4. Advanced Combustion Engine Technologies

Introduction

The Advanced Combustion Engine R&D subprogram of the U.S. Department of Energy's Vehicle Technologies Program (VTP) is improving the fuel economy of passenger vehicles (cars and light trucks) and commercial vehicles (medium-duty and commercial trucks) by increasing the efficiency of the engines that power them. Work is done in collaboration with industry, national laboratories, and universities, as well as in conjunction with the FreedomCAR and Fuels 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. 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	Mark Musculus (Sandia National Laboratory (SNL))	4-8	3.83	3.67	3.83	3.33	3.69
Light Duty Combustion Research: Advanced Light-Duty Combustion Experiments	Paul Miles (Sandia National Laboratory (SNL))	4-11	3.75	3.75	3.75	3.50	3.72
Sandia Optical Hydrogen-Fueled Engine	Sebastian Kaiser (Sandia National Laboratory (SNL))	4-13	3.33	3.33	3.17	2.83	3.25
HCCI and Stratified-Charge CI Engine Combustion Research	John Dec (Sandia National Laboratory (SNL))	4-15	3.75	3.88	3.63	3.50	3.77
Low-Temperature Diesel Combustion Cross-Cut Research	Lyle Pickett (Sandia National Laboratory (SNL))	4-18	3.50	3.50	3.50	3.17	3.46
Automotive HCCI Engine Research	Dick Steeper (Sandia National Laboratory (SNL))	4-20	3.60	3.60	3.80	3.60	3.63
Large Eddy Simulation (LES) Applied to LTC/Diesel/Hydrogen Engine Combustion Research	Joe Oefelein (Sandia National Laboratory (SNL))	4-22	3.29	2.86	3.29	3.29	3.07
Free-Piston Engine	Peter Van Blarigan (Sandia National Laboratory (SNL))	4-24	3.17	2.67	2.67	3.00	2.83
H2 Internal Combustion Engine Research Towards 45% Efficiency and Tier2-Bin5 Emissions	Thomas Wallner (Argonne National Laboratory (ANL))	4-26	3.00	3.14	3.43	3.43	3.18
Fuel Spray Research on Light-Duty Injection Systems	Christopher Powell (Argonne National Laboratory (ANL))	4-28	3.43	3.43	3.67	3.33	3.45
Visualization of In-Cylinder Combustion R&D	Steve Ciatti (Argonne National Laboratory (ANL))	4-30	3.14	2.71	3.29	2.86	2.91

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Modeling of High Efficiency Clean Combustion Engines	Salvador Aceves (Lawrence Livermore National Laboratory (LLNL))	4-32	3.50	3.57	3.50	3.00	3.47
Chemical Kinetic Research on HCCI & Diesel Fuels	William Pitz (Lawrence Livermore National Laboratory (LLNL))	4-34	3.80	3.80	3.75	3.75	3.79
KIVA Modeling to Support Diesel Combustion Research	David Carrington (Los Alamos National Laboratory (LANL))	4-36	3.40	3.20	3.00	3.20	3.23
Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes	Stuart Daw (Oak Ridge National Laboratory (ORNL))	4-38	2.86	2.57	3.00	2.57	2.70
Achieving and Demonstrating Vehicle Technologies Engine Fuel Efficiency Milestones	Robert Wagner (Oak Ridge National Laboratory (ORNL))	4-40	3.22	3.33	3.33	3.63	3.34
High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines	Robert Wagner (Oak Ridge National Laboratory (ORNL))	4-43	3.29	3.00	3.00	3.43	3.13
Ignition Control for HCCI	Dean Edwards (Oak Ridge National Laboratory (ORNL))	4-45	3.40	3.40	3.60	3.20	3.40
A University Consortium on Low Temperature Combustion (LTC) for High Efficiency, Ultra-Low Emission Engines	Dennis Assanis (University of Michigan)	4-47	3.71	3.57	3.86	3.14	3.59
CLEERS Coordination & Development of Catalyst Process Kinetic Data	Jae-Soon Choi (Oak Ridge National Laboratory (ORNL))	4-49	3.75	4.00	4.00	3.60	3.89
CLEERS Activities: Diesel Soot Filter Characterization & NOx Control Fundamentals	Darrell Herling (Pacific Northwest National Laboratory (PNNL))	4-51	3.00	3.00	3.00	3.00	3.00
Development of Advanced Diesel Particulate Filtration (DPF) Systems (ANL/Corning/Caterpillar CRADA)	Kyeong Lee (Argonne National Laboratory (ANL))	4-53	2.25	2.50	2.50	2.50	2.44
Diesel Soot Filter Characterization and Modeling for Advanced Substrates	Thomas Gallant (Pacific Northwest National Laboratory (PNNL))	4-55	3.50	2.75	3.00	3.33	3.04
Mechanisms of Sulfur Poisoning of NOx Adsorber (LNT) Materials	Charles Peden (Pacific Northwest National Laboratory (PNNL))	4-57	3.50	3.75	3.75	4.00	3.72
Deactivation Mechanisms of Base Metal/Zeolite Urea Selective Catalytic Reduction Materials	Charles Peden (Pacific Northwest National Laboratory (PNNL))	4-59	4.00	4.00	4.00	3.00	3.88
Investigation of Aging Mechanisms in Lean NOx Traps	Mark Crocker (University of Kentucky)	4-61	3.50	3.25	3.50	3.00	3.31
Kinetic and Performance Studies of the Regeneration Phase of Model Pt/Rh/Ba NOx Traps for Design and Optimization	Michael Harold (University of Houston)	4-63	3.67	3.67	3.33	3.33	3.58
Advanced Collaborative Emissions Study (ACES)	Dan Greenbaum (Health Effects Institute)	4-65	3.50	3.50	4.00	4.00	3.63
Real-World Studies of Ambient Ozone Formation as a Function of NOx Reductions: Summary and Implications for Air Quality Impacts	Doug Lawson (National Renewable Energy Laboratory (NREL))	4-68	3.60	3.80	3.60	3.00	3.63
Measurement and Characterization of Unregulated Emissions from Advanced Technologies	John Storey (Oak Ridge National Laboratory (ORNL))	4-70	4.00	3.67	3.67	3.50	3.73

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Measurement and Characterization of Lean NOx Adsorber Regeneration and Desulfation and Controlling NOx from Multi-Mode Lean DI Engines	Jim Parks (Oak Ridge National Laboratory (ORNL))	4-72	3.33	3.67	3.33	3.00	3.46
Cummins/ORNL-FEERC CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines	Bill Partridge (Oak Ridge National Laboratory (ORNL))	4-74	3.75	3.75	3.75	3.25	3.69
NOx Abatement Research and Development CRADA with Navistar Incorporated	Todd Toops (Oak Ridge National Laboratory (ORNL))	4-76	3.20	2.80	3.00	3.20	2.98
Light Duty Efficient Clean Combustion	Donald Stanton (Cummins Inc.)	4-78	3.60	3.80	3.00	3.80	3.65
High Efficiency Clean Combustion Engine Designs for Gasoline and Diesel Engines	Kenneth Patton (General Motors Corporation)	4-80	2.67	2.83	2.33	3.00	2.75
Advanced Boost System Development for Diesel HCCI/LTC Applications	Harold Sun (Ford Motor Company)	*4-83*	3.20	3.00	3.20	3.20	3.10
Low Temperature Combustion Demonstrator for High Efficiency Clean Combustion	Willy de Ojeda (Navistar International Corporation)	*4-85*	3.40	3.40	3.80	3.20	3.43
Development of Enabling Technologies for High Efficiency, Low Emissions Homogeneous Charge Compression Ignition (HCCI) Engines	Scott Fiveland (Caterpillar Inc.)	*4-87*	4.00	3.25	3.50	3.50	3.50
An Engine System Approach to Exhaust Waste Heat Recovery	Richard Kruiswyk (Caterpillar Inc.)	*4-89*	3.00	3.00	3.00	3.00	3.00
Enabling High Efficiency Clean Combustion	Donald Stanton (Cummins Inc.)	*4-91*	4.00	4.00	3.50	4.00	3.94
Exhaust Energy Recovery	Chris Nelson (Cummins Inc.)	*4-93*	3.00	3.25	2.25	3.00	3.03
Heavy Truck Engine Development & HECC	Houshun Zhang (Detroit Diesel)	*4-95*	2.25	1.75	3.50	2.50	2.19
Variable Compression Ratio Engine	Charles Mendler (Envera LLC)	*4-97*	2.80	2.40	2.60	2.60	2.55
On-Board Engine Exhaust Particulate Matter Sensor for HCCI and Conventional Diesel Engines	Matt Hall (University of Texas at Austin)	*4-99*	2.86	3.57	3.00	2.86	3.23
Develop Thermoelectric Technology for Automotive Waste Heat Recovery	Jihui Yang (General Motors Corporation)	*4-102*	3.25	2.75	2.75	2.75	2.88
Thermoelectric Conversion of Waste Heat to Electricity in an IC Engine Powered Vehicle	Harold Schock (Michigan State University)	*4-104*	3.17	3.17	3.33	2.67	3.13
Automotive Waste Heat Conversion to Power Program	John LaGrandeur (BSST LLC - Amerigon)	*4-106*	3.60	3.60	3.60	3.00	3.53
Improving Energy Efficiency by Developing Components for Distributed Cooling and Heating Based on Thermal Comfort Modeling	Ed Gundlach (General Motors Corporation)	*4-108*	3.00	2.33	3.00	3.00	2.67
Very High Fuel Economy, Heavy Duty, Narrow Speed Band Truck Engine Utilizing Biofuels and Hybrid Vehicle Technologies	Chun Tai (Volvo)	*4-110*	2.00	2.00	2.60	2.40	2.13
Benchmark Reaction Mechanisms and Kinetics for Lean NOx Traps	*Richard Larson (Sandia National Laboratory (SNL))*	*4-113*	*3.00*	*3.00*	*3.00*	*3.00*	*3.00*

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Degradation Mechanisms of Urea Selective Catalytic Reduction Technology	*Charles Peden (Pacific Northwest National Laboratory (PNNL))*	*4-115*	*4.00*	*3.50*	*3.50*	*3.50*	*3.63*
Low-Temperature Hydrocarbon/CO Oxidation Catalysis in Support of HCCI Emission Control	*Ken Rappe (Pacific Northwest National Laboratory (PNNL))*	*4-116*	*3.00*	*2.50*	*3.00*	*2.50*	*2.69*
High Temperature Thermoelectric Materials	*Norbert Elsner (Hi-Z)*	*4-117*	*3.00*	*3.00*	*3.00*	*3.00*	*3.00*
OVERALL AVERAGE FOR ADVANCED COMBUSTION			**3.32**	**3.24**	**3.31**	**3.16**	**3.26**

NOTE: Italics denote poster presentations.

Overview of DOE Advanced Combustion: Gurpreet Singh, U.S. Department of Energy

1. Was the Sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

A reviewer stated that this presentation offered a good summary and overview. Another liked the format of the presentations with relevant information condensed onto a few slides, and felt the format made it very easy to find needed information. The other reviewers agreed that the sub-program area was adequately covered.

2. Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

A reviewer stated that the plans are good, but help might be needed to understand more about the direction of future research; for example, is there any change in balance of basic versus applied research? Redirection of fuel cell versus IC versus battery etc? University versus Lab versus industrial funding split? Another welcomes expanding the research into lean gasoline/SI research. The other reviewers agreed that there were plans identified for addressing issues and challenges.

3. Does the Sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program R&D needs?

A reviewer stated that this was very good, and the group at DOE has been instrumental in developing low emission, high efficiency IC engine technology while pushing important work at times when few thought it was important and that work is now relevant. The other three reviewers agreed that the Sub-program area appeared to be focused, well-managed and effective in addressing DOE VTP R&D needs.

4. Other comments:

A reviewer stated that more areas of the government should do such a good job of anticipating needs and providing the necessary underpinnings, along with having good people to work with and fine technology development. Another liked the format of this year's presentation and commended the fact that they didn't have to evaluate each presentation, having the presentations available for reference was invaluable and the PeerNet software worked very well. One other reviewer supports expanded effort in gasoline FE due to the projected increase in global diesel demand (HD mainly) relative to gasoline (CAFE, ethanol).

Overview of the Heavy Truck Engine and Enabling Technologies R&D: Roland Gravel, U.S. Department of Energy

1. Was the Sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Two reviewers agreed the Sub-program was adequately covered and important issues and challenges identified, with one reviewer noting a good summary was presented of work being done and the reasons for the work. One reviewer also stated it would be helpful to see in addition to the previous year, progress presented in comparison over the entire duration of the Sub-program, e.g., over the last 3 years, 5 years, etc. as applicable.

2. Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Two reviewers agreed that the plans were identified for addressing the relevant issues and challenges and with no major gaps in the project portfolio.

3. Does the Sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program R&D needs?

Two reviewers stated that this Sub-program does appear to be focused and properly managed to address the DOE VTP needs.

4. Other comments:

A reviewer stated that it would be helpful for DOE to actually claim more public credit for success stories. The short term progress was charted very well, but the medium term progress seemed to be somewhat ignored and it would be beneficial to the program to track progress in the 3-5 year timeframe. Another reviewer believed some added emphasis was needed beyond DOE on the ambient air quality data and its implications for regulations. The same reviewer also said that high emitters should be studied more and identified. The last reviewer stated they were not able to comment on this presentation.

Overview of DOE Emission Control R&D: Ken Howden, U.S. Department of Energy

1. Was the Sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

A reviewer stated that a lot of things were covered so fast that they didn't get time to catch them all, but did say that good progress was being made. Another reviewer said the directions and challenges were adequately presented in summary form; however they would encourage a better summary of progress and to touch on the highlights in more detail. This reviewer then went on to ask, what were the key two or three developments in the last year in each category? The rest of the reviewers agreed that the Sub-program area was adequately covered, with one stating the progress was clearly described and the majority of important issues and challenges properly summarized.

2. Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

A reviewer stated that the plans are identified and there is a challenge to continue research versus industrial proprietary limitations. Another reviewer said hybridization/electrification of the vehicle presents interesting challenges and opportunities; for example, the battery can cover up much of the problem areas on the engine map – LT, HS, heavy transients, etc. The range extender engines essentially operate at a steady state and all of this has emissions implications that need to be explored further. They also said that there is much room for fundamental understanding and discovery and they sense there needs to be more effort here. There is too much emphasis on HCCI for diesel, that they were very supportive of these programs till this year. Emissions were limiting diesel engine penetration, however, in these modes FC goes up while emissions go down. This reviewer stated further that they encourage the DOE to consider pushing FC reduction technologies while letting after treatment handle the emissions. CO_2 will prove to be much more elusive as after treatment gets better and CO_2 regulations become tighter. Overall, this reviewer said the program otherwise seems complete with a good emphasis on LT conversion, modeling and cutting edge stuff. Another reviewer said they would welcome increased focus on sensors for control and OBD. The reviewer went on to ask, a lot of projects were focused on LNT, are any of them redundant or do they complement each other? One other reviewer stated they would like to add one item to the list of the future technology priorities, which hopefully can get included in the program portfolio: the pre-competitive, fundamental research in the area of catalysts and sensors, enabling efficient self-diagnostics of the aftertreatment system. They went on to say a full capable self-diagnosing system would go beyond meeting regulatory OBD requirements, also enabling more efficient operation of the system overall due to leaner margins, thus reducing fuel penalties (in engine or in aftertreatment) associated with meeting emissions. Furthermore, it would have a potential for reducing the system's lifecycle cost due to minimizing unnecessary replacement of aftertreatment elements, some of which are quite expensive. The last two reviewers said yes, there are plans identified for addressing issues and challenges.

3. Does the Sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program R&D needs?

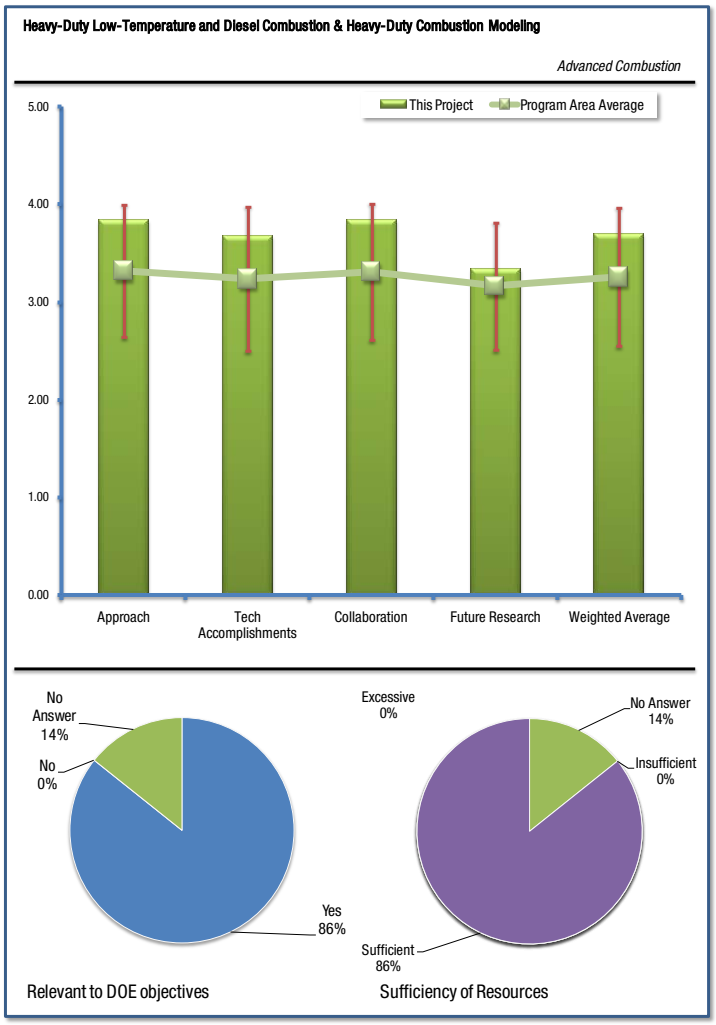
All of the reviewers who answered this question agreed that the Sub-program was well focused and well-managed. One reviewer went on to say the program managers are well connected to the work and do a good job of finding and directing opportunities. Another reviewer said inputs are solicited and taken into account; the programs seem flexible and ready to adjust. They also said there is enthusiasm and the program is developing superior talent and insight. One other reviewer commented that there was a well-defined channel for systematically collecting industry R&D gaps

(CLEERS), a good balance between different aftertreatment technologies in the portfolio, and remarkably coordinated, complementally efforts between various National Labs.

4. Other comments:

A reviewer stated that the program is quite comprehensive and they urge DOE to focus even more on cutting edge CO_2 reductions via heat recovery, new materials and methods for heat preservation (thermal barrier, coatings), bottoming cycles, and the effects of these on criteria emissions and control. This reviewer also said the Department should continue pushing the envelope on research and move even more in this direction, and the supply of fundamental information only comes from these programs, as private funding has pretty much dried up. Another reviewer liked the format of this year's presentation and commended the fact that they didn't have to evaluate each presentation, having the presentations available for reference was invaluable and the PeerNet software worked very well. One other reviewer mentioned they are not sure if DOE support is needed for after treatment device development since many of these technologies are becoming commercial. They also said that overall FE impacts are small and the incentive for improving diesel penetration in LD is diminished with shifts in global gasoline/diesel balance. The last reviewer who commented said they believe after treatment has major potential to be unlocked through further research, for enabling fuel economy improvements for the overall powertrain, and with proper research, these fuel economy gains can quite realistically go beyond incremental. The key improvements are likely to come from pushing NOx conversion efficiency to very high levels, comparable to those achieved today using three-way catalysts, which would allow us to drastically relax the emission constraints on the engine itself, wringing out its maximum fuel economy. There are a number of other areas which can aid in fuel economy improvements through better understanding of the after treatment systems, such as reduced aftertreatment-related fuel penalty. One last thing this reviewer said was even though the key types of aftertreatment systems have been successfully commercialized (LNT, SCR, DPF), the industry is essentially at the limit of what can be done empirically; further breakthroughs can only occur based on the improved understanding of the performance and aging behavior of the catalysts and sensors.

Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling: Mark Musculus (Sandia National Laboratory (SNL))



Reviewer Sample Size

This project had a total of 7 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that LTC has the potential to reduce fuel consumption, but perhaps more importantly reduce the requirement for complex and fuel inefficient emissions aftertreatment. Another reviewer noted the project addresses low temperature combustion fundamentals to spray interactions, soot, and UHC formation while one reviewer added it addresses low emission combustion system understanding needed for efficient engines. One reviewer commented this project targets enabling the use of LTC combustion in HD diesels toward meeting future emission standards. Such modes of combustion are critical for engine OEMs in producing future engines that meet emission standards while delivering acceptable thermal efficiency. Comments from another reviewer mentioned this project provides an understanding of in-cylinder LTC combustion, including sprays, mixing, emissions, and efficiency. This understanding is critical to designing practical LTC combustion systems that can deliver their full potential. Another reviewer added this project is structured to gain fundamental understandings of LTC combustion for heavy duty applications, specifically unburned HC and CO emissions. As these understandings are absolutely necessary to enable LTC architecture, the project does support the DOE objective clearly 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 stated the goal of extending the now accepted diesel combustion model (Dec et al.) to multiple injection LTC with high rates of EGR is a very worthy one. However, how much of what is seen in the present work is geometry-specific is not well understood. Obviously the interaction of the injection spray geometry and the piston-bowl is critical to understanding the soot formation problems, for example, but how are the geometries selected? For the optical engine, the geometries are fixed, but what about the modeling? In other words is there a feedback mechanism to allow the piston and injector geometries to be modified in the future based either upon experimental or modeling results or both? Another reviewer commented it's a nicely balanced experimental and modeling approach. One reviewer noted this work is needed for calibrating CFD simulations of diesel fuel sprays and combustion.

Comments from another reviewer mentioned this project is very focused on better understanding LTC combustion; it is understood that this type of combustion mode will be critical in future diesel engines that must meet very stringent emission standards. The only suggestion for improvement from a large scale viewpoint is to also try to assess thermal efficiency impact associated with various injection strategies. Another reviewer added the hardware used in the

investigations is relevant. The focus is on relevant strategies using practical piston designs. The approach is to apply state of the art optical techniques to observe the combustion and emission formation process and feed that information into CFD models. It is difficult to improve this kind of an approach significantly. Comments from one reviewer stated this project is well designed. It is a balanced project that uses 1D models (1D CFD), optical techniques, and 3D CFD to help build the necessary building blocks required for LTC.

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

A reviewer stated the development of a fully comprehensive predictive model for LTC at high rates of EGR and for multiple injections is a very important and required focus of work. The 'entrainment wave' phenomenon seems to be important, but how much of this is a consequence of normal, real injection characteristics (the end of liquid injection) and how much is a 'new' standalone phenomenon? The Wall temperature diagnostic looks to be a fortuitous discovery, but will it turn out to provide a high enough fidelity temperature measurement to be useful? Will it be optical engine specific? (glass versus metal conductivities, for example). Another reviewer added there was nicely presented results on entrainment wave measurements and soot formation work for short and long injections. One reviewer mentioned they liked the entrainment wave model. How does different in-cylinder air motion affect this wave? The collaboration with KIVA models is good stuff. This is where a long term benefit to industry is helpful. The reviewer thinks there is a lot of stuff in A/F, swirl, bmep, and EGR that have large effects on this that need investigation. Overall, they are skeptical that this LTC is relevant for Heavy Duty. The project should be showing results for 1000 to 1800 kPa BMEP at low NO_x levels. This is real heavy duty territory. What about fuel economy? Comments from another reviewer noted this project is starting to produce useful qualitative information for engine OEMs on how to more intelligently choose main-pilot injection strategies in LTC combustion mode. Much work is still required in the future to better quantify the impact of injector geometry, combustion chamber design, and the timing of events on reducing soot while hopefully keeping NOx in an acceptable concentration range. Another reviewer commented the accomplishments identified fuel lean mixing after the end of injection as a cause for HC emissions. At the same time entrainment wave rapidly oxidizes soot near the injector. The study is revealing how post-injection interacts with soot left over from main injection and can reduce soot at some conditions. Going forward, multiple injection strategies such as these to reduce emissions and PM in-cylinder are going to be the key if LTC is going to be successful. This reviewer went on to say that smaller bowls allow hot combustion gases to interact with unburnt regions and oxidize them. Such understanding will permit the intelligent design of optimum piston bowls. These measurements are being used to create new CFD Models which are being used to fill-in holes where experiments have gaps. Observations of one reviewer noted that significant technical progress has been made. The entrainment wave analytics provide a working hypothesis as to where a dominant source of UHCs are coming from. The hypothesis looks to be validated through the use of experimental optical techniques and 3D CFD. In addition, it provided clear evidence as to the benefits of split injections in a LTC environment. Lastly, it provided strong evidence that the cause of UHC were linked to overly lean regions and not overly rich. It would be interesting to know whether this would general statement would hold up with different combustion geometries.

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

Four reviewers stated that there is a good collaboration with UW and industry for the budget allocated. One reviewer also went on to say Cummins and GM using entrainment wave phenomena in their R&D programs. Going forward, more benefits of understanding the "Entrainment Wave" should be advertised so that more users and designers of LTC combustion systems will be encouraged to make use of the EW's benefits. Another reviewer added the collaboration and coordination is excellent and this project has outstanding collaboration with the ERC KIVA group toward better understanding LTC combustion around a narrow operating condition window. Additionally, there is good collaboration with Cummins Inc. Comments from another reviewer noted the presentation highlighted effective collaboration with KIVA developers, industrial partners, etc.

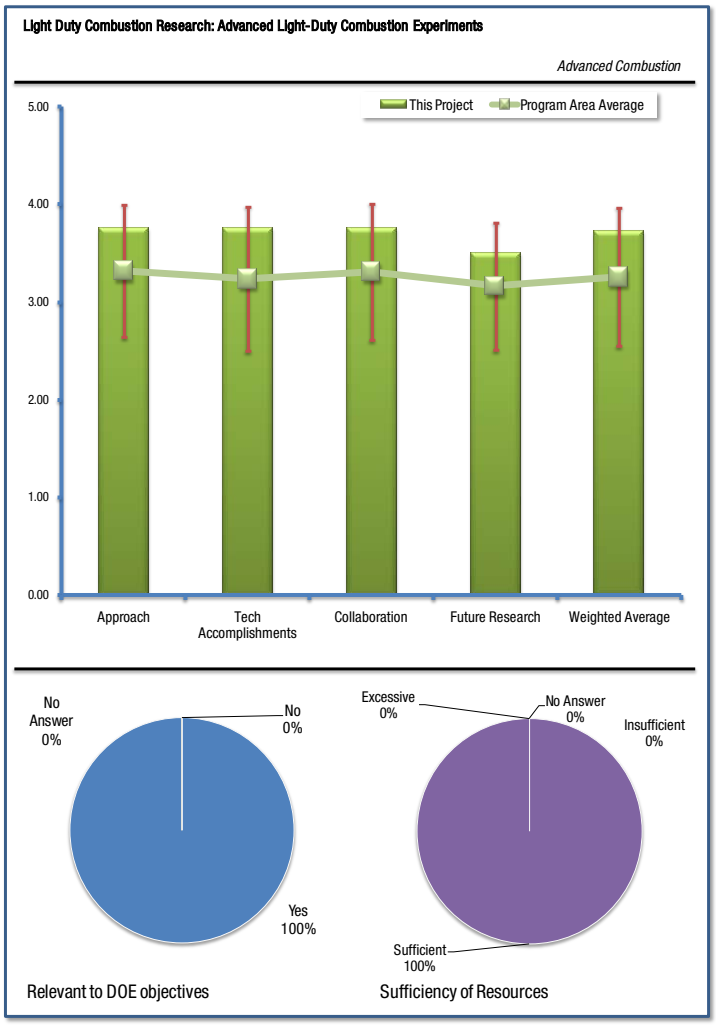
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated what about transient LTC behavior - or mode switching? The questions of relevance include will it be feasible to use the same hardware for both modes of combustion? Consider these issues or tell us that they do not matter. Another reviewer commented that wall temp diagnostics were mentioned, but not clear what future approach will be. Interactions observed with additional bowl and spray geometries would be beneficial. One reviewer noted the HD needs high BMEP and good fuel economy. They think this work is more light duty. Can we crank up the BMEP? Comments from another reviewer mentioned they recognize that there is still an abundance of experimental work in the future to improve the community's understanding of LTC combustion. Ultimately, this project must eventually result in the development of 'engineering' models or 'rules of thumb' for more intelligently choosing fuel injection strategies for LTC combustion. It would be useful to see more engineering modeling activities during the next year or two to address any ultimate goal of aiding engine OEMs in developing future LTC combustion strategies. Another reviewer added the future plans outlined in this presentation are exactly in line with the recommendations of the reviewer. The focus on various multiple injections schemes, understanding the EW's role during these multiple injection events and the interaction of post injection with main injection soot should be the focus. Observations from one reviewer stated the future program looks promising but they are left a bit unclear as to what the goals are. What exactly is meant by "a conceptual diesel model extended to LTC"?

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

A reviewer stated there was no indication of how many people are supported or the total amount of personnel time spent through the year. Another reviewer noted it was difficult to judge based on presentation. What is impeding the rate of research? One reviewer added this project has a very, very fair budget toward addressing the goals of this research. In the future it would be useful to know how the budget is split between hours (labor cost), materials, maintenance, etc in order to assess the sufficiency of funding level.

Light Duty Combustion Research: Advanced Light-Duty Combustion Experiments: Paul Miles (Sandia National Laboratory (SNL))



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this is excellent work to develop understanding of complex processes in diesel engines. Another reviewer added the project reduced UHC and CO support both improved efficiency and reduced aftertreatment cost. One reviewer noted the project addresses issues and barriers for light-duty LTC combustion. This project aims to improve load range, minimize CO and HC emissions and cost. Comments from another reviewer mentioned this project focuses on low temperature combustion for light duty vehicular applications. Specifically, the objective aims to look at the sources of combustion inefficiencies (CO and UHC) emissions. Therefore, this project does support the overall DOE objectives.

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

A reviewer stated the combination of optical, metal engine and detailed modeling is very strong. The efforts are well integrated. Another reviewer noted the approach needs to be careful research isn't engine geometry specific and can be translated to other designs. Long term goals should include plans to address this. One reviewer commented the approach is well thought out, coordinating the strengths of several institutions by focusing on near identical engine hardware. Engine matches metal engine at the University of Wisconsin. Combustion and emissions between the two engines are well matched. Comments from another reviewer mentioned it's a strong approach which uses the optical engine at SNL and couples it with simulations done at UW.

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

A reviewer stated there is a good pace or research with significant progress this year. Another reviewer mentioned that clearance volume HC and CO, and near-injector HC sources identified earlier. But measurements do not show CO formation in bowl as the CFD did. Extended diagnostics were conducted to probe this source, with PIV to visualize liquid. The effort to locate this source within the bowl is commended, and should be pursued. One reviewer noted there was a strong improvement in optical measurements relative to 2007-2008 timeframe. The improvements largely stemmed from being able to get optical measurements in areas away from the squish where CFD analysis showed significant sources of UHC and CO.

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

A reviewer stated there is excellent collaboration through the MOU with other labs, academia, and industry. These results are going directly to people who are doing real engine design. Another reviewer commented that a good

agreement is being obtained by the University of Wisconsin modeling effort. But we still do not see CO and UC source within the bowl. This discrepancy is very perplexing and should be pursued until the mystery is solved.

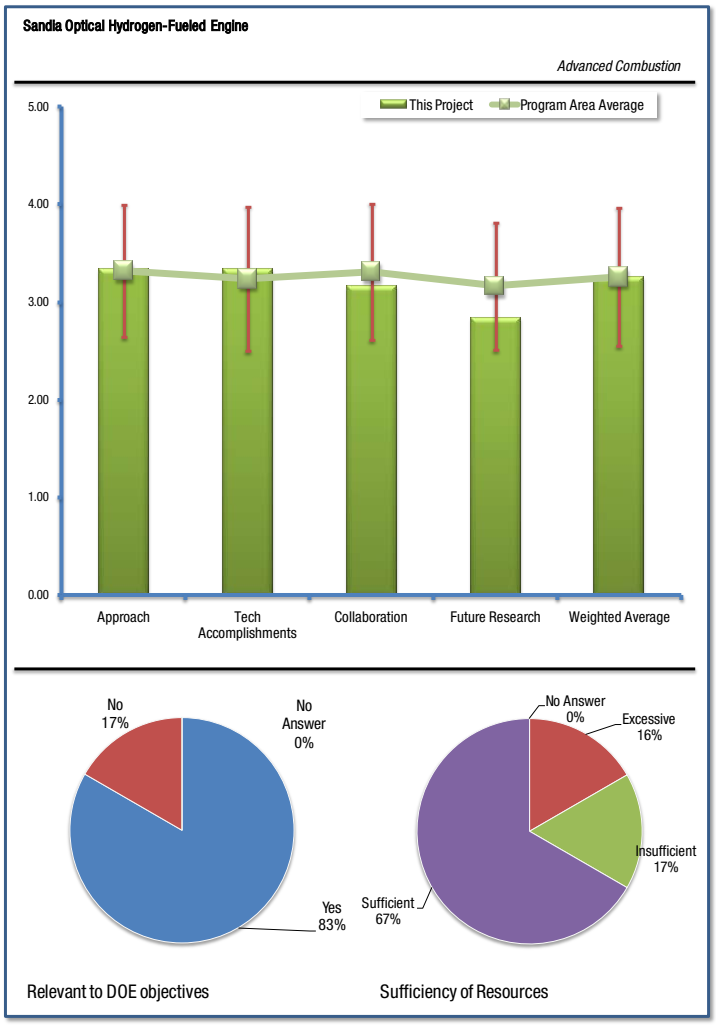
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the data should continue to be provided to refine models. Also, the planned work with close-spaced multiple late injections should be given high priority.

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

A reviewer stated the resources for the project are about right.

Sandia Optical Hydrogen-Fueled Engine: Sebastian Kaiser (Sandia National Laboratory (SNL))



Reviewer Sample Size

This project had a total of 6 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the DOE should continue to investigate hydrogen as a fuel in ICEs, even though the use of fuel cells for mobile applications is being de-emphasized. An investigation like this is important to allow us to keep up with the feasibility of hydrogen use in engines. Another reviewer noted that H2ICE can be superior to fuel cells depending on the vehicle configuration. They can be a high value approach to sustainable, near zero emission transportation; depending on the source of the hydrogen. One reviewer commented the focus is on hydrogen which is a fuel that can potentially replace petroleum. Comments from another reviewer mentioned yes, if one assumes the hydrogen does not come from petroleum, otherwise, they are afraid this is a dead end. Another reviewer added the research is important for developing hydrogen combustion systems. The H2ICE fills a key niche prior to large scale adoption of fuel cell technology. Acceptance of H2ICE still depends on infrastructure on and on-board storage as key roadblocks. A remark from one reviewer questions the use of hydrogen being able to ever meet the 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 stated the project aims at providing general insights into hydrogen injection and combustion. Engine geometries may be the key and yet it is tough to vary this in a comprehensive fashion in a project like this. Another reviewer added it's a good approach to using optical engine to obtaining better understanding of what takes place in hydrogen engine. One reviewer mentioned this is a good job of measurement and of using a tracer to make the PLIF work. Provides a reasonable insight into the combustion chamber and allows for calibrating a CFD model. Comments from another reviewer noted the project needs to insure results are generally applicable and not focused on one combustion system design (piston geometry and flow field due to intake port geometry for example).

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

A reviewer stated this is good progress but the project needs to be more integrated with simulation before the results can be used for engine design. The results were interesting on jet collapse using the 13 nozzle injector. Another reviewer noted the project developed good solutions to the problem of being able to more accurately view hydrogen stratification under different injection conditions. One reviewer commented they would like to see much more simulation. In-cylinder CFD could provide a lot of the same insight at lower cost. Now that the project has done this, the reviewer would expect to see a lot of work with simulation to optimize the setup over the speed and load map and

look at different combustion shapes and nozzle geometries. One reviewer asked, what are the targets you are aiming for fuel air mixing? What is needed for good overall efficiency and maintain low NOx? What are the maximum equivalence ratios in the chamber?

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

A reviewer stated there is a good collaboration with ANL and Ford. What about HD direct injection of hydrogen like Westport does? Another reviewer added there is a good collaboration with several automakers. One reviewer mentioned at least the project has a partner in Ford, but they could see this will be difficult to get partners due to the lack of fuel source.

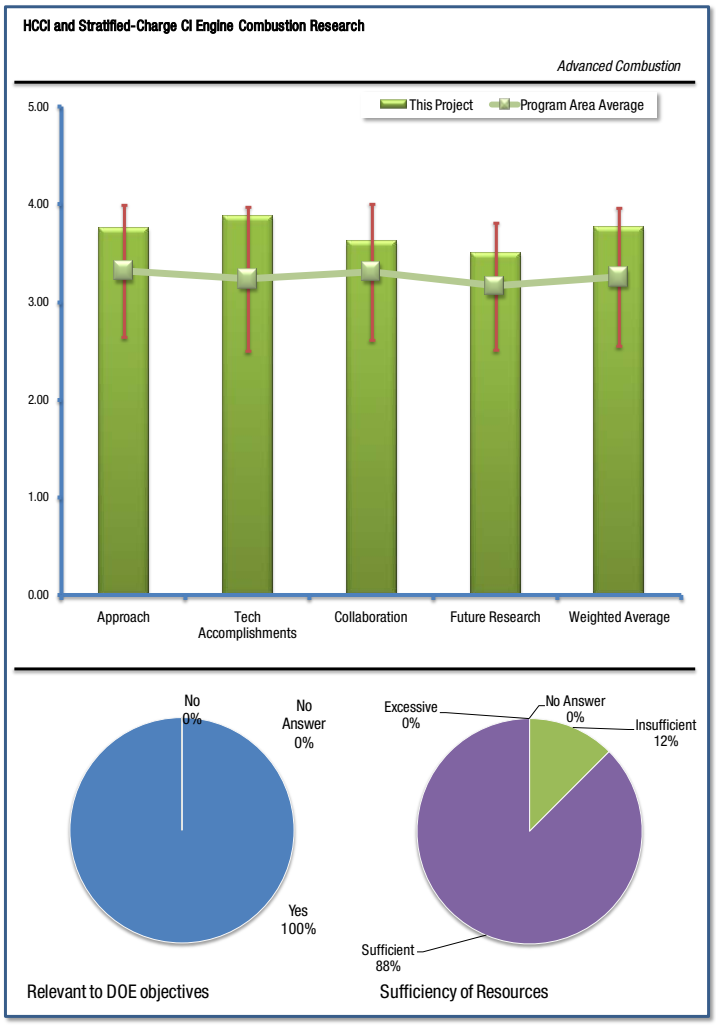
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated it is clear that this hydrogen imaging work is starting to track diesel injection strategies. Has the project considered the full range of state of the art injection diagnostics that are now being pursued for diesel work? Can the PI elucidate where hydrogen injection and diesel injection differ and where they are the same? Another reviewer commented the proposed work pan is good with extension of work to multi-injection strategies. One reviewer added they are not sure where this is going.

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

A reviewer stated that compared to fuel cell funding, this promising area receives very low funding. If a breakthrough in hydrogen storage/infrastructure occurs, effective and affordable utilization paths such as H2ICE need to be ready. Another reviewer mentioned that the resources seem sufficient. One reviewer noted that they are spending plenty on a fuel with no source and no distribution system. Comments from another reviewer question the use of hydrogen being able to ever meet the DOE objectives of petroleum displacement. Therefore, they believe that this funding is excessive.

HCCI and Stratified-Charge CI Engine Combustion Research: John Dec (Sandia National Laboratory (SNL))



Reviewer Sample Size

This project had a total of 8 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that HCCI is an important fuel efficiency and low emissions strategy. The use of ethanol in HCCI is an important, novel new step in non-conventional combustion. Another reviewer added that this is great work that really extends the understanding of HCCI combustion. One reviewer mentioned this project addresses low emissions need, fuel economy, and alt fuels. Comments from another reviewer noted this research compliments the overall portfolio of LTC projects at SNL. Boosted HCCI fits nicely with downsizing/boosting being embraced by some OEMs. Ethanol HCCI is also appropriate. Observations by another reviewer stated this project is relevant from the viewpoint of possibly enable the use of non-standard combustion modes for meeting future emission standards while pushing engine load higher; good alternative project to counter work on DI diesel combustion R&D in LTC, HCCI, PCCI, and other alternative diesel modes. Another reviewer commented this addresses LTC barriers, like extending operating range to higher loads, CO and HC emissions at low loads and an understanding of in-cylinder mixing and combustion processes. The project is now including gasoline and ethanol fuels. This project also addresses the most relevant issues pertaining to LTC gasoline combustion for light-duty application, which has significant potential for reducing light-duty petroleum consumption. One reviewer noted this provides fundamental research towards enabling HCCI combustion. HCCI combustion still looks to achieve high thermal efficiencies at ultra low emissions. As thermal efficiencies are starting to look more promising than they have in the past, this does support the 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 stated that extending HCCI to much higher BMEP levels is an important application for the commercial success of this combustion mode in the future. Another reviewer noted the thermal stratification work seems to be a primary focus, while other aspects of HCCI haven't been investigated. Perhaps there should be a more balanced approach for the future? One reviewer commented the combination of optical, metal engines and modeling is very strong. Comments from another reviewer mentioned this is a good method for addressing the BMEP limitations of HCCI. They would like to see more modeling with this, both 1D cycle simulation and 3D CFD. Another reviewer added the project needs to address NVH of the boosted HCCI. Is ringing intensity a standard metric for NVH? Observations from one reviewer stated this experimental effort is very good. The only suggestion is to establish practical load limits for HCCI gasoline engines under real world intake charge temperature limitations. For example

it is not practical to expect charge air temperature to approach ambient conditions in the real world application - this research has established such a theoretical limit based on ignition control under high load conditions. One reviewer talked about the use of a metal engine as well as an optical engine simultaneously is an excellent approach to understanding the in cylinder combustion processes. The metal engine serves as a platform that generated detailed issues for practical and relevant combustion phenomenon. These issues can then be probed in detail with the optical engine. Comments from another reviewer said one of the major technical barriers for HCCI operation is the extension of the load range. This work is clearly laying the groundwork as the load range has been extended to IMEP values that, to their knowledge, have not been previously demonstrated. This is fantastic work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated there were good results on very high load using gasoline. Ethanol results are also very interesting and potentially important. One reviewer added the thermal stratification work is very interesting and helps clarify HCCI ignition while another reviewer said "good work on getting some high loads out of HCCI." Another reviewer commented they would like to see some cycle simulation work to go with this to show what is really needed from the air system to support this operation with high EGR and high boost. This could provide some good brake thermal efficiency estimates. Comments from another reviewer mentioned that there is good progress to date on establishing load limits on gasoline HCCI, in assessing ethanol versus gasoline combustion variances, and in exploring thermal stratification effects on combustion control. Observations from another reviewer noted thermal stratification is one key to increasing the high-load limit of HCCI, it allows lower pressure rise rate. Retarding injection timing further reduces pressure rise rate, so does EGR. Understanding how thermal stratification (TS) evolves has been advanced. TS develops as cold pockets, which are then transported into the central region as we progress towards TDC. TS increases as we progress towards TDC. Intake boost results: Run out of injection retard and reduction of intake temperature. They have determined that addition of EGR can result in further increases in load. The load levels achieved are impressive. Another reviewer stated it is great progress. Showed significant increases in load capability for gasoline based HCCI combustion (up to 16 bar IMEP).

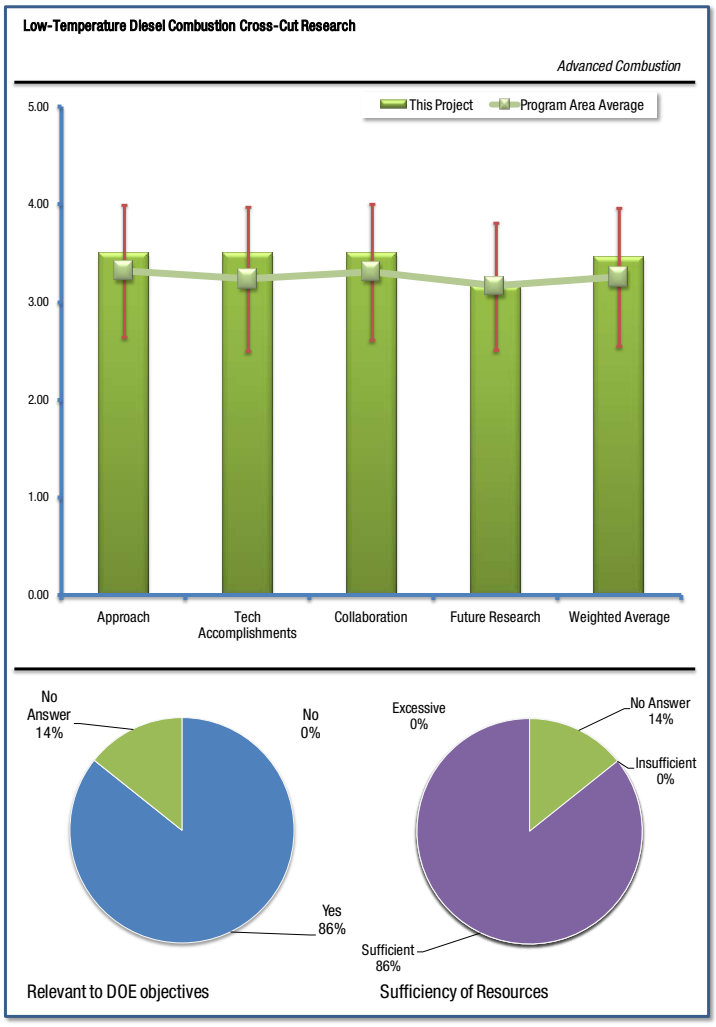
Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated there is a good collaboration and dissemination of information. Another reviewer mentioned this is a major part of the MOU collaboration. There is a solid transfer of knowledge to the industry and other researchers. One reviewer asked, are we working on being able to CFD simulation of this? The reviewer didn't see anything on this. This may require modeling the iron to get correct wall temperatures? Comments from another reviewer noted there is excellent collaboration with industry and another national lab. Possibly including UW-ERC in the future might be worthwhile in the kinetics development area. Another reviewer added appropriate and sufficient collaboration with relevant combustion modeling efforts at national labs, and consultation with OEMs and working groups is taking place.

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 stated a good future pathway has been established. Another reviewer noted generally, the proposed research is very good. The only suggestion is to limit the high load HCCI excursions to practical intake temperatures during some part of this study, otherwise an opportunity will be lost to provide engine OEMs with practical boost limiting operating conditions. One reviewer mentioned the future work listed is all very relevant and critical. All aspects of this program should be continued.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated that more funding would be useful, but managing the research effort gets tricky. Another reviewer noted the resources for the project are about right. One reviewer commented it is a well funded project. It would be nice to see the budget breakdown by labor, materials, maintenance, etc. Comments from another reviewer mentioned

this program is making wonderful strides in extending the load range capability of HCCI. This is particularly important for engine applications that operate at high load for majority of their duty cycle.

Low-Temperature Diesel Combustion Cross-Cut Research: Lyle Pickett (Sandia National Laboratory (SNL))



Reviewer Sample Size

This project had a total of 7 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the project is working on complex injection spray dynamics and visualization important for modeling and simulation efforts, which in turn will lead to better engine designs for high efficiency, low emissions engines. One reviewer added the project addresses key fundamentals on mixing / atomization of Diesel combustion while another reviewer said the project is understanding injection and mixing is the key to understanding combustion. Another reviewer noted this project works on better understanding spray targeting under LTC conditions is relevant because it aids engine OEMs in developing injection strategies that must address any potential liquid-wall impingement effects that could lead to UHC and PM formation issues. Comments from another reviewer mentioned this work provides fundamental understanding of injector and spray effects on engine combustion and emissions. Another reviewer stated this work is fundamental to enabling low temperature combustion and avoiding the problems of liquid fuel impingement on liner surfaces.

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 stated this is a good approach to a complex situation - rendered complex by virtue of the large number of potential variables that can be varied while another reviewer said the presentation wasn't clear on what results were from optical engine and which from a combustion vessel. Another reviewer commented this is a good method of measuring liquid and vapor and putting the two together. They like how the project shows the variability of shot to shot. This is something that is often overlooked due to the lack of models being able to measure this. One reviewer added that one limitation to the experimental approach is lack of real world engine geometry that may impact the vapor head of the jet. Nevertheless, this constant volume bomb work is important for better understanding the transient behavior of the liquid jet regime and applying such knowledge to engine OEMs toward such combustion system development activities under LTC-like conditions. Comments from another reviewer mentioned the approach is to mimic engine temperature and pressure conditions in a constant volume chamber. While engine flows are not reproduced, the fundamental and quantitative understanding in a controlled environment is invaluable. The understanding not only directly impacts engine design but also aids in the development of engine combustion models via the Engine Combustion network. Observations from one reviewer noted the scope of project effort has strong focus on establishing the fundamentals of liquid length penetration and how it depends on in cylinder conditions and fuel properties. The reviewer sees this as fundamental to facilitating designs that allow early injections without causing liquid fuel impingement problems.

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

A reviewer stated there were good experimental results. Another reviewer added that there was impressive liquid/vapor during spray imaging. More background on technique would be nice in the presentation. One reviewer noted the project is showing the limiting factors that need to be understood to design a LTC combustion chamber. This is useful for designing a successful system, or for showing how it can't be done. Comments from another reviewer noted the generation of experimental transient liquid length data and the development of the steady-state time of liquid length scaling are significant accomplishments. It would be useful is these accomplishments were expanded to include the impact of the injection profile with time (effect of injector actuation) and also the latter steady-state liquid length scaling was explored using CFD under well known experimental conditions. Another reviewer stated the accomplishments help understanding liquid impingement on walls, especially at early injection conditions; advanced injection timing causes increased penetration. Studied effect of fuel type on penetration; exercised Siebers model for understanding. Existing spray models can be improved with this data.

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

A reviewer stated the concept of the ECN and the uniform injector (Spray A) show that this group is attuned to close collaboration and coordination. The use of this project's results by others shows the importance of this work. Another reviewer noted the engine combustion network is a powerful database. Further examples on how information is applied would be useful. One reviewer commented that ECN is an excellent concept while another reviewer added this work is well published and advertised. Comments from another reviewer mentioned it looks like the future will include more collaboration with Universities and other labs. This list did not include the UW-ERC KIVA group - possibly it would be valuable to collaborate with this group given their extensive experience with various diesel engines.

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?

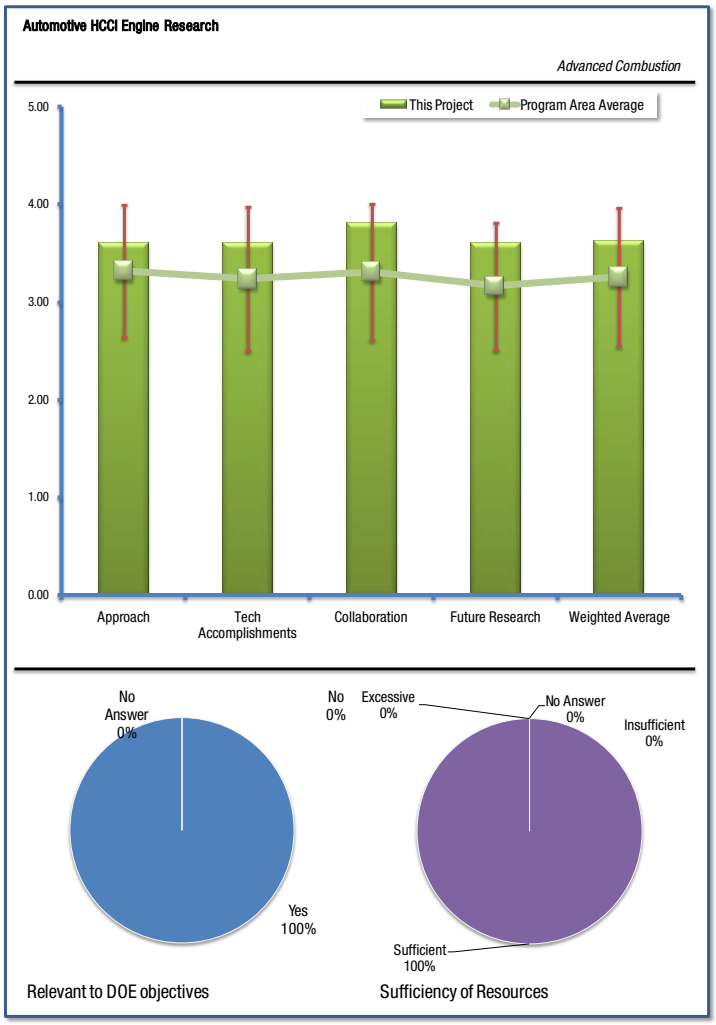
A reviewer stated the project needs to keep up the momentum. Another reviewer mentioned that some effort towards a user friendly engineering tool to make use of these findings would be beneficial.

One reviewer added this work is aimed at LTC, which is highly suspect as a long term solution for high BMEP engines. This means the challenge may be to have a combustion system that can run in a LTC mode and as a conventional high BMEP mode. Comments from another reviewer noted that overall, the proposed research is logical. It would be helpful to provide more validation of the proposed steady-state liquid length scaling as a function of parameters such as transient injection profile and injector nozzle geometry (internal geometry changes; k-factor, and internal hydro grinding).

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

A reviewer stated that more is always better when it comes to funding, but this is a good use of available funding. Another reviewer noted it’s hard to access without further information. One reviewer mentioned the funding is very fair for this project. It would be helpful in the future if funding was broken down by labor cost, material cost, maintenance, etc.

Automotive HCCI Engine Research: Dick Steeper (Sandia National Laboratory (SNL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the extension of HCCI combustion regime(s) to light-duty applications is important and should be pursued. Another reviewer asked what is HCCI benefit once an engine has been highly downsized and the window of HCCI operation is limited? One reviewer mentioned this project improves basic understanding of LTC for gasoline-based LD applications while another reviewer added the research dovetails well with overall portfolio of research being conducted on HCCI by SNL and others. Comments from another reviewer noted this project provides fundamental understanding of LTC combustion for light-duty application.

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 stated the focus is good, but it's not clear if this is aimed at diagnostics or modeling or experimental results (presumably a combination of all three). Another reviewer noted the simultaneous temp / composition diagnostics work seems very promising. What has limited the use of this technique on other applications? One reviewer commented this is a good solid approach. Comments from another reviewer mentioned the approach has been to use a metal engine and an optical engine to study the effects of thermal stratification and equivalence ratio stratification on the LTC process. Results are used directly for engine development as well as model improvement.

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

A reviewer stated there is good progress on a number of fronts. Another reviewer commented this was a nice presentation of split vs. main injection comparison. The affects of adding tracer on heat release, experimental and Chemkin are very useful. One reviewer added the project and accomplishments are making nice progress. Comments from another reviewer noted a comprehensive study of HCCI combustion utilizing negative valve overlap strategy has been undertaken. Various aspects of NVO HCCI fuel, heat release and phasing effects are beginning to be understood.

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

Two reviewers stated there looks to be good collaboration and integration with industry and others. Three other reviewers noted the collaboration with Stanford/LLNL/ UWM is very good.

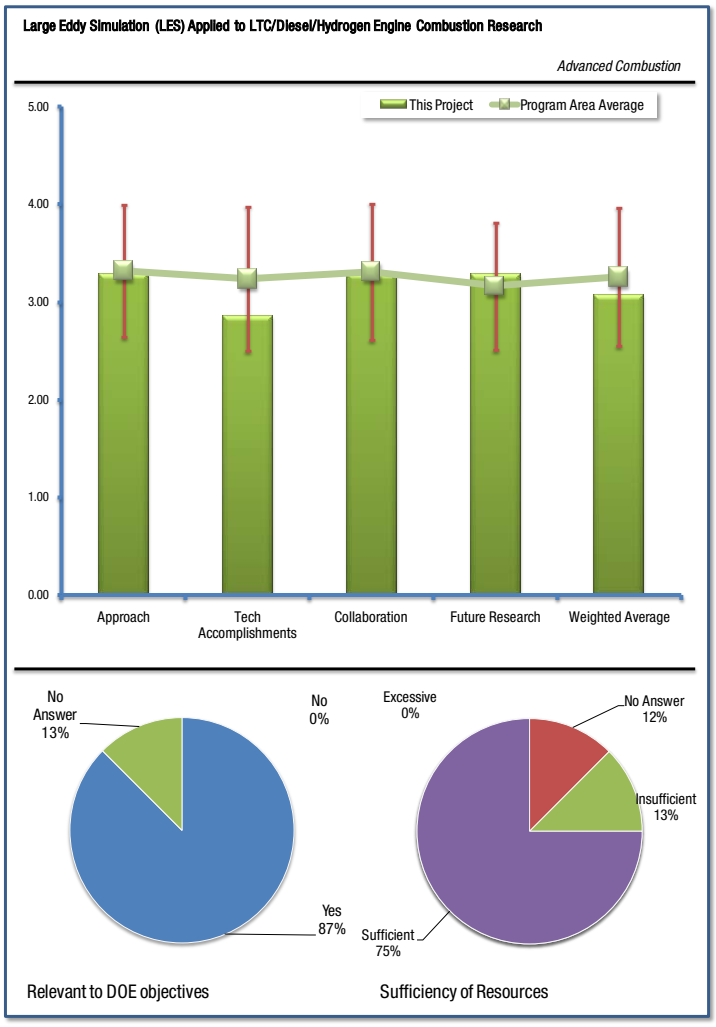
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the use of CO diagnostics seems promising - the motivation for using CO rather than other tracer's needs to be better quantified (other than a component/product usually found in combustion). Another reviewer asked is there any plan to address sensitivities to real world factors such as varying humidity, fuel composition, temperature etc? One reviewer mentioned it is good work and they look forward to the results. Comments from another reviewer noted that more experiments are planned to complete the understanding of NVO combustion on the main HCCI combustion.

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

A reviewer suggests accelerating work on transient combustion effects in mode transitions. Side vs. Central differences on mixing during NVO may be interesting. If hardware upgrades are hindering this work, then perhaps additional funding may be helpful?

Large Eddy Simulation (LES) Applied to LTC/Diesel/Hydrogen Engine Combustion Research: Joe Oefelein (Sandia National Laboratory (SNL))



Reviewer Sample Size

This project had a total of 8 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this is a long term project with high potential payback. This kind of work can only be done in the national lab environment - and needs to be done. One reviewer noted the fundamental research is useful to confirm / dismiss theories based on experimental observations while another reviewer added LES may be an important tool for the future for the modeling of future engines. Another reviewer commented this is the kind of really fundamental work that industry can't do. Only the government can apply this level of resource. Comments from another reviewer mentioned it is relevant, but at this point the connection is weak due to the development nature of this computational tool. Ultimately, the hope is that this tool in the future will be used to study fluid mechanics and eventually combustion in engines such that future engine design efforts by engine OEMs will reap the benefits. This tool is years away from being useful as an engineering tool. Observations from one reviewer stated this project aims to develop multi scale models of various relevant engine combustion modes, including LTC, diesel and hydrogen. Another reviewer commented yes, this program can lead to fundamental physics understanding that cannot be gained through other computational approaches or even experimentally.

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 stated the integration of this form of highly complex modeling and experimental results is a useful approach. One reviewer commented that validation on H2ICE is useful, work towards application on hydrocarbon fuels while another reviewer added this is good work on an important problem. Another reviewer mentioned they like what the project is doing. We could never do this in industry. They would like to see diesel fuel instead of hydrogen. Comments from another reviewer noted the PI is doing his best to validate the fluid mechanics models and turbulence in particular. This effort definitely needs much more experimental validation and should include more collaboration with other sources who can provide data and/or perform necessary experiments. Observations from another reviewer commented the High Performance Computing capability of this project for numerical applications is unmatched. Another reviewer stated a strong case was made for why these simulations are needed and why the problem is so challenging. However, it is not clear how the high computational resources are intended to be used. Are there specific combustion modes that will be investigated? Hydrogen was mentioned as an early case study but wonder if that is a wise choice. Is there a roadmap? The presenter did acknowledge that this is the early stage and not so results oriented yet. This reviewer went on to say that more thought needs to be given as to how results will be

validated. Although LES provides much more statistical information, the high level macroscopic variables should be compared first (average swirl, near wall velocities, etc.).

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

A reviewer stated they need to see more results - journal publications are good, but do we have access to actual animations of in-cylinder flow and injection characteristics? Another reviewer asked what specific understanding has resulted from this work that could not be obtained experimentally? More examples of validation cases would be useful. One reviewer noted interesting results; need to keep going to find how well it really matches the experiments and how predictive it is. Comments from another reviewer mentioned there were lots of neat pictures and look similar to the data. It seems as if the presenter is almost overwhelmed by all the data. The reviewer thinks this is one of the main challenges of LES. Once it is run, what does the reviewer do with all this? They think a methodology on how to post process all the data would be helpful to everyone. Observations from another reviewer noted it is difficult to assess the progress because the validation has been minimal to date. The reviewer recognizes that this effort is important toward providing engine OEMS with another diesel engine design tool and thus provides a fair rating but anticipates much progress within the next couple years. Another reviewer stated that good progress has been made in modeling hydrogen injection processes.

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

A reviewer stated good collaboration - but it would be useful to have more input from industry, particularly as this is the sort of work that industry would like to do, but simply cannot. Another reviewer noted the project is good at trying to model some hydrogen data, but they think more useful stuff is with diesel injections at very high pressures (300 MPa). This would be something to work towards. One reviewer asked why not have a CFD industry partner in this? Comments from another reviewer mentioned this project has shown very little collaboration with sources that could provide data or experimental services to support this effort. Is it possible to collaborate with UW-ERC, UMich, or others towards this end? Three reviewers agreed there were collaborations with other National Labs, along with Universities and other DOE offices. One of the reviewers also added there was a useful validation on H2ICE.

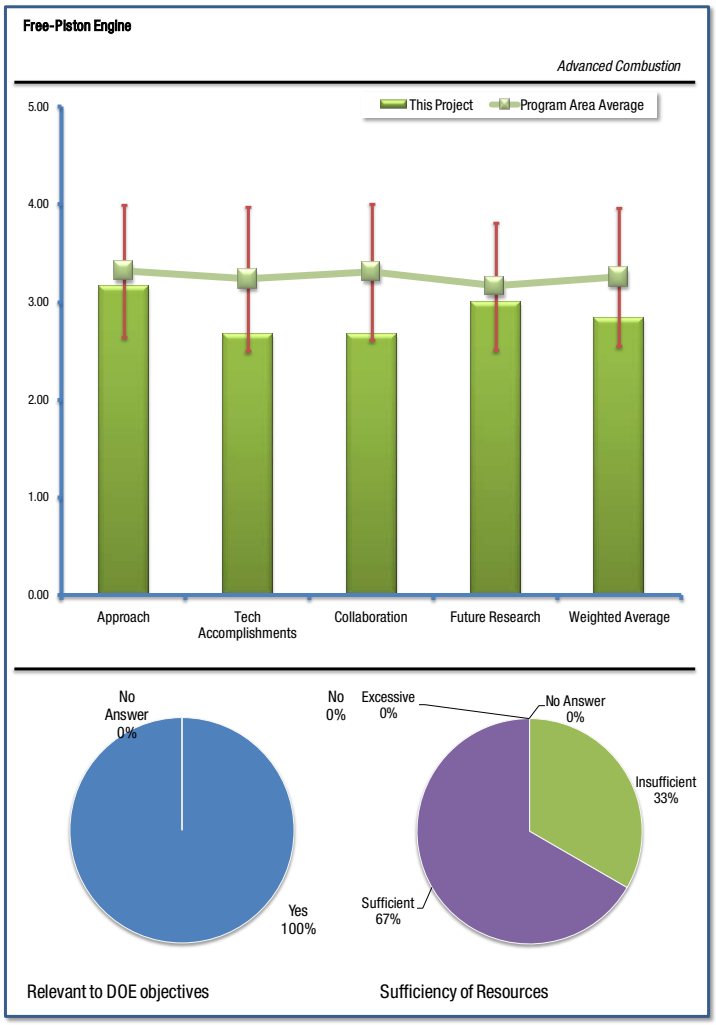
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated there was good future progression shown. Extension to HCCI is important, but is the hydrogen work really a priority, especially as this work is really only scratching the surface of diesel and HCCI simulation. Another reviewer commented direct injection process work planned for gasoline. One reviewer mentioned there is a good approach. The presenter seems a bit fuzzy on how they will quantify the benefits and quality of results. Work is needed on how to compare simulations to experiments and what constitutes "good enough". Comments from another reviewer noted they think this is important key work looking toward the future and is some of the most difficult work being done while one other reviewer would like to see more other toward validation with other labs and universities. Observations from another reviewer added the rate of progress to model liquid fuel sprays and HCCI mixing and combustion in engines should be accelerated.

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

A reviewer stated that more is always better particularly when Cray hours are concerned. More output would be useful. Another reviewer added that assuming access to appropriate computational resources exists in the future. One reviewer noted this might be an area where more investment is needed. Comments from another reviewer mentioned this project has a very fair amount of funding - it would be helpful to see a cost breakdown including labor cost, materials, test and evaluation, etc.

Free-Piston Engine: Peter Van Blarigan (Sandia National Laboratory (SNL))



Reviewer Sample Size

This project had a total of 6 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this is a high risk, long pay-off project, but it should be pursued by DOE (if DOE didn't fund it, who would?) The potential efficiency of this engine makes it worth pursuing. Another reviewer mentioned this project is about hydrogen alternate fuel. One reviewer commented the focus is on engine design that could potentially be more efficient than conventional ICE's. Also potential for variety of fuels, including non-petroleum derived. Comments from another reviewer noted if implemented it supports overall DOE objectives. Understanding more of how the OEM partner, GM, values the project would be helpful. Observations from another reviewer added has the potential of very high efficiency via high compression ratio and constant volume combustion; has multi-fuel capability; employs LTC combustion and so has the potential for low NOx; also low cost. They are expecting 56% indicated thermal efficiency and a 50% brake thermal efficiency. Another reviewer stated this program provides an interesting approach to enabling HCCI combustion and is also looking to break the thermal efficiency barrier of 50%. Therefore, this does support the overall objective 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 stated this is a long and slow progress. The approach seems to be ad-hoc on a year to year basis, probably as a result of the limited and erratic funding. One reviewer noted there is too much on power electronics side, without addressing high CR hydrogen in a low-cost prove-out rig for heat transfer effects etc. while another reviewer said the proposed approach of building and testing a research prototype one of these engines is good. Another reviewer commented it is understood the research is proof of principle but the key barriers with a practical implementation need to be understood for research which has been conducted for this period of time. Comments from another reviewer mentioned there is a need to understand the overall efficiency to allow it to be compared to other ICEs. Another reviewer stated the approach is to design and build a free-piston engine alternator that can demonstrate the high efficiency claims. Observations from another reviewer added the approach seems reasonable. However, in looking at the historical timeline, it appears that the program has moved around quite a bit with the most recent change being to an opposed piston design. This design can offer some benefits although it may be more complicated to realize in principle. The reviewer would have preferred to have seen this demonstrated without the opposed piston first, in addition, expect that this concept also has value for non HCCI type combustion events. Would be nice to understand why those have not taken off. This reviewer agrees that HCCI is interesting because of

the variable compression ratio capability. It was not clear exactly how the variable compression ratio would be used across the load schedule.

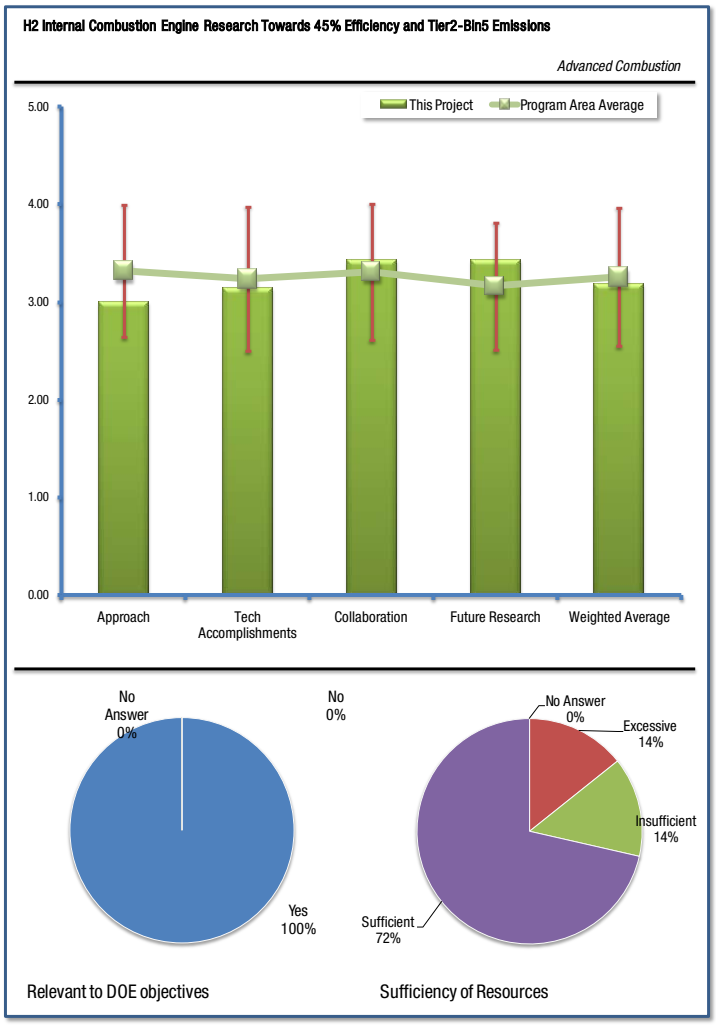
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated there were good accomplishments for the budget expended. Another reviewer noted to get it running. One reviewer added the progress seems to have been good on design and construction of the engine setup. The key will be to continue progress with experiments. Comments from another reviewer mentioned there is reasonable progress but need to see testing. Two reviewers agreed the progress has been slow with one of them adding need to establish proof of principle and key implementation barriers and then make a go/no go decision. The other reviewer who said the progress was slow also stated perhaps funding should be increased and more resources put on the project, especially the experimental part. The important thing is to demonstrate the potential for high efficiency just for the engine first. Has that been experimentally demonstrated in the last 14 years? On the other hand, is piston synchronization going to be the Achilles heel for this concept? Is the ability to achieve and maintain the desired compression ratio going to be the main problem? These are serious questions but it seems like progress towards answering any one of these questions has been slow.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated better collaboration with others would be preferable, although the limitations of the budget and the scarcity of interest from outside interest would explain this. Another reviewer commented LANL, GM, UM, and Stanford were listed as partners, although not clear what roles each play and extent of collaboration. One reviewer mentioned the collaboration is unclear. Appears that there are industrial partners interested but didn't seem as integrated as other DOE programs under review.

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 stated the future work is claiming that a wide range of conventional and alternative fuels will be tested in the next period is probably premature, noting the history of this project. Another reviewer added the key will be results from initial proof-of-concept experiments. One reviewer noted the future plans look ambitious and speak to testing all sorts of different fuels. Good to be forward looking but it appears that there is an enormous amount of learning that needs to take place with a single fuel first.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the funding for this project has never been enough to do much more than keep it on life-support. Another reviewer commented there is no evidence that resources are not appropriate. One reviewer added it seems like more funds to accelerate the experimental part of the program is needed. Comments from another reviewer mentioned recognizing that this is a different engine architecture with high risk; it is possible that increased funds to help get experimentation underway may provide benefit.

H_2 Internal Combustion Engine Research Towards 45% Efficiency and Tier2-Bin5 Emissions: Thomas Wallner (Argonne National Laboratory (ANL))



Reviewer Sample Size

This project had a total of 7 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated hydrogen as a fuel in light-duty and heavy-duty engines is a worthwhile approach. Another reviewer added H2ICE can offer a clean, sustainable path to efficient transportation. While shown to be comparable efficiency to fuel cells, H2ICE has only a tiny fraction of the development budget. One reviewer noted the project has some relevance if hydrogen should go anywhere while another reviewer said yes, if you have a hydrogen source that is not derived from petroleum. Comments from another reviewer mentioned H2ICE fills niche prior to widespread roll out of fuel cell technology. This dovetails well with the other H2ICE project (Kaiser). Another reviewer stated it has potential for high efficiency. No carbon combustion is involved. Observations by another reviewer commented it is their opinion that hydrogen research with regard to internal combustion engines will not lead to the DOE objective of petroleum displacement. There are currently too many barriers (production, storage, distribution, etc). This program does provide fundamental learning but without line of sight to hydrogen based transportation system; this reviewer doesn't see this work as supporting the 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 stated the project is well-defined and responsive to modifications suggested in previous years. Another reviewer added the approach with one hole injector allows fundamental mixing/timing investigations. One reviewer mentioned the approach is developing diagnostics. Comments from another reviewer noted it seems like they threw together some hardware and found it doesn't work so well. Maybe we should do some CFD analysis first! Maybe we do some cycle simulation analysis to show how we are going to get to 45% efficiency. The reviewer would like to see a good analysis done first. Observations from another reviewer suggested having more detail on whether the project will estimate the emissions vs. goal of T2B5. Is T2B5 still appropriate for ongoing work? Another reviewer stated the approach is sound, involving integrated optical engine work, CFD, and injector design work.

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

A reviewer stated there is very good progress. The incorporation of EGR and water injection is promising technologies. The efficiency improvements shown do not corroborate the 45% thermal efficiency claim. One reviewer added there is good work balance of efficiency vs. emissions tradeoff while another reviewer said good progress, but still missing many variables. Another reviewer asked what is the optimized bore/stroke ratio? What analysis

supports this and how much gain is there? If we were going to do EGR, we should have modeled the effect and then designed a system and ran it. Comments from another reviewer mentioned the work seems like it could progress faster. Did they have to spend time investigating injection angle values where they know the engine would run poorly? Also, some perspective needs to be given to the program. What is the target efficiency for the program? How do they know whether they are doing good or bad? Would not any conclusions for NOx reduction have to be made at constant thermal efficiency? How are the test points chosen? E.g., how is the 1000 RPM, 6 bar IMEP point relevant? More focus should be on answering the key question of whether a Hydrogen ICE has a chance as a competitor to the gasoline or diesel ICE.

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

A reviewer stated that collaboration with Sandia, BMW and Ford seems to be at an appropriate level for a project such as this. Another reviewer noted the Sandia collaboration is promising, encouraged to continue. One reviewer added there is a close relation with industrial and research partners while another reviewer commented that continued collaboration with OEM is valuable. Comments from another reviewer mentioned some collaboration with Ford and BMW in the future. Will there be any collaboration with anyone else? This seems like a project for Ford. Another reviewer stated the collaboration is adequate.

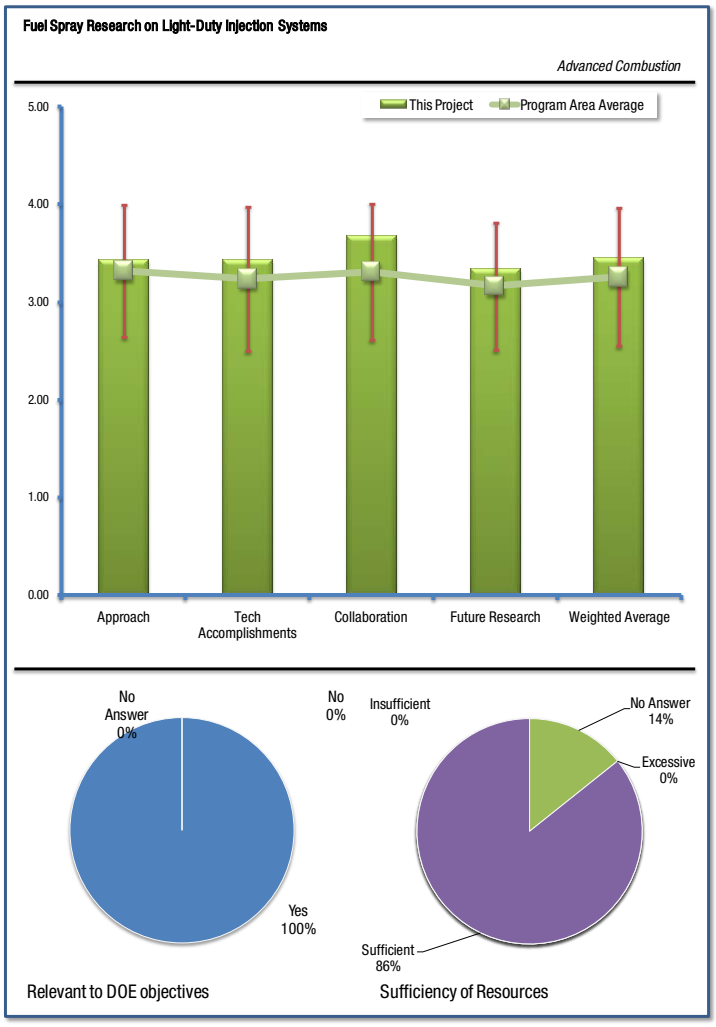
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the use of next generation piezo injectors and EGR are a good addition to this project. Another reviewer commented there is a logical continuation of the program. One reviewer added the project is showing EGR is needed. But is it a really a mixing problem. The reviewers understanding is that hydrogen can burn lean enough to not create NOx. Comments from another reviewer noted an assessment of the engine's efficiency and engine-out NOx at a couple of common points should be made relative to a relevant gasoline or diesel engine benchmark.

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

A reviewer stated that compared to fuel cell research, H2ICE is nearer term and with similar costs to gasoline conventional engines. With additional funding, H2ICE may further improve such injector challenges and overall efficiency.

Fuel Spray Research on Light-Duty Injection Systems: Christopher Powell (Argonne National Laboratory (ANL))



Reviewer Sample Size

This project had a total of 7 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the quantitative measurement and diagnosis of sprays is an important task that has widespread relevance to SI and CI combustion using a wide range of fuels. Argonne has a unique capability in this respect. Another reviewer mentioned additional spray measurement technique lends to knowledge base. Mixing and atomization of diesel sprays have been shown to be the key to efficiency and emissions behavior. Spray modeling advances are needed. One reviewer added the focus on making low temperature combustion is more practical while another reviewer said all DI engines are dependent in injector spray; this needs solid understanding. Comments from another reviewer noted this can lead us to a better understanding of how to make better fuel injectors which will lead to better engines. Observations from another reviewer commented the project provides basic understanding of fuel spray behavior. This understanding should help improve models of sprays and the design 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?

A reviewer stated there is good focus on experimental studies of sprays. These studies are of great interest to the modelers and this is a unique capability that deserves to be supported. One reviewer noted impressive results of injector needle and spray behavior while another reviewer added the approach of using x-rays to study the spray seems reasonable. Another reviewer commented nice use of very special equipment for a practical set of experiments. There isn't any other way to see this stuff. Comments from another reviewer mentioned a good technical approach to measure needle motion and fuel sprays and it has yielded good results. Observations from another reviewer said X-ray imaging to produce time based resolution is unique to this project. Project needs to continue to tie research to engine performance (or performance deficiencies). Another reviewer stated X-ray imaging is a unique diagnostic that most conventional diagnostics cannot match. It provides a true nature of dense sprays.

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

A reviewer stated there has been good progress over the years, with a good plan laid out. Another reviewer asked what is the significance of a wider spray from the 3 hole nozzle versus the 5 hole nozzle in engine operation? One reviewer mentioned there are very interesting results showing irregular, nonsymmetrical oscillatory motions of actual needles. There is also good work in linking that to observed spray patterns. Comments from another reviewer noted

this is some of the best visualizations of needle motion and fuel spray visualization they have seen. Another reviewer added the following: Effect of L/D, 3-d distribution and needle lift visualization.

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

A reviewer stated there is good collaboration - these are very important studies for calibrating spray dynamics for high resolution CFD work. Another reviewer noted it's good to collaborate with Bosch and Delphi. One reviewer added some collaboration mentioned with ERC and Sandia. The PI also mentioned getting injectors and nozzles from Bosch and Delphi - not clear if these are collaborations or just donation of equipment from those companies. Comments from one reviewer mentioned there is close work with industry and other researchers while another reviewer said its good tie in to fuel manufacturers who can benefit from this. Another reviewer stated to continue collaborations with injector suppliers and combustion research to isolate important injector design factors.

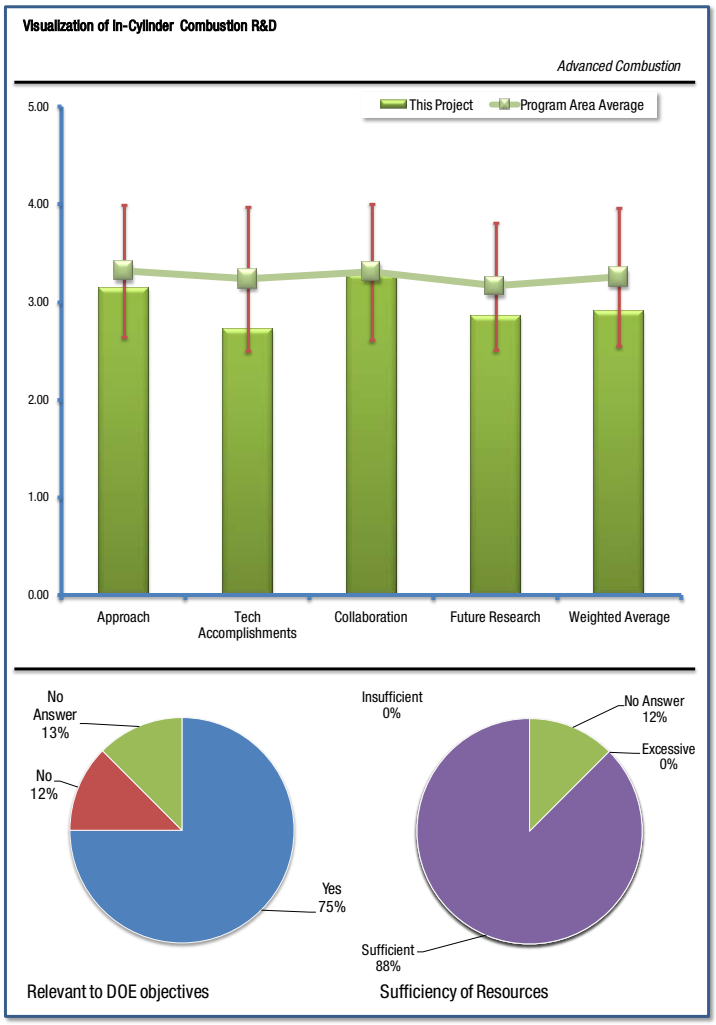
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated there are realistic plans for future work. Another reviewer commented strengthening ties to engine experiments should occur as a high priority. One reviewer mentioned the plans seem to support and built on recent progress. New dedicated experimental station should enable even faster progress.

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

A reviewer stated this is a good use of funds allowed. Cost sharing (effectively) from BES, this is encouraging to see. Another reviewer added it was nice to hear that greater facility access has been arranged. How will increased time be used most effectively? One reviewer noted there was no indication that resources are insufficient or excessive.

Visualization of In-Cylinder Combustion R&D: Steve Ciatti (Argonne National Laboratory (ANL))



Reviewer Sample Size

This project had a total of 8 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the in-cylinder visualization in LTC is an important adjunct to the spray visualization studies and modeling studies. Another reviewer added that low temp combustion offers fuel economy and emissions benefits. One reviewer mentioned that HCCI combustion is relevant. Comments from another reviewer asked this improves fuel economy how? The project is still using petroleum fuels. Lower CR leads to lower economy. Observations from another reviewer noted this project is relevant - it should help establish high load operating limits on LTC combustion based on critical fuel properties (cetane number and volatility). The current state of the project is in the experimental set-up phase and future results will be relevant. This is a good project. Another reviewer stated this project aims to add understanding to control of 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?

A reviewer stated the project is very responsive to previous comments and reviewer input. Another reviewer commented nice engine controller layout. Realistic constraints on combustion NVH should be incorporated into plans. Expand more on endoscopic plans. One reviewer added they don't see that much new. The endoscope is quite limited compared to optical engines so they would not expect new observations. It may be useful for investigations where optical engines are not available. Comments from another reviewer mentioned it appears to be just a large mapping exercise to see if we can calibrate an engine to run in this BMEP range by giving ourselves a lot of knobs to turn to try and optimize stratification. Be clearer on how the endoscope will give information that will feed back into the engine operation. Observations from another reviewer noted this project is at the state of commissioning the experimental set-up and the proposed approach is excellent covering wide ignition range fuels with various volatility ranges. Another reviewer stated the approach is good. However, can an endoscope provide enough information to aid in understanding the LTC combustion process well enough to better control it? One other reviewer said the mechanism to control LTC is an area that still needs fundamental research. Looking at low cetane/low octane "crossover" type fuel is an interesting concept to study. Not sure if power density in the 5 to 10 bar BMEP is attainable.

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

A reviewer stated there is good progress in getting engine and engine control up and running. Now there is a good open avenue ahead for future progress. Two reviewers agreed the project is still just starting, with one adding that substantial findings are expected during 2009. One reviewer noted the project is doing an excellent job of putting an engine test together and getting all the hardware and test equipment to come together. The reviewer is not sure what

the efficiency goals are? What does the CFD prediction say about the lower compression ratios? Comments from another reviewer added this appears to be a relatively new project and the experimental set-up should be commissioned very soon. Accomplishments and results are not available yet. Observations from another reviewer mentioned faster progress will have to be made in the next period if significant contributions are going to be made before the project ends in 2010. Another reviewer stated progress on setting up test engine appears to be significant. Progress appears to have been dependent on getting a new post doc student on site.

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

Two reviewers stated there is a good collaboration with OEMs, injection system suppliers, universities, fuels providers and National Labs. Another reviewer added the project should continue ERC communication. One reviewer commented the project seems to be plugged in to other activities. Comments from another reviewer noted if they can use measurements to calibrate some CFD models and then use the models to improve the engine, then they have something. Observations from another reviewer mentioned the collaboration seem adequate among the partners. Another reviewer stated the use of low cetane/high volatility FACE diesel fuels will be possible.

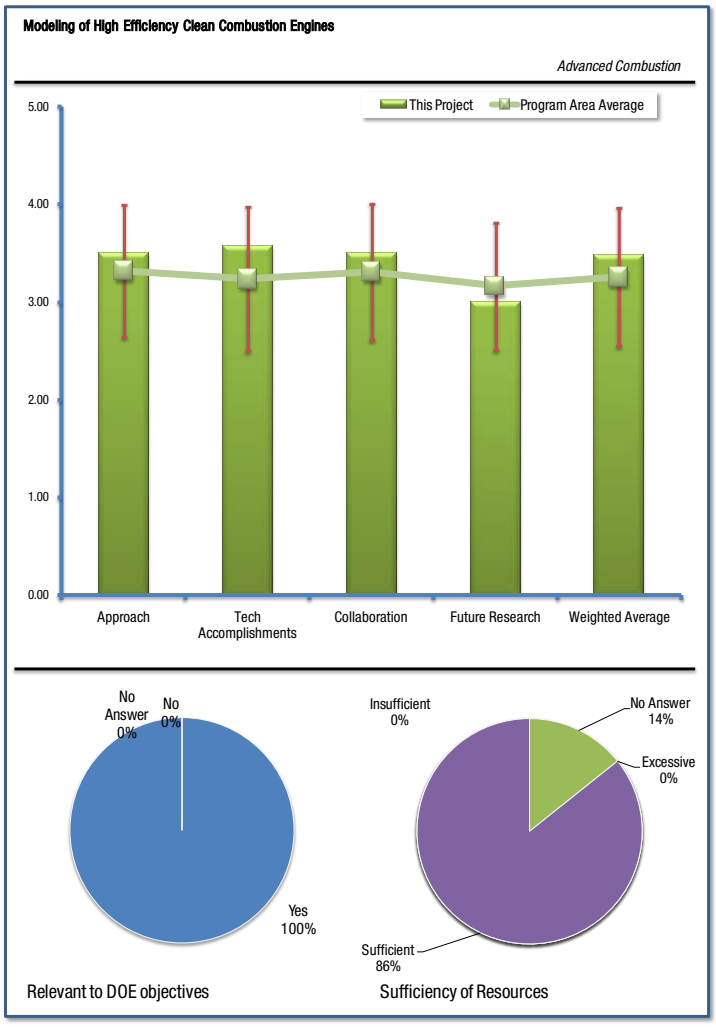
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the future path seems well thought-out, even if the plans for the future seem somewhat 'spur of the moment'. They expect good things from this project - if only because it is a truly one-of-a-kind project. Another reviewer noted they don't expect much of anything new from this. The approach seems fuzzy and undefined, more of "let's go see what we see". The reviewer thinks the endoscope will turn out to be quite limited. One reviewer mentioned the experimental set-up will be commissioned soon and the proposed research plan is good for now and will be expanded in the future based on output during the next fiscal year. Comments from another reviewer added there is one problem with this project is that it overlaps with similar projects at Sandia, Oakridge, U. of Michigan Consortium and perhaps others. It has also started fairly recently (last year). The reviewer doesn't clearly know how this project is going to be distinct from these others. What is it going to contribute to the control of LTC combustion that the others are not already doing so? Also, this project should pay close attention to what has already been done at these other institutions so unnecessary duplication does not take place. Observations from one reviewer commented that research into a low cost fuel that may simply be a heavy straight run naphtha off a crude unit would be of interest to the oil industry.

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

A reviewer stated the work seems to match the budget. Another reviewer added there should be a large enough budget to execute this effort assuming the PI doesn't run into any more major hardware issues.

Modeling of High Efficiency Clean Combustion Engines: Salvador Aceves (Lawrence Livermore National Laboratory (LLNL))



Reviewer Sample Size

This project had a total of 7 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the development of computational tools for future engines and new combustion regimes is an important area for DOE's involvement. One reviewer noted there are clean, efficient engine analysis tools while another reviewer said the numerical modeling work should enable the design or cleaner, more efficient engines. Comments from another reviewer mentioned this project should provide a possible simplified combustion analysis tool for engine researchers working on direct injection, near homogeneous combustion strategies for both gasoline and diesel engines. Another reviewer commented this project provides the modeling support necessary for the all the experiments being conducted in the other labs. Modeling such as this is the vehicle that retains the integrated learning and intelligence.

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 stated it's a good, broad-fronted approach to collaboration in engine modeling is a worthy area for DOE to sponsor. Another reviewer mentioned the approach of finding ways to significantly reduce computational time is very valuable. One reviewer commented improving accuracy at higher intake pressures supports downsizing boosting approaches. Comments from another reviewer noted this project has been predominately focused on developing simulation tools for HCCI type combustion mode researchers. The only concern with this approach is lack of experimental validation. The reviewer realizes the major objective is model development, but validation will be critical if such tools are to be useful for engine OEMs. Observations from another reviewer added CHEMKIN; come up with a faster algorithm to generate and solve the Jacobian.

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

A reviewer stated a wide range of tools under development for computational modeling - the 'democratization' of high fidelity engine modeling is useful for most researchers. Another reviewer commented there has been excellent progress in reducing computation time by 1-2+ orders of magnitude. Also very good success in applying the models to the unstable combustion results obtained at ORNL as EGR was increased. The project also made improvements to kinetics model for combustion of a surrogate fuel and to the KIVA models. One reviewer noted reducing computational time to enable detailed multi-zone kinetics on a desktop is a significant accomplishment. Modeling of the transition will be very helpful in developing LTC control systems and calibration. Comments from another reviewer noted this project has continued to improve upon the required computational time for solving the governing

equations associated with multi-zone, homogeneous type combustion. Excellent work reducing the computational requirements down to a PC level processor. Observations from another reviewer added the accomplishments successfully modeled ORNL data on transition between SI and HCCI combustion modes along with the Sandia HCCI engine (Steeper). Another reviewer asked what are the accomplishments and progress toward optimizing kinetic simulations of HCCI operation?

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

A reviewer stated there are a wide range of collaborations with universities, OEMs, and others. Another reviewer noted very good extent of collaborations with researchers at other national labs and universities. There are fewer collaborations (one) with industrial companies. One reviewer commented to continue interaction with ORNL engine research. Comments from another reviewer added there is a great collaboration with other labs and various Universities. It would be useful if industry was involved in order to help validate the developed models versus taking on this process after the fact.

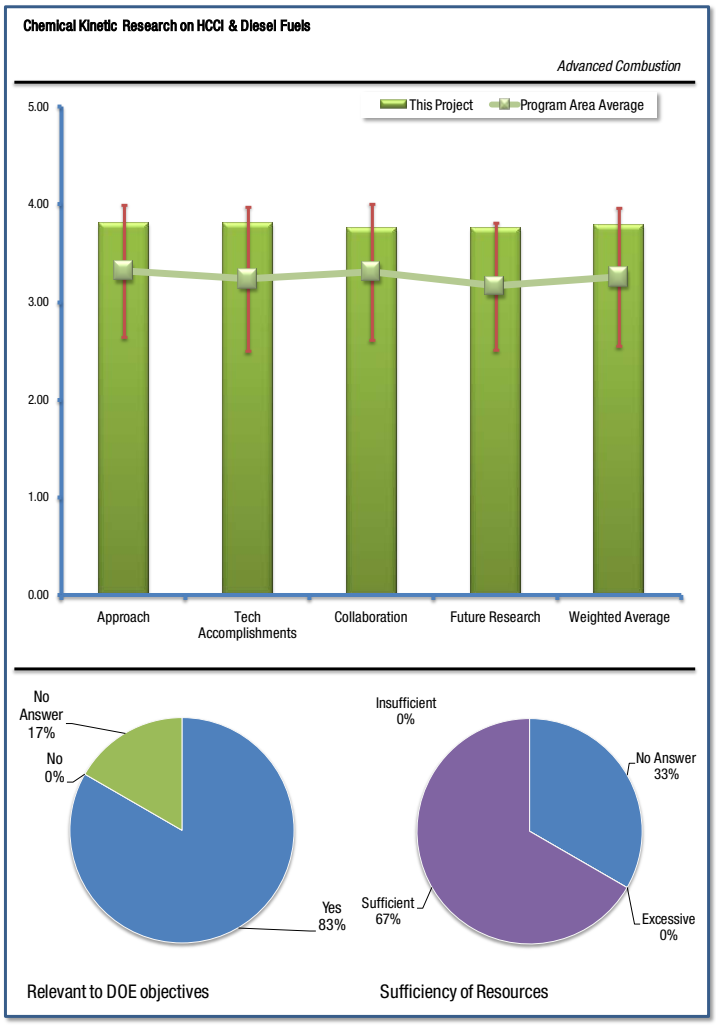
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the future plans look somewhat thin and sketchy but appropriate under the circumstances, they suppose, noting that the idea behind this work is to be responsive to outside users. Another reviewer added the goal of enabling CHEMKIN and KIVA type models on PC's instead of supercomputers is a very desirable one. One reviewer noted the future research needs more detail. Comments from another reviewer mentioned overall, commercialization of the various codes is great. It would be nice to see more validation with industry and an associated iterative process to improve/modify each combustion system model. It wasn't clear if this project will be engaged in such an iterative process in the near future.

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

A reviewer stated this project has a fairly lavish budget by present-day funding standards. Another reviewer commented this project seems to have a very good funding profile - it is difficult to assess if funding is excessive without studying the cost breakdown, i.e. labor, subcontracts, etc.

Chemical Kinetic Research on HCCI & Diesel Fuels: William Pitz (Lawrence Livermore National Laboratory (LLNL))



Reviewer Sample Size

This project had a total of 6 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the development of chemical kinetic models (both fully comprehensive and reduced order models) is very important to extend the use and reach of computational engine models that include chemical reaction modeling. Another reviewer noted there is a strong relevance especially for HCCI/PCCI work. One reviewer added this project is the same as the previous presentation. Comments from another reviewer mentioned this project improves our basic understanding of fuels.

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 stated this looks like a systematic approach to model the major components (or surrogates thereof) of diesel and gasoline fuel. Another reviewer added this is the right approach to extending and improving combustion models. One reviewer commented the PI has a good plan and have laid out a nice order of fuels to model. Comments from another reviewer noted that looking at a wide variety of fuels that have the potential of displacing petroleum based fuels. This project is developing models for each of these.

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

A reviewer stated there were a wide range of technical accomplishments on this project, which broadens the reach of this type of modeling. Another reviewer mentioned nice progress on molecules of interest. One reviewer noted we now finally have models for typical automotive fuels. Comments from another reviewer added that work on surrogates for diesel fuel is a significant accomplishment. This is a good start on biodiesel.

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

A reviewer stated there is a good collaboration and coordination with users and experimentalists. This is to be commended. Another reviewer noted there is a good model of government sponsored research supporting academic and industrial needs.

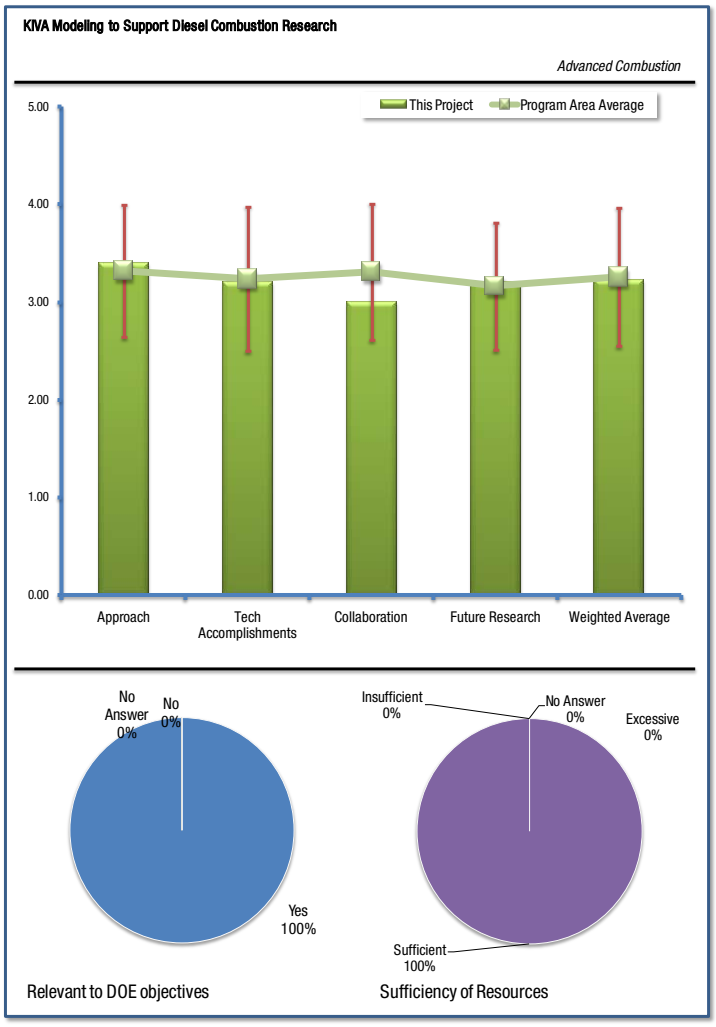
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the future plans seem systematic in establishing priorities for studying the next set of fuel components. Is there not more interest in creating reduced order kinetic models amongst the end-users? Another reviewer commented to keep closing the loop holes.

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

None of the reviewers commented on this question.

KIVA Modeling to Support Diesel Combustion Research: David Carrington (Los Alamos National Laboratory (LANL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that KIVA has become an industry standard, and so needs to be maintained and updated. Another reviewer noted that good modeling is the key to improving engine efficiency. One reviewer commented the project supports the objective indirectly by enabling improved understanding of combustion. Comments from another reviewer mentioned this project is relevant at some level - it is aimed at developing KIVA-IV for use in modeling IC engines. It is unclear at this point what level of anticipated improvement in engine design is possible in comparison to KIVA-III. Observations from another reviewer added KIVA has been the primary model that industry and others have used. A continuous improvement of all aspects of the model must continue to keep up with the latest needs of modelers, improvements in numerical algorithms and computer speed and memory, and changes in the needs and direction of the end users.

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 stated the selection of problems to choose to investigate seems confusing (heat transfer in solids?). Another reviewer commented it is clear what the plans are to improve KIVA and goes well with engine research. One reviewer mentioned that cut cell meshing technology is a very important technology for IC engine simulations. A commercial code called Converge already has such capabilities. How does this approach compare? Comments from another reviewer added that overall the approach is very good, but it would be nice to include more experimental validation. Perhaps collaboration with UW-ERC or some other engine test/evaluation lab could provide experimental data to assist with such validation. It will be critical that the PIs iterate on improving the thermal boundary layer equations and wall-film modeling solution resolution if this tool will more accurately assess heat transfer in comparison to KIVA-III. Observations from one reviewer added there was a good understanding of the needs of KIVA users is evident.

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

A reviewer stated it's not clear what transient 1D thermal conduction in a slab has to do with KIVA, or any other in-cylinder engine modeling. Heat transfer at the wall or to the wall is obviously important, but don't engine model developers have better things to do with their time and efforts? Another reviewer noted the cut cell and the h-p methods will be great improvements. One reviewer commented there is fair progress in modifying KIVA-III to accommodate the new grid generation approach and also other sub models such as wall film and boundary layer

thickness. Much work still needs to be done to validate these sub models; the current mesh size is insufficient for predicting both predicting heat transfer and liquid film. Comments from another reviewer added that good progress is being made.

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

A reviewer stated that collaboration exists but why were those particular partners chosen? Another reviewer added that partnering with Iowa State to test model vs. experimentation is good. Continue to pursue experimental validation of model improvements. One reviewer mentioned it seems like UW-ERC or some other lab could collaborate with the PIs to help with validation. To date, validation appears to be minimized. It is unclear at what level Iowa State has validated boundary layer and wall film models, along with any general overall combustion system behavior (combustion characteristics such as heat release, exhaust temp. etc.) validation for a single or multi-cylinder engine. Comments from another reviewer noted that necessary links to other national labs, universities and industrial users are evident.

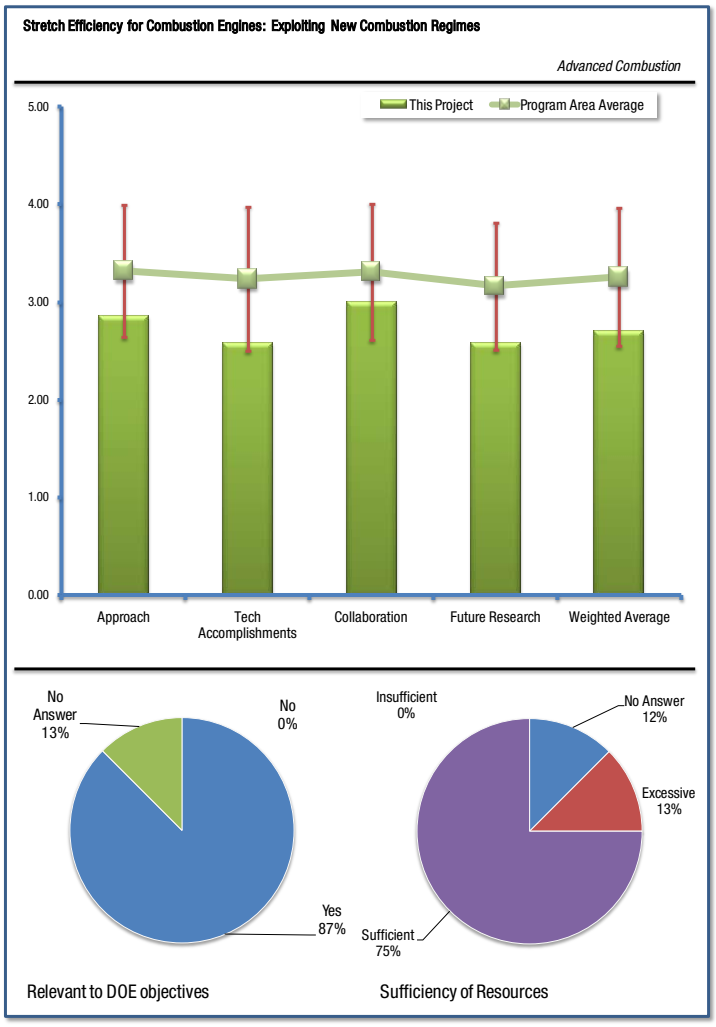
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the future research is not well motivated at all. Another reviewer commented there are good plans for improvements to KIVA. They like the ideas to try and put this into the hands of combustion and development engineers. This is where the potential for this code can really show.
One reviewer added the future work doesn't include enough engine level validation. The PI should really pursue sources that can provide engine measurements for validation.

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

A reviewer stated this project is well funded to support these modeling/software development activities.

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



Reviewer Sample Size

This project had a total of 8 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this is a highly speculative area of research that is worth pursuing. Another reviewer added the project is understanding and potentially reducing combustion irreversibilities: more research is required. One reviewer commented the project works on the basics of energy use efficiency. Can we reduce large irreversibility losses? Comments from another reviewer mentioned the program is looking to identify fundamentally new combustion concepts to improve thermal efficiency. There is a clear alignment with DOE goals. Observations from one reviewer added the project improved efficiencies while another reviewer said the fundamental understanding of limits to fuel economy improvement is the key to long term progress. One other reviewer stated that stretching the range of HECC and HCCI engines to achieve maximum energy efficiency is a key enabler to reducing fuel consumption and thus oil demand.

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 stated the approach is ad-hoc. By this time a more detailed fundamental paper study should have uncovered some promising theoretical approaches to the use of thermochemical recuperation, or just thermal recuperation. We need to move beyond a naive discussion of energy, availability and energy losses - these concepts we know, in the intellectual sense, but how do they apply to real engine design? This is the part that is not clear. Another reviewer commented the efforts towards constant volume combustion are applauded. One reviewer added the modeling and lab experiments seem very appropriate while another reviewer said a relatively simple experiment is the key to testing theory. Comments from another reviewer asked, what led to the 50% reduction in combustion loss goal? Do you have some sort of modeling work that identifies this as achievable? How do you model combustion irreversibility? Observations from one reviewer noted the approach would test HC with less branching than iso-octane. Work does appear to strive for a holistic approach to reducing the destruction of available energy. But, the concepts still appear to raise more questions than they do answer. For example, concern from audience regarding charge air heating raised doubt as to how this concept could lead to a net benefit. Another reviewer stated that clarifying theoretical thermodynamic ICE efficiency limits is a difficult task. Reducing the combustion irreversibility losses by half appear to be a stretch goal and may be difficult to prove.

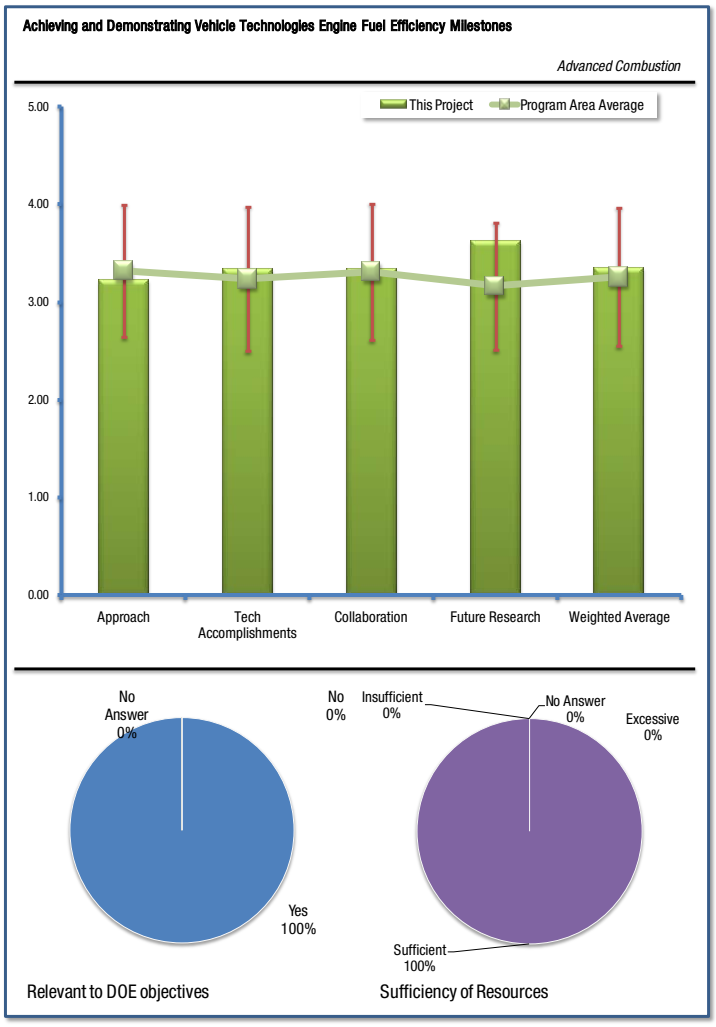
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated the progress is slow - perhaps a reflection of the budget and the changes in scope in previous years. Another reviewer mentioned the building hardware - they look forward to the test results. One reviewer commented the accomplishments showed no real combustion modeling. It showed some pressure curves from the constant volume device, but the reviewer wasn't sure what the results on combustion efficiency were. Comments from another reviewer noted there was good progress in the experimental set up. Observations from one reviewer added the accomplishments are unclear at this point. Would prefer to see a fundamental architecture that is trying to be worked and identifying what are the critical accomplishments that would have to occur on the component level to reach system level success. For example, presenter cited that the combustion of syngas resulted in less destruction of chemical availability. However, the production of syngas and the availability destruction may challenge this approach. Another reviewer stated the progress appears to be slow, but if the RAPTR experiment was easy to do, it would have been done recently. Having to change reactor design mid-way through experiment is unfortunate.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated a collaboration with un-named 'not for profit institutions' does not inspire great confidence. Why are they insisting on being un-named? Another reviewer noted that having additional catalysts and/or partners may accelerate the progress. One reviewer mentioned the involvement of several industrial concerns.

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 stated the future seems murky. Also a casual observer is left with the impression that work just seems to be done immediately prior to the annual review. Another reviewer commented the potential applications of the learning are rather fuzzy; perhaps this is inevitable since you don't know what you will learn until you learn it. One reviewer added they don't see a path toward a useful engine here. They expected to see a modeling effort or calculations that predict what we are going to do. Comments from another reviewer mentioned the key will be relating experimental results to engine design. Observations from one reviewer noted that steam reforming of wet ethanol, to save on LCA energy costs since it doesn't have to be dried for fuel use, is an interesting concept. Would there be an issue with water causing corrosion in the combustion chamber during cold start?

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated this project just seems to limp along with minimal funding and effort. Another reviewer added they have no vision at all where this is going.

Achieving and Demonstrating Vehicle Technologies Engine Fuel Efficiency Milestones: Robert Wagner (Oak Ridge National Laboratory (ORNL))



Reviewer Sample Size

This project had a total of 9 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that reduction of light-duty engine fuel consumption through waste heat recovery and systems integration is a useful endeavor. Another reviewer noted that while peak efficiency engine operating region can be far from drive cycle regions, it is still important to track engine progress. One reviewer commented this project supports better fuel economy while another reviewer said this is the only project devoted demonstrating DOE Vehicle Technologies efficiency & emissions objectives of 45% peak BTE. Comments from another reviewer mentioned yes, this project focuses on incremental improvements in peak engine thermal efficiency and part-load efficiency at a key operating point, and also appears will include this year and next year any engine generated maps for projecting vehicle miles per gallon improvements based on assumed vehicle characteristics. Observations from one reviewer added that making use of heat losses is the key to improving efficiency. This project would have a much bigger impact if applied to LD gasoline. Another reviewer stated this may be the only program that demonstrates engine efficiency improvements and system level efficiency gains. This is because practical engine and after treatment hardware are being used. Emissions compliance is assured while the efficiency gains are demonstrated. The numbers generated by this work is the metric used to gage progress of much of the DOE work on advanced combustion concepts. One other reviewer commented that waste heat recovery systems, although demonstrated and promising, still are lacking fundamental knowledge in how to implement for various load cycles and transient operation. Until that occurs, these devices will not be embraced fully by OEMs. As such, they believe supporting this effort is a very wise choice and has a clear alignment with DOE goals.

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

A reviewer stated the integration of waste heat recovery in the form of an ORC is a useful approach. The use of thermal 'capacitance' or storage would seem to be an important part of a system like this. The availability of waste heat-derived energy is typically not well matched to high power requirements due to thermal lags. Another reviewer commented this is a good study of where the energy is going and where gains can be found. One reviewer mentioned the project may have reached the point of diminishing returns (from a value standpoint). It is more important than ever that the systems implications of turbo compounding or Rankine cycles are evaluated for their overall benefits. Comments from another reviewer noted this is a very good real world systematic approach toward exploring incremental gains in engine peak thermal efficiency by taking advantage of possible electrification accessory gains,

exhaust energy recovery gains, friction gains, and fuel property gains. This project has a very good integrated engine system approach. Observations from one reviewer added the use of relatively simple concepts is a good first step while another reviewer said improving peak load efficiency is the key for hybrid applications. Another reviewer stated that the focus is on identify and demonstrating promising technologies for efficiency improvement, with minimal development. This focus on proof of principle is appropriate, divided between engine, after treatment, loss recovery and controls. Biggest potential gain is in recovery exhaust waste heat and coolant waste heat recovery, and more effort is beginning to be expended in this area. One reviewer commented that there is a lot of work ongoing. Turbo compounding concept is an interesting idea and further investigation seems warranted.

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

A reviewer stated the progress seems lower than anticipated given the budget and funding history while another reviewer said there is nice availability scoping for BTE opportunities. One reviewer added there is good progress so far. The challenging part is now ahead. They like the approaches with turbo compounding and the Rankine cycle. Another reviewer noted they think a look at a smaller engine combined with a hybrid system, would change some of the technical approaches. They also think an analysis of which path would give better overall efficiency would be worth the effort. Comments from another reviewer mentioned it's good to see vehicle level models being developed and used. This project could end up spending a lot of time on the details of the Rankine cycle and turbo compounding component design for best efficiency on test engine. Observations from one reviewer commented this project is addressing a real world perspective on recovery energy from the engine system. The information produced from this project including limits of exhaust and EGR energy recovery, friction gains, and coolant pump gains is valuable as benchmark information. One reviewer said they recommend application of heat recovery techniques to light-duty gasoline since potential for recovery is larger. Another reviewer stated that demonstration of peak thermal efficiency is on target. Work on reducing emissions at the part load point with minimal efficiency loss is progressing well. Individual component efficiency contributions to the overall efficiency gain have been quantified. Models of hardware used for exhaust waste heat recovery systems have been built. This step is very important to understand the system-level efficiency potential of waste heat recovery concepts.

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

A reviewer asked how was the collaborating suppliers chosen, or are they merely whoever came along and showed interest in this project? Are they collaborators or paid suppliers? Another reviewer mentioned try to formally align with key supplier to develop energy recovery devices. One reviewer commented there is a good working relationship with GM while another reviewer said they are making good use of components from other groups. Comments from another reviewer added the PI has made the critical collaborative links with the engine OEM and Cummins Inc. for exploring Rankine Cycle WER; this project appears to be well integrated with other DOE programs. Observations from one reviewer noted appropriate consulting with Cummins on the organic Rankine cycle and with Woodward on turbo compounding is occurring. Also regular consultation occurs with industry OEMs, DOE working groups and the ACEC tech team. Another reviewer stated the program appears to be doing a good job of sharing information informally rather than through structured collaborations.

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?

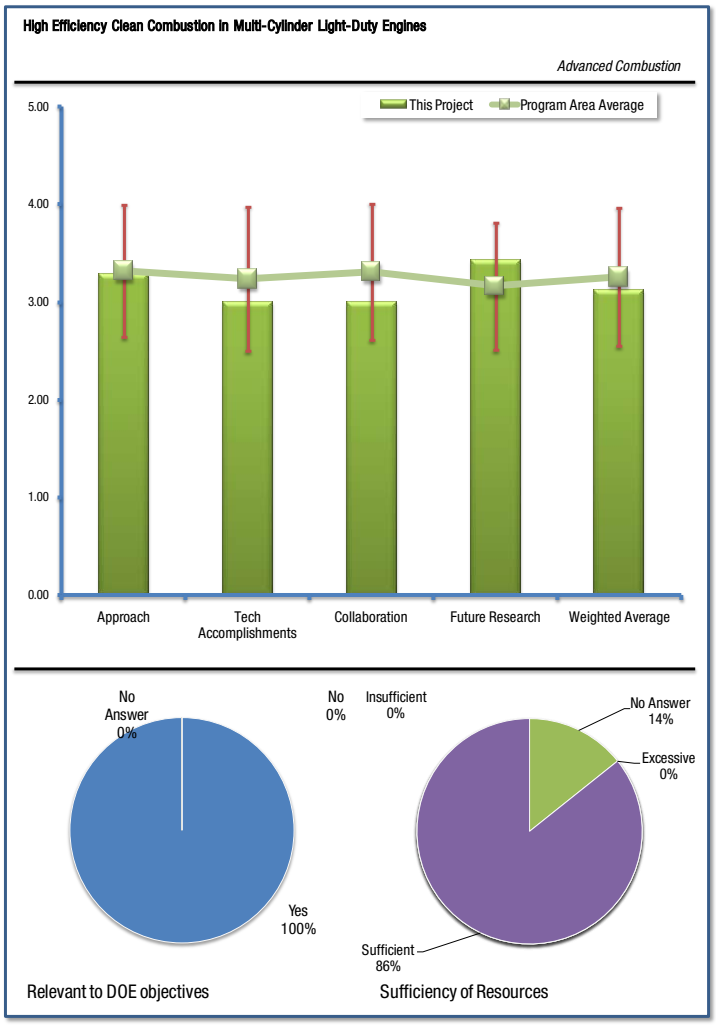
A reviewer stated the future efficiency plans look good. What sort of an efficiency gain can be made through running the engine at a more efficient operating point rather than increasing the complexity of the engine? What about hybridization (either series or parallel) of a lower efficiency engine rather than a massive increase in engine complexity? Another reviewer added they recommend detailed study around EGR with various boost devices. Low vs. mid vs. high pressure EGR can affect matching and efficiencies greatly. An effort to repeat key operating points/configurations, or present data if it exists would be beneficial as the project looks for small efficiency deltas over time. One reviewer noted excellent integrated engine system and vehicle level path forward toward addressing

potential fuel economy gains. The reviewer is looking forward to hearing the results next year. Comments from another reviewer mentioned the work needs to be completed on incorporating the organic Rankine cycle concept, and start developing the turbo compounding concept. It is critical that every effort is expended to arrive at the practical potential of these waste heat recovery concepts without losing focus.

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

A reviewer stated that funding is commensurate with the overall analysis and experimental activities associated with the PI's path forward.

High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines: Robert Wagner (Oak Ridge National Laboratory (ORNL))



Reviewer Sample Size

This project had a total of 7 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that combustion optimization in multi-cylinder light-duty engine operation is an important research area. Another reviewer added this is an investigation if issues are around LTC - many questions, this is addressing useful ideas. One reviewer mentioned that better efficiency means less oil usage while another reviewer said that taking HECC to the systems/multi-cylinder level is important. Comments from another reviewer noted there is some benefit in improving light-duty diesel emissions/efficiency. Much larger improvement possible by improving LD gasoline due to projected future increase in diesel demand (HD+air) vs. gasoline (CAFE, ethanol) in base case.

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 stated the approach seems piece-meal, a bit of this and a bit of that. How much of this work is a poor reproduction of work that is normally done at the OEMs in the course of their own development? Another reviewer mentioned the approach is generally good. In some respects it seems like you are going after "today's question" as opposed to having a cohesive long-term research plan. Having said all of that, you have an outline of multiple programs that seem well coordinated.

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

A reviewer asked to what extent is this project merely chasing the level of sophistication at the OEMs, and not catching up? This is particularly important for engine control. Too many of the results were 'from some time ago' and a mixture of old and new (MB and GM) engine results. One reviewer stated to note very clear how this differs from other ORNL Doe projects using 1.9 L GM diesel while another reviewer said a lot of high quality data is being generated. Another reviewer noted they would like to see a clearer picture of what you call PCCI and how does this compare to what SNL is doing for HCCI and stratified HCCI. They would hope that SNL would have something to contribute here. Good to see some KIVA modeling. Comments from another reviewer mentioned they were glad to see PSAT analysis. The reviewer would like to see the reduction in after treatment penalty due to the lower engine out emissions. Is the increased HC and CO significant? Observations from one reviewer commented that adding O_2 fraction as a third dimension to the typical map showing thermal effects on emissions is an interesting way to show how high dilution can minimize soot while staying away from the NOx production zone. It would be interesting to see other LTC methodologies on this 3D map.

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

A reviewer stated the collaboration seems to be unfocused and not systematic. Another reviewer commented that aligning with piston or injector vendor may allow further progress. Current roadmap seems to overlap with what was already understood by OEM on production engine. One reviewer mentioned the project is well matched with Tech Team needs and wants, but not a specific hands-on partner(s). Comments from another reviewer noted it would be great if the project could show something incorporated from SNL on HCCI onto the engine and showed a performance benefit from it. Maybe this should be a goal for SNL or UW to convince the PI they have something to benefit the project. The project is trying to meet emissions and improve fuel economy. The reviewer sees the improved fuel economy as a weakness of SNL and UW. Observations from one reviewer added they are looking forward to future comparison of results from the various labs using the GM 1.9L test stand using common fuels. Closer collaboration is encouraged.

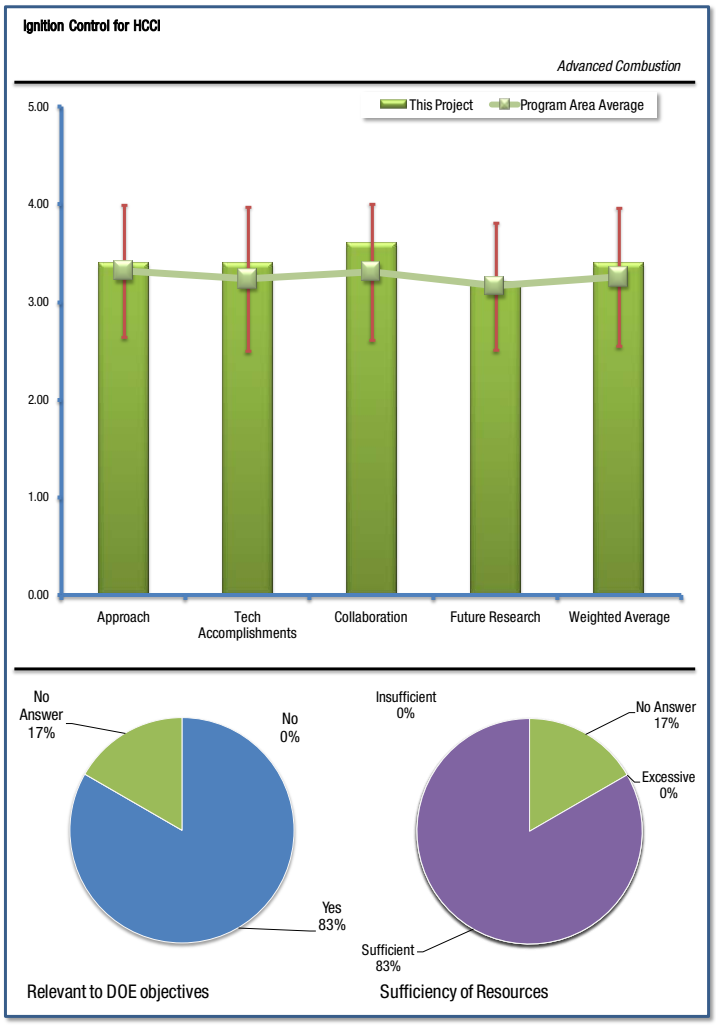
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated there seems to be a everything but the kitchen sink approach - what are the priorities? Is this project any more than just a voyage of discovery for ORNL at the tax-payers' expense? If so, the results should be better presented and packaged. Another reviewer added there are good plans for transient analysis. Suggest investigating interactions with hybrid strategies. One reviewer noted the transient and systems integration issues are excellent next steps while another reviewer said that overall FE improvement vs. conventional combustion unclear. Comments from another reviewer asked can you develop a more cohesive research plan to clarify how this fits with other work, what basic things needs to be understood and what experiments will get there?

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

A reviewer stated there are nice facilities are in place and it is nice to see them used for this work.

Ignition Control for HCCI: Dean Edwards (Oak Ridge National Laboratory (ORNL))



Reviewer Sample Size

This project had a total of 6 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that research into methods of mode transition control for LD HCCI engines is important. Another reviewer added that automotive HCCI address efficiency and emissions areas. One reviewer commented that extending load range of multi-mode operation is directionally correct for maximizing HCCI fuel economy. Also directionally correct for a downsizing and boosting approach. Comments from another reviewer noted the project is improving light-load gasoline 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?

A reviewer stated the approach is sound. Another reviewer commented there is a good understanding of challenges of extending HCCI region (NVH, stability etc). One reviewer added engine control is the key to improving HCCI operating range while another reviewer said spark assist is a niche application, but looks to be critical to expand the operating range of gasoline HCCI operation. Comments from one reviewer noted since there is a danger that the results will be very engine specific, one of the outputs of this research should be a method to develop this on other engines.

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

A reviewer stated that one of the major issues with LD HCCI is the transition into and out of true HCCI mode(s) of combustion. To what extent is GT-Power, which is intrinsically a steady-state tuned engine modeling suite, useful for transient or dynamic operation? Another reviewer noted there is a nice investigation of cylinder cross talk. One reviewer commented that multiple injection/multiple ignition may be a useful path forward to control the HCCI instability issues and smoothing transitions between combustion modes.

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

Two reviewers stated the path to potential commercialization and substantial interaction with Delphi seems sound.

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?

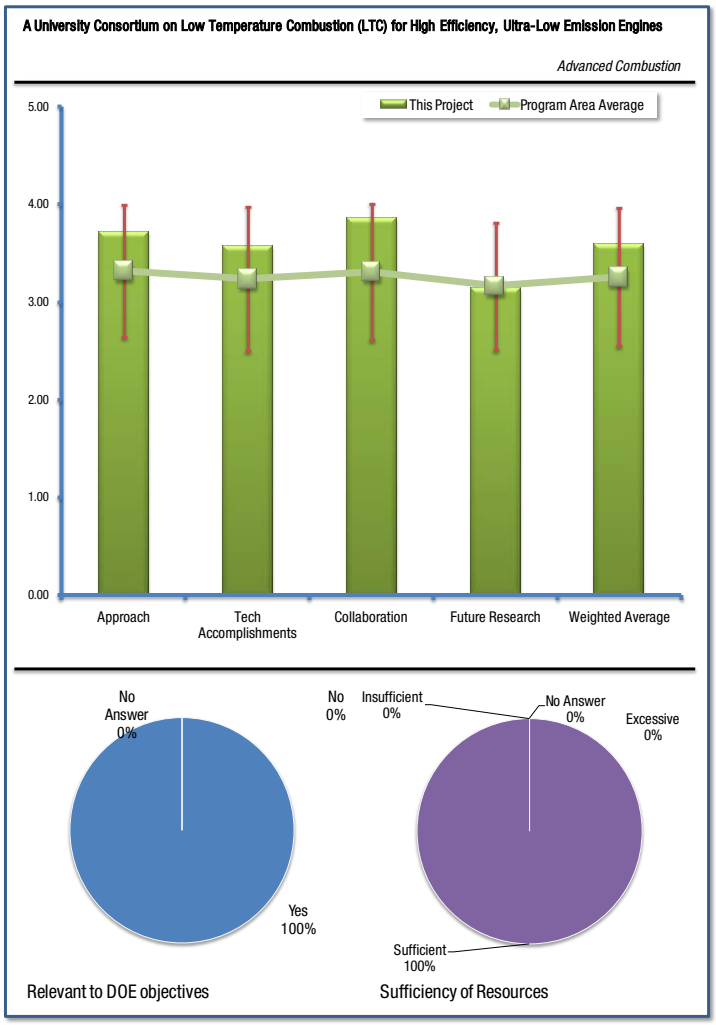
A reviewer stated the use of VVA via the Sturman mechanism is an important improvement in capability that adds an additional level of control input that will be extremely useful in future engine control and operation. Another

reviewer commented the turbo DI may shrink HCCI region in drive cycle. Future investigation of HCCI with GTDI may be useful. One reviewer added the timeline will be challenging to finish phase 3 by end of 2009.

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

A reviewer stated the budget seems suitable for this project. Another reviewer noted HCCI control complexity could easily require far more resources, to fully understand.

A University Consortium on Low Temperature Combustion (LTC) for High Efficiency, Ultra-Low Emission Engines: Dennis Assanis (University of Michigan)



Reviewer Sample Size

This project had a total of 7 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this program is a very comprehensive approach to addressing the relevant issues involved with LTC. Established and renowned researchers in five universities led by the University of Michigan are engaged in understanding the complex issues involved. The breadth and depth of activities is impressive. Another reviewer commented yes, it is a nice engine system effort focused on enabling new more homogeneous combustion schemes at light to medium load conditions with is important for enabling such combustion schemes in future, smaller, and hopefully more efficient automotive engines. One reviewer noted that improved light-duty LTC is an important potential method for fuel consumption reduction while another reviewer said it is Important to increase gasoline HCCI operating region. Comments from another reviewer mentioned the HCCI region extension is the key to the adoption of this technology. Once highly downsized, the useful HCCI region becomes much smaller.

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 stated there is a good multi-front approach to a complex set of problems. Another reviewer noted this is a very good approach aimed at understanding all initial and boundary conditions influencing the load operational range of more homogeneous combustion approaches through modeling, simulation, and experimentation. One reviewer mentioned that load range extension, mixed mode combustion, system level evaluations are all appropriate while another reviewer said there is good focus on fundamentals to overcome barriers. Comments from another reviewer added that each of the elements of the comprehensive program is very appropriate. These include the very important task of extending the high and low load limits of HCCI. This is required to fully realize the potential of HCCI. Wall effects and heat transfer continue to be understood further. Spark assist has been included which will be important for the control of HCCI in practical applications. A comprehensive modeling effort to support and understand the experiments continues.

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

A reviewer stated there is a solid set of accomplishments - difficult to summarize in a forum like this. The publication record speaks for itself, they suppose. Another reviewer commented it was difficult to tell from the presentation how much of the overall project accomplishments were done in the past Fiscal Year. One reviewer noted this project is producing a significant amount of information concerning load limits of homogeneous type combustion mode for light

duty engines. The output research to investment ratio appears to be very high. Comments from another reviewer mentioned that a new area now investigated is the effect of intake boosting. This is an important area considering that industry is moving towards downsized and boosted engines. The current high-load HCCI region has been mapped out; misfire and ringing-index limits have been identified in this region. The low-load limit has also been reduced. In this region the need to lower equivalence ratios to tradeoff reformation and exothermicity has been identified. This reviewer went on to say continue to understand combustion chamber deposits on wall heat transfer. Now spark assisted HCCI has been visualized in an optical engine. This fills a critical gap in the diagnostics to understand spark-assisted HCCI. KIVA and DNS models continue to be developed to understand experiments. Understanding ignition properties of biofuels and blends is beginning which will be important going forward as the industry seeks to use more biofuel. One reviewer added that 8% rebreathing and 11% recompression improvements to HCCI operating range appear reasonable.

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

A reviewer stated there is a good united front. However are 'discussions' with OEMs good enough to qualify as 'collaboration'? Another reviewer asked for spark assisted HCCI, has there been collaboration with Edwards at ORNL? One reviewer added includes multi-university and industry involvement/oversight. Only suggestion is to leverage HCCI work underway at UW-ERC through some type of collaboration. Comments from another reviewer noted the coordination and sharing of information among the university partners and with industry continues to be good via the AEC and MOU. LANL modeling expertise is being exercised appropriately to understand ignition of biofuels.

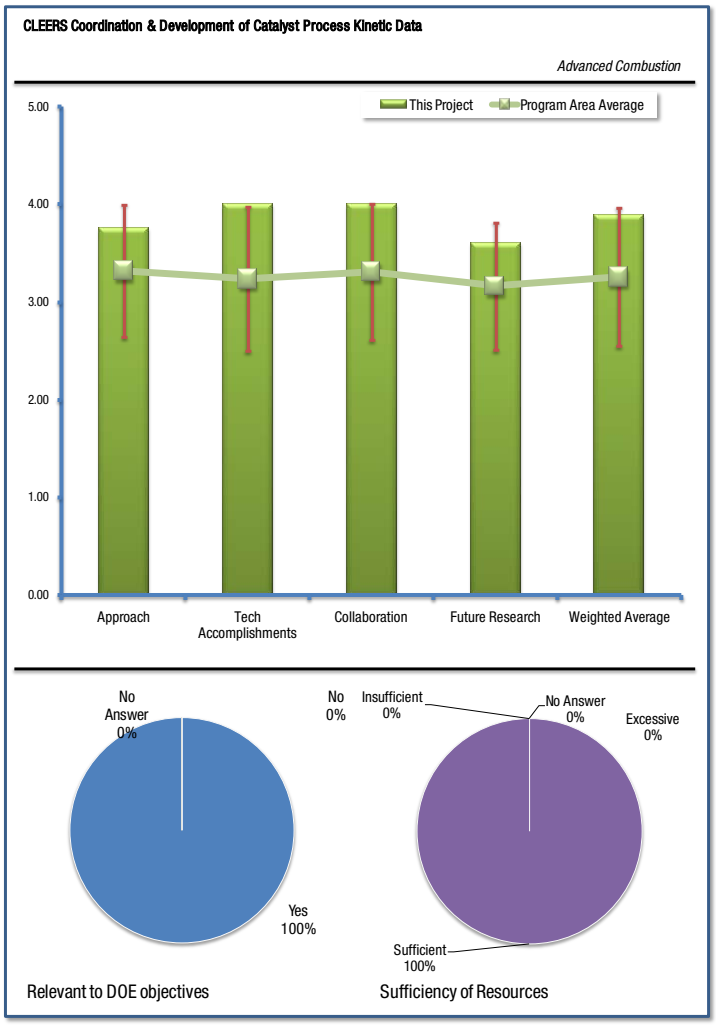
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated as engines are downsized, the LTC operating zones shrink accordingly, and the FTP speed and load regimes move higher up the engine operating envelope. In the limit, does this render LTC operation an unnecessarily complex and difficult combustion regime to use? In other words, can we get the same or similar benefits from hybridization and transmission improvements? Another reviewer noted that overall; the short term direction is good. The presenter mentioned experimental exploration of valve timing for extending homogeneous combustion operating range using a multi-cylinder engine with the Sturman VVT, but didn't include that bullet in the attached presentation material. Does the PI plan to perform such experiments this year? One reviewer mentioned there is very good potential for achieving significant fuel economy gains. Comments from another reviewer added that continuing to push the high load limit of LTC is appropriate. Equivalence ratio stratification and cooled external EGR should be considered to control the combustion process as the intake boost and load is increased. Spark-assisted HCCI should be given more focus, since this may prove to be a necessary control lever for transient control of the combustion process.

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

A reviewer stated it looks like an efficient use of funding. Another reviewer added this project seems to have barely a sufficient amount of funding for covering the multi-university effort. It might be worthwhile increasing the funding by $100k or so.

CLEERS Coordination & Development of Catalyst Process Kinetic Data: Jae-Soon Choi (Oak Ridge National Laboratory (ORNL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated both of the technologies studied here allow the implementation of lean burn systems. Lean burn systems are inherently more fuel efficient as long as the fuel economy penalty for using them is not excessive. The workshops have been extraordinarily successful in that it brings the unique technologists together. These projects are quite well focused for the mission. Another reviewer commented this project is very relevant. CLEERS is incredibly useful in coordinating and communicating in the catalyst community. The catalyst research is also quite useful. One reviewer noted that overall fuel economy benefit relatively small due to small impact of after treatment and small light-duty diesel penetration. Comments from another reviewer mentioned that CLEERS activities overall support the fuel efficiency objectives by enabling development of more capable aftertreatment systems, allowing the engine to be tuned with more emphasis on fuel efficiency. In particular, CLEERS plays two important roles: 1) providing a channel for systematically tracking R&D needs and gaps in the area of after treatment and 2) providing funding for coordinated, targeted experimental and modeling work to address the key gaps.

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 stated these presentations tend to cover a lot of ground. The CLEERS workshop and focus groups deserve a 4. The HC poisoning deserves a 3 because no clear path to model implementation is shown. Specifically should this data be able to be implemented as an inhibition term or will it have to be a full kinetic model? The sulfation of the LNT deserves a 4 as it is addressing some critical needs. The calcium doped work is interesting. The ammonia formation work from LNT's is very interesting, but is not well justified. The reviewer believes that there is a similarity between the ammonia formation mechanism in three-way catalysts and LNT's. They do not see that issue addressed in this work. Another reviewer mentioned CLEERS does a fine job of identifying research needs and accomplishments and communicating these to affected groups. One reviewer commented the approach has improved fundamental understanding of sulfur poisoning. Comments from another reviewer noted the ORNL/FEERC part of the CLEERS work, reported in this specific presentation, appears to be well-planned and employs proper experimental tools to fill in the critical gaps in the LNT and SCR technologies.

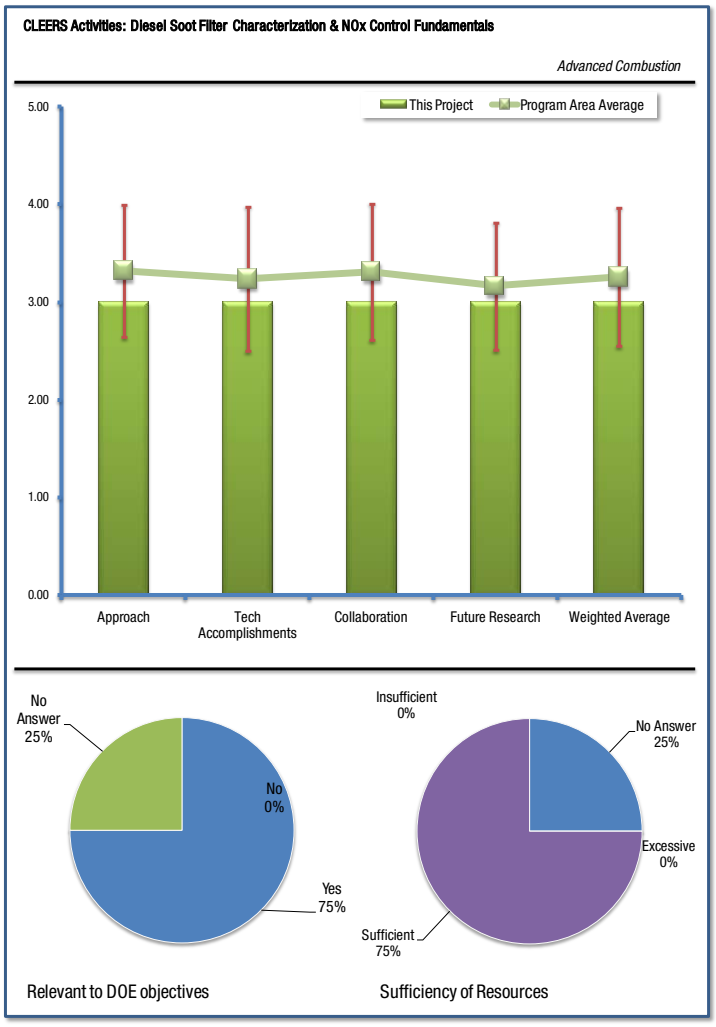
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated all of the projects are technically superior. Another reviewer added nice progress in understanding these complex systems. The use of a commercial catalyst that can be fully analyzed is a key capability. One reviewer noted there is an excellent job coordinating CLEERS projects relating to experimental work and modeling work. Comments from another reviewer mentioned the combination of spatially-resolved catalyst studies, targeted in-situ studies and quantitative performance/poisoning studies allows the ORNL/FEERC team to produce useful, high-impact knowledge.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated the interaction between labs like PNNL and SNL are very good. The communication of results to the industrial partners is excellent. Another reviewer commented that CLEERS is fundamentally a collaborative effort. One reviewer added excellent job collecting input and disseminating the results through CLEERS.

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 stated the CLEERS organization future plans are great. HC poisoning of ammonia SCR is okay. Where and when is it going to be put into a model? LNT sulfur poisoning is on a solid path. There is ammonia production from LNT's. Where are the applications and what is the value? The reviewer believes the value is very high, but they do not see that called out in the work. They would very much like a clearer definition of application and how the research is going to impact that. Another reviewer noted there were nice plans and they were well presented. One reviewer commented the pursued issues are relevant to the practical application of the technology, and at the same time scientifically challenging.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the organization for CLEERS is properly staffed. HC poisoning needs more modeling support. Interaction between SNL and ORNL on LNT modeling is excellent and sufficient. Utilization of analysis equipment for sulfur poisoning for LNT's is exactly where the national labs should be. Is there an overlap between this work, the work at PNNL and the work at the University of Houston?

CLEERS Activities: Diesel Soot Filter Characterization & NOx Control Fundamentals: Darrell Herling (Pacific Northwest National Laboratory (PNNL))



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated both of the projects discussed in this presentation allow the greater market penetration of lean burn engines, specifically diesel. These projects address the emission requirements for implementing these technologies. Another reviewer commented excellent fundamental support of other DOE programs. DOE funding on these types of fundamental studies are critical to long term energy reduction. Very important building blocks to technology development and understanding in a broad range of emissions issues. One reviewer mentioned CLEERS activities overall support the fuel efficiency objectives by enabling development of more capable aftertreatment systems, allowing the engine to be tuned with more emphasis on fuel efficiency. In particular, CLEERS plays two important roles: 1) providing a channel for systematically tracking R&D needs and gaps in the area of after treatment and 2) providing funding for coordinated, targeted experimental and modeling work to address the key gaps.

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 stated SCR measurements and modeling are a good combination. Two major "nits": 1. No detail on the accuracy and completeness of the model; and 2. Which Fe zeolite is in use? Commercial or synthesized separately? They do have an issue with the comparison of the model to the measurements. The temperature measurements for the inlet gas and the brick are not clearly delineated. The concentration predictions will be very dependent on the brick temperature. The front edge concentrating discrepancies are most likely due to a wrong temperature for either the inlet gas or the bed temperature. If the temperature measurements are made using a "slow (thick)' thermocouple, then the temperature measurements are very spread out and do not reflect sharper temperature gradients that may be occurring in the front edge of the monolith. This reviewer went on to ask does this model solve the energy equation or is it simply using the measured temperature profile? If the temperature measurements are using a "slow (thick)" thermocouple, then they are very spread out and inconsistent with the temperature profiles the concentrations are responding to. DPF work has consistently addressed important filtration aspects. DPF studies are difficult and this work provides a clear description of important aspects of the filtration process. Another reviewer noted they sense the team is not completely up-to-date on ammonia nitrate formation or DPF regeneration. TU Milano (Tranconi), Paul Scherer Institute (Kroecher), and Waseda University (Daicho) have investigated this for several years. Try not to duplicate efforts, but you are addressing the modeling gap. On DPF regeneration, new catalyst understanding is

emerging on direct oxidation of soot at the soot-catalyst interface. This will become more important than through NO_2. However, the modeling, again, is missing and a critical building block. Focus on new methods. Use your imagination for breakthroughs. The tomography representation of DPF porosity is an excellent example.

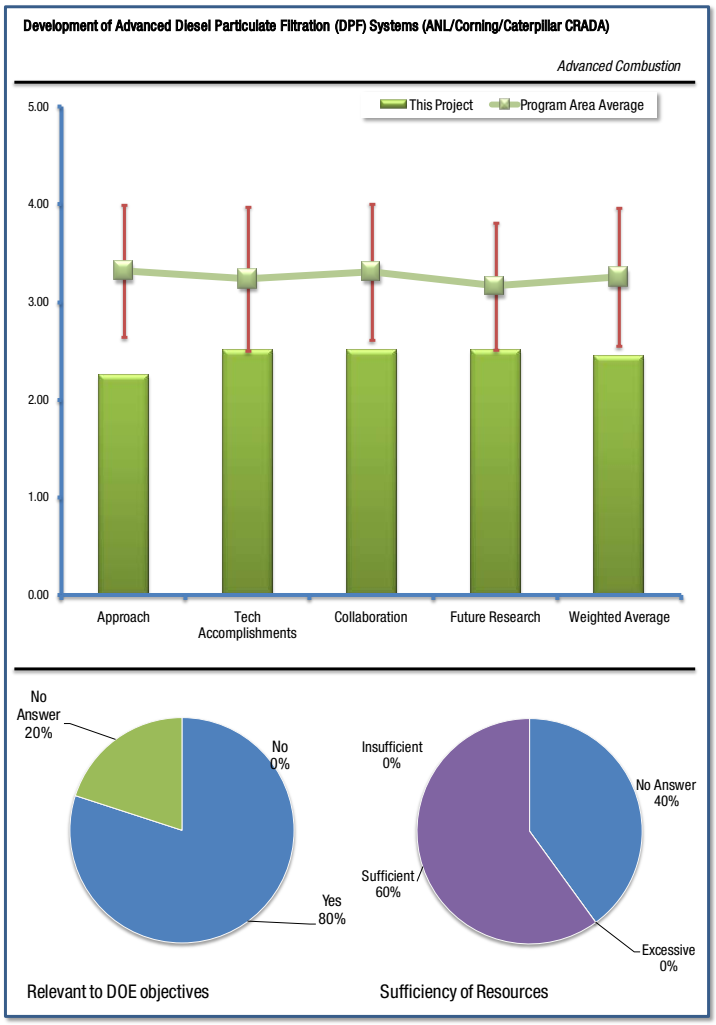
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated SCR modeling and comparison with experiments is good work. It is not necessarily ahead of the industry. There are other papers out there that have done similar work. The presentation does not show the special accomplishments. Another reviewer commented the DPF studies are, they believe, very new work and interesting accomplishments. One reviewer mentioned the models are coming up to speed and hypotheses in place to address gaps.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated there is a decent communication of results. More direct collaboration would be better. Another reviewer added no sense of collaboration in presentation. Seems the project needs to work closer with the experimental groups at ORNL and ANL for model substantiation. The reviewer thinks they might be wrong. One reviewer noted great job collecting input and disseminating results through CLEERS.

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 stated to keep the models flexible as things are changing quickly. You don't want the projects understanding to be obsolete when it is finished. New catalyst families (acidic zirconia, Ce-based soot catalysts) are promising and emerging. Another reviewer noted the future work includes surveys.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated that leveraging the National Lab instrumental resources has always been a major strength of these projects.

Development of Advanced Diesel Particulate Filtration (DPF) Systems (ANL/Corning/Caterpillar CRADA): Kyeong Lee (Argonne National Laboratory (ANL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that DPF is a necessary technology for diesel vehicles. Another reviewer noted that meeting 2010 PM standards is critical to introducing light-duty diesel engines. This project addresses the issues involved with diesel particulate filters. One reviewer commented that a better understanding of DPF operation should enable reduction in its fuel 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?

A reviewer asked, has the work of others been reviewed? What are the innovations here? Another reviewer mentioned this is a good approach but fairly similar to other efforts. One reviewer added experimental observations are made of the soot filtration process. Further experimental analysis of the particulate mass and heat release is conducted. Information is used to form models of the filtration process. Particularly, the ANL Advanced Photon Source is used to X-ray image the soot cake and ash particle structure along the membrane channel. Emphasis is also on back pressure characterization and regeneration characterization to reduce the fuel penalty. Approach is primarily experimental with some modeling support. Comments from another reviewer noted good capabilities and great partners, but the approach is unclear. What specific questions about DPF operation are being addressed? This appears to be a broad, generic survey of various aspects of DPF operation, from soot deposition to soot oxidation, rather than a focused technical effort.

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

A reviewer stated there seems to be a question on the accuracy of the heat of combustion data -- and thus, on the methods used to estimate it. Another reviewer commented that measurements of pressure drop as a function of flow rate and surface area for various membranes have been completed. Cordierite membranes are looking promising. Thermogravimetric experiments to measure soot oxidation rate have been completed. Significant amount of metal components were found in the ash. The heat release of the soot deposits has been measured. The above measurements are used to differentiate various samples of particulate materials. The soluble organic compounds in the PM provide better ignition performance for regeneration. The specific heat of diesel soot as a function of temperature has been measured. Numerical modeling of the membrane channels has been completed. All of these measurements is impressive progress. One reviewer noted each individual piece of work did not go beyond what is known or intuitive to the technology practitioners: The micro-imaging illustrated soot deposition on the DPF wall, but did not yield any new findings or point how specifically the work will lead to anything new; Backpressure studies did

not appear novel; Soot oxidation studies were rudimentary. The heat of combustion part of it was at best unclear, as pointed out by several reviewers in the follow-up discussion. What is the significance of ash loading being 7%? That is not a fundamental characteristic of soot; the amount of ash may vary widely depending on the deposition mode, oil consumption rate, etc.

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

A reviewer stated the project is more of a work for others than an original R&D project. Another reviewer mentioned that although partners were listed there was no indication what the partners did other than Caterpillar providing an engine for testing. One reviewer added that an appropriate partnership with Corning, Caterpillar, and University of Wisconsin exists that leverages their unique strengths. Comments from another reviewer noted there is a very impressive list of partners, but not clear how their expertise was leveraged.

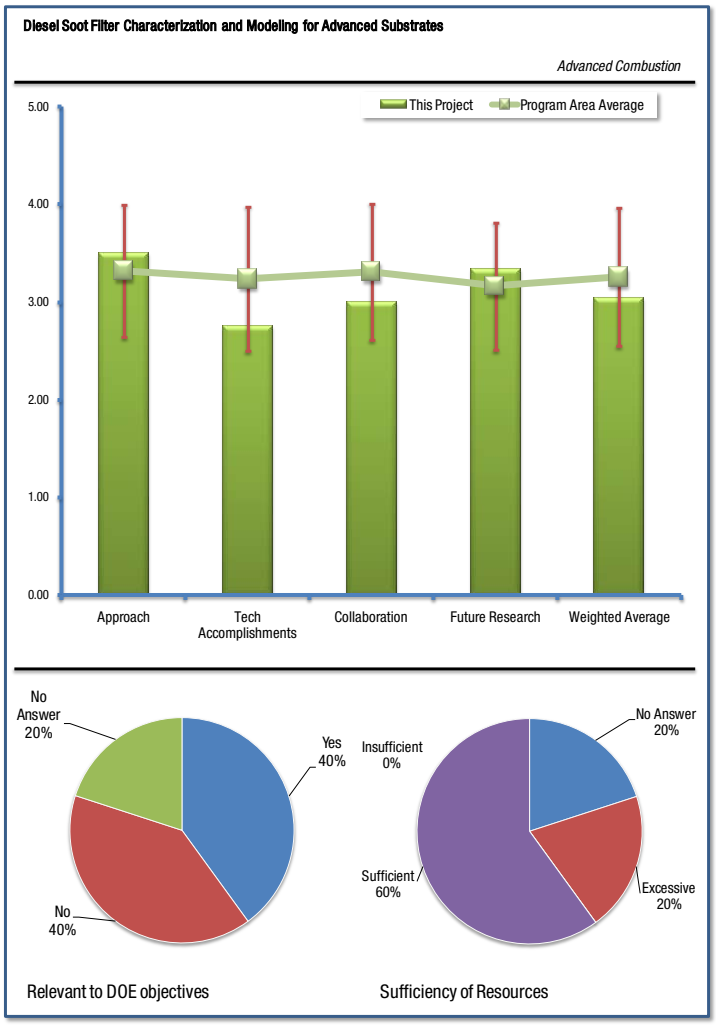
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer asked, what core competency does the Lab impart on the project? Another reviewer noted perhaps there is too much overlap with other DPF work. One reviewer commented the project will measure PM filtration efficiencies; evaluate effect of catalytic coatings. The project will do the above experiments as a function of engine conditions. They will also make measurements of the morphology of partially oxidized soot and ash particles. These are appropriate next steps.

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

A reviewer stated this is hard to evaluate. How much is spent on "brick and mortar" and how much is on the core research?

Diesel Soot Filter Characterization and Modeling for Advanced Substrates: Thomas Gallant (Pacific Northwest National Laboratory (PNNL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated they don't see that this technology will displace cordierite. So what is the value to jumping into a two-way after treatment system? This continues to feel like a way for Dow to leverage development costs and reduce risk. So far no tangible evidence has been shown to indicate that this will get to the marketplace. Another reviewer noted that de-NOx is tied to fuel consumption via the fuel consumption vs. NOx relationship. DPF enables diesel engines. However, the limited scope of the project gives results that mostly appear pertinent only to a specific type of filter that is not widely used. The results appear too parochial to the ACM as to not be universal. The ACM is not in production and seems niche. If DOE does CRADA work, it should be universally applicable to products or approaches that are widely used. This one seems more like publicly funded contract research for Dow.

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 stated it seems like this approach is climbing further out on a very thin branch. Another reviewer added the approach seems based on sound approaches - literature review, simulation, experimentation. One reviewer commented the areas of focus closely aligned to address barriers identified from CLEERS project concerning wash coats and substrates.

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

A reviewer stated there is no evidence that this technology is getting any marketplace acceptance. Another reviewer commented the accomplishments addressed Dow's issues from various angles. Multi-faceted approach covered the relevant areas. Another reviewer commented the results shown seem modest versus the time and expenditures. Perhaps much effort was spent on developing the models for the new materials. NO_2 cycling results are impressive and interesting. One reviewer noted it is difficult to figure how significant the progress was over the past year. This is the last year of CRADA. The reviewer would guess that if the outside partner decides to move forward with production of ACM substrates, the technical accomplishments here are outstanding.

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

A reviewer stated they are obviously working very closely with Dow. Another reviewer noted the end users collaboration beyond CLEERS is not obvious. One reviewer added there seems to be good collaboration between

industry and PNNL. They like the fundamental nature of the work. Comments from another reviewer mentioned there is a partnering with CLEERS with a report planned. What about SAE or other publication?

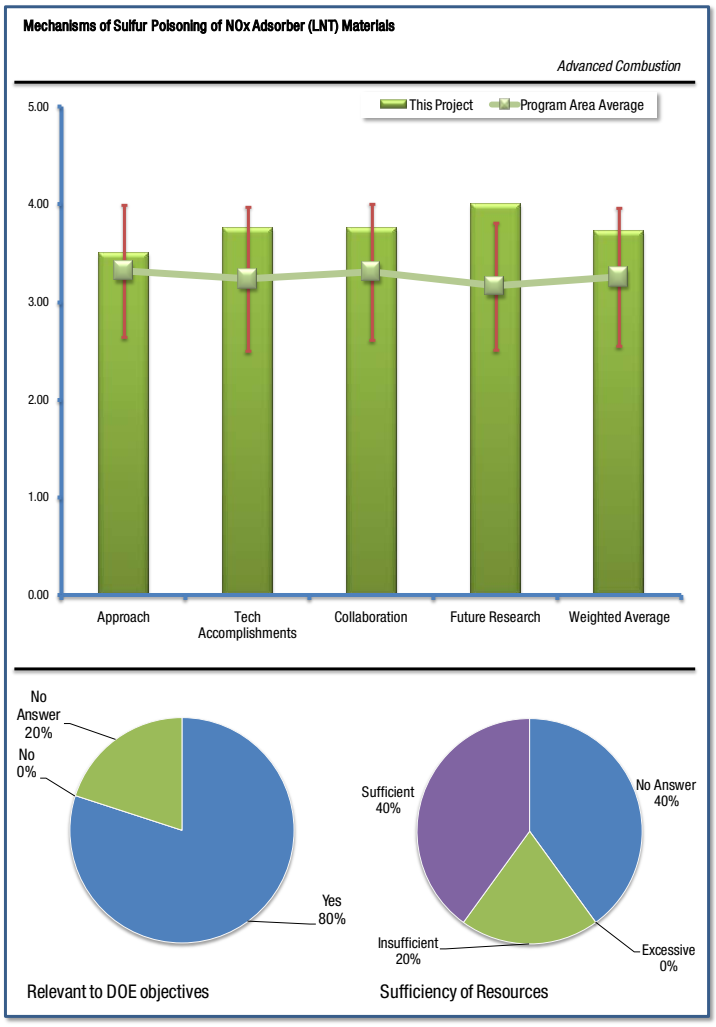
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two reviewers stated it is time for this project to be completed. September '09 should be the end. Another reviewer added wrap up will provide more insights into wall flow vs. flow-through catalysis. Some work has been demonstrated by others, but much more insight is needed.

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

A reviewer stated they have never seen much future for this project.

Mechanisms of Sulfur Poisoning of NOx Adsorber (LNT) Materials: Charles Peden (Pacific Northwest National Laboratory (PNNL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that absolutely this program was a contributor to LNT commercialization and thus to U.S. dieselization. Another reviewer noted deNOx function is directly tied to fuel consumption impacts via the fuel consumption vs. NOx relationship; LNTs are a viable technology for light-duty, medium-duty, and non-road. This project is addressing the fundamental understanding of LNT deficiencies and durability. It is also an excellent example of government and industry cooperation yielding useful results. One reviewer mentioned sulfur in the U.S. fuel is now a barrier to lean combustion technologies. Understanding sulfur poisoning and desulfation methods is critical to removing this barrier and thus enabling high efficiency lean combustion technologies to become feasible.

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 stated this was a rare opportunity for National Lab tools to be applied to realistic commercial catalysts. PNNL has done great work and because they have honored proprietary issues I think they open the door for other companies to be willing to do such work. Another reviewer commented the cooperation between industry and PNNL is obvious. The testing is fundamental yet reality grounded in its objectives. Testing methods are defendable; the results are useful and add to the fundamental understanding within the industry. One reviewer noted focus in on understanding poisoning mechanisms first before suggesting changes in catalyst formulation and sulfur regeneration algorithms. Wide array of state of the art techniques for catalyst characterization and testing at PNNL are brought to bear on the problem.

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

A reviewer stated there is a great fundamental learning. This work has helped us greatly, even though the reviewer is sure we only know part of what was found. This is a great example of high power government labs helping industry build better products. Another reviewer added there are multi-faceted results on Pt utilization, LNT desulfation, BaO/Al_2O_3 reactions, etc. They suspect there is a multitude of results and learning's not captured in the published information, thus delivering "proprietary" knowledge to the partners. This is needed to continue industry involvement. Learning's here added to the knowledge base on LNTs and will result in improved performance. One reviewer commented that most significant deactivation mechanism identified thus far is the sintering of precious metal and thus a loss of activity. Ceria is able to help reduce overall deactivation by inhibiting precious metal sintering. Most of the sintering occurs fairly early and so does the loss on NOx conversion. Incorporating Ceria into the catalyst

formulation reduces the amount of platinum sintering. A testing protocol to separate effects of sulfur and high temperature has been developed. Also desulfation behavior is a strong function of the amount of Barium loading. The positive and negative aspects of water in the desulfation process have been identified. Real world samples from the 2007 Dodge Ram Heavy duty pickup truck have been analyzed.

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

A reviewer stated there were good Ford & Cummins interactions. Another reviewer mentioned there was a close relation with catalyst supplier and OEM means the learning goes right into products. The industry people could not have done this without the Lab. One reviewer added collaboration is obvious. There was catalyst understanding from industry with fundamental measurement and theoretical aspects provided by the scientists. This is an excellent example of synergy. Comments from another reviewer noted collaboration is limited to Johnson Matthey via Caterpillar because of the CRADA between them. However, because of this understandably some of the information is not available to other interested OEMs and suppliers.

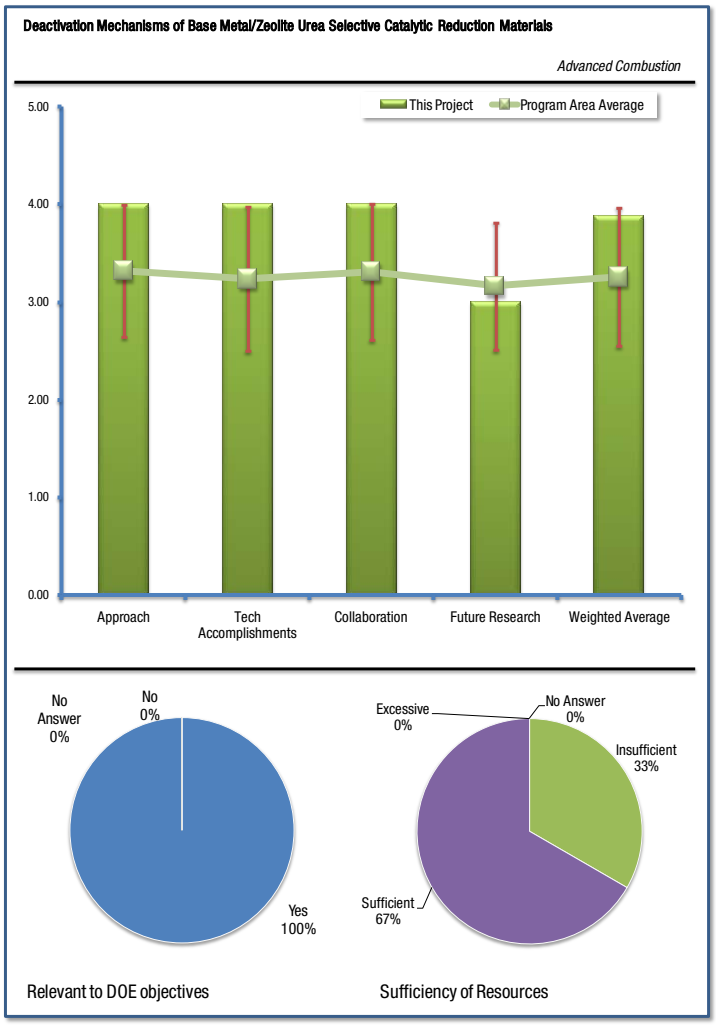
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated this is not applicable as the project is completed. Another reviewer added they hope the follow up on CRADA will get going. One reviewer commented there are very good future suggestions in regards to HT LNT formulations. They would advocate looking at speciation upon desorption/regeneration, especially as it pertains to ammonia generation, N_2O. Need fundamental understanding on HT LNT functionality and limitations. Comments from another reviewer mentioned that CRADA is done. Pending signing of a renewal, extending LNT performance to higher temperatures is planned. This is very appropriate, especially as the knowledge can be applied to lean gasoline engine combustion where temperatures are much higher.

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

A reviewer stated this is not applicable as the project is completed. Another reviewer mentioned the works was done, presumably on time. One reviewer noted CRADA has expired. New proposal has been made and should be renewed. Also, a CRADA aimed at addressing the sulfur issues for lean gasoline engine technologies should be considered.

Deactivation Mechanisms of Base Metal/Zeolite Urea Selective Catalytic Reduction Materials: Charles Peden (Pacific Northwest National Laboratory (PNNL))



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this is a very clear indication of the effect of the DOC preceding an SCR on sulfur poisoning. The SO_3 aging effect is a very important piece of information. Another reviewer noted that pushing SCR NOx conversions to higher levels will enable re-running engines for higher fuel 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?

A reviewer stated this was very sharply focused and easy to understand. Another reviewer mentioned the fundamental understanding of the deactivation mechanisms of the SCR catalyst is essential. PNNL is utilizing their core competency to push the SOA envelope. One reviewer added the CRADA is focused on several key fundamental challenge areas for the SCR technology, such as urea-related deposits, deactivation of zeolite-based SCR catalysts, and sulfur poisoning/regeneration of the SCR catalyst.

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

A reviewer stated slides 15 and 19 show the SO_3 effect and show the recovery from it. This is very good and important information. Another reviewer added the amount and impact of work is impressive. For example, the findings related to Cu agglomeration de-coupled from the zeolite dealumination when SCR catalyst degrades, are novel. Similarly, the information about the large difference in the impact of SO_2 vs. SO_3 on SCR catalyst is new and relevant.

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

Three reviewers all said there was coordination with Ford and PNNL. One also said it's hard to image a better collaboration.

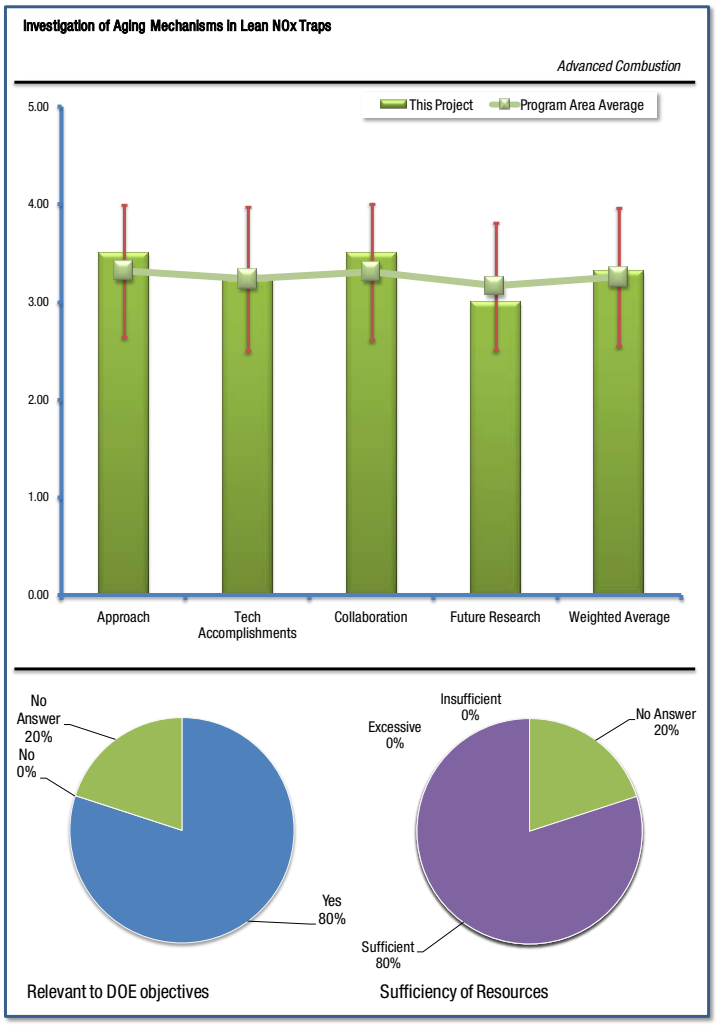
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they would like to see the correlated aging approach. It seems as if Ford is going to keep that in house. That is disappointing since it would be helpful to the entire community and they are not convinced that it is a competitive edge for Ford.

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

A reviewer stated nice orchestration of PNNL and Ford resources to get a quick and useful result. Another reviewer added the project funding is lacking the planned level.

Investigation of Aging Mechanisms in Lean NOx Traps: Mark Crocker (University of Kentucky)



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this is useful work on LNT for diesel and gas engine use. Another reviewer noted deNOx is related directly to fuel consumption; project pointed to deNOx efficiency. One reviewer mentioned LNT catalysts are the key to introducing lean combustion technologies. Specifically sulfur poisoning, durability and cost (precious metal loading) are the issues. This project addresses these critical areas.

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 stated meaningful model catalysts allow detailed study of aging effects. Another reviewer commented solid approach but perhaps too heavy on experimentation, as one would see in an industrial lab, with little heavy analytical methods characteristic of and unique to National Laboratories. They would prefer to see an iterative approach where experimentation is supplemented in parallel with detailed analyses to develop and prove hypotheses, which can then be used to design better experiments. One reviewer noted the approach is highly experimental in nature. Approach is to characterize various samples (with and without ceria) by subjecting them to various feed gases and an aging cycle, measuring NOx conversion performance and examining substrates with mass spectral techniques. Comments from another reviewer mentioned the sample matrix for this study was planned very systematically, to address several key questions about the impact of the typical LNT constituents, on its performance. The experimental conditions were judiciously chosen, a particular challenge for LNT studies.

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

A reviewer stated nice data; it seems that good conclusions and theories are coming along. Another reviewer added the results are interesting but generally are consistent with other studies. The new work will come from high tech analytical evaluations. For example, you results on ceria storage of sulfur are interesting and new, to the reviewer's knowledge. This came from unique instrumental analyses. One reviewer mentioned with ceria wash coats the reduction in NOx conversion efficiency was significantly reduced. Ceria acts as sulfur sink protecting the Barium NOx storage phase. Halving the loading of Rhodium did not affect performance. Significant sintering of the Platinum occurs without Ceria. Significant durability performance has been achieved with Ceria based wash coats. It is good to see that the results of this program are in agreement with the work at PNNL. Comments from another reviewer noted interesting findings, e.g. the impact of OSC component on the selectivity towards NH_3 vs. N_2 selectivity on the aged catalysts.

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

A reviewer stated there is a good relation with Ford, ORNL. Another reviewer mentioned the exchange between state-of-art catalyst and OEM aging and inputs are invaluable. However, they urge more fundamental study. One reviewer noted appropriate coordination among the CRADA partners (Ford, Umicore, and ORNL) exists.

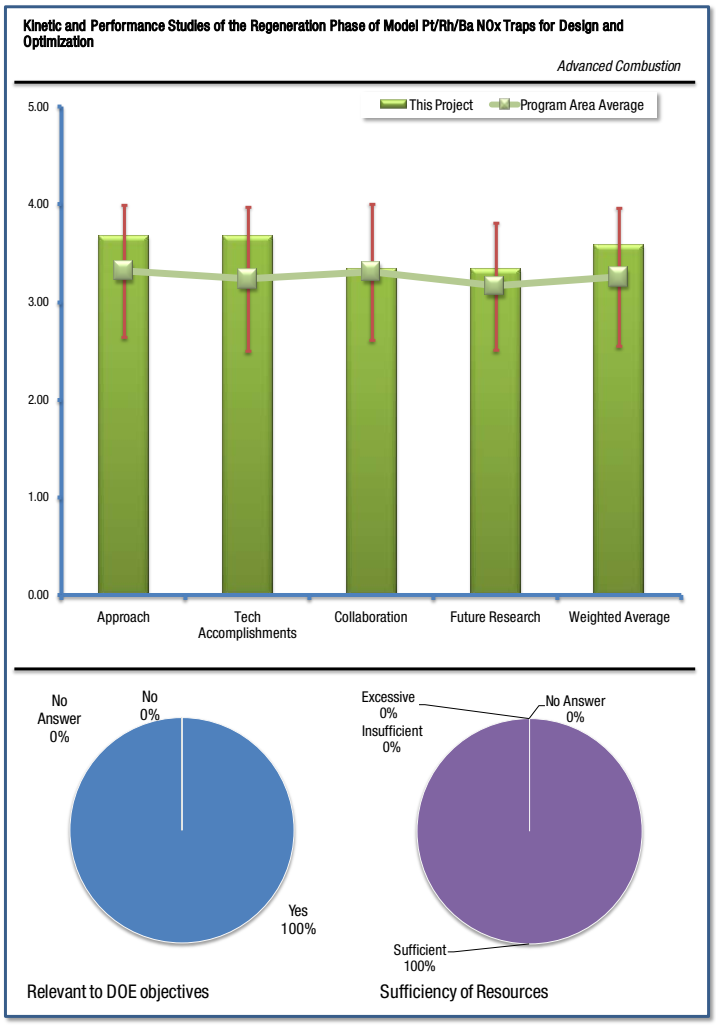
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Three reviewers stated the program is nearing its end in September 2009 with one reviewer adding, the remaining plans seem appropriate and useful. Another reviewer added finish up on analytical testing while one other reviewer said work remaining is modeling work to capture the experimental observations.

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

No reviewers commented on this question.

Kinetic and Performance Studies of the Regeneration Phase of Model Pt/Rh/Ba NOx Traps for Design and Optimization: Michael Harold (University of Houston)



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated detailed mechanism for LNT activity is necessary for implementation and more significantly for the control strategy for that device. LNTs maybe a technology that is used in lean gasoline, diesel and highly diluted gasoline technologies. The reviewer does question whether there is not a lot of DOE resources applied to LNT projects. Another reviewer mentioned this project has good relevance. One reviewer commented high-efficiency NOx traps allow engines to be tuned for higher fuel efficiency. Also, better understanding of the details of LNT operation, especially regeneration, should lead to reduction in fuel penalty associated with the LNT regenerations.

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 stated a technical barrier of an LNT model is just a bit diffuse; however, the work clearly addresses exactly that problem and has provided insights. The integration of experiment and modeling is very well done. The reviewer is however, very disturbed that the model can be multi-valued. They cannot see justification for that. In addition it would be very helpful if the experiments which were used to develop the model were defined. And then, separately, if the model could be compared with validation experiments which were not used in the model development. With this many parameters, one could conceivably fit an "elephant". Another reviewer added TAP reactor and range of catalysts is very good. No one else seems to be doing these isotope studies. One reviewer mentioned excellent combination of experimental tools and methodologies (bench reactor studies, TAP, isotopic labeling), focused on some of the most challenging fundamental LNT questions, such as relative reactivity of NH_3 and H_2 as NOx reductants, etc.

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

A reviewer stated the isotope results are quite interesting. Another reviewer noted there is good progress and interesting results. One reviewer added Dr. Harold's group's results from this program provide unique insights into the chemistry of LNT regeneration.

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

A reviewer stated the presentation indicates collaboration with Ford; however, there was little evidence of it in the presentation. Another reviewer commented there are good connections in academia and industry.

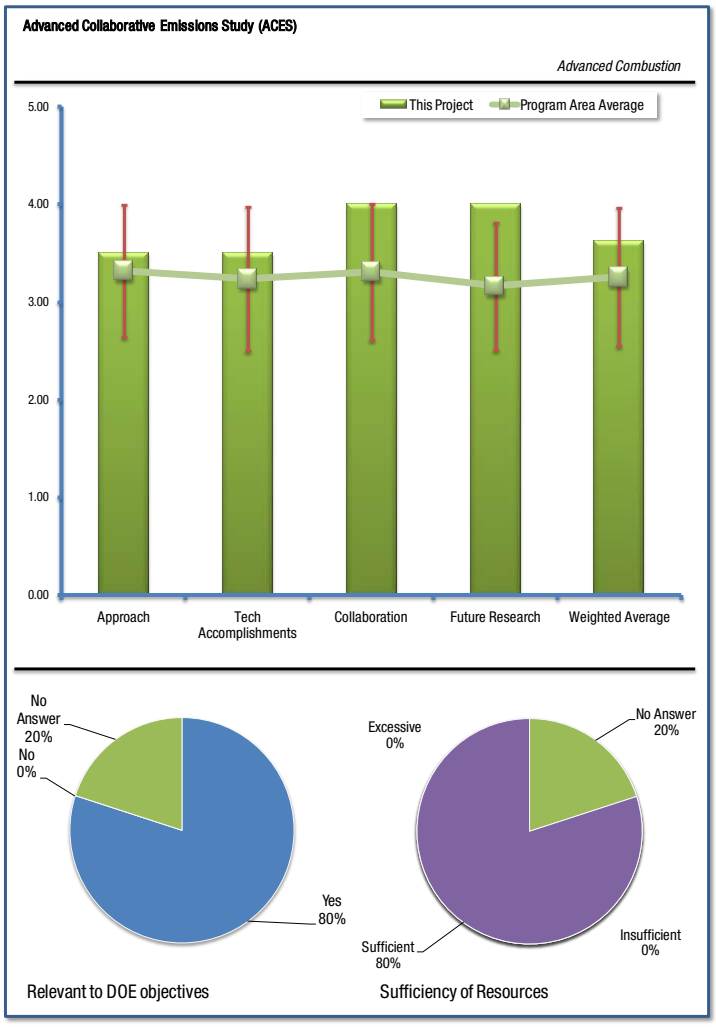
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they would like to see some model validation comparison with experiments. The future work is pretty weak on transient experiments. Another reviewer mentioned the project is reaching an end, they hope it will be continued.

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

A reviewer stated the resources are sufficient if it gets extended.

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



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that although study of health effects does not directly contribute to petroleum displacement, it is crucial to understand potential health impacts of new fuels and how they differ from those of existing fuels so that effort is not wasted on development of new fuels or technologies that would later face an unanticipated roadblock. Another reviewer mentioned diesel engines are 30-40% more fuel efficient than gasoline engines. As the US moves to the new diesel technologies in some applications, it will be important to ensure that there are unintended adverse health consequences related to exposures to new technology diesel exhaust. The ACES program describes by Mr. Greenbaum will address this issue. One reviewer commented much of the work will have to be done to find better catalysts so that as emission standards are tightened fuel economy does not suffer. Health effects of vehicles with different emissions are unknown. There is a concern that ultra fine soot particles may do more serious harm in the lungs during regeneration. Comments from another reviewer noted new fuel reduction technologies in general should be tested for any unintended impacts on health. This project fulfills this role for heavy-duty diesel engines. Would light-duty diesels be different? Market penetration so far probably doesn't warrant testing.

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 stated the approach is very straightforward and logical. Measure the emissions. See what happens if rats breathe them. They hope that the future work will include some information on dose vs. response for the exhaust (time series?). Also, it would be useful to know if it is specific individual components of the exhaust that are bad actors, or if the combination makes the impact worse than the sum of the individual components' impacts. This might be more useful and more elegant. Another reviewer commented there has been extensive planning of this study by a host of stakeholders, including DOE, EPA, CARB, engine manufacturers, and the petroleum industry. There have been a number of technical barriers that have been and are being addressed to measure the components of diesel engine exhaust and to ensure a consistent 2+ year exposure of animals to new technology diesel exhaust in a chronic bioassay. One reviewer noted the use of multiple engines, multiple test cycles and independent research organizations ensures that the approach is thorough. Comments from another reviewer mentioned it was a well planned out for such a complex (800 species) test. Stakeholder input was well utilized.

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

A reviewer was particularly interested in the reduction of as-yet unregulated emissions. This allows us to avoid possible surprises if EPA decides to regulate these compounds. Another reviewer added for various reasons, there have been significant delays in getting the study started and making progress is exposing animals to the new technology diesel exhaust in a chronic bioassay. Some of the delays have been related to technical issues that needed to be addressed. Others related to the long process of developing consensus on issues among the host of sponsors of the study. HEI is doing a reasonable job of "herding cats" on this project in making sure that most of the sponsors on the path forward. Having an excellent expert "oversight committee" has been a great help moving things forward. One reviewer commented the timing of the phases of the project is just about on track. The delay in phase three is not critical and much of it will be made up throughout the project. The results of phase one that was presented show how thorough and detailed the testing has been so far. The report coming out of this phase will be very important in determining future emission regulations. Comments from another reviewer noted interesting results so far. What will the 2010 engines bring?

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

A reviewer stated this project has a strong and reputable set of partners and advisors for both the emissions and health effects work. Another reviewer commented there has been a large amount of collaboration and coordination with other institutions on this study. Experts in the areas of engine emissions characterization and particle and diesel emissions toxicology have been brought together to design and oversee this study. In addition to setting up emissions characterization study at Southwest Research Institute, HEI has also been involved with designing and setting up the animal inhalation study at Lovelace Respiratory Research Institute. This is a very time consuming and complicated process. In addition to these core studies, HEI has coordinated with other academic researchers to assess other health-related endpoints as part of the ACES study. On the negative side, periodically, there is some frustration among the sponsoring engine manufacturer that they are being left out of the decision making process regarding how this project goes forward. This issue is being addressed by HEI. One reviewer noted the mix of engine manufacturers, regulators, independent laboratories and national labs makes for a well balanced team. Preliminary data suggests that 2010 engines may not meet specifications. The reviewer finds it encouraging that discussions are underway with all stakeholders about best way forward. Comments from another reviewer mentioned many of the industry stakeholders are engaged either directly or through industry organizations.

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?

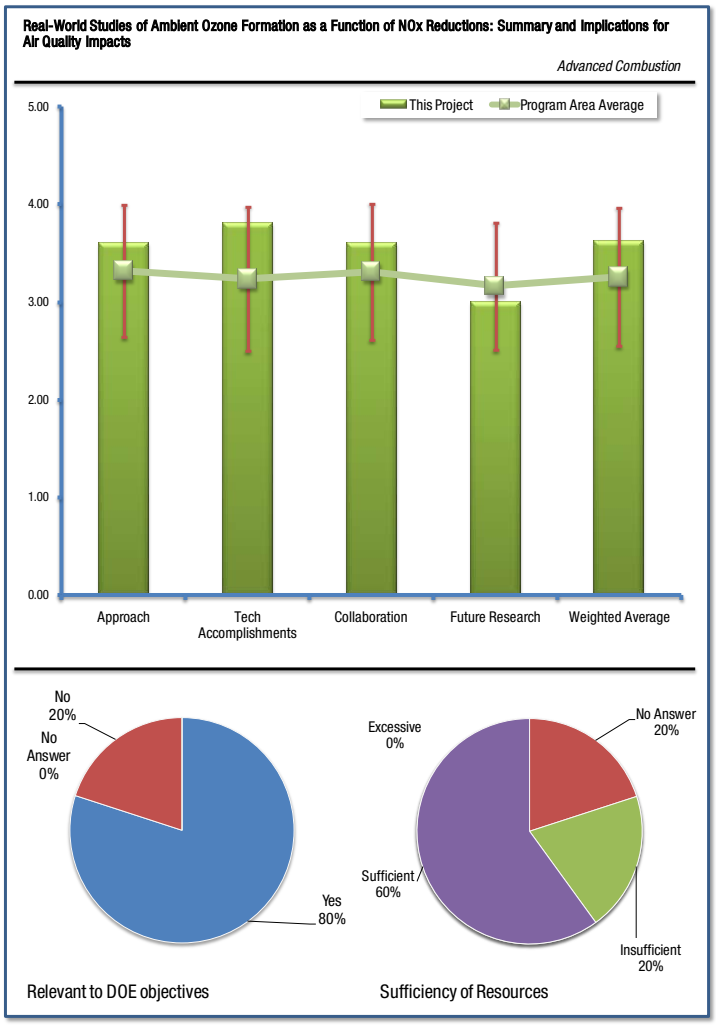
A reviewer stated it is especially important to carry the exposure tests down to low exposure levels to insure that there are no important residual impacts at these levels. It would be useful to demonstrate if engines have gotten so clean that they do not need to be regulated even more stringently. They suggest also measuring emissions for biodiesels. Another reviewer added there has been excellent planning of the ACES study, with significant discussion at decision points so that logical paths forward were developed. HEI has done a great job of bringing together all the stakeholders at these decision points and developing a consensus on how to move forward. One reviewer commented the hardware and equipment for testing the health effects on animals is in place and exposure testing will start soon. Comments from another reviewer asked, were the all unregulated emissions (XAD sampled) above the minimum detection limits with the DOC/DPF used by 2007 engines? If not, would it be worthwhile to investigate improvements to this method?

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

A reviewer stated this project seems to be adequately funded. There do not seem to be major areas that have been left out due to lack of funds. Another reviewer noted it is essential that DOE continues to provide their commitment to funding a portion of the ACES project. This is especially important during the current economic downturn, which is having a very adverse financial impact on some of the sponsoring companies. This study is absolutely critical to

assessing the potential adverse health effects after a major change in diesel engine technology. Without this study, our society may suffer unintended adverse health consequences that would not be known until potential health effects are observed in humans many years in the future. One reviewer mentioned this is very important work that was well presented while another reviewer said great combination of government and industry contribution.

Real-World Studies of Ambient Ozone Formation as a Function of NOx Reductions: Summary and Implications for Air Quality Impacts: Doug Lawson (National Renewable Energy Laboratory (NREL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated although this work does not directly reduce fuel use, emission studies enable continued use of diesel fuel, which is more efficient than gasoline. It is important to recognize connections of transportation technologies to real-world impacts. It is also important to understand how tighter air quality regulations impact fuel economy. Another reviewer added continuing to reduce NOx emissions from engines results in lowered fuel economy. Dr. Lawson's studies are showing that lowering ambient NOx levels in most regions of the US does not lower ozone, but in many cases increases it. Therefore, there is no reason to further lower NOx emissions from vehicles or power plants. One reviewer commented this project supports that we are wasting fuel to control NOx. Comments from another reviewer noted NOx reduction to meet future emission the fuel economy of heavy duty trucks may be reduced with current catalyst technology and engine design. This study correlates ozone formation with NOx reductions and may change our way of thinking about additional NOx reductions. Background data was shown that ozone levels have not changed in years based on California data trends. One reviewer asked, is this focused on reducing petroleum consumption by removing emission controls? Is this appropriate?

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 stated the weekend/weekday comparison is excellent because it enables the team to see the impacts of changes in relative concentrations of the pollutants over a short time. It also allows inference of correlations. Another reviewer commented in the initial phases of Dr. Lawson's studies, he observed the weekend ozone effects in Denver and Los Angeles. Some argued that these effects were peculiar to only these areas of the country. So, Dr. Lawson extended his studies to the other metropolitan areas of the US and found the same effects. His challenge now is to convince government policy leaders of the importance of his findings and the change air quality standard for NOx ambient levels and emissions accordingly. One reviewer noted lots of good data that speaks for itself. There appears to be a non-technical barrier here and that is getting the word out. Comments from another reviewer mentioned the researchers brought on board regulatory bodies as partners so that the regulators could get first hand data on the effects of NOx and ozone. Wise move! One reviewer asked, what should be done to reduce ozone? This may be a good future focus. If emission controls is not effective, what would be effective?

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

A reviewer stated this is another criterion that is not very applicable to this project. The team is making excellent progress towards its goals of understanding the dynamics of ozone formation. The reviewer's only criticism is the failure to bring the results to the attention of the regulators who seem to have the misconception that it is always better to reduce air concentrations of any pollutant as far as you can, no matter what the cost. It is not a technical goal, but visibility of this work is crucial. Another reviewer mentioned Dr. Lawson has made excellent progress towards the objective of showing that further lowering of NOx levels in the US will not result in lowering ozone levels, but in fact will increase ozone in many areas of the country. He has been able to address every criticism of his studies. For instance, it was argued that downwind of high-NOx areas, there would be an increase in ozone formation. Dr. Lawson did a number of ozone measurement studies downwind of high-NOx areas and showed that the weekend effect applied there as well. One reviewer mentioned monitoring ozone data at 540 sites in 23 states outside if California is a significant accomplishment in itself. The data supports what the California trend lines have shown and that is that there is no weekend reduction in ozone levels on weekends when heavy duty track travel is reduced. The publication of nine peer reviewed papers by the Health Impacts Program is a great way to get the message out. One presumes these are published in technical journals. There should also be a version for the press and news outlets to reach a larger audience. Comments from another reviewer noted the broadening of data sources is good.

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

A reviewer stated if CARB is really a partner, they suggest trying to make them understand that reducing NOx may mean increasing ozone, and vice versa. Another reviewer added Dr. Lawson has done an excellent job collaborating with the Desert Research Institute, other academic research laboratories, and regulatory agencies, including the US EPA and the California Air Resources Board. One reviewer asked, how can you coordinate with the EPA? With policy makers? It sounds like you have invited them to the party, but they are showing up. Comments from another reviewer mentioned partnering with the regulators is a good move. Observations from one reviewer noted government biased collaborators, otherwise a good collection of collaborators.

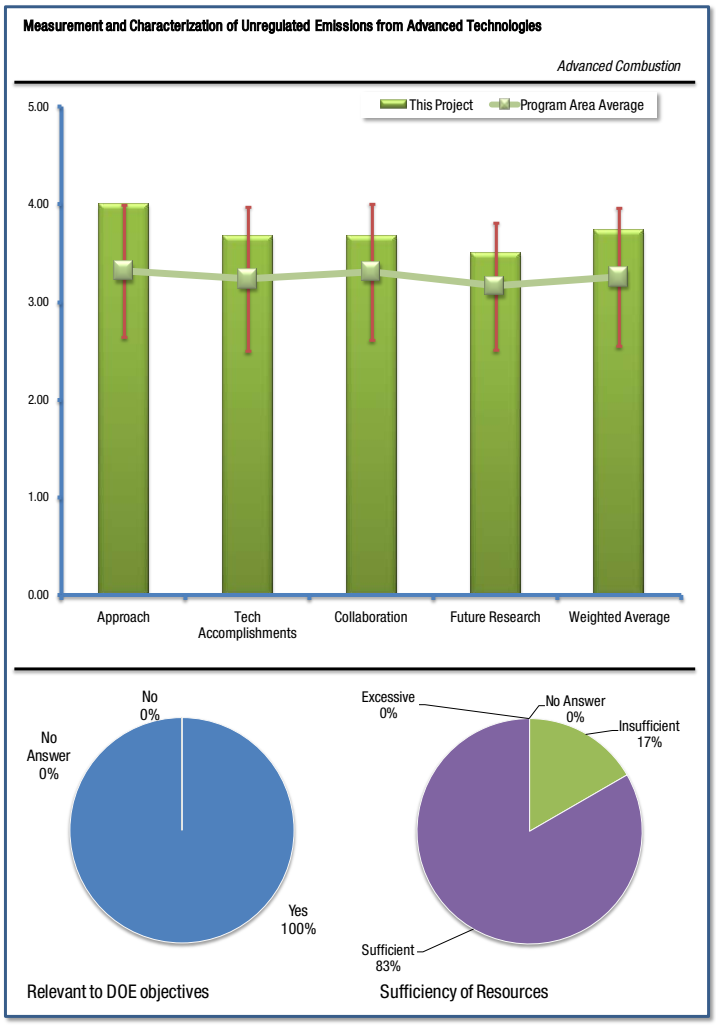
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated hard to tell from slides, but additional measurements and comparisons along the same lines would be very useful. Another reviewer commented Dr. Lawson has done an excellent job over the years of addressing criticisms of his findings, especially by policy makers, who want to continue to reduce NOx levels. His future research will continue to examine the weekend effect in other regions of the U.S.--perhaps he needs to look at other regions of the world, such and India and China, where NOx levels are very high. One reviewer mentioned ultimately, this work is to guide policy making to get the right things done. They are not sure they see a plan here to do this. Comments from another reviewer noted the next four years of on-road measurement activity will gather more valuable data. Observations from one reviewer said no discussion of future research. Again, what should be done to reduce ozone?

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

A reviewer stated the team seems to be doing good work with allocated funding. Another reviewer noted funding for this project needs to be continued, so that the issues raised continue to be presented to air quality policy makers in the US. Much of the funding needs to go towards educating the regulatory agencies on the implications of Dr. Lawson's findings. One reviewer commented the overview page did state that this is one of multiple projects co-funded over several years but the FY09 budget of $80,000 will not fund even one full time grad student.

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



Reviewer Sample Size

This project had a total of 6 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that although study of emissions does not directly contribute to petroleum displacement, it is crucial to understand potential impacts of new fuels and how they differ from those of existing fuels so that effort is not wasted on development of new fuels or technologies that would later face an unanticipated roadblock. Another reviewer noted advanced engine technologies can reduce air toxics emissions and improve fuel economy (e.g. hybrids). It is important to measure emissions of not only regulated compounds, such as particulate matter and NOx, but also unregulated emissions, because the latter have as great or greater potential health effects. As the U.S. moves to cleaner and more energy efficient vehicles, it is essential that the levels of potentially toxic compounds in the emissions be assessed so that there are no unintended health consequences of the new technologies. One reviewer commented all emission control is done to reduce risks to health. It is essential to be sure new technologies don't create new concerns but in fact help reduce health risks. Comments from another reviewer mentioned the use of petroleum and renewable fuels blends does dramatically reduce petroleum use. The greater the ratio of renewable fuels the higher the displacement. The project did not pick winners or losers in what the source of the renewable fuel was. This is good since there are many opinions on that issue. Observations from one reviewer added the project addresses the 'no harm' clause and petroleum displacement (ethanol, diesel) well.

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 stated the work directly addresses potential emission problems that could impede introduction of alternative fuels. Who knows what the EPA will decide to regulate? Another reviewer commented Dr. Storey's research is sharply focused on understanding emissions from new engine technologies. He has been very proactive and innovative on the conduct of these studies. One reviewer mentioned nice job of analytics, and good work to find reasonable test engines. Comments from another reviewer noted the use of multiple blends ratios with two different manufacturer's vehicle of different vintage and mileage gave an interesting perspective on the effect on the tailpipe emissions. It was not mentioned if the vehicles were specifically flex fuel or not. This test would be interesting on non-flex fuel vehicles. The work on the diesels and particulate matter showed some interesting results. Another reviewer asked, is there anything to be gained from better sampling methods? Repeat measurements? Many of these species are very low and the measurements are highly variable.

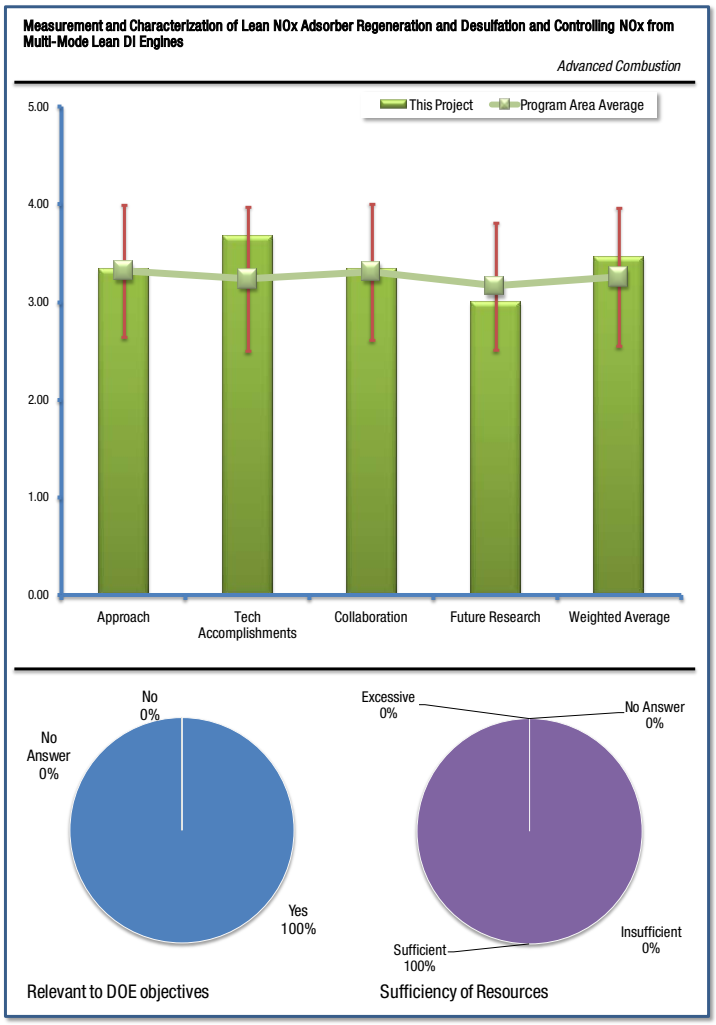
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated important new results have been obtained. It is particularly interesting to see how emissions vary for a given fuel combusted differently. Another reviewer noted Dr. Storey has made excellent progress in determining urea decomposition products. This is very important for assessing the potential adverse health impacts of implementing the SCR/urea technology in 2010 to reduce NOx emissions from on-road vehicles in the US. Dr. Storey has also made excellent progress in implementing technologies to measure MSATs. One reviewer added the data shared shows good progress with the project. The particulate separator sure is a novel device.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated the team includes experts from several excellent institutions working together. Another reviewer added Dr. Storey is collaborating with a number of government and academic research laboratories. These collaborations have been well-coordinated. Dr. Storey's research needs to be published in the peer-reviewed literature--this will have a greater impact on driving the implementation of new engine technologies and advanced fuels. One reviewer commented active participation with CRC and similar groups. Comments from another reviewer mentioned they were pleased to see university participation along with regulatory agencies and national laboratories. This is a good mix for a fair and accurate research project. Observations from one reviewer noted a good range of collaborators. Is there any collaboration interest in industry for the project?

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated analysis of additional alt fuels and combustion technologies is appropriate if these are expected to see important contributors to future fuel supply. Work on SCR emissions is important. EPA regulations have been known to have their own impacts. Another reviewer commented Dr. Story's future focus on looking at MSATs from the use of ethanol blended fuels is extremely important. These renewable fuels will be important in addressing climate change going forward, but it is important to determine whether there will be unintended consequences of use of the new fuels in terms of increased emissions of MSATs. Dr. Storey needs to also focus on the potential release of unregulated air toxics from the SCR/urea technology, which is being implemented by most truck manufacturers starting in 2010. It is very important to assess whether this new technology will have the unintended consequences of increasing air toxic emissions. Again, Dr. Storey and his collaborators need to be more active in getting his results into the peer-reviewed literature. One reviewer noted the plans presented are right on target for what needs to be done yet. It would be interesting to determine the effects on engine durability and performance on non-flex fuel vehicles running on blended fuels over extended operating times.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the team seems to be able to do excellent work with the funding allocated. Another reviewer added funding levels should be increased, since there are so many different new engine technologies and fuels being proposed for the future, and emissions of these new technologies need to be assessed. Dr. Storey needs to be provided the time and resources to write papers for publication in the peer-reviewed literature. One reviewer mentioned this is a large project but with combined funding from DOE and EPA it is about right.

Measurement and Characterization of Lean NOx Adsorber Regeneration and Desulfation and Controlling NOx from Multi-Mode Lean DI Engines: Jim Parks (Oak Ridge National Laboratory (ORNL))



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this is a critical understanding of deNOx function, which is related to fuel consumption. Another reviewer added this program addresses the after treatment issues of lean and LTC combustion technologies and therefore is critically relevant. One reviewer commented enabling broader market penetration of more fuel efficient, diesel 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?

A reviewer stated this is an excellent engineering approach - set up the devices, put together an operation strategy, run the tests and analyze the results. It is missing the scientific approach that might be expected more from a National Laboratory: develop hypotheses, run experiments, adjust, and run again to gain system or fundamental understanding. We need more fundamental understand of LNT+DPF systems and LNT+SCR systems. Interaction, composition effects, feed gas effects, etc. Another reviewer noted the focus is on reducing fuel penalty during regeneration of catalyst. The approach provides a link between and system level performance. The approach also provides a platform for multimode engine operation and its effects on various after treatment philosophies. Approach is to supply data to CLEERS, universities and other national labs as feedback. One reviewer mentioned this is a much focused effort, clearly leveraging major learning from the previous years of this project, including rich engine calibration for optimal LNT efficiency; NH_3 formation and evolution across LNT, etc.

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

A reviewer stated characterization of the DPF+LNT and LNT+SCR systems is advancing. These data, added to other data from the literature is adding to the knowledge base. It is good to get this into the public domain. Much information is coming from this program, but more exploration into cause and effect would be more useful. Another reviewer commented the lower fuel penalty to regenerate DPFs for HECC combustion has been demonstrated. Lower desoot frequency also results in less time at high temperature for the catalysts. HECC combustion also results in lower back pressure rise rate. Work has also progressed to characterize ammonia formation and utilization in an LNT-SCR hybrid system. Ammonia generated during rich regeneration of LNT. SCR after the LNT cleans up NOx that breaks through the LNT. Challenge is to produce sufficient ammonia across the LNT. One reviewer added the results for a sequential LNT-SCR system are very interesting, especially the complementary comparison of NOx conversion and fuel efficiency.

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

A reviewer stated the evidence of collaboration is apparent, but could be better. Did you get the best LNT formulation for NH_3 generation? Why wasn't OSC used on the DPF? Are you using a post injection strategy optimized for NH_3? Are you using the best analytical or modeling tools to delve into the fundamentals? Another reviewer noted good relationships exist between catalyst suppliers, CLEERS and other national labs.

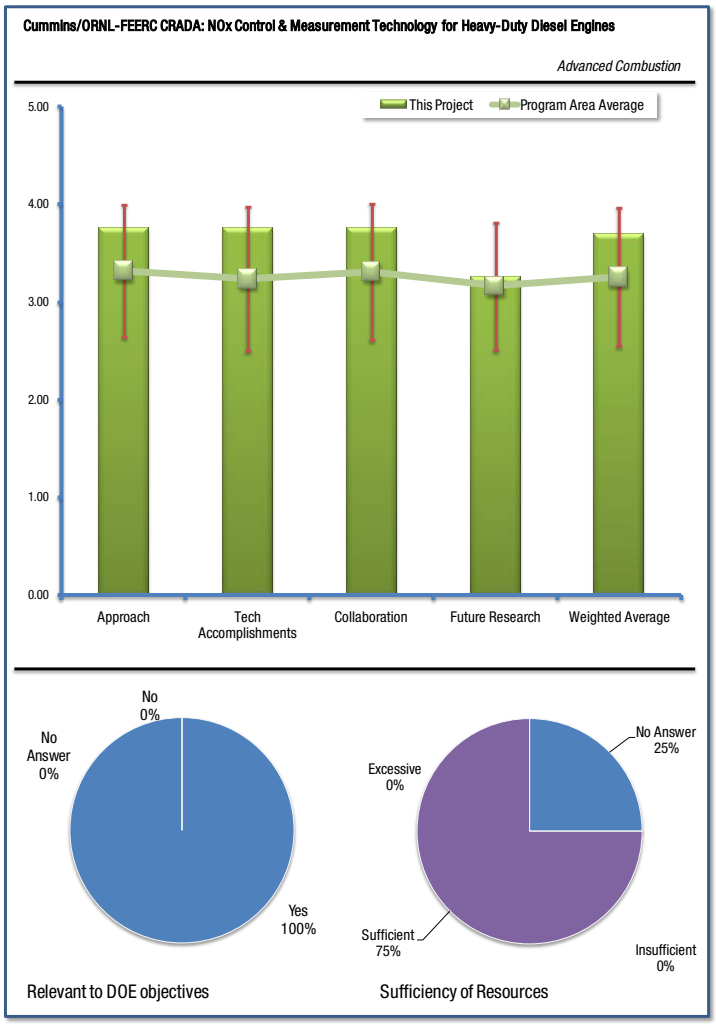
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they would prefer to see more fundamental analyses and system optimization on LDD before proceeding to gasoline. Lean burn gasoline is not in the cards for the US due to high sulfur levels. However, perhaps this study will show a pathway which could be interesting. Make sure the project explores these sulfur effects. The data will be useful for evaluating sulfur reductions in gasoline. Another reviewer added one of the barriers to introducing lean combustion technology is the cost of LNT-based after treatment system due to the high cost of precious metals. Future plans should include a focus on trying to reduce PGM loading on the LNT in order to reduce cost. Ways of shifting a larger burden of NOx reduction to the SCR should be investigated.

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

A reviewer stated it seems that for an engineering study like this, the staffing is adequate. However, they would like to see more fundamental resources (modeling, analytical) added to really add to the base knowledge.

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



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated both topics support the overall DOE objectives of petroleum displacement. Another reviewer noted excellent connection with needs. One reviewer added instruments will help to calibrate engines better and faster to operate in a more efficient mode. Comments from another reviewer mentioned this program addresses the state of art in after treatment of lean combustion emissions and has already proven itself by impacting commercial product.

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 stated typically the work on this project has provided the instrumental development and support for a range of DOE initiatives. As such it has been very successful. The direction of the project has adjusted in a continuous fashion to support the other projects in the EERE DOE portfolio. Another reviewer commented nice application of scientific analyses to engine development problems. One reviewer mentioned very good results from your new measurement techniques. Comments from another reviewer noted the approach is well balanced utilizing the strengths of ORNL to develop and demonstrate diagnostics to gain system insights, and strengths of Cummins to apply these diagnostics to develop engines. CRADA has some benefits for the broader community through regular interaction in the various DOE workshops.

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

A reviewer stated the instrumental accomplishments have been outstanding. The SpaciMS has moved into the expected research technology. The optical backscatter probe shows great promise. The negative about this work is that it is typically support work and often has no specific identity of its own. Since the researchers have been very successful working with other groups this is not a significant negative. Another reviewer added very nice work with solid results. One reviewer commented very good measurements. They think real final progress would be to put these instruments into the hands of engine makers. That is another barrier to be overcome. Good works on helping us understand SCR performance. Comments from another reviewer mentioned Fuel-in-Oil (FIO) diagnostic development has been completed and transfer of that technology to Cummins has been completed. The accomplishments also have developed a fast cycle-to-cycle and cylinder-to-cylinder diagnostic for PM measurements. The benefit of this sensor is its simplicity and ease of use. Both the above probes should be considered for commercialization. By sensing the Water Gas Shift Reaction, a tool is being developed to diagnose the NOx storage

and sulfation levels of a catalyst. This will be useful for OBD II diagnostics. Progress has been made on understanding sulfation and ammonia production characteristics.

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

A reviewer stated the instrumentation is willingly and enthusiastically shared. It would be hard for them to believe that collaboration could be any better handled. Another reviewer mentioned there is a close relation between industry partner and Lab. As an outsider, it is obvious this has been very valuable. One reviewer added they would think a partnership with an instrumentation company would be helpful. The reviewer knows there are other optical pm measurement devices on the market. How does yours compare? Comments from another reviewer noted this is a CRADA between ORNL and Cummins and collaboration is excellent.

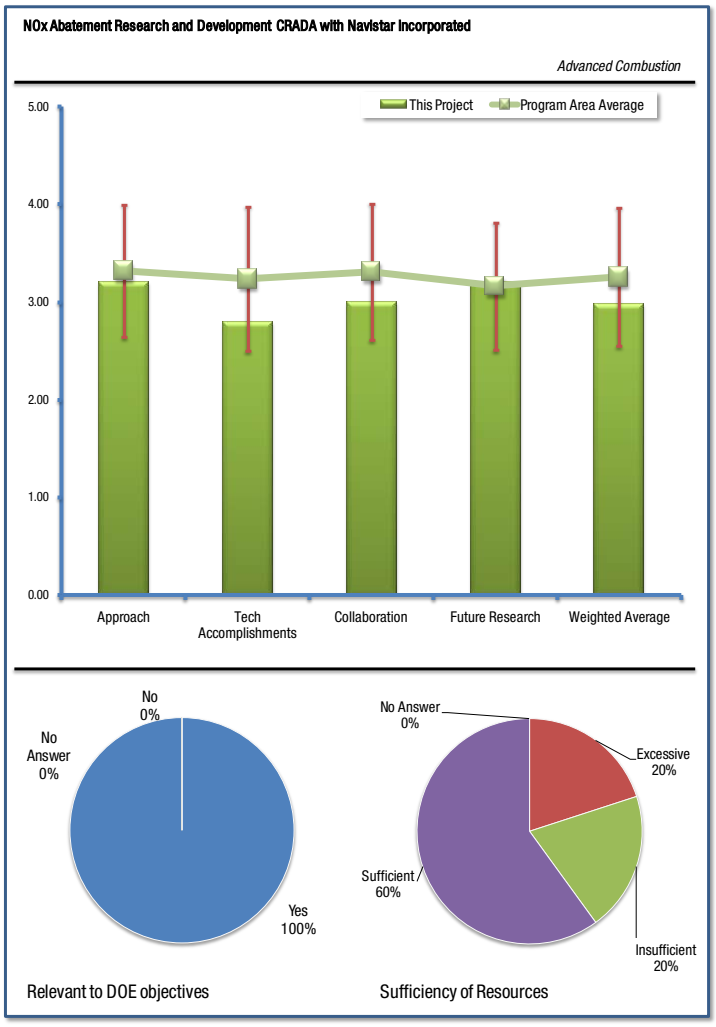
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated as long as the close collaborations are continued, the future work is well selected. If the collaborations are not actively pursued, then they do not feel there is cohesiveness to the future plans. Another reviewer noted seeing the development work completed on the optical backscatter probe and the sensing of the WGSR to monitor sulfation will be very valuable. Similarly, understanding sulfation effects on ammonia formation is also the key to developing low cost SCR hybrid after treatment systems.

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

A reviewer stated the National Laboratory unique and complete instrumental availability is very well leveraged. Another reviewer commented it sounds like the CRADA should be extended.

NOx Abatement Research and Development CRADA with Navistar Incorporated: Todd Toops (Oak Ridge National Laboratory (ORNL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated SCR after treatment technology is presently the front runner for significant implementation for after treatment of lean burn engine technologies. LNT after treatment technologies will be used on at least part of the implementation of lean burn engine technologies. The high cost of the precious metals is a concern for significant penetration of this technology. This work addresses both of those applications. Another reviewer noted the project feeds into deNOx and fuel consumption relationship; may enable better medium-duty and light-duty diesels. One reviewer commented the project is using SCR systems most efficiently lead to better fuel efficiency. Comments from another reviewer mentioned the project is supporting broader penetration of fuel-efficient, diesel 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?

A reviewer stated the evaluation of the CLEERS proposed SCR protocol is a major need in order to provide an industry wide implementation of this technology. Having an independent and well instrumented laboratory provide that baseline evaluation is of great value. The reviewer continues to be concerned that the step changes in concentrations must be well characterized and need to minimized as much as possible diffusional spreading in those step changes. The authors need to provide more detail on that portion of the protocol. Another reviewer commented the approach towards SCR understanding seems satisfactory. There is a need for understanding on NH_3 storage, oxidation, and deNOx effects vs. operating parameters. One reviewer mentioned they are not sure what technical barriers are being overcome here. Comments from another reviewer noted collecting transient data and evaluating sensors for closed loop control are critical research areas. Observations from one reviewer added the experimental approach on the ORNL side is solid and clear, however on the side of the industrial partner; the requested work appears to be filling gaps in their basic lab capabilities, rather than addressing some major fundamental technology challenges.

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

A reviewer stated the experimental results are very good. They are a bit disappointed that there is limited physical "explanation" for the experimental observations. There is not too much unexpected in the experimental observations. Much of that information is expected. The authors need to go a bit beyond the simple observations. Another reviewer added the results incrementally add to the state of knowledge. Data will be useful for modeling and CLEERS

inputs. Good build-up to fundamental understanding of SCR reactant interactions; much of the data, however, is available in the literature. One reviewer commented there were good, methodologically thorough results.

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

A reviewer stated good reporting. There is very little information shown from any partner. Are they just being pulled along? The reviewer would sure like to see a few Navistar and MTU slides showing some of their work. Another reviewer noted the plan seems reasonable with the University of Michigan and Navistar, but little evidence of collaboration on this segment of the investigation. One reviewer mentioned it seems like a good deal for Navistar. Every engine maker is out there working on this in cooperation with their SCR catalyst supplier. Why would the government help Navistar with this? Comments from another reviewer added MTU modeling capabilities is an excellent recent addition to the program.

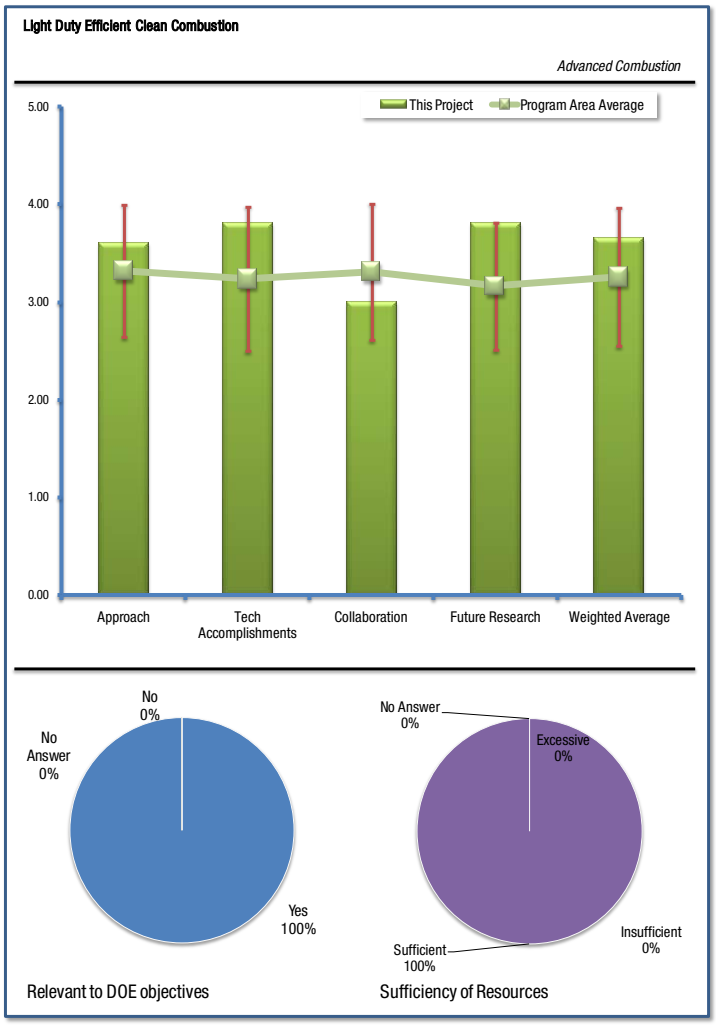
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the future work seems to be okay. Not much specific detail, just business as usual. Another reviewer added space velocity SCR impacts will round out study. Much is in the literature on the topic, so try to fill in the gaps. Filling out the options with a DOC + DPF study will be interesting. New information that is needed is the effect of alt combustion strategy on DPF regeneration. It looks like this will be accomplished.

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

A reviewer stated no modeling results shown. They thought that was a part of this project. Another reviewer noted they don't see justification for this. 2010 engines are coming out with this. How is this advanced work?

Light Duty Efficient Clean Combustion: Donald Stanton (Cummins Inc.)



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated it directly impacts automotive market fuel efficiency while maintaining low emissions signature. Another reviewer noted the proposed work intends to evaluate a combination of technologies for efficiency improvement in diesel engines. Moreover the final mix has the possibility to be used across a slew of engine ranges. One reviewer added it is hard to be more relevant than an engine manufacturer trying to improve fuel economy and emissions. Comments from another reviewer mentioned this is one of the more important and impressive programs within the DOE ACE portfolio. Fuel efficiency reductions improve year on year with potential for real engine-based reductions of 10+% while maintaining very low 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?

A reviewer stated this is a very comprehensive approach that addresses just about every challenge in this area, such as combustion system technology integration (boosting, EGR, injection, etc.). However, only in this year have they considered integration of after treatment technology. Another reviewer commented they would have liked issues such as cost-effectiveness, transient response (especially with two stage turbo charging) addressed in addition to packaging issues. Else, there is a possibility for this to remain as a lab curiosity. One reviewer mentioned the approach is starting from sound models and moving toward full engine tasting is the right approach, which is nicely done. Comments from another reviewer noted a very impressive balance of hardware evaluation, modeling, measurement, strategy. There is also an impressive focus on barriers and objectives - efficiency, emissions, commercialization potential. Observations from one reviewer added minimizing the noise at intermediate loads is a good area of research; minimizing air entrainment for better flame propagation sounds like a big enabler for achieving bin 5 with in cylinder combustion control.

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

A reviewer stated there was excellent progress on the combustion system and integrating simulation with experiment to achieve practical BMEP levels (6-8 bar) while achieving a slight increase in efficiency while getting close to Tier II Bin V. Another reviewer added excellent! Exhibit a willingness to change course should the opted path not work prove less attractive. However, considering the exploratory nature of some of the elements of this work, very little is reported in open literature. This reviewer would encourage a few SAE publications, for posterity. One reviewer noted very good progress and outstanding results. Comments from another reviewer mentioned impressive year-on-year advancements. There is a huge amount of data and progress.

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

A reviewer stated it is not clear at all what Chrysler is contributing, but that may be more an effect of the financial state of Chrysler than any fault on Cummins part. Also not very clear what contribution BP is making, although BP involvement is a plus. Another reviewer mentioned collaboration with neither Chrysler nor BP nor the DOE seems apparent. It looks as if the DOE is funding contract work at Cummins. This might be appropriate to get the necessary information into the public domain. One reviewer commented they would have liked some collaborative efforts (to the extent possible) with national labs and universities. Comments from another reviewer added this builds on long history of Cummins involvement in research and modeling. It shows the benefits of long term research.

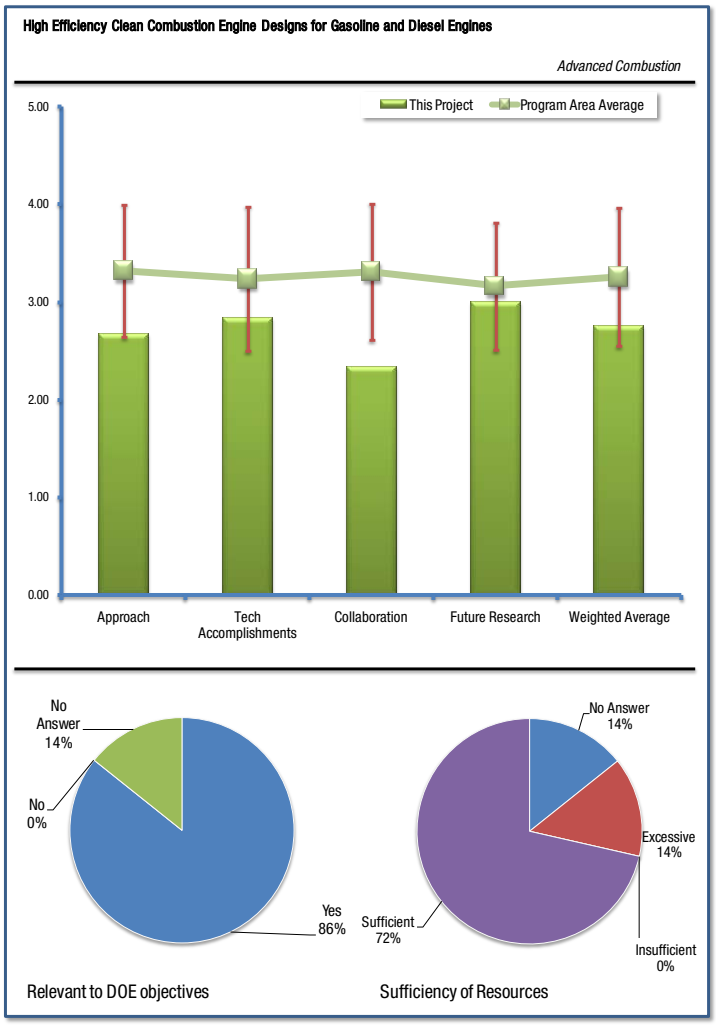
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated alternate pathways have not only been identified, in some cases they have been implemented; such as NOx after treatment integration. It probably should have been included from the beginning, but it seems to be working well at this time. Another reviewer noted the project is moving toward the product very nicely. One reviewer added the future directions are solid and they can hardly wait.

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

A reviewer stated it appears that the resources match well with the project and the accomplishments/goals. Another reviewer mentioned they are very surprised at the high return on the dollar.

High Efficiency Clean Combustion Engine Designs for Gasoline and Diesel Engines: Kenneth Patton (General Motors Corporation)



Reviewer Sample Size

This project had a total of 7 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this project does indeed, on some level, address improvement in fuel efficiency. Another reviewer commented there is good relevance to GM engine design planning. One reviewer added that improvements in gasoline and diesel HCCI engine operation meets DOE goals of reducing fuel consumption and reducing emissions. Comments from another reviewer mentioned the HCCI work shows at least 6% fuel efficiency up to a 20% fuel efficiency. The PI did not describe or evaluate the VVT technology on a standard SI or CI combustion system. Observations from one reviewer noted the project addresses emissions and efficiency objectives which are in direct support of reduced 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 stated this project appears to be an opportunity to test several different VVA strategies, whether they have applicability to LTC or not. This is not to say that LTC does not benefit from VVA, but more conventional combustion systems also benefit from VVA and this presentation did not address that characteristic. In addition, it was entirely unclear why there were different VVA partners for each program, and the presenter did not provide a technical answer as to why the VVA partners were different. The efficiency gains appear to be very modest with a very limited operating envelope for the gasoline HCCI strategy - leading to the question as to whether the gasoline HCCI system is even remotely worth the effort. Another reviewer noted there are a large number of technologies included. It seems there is risk of diffusing the effort. One reviewer commented enhancing the transition between HCCI and SI modes was emphasized as an important part of the work, but very few details of how this has been enhanced were given. How is the FFVVA being used to achieve this? For internal EGR: if you can't measure the rate of EGR, how will you quantify the variability between cylinders when you go to the multi-cylinder? What is being done to remove this barrier of quantifying the internal EGR rate? If internal EGR can only be used at light loads, how can it be used to control NOx emissions at higher loads where it is needed more? Comments from another reviewer mentioned there was no comparison to standard combustion system improvements with this technology. VVA technology was chosen for the projects not because of technological advantages but because of working relationships. In some respects this looks like an attempt at evaluating VVA technology and not low temperature combustion. Observations from one reviewer added the approach of using VVA technology with controls to understand potential of more production viable systems makes sense. Both gasoline and diesel approaches are reasonable. More information on emissions plan/integration with combustion would have been interesting. Another reviewer stated incorporation of FFVVA to improve operating range of gasoline HCCI is an

interesting approach and may lead to this new technology to become acceptable in a wide range of commercial applications.

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

A reviewer stated if this program has received $6.5 million over 5 years and they are just getting to the point of spinning a multi-cylinder engine (not operating, spinning) with the respective VVA systems: that seems like fairly slow progress. The reviewer can appreciate how difficult it is to actually implement these systems, but that seems to be a significant amount of time/money for the apparent progress. Another reviewer added there was good progress on several items but it is not so clear you have a real direction forward. The project is working on many systems and many concepts. The project also needs to have a plan to down select and move forward with a system concept. It is not clear how well you have used models to focus the research needs. One reviewer mentioned the spin rig testing of VVA work was good. No progress on mode switching was reported. "Lack of cylinder pressure sensor" was cited as a remaining obstacle for doing closed loop feedback. The reviewer assumes this comment is based on some cost criteria. Cylinder pressure sensors are certainly available on a test or proof of concept basis. Can the multi-cylinder demo meet Tier 2 Bin 5 without aftertreatment? If not, why not? Just making the statement that "This program will have an impact on future GM production engine designs" is like saying "trust me." The reviewer thinks GM owes a better explanation to DOE (i.e. tax payers) of what the impact will be, and should this be shared with other U.S. companies. The accomplishments to date from the beginning of this project seem to be disappointing with the level of funding that has been received to date. It is understood that the progress from last year was small due to the low amount of funding received in FY09. Comments from another reviewer noted progress towards their milestones were good. Fuel efficiency gains were impressive also. Progress seems on-track. Several specific comments were provided by this reviewer:

- Slide 6 - What is the reference for efficiency/emissions improvements? It would help to understand the significance of improvements. Also would be nice to have numbers on axes but understand the sensitivity.
- Gasoline and diesel activities use different suppliers for VVA systems. The reviewer is curious as to why. Perhaps gasoline and diesel teams have different histories with VVA suppliers.
- Gasoline portion did not talk much about transition to more realistic VVA system for production. The reviewer would be interested in the anticipated path. The diesel portion did address this.
- For diesel portion, exhaust re-breathing was approach of choice. The reviewer realizes heat loss will be less with exhaust as compared to intake re-breathing, but is it still not an issue?
- For both activities, more quantitative information on goals/objectives would be useful. Focus seems more on tools development. The reviewer does realize the tools are necessary to get to the efficiency/emissions improvements and development is a long, hard process.

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

A reviewer stated GM certainly has a good track record of working with suppliers and it appears that they are starting to see the fruits of these collaborations in hardware at this time. However, aside from supplier interaction, it doesn't even appear that there is internal communication between the gasoline and diesel HCCI projects being funded here, much less effective communication or interaction with other organizations. Another reviewer noted many suppliers seem to indicate some indecision and perhaps limit how closely the supplier is willing to work with you. One reviewer commented the response to last year's reviewer comments was disappointing in regard to the technology transfer. It doesn't appear that GM "gets it" in terms of how to work with academia. This project is ideal for working with a university, but the tech transfer would most likely be from a university to GM. The responses indicate that transfer of research understanding occurs only from GM....a rather presumptuous statement that "GM knows it all" and wouldn't learn anything from another partner. Comments from another reviewer mentioned there were no outside institutions used. They only worked with their suppliers. This is not a fair way to judge OEM's. OEM's cannot collaborate extensively on new technologies for fear of losing their economic advantage. Observations from one reviewer added this is a GM/DOE partnership with good use of resources and collaboration with others.

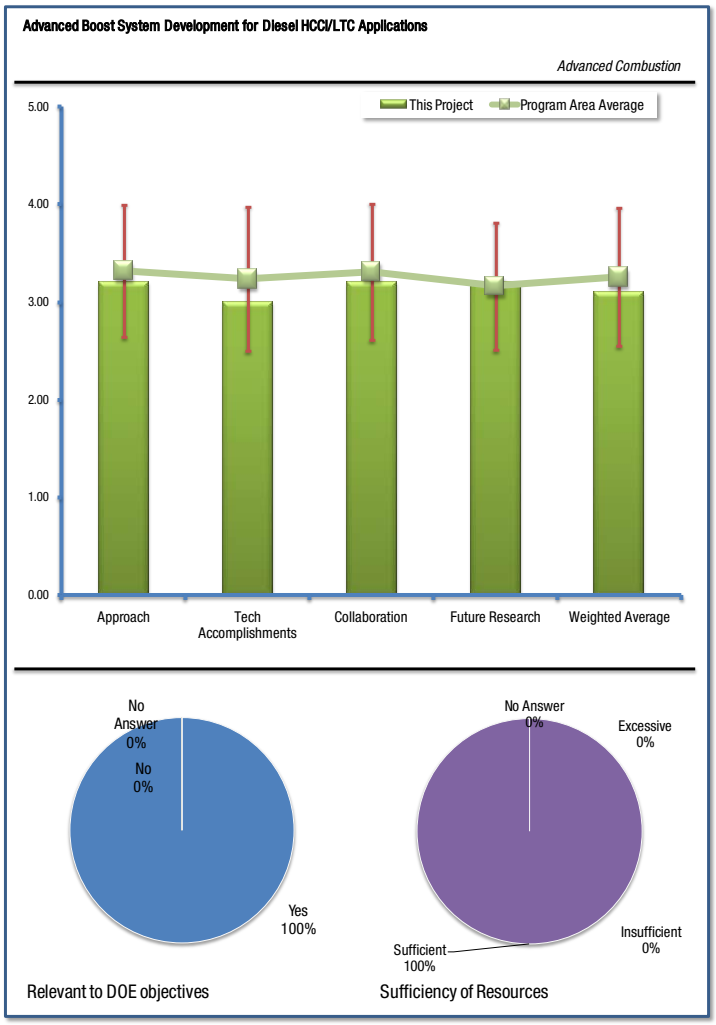
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated it doesn't appear that this project is focused upon advanced combustion, but rather VVA technology. Not much in terms of alternative pathways for LTC seem to be accounted for if any of these VVA systems do not function as advertised; and there is little engine/vehicle operation evidence that was shown to provide confidence that these VVA technologies will be significant enablers for LTC. Another reviewer commented the plan to move forward seems fuzzy. Will you continue both gasoline and diesel? Will you select a system concept to move forward? One reviewer mentioned that completion of multi-cylinder VVA systems will be important to finish up this program. Comments from another reviewer added the project is in its final stages. There is no proposed future research. Observations from one reviewer noted the path forward seems good. They would like to see more detail on where the gasoline program is going in terms of production viable VVA. Plans seem well thought out and reasonable.

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

A reviewer stated at least to this point, the resources committed by DOE over the timeframe of this entire project do not seem to match well with the progress or the stated DOE goals. Another reviewer noted nice project, nice progress, and good example of successful industry/DOE partnership.

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



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated combustion air handling systems and heat recovery are tools to increase fuel efficiency; these characteristics are significantly different in LTC operation and this project reflects that. Another reviewer noted this project has the potential to provide a high efficiency turbocharger that can be an enabler for HCCI technology in diesel engines. One reviewer commented that turbo-machinery is extremely important driver to enabling LTC and other approaches to improved efficiency and emissions. This project addresses this. Comments from another reviewer mentioned advanced diesels have the opportunity to displace petroleum. The speaker indicated that turbo manufacturers were unable or unwilling to explore the range of operation of interest to improve compressor efficiency at low mass flows.

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 stated there is a good mix of simulation and experimental work in this project to guide the development of this turbocharger. Integration with the engine combustion system people at Ford is critical to insuring the success of this project. Another reviewer commented the technical barriers were adequately addressed on the technology down selected. A discussion about the technologies considered and details about the down select process need to be documented somewhere. Nevertheless, a unique combination of modeling and rigorous testing (14 iterations) holds the promise of a deployable technology. One reviewer mentioned turbo-machinery is extremely important but the connection to improved efficiency and emissions was never tied into the advances in turbo-machinery. The reviewer does realize that this is perhaps proprietary. Some insight would have been helpful. Comments from another reviewer noted it seems like a good approach and progress was made. This reviewer suggested that slide shows "major turbo manufacturer" under partners, even if the company does not wish to be named at this time.

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

A reviewer stated this project has made significant progress toward the goals of developing a high pressure ratio/low mass flow turbo for LTC engine application. Developing these simulation design tools will be very helpful for future engine development, since high EGR rates are likely to be utilized in any future combustion system, conventional or LTC. Another reviewer noted good progress exhibited through bench-scale testing. One reviewer added nice progress toward improved turbo-machinery. Nice modeling and overall progress. Supplier partnering is good and necessary. Comments from another reviewer mentioned good progress has been made, including modeling and fabrication of prototype parts.

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

Two reviewers stated the collaboration with the turbo company appears to exist, although not "officially" for technicality reasons concerning the contract. One of the reviewers went on to say partnering with a university for the simulation work is a great choice. It was less clear the role of the consulting company. Another reviewer added the Ford team willingly works with others. Also, their willingness to publish part of the work in SAE publications is commendable. One reviewer commented the collaboration is great, working with supplier and DOE collaboration important to enabling improved turbo-machinery for LTC.

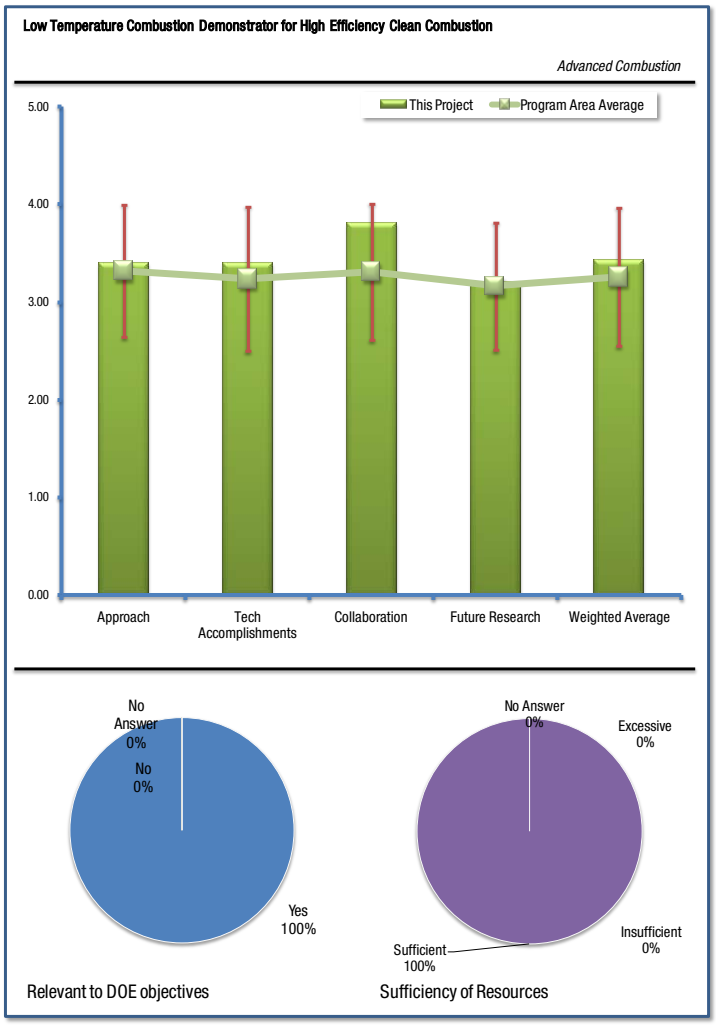
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated this project appears to have the barriers well-identified and the current progress has both identified and helped to overcome additional barriers that have been overcome. They would expect to see more specific information regarding the engine/s of choice for this turbocharger at the next review, with the required speeds/loads and air mass flows and pressure ratios identified. Another reviewer mentioned the future bench-scale testing needs to address low-flow areas as well. This is important considering use of high EGR rates. One reviewer noted they are anxious to better understand potential improvements and integration with engine. It is not clear what will actually be demonstrated on engine. 3-5% is a good target.

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

A reviewer stated this project appears to be applying the correct amount of resources to accomplish the project goals. Another reviewer noted the resources are adequate in every respect.

Low Temperature Combustion Demonstrator for High Efficiency Clean Combustion: Willy de Ojeda (Navistar International Corporation)



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated nice efficiency improvement at emission requirements. Another reviewer added the increase in BMEP of LTC is one of the major barriers needed to make the combustion this combustion regime viable. One reviewer commented efficiency gains are demonstrated in this project. Fuel economy was demonstrated while meeting the NOx target of 0.2 g/bhp-hr. Comments from another reviewer mentioned expanding LTC operating envelop and efficiency while lowering NOx contributes toward program goals. Observations from one reviewer noted yes, nice demonstration as well as strategy 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?

A reviewer stated nice application of models followed by hardware design and test. Another reviewer mentioned from the presentation, they couldn't get a feel for the diesel fuel impacts being studied. It was indicated that a range of cetane number fuels were made available, but have they been explored? One reviewer asked how the ROI model is incorporated into the combustion model. Is it a new sub-model within the CFD code, or a separate stand alone model? Who is doing this part of the work? Comments from another reviewer noted the work was good but they have not quite achieved their goals. They are within 5% of their BSFC goal while maintaining low NOx emissions. Observations from one reviewer added good control strategy and good use of existing models and technology to predict performance. Another reviewer stated the PI had a good plan that was well thought out and explained in presentation. Progress and results reflect this good plan.

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

A reviewer stated the increase in BMEP to 16.5 bar is indeed a significant accomplishment. The claim on fuel economy improvement is a little confusing...5% over 13 mode cycles vs. 1.2% with PCCI at low emissions. Are these compared to the same base, or is the 1.2% an additional improvement over the 13 mode data? The reviewer looks forward to the additional improvements you will achieve with the VVA. Another reviewer commented LTC fuel economy potential was demonstrated with respect to current product over the 13 Mode cycle with 0.2 g NOx/bhp-hr. Improvements of 5% were obtained at some of the 13 Modes. One reviewer added utilization of sensors and reduction in response time for controllers represents significant accomplishment that enables control. VVA reduction of sooting very good and there is ROI model contribution. Comments from another reviewer noted nice progress with a few comments:

- Slide 8 -- Increasing fuel injection pressure showed improvements in ISFC. If you take into account the energy necessary for higher pressures, is efficiency improvement still significant? In other words, what does this look like with BSFC?
- Slide 9 -- EGR distribution biased to cylinders 1 and 2. What about air mass distribution and overall impact on equivalence ratio in each cylinder? Where does EGR transfer line originate in exhaust? Does this affect boundary conditions of each cylinder differently?
- Slide 10 -- Nice work with ECU capability.
- Slide 11 -- Nice injection control with nice illustration of benefit to soot reduction.
- Is VVA system production viable? It wasn't clear.
- Fuel economy improvement is modest. The reviewer would have expected higher. They do understand the project is also meeting emissions.

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

A reviewer stated it seems well integrated with several suppliers. Two reviewers mentioned there is a good mixture of partners for this program. One reviewer noted the OEM had nine collaborative partners including universities. Comments from another reviewer added there is DOE/Navistar collaboration with relevant supplier.

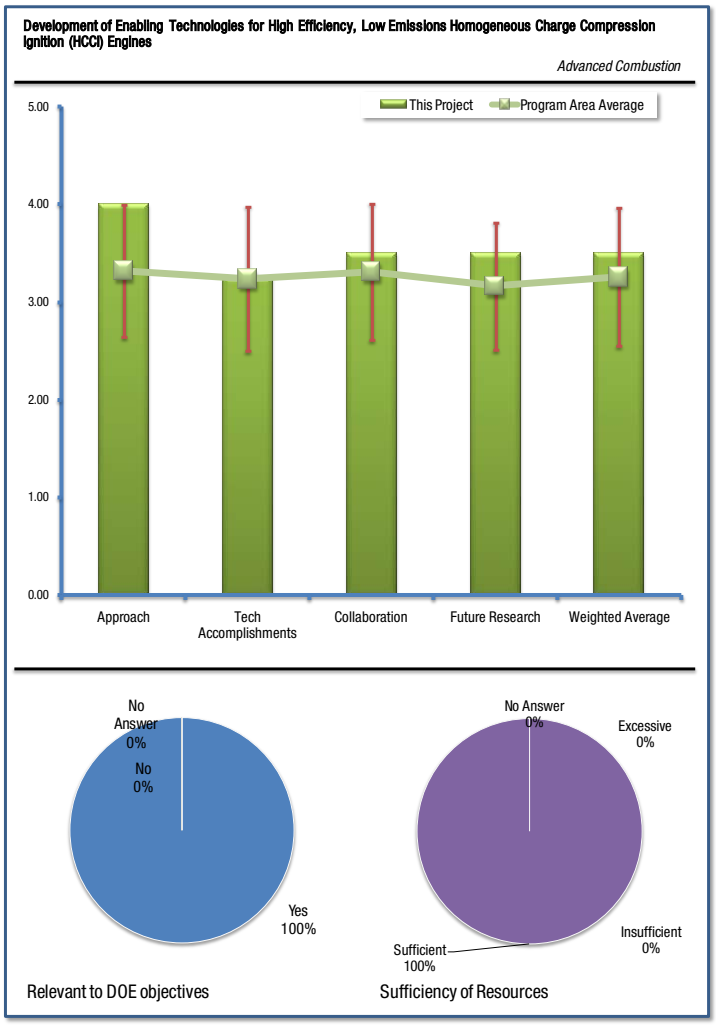
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the program is ending; looks like this technology will go toward production. Another reviewer commented the VVA work will be interesting to see and the program will be wrapping up this year. One reviewer added the proposed future research is to go after the remaining fuel economy benefits that were proposed. This may be aggressive but not out of line with what can be done with the time they have left. Comments from another reviewer mentioned there is minimal work to be done while the initial work on transients is promising. Observations from one reviewer noted the project is nearly complete with objectives to be met, which is rare.

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

A reviewer stated good use of resources to achieve targets. Another reviewer noted overall, a very nice demonstration. Efficiency improvements seem modest even with meeting emissions targets. Nice development of controls, hardware, strategies, etc.

Development of Enabling Technologies for High Efficiency, Low Emissions Homogeneous Charge Compression Ignition (HCCI) Engines: Scott Fiveland (Caterpillar Inc.)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated implementing LTC into a production engine will increase fuel efficiency and reduce fuel consumption. Another reviewer noted the project is very relevant; important work to couple research into product designs. One reviewer commented the project attacks HCCI issues effectively.

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 stated the approach to clear the barriers to LTC implementation is well described. Cat and their partners are addressing each major hurdle and look to be on the way to success. Another reviewer mentioned the approach seems to be very good, although such a short presentation has to gloss over many steps. The reviewer assumes the intermediate steps were done properly. One reviewer added there were clear goals for LTC and systems approach. Recognized gaps and developed effective strategies to address. Consideration of fuel effects adds significant value. Tank to wheels approach effective. Good blend of fundamental and applied.

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

A reviewer stated the progress thus far has been excellent. There is actual engine data that supports the technology goals, with multi-cylinder engine data forthcoming. Another reviewer noted it is hard to judge; there seem to be a great number of excellent detail results but a short presentation can't detail them. It seems system decisions are coming. One reviewer commented good findings on single and multiple cylinder engines. There were significant findings on fuel effects.

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

A reviewer stated that collaboration with partners like Sandia, ERC, and others appears to be well-coordinated and integrated. Each partner brings specialized expertise to the project. Another reviewer added good team and very good utilization of strengths of partners.

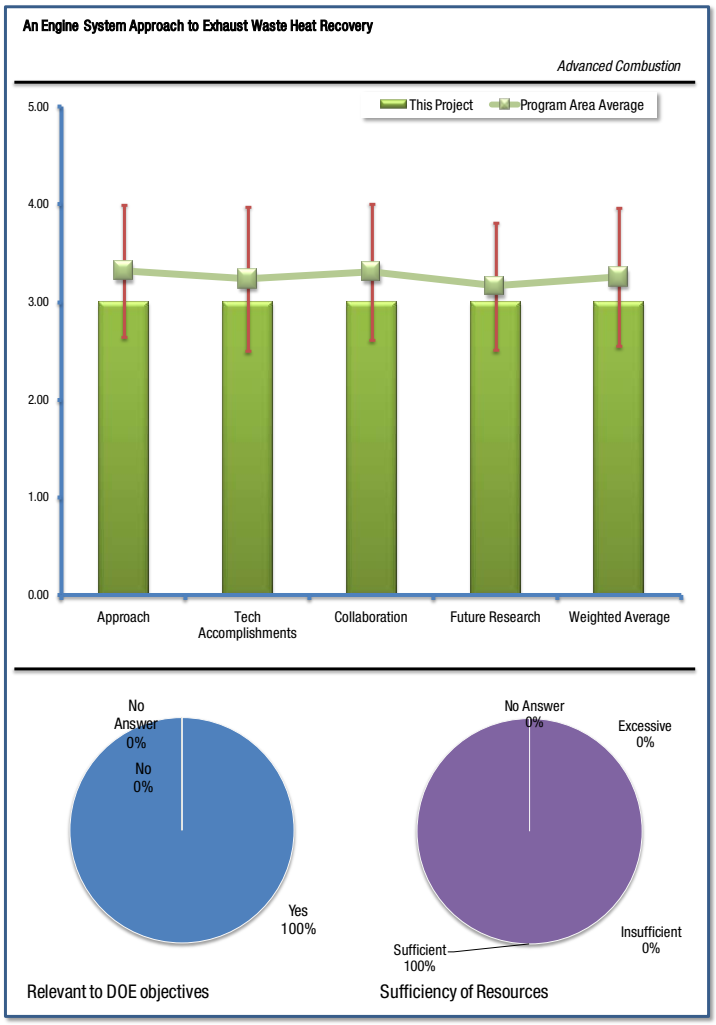
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the critical barriers have been identified with a clear plan to overcome these barriers. Another reviewer mentioned the future work is moving research to production effectively. One reviewer noted good plans to build off existing developments to move toward controlling transition between PCCI and conventional operation.

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

A reviewer stated the staff and equipment/facility resources appear to be well matched with the expected progress and work plan. Another reviewer noted this is not enough time to give a coherent review of such a large project. One reviewer commented Cat and its partners are well equipped to carry out this work.

An Engine System Approach to Exhaust Waste Heat Recovery: Richard Kruiswyk (Caterpillar Inc.)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the project could lead to the development of potential waste heat recovery technologies and thereby lead to higher efficiency power plant. Another reviewer commented these are the next steps in improving energy efficiency. One reviewer mentioned yes, a 10% improvement thermal efficiency would meet the DOE objectives. Comments from another reviewer noted the project is working towards a demonstration of 8 to 8.5% BTE improvements using turbo compounding.

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 stated the approach followed constitutes a revisit of previous technologies and an attempt to marginally improve them. A clear cut approach with an initial system evaluation and down select for an improvement path is advisable. Also, recommend sharing/ publishing the results of the configurations being evaluated. This could lead to model development for future system analysis. Another reviewer added there is a good analytical base. One reviewer noted this is a good systems approach, and appears to be very comprehensive in nature. Caution is advised on the decision making based on cost. This is obviously an issue that is highly dependent on the current cost of oil/fuel in terms of what a customer would pay for fuel savings. Decisions made based on today's operating costs may not be appropriate when performing research like this for future implementation. The reviewer would hate to see novel approaches discarded on this basis. Comments from another reviewer mentioned the approach is well focused on areas where realistic gains can be achieved.

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

A reviewer stated the progress on individual efforts is excellent. However, identifying a clear-cut pathway for implementation on an engine along with improved combustion technologies -PCCI, LTC, etc. - or aftertreatment is missing. As a result, issues such as cost effectiveness, packaging, reliability, etc. remain unaddressed. Another reviewer mentioned a lot of good detail work on component optimization. One reviewer commented Caterpillar has demonstrated 8 to 8.5% of the 10% goal with a path for the 10% solution. The solution is application dependent. It would be good to extend this approach to a LTC operation for comparison to see if the economies are comparable. Comments from another reviewer noted the project is well behind schedule for a 4 year project.

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

A reviewer stated in the work that was presented, the contribution of Oak Ridge National Laboratory was not clear. Another reviewer commented outside partners mostly related to turbo manufacturing or related companies. Is there a place in the program for a university or National Lab participation, perhaps in the heat transfer area? One reviewer added the OEM had four turbo related manufacturers and no universities or national labs.

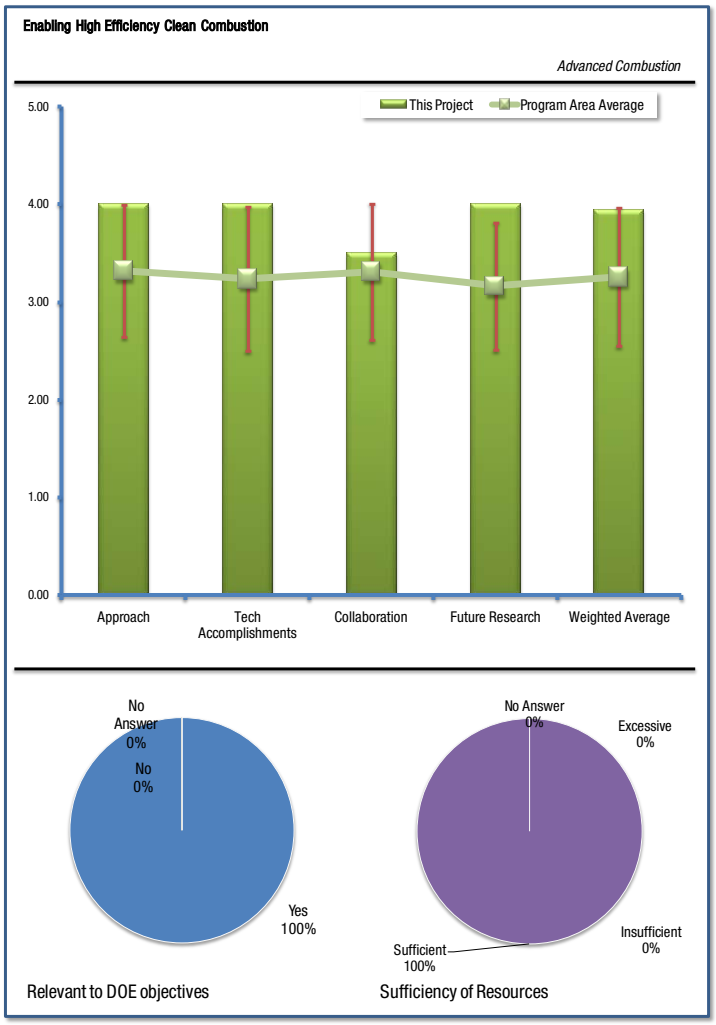
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated some of the configurations propose to be evaluated "Under future work" were previously evaluated and presented by caterpillar as early as 2002. The need to revisit them again needs to be justified. Another reviewer noted it will be interesting to see the system design and performance, and especially how it works for various customers and drive cycles. One reviewer commented the plans look reasonable and on target to achieve the stated goals. Comments from another reviewer mentioned the future research is focused on areas of greatest benefit.

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

A reviewer stated it appears to be a well funded project, with good results being achieved for the investment.

Enabling High Efficiency Clean Combustion: Donald Stanton (Cummins Inc.)



Reviewer Sample Size

This project had a total of 2 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the project has a direct effect on product - how relevant can you get? Another reviewer commented excellent demonstration of efficiency improvements as well as technology path to more improvement. Also mention of transferring technology to product.

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 stated there is excellent focus, with well organized thoughtful approach. Another reviewer noted nice, comprehensive approach. The barrier and potential solution slide is a nice addition to help us understand the issues and potential solutions. This is obviously a well thought out plan which is confirmed by steady progress.

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

A reviewer stated very good efficiency results in realistic engines. Another reviewer mentioned nice progress. More detail would be interesting but understand time issues and Cummins policy limits amount of information you can share. Slide 15 really demonstrates the progress. The reviewer is also very impressed on how the project is using similar technologies for two engine classes. A challenge Cummins met head on with success further increasing value of the research to the country. More detail on lifted flame approach would have been interesting. The reviewer needs to check the literature to see if Cummins has published any of this in detail. The reviewer knows others are working on this but appears Cummins is probably ahead of the game.

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

A reviewer stated the collaboration seems primarily in-house but that is appropriate. Another reviewer commented nice collaboration across the board including industry, academia, and national laboratories. Also, the good transfer to marketplace helps demonstrate the value of government collaboration to reducing fuel consumption.

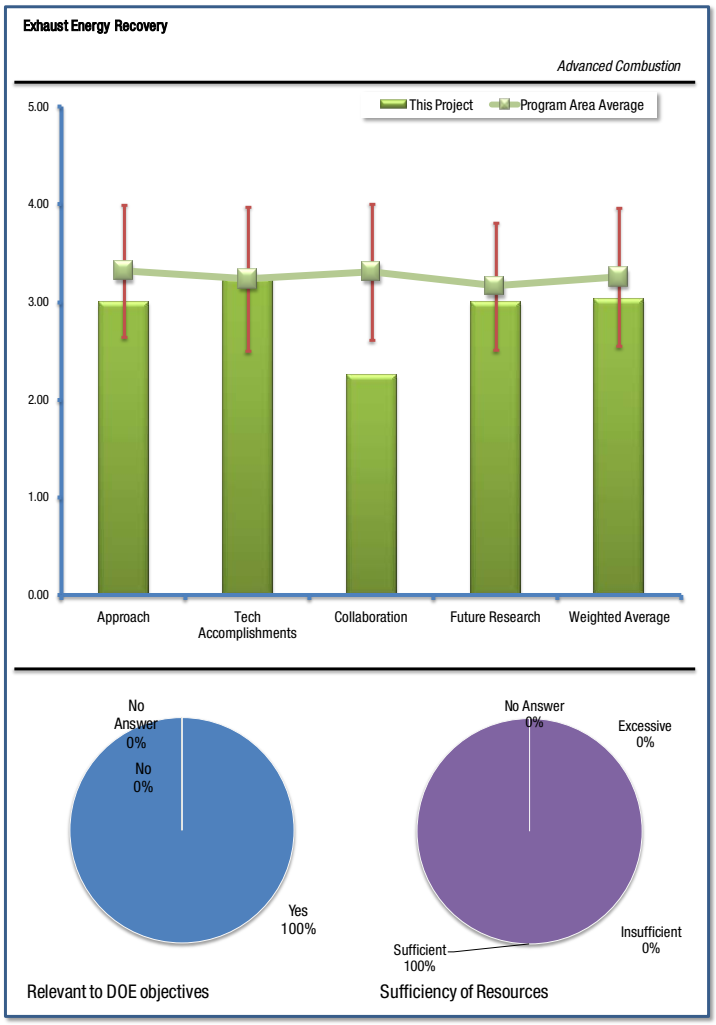
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the project has a good plan for the future work. Another reviewer noted the future work makes sense based on current progress. The future work was well described in program schedules. This reviewer would like to have seen the presenter go through these slides but realize there simply is not time in 20 minutes.

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

A reviewer stated "great job." They wish they had something more constructive to add but the reviewer thinks Cummins has done a top job in defining the barriers, presenting possible solutions, and then enabling the solution which make the most sense.

Exhaust Energy Recovery: Chris Nelson (Cummins Inc.)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that waste heat recovery is an effective technology to improve fuel efficiency. Another reviewer mentioned the project develops a nicely integrated system using an organic Rankine cycle and EGR for waste heat recovery leading to efficiency improvement up to 10%. Further accommodates after treatment and is applicable and usable on a variety of engines. One reviewer commented the project directly addresses efficiency improvement while another reviewer said yes, a 10% improvement thermal efficiency would meet the DOE objectives.

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

A reviewer stated the simulation work and experimental work to date have shown the technology barriers and have made reasonable progress to overcome the barriers. The change mid-stream on the part of Cummins to pursue SCR catalysis, compared to their previous position, has hampered the progress of this project to some degree. Along the same lines, it would have been better to see a little more coordination between the WHR project and the Heavy Duty LTC project so that they were not operating in a vacuum from one another. Another reviewer noted the approach exhibits a clear pathway to success by addressing the associated issues adequately. One reviewer added the project needs to sort out emission levels and system effects, otherwise the approach excellent. Comments from another reviewer mentioned the approach has been good and comprehensive up to this point in the project; however, it would be prudent to focus more on the LTC concepts being promoted for low emissions / improved fuel economy to see how effective the approach is with lower temperature exhaust (lower quality heat). The reviewer is glad to see the approach is being modified to account for the use of SCR after treatment. Are effects of DPF being considered too?

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

A reviewer stated this project has displayed reasonable progress toward an effective strategy to improve thermal efficiency by waste heat recovery. The opportunity to improve BTE by 10 percentage points seems feasible with the current accomplishments and plan. Another reviewer added projected significant waste heat recoveries through simulations, which were later validated through engine testing. Though the decision by Cummins halfway through the program to use SCR after treatment reduces the overall effectiveness, it is worth a try to establish the full potential of the proposed technology. However, would like estimates for penalties incurred in cost, weight and durability. Two reviewers mentioned good results with one adding this is an interesting concept.

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

A reviewer stated there are no other listed partners in this work, aside from a slight collaboration with a turbocharger company. Three reviewers added most of the collaboration appears to be within Cummins with one reviewer adding they recommend publishing some of the results, or the overall implication for record and posterity. Another reviewer mentioned the collaboration is mainly in-house but that is appropriate here. One reviewer noted it would seem that other outside institutions could lend assistance with the Rankine cycle optimization.

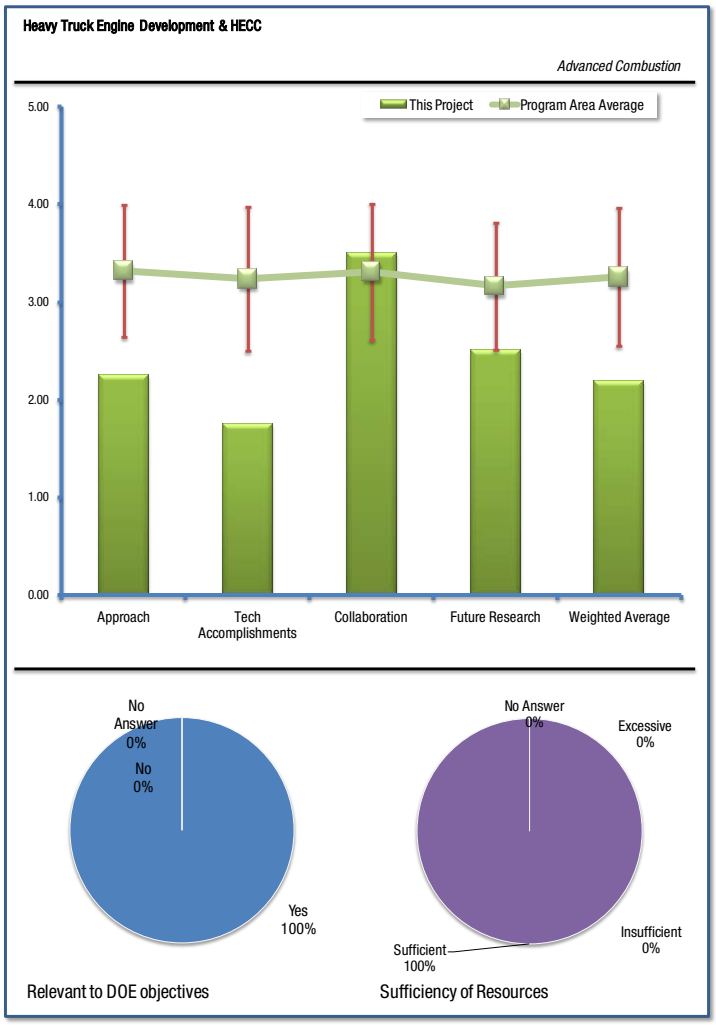
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the plans to integrate this work with the LTC project are a good step - although LTC may provide further challenges to the goal of a 10 percentage point improvement in BTE. Less waste heat that is available to recover will reduce the opportunity for WHR. Another reviewer commented the projected efficiency gains for each of the potential improvements of heat recovery (viewgraphs 18 - 26) are somewhat reasonable. However, they might not be additive as projected in viewgraph 26. The project gain of 11.7% might be a stretch. One reviewer added to keep going and look at other potential applications and drive cycles. Comments from another reviewer mentioned there is LTC and after treatment incorporation into the future testing plans.

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

A reviewer stated that especially since this project did not appear to be funded in FY 09, the progress displayed as admirable and the overall project appears to be an excellent value for the research dollar.

Heavy Truck Engine Development & HECC: Houshun Zhang (Detroit Diesel)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the project has direct relevance to the overall DOE objective. Another reviewer added the goals of this project are to reduce fuel consumption while improving HCCI combustion. One reviewer mentioned there is a clear tie to increased fuel economy and reduced emissions. Comments from another reviewer noted the project addresses DOE goals of efficiency and emissions compliance, but concerns about cost-effectiveness due to complexities of approach.

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 stated the approach seems fragmented. Is this an injector program or an engine system program or a control system program? The various elements are all interesting but the approach seems disjointed. Another reviewer noted the project has been spinning its wheels for three years with the dual injector system which by their own admission they believe probably won't work. The reviewer doesn't believe that they will overcome the technical barriers by the end of the fiscal year and their project to get this system to work. There has been no real progress on the engine work side of this project except for the next generation controller. More than the controller is needed to enable this to go into production. One reviewer commented not clear on the set of technologies being applied to increasing efficiency/reducing emissions. Are new technologies being developed or is investigator optimizing use of "off the shelf" parts? Can one use multiple injection events to get performance approaching performance from two injectors? Is the increased performance from two injectors/cylinder worth the money and effort required to implement? Approach appears to be more piecemeal as opposed to systems-level approach. Comments from another reviewer mentioned the approach has positive and negative aspects. Positive aspects include use of multiple technologies to achieve the goal. Also, use of control system to tie all technologies together and support of modeling results is good. Negative aspect is concern of the complexity of the fuel injector technologies. Specifically, plan for dual injector experiments will use a lot of resources that may be better spent on accelerating the development of the MVCO injector. This reviewer went on to say the high risk of MVCO injector is reasonable, but need to keep resources focused on that aspect to maximize possibility of high reward. Another approach comment considering feedback control...would be nice to see limitations of speed of feedback. And, what other parameters besides SOI can be used for optimal control (mass fraction burned, peak heat release, etc.)?

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

A reviewer stated the results shown are disappointing. The injectors don't seem to have worked (although not time to give up). Perhaps the presentation did not explain the controls well enough. Will you really use two injectors in one

engine for anything other than a theoretical research test? Another reviewer commented the progress is poor. The same comments that were applied to last year's peer review can be applied to this year's presentation. While work has occurred, it does not appear that any progress towards the goals of this project has been made. A suggestion for the presenter is to show Gantt charts with relative dates and goals. Saying "Status: On Schedule" is not informative and does not let us know what has happened over the past year. One reviewer mentioned there was some efficiency increase, but approach doesn't appear to deliver exceptional fuel economy benefit while simultaneously reducing NOx and soot. NGC results are promising. Comments from another reviewer noted the progress on individual aspects of approach has been good, but overall system demonstration on engine is weak. The team needs to have more engine experimental data to validate approach.

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

A reviewer stated there is some collaboration with injector suppliers, but not obvious there is real work as opposed to buying some parts from them. Another reviewer mentioned the project involved an OEM, parts manufacturers, National Labs and universities. It is a shame that the project isn't showing any progress. One reviewer commented good list of collaborators, but not clear that partners are involved beyond supplying parts. The reviewer would like to see more evidence of real collaborative effort. Comments from another reviewer added the collaboration is good. In particular, project has good collaboration with many suppliers.

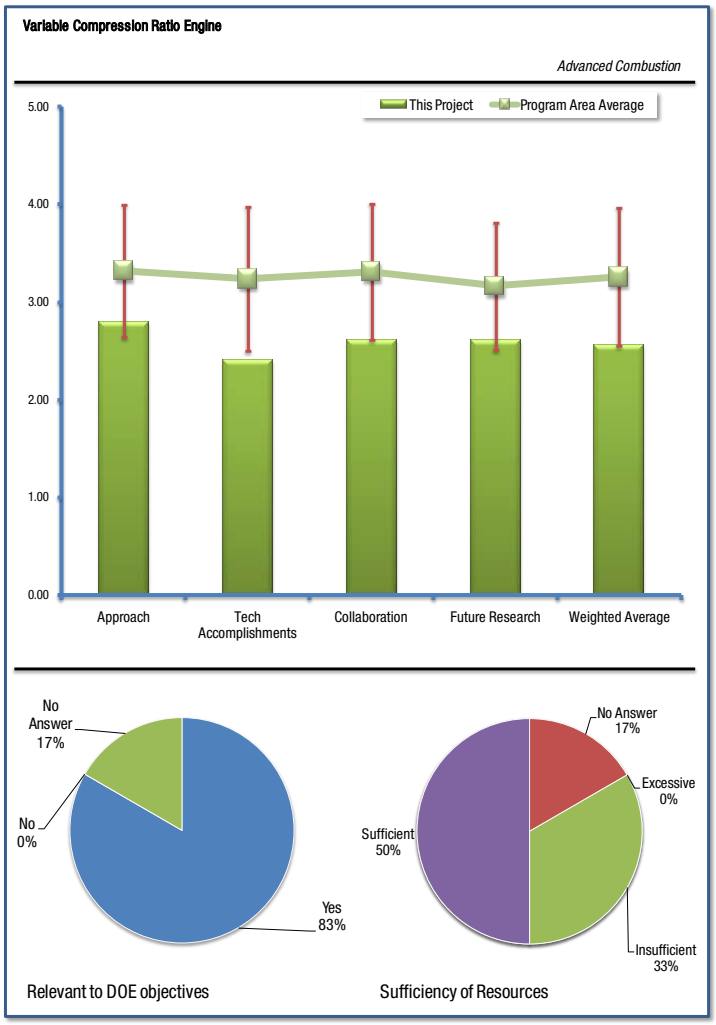
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the future work is disjointed. Some focus is needed to select some concepts and make some progress on it. Another reviewer noted it appears that this project has run into barriers that it has no ability to solve. There were no long term plans proposed since this was the last year of the project. One reviewer mentioned the proposed research plan is generally good, but problems exist with the plans for duel injector approach. The reviewer would rather see extensive resources/effort on addressing this complicated work spent on other project tasks.

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

None of the reviewers commented on this question.

Variable Compression Ratio Engine: Charles Mendler (Envera LLC)



Reviewer Sample Size

This project had a total of 6 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated VCR is a technology that can improve efficiency and reduce fuel consumption. Another reviewer commented variable compression ratio has high value if it can be managed and reliable. One reviewer mentioned the concept to develop a variable compression ratio mechanism could enable mixed mode engine operation. This could enable the use of high efficiency combustion modes, especially under low-load operation. Overall the technology that is being pursued offers higher fuel economy. Comments from one reviewer noted the project is moderately relevant; this was not really well explained while another reviewer said variable compression ratio is another parameter to be tuned for better 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?

A reviewer stated it appears that the project has taken a decent approach to using simulation and modeling to identify barriers and hurdles early so that overall cost and development time are minimized. However, there are many things that can only be learned by building hardware and there is no hardware built for the current configuration. Another reviewer noted the concept seems viable, but certainly needs testing in latest configuration. These kinds of systems often have major problems with wear, fretting, and durability. One reviewer commented the contractor has previously developed this concept and has made marginal improvements under the present funding. Evaluation of the full potential of the present concept - on a working engine with tests performed spread over a typical engine operation is recommended. Also, from the presentation, design targets for the time response of the actuator were not clear, nor were the achievements. Comments from another reviewer mentioned the mechanism design seems well done but they did not present a convincing rationale why you would want this if it works. Observations from one reviewer added the focus has been on the mechanical design to get an improved working prototype. The PI seems to have a good handle on the importance of a rigid and manufacturing assembly.

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

A reviewer stated there has been progress in the design changes - specifically the hydraulic pressure requirements to actuate the VCR mechanism. Again, the progress has all been on computer screens, not in any hardware. There are likely significant issues to be addressed in the one year left on the contract before a working prototype of this new design is functioning. Another reviewer commented good progress on concept but little on development and testing. The project will need engine testing both for reliability and performance. One reviewer mentioned that just stating "project completed" without providing any proof or evidence leads us to place less confidence in the claims.

Comments from another reviewer noted it was an interesting design. Observations from one reviewer added that getting a design with a lower pressure requirement looks to be a good idea and avoids the need for the higher pressure hydraulic source. Good FEA analysis to give confidence in the design. Another reviewer stated it looks like the project has a good lab engine that can be used to explore the benefits of VCR. The reviewer was not clear from this presentation exactly what those benefits are, though for HCCI operation, they could see this as helpful to maintain stable operation.

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

A reviewer stated there are no collaborators by design, since this is a proprietary technology. One reviewer noted the collaboration was adequate while another reviewer said the PI mentions conversations with various OEMs, but no real customer seems to be lined up or participating in the work. Another reviewer mentioned there was good manufacturing input from the auto companies. The reviewer likes that PI is in discussions with them and are striving to make a manufacturable design.

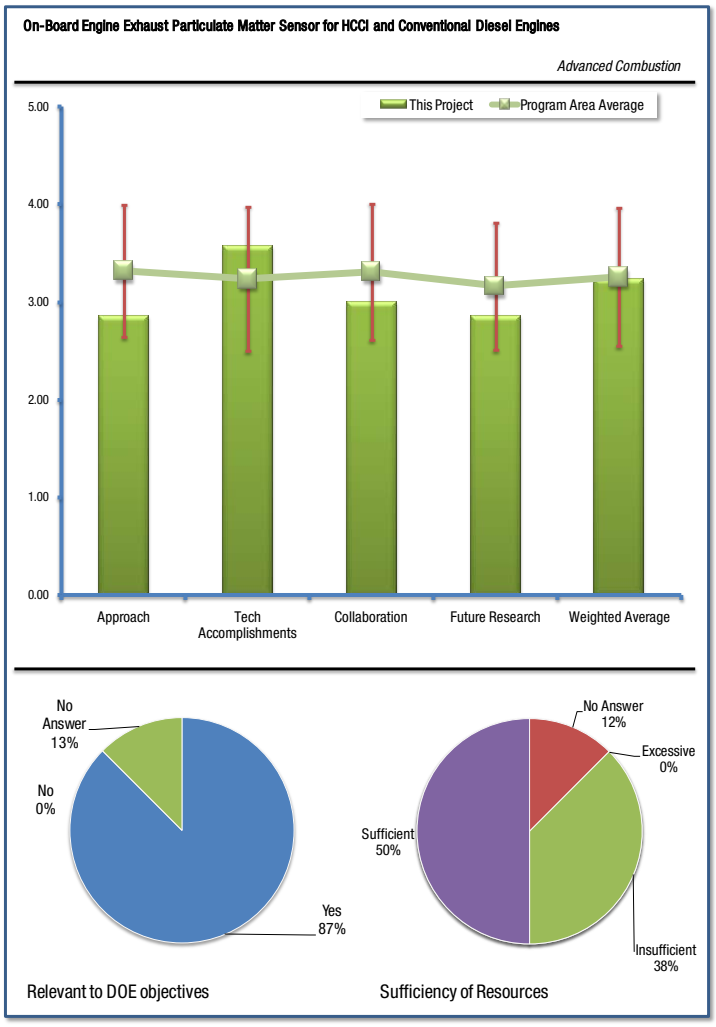
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the progress on the actuator appears to be reasonably good, but it is very unclear what the benefit to VCR in a gasoline engine downsizing program might be. The efficiency gains are very nebulous, since the intent is to have very high CR but throttle the engine heavily for medium load output. It needs to be shown much more clearly that there are efficiency gains to be had in this approach, since the cost and manufacturing issues are likely to be high compared to current technology. It would be critical to display that the engine has significant benefit to run highly throttled at high CR, versus mostly open throttle at lower CR. Another reviewer noted the plan is in place. The project should be targeted more on SI engine rather than diesel for initial application. One reviewer mentioned the engine testing will be interesting but they did not hear a plan to really run tests or come to an evaluation of the concept.

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

A reviewer stated if the goal of the project is to validate the actuation mechanism; the resources appear to be sufficient. However, the case needs to be made much more clearly that this VCR approach is worth doing in the first place. Another reviewer commented the project probably will require much more effort to demonstrate conclusively. One reviewer noted there is no apparent plan to test it once it has been built.

On-Board Engine Exhaust Particulate Matter Sensor for HCCI and Conventional Diesel Engines: Matt Hall (University of Texas at Austin)



Reviewer Sample Size

This project had a total of 8 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the device could be quite useful in managing DPF regeneration, OBD, and HCCI control if successful. Another reviewer added the pursued work is very relevant to ensure smooth operation of advanced diesel engines that offer high efficiency and low emissions. The PM sensor that is being developed can enable the use of advanced closed-loop controls in addition to engine component failure detection. One reviewer commented a good Pm sensor in front of the DPF can help minimize the fuel usage for DPF regeneration, by avoiding unnecessary regenerations while another reviewer said PM sensors allow auto manufacturers to use PM filters more effectively. Comments from another reviewer mentioned the PM sensor provides a potential enabling technology for aftertreatment (DPF) failure detection, and possibly for closed loop feedback for HCCI type combustion. Observations from one reviewer noted it is extremely relevant and important to enable advanced emission controls which will lead to more optimal regeneration strategies, OBD, and ultimately more efficient engines. Another reviewer stated the PM sensor has been a highly desired diagnostic in this program for years. Closed loop control of the advanced diesel could hinge on exhaust sensing to best balance NOx, PM, and fuel consumption. Sensor sensitive and cheap enough for OBD such as downstream of the DPF would be desirable as well. Relevance of a sensor is high; however focus of this project could be 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?

A reviewer stated the project does not appear to have clear and measurable targets- accuracy, durability, sensitivity, response time, temperature range, etc. Without this, it is not possible to design an appropriate evaluation program or to judge progress. Another reviewer noted the approach followed is novel - it encompasses simplicity with the needed performance. The reviewer would have liked to have seen a performance comparison with established instrumentation in addition to light extinction. One reviewer mentioned the need for the Cummins engine data was highlighted in the presentation. Hopefully, this will provide answers to many of the questions of calibration, sensitivity, and compatibility with various sensor locations. Comments from another reviewer added they would suggest modifying the project plan to have Cummins help answer some of the calibration questions. They have the instruments needed to correlate the sensor output to particle number & size, as well as mass. This information will be critical to making the go/no go decisions for various applications of the sensor. The reviewer would have rated the approach outstanding if the PM measurements were made with a CVS/dilution tunnel. They are afraid that PM mass

may be lost in the sampling system. The reviewer believes a lot of PM's would have condensed on the walls of the sample bags. Observations from one reviewer commented that more information is necessary on sensor sensitivity to exhaust temperature and pressure. The presenter showed velocity sensitivity. What is the impact of that in a real world environment? Does it change with temperature and pressure? If the pressure is sensitive that would be an issue upstream from DPF. Another reviewer stated early experiments with vehicle perhaps not best route but understand necessity while waiting for Cummins engine. The reviewer would like to see more data to support comment that sensor output is linearly related to soot density. That was not clear from soot data or the opacity measurements. One reviewer said the approach is okay but sensing before and after the DPF seems very challenging with the same sensor. The innovation of the sensing approach appears fine. The test and development that has followed seems somewhat meandering and overly ambitious. Blaming the partner (Cummins) for lack of an engine for testing is a bit unprofessional (several shots at Cummins for their tardiness). A more appropriate statement would be to simply state that Cummins had some internal issues that delayed delivery of the engine. As one reviewer pointed out, if testing the sensor downstream of a DPF was an important milestone, there are numerous diesel vehicles equipped with DPFs are available in the marketplace that could be rented to test the sensor downstream of a DPF.

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

A reviewer stated that despite lack of clear targets, the work is very promising. This should drive strengthening the approach rather than stopping it. Another reviewer added that within the limited budget, the researchers have made excellent progress. One reviewer commented the results to date look very good. They would like to see a correlation of engine-out PM in g/kWhr to PM concentration in mg/m^3. This would help the reviewer understand if the PI is getting low enough in measurement. Comments from another reviewer mentioned the level of accomplishment in this program is impressive with the very modest funding level. However, the reviewer does believe there is a significant amount of work left to be done to make the sensor commercialization ready to hand off to your partner Ceramatec or someone else. Observations from one reviewer noted the have followed the progress of this project while at USCAR. UTA has come a long way with little budget, nicely done. Another reviewer stated more information on sensitivity and linearity would be helpful to better understand actual status of sensor. Also as one reviewer commented, a set of specifications and well defined intended use is necessary. If only interested in DPF failure, requirements would be "softer" than necessary for cylinder-to-cylinder balancing or HCCI feedback control. Vehicle vs. engine tests showed considerable difference in sensor sensitivity. This reviewer does not believe 204 vs. 350 mg/m^3 V to be "close". Why such a large difference? Was there an error in measurement method, i.e., vehicle versus steady state engine? One reviewer said the progress appears modest, but is okay considering the budget. The project could have tested sensor downstream of a DPF by renting or borrowing a late model diesel vehicle.

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

A reviewer stated stronger links with the engine company should be established to clarify targets and improve development process. Another reviewer commented their teaming with Cummins and an instrument developer is commendable. Recommend working with a national lab that already has the needed instrumentation for performance evaluation of the sensor. One reviewer mentioned a good partnership with Ceramatec and Cummins make a well diversified team. Since the engine data seems to be behind schedule, perhaps Cummins could do some engine testing or durability testing to help catch up and finish this project on schedule? Comments from one reviewer noted they have followed this project through USCAR and it does have several collaborators. They are not sure how serious Cummins Engine is but the collaboration with the other partners is good. Observations from one reviewer added the collaboration plans is good. The project has included a commercialization company and an engine company. Unfortunately the engine company is not as responsive as one would hope, but appreciate challenges engine companies are facing in current market. Another reviewer stated a Cummins engine was donated, but is Cummins really involved other than supplying the engine? Collaboration with the sensor company is good if the technology is to be commercialized.

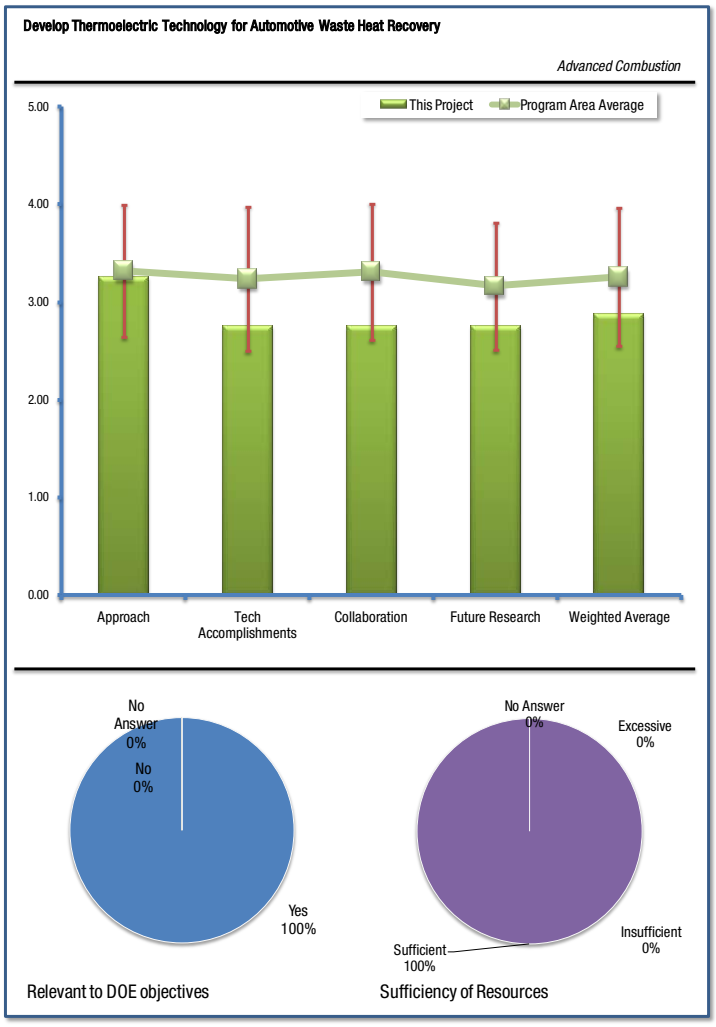
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated that better planning is needed. Another reviewer noted it is a well known fact that the charge on PM emissions varies with engine load and speed. It might be worth to conduct two sets of tests: one with charge neutralization prior to use with the sensor, the other without neutralization. One reviewer commented they think this sensor belongs in front of the DPF and then it can be used to prevent DPF failure and plugging. Comments from another reviewer mentioned the future work appears to be right on target to address open issues that remain to be resolved. The reviewer somehow doubts that they can be completed by the end of this year. The PI should request an extension of this program, as it could be valuable in particular for DPF failure detection, as you indicated. Observations from one reviewer added there is still a lot of work to be done in a short time. Another reviewer stated the project appears to be on path this year but really need to make sure final iteration is well defined to meet a specific purpose. One reviewer said UT should better define goals of the project. After Q&A, the speaker finally settled on the OBD application of the sensor being the main thrust, but also mentioned HCCI control, upstream of DPF sensing, etc. If OBD is the primary objective, then a post-DPF test should have had higher priority. Multiple applications have different requirements. Again, the innovation here is good and interesting and may show promise, but the research could be better focused.

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

A reviewer stated that more resources are needed to do the proper job. If it is promising, maybe added funding could be found from a sensor company or engine manufacturer. Another reviewer mentioned it looks like some more work to be done, but this might be the potential manufacturer's responsibility. The funding level needs to be increased and extended for another year to achieve the desired outcome of this project. One reviewer mentioned the project has good resources. Delays in Cummins dynamometer engine is outside of the control of presenter. While vehicle tests are probably not perfect for calibration, it is good to proceed with that method so program does not stall while waiting for a dyno engine. The resources appear fairly moderate. However, this reviewer does not recommend a large increase in funding for UT. The sensor manufacturer probably has enough at this point to take the sensor to commercialization. Perhaps a neutral third party assessment of an advanced prototype would be appropriate here.

Develop Thermoelectric Technology for Automotive Waste Heat Recovery: Jihui Yang (General Motors Corporation)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the objective is to obtain a 10% improvement in fuel economy without increasing emissions. Another reviewer added these waste heat recovery programs in general are a great example of government sponsored research. One reviewer commented the modeling indicates that they will improve fuel efficiency by 5% in large SUV. However, there are a number of assumptions that went into that model that have yet to be verified. Also, the goal of the program is a 10% efficiency gain. Comments from another reviewer noted this project supports the overall DOE objectives of petroleum displacement since the TEG converts waste heat from exhaust gas to electrical power, thus the engine will be more efficient resulting in less fuel 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?

A reviewer stated a systems-level approach has been taken. This will ensure a high probability of successfully overcoming barriers and achieving success. It would have been helpful to learn exactly what barriers were encountered. Another reviewer commented there is a good combination of modeling and hardware testing. One reviewer noted the approach is valid. However, they are heavily dependent on the success of their high temperature material. ZT claims are just for n-type and at material level. At this point in the program they should be measuring module level ZT. Are they really seeing 850°C at the hot side of material? Skutterudite stability at high temperature is a known issue and is not addressed (as it is in MSU program). Comments from another reviewer mentioned the project is well thought out and all the barriers are addressed adequately.

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

A reviewer stated a systems approach is critical to advance this technology. Such an approach appears to have been taken, but one would expect a clearer identification of the barriers to evolve by exercising the model that was discussed. For example, it is well known that increases in ZT will increase the efficiency of the thermoelectric device, but at a decreasing rate. Therefore, at some point further increases in ZT are no longer cost-effective and would begin to adversely affect the stated performance metric of dollars-per-Watt. Because a systems level model is presumably in place, it would be very important to know what ZT value corresponds to the maximum dollar-per-Watt metric (it is not a ZT of infinity). Another reviewer mentioned the project seems to be coming up short of the 10% goal. Can 10% be achieved? If so what is the path to reach this level? One reviewer added it seems they have made little progress over the last year. At last year's review, they extensively discussed their new test facility, but didn't show any data

from it. All of new data was based on simulations. They still haven't finalized thermal system design. Most of the materials are still legacy. Comments from another reviewer noted significant technical accomplishments have been demonstrated toward DOE goals.

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

A reviewer stated they did not see evidence of strong collaboration with other institutions, although collaboration among the various topics (materials, thermal control, and electrical control) appears to be good. Another reviewer added there is a good mix of government labs, universities. Are there other companies that could pick up GE's role? Are there other suppliers that could commercialize the product if it is worthy? One reviewer noted there is very little discussion of work going on at other institutions and how it is integrated. GE pulled out and was responsible for much of thermal system design and experimental verification. There was no discussion of the role of ORNL, BNL, USF. Comments from another reviewer mentioned they would strongly recommend that the TE material properties needed to be verified by NIST before commercialization.

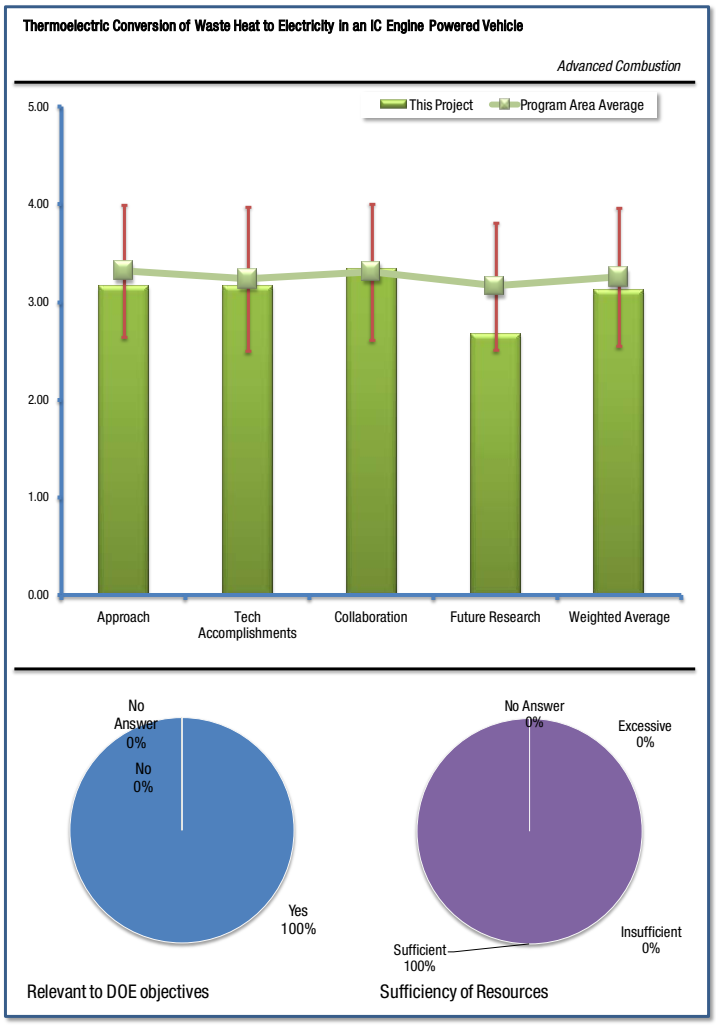
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they did not see a strong discussion of barriers in the future proposed research. Another reviewer asked if FE improvements can be increased. Otherwise this showed a good plan. Does further material research need to be conducted for better performance? One reviewer added the plans are clear, but seem similar to last year's. Comments from another reviewer noted the proposed future research is logical and technically sounds. However, the estimate cost of the devices in terms of dollars per watt should be included.

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

A reviewer stated it seems like they have received very little of their FY09 funds. $700K per year doesn't seem adequate to perform this work. Another reviewer noted this project is very interesting and if it is successfully accomplished, we will benefit a lot from this program. This project should be continuously funded.

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



Reviewer Sample Size

This project had a total of 6 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the goal is to provide a 10% improvement in fuel economy for an over-the-road truck. Another reviewer noted thermoelectrics have the potential to improve vehicle overall thermal efficiency and reduce fuel consumption. One reviewer commented thermo-electric generators have the capability to use exhaust heat to create energy that can be put back into the vehicle system, lowering fuel consumption. Comments from another reviewer mentioned the project expects 3-5% efficiency improvement in large truck. However, the goal of the program is a 10% efficiency gain. Observations from one reviewer noted this project supports the overall DOE objectives of petroleum displacement since the TEG converts waste heat from exhaust gas to electrical power, thus the engine will be more efficient resulting in less fuel 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?

A reviewer stated the presentation was focused on materials development and increasing ZT. Discussion of other barriers was minimal. This is surprising, since the team that was assembled includes expertise over a broad range of skills. For example, there appear to be significant challenges in packaging the thermoelectric material in an effective manner, but full utilization of the team's cross-disciplinary strength in addressing packaging barriers was not evident. Indeed, the 14% efficiency that was included in the presentation is based upon surface temperatures of the thermoelectric material. The reviewer doesn't see how this definition of efficiency is meaningful, from the systems-perspective. Moreover, in the Q and A, it was indicated that the efficiency might drop to 3 or 4% if the efficiency is (appropriately) based upon exhaust and coolant temperatures. This implies that the primary barriers (10 or 11 out of the 14%) are not materials dominated, but are related to issues such as but not limited to: electrical and thermal contact resistances (CTE issues), control of convective heat transfer external to the thermoelectric material, and electronics control. Another reviewer commented the approach appears to be very sound, with good focus on addressing the overall system technical barriers and not just the material barriers. One reviewer asked does more work need to be done on basic materials? Is there a theoretical limit to these devices? Comments from another reviewer noted the focus is on development of high temperature materials with suitable thermal and mechanical properties. A number of different materials have been considered and they have shifted to skutterudites this year as a result of improved thermal stability. Observations from one reviewer added the project is well thought and all the barriers are addressed adequately.

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

A reviewer stated the team has made impressive strides in materials development. However focusing on increasing ZT may be misleading. Something akin to "dollars per Watt" might be used. It is well known that increasing ZT will increase the efficiency of the thermoelectric material, but at a decreasing rate. This implies that an optimal ZT value exists, in order to maximize the dollar-per-Watt metric (and the optimal ZT value will not be ZT equals infinity). Another reviewer added this project has demonstrated excellent progress toward the goal of overcoming the barriers to TE technology, with more than one path to success as advancements and discoveries are made. One reviewer noted hopefully the second phase will be complete soon. They would like to see a demonstration on a truck. Comments from another reviewer mentioned that barriers appear to be in the basic material capability that is not covered by this project. Otherwise the progress in developing a system and manufacturing parts is impressive. Observations from one reviewer commented the project seems to have made major shifts in program over the last year and are now focusing on skutterudite materials developed at JPL. The PI needs to clarify relationship of materials development under this program and other government funding. No progress reported on development of segmented materials which is one of the objectives of this program. Underestimating the significance of cold side heat transfer is a problem. Another reviewer stated significant technical accomplishments have been demonstrated toward DOE goals.

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

A reviewer stated the team that was assembled appeared to be cross-disciplinary. However, the reviewer did not see a strong evidence of coordination, given the focus on materials development. Another reviewer commented this is an excellent team and the partnership with Cummins will prove to be invaluable as the project moves forward. One reviewer mentioned there is a strong collaboration with JPL and Iowa State in materials development. The project will need a closer relationship with Cummins as they move toward generator integration. Comments from another reviewer noted they would strongly recommend that the TE material properties needed to be verified by NIST before commercialization.

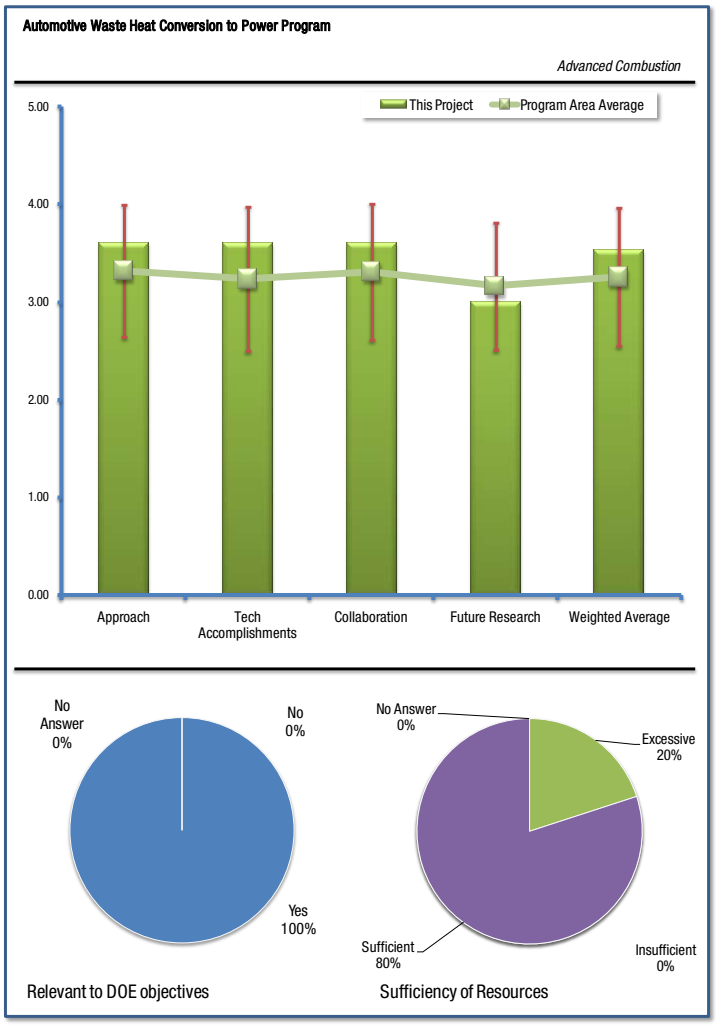
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they did not note a strong vision of future work. Another reviewer noted the plan for the future appears to be adequate to realize the proposed gains. One reviewer added it was mentioned that idling of busses in cities could be used to run APU's. Most large cities have anti-idling ordnances. Also, there is not a lot of heat in the exhaust of an idling diesel engine. High load appears to be where this technology would be effective. Comments from another reviewer mentioned it seems they still have parallel materials development of the segmented PbTe-PbS/LAST system and the skutterudites. At this point they should be making a down select and working on scaling selected approach. Observations from one reviewer commented the proposed future research is logical and technically sounds. However, the estimate cost of the devices in terms of dollars per watt should be included.

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

A reviewer stated the resources appear to be sufficient. The team might want to focus more on optimizing the system behavior. Another reviewer added the resources appear to match the expected outcome. One reviewer noted the resources seem sufficient for level of effort while another reviewer said it is a very good project and it should be continuously funded.

Automotive Waste Heat Conversion to Power Program: John LaGrandeur (BSST LLC - Amerigon)



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the project objective is to obtain improvement in fuel economy. Another reviewer noted this project is to develop TE technology supports the goal of increasing fuel efficiency. One reviewer commented the project has shown fuel efficiency improvements of 3% for available TE materials. Modeling indicates that a 10% improvement is possible, but that model may have unrealistic assumptions. Comments from another reviewer mentioned this project supports the overall DOE objectives of petroleum displacement since the TEG converts waste heat from exhaust gas to electrical power, thus the engine will be more efficient resulting in less fuel 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?

A reviewer stated a systems-level approach is taken. A very clear explanation of the many technical barriers was presented. This was the most impressive presentation this reviewer saw, based upon what they felt was a very clear identification of issues such as electrical and thermal contact resistance due to CTE mismatch, electrical control, materials development, and packaging. Another reviewer commented the approach appears to be very sound to identifying the barriers to this technology and plans to understand and overcome those barriers. One reviewer mentioned some novel solutions to the barriers are encountered. Cost benefit was not discussed. Evidently it is good enough for the OEM's to be proceeding. Comments from another reviewer added the project is evaluating a number of thermoelectric materials for performance at the couple as well as module level. The project plans to develop a segmented device with BiTe and selected high temperature material. A rigorous system level design approach used throughout. Observations from one reviewer noted the project is well thought and all the barriers are addressed adequately.

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

A reviewer stated the technical barriers were clearly identified, and this has led to a novel stack design that shows promise. The efficiencies of the device were defined in terms of the overall temperature difference (from exhaust gas to coolant) in the system, which is relevant and was refreshing to see. An upfront discussion of efficiencies was provided, along with a discussion of the reported efficiencies not being maximized due to a mismatch with the electrical load used in the simulation. This is a very creative and exciting project. Another reviewer mentioned this section would have been rated outstanding had the single-cylinder engine test been accomplished - things certainly break during projects like this, so it is fair to acknowledge that; but the fact remains that there are considerable things to learn from implementing this technology on an engine. One reviewer commented this is a very well coordinated

and organized project. Comments from another reviewer noted the project has demonstrated 530 W of power production under realistic conditions using a segmented TEG. This is a major accomplishment. The project has also made progress on all components of system from new materials to power electronics. Thorough evaluation is needed of available materials and selected half Heusler alloys which are manufacturable in volume quantities. Significant modeling advancements were made this year, but haven't yet quantified system benefit of increased ZT. Observations from one reviewer added significant technical accomplishments have been demonstrated toward DOE goals.

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

A reviewer stated they did not see evidence of collaboration among institutions, but the systems-level approach suggests strong collaboration among individuals with different technical skill sets. Another reviewer noted this project appears to have excellent collaboration with the project partners, both OEM's, Tier I's, National Laboratories and Universities. One reviewer added there is great leveraging of OEM's and labs. Comments from another reviewer mentioned this is a very strong team. They have demonstrated their module on a Ford engine and plan demonstration this year using a BMW engine. These parallel paths strengthen possible commercialization of developments.

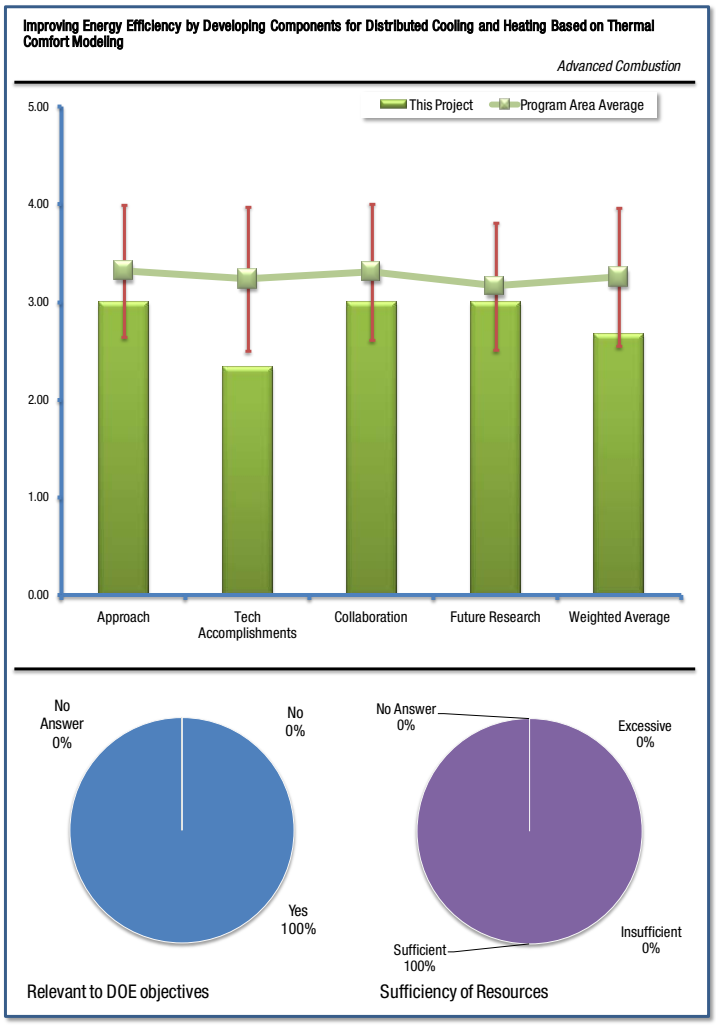
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they did not see a strong vision of future work. Another reviewer mentioned that installing this device at NREL to perform multi-cylinder testing is a great step. One reviewer commented the future work is tied to vehicle integration and scale-up issues appropriate for last phase of program. They are well positioned to demonstrate 500 W modules on actual engine at NREL this year. Comments from another reviewer noted the estimate cost of the devices in terms of dollars per watt should be included.

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

A reviewer stated the only negative to this project is that it seems that the funding distribution is overwhelmingly DOE, with the industrial cost share is roughly 25% of the total, rather than the approximately 50% of the total in several other projects. Another reviewer noted the resources seem sufficient for level of effort. One reviewer mentioned it is a very good project and it should be continuously funded.

Improving Energy Efficiency by Developing Components for Distributed Cooling and Heating Based on Thermal Comfort Modeling: Ed Gundlach (General Motors Corporation)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the objective of this new project is to obtain increases in fuel economy by providing customized TEM-based thermal management for passenger comfort. The relevance to hybrid vehicles, all-electric vehicles, and high efficiency ICE-powered small vehicles, is evident. Another reviewer noted that improved energy efficiency through distributed TE cooling supports overall DOE goals. This program may have more significant impact on DOE goals than waste heat power harvesting. One reviewer mentioned this project does help the engine runs more efficient by using less fuel consumption for automotive HVAC system.

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 stated the approach being taken is interesting and appropriate, although some thought should be given as to the relevant metrics for system performance (for example, an uncomfortable passenger is likely to spend less time driving...). No discussion of technical barriers was presented, although the reviewer imagines these will become evident as the research progresses. Another reviewer commented the project plans to develop system model and distributed HVAC components for a light duty hybrid vehicle. There is a strong focus present on developing a human comfort model from human testing which can be integrated into their vehicle system design tool. This will lead to specifications for the cooling and heating components. The approach lacks depth on the technological innovation expected. The PI provided no details on thermoelectric materials for the HVAC application or components they plan to develop.

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

Three reviewers stated not applicable since the program is just starting. One of the reviewers went on to say the only reason they are giving this a "poor" rating is because the project appears to be so new that there aren't any accomplishments of note yet, and the technical barriers haven't been well-defined at this stage.

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

A reviewer stated the collaboration with researchers at Berkeley is noted. The reviewer assumes further collaborations will be forthcoming. Another reviewer noted there are good partnerships with academia and will have to see if they deliver.

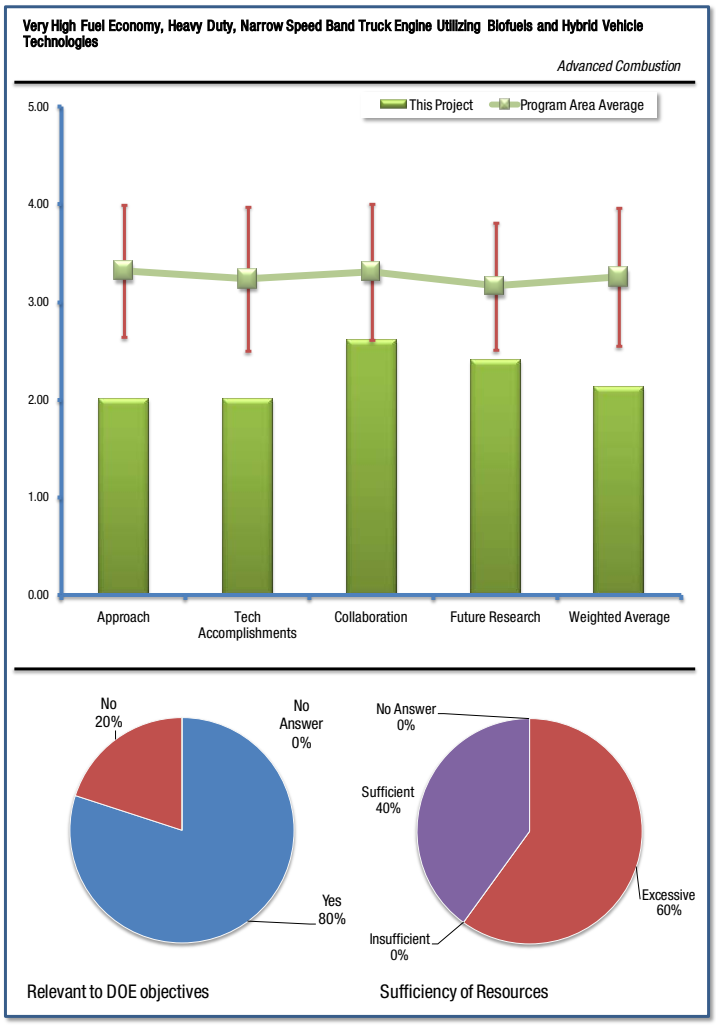
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the details are lacking and they assume these will become clear in the near future. Another reviewer commented the proposed research is consistent with goals and approach. Too early to tell how this will evolve.

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

A reviewer stated it is too early to say much. Another reviewer noted the resources seem sufficient for this project.

Very High Fuel Economy, Heavy Duty, Narrow Speed Band Truck Engine Utilizing Biofuels and Hybrid Vehicle Technologies: Chun Tai (Volvo)



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this project does address several efficiency improving technologies, such as WHR and biofuel use. Another reviewer noted most of the class 8 trucks that use HD diesels cruise at more or less a constant speed over the interstate. The fraction that is subjected to stop and go driving is very small - as in waste haulers. As a result, the proposed strategy of an optimized engine for a narrow speed range compounded with mild hybridization offers very little promise to displace our oil usage. The benefits cannot justify the large investment by DOE. One reviewer commented the overall goals are acceptable, but it is not clear why there is not a specific goal for amount of fuel consumption reduction. Comments from another reviewer mentioned this activity appears to support efficiency/emissions activities toward reduced petroleum consumption. Mild hybrid, fuel research, and narrow band operation are all relevant topics. Observations from one reviewer added the project appears to be investigating a wide range of technologies that are all of interest and have potential to displace petroleum. The end point of the program is to build two demonstration vehicles featuring many advanced technologies. The presentation was not terribly clear, and many details had to be fleshed out during Q and A.

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 stated this project does not seem to be well-integrated with regard to the various technologies that were under study/exploration. It isn't entirely clear which barriers were being addressed by each technology, and why they are better in concert than individually. There does not appear to be much effort spent integrating these project aspects and may be better served by focusing upon the narrow-band engine operation and the hybridization rather than the other aspects. Another reviewer added the initial reaction to the proposed strategy - of highly optimized narrow speed range HD diesel along with mild hybridization - is overwhelmingly positive. However, a careful review shows that with a typical class 8 spending 80% of its life cruising on the interstate, the technology offers very little promise. The idea of improving the tolerance to a variety of fuels while the basic concept itself is yet to be proven is not the right approach. Recommend a two stage process: (1) develop a HD diesel with improved system efficiency, and subsequently (2) improve the tolerance to a variety of fuels. One reviewer mentioned this appears to be a shotgun approach. It was difficult to put the pieces of the puzzle as presented and figure out how they fit together. These appeared to be three separate efforts and not connected to one another. The reviewer requested that the PI please show the tie in between these three areas and how they achieve some specific overall goal. Comments from another reviewer noted the overall approach was very difficult to understand. The Q&A cleared up some of the issues. Most

notably was the presentation of a plan with four stages with current activities in the first stage. This status was estimated as 80% complete with overall completion in September 2009. Through further questioning, it turned out the proposed budget and plans were only for stage one. There appeared to be no clear plan (or at least explanation) for who would fund the last three phases of the activity. This project is very confusing overall. Also there was a slide on stoichiometric diesel with no real explanation who the purpose. Observations from one reviewer commented that after Q&A, the reviewer feels that the approach is probably adequate, although based only on the presentation one might conclude that it is a disjointed array of investigations. The reviewer is being generous and giving the contractor the benefit of the doubt with this score, but strongly recommends better preparation for the next Merit Review.

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

A reviewer stated again, it looks like there has been decent progress made in the areas of narrow-band engine operation and some progress made in turbocompounding, but very little progress or integration of the biofuel or other portions of the project. The "stoichiometric diesel" portion was particularly poorly explained with regard to why it addresses the DOE goals. Another reviewer commented per the presented material at the peer review it was apparent that very little thought went into charting a course or executing the program. It appeared to be a concoction of disjointed efforts. Details as to why a stoichiometric engine development was pursued, details of the waste heat recovery strategy, some schematics, would help evaluate this program better. In their absence, this program cannot be rated very high. One reviewer noted overall accomplishments were disappointing considering the level of funding received to date. FY09 funding was small. Comments from another reviewer mentioned as with the approach, this was very confusing. It was not clear that much technical progress had been made on the activity. The reviewer realizes it is extremely difficult to present a lot of accomplishments in such a short period of time, but the accomplishment seemed like a collection of random items. The reviewer thinks there is probably some good work here and it just did not come through in the presentation. Observations from one reviewer added the presentation and follow-up questions indicate that Phase 1 is 80% complete, but it did not appear that any decisions were forthcoming about the approach for subsequent phases.

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

A reviewer stated the presentation was very unclear as to the roles of each partner and which portion of the effort was accomplished by each. There is a general impression of "lack of coherence" with the entire project. Another reviewer added from the presented material there was very little collaboration with other institutions. One reviewer mentioned maybe the project could include an academic institution too, particularly in the biofuel portion. Comments from another reviewer noted the list of partners was good and there is collaboration with the U.S. Government. There was not much explanation on the collaborations beyond the overview slide. Observations from one reviewer commented Volvo, Mack, SwRI, AVL, and Ricardo could certainly make a formidable team for development, design, and build up of a demonstrator vehicle. It was not clear that all team members contributed or what individual team member responsibilities are.

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?

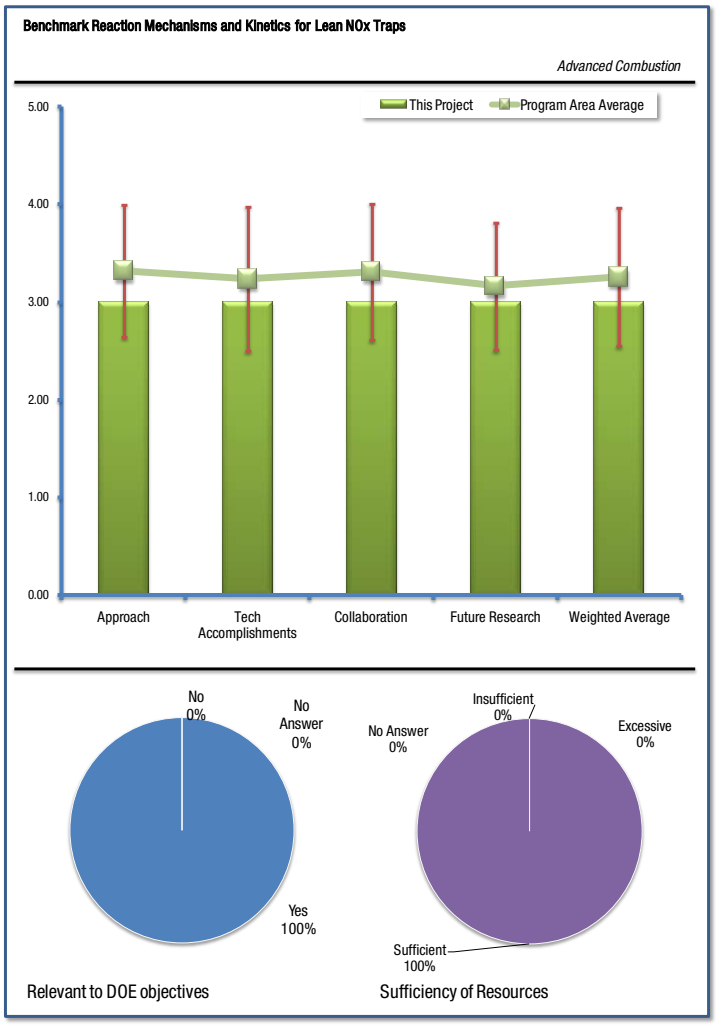
A reviewer stated if the project focuses upon the portions of the project that have been successful to date, then it is worth continuing. However, there is no clear plan to describe how the future work will be integrated into the current work or how the current work will enable the other portions of the future work - i.e. biofuels etc. Another reviewer noted they recommend developing a project roadmap and a schedule. The one presented was very feeble. One reviewer commented please provide more detail on this for future reviews. Comments from another reviewer mentioned the plan forward sounds interesting. There are three more phases with demo vehicles in the end. What was not clear is whether this work would be funded internally or in part by the DOE. More detail on proposed timeline and funding sources would have been good. Observations from one reviewer added the plans may be better

than what was presented, but based on presentation and discussion, the reviewer feels that the leaders of this program could be more focused.

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

A reviewer stated the resources do not appear to balance with the limited, incoherent results. The project must be managed more effectively to accomplish the stated goals. Another reviewer commented the progress made is not commensurate with the lump sum award of $2.75 million. One reviewer mentioned this is a hard question to answer sometimes. The reviewer marked sufficient for resources due to collaborations and apparent commitment of Volvo to the four phases, but they simply could not understand what resources were being brought together for this activity. Comments from another reviewer noted it is not clear what the budget beyond the first $3 million of DOE funding would be. Industry cost share of $6 million is laudable. High risk technologies are worthy of government investment, but with limited government funds, DOE should look hard at whether better bang for the buck could be had elsewhere; or, DOE should fund future phases of this program only if the contractor can show a more convincing plan forward.

Benchmark Reaction Mechanisms and Kinetics for Lean NOx Traps: Richard Larson (Sandia National Laboratory (SNL)) - POSTER



Reviewer Sample Size

This project had a total of 1 reviewer.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated after treatment component modeling is part of a comprehensive approach to optimizing after treatment architectures. This work is the most detailed micro kinetic like approach that we have on our collective plate. It is pre-proprietary and needs to continue. Personally the reviewer would prefer this detailed modeling to be directed toward ammonia SCR.

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 stated they are not personally convinced that developing converter kinetics is best done using ramp and step reactor experiments. Those types of experiments are actually designed to provide a conceptual understanding of the component response. The reviewer believes that a comprehensive approach to developing kinetics involves the use of isothermal like experiments where the inlet concentrations are varied based on design of experiment type approach. The collaboration between SNL and ORNL has progressed to that unified approach.

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

A reviewer stated that refining the kinetics is a very difficult task. The PI has been solidly successful. It is disturbing that Rich has not been able to assign some of the prediction anomalies to specific sub models in the mechanism. That seems to imply that there are missing or incomplete sub models. Resolution of this situation is important.

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

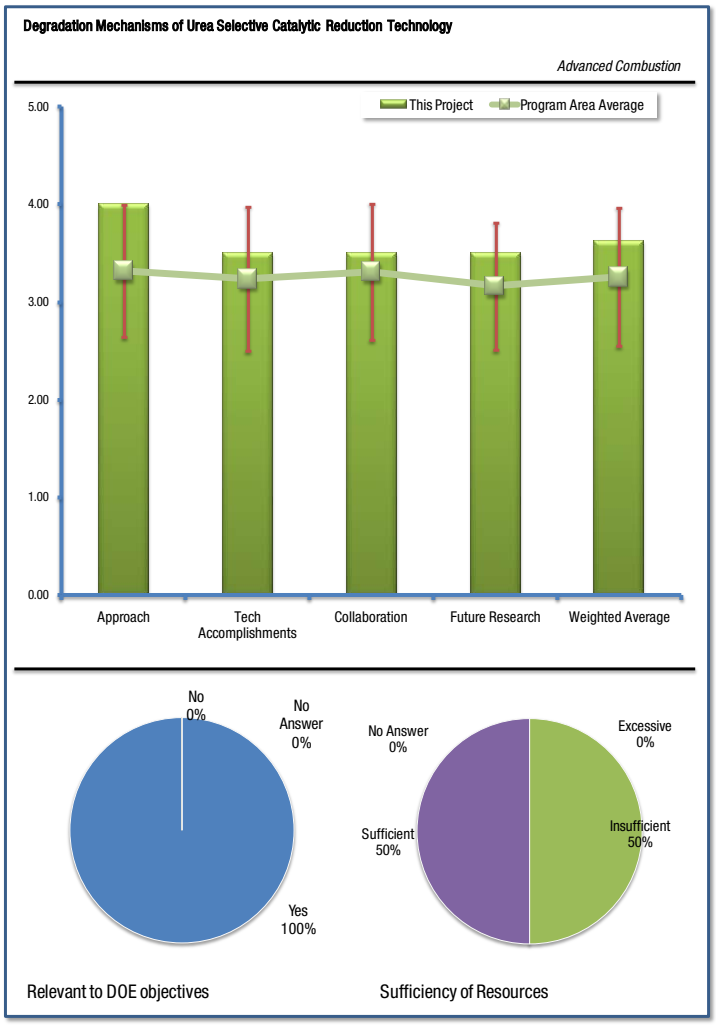
A reviewer stated the interaction between SNL and ORNL is outstanding. They do believe that a more comprehensive approach to rate contact development which requires even more synergy between the experiments and modeling is needed.

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 stated the future plans are quite good at providing closure to this work. They are well designed to accomplish that goal.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated there is very nice utilization of resources at two separate National Labs.

Degradation Mechanisms of Urea Selective Catalytic Reduction Technology: Charles Peden (Pacific Northwest National Laboratory (PNNL)) - POSTER



Reviewer Sample Size
This project had a total of 2 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?
A reviewer stated that SCR catalyst durability is critical to future diesel vehicle 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?
A reviewer stated the approach capitalizes on PNNL core competency and addresses critical industry needs. Another reviewer noted the application of PNNL's state of the art analytical methods to production-like catalysts will provide very valuable insights on aging mechanisms.

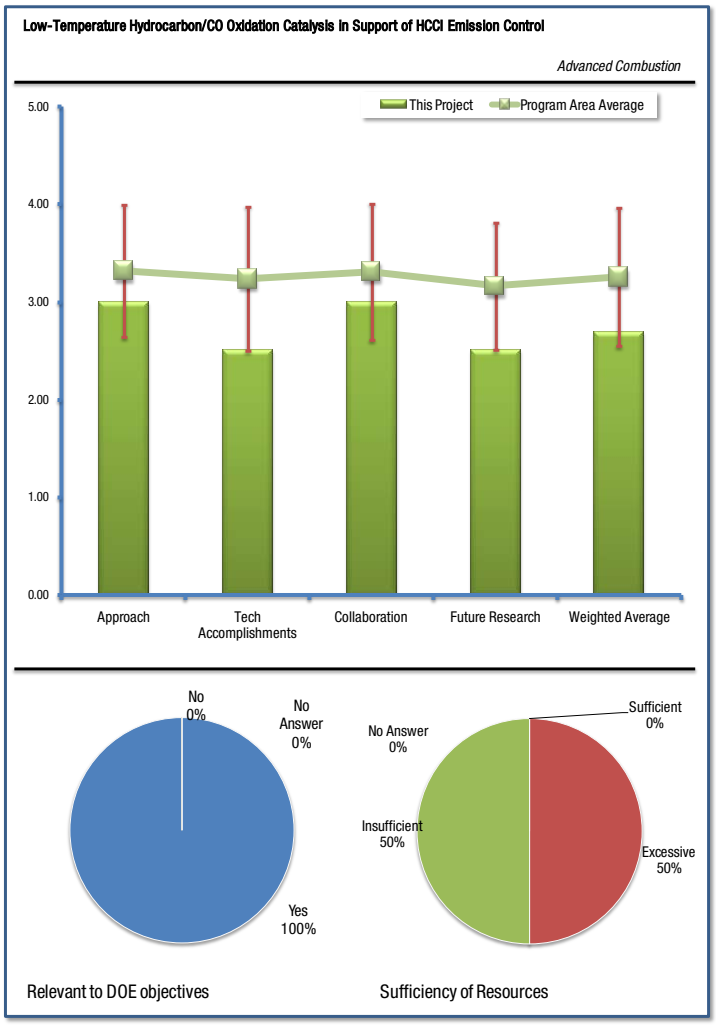
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
Both reviewers stated the program just started and it seems to be on track for a good start.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated there is a good GM-PNNL interaction. Another reviewer noted there is collaboration with GM for CRADA.

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 stated they suggest involving the internal GM customer (AT advanced dev team) into this for guidance and expedient tech transfer in the future. Another reviewer added there is a good plan to support development of improved catalysts.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated $100K is part of a junior researcher; this really limits how much can be done.

Low-Temperature Hydrocarbon/CO Oxidation Catalysis in Support of HCCI Emission Control: Ken Rappe (Pacific Northwest National Laboratory (PNNL)) - POSTER



Reviewer Sample Size

This project had a total of 2 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the goal does support the overall DOE objectives of petroleum displacement. They do believe however that the approach is seriously flawed. Another reviewer noted that low temperature oxidation of CO and HC is critical for future systems, especially hybrid.

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 stated the major weakness is the lack of catalyst aging. None of these results can be viewed as valid unless a reasonable aging was done on each sample. There was little point in investing much analysis time into any of these formulations until they are shown to have a reasonable resistance to thermal aging. Another reviewer added this is a good approach to find improved catalysts.

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

A reviewer stated that without aging evaluations none of the conclusions can be viewed as relevant to the goal of the project. Another reviewer mentioned that good results were achieved.

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

A reviewer stated it is apparent that the interaction between Caterpillar and PNNL was regular and frequent. Another reviewer noted there was collaboration on CRADA with OEM manufacturer. Perhaps it would have been stronger is a catalyst supplier were willing to participate.

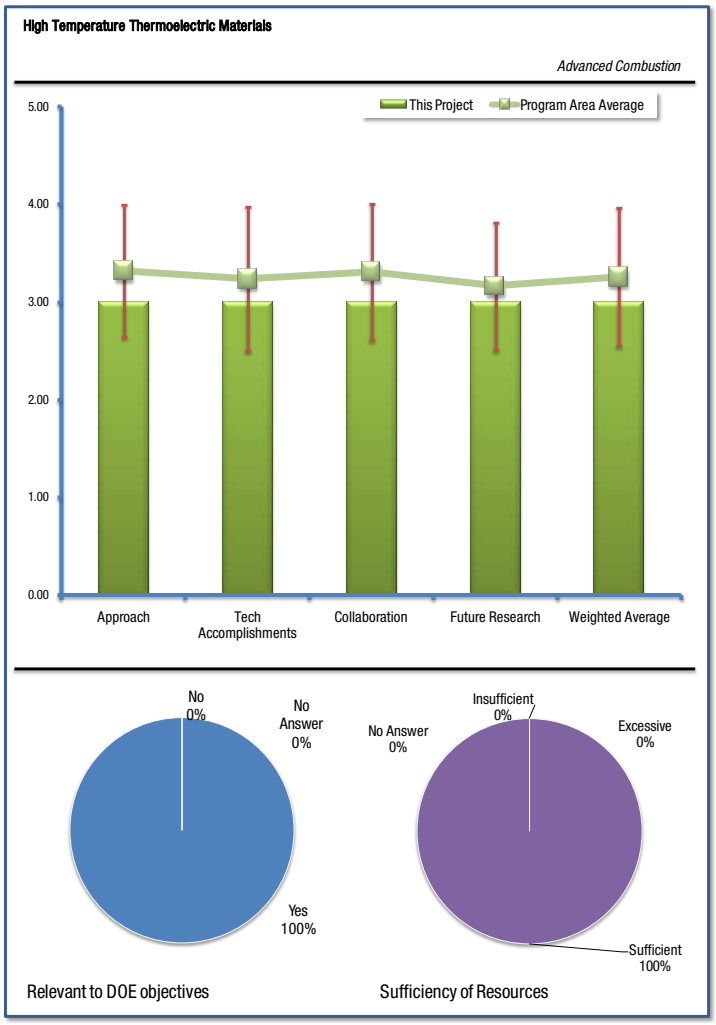
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Both reviewers stated the project is complete. One reviewer added if a continuation is contemplated then I believe a major overhaul of the approach is needed.

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

A reviewer stated since they believe the approach is flawed then too many resources were applied to this project. Another reviewer noted the program has ended so this question isn't relevant.

High Temperature Thermoelectric Materials: Norbert Elsner (Hi-Z) - POSTER



Reviewer Sample Size
This project had a total of 1 reviewer.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?
There was only one reviewer for this presentation and they didn't comment on any of the questions.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
There was only one reviewer for this presentation and they didn't comment on any of the questions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
There was only one reviewer for this presentation and they didn't comment on any of the questions.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
There was only one reviewer for this presentation and they didn't comment on any of the questions.

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?
There was only one reviewer for this presentation and they didn't comment on any of the questions.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
There was only one reviewer for this presentation and they didn't comment on any of the questions.