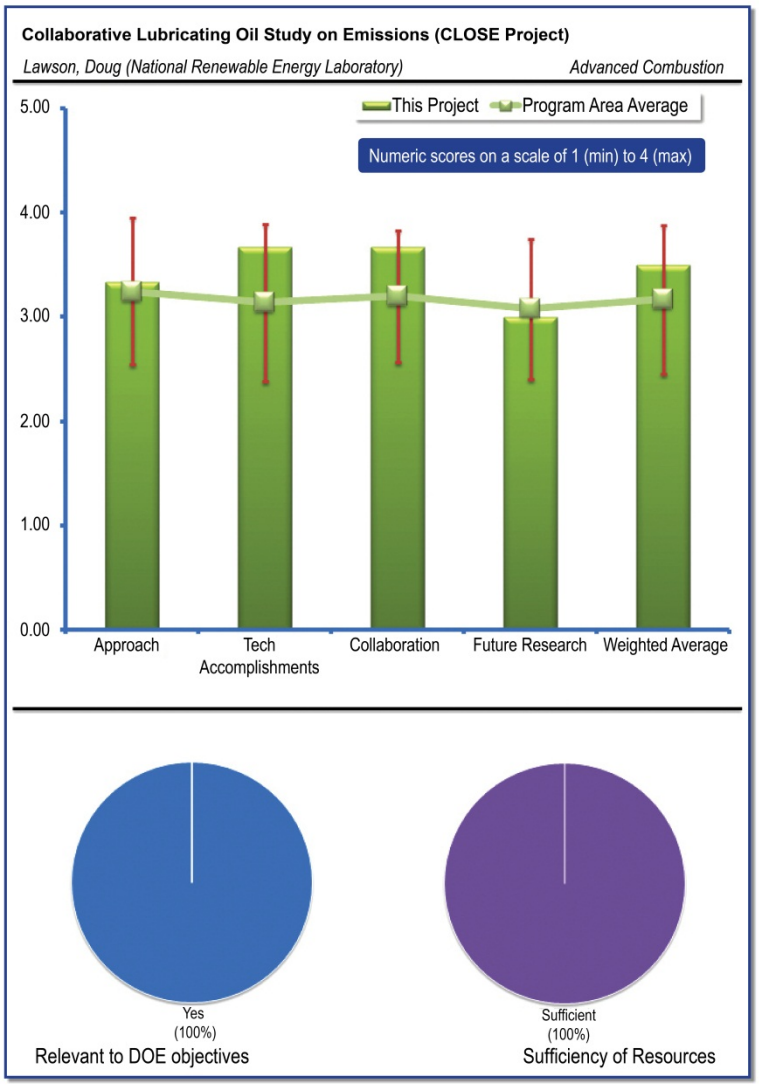
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer believed that evaluating stop-start is a very good task since this technology is getting into common use in the lean and dilute engine production arena. The reviewer stated that definitive knowledge of the effect of stop-start on particulate emissions is needed. The second reviewer felt that the work with urea by-products is excellent. This reviewer noted that Storey has a strong background here and will make good contributions. This reviewer also added that more work is needed on RCCI and that there needs to be analytical work on PM and PN composition. All particles are not the same in terms of toxicity. The final reviewer felt that the morphology work seems to add little to the base understanding.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer struggled with the question of whether there is too much of an overlap in facilities between ORNL and PNNL in this area. This reviewer believed that PNNL can do all the measurements that ORNL would like to do with the new engine exhaust particle sizer and questions the need for duplicate capabilities. The final reviewer thought the resources appropriate and stated that the authors have accomplished much with the resources. No more or less is needed.

Collaborative Lubricating Oil Study on Emissions (CLOSE Project): Lawson, Doug (National Renewable Energy Laboratory) – ace046



Reviewer Sample Size

This project had a total of three reviewers.

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

The first reviewer stated that tracing the effect of engine oil on pollutant fractions shows that the oil contribution is indeed significant. However, it was not clear exactly how that effect can be controlled but showing the level of the effect is the first step and this does show that the engine oil components have an effect on the character of the organic emissions. Another felt that as we move to alternative-fueled vehicles, we need to understand the impact on toxic emissions that might not be addressed with current or contemplated aftertreatment. PM from gasoline and compressed natural gas (CNG) vehicles is an example. The final reviewer believed that this study lays out a valid experimental approach that can how serve as the basis for more thorough evaluation.

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 acknowledged that using the inherent tracers in the oil and then comparing those with added deuterated high organic compound is rational and appropriate. However, the reviewer was disappointed that more, high emitter vehicles could not have been included in this study. Another maintained that the experimental approach is a good one, including select representative vehicles and measure them in laboratory conditions, use tracers to discern between fuel and oil PM, and valid PN measurement methods. This reviewer applauded the choice of the CNG buses, as this is a contemporary issue. The third reviewer was a little puzzled by the treatment of calcium. This reviewer assumed the authors know the material balance on ash components with DPFs show more than half is missing. Clarifying that less than half the amount of ash estimated by lube oil consumption is retained on the DPF. It is now known that the DPF traps almost all of the ash that goes into the exhaust. The final reviewer also expressed a desire to have preferred to see at least one DPF vehicle and one with much EGR (2002-2006).

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

Reviewers thought that showing that the oil contribution is 20% or less is important. The reviewer also acknowledged that the observation that the oil contribution increased dramatically just after an oil change is important to future particulate evaluations. The PM and lube oil emissions rates are logical and well documented. Data-spread is expected and handled very well. It was felt that the study is a benchmark for further work. One reviewer did mention that it would have been nice to see some analyses of the various size fractions. Such as an explanation of the metal oxide component in the PM, which is emerging as a major health issue of interest.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer felt that the partner list seems to be quite good but mentioned that it would have been helpful to get some indication of how well the results were being incorporated into the consideration of those regulatory groups. Another expressed that it is excellent to see the regulators involved! This reviewer also pointed out that the transit authorities and companies can benefit from the work, as well as the inverse.

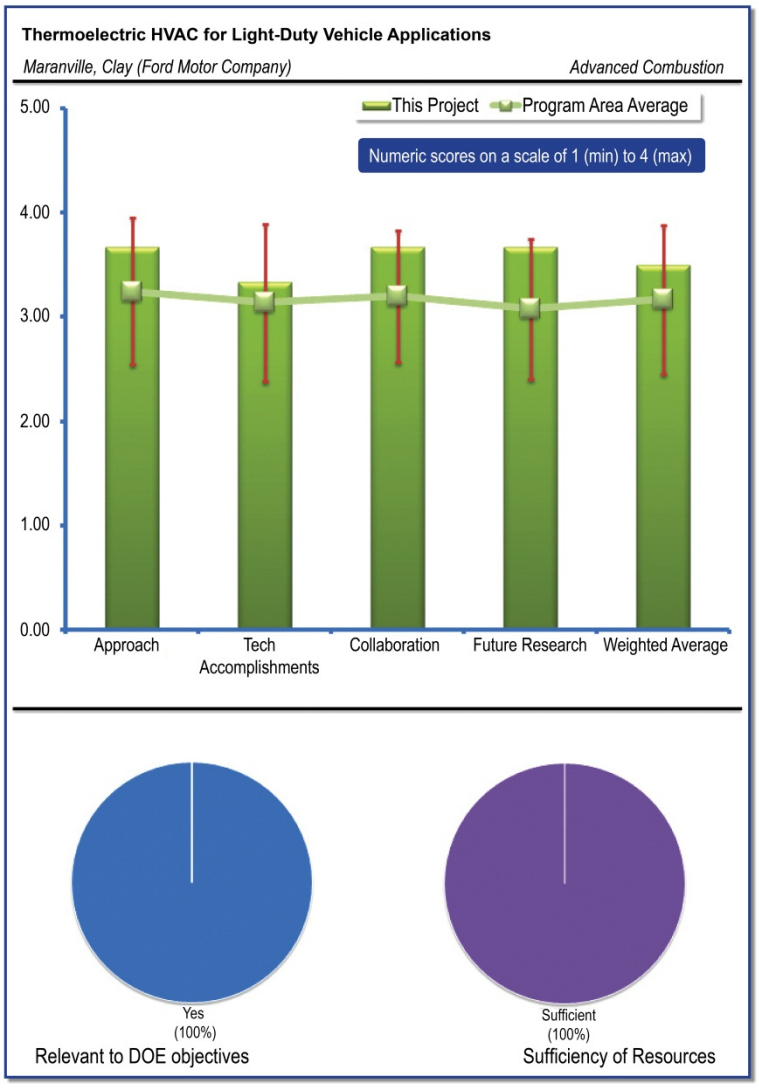
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer felt that working with a greater number of vehicles would have added to the credibility of the program which is apparently complete. The reviewer also mentioned that if DOE does not extend it, there seems to be no indication that the other interested parties are going to take up the funding mantle which is disappointing. Another reviewer noted that no comments were made here; however, this reviewer expected the lead investigators to propose follow-up study on GDI, LD NG, new light-duty diesel (LDD), etc.; and to look as metal oxide emissions and possibly toxicity.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewers saw that obviously there were sufficient resources because the project is complete so by definition the funding was sufficient.

Thermoelectric HVAC for Light-Duty Vehicle Applications: Maranville, Clay (Ford Motor Company) – ace047



Reviewer Sample Size

This project had a total of three reviewers.

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

Reviewers commented that the project supports DOE objectives. The first reviewer pointed out that this project is a systems integration effort for a thermoelectric system into light duty vehicles. This reviewer felt that such an effort is, of course, very important and Ford is well positioned to succeed in this activity. Another reviewer stated that the Ford Motor Company is developing an alternative cooling technology for use on automobiles. This work supports petroleum displacement by reducing mechanical loads on the engine, thereby requiring less fossil-based fuels. Instead, the cooling system is purely electronic. The final reviewer felt that the project fully supports the overall 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 reviewer acknowledged that the overall effort concerns developing test protocols for automotive HVAC systems, bring to bear a combination of computer aided engineering (CAE), thermal comfort models, and subject testing to determine optimal heating and cooling node locations, develop advanced thermoelectric materials and device designs that enable high-efficiency systems, and design, integrate, and validate performance of the concept architecture and device hardware in a demonstration vehicle. Another reviewer stated that regarding thermoelectrics (TE) materials, bismuth (III) telluride (Bi2Te3) systems have been selected for the modules that would be integrated into a commercial product. This reviewer felt that if there are concerns with meeting supply of TE in particular (e.g., if TE systems were integrated into all new vehicles in the U.S. - some 10M or so per year), a backup plan might be worthwhile to consider for an alternative material system. The third reviewer pointed out that this work is dramatically new, so much analysis work is needed before leveraging the system to production automotive platforms. In the present work, they are developing test, evaluation, engineering and testing metrics upon which the new technologies can follow the path to production. The final reviewer felt that the approach to meet the project objectives is clearly defined and presented and that the project was well designed with good approach to overcome the barriers that could be encountered

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

Overall, reviewers felt that the progress has been demonstrated well toward DOE goals. The first reviewer maintained that Phase I, completed this past year, included modeling to demonstrate that a zonal architecture for a TE system in a light duty vehicle was

viable. Some detailed results were presented to show cooling energy consumption, thermal sensation/comfort analysis options, evaluation of distributed outlet configurations to identify climate zonal system architectures, and modeling to perform initial sizing calculations (among other aspects). Also, a calorimeter test apparatus was designed and built to validate device performance. The model developed was shown to predict performance and allow for sizing models. Another expressed that it would be beneficial to have more specific data to judge, but the reviewer understands the nature of the proprietary data and protection of work for internal use (e.g., the modeling work done by the Visteon subcontractor reported no quantitative results in this presentation, only qualitative, which is understandable but makes review somewhat of a challenge.

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

The reviewers felt that the collaboration effort is excellent. One pointed out that the partnerships with Visteon, BSST, NREL, ZT::Plus, Ohio State University, and Amerigon are very effective and add significantly to the project. Another expressed that Ford has selected the best academic (e.g., Ohio State) and sub-contractor partners. They have done an excellent job or reducing risk. Ford should encourage collaborators to reduce risk further by investigating new materials whose earth-abundance is more advantageous (chalcogenide-free alternatives).

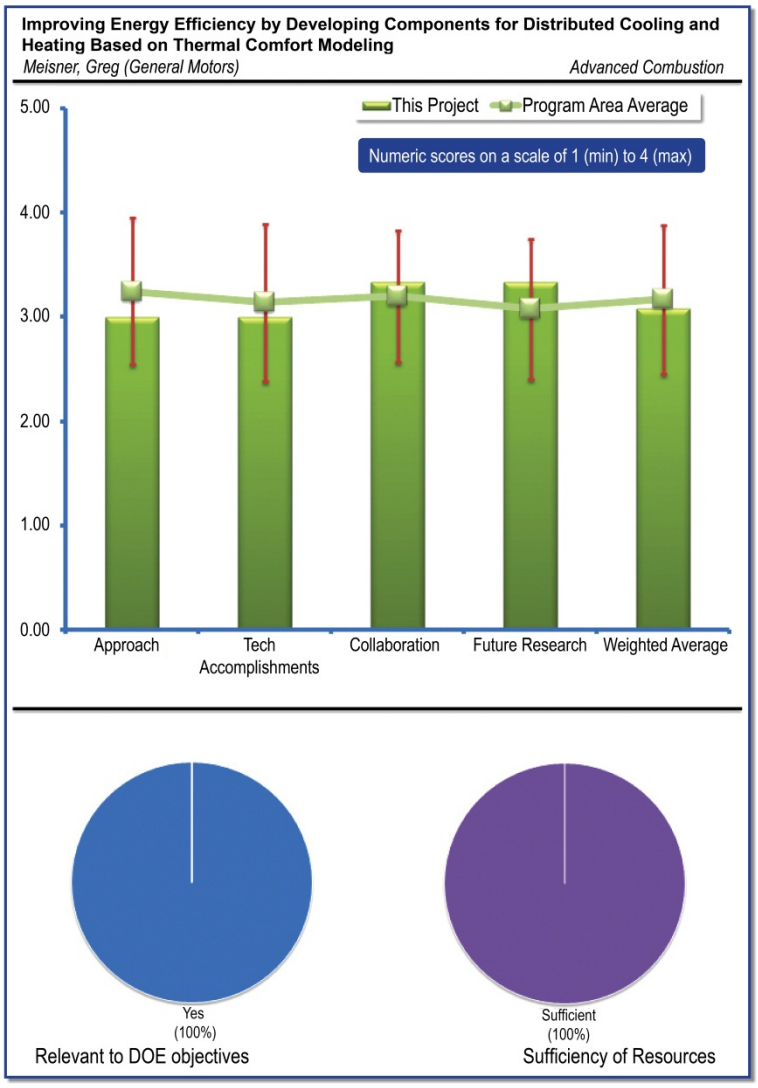
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer felt that the proposed phase III (FY 2012) will involve developing prototyping controls, system cost analysis, hardware fabrication and bench testing—all logical extensions of the modeling effort carried out this past year. Another stated that some elements of the project overlap with GM and that it would be useful, and ultimately (perhaps) facility deployment, if there could be some element of cooperation. This would certainly be advantageous for DOE's investment and ultimately it might reduce the timeline for system integration into a commercial product. Other reviewers felt that Ford has a good plan for continuing to push this new technology closer to production and that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk.

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

The first reviewer pointed out that DOE is investing a lot in this project, with over $1M this past year alone. Hopefully, the overall timeline for Ford to integrate a zonal TE system into a product line will be facilitated by the efforts being pursued. Another manufacturer, BMW, is also pursuing TE systems. Perhaps, Ford might consider benchmarking their efforts in a broad-based sense against them to learn what BMW is doing to facilitate integration of TE waste heat recovery into some of its product line. Doing so will enhance DOE's return on investment and improve Ford's product line. Another reviewer recommended increasing funding to the Ford performer to investigate new materials that would be more production worthy. The reviewer also encouraged Ford to describe their thermal management strategy for the hot side of their cooling system (where the heat is "dumped"). The reviewer questioned if that is an area that deserves attention, and if so, whether additional performance be obtained by thermal management of the cooling system.

Improving Energy Efficiency by Developing Components for Distributed Cooling and Heating Based on Thermal Comfort Modeling: Meisner, Greg (General Motors) – ace048



Reviewer Sample Size

This project had a total of three reviewers.

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

Overall, reviewers agreed that the project fully supports the overall DOE objectives of petroleum displacement. The first reviewer felt that the successful development of a thermal comfort modeling effort has good potential to impact (reduce) our use of gasoline. Another stated that this GM program does support the overall objective of reduced fuel usage. The goal is to eliminate heavy air conditioning units that add unnecessary mechanical loads to IC 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?

The first reviewer pointed out that the overall objective is to use TE HVAC for distributed cooling/heating as well as to improve efficiency of TE generators. Phase I efforts included developing thermal comfort models, identifying locations for distributed HVAC components, and carrying out environmental tests to identify locations for distributed heating & cooling. The reviewer also stated that the research also includes lattice thermal conductivity modeling to identify the role of phonon scattering, including nano-cluster doping effects and phonon density of states to examine the role of low frequency phonon modes for lead (II) telluride (PbTe) materials. The material selected appears to be PbTe, so issues of long term availability should be considered and alternative materials considered. Various skutterudite materials (CoSb3) are being included. The modeling is interesting; however it is unclear how results from the TE materials simulations will translate to fabrication and integration. Another reviewer stated that their approach is primarily to study practical system implementation, not to develop new component level technologies. The reviewer felt that is a weakness considering the potential lack of availability of some materials needed. The reviewer also stated that there appears to be very little value added from the University of Nevada Las Vegas (UNLV) collaborator for this work; the focus of the UNLV effort is on high-temperature power-generation materials which are completely irrelevant to this work. The final reviewer maintained that the approach to meet the project objectives was clearly defined and presented.

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

The first reviewer asserted that a range of accomplishments were achieved over the past year, including identification of initial set of components for distributed heating and cooling development, building a vehicle with simulated TE devices, developing testing protocols to evaluate performance, and wind tunnel tests to build a "mule" vehicle with simulated TE devices for predicting a thermal

comfort evaluation strategy. The reviewer also noted that GM and Delphi jointly selected the Cadillac SRX for the demonstration project. Vehicle occupants were modeled and test and simulation procedures established. A fully instrumented “thermal mannequin” was developed by the university partner, University of California-Berkeley. Regarding materials, this reviewer noted that extensive modeling of the PbTe nanocluster systems was performed. According to another reviewer, the GM team has made reasonable progress towards testing and understanding the cooling potential for a viable thermoelectric cooling system on vehicles. They have designed and tested the system using the Berkeley mannequin. They have obtained data that adds value to the DOE application. Two unaddressed issues arise from the effect of humidity on the system: First, cooling humid air requires much more heat pumping than dry air (must add latent heat), and humidity adds an additional level of "discomfort" to the passengers that the mannequin may not detect. The final reviewer believed that the progress has been demonstrated well toward DOE goals.

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

Reviewers felt that the collaboration effort on the part of the project team was excellent. The first reviewer specified that the collaborations with University of California, Delphi Thermal Systems, and University of Nevada-Las Vegas: thermoelectric materials computational research, and GM Vehicle Engineering: vehicle requirements are effective. Another reviewer felt that the GM team has partnered with capable team members, but some appear to have irrelevant focus. The UNLV task seemed to be misguided at best. For the power-generation program, GM teamed with Marlow, so that relationship should be leveraged to the advantage of GM's cooling 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?

The first reviewer felt that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The second reviewer pointed out that the proposed continuing work will involve CFD and vehicle Design of Experiments (DoE) analysis, developing a design of experiments analysis and developing control strategies. However, it was unclear precisely how the materials modeling effort would be translating into integration and synthesis of the materials being modeled. The third reviewer felt that since some elements of the project overlap with Ford, it would be useful, and ultimately (perhaps) facilitate deployment, if there could be some element of cooperation. This would certainly be advantageous for DOE's investment and ultimately it might reduce the timeline for system integration into a commercial product. The third reviewer mentioned that their future plans are reasonable; however, very little specific technology was described. The reviewer had questions such as what does the cooling systems look like, where does the TE module deposit the heat, to the chassis, or flowing air. The reviewer also questioned what alternative materials are under consideration, especially considering that the availability of key materials (tellurium) may be a significant technical issue.

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

A reviewer noted that the DOE investment is extensive and, as remarked above, it might be prudent to find a way to facilitate information exchange with Ford (and vice versa). Doing so will allow for leveraging the DOE (and GM) investment and ultimately assist integration of a zonal climate system and waste heat recovery. Other reviewers felt that GM appears to have adequate resources to complete the tasks, and address the issues.

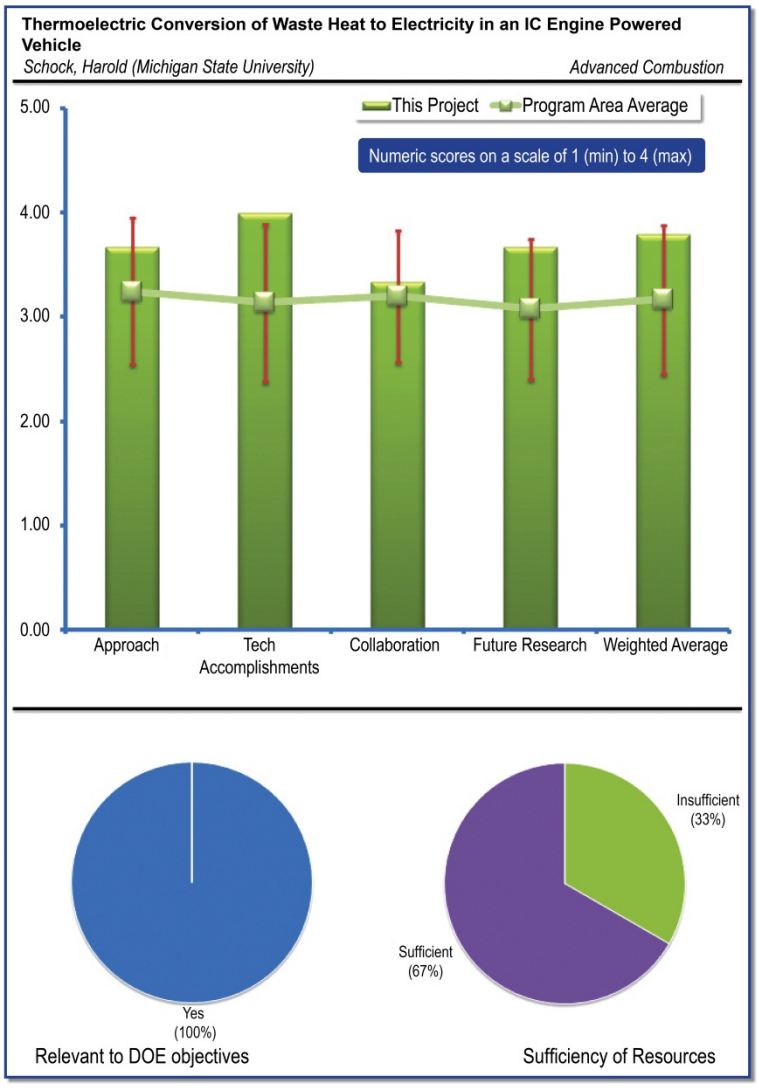
Thermoelectric Conversion of Waste Heat to Electricity in an IC Engine Powered Vehicle: Schock, Harold (Michigan State University) – ace049

Reviewer Sample Size P.6

This project had a total of three reviewers.

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

Overall, the reviewers felt that the project fully supports the overall DOE objectives of petroleum displacement. The first reviewer stated that this project is a successful development of a TE device for waste heat recovery and is certainly a relevant effort to DOE's objectives. The goal is to show that TE materials can provide a cost-effective approach to waste heat conversion to electricity. The effort on materials development and the issues involved are well developed. Another reviewer agreed by stating that the work performed by the Michigan State University team is highly relevant to the overall objective of reducing petroleum usage. Their strategy is to implement thermoelectric power generators to produce electrical power from the waste-heat from vehicles. Petroleum usage is reduced because the mechanical load to the engine is lowered (alternator) and fuel economy is improved.



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 approved of the approach taken in this project. The first stated that this project has involved a lot of collaborations and interactions to pursue a broad range of tasks including thermoelectric generator (TEG) design and construction, TEG simulation, CFD analysis and systems utilization. The PI team is similarly extensive. The second reviewer was very impressed with the approach used and stated that the Michigan State University (MSU) team rapidly identified difficult technical issues and has developed viable and clever solutions. One issue is differential thermal expansion which causes the fracture of the main components of the converter. They developed at least two innovations to help solve that problem: a compliant hot-side electrical contact that provides mechanical strain-relief, and an electrical means of "by-passing" failed elements. Although the issue remains unsolved, there is little doubt that their innovation and creativity would produce a viable long-term solution. They have made impressive progress and produced working prototypes that were integrated with test-beds. They have generated valuable experimental data and new innovations. The final reviewer felt that the approach to meet the project objectives was clearly defined and presented and that the project was well designed with good approach to overcome the barriers that could be encountered.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer pointed out that the PI developed "coupled bypass technology" which is novel; a range of 1 to 200W generators were developed and highly insulated modules using aerogel wool insulation were demonstrated in the Phase 2/3 efforts. Effective integration between numerical and experimental studies were essential to developing significant progress. The reviewer also asserted that the identification of skutterudites (non-heritage materials) is prudent and well thought out. The team developed a fabrication method for the skutterudie materials and the TEGs themselves. This would seem to be a significant accomplishment and allow for adopting these materials in production. The reviewer also acknowledged that the PI developed a system for "laboratory scale" TE module fabrication method, so the PIs have a lot of expertise in this area. A fully instrumented TEG system was developed for testing that allows for attachment to cylindrical shapes (important for exhaust system attachment). The TEGs were integrated into a circuit board to allow for monitoring and data evaluation. Extensive tests were carried out and detailed modeling was pursued to predict TEG output and the results agreed well with measurement. The reviewer found the identification of failure modes of the insulation is interesting and was impressed that the efforts also included development of methods for laboratory scale mass production of skutterudite, This seems to be a significant result. Another reviewer noted that the technical issues for this project are severe, and despite that, Prof. Shock has made remarkable progress and shown creative, innovative solutions. A realistic implementation has been demonstrated and important lessons have been learned. The third reviewer felt that the technical accomplishments are great and the progress has been demonstrated well toward DOE goals.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

All reviewers felt that the collaboration effort is excellent for this project. One reviewer pointed out that the collaboration with Purdue, NASA-Jet Propulsion Laboratory (JPL), Northwestern and Tellurex, Office of Naval Research, DOE Oak Ridge High Temperature Materials Laboratory, and the Air Force Research Laboratory, Wright-Patterson Air Force Base (WPAFB) is excellent and brought a lot to this effort. Another maintained that the MSU team has an extended family of partners, all of whom seem to closely collaborate. There appears to be some redundancy, which helps reduce overall risk.

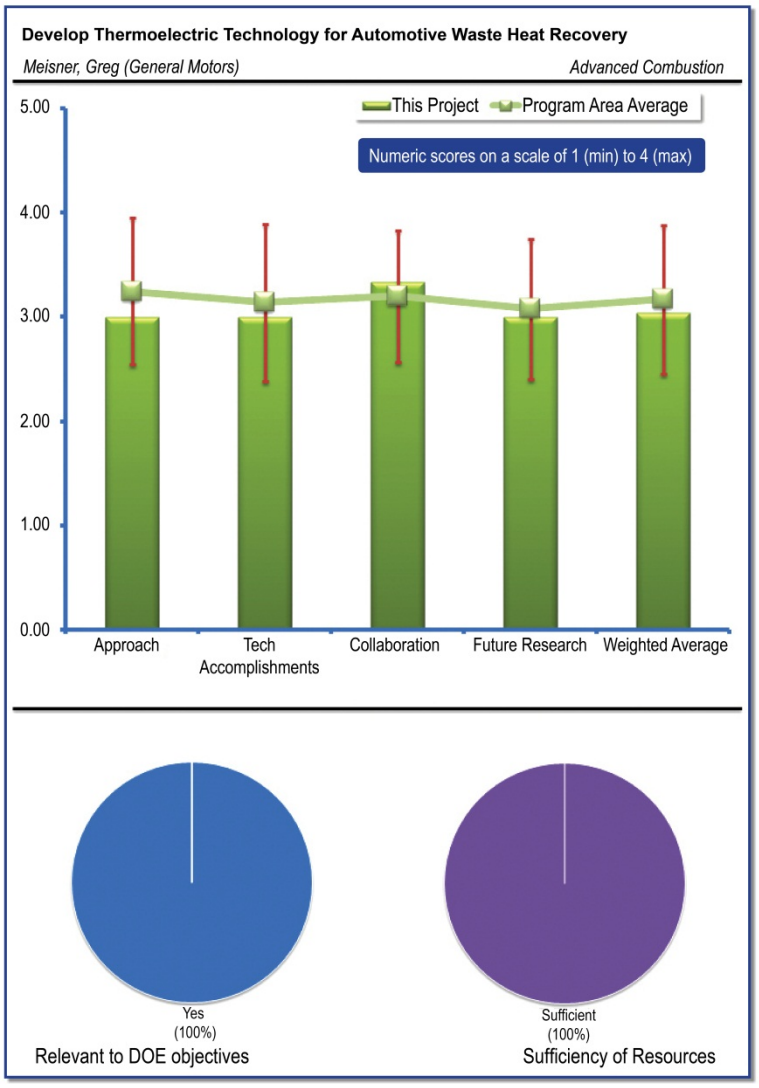
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Reviewers observed that according to the PI the project has apparently ended and future work appears to involve development of follow-on proposals. A reviewer did note that although it appears this project has ended, the future plans appear to be well considered and addressed appropriately. This reviewer admitted liking this work, and although there are significant issues, it appears that the PI have a good understanding of them, an excellent track record of innovative solutions, and a reasonable path to be successful. The final reviewer felt that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewers felt that the team assembled for this effort is extensive (many PIs and tasks). The funding level seems to be adequate for the number of PIs involved and the extensive array of tasks performed. However, one reviewer noted that this project was reported to have ended early.

Develop Thermoelectric Technology for Automotive Waste Heat Recovery: Meisner, Greg (General Motors) – ace 050



Reviewer Sample Size

This project had a total of three reviewers.

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

All reviewers perceived that the project supports DOE objectives. The first reviewer felt that a successful demonstration of TE technology for automotive waste heat recovery would certainly be a significant accomplishment and, in this regard, the project is highly relevant. Another reviewer asserted that the GM work supports the overall goal of reduced fuel usage. Their long-term goal is to use skutterudite materials as the active device material in thermoelectric energy converters, although, for the present work, they are using an alternate, better known material to prove their system. The final reviewer maintained that this project fully supports the overall 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?

A reviewer pointed out that the approach involved fabrication and prototype assembly, outfitting a demonstrate vehicle, evaluating performance in the vehicle, and developing a material synthesis protocol for skutterudites. The materials used were BiTe for TEG#1 and TEG#2. Skutterudites materials were integrated into a TEG#3 module. This reviewer went on to explain that the tasks have included attempting to improve ZT by triple filling n-type materials, evaluation material mechanical properties, and exploring new TE modules. The second reviewer noted that their approach is reasonable, but not very aggressive. This reviewer thought that there is large risk that the lessons learned from the industry standard materials will not translate to their long-term strategy for skutterudite modules. There is significant risk when transitioning to new modules, such as the need for high-temperature stability of the hot-side electrical contact, for managing differential thermal expansion, for mitigating sublimation/oxidation of the active materials. Overall, they are focused on important technical barriers and are making excellent progress towards overcoming them. The final reviewer acknowledged that the project was well designed with good approach to achieve the objectives and at the same time overcome the barriers that could be encountered.

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

The first reviewer expressed that the bench scale tests was carried out to evaluate performance of various TEG modules. Prototypes TEG #1 and #2 were fabricated and tested and open circuit voltages measured. An extensive test arrangement was designed for evaluating performance and monitoring output from each TE module in the overall integrated system. Also, materials synthesis efforts were pursued. Another reviewer thought that the GM team has made reasonable progress towards a viable integration path for

thermoelectric power generation on vehicles. They have designed and built a modular, reconfigurable test-bed that can dramatically increase the speed of identifying technical issues. However, they really need to produce active prototypes where lessons learned from the test-bed are implemented, shown, proved and validated. The final reviewer felt that good technical accomplishments and progress toward the DOE goals had be realized.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers felt that the collaboration is very good. Marlow is developing the TE module; ORNL is assisting with material and thermal property characterization; Future Tech is involved with TEG system development; and UNLV is pursuing efforts with computational materials development. It would be useful to provide a better linkage between the materials simulation and synthesis efforts to show greater value to the material simulations. The second reviewer noted that the GM team has partnered with the flagship thermoelectric module producer in the United States, which is fantastic, and should dramatically simplify eventual plans for production. Marlow has a long track record of excellent performance, and have proceeded up many learning curves.

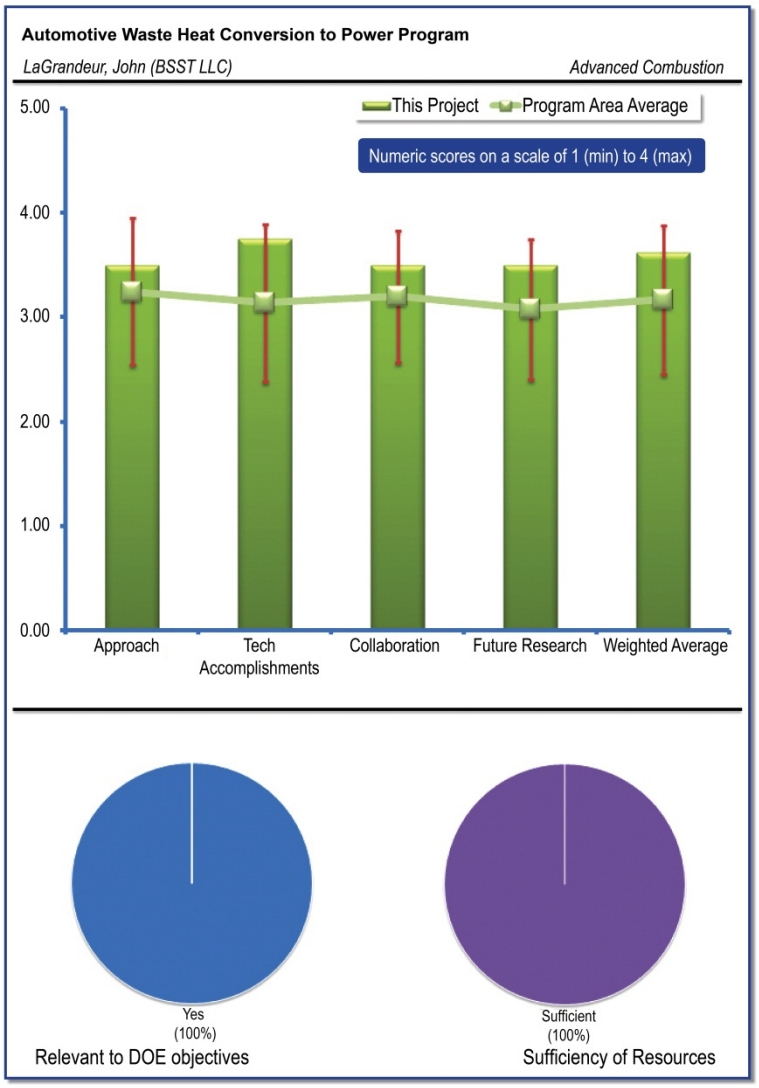
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer observed that since the project has apparently ended, the future work is based on proposals pending. The proposed tasks are reasonable for follow-on work, as they would include further work with skutterudites, assembly of new modules, and dynamometer tests. The PI should endeavor to work out a timeline for full integration of a TE system into a product line. Another reviewer felt that their future plans are excellent, in that their next plan of action is to transition from the legacy bismuth telluride technology into the more relevant skutterudite devices. It cannot be encouraged more highly to increase the rate of progress on the work. There appear to be significant challenges that will be encountered and progress needs to be faster. The final reviewer noted that the proposed future work is good and clearly demonstrates that the work plan can mitigate risk.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer noticed that from the budget figures given, it seems that DOE has invested more than GM. The reviewer felt that this may not be the optimal situation, as presumably GM will derive profit and develop a competitive edge if successful, and that GM management should see the wisdom of thermoelectric and contribute a greater share. The second reviewer asserted that GM appears to have adequate resources to complete the tasks, and address the issues. If one area deserves a plus-up of funding it is to the Marlow partner, because the main issues that will be encountered are those at the Marlow level. The main stumbling blocks going forward are device-related, so it would seem prudent to allocate more of the present funding towards Marlow.

Automotive Waste Heat Conversion to Power Program: LaGrandeur, John (BSST LLC) – ace051



Reviewer Sample Size

This project had a total of four reviewers.

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

Overall, the reviewers agreed that the project fully supports the overall DOE objectives of petroleum displacement. The first reviewer felt that this is a very relevant project by its development of a circular TEG module for waste heat recovery. The material selected is skutterudites, and the PI has developed a range of testing and fabrication activities. The reviewer also noted that the TEG module is very novel. Another felt that waste heat recovery is clearly needed to meet fuel economy targets set by DOE. The third reviewer asserted that the BSST project for reclaiming waste-heat strongly supports the DOE objective for reducing fuel usage on vehicles. This reviewer stated that their strategy is to produce electricity for on-board use from the waste-heat, thereby eliminating the need for an alternator which adds unnecessary mechanical load to the engine.

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 pointed out the broad-based approach is to improve the manufacturability of TEG systems for TE engines. A novel circular TEG was developed and fabricated which facilitates attachment to a cylindrical surface. Apparently, close tolerances are needed to reduce contact resistances between the TEG elements and the cylindrical surface and maintaining contact pressure is crucial to retard degrading performance. This reviewer also acknowledged that much of the effort over the past year involved fully characterizing the cylindrical TEG, no doubt a crucial effort for its long term reliability. Another reviewer asserted that this is an innovative design and practical implementation strategy. Although there have been setbacks due to manufacturing issues, many technical barriers which require invention have been managed well. The third reviewer believed that the BSST approach builds on their numerous significant innovations. The project team employs their "Y" device design for improved thermal and stress management. The reviewer pointed out that one design they may want to reconsider is the cooling pipes (bellows) between neighboring devices, which would seem to add significant complexity and perhaps reduced production-ready technology. One of their principal issues is interfacial contact resistance and they have a well-considered path to understand and address that. The final reviewer emphasized that the project has a good approach to achieve the objectives and at the same time overcome the barriers that could be encountered.

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

A reviewer noted that a thorough set of tests were carried out to understand the role of interfaces on TEG performance. It was shown that the electrical interface resistance has a strong effect of power output. Much of the effort seemed to have been devoted to

diagnostics to probe the role of heat transfer between the ring and TE engines. It was found that tighter tolerances are needed to reduce contact resistance. The method of assessing contact resistances was unclear. Some of the results are self-evident (e.g., effect of power output on thermal grease thickness), the documentation of which is nonetheless very important. This reviewer also pointed out that the (understanding) reliance on tight tolerances raises the question of product costs, as tighter tolerances will presumably increase fabrication costs. A number of design changes were identified to improve performance. The hot and cold side heat transfer exceeded expectations, while the role of interfaces is currently a work in progress. A reviewer noted that the potential target for production is 2018 with projected volumes of 100K/yr. Another reviewer expressed that significant progress has been made to produce a viable thermal electric subsystem for an under floor exhaust system. The novel design is packageable, and although there have been assumptions and manufacturing issues which have reduced projected performance from 1kW, the progress is still outstanding. Samples are being packaged for vehicle testing at OEMs with a power range of 300-500+ Watts. The reviewer pointed out out that the vehicle TEG system on-cost is targeted to be 500 Euro with 30% material cost, including 100 Euro Valve, 50 Euro Can, 50 Euro Power electronics, and 50 Euro Other. The fourth reviewer maintained that BSST has done an excellent job of integrating their novel device structures into a working prototype (test-bed). They have shown reasonable power generation, and have proposed excellent "countermeasures" for mitigating future risk. It was felt that the technical accomplishment is great and the progress has been demonstrated well toward DOE goals.

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

Reviewers acknowledged that the partnerships include Ford and BMW, JPL, Caltech and NREL, and that the collaboration effort is excellent. The second reviewer specifically pointed out the excellent use of OEM involvement and material suppliers to solve some technical issues. Ford and BMW modeling contributions were also noted. The final reviewer emphasized that BSST has assembled an excellent team who seem to have good collaboration. And although there is some redundancy, that helps reduce risk. One issue is that they are planning to transition to skutterudite materials, which seem to offer mammoth technical challenges, including differential thermal expansion, sublimation, oxidation, and issues with the stability of the hot-side contact.

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, the reviewers felt that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The first reviewer stated that the future work will involve dynamometer testing, and installation and testing in a BMWx6 and Ford Fusion. Additional work is recognized to improve TE materials scale up. It might be prudent to consider a cost analysis of the TEG system being developed and some form of accelerated reliability testing. Also, thermal interfaces are as important as electrical interfaces. Some means to characterize the thermal contact resistance would be prudent to evaluate performance and thereby suggest design changes if needed. The second reviewer felt that the project had very good plans for additional materials research, vehicle development and commercialization. The reviewer also pointed out that if the results continue to be this impressive, private investment funding should soon overtake the DOE funding to commercially implement this technology. Another reviewer asserted that BSST has proposed future work that adds value to the DOE program, and offers a path towards production viability. However, the technical barriers along that path are severe. The track record of significant innovations from BSST would seem to be well-suited to produce important solutions to these barriers.

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

The first reviewer noted that the costs are reasonable for product development, with DOE contributing about 60% and BSST about 40%. Another reviewer labeled the resources currently sufficient and necessary; however, based on current track record of success, additional funding is not expected to be required in the near future. The third reviewer stated that BSST appears to have adequate resources to complete the tasks, but increased funding may be warranted because of the significant future technical barriers.

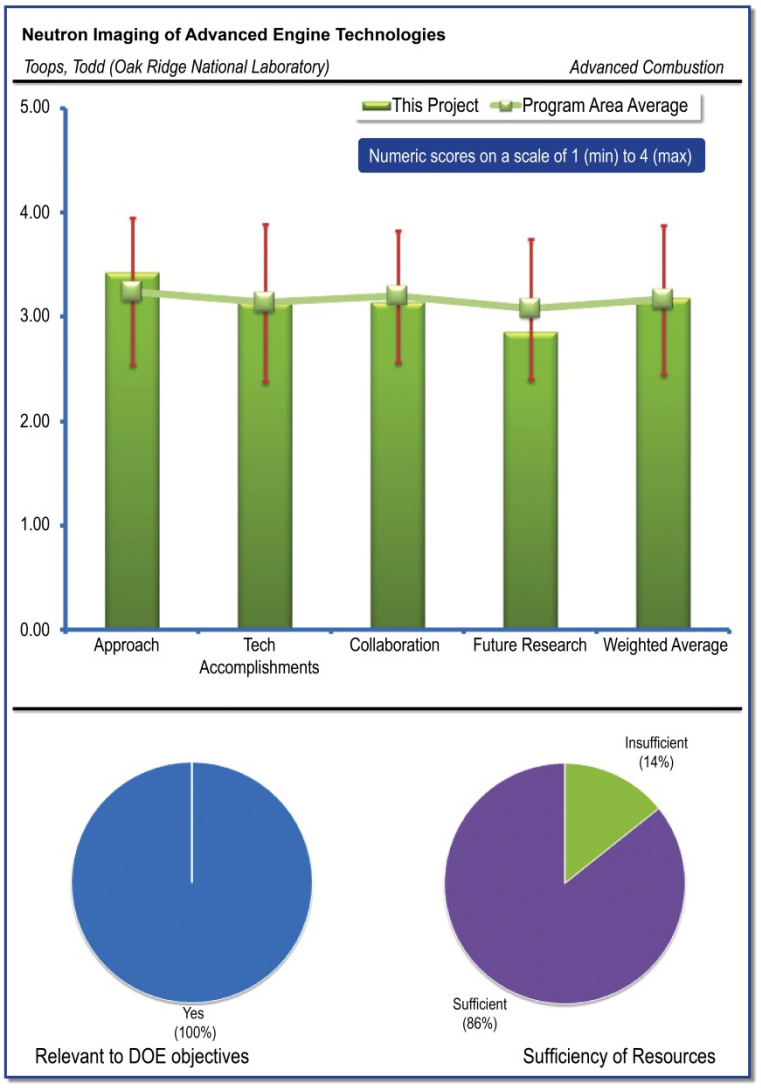
Neutron Imaging of Advanced Engine Technologies: Toops, Todd (Oak Ridge National Laboratory) – ace0052

Reviewer Sample Size

This project had a total of seven reviewers.

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

The first reviewer felt that managing DPF regeneration and efficient EGR cooling are significant contributors to fuel saving. Another said that this project was an application of a unique DOE capability to a problem of interest. The third reviewer noted that this project is focused on developing and demonstrating a tool for improving PM filter design and regeneration; though this may have a minimal to small impact on vehicle fuel economy it is important project for engine suppliers and their suppliers for improving future engine system designs and also exploring combustion modes that lead to higher thermal efficiency while possibly producing more PM which must be filtered/regenerated in a PM filter. The final reviewer acknowledged that the project addresses barriers to improve regeneration of DPF's to enable diesel engine combustion to decrease fuel economy penalty.



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 the testing was somewhat scattered, but that it seems appropriate for such an exploration of possibilities. Another reviewer stated that this unique capability unavailable elsewhere. The reviewer also questioned if the results could be quantified rather than evaluating quality of image. The third reviewer felt that the project's strength is the development of an advanced diagnostic tool for PM filters, EGR coolers, and possibly fuel injectors. There is still much to learn about PM filter reliability, performance, and regeneration using this new tool. The final reviewer explained that this uses a nondestructive neutron imaging technique to study the inside morphology of particulate filters and that a tomographic technique is employed.

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

Reviewers felt that it was early in the project to evaluate any real accomplishments. However, the second reviewer would like to see better connection to needs of experimental combustion development work. Another felt that these were good initial results, but had yet to see something really new that compels use of this method. The fourth reviewer acknowledged excellent progress for new project. However, the reviewer thought the project needs to continue to scope out applications of this technique. Another asserted that the initial results generated from this tool are very promising toward studying PM filter soot loading and regeneration on a near real

time basis. The real value of this tool will be realized in the future. The final reviewer pointed out that the potential to visualize soot layers with increased resolution has been demonstrated. Model as standards have been imaged. Determined that Ca-based ash is difficult to image. These imaging techniques are also being applied to EGR coolers.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer mentioned that the DPF and EGR cooler manufacturer involvement could be increased. Another pointed out that there were interactions with multiple industrial partners. The third reviewer expressed that the PI has collaborated with other parts of his organization, a catalyst supplier, and engine suppliers during the development of this new tool to initially assess its visualization capability. The final reviewer asserted that appropriate partners like neutron scientists, beamline access, and the Technical University of Munich, which has right expertise, exists.

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 the need to identify reasons why this must be used and verify that what is seen here is not different from conditions in-situ (the method is not portable!). The second reviewer expressed the need to make sure this does not become redundant with the ANL APS. Another reviewer felt that based on funding support, the PI may want to focus on one or two applications versus three for this new tool. Possibly focusing more on PM filters and EGR coolers would be most appropriate versus fuel injectors. The final reviewer pointed out that the PI will look at pressure drop characteristics with regeneration, will apply the technique to fuel spray imaging; the potential exist to visualize fluid flowing in passages. The reviewer also noted that it looks like ultimately this technique can be used to study the interaction between fuel injection and air flow within a metal engine cylinder, which will supplement data from optical engines.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer stated that the resources were acceptable for the exploratory phase, and a second reviewer suggested expanding to fuel injection, EGR coolers, etc. A third reviewer pointed out that this appears to be an adequately funded project as long as partners continue to supply the PI with test pieces.

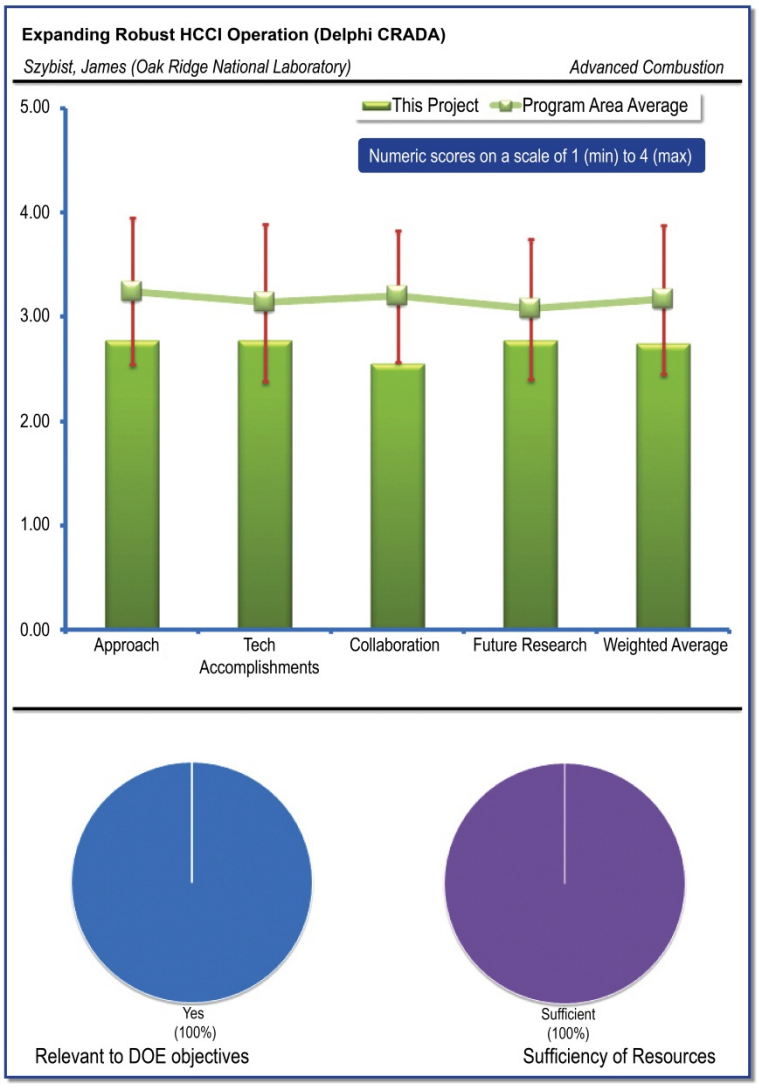
Expanding Robust HCCI Operation (Delphi CRADA): Szybist, James (Oak Ridge National Laboratory) – ace053

Reviewer Sample Size

This project had a total of nine reviewers.

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

The first reviewer acknowledged that engine modeling and control are important adjuncts in the development of high fuel efficiency engines, which will in turn result in a reduction in petroleum usage. The second reviewer felt that the low NOx, high efficiency combustion mode is relevant. Another reviewer stated that this is one possible approach for achieving objectives of reducing fuel consumption. The third reviewer asserted that expanding range of successful HCCI operation would improve fuel economy and thus reduce petroleum requirements. Another reviewer added that controlling and extending HCCI operation is necessary to move toward production. The final reviewers noted that this project addresses application of HCCI technology closer to production concepts with a major supplier and that this project addresses the controls challenges of HCCI combustion concepts.



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 the approach seemed well-thought out and systematic. However, this reviewer pointed that the use of GT-POWER for fully transient engine control is questionable – it was never designed for that purpose. The second reviewer noted that this project may represent an important step toward eventual implementation of HCCI combustion in light-duty engines. The only concern is that elements of the project have the appearance of a calibration exercise, with little emphasis on instrumentation for advanced understanding. Working to integrate this project with other modeling and fundamental combustion activities is important to the success. Another felt that the approach of coupling experimental data and modeling makes sense. The fourth reviewer pointed out that this was an overall good approach, but it is strange to start this work without cooled EGR and multiple injection capability. These should be fundamental considerations for HCCI work. The fifth reviewer believed that the objectives were limited, but were deemed appropriate for the CRADA purpose. Another reviewer warned not to discount the importance of NOx values since they directly impact the frequency of the NOx aftertreatment regeneration and therefore the overall cycle efficiency. The final reviewer felt that this project does not seem to be starting with a well-developed HCCI base engine. The minimum net indicated fuel consumption reported is very poor, about 250 g/kWhr, which is well above typical HCCI levels. The combustion constraints of ringing index below 7 Mw/m2 and COV of IMEP below 5% are too liberal and do not represent a practical engine. The reviewer also questioned the point of developing a control system that seeks to expand the robust HCCI operating range of a substandard base HCCI engine. By the time the

base HCCI engine is developed and improved, time would have run out and not much time will be left to develop a meaningful control system.

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

The first reviewer felt that there has been fair progress to date considering the project has only recently been initiated. The second reviewer stated that more comparison to current SI combustion would better frame efficiency opportunity. ISFC's seem higher than expected for HCCI. Another maintained that the progress to date using the flexible HVA system has yielded a good baseline understanding of the capability of the hardware. However, better definition/alignment of the ISFC and IS emissions goal is needed. For example, the 8-9-10 g/min fueling rate does not seem to correlate with the WWMP targets of other programs. The fourth reviewer acknowledged that the results are interesting, but not clear from results to date whether these approaches (vs. other approaches) will lead to significant changes in HCCI operating range. Other reviewers felt that the results were good within the limits of hardware and that they were presumably useful for the CRADA partner. The seventh reviewer needs to understand what success looks like. Stated goals are HCCI in production like environment. The evaluator questioned if this will include an assessment of environmental and customer noise factors. The final reviewer stated that as mentioned earlier, the HCCI engine being used for study is substandard. The net ISFC numbers reported are poor. The response to start of injection (SOI) timing for NVO injection has already been reported in the literature and is not new information.

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

Reviewers mentioned that the only collaboration mentioned is a CRADA with Delphi. The first reviewer believed that collaboration with Delphi offers assurance that any ideas or technology developed under this project should at least be considered for production. However, another reviewer felt that the collaboration with Delphi is valuable, but collaboration with other more fundamental HCCI programs is recommended. The third reviewer stated that it seems like Delphi should have been involved to provide more capable fuel injection system. Another felt that the project was outstanding with one partner, but only with one. Another reviewer pointed out that it seems to be related to Steeper's work at SNL and that the two projects would benefit by working more closely together. The final reviewer expressed that Delphi is not an expert in base HCCI engine technology and without a properly designed HCCI combustion engine, or without knowing what results to expect from and HCCI engine, this project may not meet its goals.

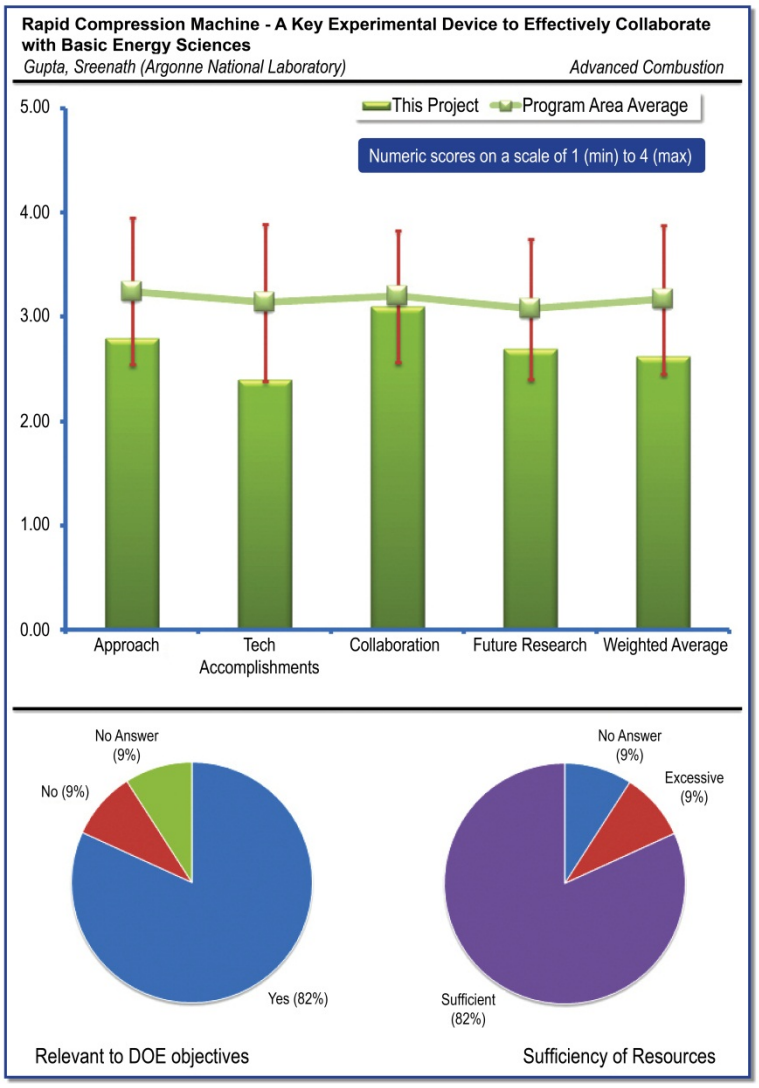
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer asserted that the future plans to expand the limits of HCCI are good, but the engine operation is highly constrained by emissions levels, required engine efficiency, knock limits, etc. Also the use of GT-POWER for transient, multi-cylinder engine operation is questionable. The second reviewer agreed by stating that the future research proposed is certainly reasonable, but may benefit from some stretch goals being laid out for the program for ISFC and emissions. Another pointed out that the CRADAs limited objectives will be served by the plan. The fourth reviewer would like to see more explicit goals shown with load range expansion. The final reviewer felt that so far, this project does not seem to have the in-house expertise to develop a typical HCCI engine, let alone expand its robust operation. The future plans simply mimic what has already been demonstrated. The project should focus on first being able to execute what has already been demonstrated in the open literature.

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

Respondents agreed that the level of funding is appropriate to continue the collaborative work of this nature with industry.

Rapid Compression Machine – A Key Experimental Device to Effectively Collaborate with Basic Energy Sciences: Gupta, Sreenath (Argonne National Laboratory) – ace054



Reviewer Sample Size

This project had a total of 11 reviewers.

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

The first reviewer agreed that fundamental studies of fuel combustion kinetics are important for the development of fuel efficient engines. The second reviewer pointed out that understanding the fundamental combustion chemistry of conventional, unconventional, surrogate and model fuels under conventional and advanced combustion conditions (elements of the grand challenge from the Basic Research Needs [BRN] Workshop on 21st Century Transportation Fuels) requires detailed combustion data. This project will add to the capacity to generate such information, and thereby will contribute to the data needed to generate a predictive capability to design the engines of the future. With that capability, higher efficiency engines can be developed more efficiently. Another felt that there is certainly new information to learn via Rapid Compression Machines, but it is not well explained exactly the void in past research this work is focused on. The fourth reviewer asserted that improved fundamental understanding of combustion kinetics should enable improvements in engine design/operation with improved fuel economy. The fifth reviewer stated that this project has no added value, as it duplicates (many) other setups that have existed for a long time. See for example presentation # ace019 for a variety of RCM's that have been used for years prior. The evaluator added that even if this "new" mouse trap brings additional features, it can hardly qualify for OVT funding. The evaluator continued by stating that it indirectly support DOE objectives by providing others with ignition data on various fuels of interest that could be candidates for advanced combustion modes in efficient CI or SI engines. The final reviewer noted that this project enhances the predictive capability of in cylinder combustion performance and emissions of advanced combustion concepts.

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 indicated that development and use of a rapid compression machine will provide useful chemical and combustion kinetic information for the development of high efficiency engines operating on a range of fuels. Another reviewer confirmed that using an RCM is a practical choice since throughput of fuels and rate of generation of data, as well as ease of simulation, is good. The reviewer also noted that it provides an additional level of experimental data between shock tubes, flow reactors, and engines. It will have two methods for getting fuel into the RCM, heating for low boiling point fuels and a nebulizer for high boiling point fuels. The key feature is having high pressure capacity in the RCM and enabling delivery of higher boiling fuels. The third reviewer acknowledged that the approach of using RCM is good, but appears to be tremendous overlap with efforts at other organizations, such as the RCM efforts at University of Michigan (very similar/identical fuel components to those already studied or in progress) and

chemical mechanism validation at LLNL. Another reviewer noted that it should be made clear why another RCM is needed and what will be done that others cannot or do not do while the fifth reviewer questioned if the device unique to the national labs and/or universities. Another reviewer mentioned that the PI has spent a fair amount of time considering fuel ranges and operating conditions that the RCM must handle in the future. This approach lead to design modifications of the RCM which will pay-off in the future due to the relevant boundary conditions the RCM will address for various fuels. The final reviewer pointed out that this RCM facility seems like a duplicate of other existing RCM facilities. The claim is the high pressure capability is unique. However, at least for automotive applications, pressures up to 365 bar are not necessary. The ability to get a uniform fuel-air mixture with the nebulizer approach seems uncertain. The ability to get valid samples with the piezo fast-sampling approach seems uncertain.

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

Reviewers were of the opinion that the technical accomplishments are good although overall progress is slow. The second reviewer noted that the PI is working on a redesign of an existing RCM and has mostly completed auxiliary systems to get fuels into the RCM and rapid sampling and imaging. The reviewer also stated that they will perform tests on both low boiling point (BP) fuels and some high BP fuels in this calendar year. However, one reviewer did note that there were no data yet but another noted that they are busy with hardware design and experimental setup, only with barely any accomplishments. The fourth reviewer pointed out that although much effort has been spent designing and developing the RCM hardware, the major accomplishments for this project lie in the future. It was also indicated that there has been some delay due to equipment damage, however, work has continued on other hardware such as the fuel air aerosol generator and the fast sampling system.

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

The first reviewer pointed out that participation in the RCM group is a good development to allow sharing of information on the machine hardware design and operation. The second reviewer noted that strong university involvement is a valuable component to include for such work. The reviewer also added that it may be valuable to include collaboration with NREL or a U.S. Department of Agriculture (USDA) lab to provide more interaction with those who are developing emerging biofuels. However, another reviewer indicated that the project is focused on developing an experimental capability at a selected location and thus does not include much collaboration beyond support from those at other institutions who helped the PI develop RCM hardware. The final reviewer agreed by adding that appropriate advice and know-how has been obtained from other labs and institutions.

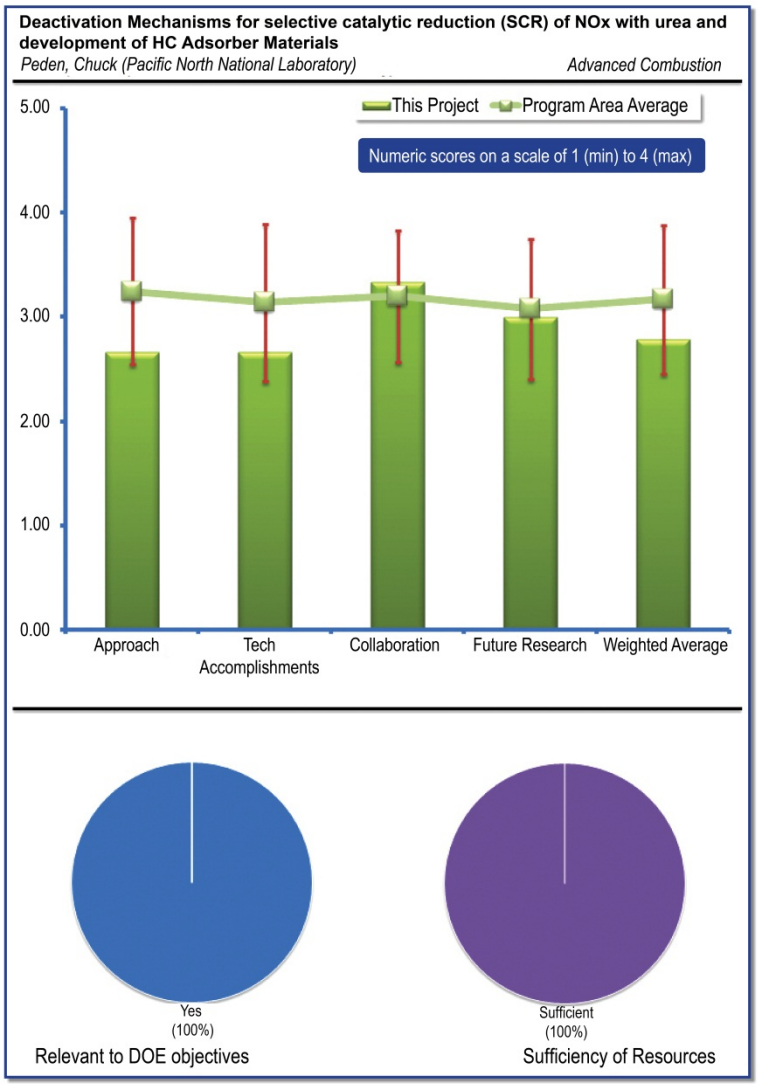
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers asserted that extensions to alternative fuels including biodiesel should provide useful information in engine design and emissions studies. Another noted that plans to study various surrogate fuels to complement other basic studies in shock tube apparatus will generate data to supply to LLNL kinetic model development activity. The third respondent's only suggestion was to include gasoline and diesel fuel (DF-2) as fuel candidates in future RCM studies and that the latter is a good baseline case given the reasonable amount of ignition literature on DF-2. The final reviewer acknowledged that the limitations in the RCM approach to generating chemical kinetic data seem to be recognized well and methods to overcome them have been planned.

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

Some reviewers thought that it was a healthy funding profile, and support from BES as well and overall seems appropriate. Another reviewer stated that this has been a well-supported effort to bring new capability to the PI's institution that hopefully will pay off in the future. The final reviewer indicated that the budget is quite generous compared to the progress to date.

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



Reviewer Sample Size

This project had a total of three reviewers.

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

The first reviewer felt that this project supports petroleum displacement, though somewhat indirectly. Identification of SCR catalyst degradation mechanisms and laboratory aging protocols will help speed testing of emissions-compliant high-efficiency diesel engines. The second reviewer confirmed that extended performance of SCR systems are needed so in-use vehicles keep operating with high-NOx high-efficiency calibrations as they approach full useful life. We need to learn more about the fundamentals of these degradation mechanisms. Another noted that HC absorbers are emerging as a critical cold start technology for meeting LEVIII regulations. Much engine measures are used to overcome cold start HC emissions. These resources might be better spent on fuel efficiency which these studies facilitate. The third reviewer included that SCR catalysts and HC traps are currently necessary to enable use of Diesel powertrains in the USA due to stringent NOx regulations. It is unlikely that this project will have significant direct impact on DOE goals for petroleum displacement because 1) SCR injection systems are still needed and too expensive for passenger cars so durability improvements will not significantly increase diesel use and 2) alternative NOx reduction techniques requiring dual fuels or low temperature combustion have not been demonstrated to improve realizable thermal efficiency require invention and may point to a need for other types of research beyond HC absorbers.

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, after noting that this project is outside of this reviewer's area of expertise and that comments should be considered accordingly, stated that it seems that in the absence of complete understanding of the chemical, mechanical, and possibly other aging mechanisms involved, there is a risk of getting misleading results when comparing catalysts that are aged for hundreds of hours in an engine aftertreatment system with catalysts that are subjected to an accelerated aging process for a few hours in a lab. Unless the investigators know all of the relevant parameters to consider, the lab-aged catalysts may mimic some aspects of the degradation in engine-aged catalysts but produce different behavior in other aspects. The second reviewer approved of the approach of taking OEM inputs and previous work and then elaborating and fundamentally explaining observations and then getting into public domain and said this method is excellent. The reviewer also added that the fundamental approaches are noteworthy, such as hypotheses and tests to support or refute and simplify and focus on mechanisms, which were very nicely done. Another reviewer indicated that with the basic

premise defined to identify and characterize deactivation mechanisms of SCR catalysts, and to evaluate HC absorber technologies, the activities are implemented reasonably well and promising formulations and deactivation (failure) mechanisms are being evaluated.

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

The first reviewer began by noting that the project started Februrary 2007 and is scheduled to end FY12, so it is largely complete (HC Trap work just started last October). This reviewer went on to comment on the presenter's statement that "there is a critical need to develop realistic laboratory aging protocols that effectively simulate engine aging induced catalyst deactivation. For this, a fundamental understanding of the deactivation mechanisms is essential." The reviewer indicated that this sounds like a reasonable premise, however the reviewer indicated that it does not seem like they have gained a full understanding yet. As best as this reviewer could tell, they have identified some effects of catalyst aging but are only beginning to understand the underlying causes. The second reviewer expressed that sulfur dioxide (SO2) versus sulfite (SO3) impacts on CuZ needed a little more fundamental understanding. This reviewer also questioned how this helps compositional development. Another reviewer thought that hydrothermal aging of SCR was "classic work!" The reviewer added that they could run some experiments to quantify, develop a hypothesis, and test to confirm. The reviewer also noted very nice fundamental insight that may deliver new approaches. The reviewer also felt that the HC absorber was very interesting and valuable building of fundamental understanding which included pointed results that address needs. Another reviewer commented that there was no significant breakthrough and only moderate progress. This reviewer summarized the testing results as 1) strong interaction between Cu and Aluminum (Al) in the aged catalysts that show good high-temperature NH3-SCR performance and 2) lower silicon (Si)/Al ratio zeolites appear more effective for HC adsorption and desorption.

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

With respect to PNNL and Ford only, the first reviewer deemed the collaboration probably adequate, but might be more effective with more people involved. This reviewer also noted that later it was revealed that PNNL is pursuing other SCR studies with GM. IP concerns necessitated keeping the projects separate. The second reviewer indicated that the project team is hooked up with the OEM leader on zeolites and SCR-Ford. This reviewer added that they are obviously quite involved and helping to guide the programs and needs and that this is a model program of OEM collaboration and the NLs delivering fundamental understanding. The reviewer also noted that the GM program has a similar objective but a very different approach and results. This is helping to build knowledge on perhaps different formulations. This will further the fundamental understanding for societal benefit. The final reviewer noted that the Ford CRADA shows support and credibility.

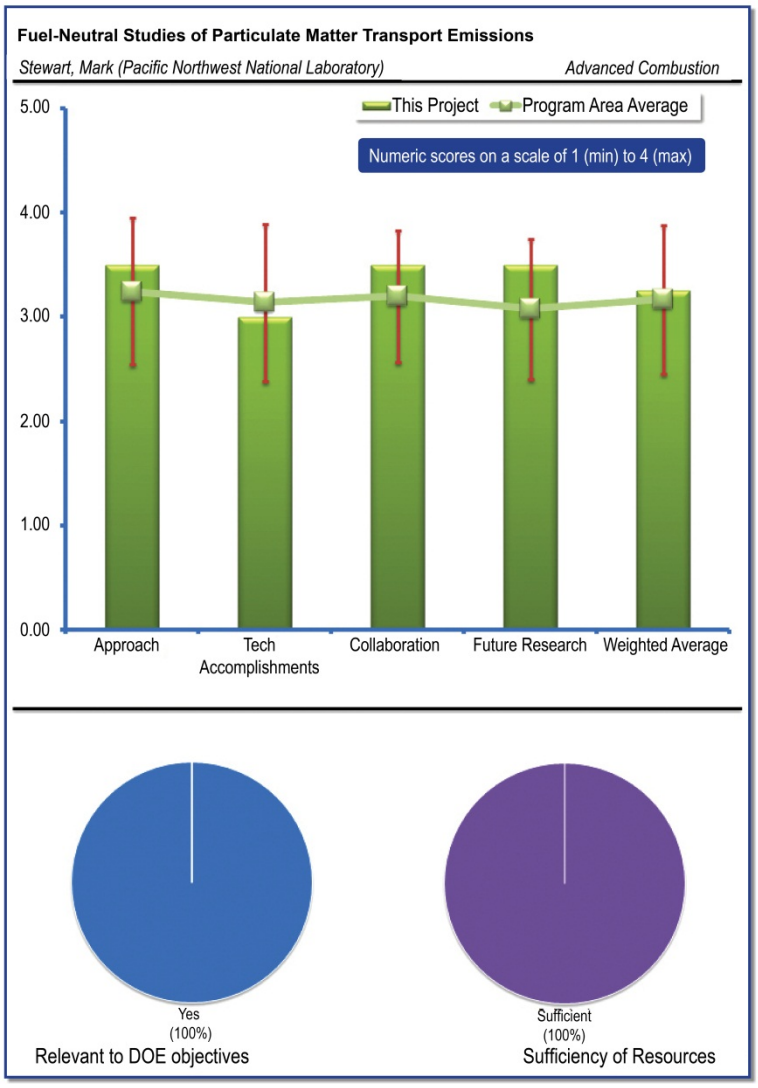
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewers felt that the proposed future research appears appropriate, useful, and achievable. The second reviewer stated that they should keep it going, adding that the team knows what is needed and how to get it. Another reviewer asserted that the fact that the "future work" is now morphing into SCR behind LNT shows flexibility for the project to react to engine technology evolution and trends, but points to only early understanding of the true need for this work.

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

The first reviewer pronounced that the project team seems to have made notable progress with relatively modest resources. Other reviewers agreed that the team is very efficient in delivering the fundamental understanding. Adding that the levels of funding, along with that of the GM program seems adequate to add value.

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



Reviewer Sample Size

This project had a total of two reviewers.

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

The first reviewer confirmed that advanced DISI engines are expected to become a key higher efficiency, low cost powertrain in North America. Health effects associated with DISI particulate is important as fuel and engine hardware evolve. The second reviewer noted that it is still expected that gasoline engines will be the primary engine for the foreseeable future. Lean gasoline has the potential for significant fuel economy benefits. This work gives us a significant step into identifying needs for particulate filters in the DI gasoline engine arena.

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 the project had excellent equipment for the job and that it builds on demonstrated experience to expand understanding in an important new area. Another reviewer noted that as always the work is quite good and state of the art. However, at present this reviewer saw no connection with modeling and questioned how it was going to be solved.

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

Reviewers noted that work is moving forward well and that it covers a very good range of conditions. However, one reviewer did not see a distinction between soot cake and no soot cake filtration in this study.

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

The first reviewer liked the collaboration with GM and ORNL. Another noted that the collaboration is quite good, adding that incorporating the input from an OEM is very important and the group selected from the OEM is quite knowledgeable. However, as noted above, this reviewer thought there seems to be no modeling collaboration.

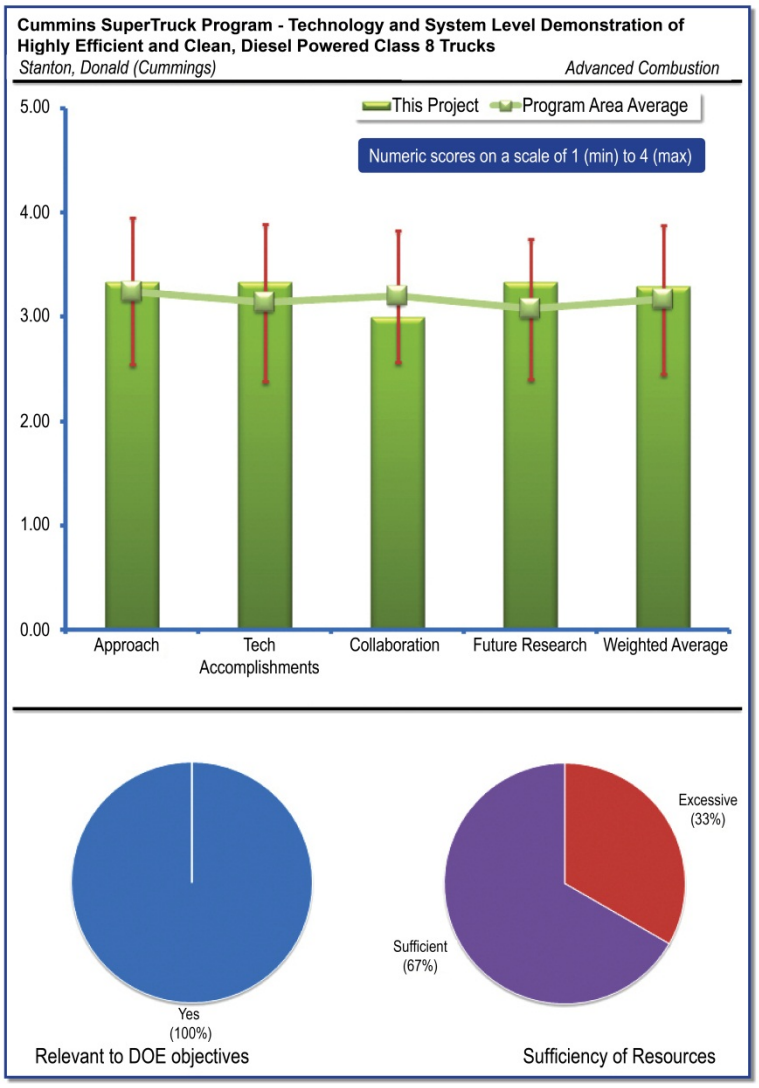
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer confirmed that the future work broadens our understanding of particulate from a NA engine with a range of fuels to complement previous studies with European and earlier generation DISI engines. The second reviewer agreed that work on the soot oxidation kinetics is needed. Especially since the data seems to indicate that the character of the soot particles is different than what is observed from diesel engines. However, this reviewer noted that some aspects of this work overlap with the project of John Storey at ORNL and the reviewer would like to see more coordination so that work is not duplicated.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer pointed out that the high level of collaboration is clearly leveraging the resources very effectively. This reviewer also noted that it is sort of a catch-22; the more effective the leveraging, the more likely it is that the resources are deemed adequate. However, this reviewer did think that some resources have to be allocated to the soot production modeling.

Cummins SuperTruck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks: Stanton, Donald (Cummins) – ace057



Reviewer Sample Size

This project had a total of three reviewers.

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

The first reviewer felt that the overall objectives of this project are to improve the efficiency of a HD engine to > 50%, and that of the total tractor trailer by 50% over the current efficiency. Such an improvement while being overly optimistic does provide a stretch goal for fuel efficiency. With a significant portion of fuel being consumed by Heavy-Duty trucks, such increased fuel efficiencies can translate to significant fuel savings. The second reviewer indicated that the project is directly relevant to major DOE fuel efficiency (FE) targets and Recovery Act targets. The final reviewer thought that the program aims at the DOE Supertruck goals, as well as the ARRA 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 confirmed that the PI acknowledges a multi-pronged approach in achieving the > 50% engine efficiency and a 50% improvement for the total vehicle. However, the improvement in one aspect could negatively impact another: For example, use of WHR could improve engine efficiency but adds to the overall weight. With only projections provided so far (as opposed to test results) it was difficult to judge the net efficacy in able to meet the objectives. The second reviewer thought that the projections of FE improvement are amazing and provide a solid plan for vehicle integration and commercialization of many advanced technologies. Another reviewer felt that the comprehensive approach is projected to exceed the target goals for efficiency improvement. The approach seems to be heavily dependent on significant improvements in SCR aftertreatment efficiency to handle increased engine-out NOx emissions. This may be achievable for demonstration purposes, but may have cost roadblocks for commercialization. This reviewer added that a few of the elements are novel and will be interesting to see next year's progress, particularly the use of VVA to allow over expanded / Miller cycles / 6*8 stroke aftertreatment regen. This reviewer also thought that the details of the third generation fuel system would be interesting to reveal next year too.

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

With the information shared so far (which is very little), the first reviewer felt that the technical progress appears to be on track. The PI does acknowledge three specific issues that were realized early – under hood cooling, weight gain by WHR, etc.–and provides assurance that they have been addressed. Projections are also provided for performance improvement of the tractor-trailer through

weight reduction, reduction of rolling resistance etc. Another reviewer asserted that 51% BTE by year end will be most impressive. The third reviewer noted that just completing the first year of a 4-year program, progress has been made in going from 42% BTE to 47.5% now. Reaching 50% by end of year seems achievable based on the material presented. The reviewer also added that the program will need a lot of success in SCR efficiency improvement.

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

The first reviewer indicated that the collaborations with parts suppliers are very relevant and stand to leverage their respective expertise. However, the roles of ORNL and Purdue University are somewhat hazy; other than including them for team building, there is very little involvement. The second reviewer confirmed that the project had a solid team of manufacturers and suppliers. The final reviewer agreed that there was a good mixture of industry, academia, suppliers, and national lab. The reviewer also pointed out the heavily dependent on internal Cummins groups, which was deemed to be okay.

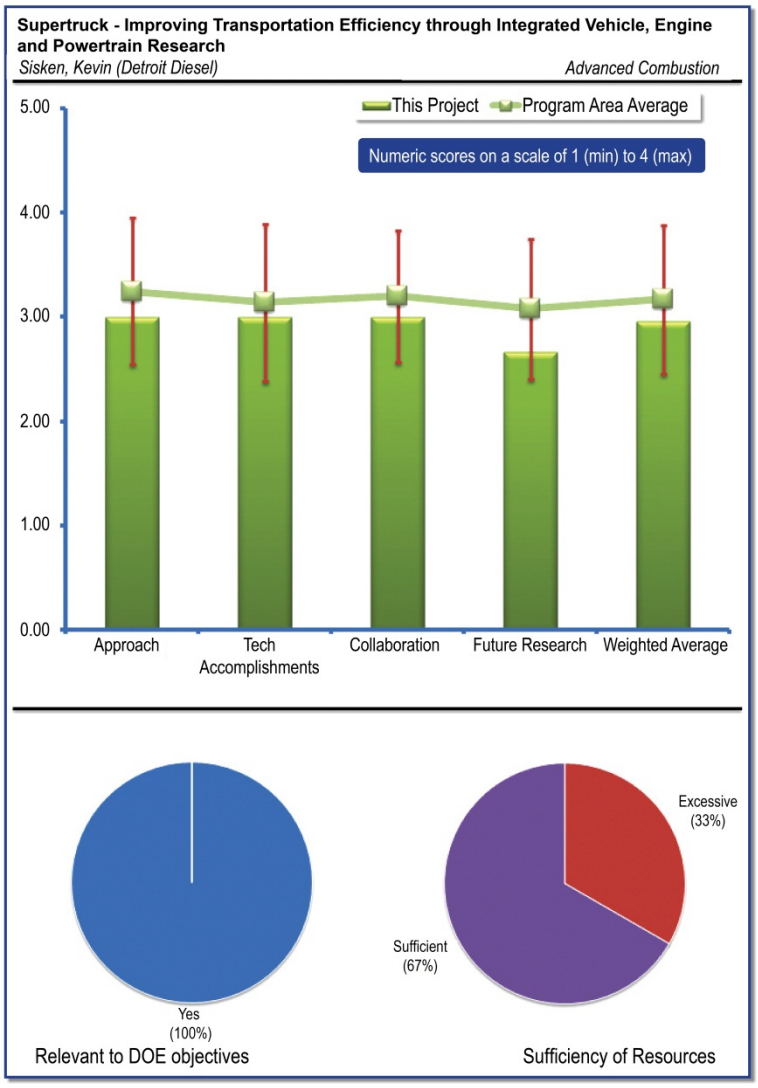
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

From the presentation, the first reviewer noted a path for project progress appears to have been identified. This being the very first year they have shown sufficient progress to be on track with the initially proposed schedule. The second agreed that a solid plan should meet objectives. The third reviewer requested more specific detail next year on the SCR and fuel system technologies that are being incorporated.

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

The first reviewer indicated that $39M for the proposed effort is excessive. WHR and other technologies have been developed by Cummins as a part of previous efforts. While 50% performance improvement for the tractor trailer is a stretch goal, it might be worth providing a more achievable goal while keeping the funding at a commensurate level. The second reviewer saw the big program properly funded. The final reviewer was impressed with the leverage of DOE funds with >50% cost share.

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



Reviewer Sample Size

This project had a total of three reviewers.

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

The first reviewer felt that since the main objective of the program being to achieve 50% improvement in freight efficiency of tractor-trailers, it supports the overall DOE objectives of petroleum displacement. Other reviewers indicated that this has direct relevance to fuel use and the Supertruck and ARRA goals are being addressed.

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 noted that a pathway for project execution has been identified, and areas for efficiency improvement – engine combustion modifications, friction reduction, WHR, reduction of pumping losses, intelligent controls and better aftertreatment – have been identified. The reviewer added that while most of them appear to lead to an improved product, additional weight due to WHR system could be an issue. For marginal improvement in efficiency, the additional cost of the WHR system may not be justifiable. Similar identification of issues and pathways for overall improvement of tractor-trailer performance is necessary. Especially, pathways for reduction in fuel consumption during idling/ or being at a rest stop are necessary. The second reviewer thought that the project had a solid approach, although noting some uncertainty on how well things are really going to work. The final reviewer felt that Downsizing/Downrating is a major element in the strategy which is good for improved BSFC, but doubted its abilities to regulated emissions. Relaying in improvements to SCR to control the higher NOx, which will take back some of the fuel efficiency gains. Controls and predictive driving route is an interesting concept, but the reviewer wonders how much is there to gain from this.

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

The first reviewer expressed that this being the first year of the project, Detroit Diesel Corporation (DDC) has identified a number of areas for improvement and is working towards them. They have already shown improvement through friction reduction, reduced parasitic losses, and combustion chamber modifications. Another felt that it is a good demonstration so far. Others went on to point out that it is year one of a 5 year program completed and a 3% efficiency improvement will be demonstrated by end of the year. This reviewer also noted that a waste heat recovery - Rankin cycle resulting in a gain of 5% is expected. This reviewer indicated that it was difficult to understand the contributions of the other technologies being proposed, Slide 5 kind of does that, but it wasn't very clear.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first respondent pointed out that DDC is partnering with various organizations to leverage their respective areas of expertise. Especially, their partnership with MIT to identify ways to reduce friction is commendable. On the same token, their partnership with ORNL to develop a viable WHR system is questionable. Instead, a working with an industrial supplier like ORMAT (or others) is recommended. Another deemed the project mainly in house, but well supported. It was observed that it is a small team, but looks OK. No major suppliers were considered to be significant players (i.e., aftertreatment).

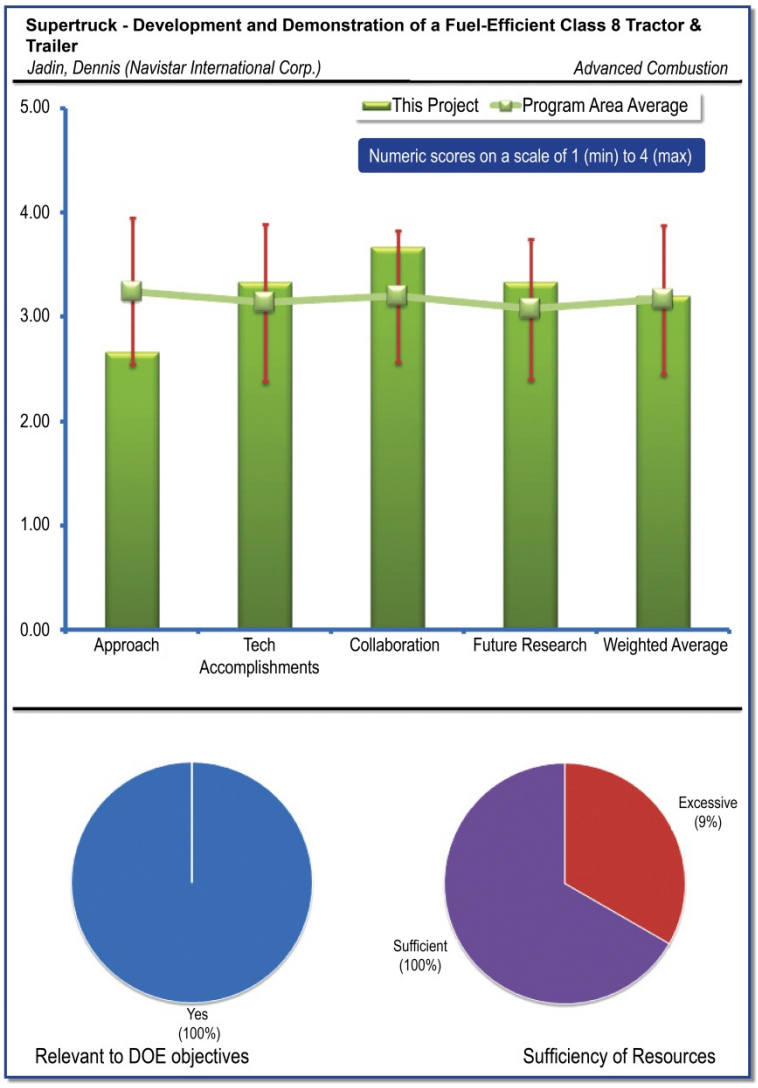
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer pointed out that not many details are provided regarding the future work to provide a fair assessment and a "fair" ranking has been issued based on past performance assuming a similar trajectory into the future. The second reviewer felt that solid plans for major improvements were established. The final respondent noted that future work was okay but the presentation was a little vague.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer thought it was a well-funded program making good progress. The second reviewer noted that it was difficult to tell much in the first year but should be able to better evaluate next year. The final reviewer stated that the allocated funds, to the amount of $40M, are excessive considering the nature and scope of work. They may have been justified in having to address the stretch goals of 50% improvement in tractor-trailer performance. More reasonable goals with commensurately matched (reduced) funding levels are recommended.

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



Reviewer Sample Size

This project had a total of three reviewers.

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

The first reviewer indicated that this project aims to improve the fleet efficiency of tractor-trailers by 50% over the current levels. As on-highway trucks account for a major portion of our fuel consumption, this project supports overall DOE objectives to reduce petroleum consumption. Another reviewer noted direct relevance to DOE goals. The final reviewer noted that this project addresses technologies for 50% improvement in overall freight efficiency from tractor-trailer combination.

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?

From the presented material the first reviewer noted that it appears that Navistar has adequately identified the barriers and potential pathways to address them but on a second look, their approach appears ambiguous. For example, they appear to pursue PCCI and in a parallel path reactivity controlled combustion. In a similar manner, they appear to pursue both Organic Rankine Cycle as well as turbo-compounding. Instead of turning every stone, following an approach guided by sound engineering sense would be prudent. However, continued this reviewer, their efforts to improve efficiency through combustion improvement, friction reduction and parasitic loss reduction are commendable. This reviewer added that not many details are provided in improving the overall vehicle (tractor-trailer) as opposed to just improving the performance of the engine. The second reviewer indicated some uncertainty in the WHR plan and engine out NOx level. Another noted the detailed technology roadmap but was unsure of the reasoning for the optional paths and parallel paths. It seemed paths are distinctly different rather than complementary. For example, PCCI may require NOx aftertreatment whereas dual-fuel may not. The reviewer questioned whether the project team intends to down-select soon or continue on multiple paths and options and when are the decision points? The reviewer also questioned if the team expects significant recoverable energy in EGR loop when running dual-fuel mode. Exhaust temperature is normally lower for dual-fuel. This reviewer asked if turbo-machinery efficiency improvements still be there when high dilution is run with dual-fuel.

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

The first reviewer stated that Navistar's efforts towards efficiency improvement through combustion system development have shown progress at medium and high speeds. However, the system has shown moderate progress at low speeds. However, they have shown significant improvements in air system development, parasitic loss reduction and friction reduction. While they seem to be on track

with developing turbo compounding, their progress towards Organic Rankine cycle appears to lag behind. The efficiency gain stack up that they provide is a combination of test results and simulations. Furthermore the net system performance is also dependent on coupling of engine performance with aftertreatment system. The second reviewer deemed the project to be somewhat behind the others, but many good technologies are on the way. The final reviewer indicated nice progress and parametric study on BTE. This reviewer questioned the 4% increase in turbocharger efficiency with dual-fuel. However, the reviewer stated that the consideration of engine systems was nice and appears to be a very thorough study. The reviewer questioned if the team will include WHR if they take the dual-fuel path in the end. The reviewer thought that 55% BTE with dual-fuel is very aggressive goal and reported that dual-fuel peak BTE on a similar size engine is approximately 59% gross ITE. Bridging that will be a challenge, but not thought to be impossible.

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

The first reviewer indicated that Navistar is partnering with various organizations in this effort to leverage their respective areas of expertise. Though they are working with Wisconsin ERC, who has the current expertise with RCCI, they are not readily acknowledged. Another reviewer thought the project seems well integrated with suppliers and partners. It was also stated that the team is great for this project and has many of the best partners in the technology areas.

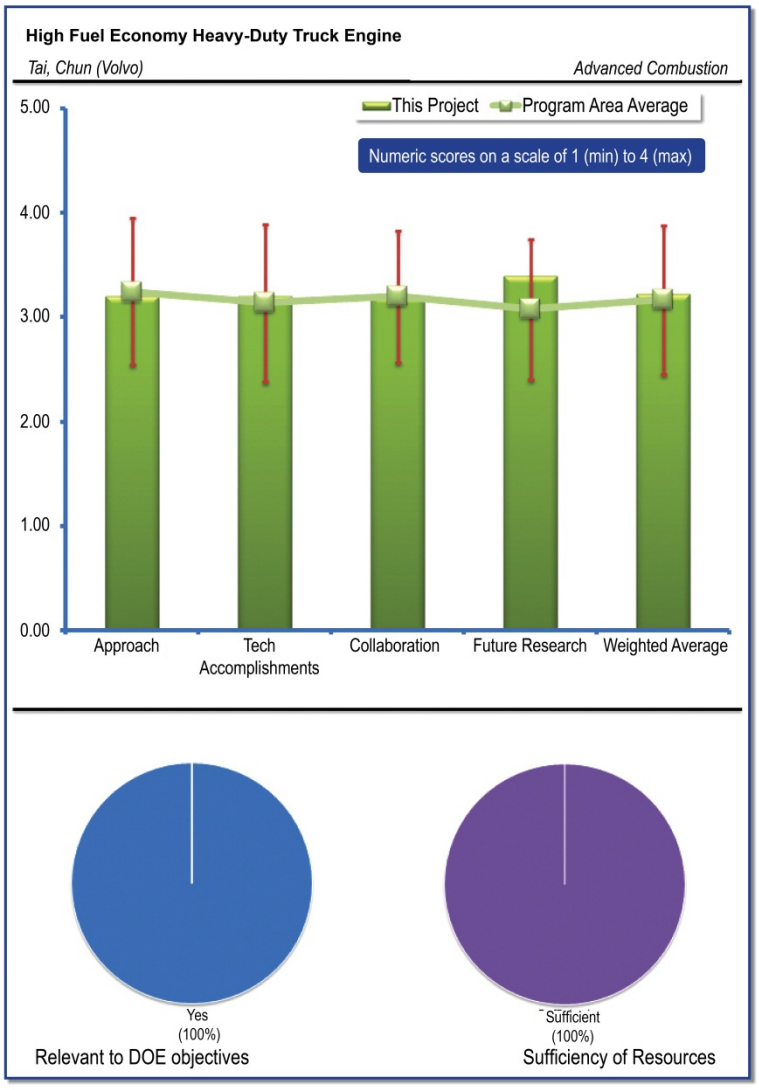
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that details are provided only for the proposed work in the rest of FY 2011 and not many details are provided for work proposed thereafter. The second reviewer expressed interest in dual fuel work. Although the reviewer was not so sure it is the answer, this reviewer was glad to see it getting attention. The final reviewer felt the plans forward were great and is looking forward to seeing a report out next year.

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

The first reviewer felt that the $37M allocation for a stretch goal of 50% improvement over current (tractor-trailer) performance is commensurate. Another reviewer felt that the work was well funded.

High Fuel Economy Heavy-Duty Truck Engine: Tai, Chun (Volvo) – ace060



Reviewer Sample Size

This project had a total of five reviewers.

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

The first reviewer indicated that with an objective to improve the fuel conversion efficiency by more than 10% for long Haul (Heavy Duty) trucks, and particularly promote use of renewable fuels like biodiesels, the current project supports the DOE's overall objective of petroleum displacement. Other respondents noted that the project results in vehicle efficiency improvement and cost effectiveness. Another reviewer questioned if a biodiesel demonstration was part of this solicitation.

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 while the approaches for combustion system optimization, turbo-compounding, and Organic rankine Cycle follow that of other truck manufacturers, novelty of this approach is in investigating (i) mild hybridization and (ii) evaluation of biodiesels for promotion of renewables. Considering the fact that HD trucks spend very little time in transient operation, hybridization is likely to offer very little improvement. Evaluation of biodiesels appears somewhat misplaced as compared to the main objective of efficiency improvement for this project. Another reviewer felt that a good approach for the scope of the program had been used and a nice balance of simulation and test had been employed. The third respondent asserted that the project had well defined milestones and status. The reviewer also noted that the approach was nice that included optimized air/dilution handling, mild hybridization, idle reduction, and thermal energy recovery. The reviewer also commented on the experiment and simulation which goals exceeded with 14.5% improvement in in-use efficiency. The project included non-hybrid and hybrid demonstrators, bio-fuel research (which was deemed very important with increased penetration of bio-fuels), high dilution combustion for reduced NOx. This was noted even if lean NOx aftertreatment is required in the future; the reduction in PGM due to reduced engine-out levels will be cost effective. Another reviewer indicated that the project fully funded. It is finished!

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

The first reviewer noted that adequate progress is being reported for the pathways identified for efficiency improvement and GHG reduction including: *Combustion/Eats Optimization* - offers 5-6% point efficiency improvements; t*urbo-compounding* - fully mechanical system with fixed speed ratio offers promise; *WHR through ORC* - through simulations optimal configuration and ideal hardware identified; m*ild Hybridization* - simulations showed hybridization to offer very little improvement for HD trucks; and b*io-*

Diesels - sufficient data generated to estimate short term impacts. Another reviewer noted that after looking in the rearview mirror, this industrial partner did "OK". The third reviewer noted that the project had beaten the expectations. The fourth respondent expressed good integration with hybrid vehicle but was unsure if there were any specific milestones this program was supposed to achieve. Another reviewer noted that the project is very near completion with goals met and there is a no-cost extension to clean up a few details. The Rankine system will continue to be developed and eventually on-vehicle. The reviewer added that the accomplishments appear consistent with plan and results to-date show original goals were exceeded by Volvo. The reviewer was interested that the mechanical turbine coupling was most efficient and questioned what the barrier losses for electromechanical were. This reviewer also noted a nice Rankine simulation and design and questioned if the piston expander has an advantage over scroll expander, noting that both can handle a small amount of liquid water.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers agreed that the team is comprised of entities with unique and needed expertise. Another reviewer noted that the PI used Ricardo, internal organizations, and academia to help out. The fourth reviewer noted that the Rankine system was developed with Ricardo, University of California, Los Angeles (UCLA) and biodiesel work was collaborated with Penn State University.

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 indicated that the contractor promises to complete the remaining activities to wrap up this effort by end of FY2011. This reviewer pointed out that in the overview slide (pg.2) the project is projected to end by Oct. 2011, but on pg. 18, it is stated that the promising technologies will be integrated into demo vehicles in 2012. Based on this, the reviewer concluded that the total efficiency gains are just projections based on prototype system tests and model predictions. Another reviewer noted that the program is ending, but it seems internal work will continue. The final reviewer questioned if the Rankine system be part of the final package for this project. This reviewer also inquired if the bio-fuel impact WHR heat exchanger efficiency is different from conventional diesel fuel, and concluded by noting that the goals are met and the no-cost extension is to clean up the details.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Overall, reviewers felt that the resources are sufficient and the program was sized about right. It was also pointed out that there was good leveraging of DOE funds at a 2:1 ratio.

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

Reviewer Sample Size

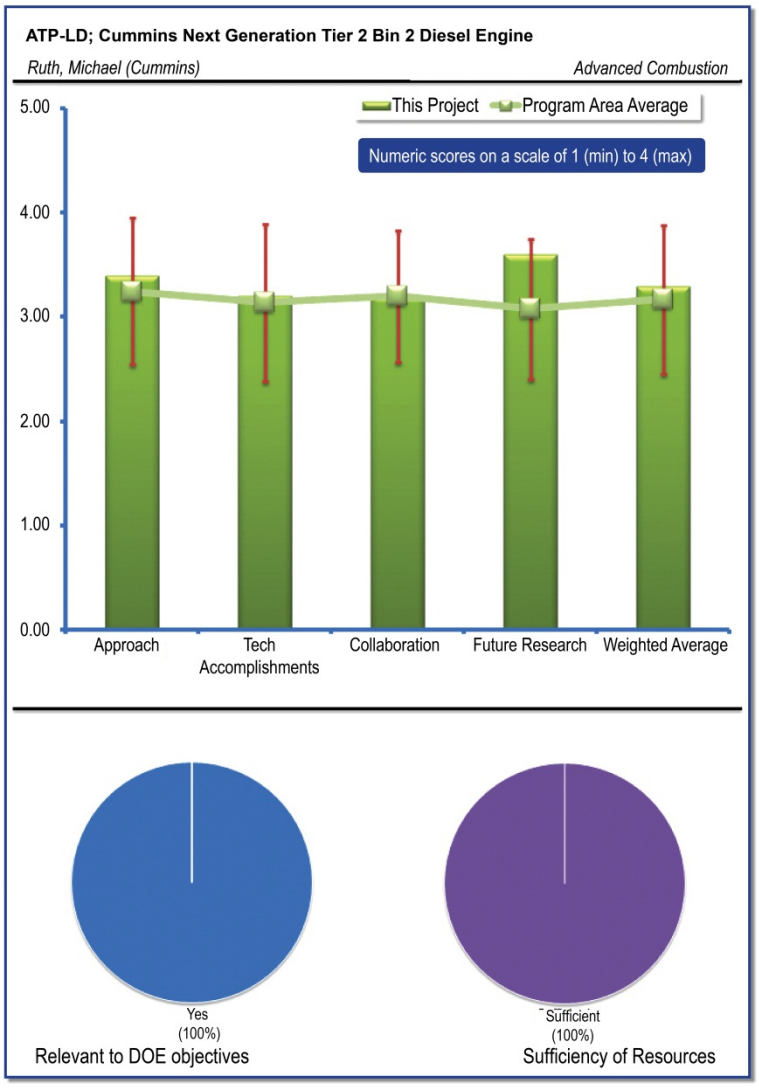
This project had a total of five reviewers.

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

Overall, reviewers confirmed that this project aims to improve the fuel economy of a 1/2 ton pick truck by 40% and that such reductions will lead to less petroleum consumption and is in accord with overall DOE objectives. Reviewers also noted that this work is at the core of DOE/OVT mission.

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, considering the fact that this project was awarded in 10/2010, expressed that it appears that the team is still in the initial stages of developing a strategy. Current strategy includes a combination of down sized engine, extension of PCCI, reduction of fuel penalty due to aftertreatment besides others. In addition to these traditional approaches (low-hanging fruit) this reviewer highly recommended that the team look into dual-fuel strategies, reactivity controlled compression ignition (Wisconsin ERC), and use of low-quality gasoline in a diesel engine (ANL), that are showing promise. The second reviewer thought that the project was systematic and sound and reflects high competency. This reviewer asserted that the polynuclear aromatics (PNA) approach is innovative, and is worth pursuing. This reviewer felt that the LP-HP EGR combo is expensive and challenging for a MD truck application, even though some after-marketers are touting it. The third reviewer wondered if a 4 cylinder with the same torque as a diesel will be marketable and noted that the project is depending on customers being very interested in FE. Another felt that the overall approach appears to be comprehensive and should lead to a successful program. Using low pressure EGR to reduce the pumping work is good but weight reduction goals are pretty aggressive, with some risk there. This reviewer inquired if the piston goals realistic (same as gasoline engine piston weight goal) what the risk of not achieving these is. The reviewer also pointed out that downsizing is helping with the quality of exhaust for better aftertreatment performance. The final reviewer felt that the approach outlined in 2011 milestones is consistent with goals and that the inclusion of mule vehicle operation in first year is big plus. The reviewer also felt that the longer term, 2012-2014, milestones also seem reasonable in combination with more detail from later slides. This reviewer added that it was great to make use of knowledge discovery from previous studies. The use of low pressure EGR to reduce EGR pumping work makes sense to reduce penalty. This reviewer was glad to see that the project team was not abandoning EGR in pursuit of only aftertreatment (AT). The combined approach will lead to lower precious metals requirements and cost. The down-sized approach helps with power density and FE. The PNA is a good approach to more efficient AT. However, the reviewer did not know the details but understand the reasons. Overall, the approach appears to be integration of technologies well understood by Cummins.



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

The first reviewer noted that the progress shown is commensurate with the late start of this project. The team has identified downsizing of the engine to be their main strategy which, in addition to Low-pr loop EGR, and reduction of fuel penalty due to aftertreatment, are their chief strategies. This reviewer added that they appear to be making progress in that direction. The second reviewer felt that the PI laid out a sound plan and executed well in the first few months of it by getting up and running with the many facets of the program. Another indicated that this was a good start from a high baseline of technology. The fourth added that the program is only six months old and it will be better able to evaluate next year. The final reviewer would have liked more information on accomplishments but did realize that the time does not allow for more, and added that having the mule engine built and simulated early on will go a long way for the success of this program and that progress there looks great.

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

The first reviewer confirmed that this was a good team to address technology challenges and did not see any missing partners who would make this stronger. The second reviewer asserted that while the overall team appears to bring the necessary expertise, the inclusion of NexGen and Oak Ridge National Lab is nebulous. Their role is not clear in the overall project. The third reviewer noted that the project is carrying out multi-suppliers' collaboration, such as Bosch and JM and that it may be enhanced by including high-power expert entities, such as the University of Wisconsin-Madison and ORNL, in engine combustion, controls, experimentation, etc. The fourth reviewer maintained that the university collaborations are a little weak and NexGen was mentioned, but now are out. Johnson-Matthey for aftertreatment looks good.

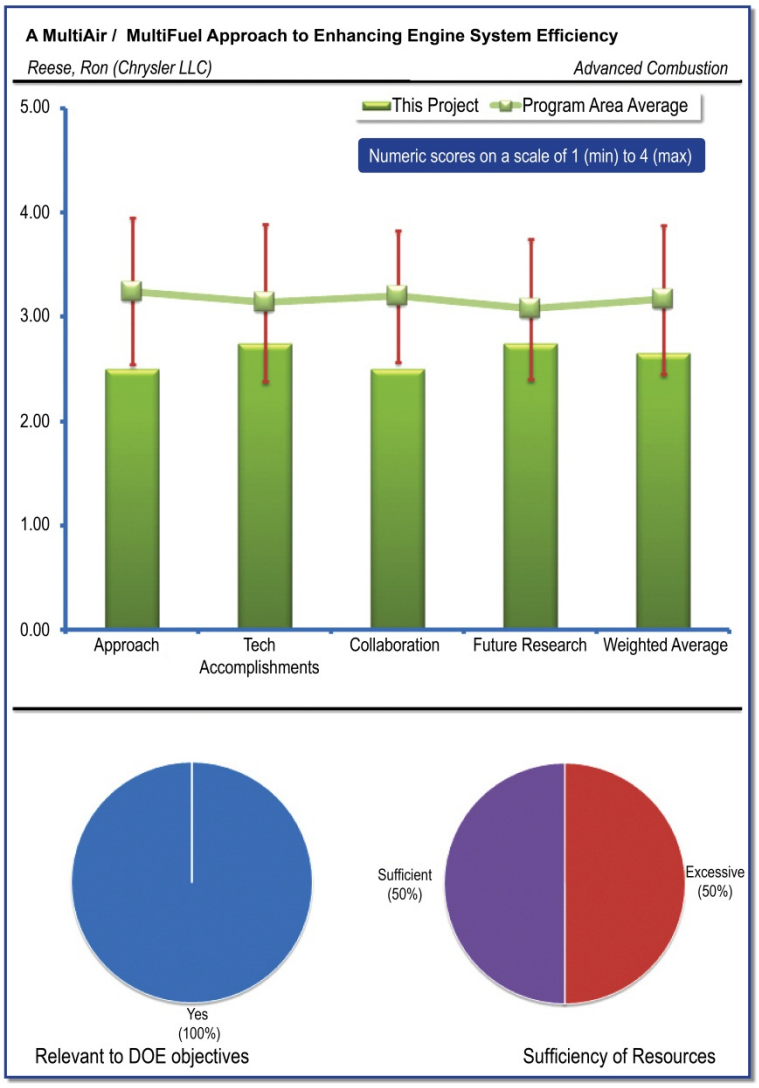
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer recommended evaluating dual-fuel (or RCCI concept) that shows high efficiency gains with concommittant reduced emissions. The second reviewer felt that this was a good plan should result in successful design. Another pointed out that this seems reasonable, but since this just started six months ago, there are not results yet to guide any revisions to the proposed future work. The final reviewer agreed by stating that it is early in program but it is on track. The future (approach for upcoming years) makes sense to meet objectives.

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

The final respondent noted that only 3-4% of the budget has been spent in the first 6 months. This was assumed to be just the inertia of getting the program started, and will track closer in the following years.

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



Reviewer Sample Size

This project had a total of four reviewers.

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

Reviewers noted that the project aims at increasing fuel economy, reducing greenhouse emissions, provides FE improvement for large volume LD vehicles and that achieving 25% reduction in FE is clearly supporting petroleum displacement. The final reviewer felt that this was well matched with DOE objectives for LD fuel economy improvement. Selection of Chrysler minivan makes sense due to high volume.

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 approach reflects the assembly of few recycled technologies and that the team has included "the kitchen sink" in a collection that is not really practical for ARPA or for serious product development. However, it has been known for over a decade now that downsized and boosted, if applied properly, will be valuable. The second reviewer confirmed that the high EGR, boosted, stoichiometric system seems unique in the DOE projects, and that given excellent results published by the Southwest Research Institute (SwRI) High Efficiency Dilute Gasoline Engine (HEDGE) consortium this seems like a good idea and very interesting work. Another reviewer thought that the use of two engines makes sense. Starting with the near-term platform to learn and provide knowledge for design of improved long-term platform. The multi-cylinder engine approach makes sense due to timeline. However, this reviewer inquired if there is value in also having simultaneous single-cylinder engine experiments. This reviewer also questioned if three spark plugs per cylinder be realistic for production, if there is modeling to support potential of three ignition sources, and if there are other ignition hardware possibilities. This reviewer noted that the compression ratio seems rather low for efficiency and if diesel used as ignition source and questions if the PI has modeled this scenario. This reviewer asserted that the project had great focus on better matching of most efficient speed/load with vehicle demands over LD drive-cycle. Taking this approach across relevant speed/load range is critical to overall FE improvement. The final reviewer indicated that for the level of funding and timing, the approach presented was at best poorly communicated, and at worst inefficient and ineffectual. The direction of the engineering, tools, partners, and all aspects of the project are not well supported. The approach had no concise strategies presented, no substantiated methodologies considered, no goals for fuel economy reduction based on technologies. The only significant approach which was clearly communicated was the hiring of additional employees by the awardee.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer felt that this was a good start and interesting result so far. The second reviewer noted that 1D simulation best approach to understanding technologies on a systems level. This reviewer added that there was nice design activity. The reviewer noted that there are a lot of head penetrations and questioned if it makes it difficult to design for higher in-cylinder pressures. Very clever design of crankshaft mounted absorber to allow for more efficient system. Great to evaluate potential of multiple CFD codes to determine best fit. This reviewer inquired if the PI is making use of the expertise of organizations such as UW (Reitz) or UM (Assanis) or other known experts to support the dual-fuel modeling. The third reviewer felt that the Alpha engine is not practical, in its totality or as subsystems! This reviewer added that it will NEVER go into production, in any form. Packaging of this collection of elements (including the kitchen sink) under the hood is extremely challenging, if at all feasible. Two-stage turbocharging, especially for gasoline engine, is likely to cause trouble for product developments beyond the preliminary "Alpha" stage. Production release of a 2-stage system in a gasoline (2.4L), 4-cylinder engine is an extremely high risk proposal, from both technical and business perspectives. The added cost of a 2-turbo system + 2 EGR systems + EGR cooler + associated components, sensors and controls should pose significant doubt on the value equation. Perhaps the developments of this skunk-work testbed is not intended for product development, but rather for building Chrysler's core technical competency. The reviewer also pointed out that adding a diesel fuel injector substantially complicated the cylinder head design. Adding a diesel C.R. fuel injection system adds complications to the engine design, controls and system reliability. Introducing diesel fuel into the combustion of a GDI, spark-ignition process is a novel RESEARCH (See ace001) that is in its early stages. It is way too early to incorporate here. Asymmetric, side GDI injector is not optimum arrangement and creates a real challenge in developing a robust combustion system for all real-life operating conditions. Two fuels onboard a passenger vehicle is not a good idea for the next several years, market research would support this claim. This reviewer also commented on Slide 10 that the idea of incorporating crankshaft pendulum absorber is to be applauded. Engine height, block redesign, and many other factors prohibited using this technology in the past. Many internal R&D programs pursued it for decades, and a few public papers addressed it. See for example published Ford's work: 1991: Society of Automotive Engineers (SAE) paper # 911876, 2003: SAE paper # 2003-01-1484 (available at http://www.egr.msu.edu/dvrl/pubs/Nester-etal_MI03.pdf). Argonne National Lab has substantial core competencies and capabilities, but 3D CFD combustion is definitely not one of them. This is why ANL contracts the University of Wisconsin-Madison and others to carry out these simulations for their R&D programs. The arrangement described in this slide benefits neither Chrysler nor ANL. This reviewer questioned if Alpha 2 is for code validation only. This effort may be viewed as a training exercise for ANL, otherwise it is better handled by having a university team (UWM or UM) and SNL involved and findings and conclusions are primitive. The fourth reviewer stated that little progress was communicated outside of eliminating the multi air product from consideration on the engine (opting for a more conventional approach due to packaging of twin turbo design. Potential directions for the technical path were identified with statements like "if one spark plug is good, and two are better, it would be great to see how three would work". Pet technologies which have not been demonstrated to work effectively were presented and will be apparently developed with public funds.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The final reviewer asserted great collaborations and thanked the team for describing team contributions where relevant throughout the presentation and noted that this was helpful. The reviewer expected different teaming for simulation and combustion studies, perhaps with a university such as University of Wisconsin or University of Michigan. The reviewer thought that Argonne is a great match for spray imaging and fundamentals and that Delphi is great match for sensing and control. This reviewer commented that Ohio State University (OSU)has wide range of expertise in hybrid controls and liked how the team is making use of that expertise for more "conventional" approach. The second reviewer indicated that this is primarily internal but some useful interactions and is appropriate for the project. Another pointed out that partners have been identified but it was not clear how this was working. The final reviewer noted that the four additional partners are well recognized names. However, their roles reflect a misfit, because they are not used in their respective core competency. Collectively, real engineering coordination and integration are not apparent. The reviewer also noted that someone at the meeting mentioned that Fiat Research in Italy has substantial know how and core competency in the subject research and development area. This is also apparent from a survey of Fiat's product fuel economy data. The reviewer questioned why Chrysler is not capitalizing on this.

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 agreed that they are looking forward to the team's results. One reviewer noted that the plan going forward is reasonable but not well defined or communicated and pointed out that the project can clearly rate a three with better communication of strategy, resources, and results. The final reviewer felt that the overall plans were good going forward and were consistent with a successful plan. However, this reviewer advised considering involving the University of Wisconsin or similar in modeling.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first respondent felt that this effort was well funded. The second reviewer felt that the merits do not seem to warrant the investment. Another reviewer added that based on the proposed plan the funding is excessive and unless plans are improved the resource level is too high.

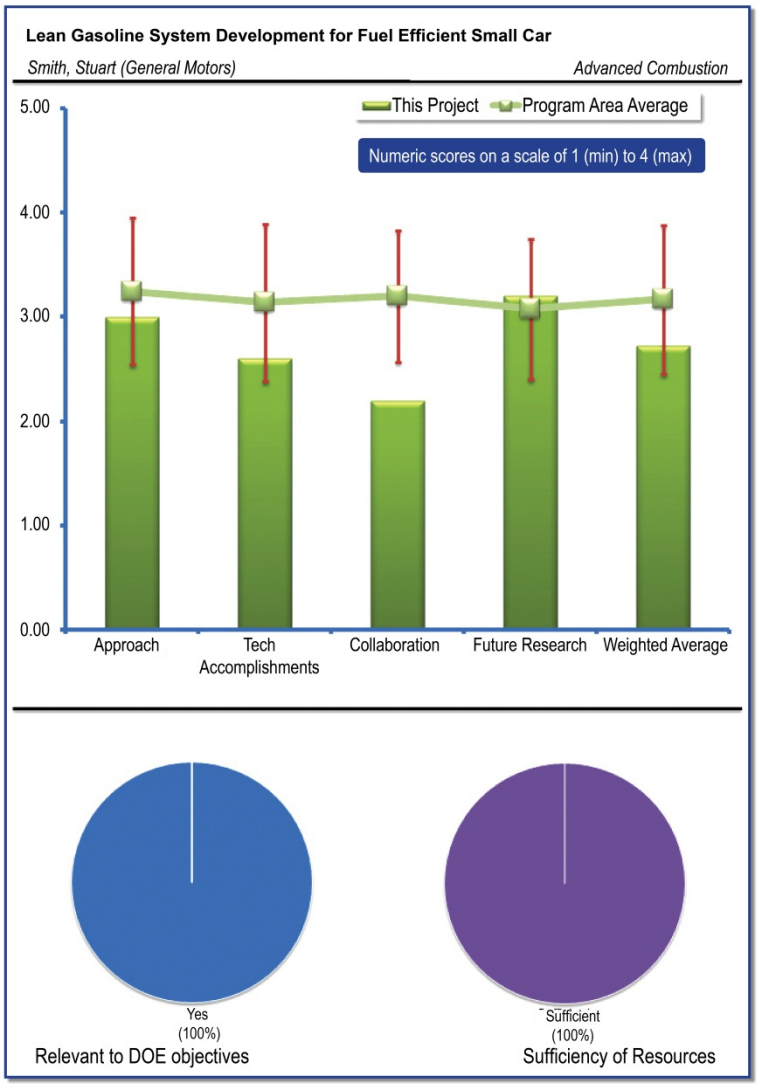
Lean Gasoline System Development for Fuel Efficient Small Car: Smith, Stuart (General Motors) – ace063

Reviewer Sample Size

This project had a total of five reviewers.

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

The first reviewer pointed out that lean burn, DI gasoline engine technology is a valid path to improved vehicle fuel economy. The second reviewer added that there is large FE improvement in high volume vehicles. Another indicated that fuel economy improvement demonstration using lean gasoline combustion to reduce petroleum consumption and that 25% improvement in FE is the goal. The third reviewer confirmed that the integrated vehicle systems approach presented has potential for real world corporate average fuel economy (CAFE) fuel economy improvements with building block technologies. A down sized and powered up approach (higher power density) is the general trend for solutions, but there is some risk that without fuel price increases, the technology may be overpriced. The final reviewer noted that objectives consistent with 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 felt that the approach to assess architectures through modeling and experience arrived at a general configuration of 4 cylinder, GDI, high EGR, lean combustion, novel approach to after treatment and a good experimental program are all excellent. Experimental program includes modeling, single cylinder dyno, hardware design of critical engine and exhaust components, multi cylinder dyno, and vehicle work. The reviewer also pointed out that there was some indication that there is fundamental knowledge to be learned at injector combustion level. The second reviewer indicated that the approach is very well defined from process to resources to demonstration. The reviewer appreciated the summary of approach on Slide 4. The reviewer inquired into the plan for operation of lean versus stoichiometric across the speed-load range and how this is addressed. The third reviewer noted that lean combustion aftertreatment development will be needed to achieve the Tier 2 Bin 2 emissions standards (T2B2) emissions levels. The approach of using the TWC to generate NH3 for the SCR is novel and will be interesting to follow. This reviewer also pointed out that the project is using a 12V start/stop system to reduce idling. The spray imaging work looks good and should help provide some insight into the disparity in performance between injector manufacturers. The final respondent pointed out that great reliance is being placed on a complex and difficult to control aftertreatment system. This reviewer was skeptical that it will do what is needed, and there is not a solid alternate plan.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer noted that GM can achieve significantly improved outcome if they capitalize on readily available relevant technologies, along with systematic development steps. The lean combustion spray "fundamental investigation" via Schlieren and magnetic-electro imaging (MEI) images does not reveal new findings. Lean gasoline combustion has been investigated by many renowned researchers in the USA and abroad, way beyond the reported findings in the presentation. This reviewer is under the impression that investigations have been within GM's own R&D extended domain in recent past. Perhaps this effort may be considered a training exercise for GM's new core of R&D staff, and thus creating job. This reviewer felt that timing sweeps and dwell time between the two injections will significantly influence the results. Other influential parameters are many such as the rail pressure. This reviewer questioned what else besides smoke was measured, how the two injectors were ranked, were the experiments repeatable, will the behavior duplicate with different set of injectors from the same respective suppliers, and did the team use a statistical DOE test matrix to prescribe the tests, or was it a non-statistical parametric testing. This reviewer noted that hopefully, GM researchers are capitalizing on the vast database and know-how that are readily available within the aftertreatment R&D community and PNNL is an example to guide such work. This reviewer questioned why GM is reinventing the wheel. The second reviewer noted that hardware and designs are in place for start of testing systems. However, this reviewer commented that CFD combustion simulations do not seem to match data very well based on the slideshow and questioned if the decisions are based on such poor simulation. The mention of risk mitigation plans can be viewed as concern over meeting the objectives or as prudent engineering. Another reviewer felt that the project was simply on target for 1st year. The fourth reviewer noted that the project was self-reported "on track" with lean performance, however, no data shown for emissions, fuel economy, coefficient of variation of the indicated mean effective pressure (COVIMEP) (combustion quality). The words say that the project is on target for highway fuel economy (HWFE) of 13% by June 2011. It seems that there would be some preliminary data if vehicle level work will show 13% by June. This reviewer noted that this is the only supporting qualitative data provided. This reviewer also felt that this project optimized BSFC over the widest operating range and confirmed the combustion system on single cylinder and multi-cylinder engines. It meets production combustion stability targets, and lean engine out NOx targets. The reviewer added that the engine was designed with production feasible and cost-effective hardware. The evaluator requested average BSFC improvement or BSFC map, average EO NOx compared to baseline, specific power change relative to baseline, and COVIMEP measurements best and worst compared to baseline. The final reviewer indicated nice experimental spray work in support of CFD modeling. Agree completely that this is a very necessary step. The commenter also stated that it was excellent to see comparison of single phase (SP) vs. dual phase with injectors from different suppliers. Results were surprising (at least to this reviewer) but very important to know. The reviewer added that the passive ammonia SCR system (PASS) approach makes sense and there was good progress addressing the correct challenges. The evaluator questioned what is PGM loading of TWC to generate sufficient ammonia and how that compares to LNT. The reviewer was guessing much lower, but is not an expert in this area.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers provided a range of comments in response to GM's level of collaboration. The first reviewer noted that this was mostly internal, but that is appropriate for this project. The second reviewer noted that the above sections contain detailed explanation of why this category scores "poor." This reviewer finds it unfathomable that the GM team would be doing this work without external team memberships. Undoubtedly, much in-kind contributions are pouring in from the many organizations that the GM team is interacting with and supporting! If this is indeed true, it is suggested that the next year's report makes these collaborations clear, even if these entities are not included in the formal DOE-GM contract (financials). The GM team will gain substantial know-how and insight by studying the current commercially available DI gasoline engines, benchmark it, and reverse-engineer it! This can be undertaken within GM, or via an external expert house. Another reviewer indicated that there was no collaboration. The reviewer noted that it was typical GM and questioned if suppliers would be more helpful if they were "partners". The fourth respondent noted stated that GM is not acknowledging any significant collaboration. It is unlikely that some work is not being done by suppliers and other operations outside GM. Acknowledging collaborators is more credible and allows some lessons learned from this work to be leveraged across the industry. The final reviewer pointed out no collaboration outside of GM so was not sure how to rate this. This does require significant collaboration within GM.

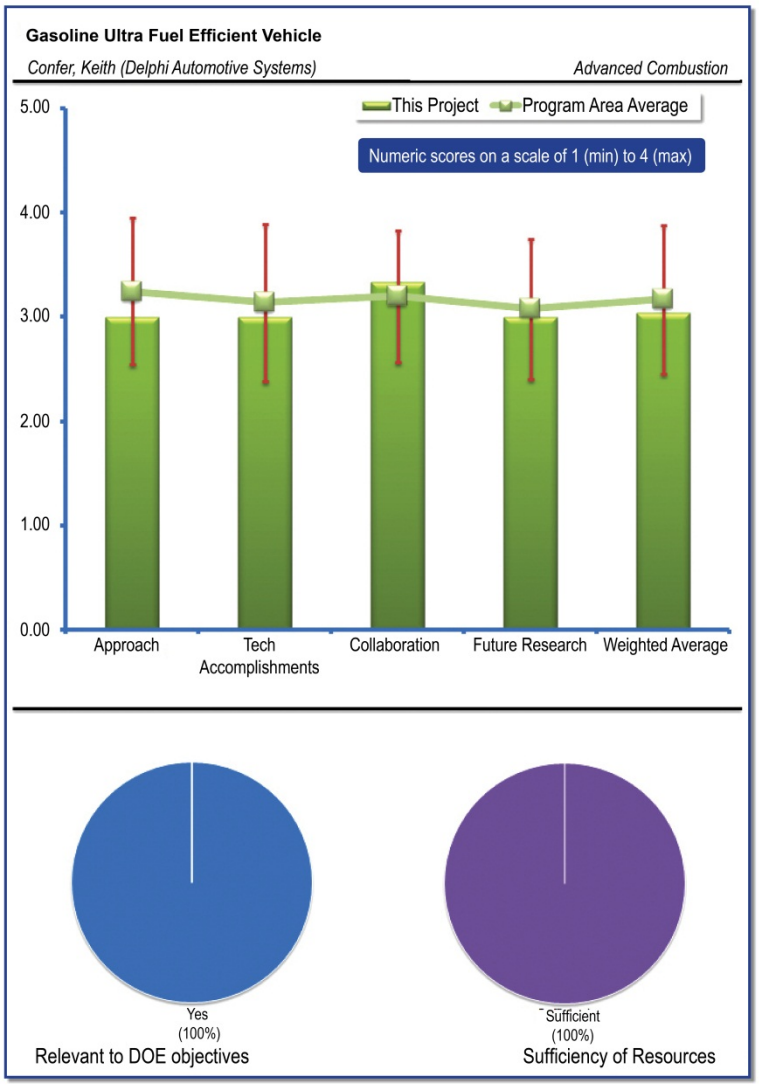
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer maintained that future plans are on target and make sense in support of approach. Another reviewer asserted that the plan appears to be addressing major issues, including PM. The fuel injector performance differences need to be understood. The reviewer would like to see more effort put into this, rather than writing it off as a disinterested supplier. The third reviewer stated that it could be improved based on the above comments and added that the program would be significantly handicapped and inferior, if the team is not investigating turbocharged configuration. The slides did not show a turbocharger. This reviewer would rate the future plans, the entire program, as "Poor" if it is restricted to NA lean burn gasoline. The fourth reviewer felt that the combustion part seems weak considering the objectives and thinks the aftertreatment will be very difficult in this concept. The final reviewer noted the novel cost effective SCR is a great one if it becomes practical. Other technologies such as supercharging/turbocharging are good architecture choices. Considerations for noise, vibration, and other issues relating to downsizing which have prevented use in the past may be worthy of future discussion.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewers felt that the project was well funded and perhaps generously sufficient. The final respondent noted that to undertake this kind of research for real world implementations takes significant investment. The resources are more than sufficient, and this level of funding requires demonstrated metrics and some care to insure that the dollars are clearly focused on the goals of this project.

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



Reviewer Sample Size

This project had a total of three reviewers.

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

The first reviewer felt that the project is staged to give solid incremental improvements in efficiency in the early phase, and larger improvements later on. It is well-balanced from a risk standpoint. Another reviewer noted big efficiency improvement on high volume vehicles. The final reviewer pointed out that this project is aimed at improving LD engine efficiency for reduced oil consumption.

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 noted that the Phase I accomplishments offer very practical improvements in efficiency. The Phase II is somewhat higher risk, from an emissions and power density standpoint, not to mention consumer acceptance. The reviewer added that more work needs to be done to extend the load-speed range of operation, and to characterize the engine-out emissions profile. The second reviewer indicated that this was an interesting concept, but the team has no data to support the full range operation in gasoline direct injection compression ignition (GDCI) which is critical to overall results. The final reviewer pointed out that GDCI is a novel approach to solving the high efficiency barrier. It was noted that this was "Not an aftertreatment project." That may be premature to say if PM regulations end up in light duty gasoline engines. The evaluator added that the single cylinder engine used for initial tests was a good approach.

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

A reviewer acknowledged that the Phase I and Phase II progress to date is good, but seems to be covering some old ground. However, the GDCI injector may be the most significant development to arise from the Phase II work, as it may have importance to others working in the area of LTC. Another felt that the results were good results so far, but data were needed for full speed/load range. Another reviewer noted that this is the first half of first year, so accomplishments are just starting. The start stop rig is functional, as well as the friction rig. Work on optimization of fuel injection strategy has made good progress.

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

The first reviewer stated that the collaboration on this project alone is sufficient and appropriate, but perhaps more work with other LTC programs on the GDCI fuel injection system would be recommended. Another noted that the project seems well integrated with

an OEM. The final reviewer added that Hyundai, Wayne State, WERC (although not indicated, assumed the KIVA modeling was done there) resulted in a good mix of industry and academia.

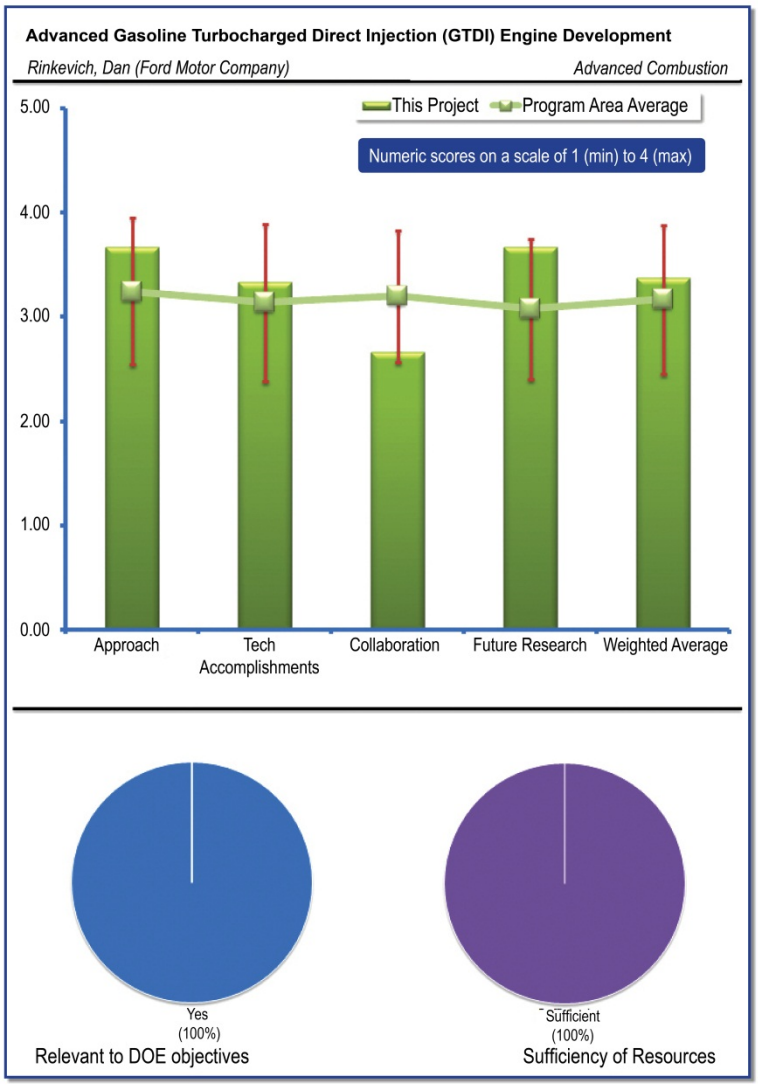
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer indicated that the key to the Phase II work will be the successful implementation of the GDCI injection strategy. The reviewer added that more work in the area of emissions characterization and exhaust heat availability would be useful to evaluate the potential of the technology. The second reviewer pointed out that the project teem needs to look off cycle, not design a cycle beater. The final reviewer felt that there was a good mixture of simulation and testing. The evaluator also noted that there is continued single cylinder testing planned and they will also build a demonstration vehicle.

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

The first reviewer indicated that the project funding is appropriate for this level of development. Other reviewers felt that the project was well funded but it was difficult to evaluate this early in the program.

Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development: Rinkevich, Dan (Ford Motor Company) – ace065



Reviewer Sample Size

This project had a total of three reviewers.

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

The first reviewer felt that in general, this project explores possibly the single most important technology for light duty engines in the next 15 years. Other reviewers pointed out that there are big efficiency improvements on high volume products and the Advanced Technology Powertrains for Light-Duty Vehicles (ATP-LD) program goals are being sought after.

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 noted that the strategy is very good and that each element of the plan works to integrate both well-known and novel technologies to yield significant overall improvement. The focus on advanced lean burn is also appropriate, but perhaps as a lower priority until other breakthroughs that would allow a broader power band of lean operation. Transitioning between lean and stoich would otherwise come with an unacceptable emissions penalty relative to other approaches. The second reviewer confirmed that this project builds on a solid technical base with good analytics and projections. The reviewer would like to see more analysis on lean versus very high EGR. The reviewer questioned if the team really gets an advantage worth the aftertreatment issues. The final reviewer indicated that the program has a heavy dependence on the engine downsizing to obtain 18% of the 25% fuel economy goal. This evaluator did not know whether this is realistic from a commercialization standpoint (i.e., engine durability & reliability). Aftertreatment development will also be a key player in the success of this approach.

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

The first reviewer noted that while the project is still in early stages, it is set on the right path for the follow-on efforts. Another reviewer felt there is solid progress. The final reviewer pointed out that it is very early in the program, so it is difficult to evaluate the accomplishments. The work on the aftertreatment that was presented looks good, as well as the single cylinder work and design of the engine components.

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

The first reviewer deemed the collaboration appropriate for this OEM-led project. The second reviewer believed that the collaboration at this point is relatively limited and that more collaboration with the national labs on the lean burn strategy would benefit the

program. The final reviewer pointed out that there is only one partner, MTU. The reviewer questioned if there is any chance of getting a supplier involved, like with the aftertreatment.

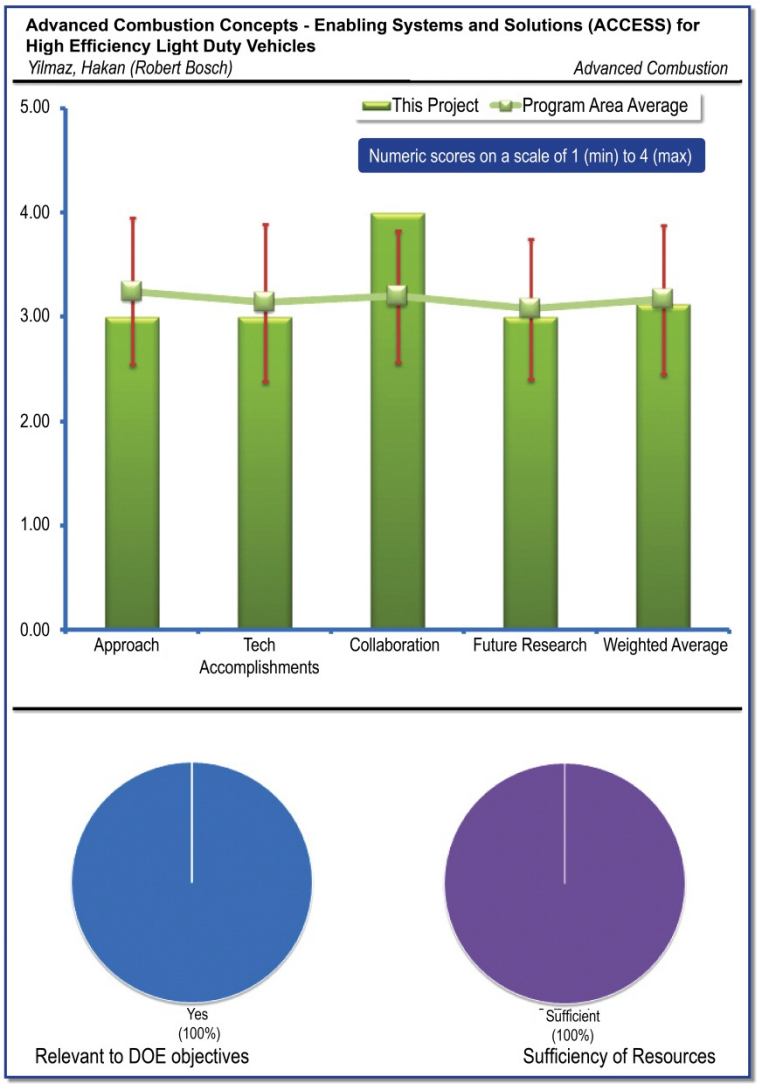
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer felt that the success in furthering turbo/downsized engine technology is critical for achieving fuel economy goals in light duty, and the research proposed addresses the most significant elements. The second reviewer thought that this was an overall good approach and plan of attack. The final reviewer noted that it looks okay but it is still mostly the original plan since it is so early in the program.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer indicated that if the efforts are expanded to include fundamental combustion studies at the labs, then further resources could be justified. Other reviewers thought that it was difficult to evaluate after only six months but it looks okay and well-funded.

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



Reviewer Sample Size

This project had a total of one reviewer.

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

The reviewer noted 30% fuel efficiency improvement.

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 reviewer felt that a very extensive organizational plan was presented. While this is impressive, it will be interesting to see the next year's presentation on how well it is working. The rerviewer also noted that heavy dependence on engine downsizing will be a key to the success of this program. Multi-mode combustion will also contribute heavily to achieving the goals.

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

The reviewer pointed out that the project has been comprised of mostly planning since this just started in October. However, some significant achievements have been noted include spray targeting completed, cylinder head design, PFI/GDI design complete, modeling at Michigan, first engine June 15th, 3 total one each at Michigan, AVL, Bosch, and rans, and LES simulations at Stanford.

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

The reviewer noted a good mix of partners across a broad spectrum with an extensive organization plan.

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, the reviewer pronounced that all proposed future work looks good.

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

The reviewer indicated that this is a rather large budget, but the number of concurrent activities seems in line with the funding level.

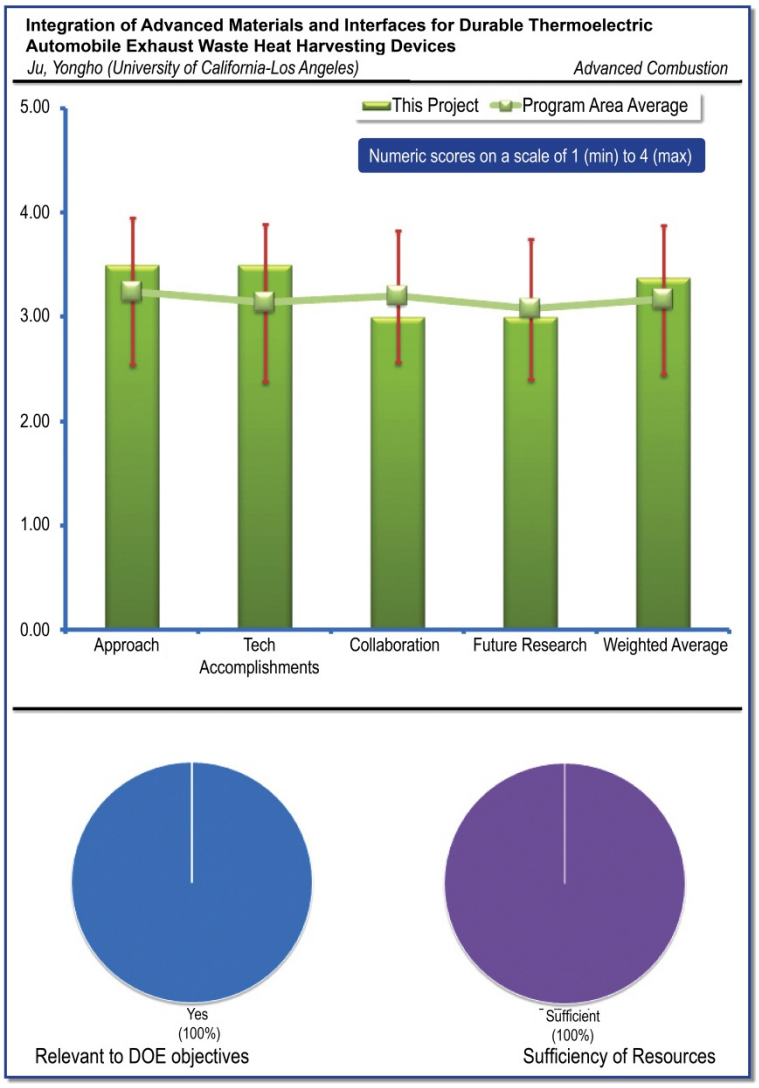
Integration of Advanced Materials and Interfaces for Durable Thermoelectric Automobile Exhaust Waste Heat Harvesting Devices: Ju, Yongho (University of California-Los Angeles) – ace069

Reviewer Sample Size

This project had a total of two reviewers.

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

The first reviewer stated that this project is addressing and developing solutions for thermal interfaces that can be implemented between various critical components in waste heat recovery systems in automotive applications. This solutions could be applied between heat exchangers and active energy conversion devices, thermal interfaces within advanced heating, ventilating, and air conditioning systems (HVAC), and at any surface where there is a strong requirement to transfer high heat fluxes in advanced automotive energy systems. This project is evaluating the thermo-mechanical reliability of their thermal interface solutions, developing bonding techniques, and developing flexible thermal interface solutions that could be quite important and relevant to automotive exhaust energy recovery and advanced automotive HVAC systems. The final reviewer felt that the project fully supports the overall 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?

A reviewer expressed that this project is well-designed and has a sound technical approach for tuning coefficient of thermal expansion (CTE) properties in metal-matrix Nano-composites through the use of silver (Ag) and ZrW2O8 Nano-powders and developing liquid-based flexible interfaces. These advanced materials could have an important impact in enhancing thermal interface design in various thermoelectric, organic Rankine cycle, and other energy systems applicable to automotive exhaust energy recovery and advanced HVAC systems. This team is dealing directly with thermal stability testing of these materials/interfaces as part of their project plan, which is an important characteristic in the intended automotive applications. This team appears well integrated with others in the technical community who are grappling directly with thermal interface design issues in these systems. The second reviewer indicated that the project was well designed with good approach to overcome the barriers that could be encountered.

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

The first reviewer asserted that this project team has some good CTE results at this early stage using Ag Nano-powders that create thermally and electrically conducting materials that could be used at critical active electrical interfaces within thermoelectric devices. Ag is expensive, but the project team has plans to transition other less expensive materials into their metal-matrix composite

compositions. Good thermal stability results so far in their project. This team appears well on their way to fabricating and charactering a complete series of metal-matrix nanocomposites that cover the expected range of CTE values for thermoelectric (TE) materials being developed by other technical teams. The project team has just initiated work on liquid-based flexible thermal interfaces, so no concrete results are available as yet. However, the project team has a good understanding of the technical challenges (i.e., evaporation loss, oxidation), a reasonable design concept, and they have identified promising materials (Bi, Sn) as filler materials in their design. The second reviewer felt that the technical accomplishment is great and the progress has been demonstrated well toward DOE goals

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

A reviewer maintained that this team has some good collaborative support from NASA-JPL. They are also already pursuing collaborative opportunities for technology transfer with potential industrial partners. It remains to be seen how successful they will be in technology development and transfer. Another felt that the collaboration effort is excellent.

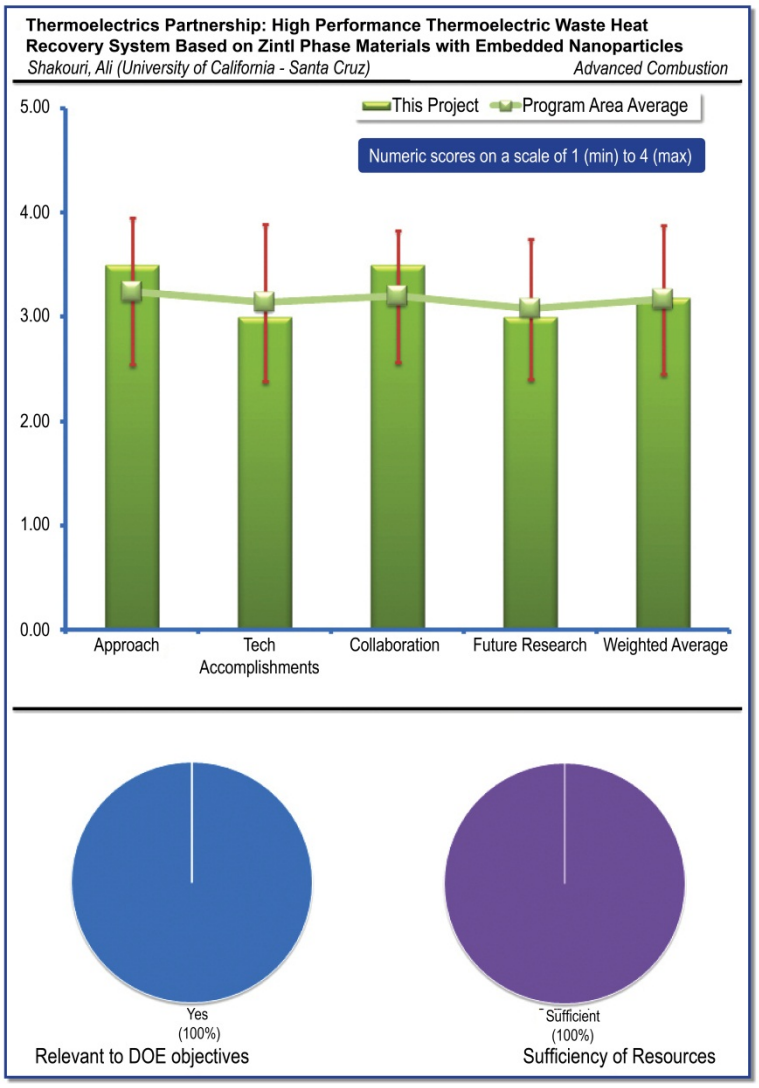
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer indicated that the proposed future work is good and clearly demonstrates that the work plan can mitigate risk. The second reviewer pointed out that their project plans appear technically sound and well thought out. However, this team could benefit more with better definition of thermal interface performance criteria and requirements to serve as technical targets.

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

No comments were made.

Thermoelectrics Partnership: High Performance Thermoelectric Waste Heat Recovery System Based on Zintl Phase Materials with Embedded Nanoparticles: Shakouri, Ali (University of California - Santa Cruz) - ace070



Reviewer Sample Size

This project had a total of two reviewers.

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

The first reviewer maintained that the project fully supports the DOE objective of petroleum displacement. The second reviewer pointed out that this project is developing environmentally benign nanosttuctured "bulk" materials with enhanced thermoelectric performance (ZT>1.3-1.8) in the 500-800° Kelvin (K) temperature range for automotive waste heat recovery. Materials being investigated are in the proper temperature ranges for automotive WHR and therefore could potentially contribute to enhance performance WHR systems that could improve vehicle on-board energy management and efficiency. The ZT goals are ambitious, but definitely at the performance level needed to make vehicle WHR using thermoelectric systems a successful technology.

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 this project has a good balance between analytic transport modeling and experimental work to validate analytic results and use both sets of results to achieve the project goals. Their approach of embedding nanoparticles into the material crystal structure appears feasible, but the devil is always in the details. The evaluator instructed the team to make no mistake; the ZT goals are ambitious and quite challenging. They also presented discussion on their material synthesis approaches and future plans, which was good. However, this project does not really address the structural properties of their proposed materials, which is a major deficiency of this project because these properties are critical to transitioning these materials into operating devices. There also are no discussions on the effect of thermal cycling on these materials, which is another critical characteristic required to transition these materials to operating TE devices. The last reviewer felt that the project was well designed with good approach to overcome the barriers that could be encountered.

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

A reviewer felt that the technical accomplishment is great and the progress has been demonstrated well toward DOE goals. A second reviewer noted that the ZT values they have reported so far with Bi-doped Mg2Si and 5% Si nanocomposite filling are quite modest (ZT ~ 0.7 at 800°K). However, the project team appears to have well thought-out plans for improving and optimizing the materials to

achieve higher performance. It is going to be quite challenging to embed the proper size nanoparticles (2-20 nm) into the Mg2Si and Mg2SiSn crystal structures and get them to stay there during all the envisioned operating environments these materials will be subjected to.

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

The reviewers thought that the project team has established good collaboration between two University of California campuses and NASA-JPL.

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 proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The second reviewer indicated that this project does not really address the structural properties of their proposed materials, which is a major deficiency of this project because these properties are critical to transitioning these materials into operating devices. The project team also does not discuss the effect of thermal cycling on these materials, which is another critical characteristic required to transition these materials to operating TE devices. There does not appear to be any plans to address these deficiencies in their current planned activities. Consequently, it is difficult to assess how successful this project team will be transitioning these materials to operating devices even if they are successful at achieving their project goals.

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

No comments were made on the resources.

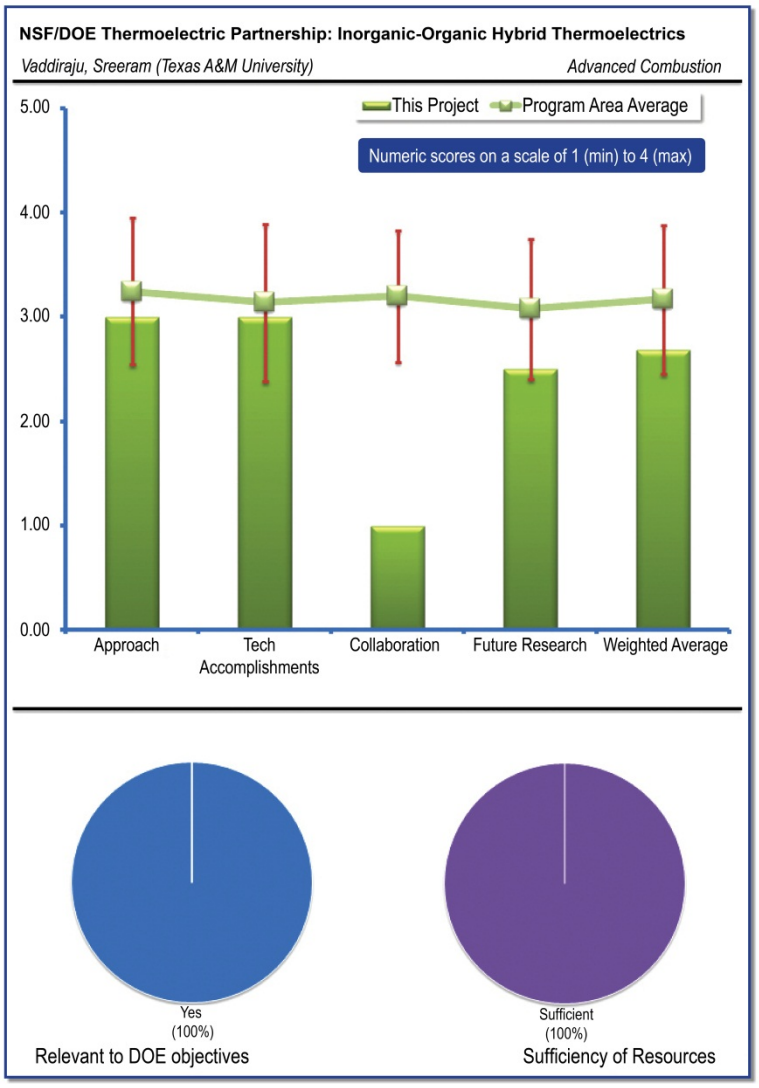
National Science Foundation (NSF) /DOE Thermoelectric Partnership: Inorganic-Organic Hybrid Thermoelectrics: Vaddiraju, Sreeram (Texas A&M University) – ace071

Reviewer Sample Size

This project had a total of two reviewers.

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

The first reviewer noted that the project fully supports the overall DOE objectives of petroleum displacement. The second reviewer expressed that the project supports the stated DOE objective of petroleum displacement by potentially offering a new, innovative technique for developing advanced, high-temperature TE materials based on bulk synthesis of inorganic quantum wire TE materials which could have a high ZT (Figure of Merit x Temperature) factor. The authors seek to develop versions of Zn3P2, InN and CoSb3 nanowires using self-catalysis for vehicular waste heat recovery systems, thereby increasing the engine and vehicle efficiency. The authors seek advanced versions of these materials that could operate at temperatures up to 800 C.



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 last reviewer thought that the project was well designed with good technical approach to achieve the objectives and at the same time overcome the barriers that could be encountered. The second reviewer stated that the author has a basic misunderstanding about what absolute temperatures or temperature differentials are available in automotive engine and exhaust systems. Temperatures of 800C or temperature differentials of 800C will generally not be available in actual operating waste heat recovery systems as stated by the author in Slide 5. It is not clear how these Zn3P2, InN and CoSb3 nanowire materials would be integrated or formed into an operating TE couple even if the author(s) are successful at developing them. There are pretty conceptual pictures, but no coherent plan is presented on how the concepts would be transformed into an operating TE couple. There is no discussion about how to electrically connect these nanowire materials into an operating TE couple. There are also no partners on the project that could help in transitioning these nanowire TE materials to an operating TE couple. The reviewer added that the milestones are insufficiently described and the time sequencing of activities and deliverables is not clearly described.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The second reviewer asserted that the technical accomplishment is great and the progress has been demonstrated well toward DOE goals. The second reviewer pointed out that the progress to date appears modest at best. This work has demonstrated self-catalytic synthesis of Zn3P2, InN and CoSb3 nanowires and the author(s) claim to have shown sub-10 nm diameters, but there are not data to support that assertion. The authors claim to have control of the nanowire diameters to less than 5 nm, but have not shown any data supporting that claim. The TE power factor measurements on Zn3P2 nanowires are only reasonably high (~28 uW/cm-K2) at temperatures of 525°K and are very low (nearly zero) at temperatures of 450K. What is worse is the temperature dependency of the power factor is very steep (high power factor temperature gradient) and this would make these materials very difficult to design and use in an operating TE device. The author(s) also did not describe the height dimensions of the 1 cm2 pellet that was tested. There is no discussion of the measurement systems used in obtaining the power factor data or what measurement systems are being used in determining the nanowire characteristics (i.e., diameters, etc.). It is not clear in this presentation how many of these TE pellets were fabricated and tested. It appears that only one has been fabricated so far.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer pointed out that there are no collaborations with outside organizations in materials synthesis techniques, material measurement and characterization, or in ultimate TE device design mentioned anywhere in the presentation. The second reviewer also stated that collaboration and coordination with other institutions need to be improved.

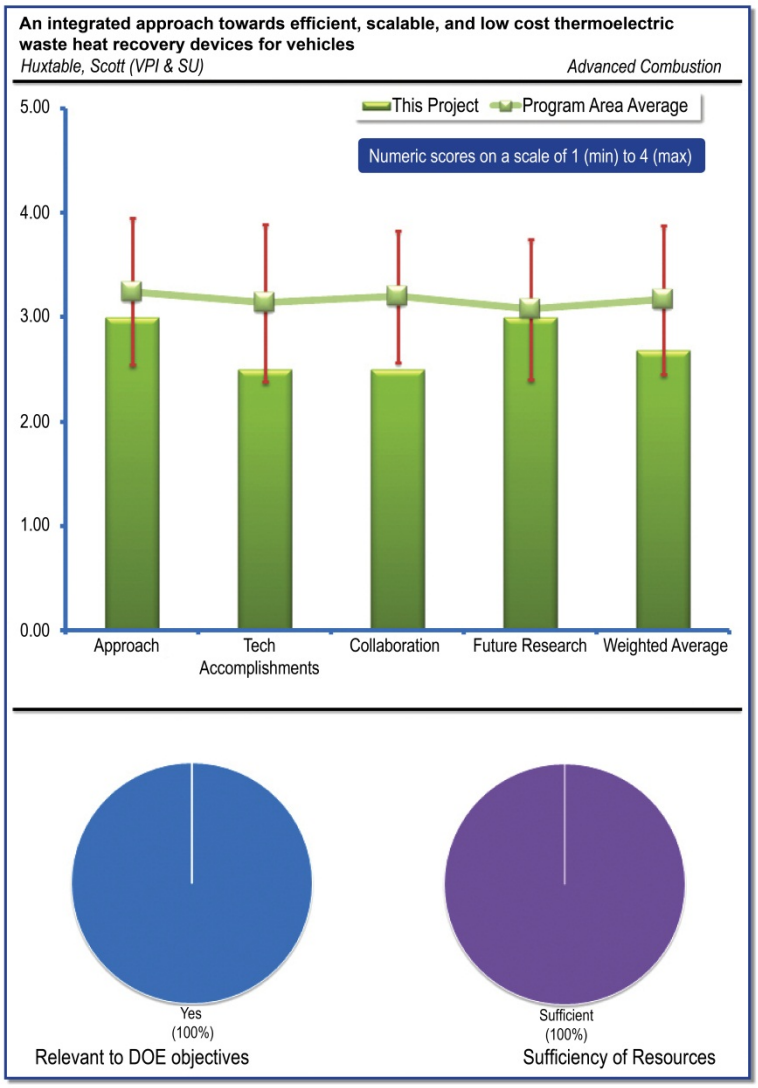
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The first reviewer felt that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The second reviewer pointed out that the author describes the future work in only general terms, but there are few specifics on how they plan to accomplish the work. In addition, milestones are insufficiently described and the time sequencing of activities and deliverables is not clearly described. Go/No-Go decision criteria are not described. There is no discussion of the barriers and challenges of "assembling the quantum wires on a large-scale into inorganic-organic hybrid thermoelectric devices by either tethering them to each other or to conducting polymer films through organic molecular linkers". This will not happen automatically and there needs to be much better discussion of how this will be accomplished, what the challenges are, and the techniques for overcoming any barriers to fabrication. No discussion on transitioning nanowire elements into an operating TE device that operates reliably over a large temperature differentials and the many thermal cycles characteristic of an automotive waste heat recovery system. There does not appear to be much planning to mitigate the risks of this technical approach.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Reviewers felt that the resources appear sufficient for the scope of work undertaken and described in the presentation.

An integrated approach towards efficient, scalable, and low cost thermoelectric waste heat recovery devices for vehicles: Huxtable, Scott (Virginia Polytechnic Institute and State University) – ace072



Reviewer Sample Size

This project had a total of two reviewers.

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

The first reviewer felt that this project is seeking to develop abundant, low-cost, bulk-scale oxide and silicide materials to be competitive with the state-of-the-art thermoelectric materials and enhance thermal management system performance for oxide- and silicide-based TE devices for vehicle waste heat recovery. They are targeting and addressing cost of TE systems, scale-up to practical thermoelectric devices, and thermoelectric device/system packaging. As such it is addressing important technical barriers in the Advanced Combustion Engines (ACE) Solid-State Energy Conversion program to increase waste heat recovery performance and diesel engine efficiency. The second reviewer noted that the project fully supports the overall 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 reviewer indicated that this team's approach is generally comprehensive and provides some new thoughts in thermal management. It is not clear how they will develop the layered cobalt oxides, such as NaxCoO2 and calcium cobalt oxide (Ca3Co4O9) and "design the novel microstructures" they seek. It is clear from their presentation and poster discussions that this team is focused on low-cost TE materials, they may not have the best thermoelectric (TE) performance but they have the potential to be inexpensive and abundant. Their thermal management work has some novel approaches to heat exchanger design and characterizing interface thermal resistances that could be useful. This team will investigate minimizing parasitic losses through interfaces and plan to use system models to address durability and lifetime of devices. This also could have some benefits in device/system design. There does not seem to be any attention on TE material structural properties or the effects of thermal cycling on TE materials. This reviewer sees this as a serious approach deficiency. The second reviewer felt that the project was well designed with good approach to overcome the barriers that could be encountered.

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

The first reviewer added that the project is still in the first phase; however, some progress has been demonstrated well. The second reviewer pointed out that there appears to be some coherent progress on TE materials development; developing, demonstrating, and

refining real-time data collection on vehicles; evaluating the dynamic response of heat exchangers; and preliminary analysis of heat exchangers. Their real-time data collection and dynamic response work should be useful in designing and developing TE devices and systems for vehicle waste heat recovery. Some of their heat exchanger work is quite similar to that already being performed by others in the field, so this is not a unique facet to their program. However, they also are investigating swirl impingement flow heat exchangers which offer some innovation in their work. The reviewer added that this team presents no thermoelectric property data to date, so it is not possible to evaluate how well their TE materials will work in a vehicle waste heat recovery system. There is not even a TE property chart on silicides or a comparison between their oxides and silicides, which their partner Romny Scientific should have (Note Slide #22 - "Our silicide materials are well established, thus we can produce working devices with those materials at a minimum."). So there should already be TE data available to report. There is a high-temperature Seebeck and electrical conductivity measurement system under construction, but this should have already been done to even propose in this field. This is definitely a problem for this team.

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

A reviewer noted that Virginia Tech University appears to only have Romny Scientific as an outside industrial collaborator. For all the TE materials and system design challenges they are taking on, it seems to this reviewer that they need more outside collaboration. There are other experts in the field that could assist them, and the poster presenter acknowledged this. This team realizes this and is attempting to establish closer ties to the government and industry leaders in this field and forming an advisory board. The second reviewer indicated that the collaboration and coordination effort with other institutions need to be improved.

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 thought the proposed future work is reasonable and clearly demonstrates that the work plan can mitigate risk**.** A second reviewer indicated that their future work plans are technically sound. However, they like others in this review lack the specific targets and goals that should go with these plans. This team could benefit from more involvement from government/industry experts in this field. For example in Slide #20, "Modeling the combined TEG/heat exchanger/exhaust system dynamic response using substructure techniques" has already done by others in the field. They risk being duplicative, like others in this review have been or risk being duplicative.

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

No comments were made concerning resources.

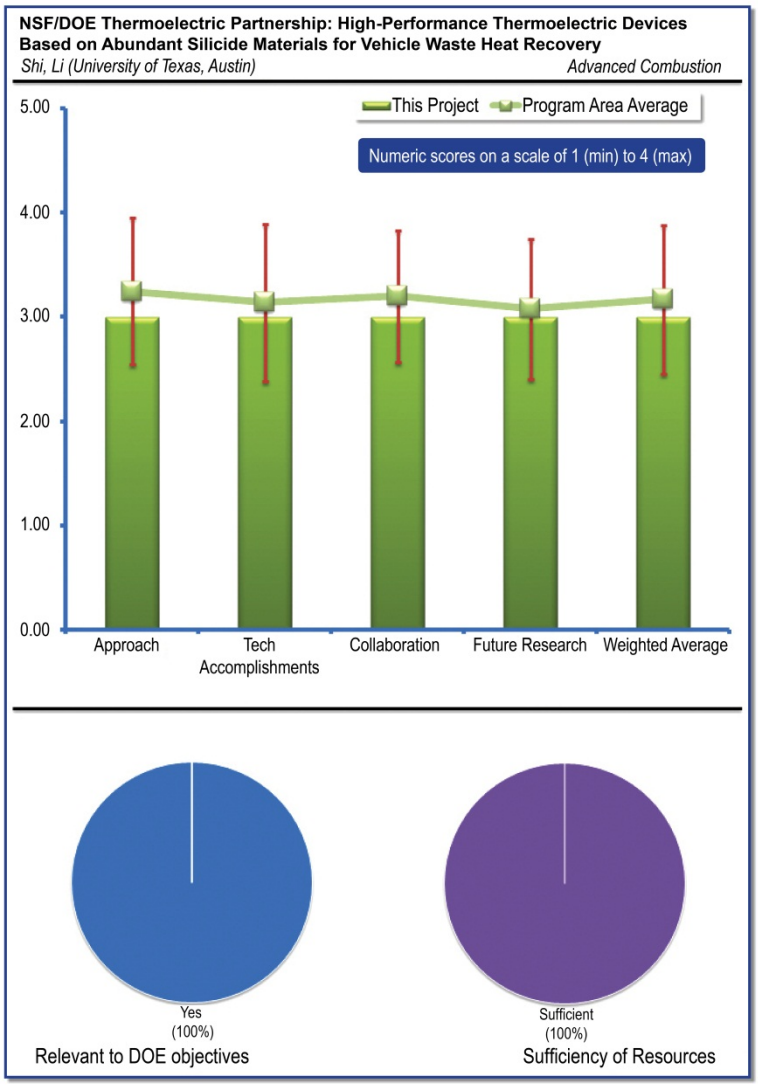
NSF/DOE Thermoelectric Partnership: High-Performance Thermoelectric Devices Based on Abundant Silicide Materials for Vehicle Waste Heat Recovery: Shi, Li (University of Texas, Austin) – ace073

Reviewer Sample Size

This project had a total of two reviewers.

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

The first reviewer added that the project fully supports the overall DOE objectives of petroleum displacement. The second reviewer pointed out that this project is seeking to increase the thermoelectric (TE) performance, ZT, of abundant, low-cost, bulk-scale silicide materials to a level competitive with the state-of-the-art thermoelectric materials and enhance thermal management system performance for silicide-based TE devices in a diesel engine. As such it is addressing important technical barriers in the ACE Solid-State Energy Conversion program to increase waste heat recovery performance and diesel engine 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 indicated that the project team is seeking to synthesize and develop bulk Manganese Silicide (MnSi) 1.75and Mg2Si1-xSnx with nano-grains or nanoparticle inclusion via both solid state reaction and chemical conversion from diatomaceous earth to fabricate single-body silicide TE legs with gradient doping instead of a segmented design to eliminate interfaces. Their intent to study and investigate gradient doping is a noble goal and would be a useful outcome of this work. The project team intends to study and develop silicide interface and interconnect materials to enhance thermomechanical durability. However, they do not have any particular outside team collaborator with experience in this area, which is a project deficiency. No results or discussions surrounding this technical area are presented in this review material. This project team also intends to investigate and develop new heat exchanger designs to enhance thermal management performance; however, there is no outside team collaborator with experience in this area. No project results or discussions surrounding this technical area are presented in this review material. Another reviewer thought that the project was well designed with good approach to overcome the barriers that could be encountered.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer confirmed that technical accomplishment is great and the progress has been demonstrated well toward DOE goals. The second reviewer stated that the project team intends to study and develop silicide interface and interconnect materials to enhance thermomechanical durability. There is no outside team collaborator in this area and no results or discussions surrounding this technical area are presented in this review material. This project team also intends to develop new heat exchanger designs to enhance thermal management performance; however, there is no team collaborator with experience in this area. No project results or discussions surrounding this technical area are presented in this review material. The reviewer added that this work has shown only low ZT values for undoped higher manganese silicides (HMS) with MnSi phases so far, ZT ~ 0.1 at 700°K shown on Slide 11. The systems modeling work appears quite similar to other work done in ACE Waste Heat Recovery and Utilization projects funded in previous years and is quite preliminary in nature. That being said, it is the type of systems modeling work one would require for any set of new TE materials. The project team appears to be investigating all the normal exhaust flow locations for the TE waste heat recovery system that other projects have investigated in prior projects. Their one assumption that a TE hot-side heat exchanger can extract all the available heat (Slide 17) in the exhaust is highly idealistic. The reviewer asserts that this simply will not happen.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The first reviewer indicated that the collaboration effort is excellent. The second reviewer noticed that there appears to be some collaboration with Oak Ridge National Laboratory to employ their high-temperature TE characterization facilities. However, there are major deficiencies in missing outside collaboration that are discussed above.

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 pronounced the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The second reviewer pointed out that the project team is intending to develop thermodynamic systems models to optimize thermoelectric device locations in engine exhaust, heat transfer models for improving TE module performance, and integrate these as one model and to account for transient exhaust conditions. This system's modeling work is quite duplicative to similar work done on other TE waste heat recovery projects in the past. Once again, this project does not really address the structural properties of their proposed materials, which is a major deficiency of this project because these properties are critical to transitioning these materials into operating devices. There also are no discussions on the effect of thermal cycling on these materials, which is another critical characteristic required to transition these materials to operating TE devices. The project team intends to test silicide TE waste heat recovery devices in a 6.7 liter Cummins diesel engine, which is a good overall plan. They are evaluating various testing locations in the Cummins engine and they have evaluated exhaust temperatures as a function of brake load. There was no discussion however on how their thermal management systems would integrate with the Cummins engine.

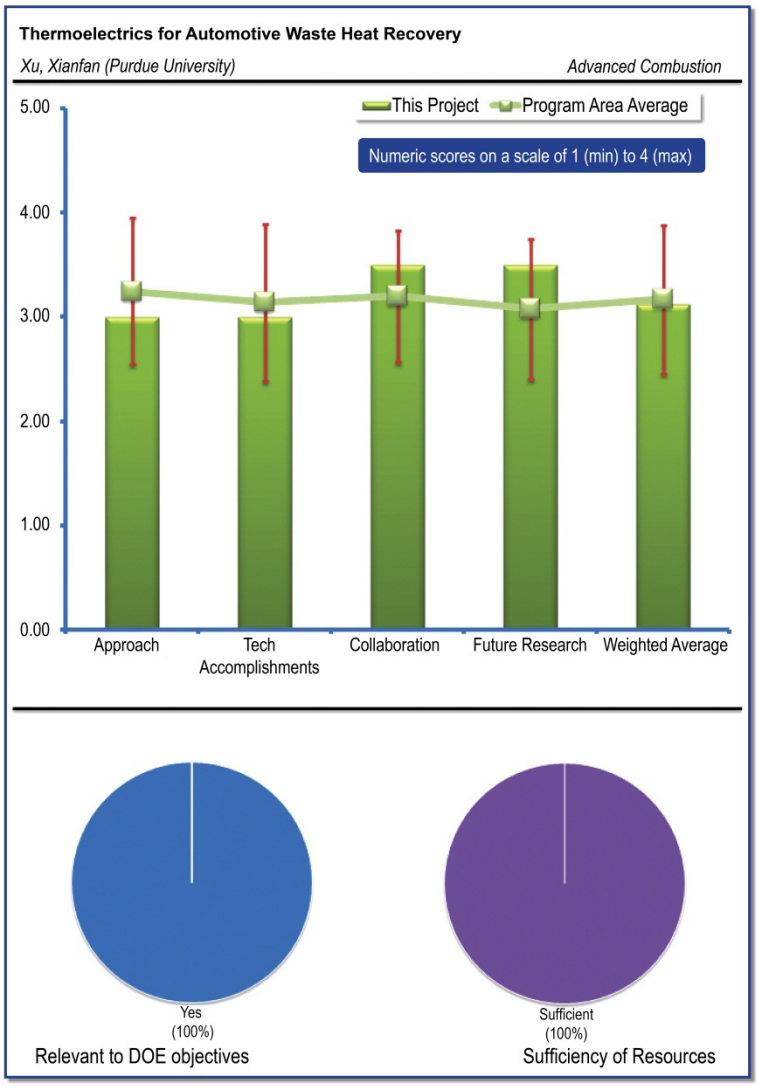
QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No comments were made on resources for this project.

Thermoelectrics for Automotive Waste Heat Recovery: Xu, Xianfan (Purdue University) – ace074

Reviewer Sample Size

This project had a total of two reviewers.



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

The first reviewer asserted that the project fully supports the overall DOE objectives of petroleum displacement. The second reviewer indicated that this project is addressing DOE's overall objective of petroleum displacement. It is addressing important technical barriers in the ACE Solid-State Energy Conversion program to increase waste heat recovery performance, diesel engine efficiency, and light-duty fuel economy improvements. However, this presentation does not clearly discuss what specific DOE Program Goals (i.e., What ACE and Solid State Energy Conversion goals & barriers) are being addressed in this project and how their project work relates to those goals and barriers. This presentation deficiency raises questions about whether the project PI's are clearly focused on the ACE goals and barriers.

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 indicated that the project was well designed with good approach to achieve the objectives and at the same time overcome the barriers that could be encountered. The second reviewer noted that their slides discuss investigating three different TE materials for this application. It is highly unlikely that this project team can effectively investigate three different TE materials, develop thermal interface materials, investigate alternate heat exchanger designs, and perform metrology work with the project team indicated. Other groups around the world have investigated nanoscale oxide materials with little success at producing high-performance TE oxide materials that can be transitioned easily to operating TE devices. The poster presenter also said a number of times that their industrial partner (GM) wanted this team to focus on filled skutterudites, which has already been done extensively at GM on other OVT-funded waste heat recovery projects. It is not clear in this presentation what new work is planned beyond what GM has already done in this TE materials area. There is also no discussion presented on what the project goal is for TE materials development (i.e., what ZT value or other metric they expect to achieve). Furthermore there is no discussion on evaluation of the structural properties or thermal cycling characteristics of the potential material classes being investigated. Thermal interface approaches are described and appear worthwhile to investigate in this work. However, the reviewer added that heat exchanger work plans were not addressed very well in the presentation so it is not possible to evaluate what improvements are expected and how they relate to current state of the art. Some of the planned activities that were presented (i.e., diffuser optimization to eliminate flow

separation, use of fins to augment heat transfer) are quite basic to those skilled in the art, already quite well known, and should have already been addressed in GM prior work in their current OVT Waste Heat Recovery & Utilization Project.

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

The first reviewer felt that the technical accomplishments are great and the progress has been demonstrated well toward DOE goals. The second reviewer noted that it appears this project has only been on-going since January 2011. Very little data are presented on what accomplishments have been made with TE materials development. In some cases they have shown a 59% reduction in thermal conductivity, but no data on Seebeck coefficient or electrical resistivity (Slide #15). Therefore it is difficult to draw conclusions on whether this is viable TE material or not. Their progress with Si-carbon nanotubes (CNT)-Ag Foil tests to obtain conversion to boron carbonitride (BCN) thermal interface materials appear to given inconclusive results at this time. The x-axis is not even properly labeled so it is difficult to evaluate completely what this team is trying to portray. This reviewer could guess what that x-axis is, but that would not necessarily be fair to the team, DOE program managers, or this review. This project team presented very little information on their heat exchanger design work. They showed one chart (Slide #20), but it did not describe what the color-coding represented. They did explain that their analysis results showed significant flow separation regions where reduced heat transfer occurred. This is a well-known phenomenon and there was no discussion on how it related to TE performance improvement in their specific design configurations. The reviewer added that in Slide #15, it is not clear how what is being presented relates to Ca3Co4O9 nanowires and sodium cobalt oxide (NaCo2O4) nanowire development and creating mechanically self-supporting, nanoporous networks of oxide thermoelectrics. The presenters must be more clear in connecting the "dots" and information. However, the reviewer also noted that the project team did show a successful metal/semiconductor laminate with TE materials (Slide #17). However, no effective thermal conductivity or TE property data was shown for this laminate, so one cannot conclude whether this would be an effective laminate approach or bulk TE material in an operating device. It was not clear how the twenty freestanding 14 µm bilayer foils 6 nm hafnium nitride (HfN)/ 6nm scandium nitride (ScN) superlattice related to the project goals. There is no indication of what TE materials are in the other pictures of laminate lay-ups presented in Slide #17 and how they relate to project goals. This reviewer is left with the general impression that much information is lacking here and prevents a complete review of this team's progress and results.

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

A reviewer indicated that there appears to be good collaboration planned with General Motors and Oak Ridge National Laboratory. Another reviewer agreed that collaboration effort with other institutions is excellent

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 added that the proposed future work is excellent and clearly demonstrates that the work plan can mitigate risk. The second reviewer thought that the future work (Slide #21) appears good, but once again there are no specifics on criteria and goals. "Investigate skutterudites with different filling strategies" is nice, but everyone working in skutterudites is doing that. The commenter questioned what is unique about this work. The reviewer noted that each item listed under Future Work (Slide #21) should have a target metric and goal and questions what they are trying to achieve.

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

No comments were recorded on resources.