4. Advanced Combustion Engine Technologies

Improving the efficiency of internal combustion engines is one of the most promising and cost-effective near- to mid-term approaches to increasing highway vehicles' fuel economy. The Vehicle Technologies Office's (VTO) research and development activities address critical barriers to commercializing higher efficiency, very low emissions advanced internal combustion engines for passenger and commercial vehicles. This technology has great potential to reduce U.S. petroleum consumption, resulting in greater economic, environmental, and energy security.

Already offering outstanding drivability and reliability to over 230 million passenger vehicles, internal combustion engines have the potential to become substantially more efficient. Initial results from laboratory engine tests indicate that passenger vehicle fuel economy can be improved by more than up to 50%, and some vehicle simulation models estimate potential improvements of up to 75%. Advanced combustion engines can utilize renewable, and when combined with hybrid electric powertrains could have even further reductions in fuel consumption. As the EIA reference case forecasts that by 2035, more than 99% of light- and heavy-duty vehicles sold will still have internal combustion engines, the potential fuel savings is tremendous.

The VTO undertakes research and development activities to improve the efficiency of engines for both light and heavy-duty highway vehicles, whether they run on petroleum-based (gasoline and diesel) or alternative fuels. We support every type of research in these areas, from fundamental science to prototype demonstration. The research focuses on improving engine efficiency while meeting future federal and state emissions regulations. It does this through four main approaches:

- Improving the understanding of advanced combustion processes, including how fuel properties affect combustion and emissions. Researchers then use this knowledge to refine combustion strategies and associated processes that minimize the formation of emissions within engine cylinders. In this area, we also research cost-effective aftertreatment technologies that further reduce exhaust emissions.
- Recovering energy from engine waste heat

Commercialization of these advanced combustion engine technologies could allow the U.S. to cut its transportation fuel use and corresponding greenhouse gas emissions by as much as 20 to 40%.

Research and development is done in collaboration with industry, National Laboratories, other federal agencies [such as the National Science Foundation (NSF)] and universities, as well as through government/industry partnerships:

- the U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability (U.S. DRIVE) Partnership focusing on light-duty vehicles
- the 21st Century Truck Partnership, focusing on heavy-duty vehicles

The major goals of the Advanced Combustion Engine R&D subprogram are:

- By 2015, increase the efficiency of internal combustion engines for passenger vehicles resulting in fuel economy improvements of 25% for gasoline vehicles and 40% for diesel vehicles, compared to 2010 gasoline vehicles. By 2020, improve the fuel economy of gasoline vehicles by 35% and diesel vehicles by 50%, compared to 2010 gasoline vehicles.
- By 2015, increase the efficiency of internal combustion engines for commercial vehicles from 42% (2010 baseline) to 50% (a 20% improvement). This goal is part of the overall SuperTruck initiative to increase Class 8 truck freight hauling efficiency by more than 50% by 2015. By 2020, further improve engine efficiency to 55% (a 30% improvement) with demonstrations on commercial vehicle platforms.
- By 2015, increase the fuel economy of passenger vehicles by at least 5% using thermoelectric generators that convert energy from engine waste heat to electricity.

Subprogram Feedback

DOE welcomed optional feedback on the overall technical subprogram areas presented during the 2013 AMR. Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

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

Question 1: Was the subprogram area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

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

Question 3: Does the subprogram area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Office's needs?

Question 4: Other Comments.

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

Subprogram Overview Comments: Gurpreet Singh (U.S. Department of Energy) – ace00a

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

Reviewer 1:

The reviewer stated that the sub-program area was covered fairly well. It took the realistic view that internal combustion engines (ICEs) would be around for a long time and mentioned that improving efficiency and reducing emissions were important goals. The presenter spoke about low temperature combustion challenges. The presenter also mentioned progress in modeling [both large eddy simulation (LES) and the conceptual flame model] as well as the reactivity-controlled-compression-ignition (RCCI) engine test work at Oak Ridge National Laboratory (ORNL).

Reviewer 2:

The reviewer noted that the sub-program was well described given the time slot. This reviewer would have enjoyed a longer presentation from the presenter with more details, as this reviewer thought this was a very important area with significant challenges and issues identified. Progress from the previous year was clearly identified and the challenges facing the current year and future years were also highlighted.

Reviewer 3:

The reviewer felt that the sub-program was adequately covered, adding that more effort could be spent in identifying and articulating challenges with advanced combustion concepts, such as transient control issues. While the programs were described in generic terms, progress in comparison to the previous year was not clearly presented.

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

Reviewer 1:

The reviewer remarked that the presenter mentioned the programs in the Advanced Combustion and Emissions Control (ACEC) research and development (R&D) that had been established to address issues.

Reviewer 2:

The reviewer acknowledged that plans for addressing many traditional issues and challenges with low temperature combustion had been identified. This person added that more emphasis could be placed on addressing the transient control issues with low temperature combustion.

Reviewer 3:

The reviewer commented that the plans for addressing the challenges, specifically bridging the fundamental research to the applied, were discussed. The one gap in the portfolio this reviewer saw was in incorporating university research into the program.

The NSF/DOE collaboration was a fantastic opportunity, but was only able to fund a very small number of projects. This reviewer added that a downside of this was that some of the traditional powerhouse universities in engine research (who have had long programs with DOE) were not funded in this mechanism, and the ability to leverage previous DOE investments was lost. Another issue with this call was that the reviewer felt that it was a little misleading in terms of the scope of the resources available per project. It was this reviewer’s belief that projects that went for close to the maximum (large-scope, large-team projects) were at a disadvantage in the review process due to their size.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program’s needs?

Reviewer 1:

The reviewer observed that this sub-program was very well focused, well managed, and had been very effective in addressing the DOE VTO goals.

Reviewer 2:

According to this reviewer, the area did seem to be focused and set up to address DOE goals and needs, and it seemed to be well managed.

Reviewer 3:

The reviewer asserted that the program was well focused and managed, and funding levels in the appropriate areas were properly balanced. However, with regard to the light-duty vehicle awards, this reviewer commented that management should continue to encourage progress in the primary areas of focus, which were advanced combustion strategies, aftertreatment technologies, and waste heat recovery (WHR). Without that watchful eye, this reviewer felt that the programs could be tempted to give up on the above challenging areas and instead focus on non-engine, non-combustion areas like vehicle- and chassis-level friction reduction (as one example).

Question 4: Other Comments

No comments were received in response to this question.

Subprogram Overview Comments: Ken Howden (U.S. Department of Energy) – ace00b

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

Reviewer 1:

The reviewer asserted that the emissions control program was very well covered. This reviewer added that the direction of developing integrated (with combustion) aftertreatment systems that minimized both emissions and the fuel penalty associated with aftertreatment was a very important issue. The challenge of hitting near-zero emissions was well defined. The progress from the last year was clear and healthy, despite the budgetary issues. This was a very important area, which this reviewer felt should have been the first one to receive additional funding if DOE got the requested budgetary increase.

Reviewer 2:

The reviewer expressed that yes, the sub-program was adequately covered and important issues had been identified. However, this reviewer added that progress in comparison to the previous year had not been clearly made.

Reviewer 3:

The reviewer affirmed that yes, the sub-program area had been appropriately covered and important challenges had been identified and addressed. However, this reviewer added that although individual catalyst technologies were in focus, combined technologies were not. Addressing combined catalyst technologies might be an important area of research to meet the aftertreatment needs of highly efficient engine and aftertreatment systems. This person added that the presenter had identified the correct barriers. The inclusion of low temperature aftertreatment research and development activities was critical to enabling highly efficient engines to enter the U.S. automotive market.

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

Reviewer 1:

The reviewer indicated that plans had been identified for addressing issues and challenges with the low exhaust temperatures that resulted from improving the efficiency of the internal combustion engine.

Reviewer 2:

The reviewer reported that, in general, plans appeared to cover the emerging combustion and aftertreatment needs of the automotive industry to meet very challenging fuel economy and emissions regulations. The reviewer added that the inclusion of low temperature catalysis was very consistent with this need. However, addressing natural gas as a fuel (as well as renewable fuels) might not be sufficiently covered.

Reviewer 3:

The reviewer highlighted that the particulate matter (PM) section of the portfolio was a little light. The characterization of gasoline direct injection (GDI) or other novel combustion strategies (chemical as well as physical), especially with regard to fuel effects (such as for ethanol and methanol), would be necessary to deal with these emissions.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:

The reviewer concluded that yes, overwhelmingly, the activities and programs were consistent with the industry need for more efficient engines and their associated aftertreatment systems. Acknowledging the need for low temperature aftertreatment as an area that must be explored more intensely was important for enabling efficient powertrains.

Reviewer 2:

The reviewer indicated that the program was focused and well managed.

Reviewer 3:

The reviewer noted that the program seemed to be very well and attentively managed. This reviewer added that perhaps more integration with the fuels team would be a useful way to leverage funding.

Question 4: Other Comments

Reviewer 1:

The reviewer offered that the Cross-Cut Lean Exhaust Emission Reduction Simulation (CLEERS) activity was certainly one of the gems in this portfolio, and noted the integration of industry, National Laboratories, and academia, on both a national and international platform.

Reviewer 2:

The reviewer indicated that the cooperative and supportive efforts of the DOE to enhance the competitiveness of U.S. automotive manufacturers were an essential element to OEM success. However, this reviewer added that the government electrification efforts should not come at the expense of liquid-fuel-based powertrain system R&D. This person went on to say that increasingly efficient and clean gasoline and diesel powertrains would represent the vast majority of transportation vehicles for many years and would help enable and support electrification efforts such as hybrid vehicles, which would act as the stepping stone to the eventual transition to a predominantly electric fleet in the coming decades.

Subprogram Overview Comments: Roland Gravel (U.S. Department of Energy) – ace00c

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

Reviewer 1:

The reviewer indicated that this sub-program bridged the research realm to the applied realm. It leveraged all of the fundamental work in the other areas of the VTO program to advance real-world applications and was the front line of technology deployment.

Reviewer 2:

The reviewer reported that this was generally well covered. The slides were rather dense and this reviewer could not read fast enough to see everything on the slides. This person added that, if the information was needed, time should have been spent to say it. If not, it should have been left off of the slide.

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

Reviewer 1:

The reviewer highlighted that the portfolio looked pretty complete and the projects were addressing the issues that seemed to need work.

Reviewer 2:

The reviewer stated it was a very thorough portfolio.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:

The reviewer stated yes.

Reviewer 2:
The reviewer summarized that this was one of the most exciting areas in the VTO.

Question 4: Other Comments

Reviewer 1:
The reviewer stated that surprisingly good results were being shown.

Subprogram Overview Comments: John Fairbanks (U.S. Department of Energy) – ace00e

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

Reviewer 1:
The reviewer stated that Fairbanks had done an excellent job of identifying a valuable niche for thermoelectrics for WHR. In many ways, this project could not fail because the energy recovered was free and otherwise wasted to the environment. The key to successful transition was cost, and the performers on Fairbanks' program had identified that as a key.

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

Reviewer 1:
The reviewer stated that the presenter seemed to have a great grasp on the materials, the device, the thermal management, and the systems analysis. If there was a gap, it could be manufacturability and cost. This reviewer thought that Fairbanks had been looking into new approaches for low-cost manufacturing and that this would be an extremely valuable addition to his portfolio. This person strongly emphasized that the presenter needed support for that.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:
The reviewer asserted that the sub-program areas were well focused and the critical/key technologies were receiving adequate focus.

Question 4: Other Comments

Reviewer 1:
The reviewer believed that the presenter's programs would have an extremely important impact on the energy needs of the consumer. Even though the energy savings were marginal on a per-unit basis, if one amortized the results over time and averaged over the immense number of units, there would be a significant energy benefit to mankind.

Project Feedback

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

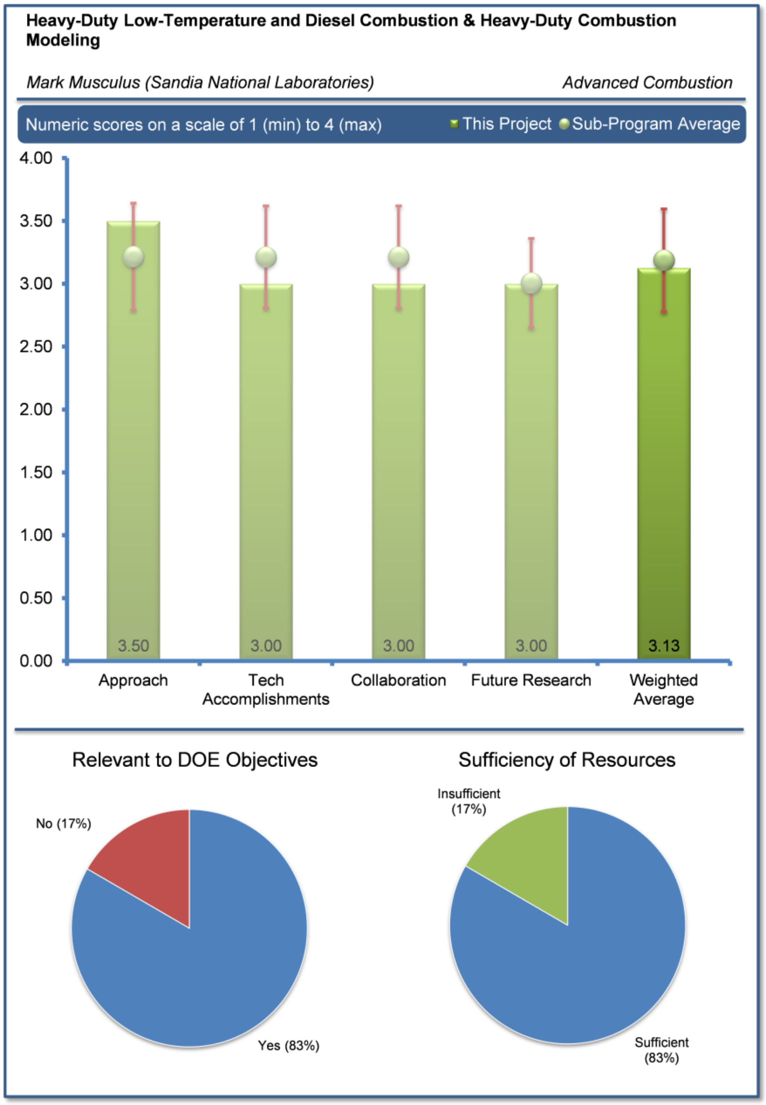
Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling	Mark Musculus (Sandia National Laboratories)	4-11	3.50	3.00	3.00	3.00	3.13
Low-Temperature Automotive Diesel Combustion	Paul Miles (Sandia National Laboratories)	4-15	3.57	3.57	3.57	3.29	3.54
HCCI and Stratified-Charge CI Engine Combustion Research	John Dec (Sandia National Laboratories)	4-19	3.20	3.80	3.80	3.20	3.58
Spray Combustion Cross-Cut Engine Research	Lyle Pickett (Sandia National Laboratories)	4-22	3.50	3.50	3.50	3.00	3.44
Automotive HCCI Engine Research	Richard Steeper (Sandia National Laboratories)	4-26	3.00	3.17	3.17	3.00	3.10
Large Eddy Simulation (LES) Applied to Advanced Engine Combustion Research	Joe Oefelein (Sandia National Laboratories)	4-29	3.67	3.17	3.17	2.83	3.25
Free-Piston Engine	Terry Johnson (Sandia National Laboratories)	4-33	2.43	2.14	2.14	2.43	2.25
Fuel Injection and Spray Research Using X-Ray Diagnostics	Christopher Powell (Argonne National Laboratory)	4-38	3.50	3.67	3.67	3.17	3.56
Use of Low Cetane Fuel to Enable Low Temperature Combustion	Steve Ciatti (Argonne National Laboratory)	4-41	3.00	3.00	3.00	2.75	2.97
Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines	Dan Flowers (Lawrence Livermore National Laboratory)	4-44	3.33	3.67	3.67	3.17	3.52
Chemical Kinetic Models for Advanced Engine Combustion	Bill Pitz (Lawrence Livermore National Laboratory)	4-47	4.00	3.00	3.00	3.33	3.29
2012 KIVA-Development	David Carrington (Los Alamos National Laboratory)	4-50	3.33	3.00	3.00	2.33	3.00
Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes	Stuart Daw (Oak Ridge National Laboratory)	4-53	3.40	3.50	3.50	3.00	3.41
High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines	Scott Curran (Oak Ridge National Laboratory)	4-56	3.67	3.50	3.50	3.33	3.52
Accelerating Predictive Simulation of IC Engines with High Performance Computing	Dean Edwards (Oak Ridge National Laboratory)	4-59	3.29	3.14	3.14	3.29	3.20
A University Consortium on Efficient and Clean High-Pressure, Lean Burn (HPLB) Engines	Margaret Wooldridge (University of Michigan)	4-63	3.00	3.20	3.20	2.60	3.08
Flex Fuel Optimized SI and HCCI Engine	Gouming Zhu (Michigan State University)	4-66	2.17	2.50	2.50	2.83	2.46
CLEERS Coordination & Joint Development of Benchmark Kinetics for LNT & SCR	Stuart Daw (Oak Ridge National Laboratory)	4-70	3.71	3.71	3.71	3.43	3.68
CLEERS Aftertreatment Modeling and Analysis	George Muntean (Pacific Northwest National Laboratory)	4-75	3.00	3.50	3.50	3.00	3.31

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Development of Advanced Particulate Filters	Kyeong Lee (Argonne National Laboratory)	4-78	2.00	2.67	2.67	2.00	2.42
Enhanced High Temperature Performance of NOx Storage/Reduction (NSR) Materials	Chuck Peden (Pacific Northwest National Laboratory)	4-83	3.00	3.00	3.00	3.00	3.00
Development of Optimal Catalyst Designs and Operating Strategies for Lean NOx Reduction in Coupled LNT-SCR Systems	Michael Harold (University of Houston)	4-86	3.40	3.50	3.50	3.00	3.41
Cummins/ORNL-FEERC CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines	Bill Partridge (Oak Ridge National Laboratory)	4-89	3.33	3.50	3.50	3.17	3.42
Emissions Control for Lean Gasoline Engines	Jim Parks (Oak Ridge National Laboratory)	4-93	3.80	3.40	3.40	3.20	3.48
Advanced Collaborative Emissions Study (ACES)	Dan Greenbaum (Health Effects Institute)	4-96	3.40	4.00	4.00	3.00	3.73
Thermoelectric HVAC and Thermal Comfort Enablers for Light-Duty Vehicle Applications	Clay Maranville (Ford Motor Company)	4-99	3.50	3.75	3.75	3.50	3.66
Energy Efficient HVAC System for Distributed Cooling/Heating with Thermoelectric Devices	Jeffrey Bozeman (General Motors Corporation)	4-102	3.00	3.20	3.20	2.60	3.08
Neutron Imaging of Advanced Engine Technologies	Todd Toops (Oak Ridge National Laboratory)	4-107	3.43	3.29	3.29	3.29	3.32
Collaborative Combustion Research with BES	Scott Goldsborough (Argonne National Laboratory)	4-111	2.80	3.20	3.20	2.80	3.05
Deactivation Mechanisms of Base Metal/Zeolite Urea Selective Catalytic Reduction Materials, and Development of Zeolite-Based Hydrocarbon Adsorber Materials	Chuck Peden (Pacific Northwest National Laboratory)	4-114	3.40	3.40	3.40	2.80	3.33
Fuel-Neutral Studies of Particulate Matter Transport Emissions	Mark Stewart (Pacific Northwest National Laboratory)	4-117	3.50	3.00	3.00	3.25	3.16
Cummins SuperTruck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks	David Koeberlein (Cummins)	4-120	3.80	3.60	3.60	3.40	3.63
SuperTruck - Improving Transportation Efficiency through Integrated Vehicle, Engine and Powertrain Research	Kevin Sisken (Detroit Diesel)	4-124	3.00	3.20	3.20	3.20	3.15
SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer	William de Ojeda (Navistar International Corp.)	4-128	2.80	2.60	2.60	2.40	2.63
Volvo SuperTruck - Powertrain Technologies for Efficiency Improvement	Pascal Amar (Volvo Trucks)	4-132	3.60	3.20	3.20	3.20	3.30
ATP-LD; Cummins Next Generation Tier 2 Bin 2 Diesel Engine	Michael Ruth (Cummins)	4-135	3.40	3.20	3.20	3.40	3.28
A MultiAir / MultiFuel Approach to Enhancing Engine System Efficiency	Ron Reese (Chrysler LLC)	4-138	3.29	2.71	2.71	3.29	2.93

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Lean Gasoline System Development for Fuel Efficient Small Car	Stuart Smith (General Motors)	4-142	3.57	3.00	3.00	3.00	3.14
Gasoline Ultra Fuel Efficient Vehicle	Keith Confer (Delphi Automotive Systems)	4-146	3.50	3.67	3.67	3.33	3.58
Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development	Corey Weaver (Ford Motor Company)	4-150	3.00	2.57	2.57	3.43	2.79
Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles	Hakan Yilmaz (Robert Bosch)	4-154	3.50	3.50	3.50	3.00	3.44
Thermoelectrics Partnership: Automotive Thermoelectric Modules with Scalable Thermo- and Electro-Mechanical Interfaces	Kenneth Goodson (Stanford University)	4-157	3.50	3.00	3.00	3.50	3.19
DOE/NSF Thermoelectric Partnership Project SEEBECK Saving Energy Effectively By Engaging in Collaborative Research and Sharing Knowledge	Joseph Heremans (Ohio State University)	4-161	3.25	3.25	3.25	3.00	3.22
Advancement in Fuel Spray and Combustion Modeling for Compression Ignition Engine Applications	Sibendu Som (Argonne National Laboratory)	4-165	3.25	2.75	2.75	2.67	2.86
Improved Solvers for Advanced Engine Combustion Simulation	Matthew McNenly (Lawrence Livermore National Laboratory)	4-168	3.33	3.67	3.67	3.50	3.56
CRADA with Cummins on Characterization and Reduction of Combustion Variations	Bill Partridge (Oak Ridge National Laboratory)	4-171	3.25	3.50	3.50	3.25	3.41
Investigation of Mixed Oxide Catalysts for NO Oxidation	George Muntean (Pacific Northwest National Laboratory)	4-174	3.20	3.00	3.00	2.80	3.03
Robust Nitrogen Oxide/Ammonia Sensors for Vehicle On-board Emissions Control	Rangachary Mukundan (Los Alamos National Laboratory)	4-177	3.20	3.25	3.25	2.75	3.18
Thermoelectric Waste Heat Recovery Program for Passenger Vehicles	John LaGrandeur (Amerigon)	4-180	4.00	4.00	4.00	3.50	3.94
Development of Cost-Competitive Advanced Thermoelectric Generators for Direct Conversion of Vehicle Waste Heat into Useful Electrical Power	Greg Meisner (General Motors)	4-183	3.20	3.40	3.40	3.25	3.33
Nanostructured High-Temperature Bulk Thermoelectric Energy Conversion for Efficient Automotive Waste Heat Recovery	Chris Caylor (GMZ Energy Inc.)	4-188	2.75	3.00	3.00	3.00	2.94
High Efficiency GDI Engine Research, with Emphasis on Ignition Systems	Thomas Wallner (Argonne National Laboratory)	4-192	2.17	2.33	2.33	2.17	2.27
Low Temperature Emission Control	Todd Toops (Oak Ridge National Laboratory)	4-196	3.20	3.20	3.20	3.20	3.20
High Energy Ignition and Boosting/Mixing Technology	Edward Keating (General Motors)	4-199	2.75	2.25	2.25	2.25	2.38
Next-generation Ultra-Lean Burn Powertrain	Hugh Blaxill (MAHLE Powertrain LLC)	4-202	2.57	3.14	3.14	2.57	2.93

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Heavy Duty Roots Expander for Waste Heat Energy Recovery	Dale Stretch (Eaton)	4-207	2.86	3.14	3.14	3.00	3.05
Radio Frequency Diesel Particulate Filter Sensor and Controls for Advanced Low-Pressure Drop Systems to Reduce Engine Fuel Consumption	Alexander Sappok (Filter Sensing Technologies, Inc.)	4-212	2.60	3.40	3.40	2.80	3.13
Overall Average			3.22	3.21	3.21	3.01	3.19

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



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the use of an optical engine with a variety of different techniques (high-speed luminosity, laser-induced incandescence, and multi-laser sheets) seemed like an excellent approach for elucidating and developing a fundamental understanding of in-cylinder soot processes. Although the results were likely affected by the specific hardware and cylinder geometry of the optical engine used, they helped advance fundamental understanding. The reviewer added that it was also very good that the experimental results were coupled with computational-fluid-dynamics (CFD) modeling.

Reviewer 2:

The reviewer emphasized the sharp focus on science base for spray, combustion, and pollutant formation for low-temperature combustion (LTC) and compression ignition (CI).

Reviewer 3:

The reviewer noted a good combination of diagnostic techniques to help provide insight into soot reduction with post- injection.

Reviewer 4:

The reviewer commented that the approach was a very good combination of experimental work and three-dimensional (3D) simulation. There had been quite a bit of input from reviewers in the past, which was addressed in this project within the limits of time and cost. The reviewer added that this work was valuable in suggesting potential strategies for reducing PM while maintaining the indicated specific fuel consumption (ISFC) in a large-bore diesel. Possible areas of future work that could be helpful include the impact of fuel injection pressure on post-injection mixing, the influence of nozzle hole size on mixing (over-leaning), and any clever nozzle/injection control strategies that could address various piston geometry impacts on observed performance.

Reviewer 5:

The reviewer stated it was both appropriate and critical to improve the fundamental understanding of combustion processes, and that multiple injection was a natural area to extend that model. Multiple injections include both post-injection and pilot injection, and the reviewer added that the expansion to post-injection was an excellent place to start. The study appeared to be well-thought out to separate the different effects. This reviewer also suggested that it might be possible to more fully leverage CFD modeling to assist in the understanding of the physical processes in the future.

Reviewer 6:

The reviewer acknowledged that there was an excellent use of experimental techniques with interesting results, but added that the modeling seemed to need more focus to explain and predict results.

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

Reviewer 1:

The reviewer indicated that excellent progress had been made and that the development of an LTC spray/combustion model was a significant accomplishment. This reviewer also noted very good progress in elucidating the influence of post-injection on soot formation.

Reviewer 2:

The reviewer commented that the principal investigator (PI) made very good progress this year exploring post-injection timing on PM reduction under LTC-type conditions, adding that there was still quite a bit of work that needed to occur, including injection control parameters, nozzle design, and piston design on post-injection strategy. This reviewer also felt that it would have been helpful to see more discussion on the ISFC impact of post-injection strategies.

Reviewer 3:

The reviewer noted significant post-injection diagnostics and planar-soot-laser-induced-incandescence (LII) that was simultaneous with high-speed luminosity, and further noted that the project moved to multi-planar soot and hydroxide (OH) diagnostics. The reviewer asked what injection pressure(s) were investigated, and what was the effect with injection pressure.

Reviewer 4:

The reviewer summarized that this work was getting started, such that some preliminary hypotheses had been formed but not yet fully vetted. This reviewer looked forward to future conclusions.

Reviewer 5:

The reviewer emphasized that good progress was made in generating a significant dataset, but went on to say that it was not so clear that a unifying theory would emerge that could be used to generalize the results.

Reviewer 6:

The reviewer suggested that the project needed some way to evaluate the tradeoffs and dependencies between soot and engine efficiency, adding that soot reduction was certainly important, but that engine efficiency tradeoffs must also be considered.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the PI is heavily leveraging the University of Wisconsin (UW) Engine Research Center's (ERC's) expertise in 3D simulation, which is valuable and will continue to be valuable in understanding the physics associated with the impact of post-injection mixing on PM at LTC-type conditions.

Reviewer 2:

The reviewer noted that the emphasis of the project work was experimental. While there is a connection to UW, there may be an opportunity to gain greater understanding to strengthen and expand that workstream. This reviewer also highlighted the interaction with the industry through the Advanced Engine Combustion (AEC) Memorandum of Understanding (MOU) and consultation as the study was developed; however, the reviewer added that there may be opportunities to strengthen that interaction.

Reviewer 3:

The reviewer felt that the list of collaborators was impressive, but it was not clear that there were appropriate supports and interaction.

Reviewer 4:

The reviewer remarked that the collaboration seemed to mainly be with UW in the area of CFD modeling and with Delphi. Interactions with the industrial members of the AEC MOU meeting were mentioned, but no specifics were given; such that this reviewer was uncertain whether the interactions were restricted to the two presentations that Mark made at those meetings or whether the interactions with members extended beyond that.

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

Reviewer 1:

The reviewer asserted that the plans seemed reasonable to continue to obtain the information needed to further develop the conceptual models and link them to CFD simulation models.

Reviewer 2:

The reviewer indicated that all the proposed pathways were valid. This person's only suggestion was to include fuel injection pressure, nozzle design, and (possibly) piston design effects.

Reviewer 3:

The reviewer emphasized that the continuation of this study and expansion to different geometries would be interesting. The development of a conceptual model of post-injection would be very interesting. In the long term, the reviewer suggested that the PI might also want to expand to pilot injections. Pilot injections are used on almost every engine in the market today, this reviewer added, but the physical processes dictating why the quantity and timing optimize the way they do to improve hydrocarbon (HC), carbon monoxide (CO), and noise emissions are not well-understood.

Reviewer 4:

The reviewer said to continue building a conceptual model understanding. This person brought up how combustion design affected heat transfer and efficiency, and suggested stronger emphasis in this area. This reviewer also indicated that more LTC work was needed (earlier injection).

Reviewer 5:

The reviewer indicated that the plan addressed the key open issues, but added that it was not clear how much could actually be achieved. This reviewer would like to see more focus on efficiency impacts.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer claimed that this project explicitly targeted strategies for reducing PM in heavy-duty (HD) diesels while maintaining ISFC and therefore supported the Department of Energy (DOE) objectives in the HD area.

Reviewer 2:

The reviewer stated that fundamental understanding of in-cylinder combustion processes should generate ideas on how to improve combustion efficiency (and thereby reduce fuel consumption) and reduce emissions, which is in line with DOE objectives.

Reviewer 3:

The reviewer reported that the project was investigating efficiency and emission challenges.

Reviewer 4:

The reviewer noted that, although the work was addressing soot formation, it was not clear how this work supported the goals of lower fuel consumption.

Reviewer 5:

The reviewer cautioned that the project was focused on soot emissions reduction without a means to evaluate the potential impact on engine efficiency.

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

Reviewer 1:

The reviewer suggested that the expansion of the CFD activity connected to this project (if it is only at a low level) might be appropriate.

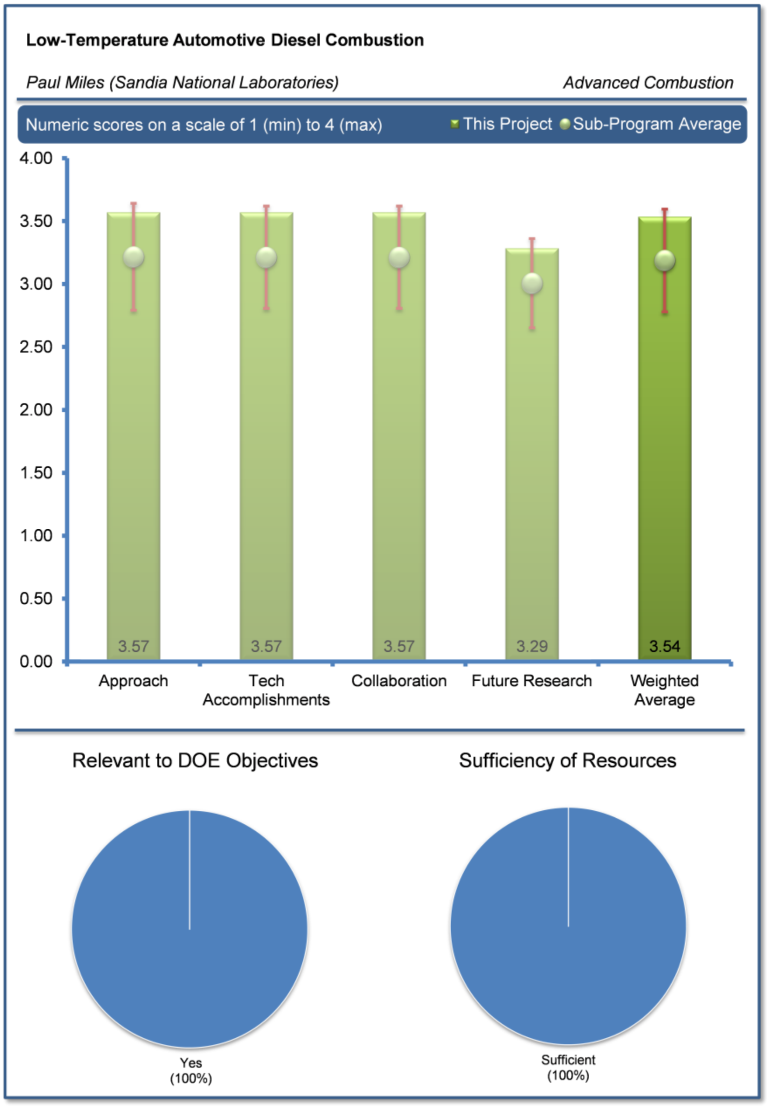
Reviewer 2:

The reviewer voiced that it looked like there was good progress versus the planned milestones, such that the resources seemed sufficient.

Reviewer 3:

The reviewer summarized that the funding appeared to be pretty consistent throughout the last few years and was adequate to address the various objectives of this project.

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



Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

The reviewer emphasized that this was outstanding work. The investigator was developing a fundamental understanding of the interaction of in-cylinder processes such as in-cylinder mixing, with emission and engine performance. The fundamental processes were being examined relative to changes in bulk engine control parameters like injection pressure and swirl. The work encompassed rigorous and detailed experiments, with comparison to 3D simulation. This reviewer added that the analysis used quantification from the experiments and was supported with explanations using detailed chemical kinetic evaluations; the work was very comprehensive.

Reviewer 2:

The reviewer explained that the project provided fundamental research to support the development of advanced light-duty (LD) diesel engines. The authors sought to develop a fundamental understanding of the combustion process by aligning the Sandia National Laboratories (SNL) optical engine with simulations carried out at the University of Wisconsin-Milwaukee (UWM). The reviewed remarked that the approach was clearly described.

Reviewer 3:

The reviewer offered that the project addressed the lack of fundamental understanding and accurate CFD models, adding that the project aided in the development of such models. This person also indicated that understanding mixture formation impacted combustion, and hence, thermal efficiency.

Reviewer 4:

The reviewer highlighted that carefully building a comprehensive quantitative data set under LTC conditions was very useful, not only for understanding in-cylinder processes and validating models.

Reviewer 5:

The reviewer stated that it was good to see production-type combustion system geometries being used.

Reviewer 6:

The reviewer voiced that the general approach of optical experiments coupled with simulation was good. At the moment, this reviewer added, LD diesel was not a large fraction of the U.S. market, but a few new offerings were entering the market. If this project is successful in meeting the 40% fuel-economy (FE) and Tier 2 Bin 2 emissions goals, the number of diesel offerings (and number of sales) would likely increase.

Reviewer 7:

The reviewer noted that the structure of the project was well set. The collaboration of an optical engine with CFD modeling, along with input from industry, was an effective means to understand the fundamentals of current clean LD diesel combustion. This person added that, given the interdependences of many variables, some form of design of experiment (DoE) should have been implemented to reduce the number of test/simulation points.

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

Reviewer 1:

The reviewer noted a very nice connection between the experimental results, simulation comparisons, and changes in emissions from the engine when typical operating parameters (e.g., swirl, injection pressure, and multiple injections) were manipulated. The reviewer added that the new understanding of lean and rich CO and HC emission phenomena were important additions to the knowledge base.

Reviewer 2:

The reviewer remarked that the lab had been updated for improved diagnostics capability and scope of experiments, and that good progress had been made on correlating the equivalence ratio with CO and unburned hydrocarbon (UHC) emissions. This person added that the effect of reverse squish flow needed to be investigated, and that it looked like many of the effects of swirl and injection timing could also be explained by the timing and strength of the reverse squish flow, and the relative timing of injection.

Reviewer 3:

The reviewer acknowledged that good progress had been made against the milestone, the sweeps of some variables yielded meaningful information, and the images were impressive. Additionally, the correlation between test and modeling was well-presented, and the directions for improvement had been well-sought out. The large crevice volume of the optical engine was a concern with regard to UHC/CO. This person further commented that, while it was not practical to modify the engine itself, some additional modeling work might be helpful. It was necessary, in the reviewer's opinion, to make sure that this difference from the production engine would not alter the outcome of this research.

Reviewer 4:

The reviewer pointed out that comprehensive data sets had been developed for one geometry and had contributed to the development of the conceptual model in LTC. The modeling work showed differences, but the source of those differences was not well-understood. This reviewer added that it was important at this point to focus on interaction with the modeling effort to identify the source of the discrepancy.

Reviewer 5:

The reviewer mentioned very interesting findings, but added that there was no direct way to gauge the impact or significance of these findings back to the stated targets of efficiency, emissions, and cost.

Reviewer 6:

The reviewer indicated that the authors did a good job capturing last year's Annual Merit Review (AMR) status and bringing the reviewers up to date on this year's activities. The authors had been focusing on the importance of the mixture formation process and its impact on soot and oxides of nitrogen (NOx), HC, and CO emissions. This work helped lay out an optimal combustion strategy approach to controlling and lowering emissions, which could provide the foundation for future in-cylinder and aftertreatment combinations. This reviewer added that the impact of injection pressure on HC and CO was demonstrated in detailed images across three planes within the combustion chamber. A similar study with resulting observations was given for varying swirl ratio and injection timing. The injection timing particularly highlighted the balance between the mixture formation and kinetics of oxidation. This person went on to say that the comparisons with the modeling studies revealed significant discrepancies. The comparison revealed serious disconnects in key parameters such as underpredicting the spray penetration, swirl velocity, and turbulent diffusion. The authors proposed to examine the gas-jet model performance and expand the simulation to the full 360-degree combustion chamber; the reviewer felt that this may be indeed necessary. At this stage of the work, the reviewer continued, the simulation fidelity should be much better. It may be worthwhile to re-evaluate the team and see if there is a better platform for the modeling work. Further, the accomplishment section closed with a description of the pilot injection tests. The data reported offered only broad responses based on CO and HC, but the reviewer indicated that this data is readily available from metal engines. The reviewer stated that the authors should focus on providing unique insight to such strategies.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported very good engagement with and leverage of the UW ERC for modeling work, as well as a strong interaction with General Motors Corporation (GM) and Ford.

Reviewer 2:

The reviewer confirmed that there was good representation comprised of many industrial partners, including heavy-duty manufacturers. This person added that the project was also connected with several AEC/DOE-sponsored projects.

Reviewer 3:

The reviewer noted that very good collaborations existed with industry partners (GM and Ford) and UW.

Reviewer 4:

The reviewer felt the project had good synergy with other institutions and a close collaboration with the industry.

Reviewer 5:

The reviewer remarked that the AEC MOU was a good framework for extending the collaboration beyond that of the principle participants.

Reviewer 6:

The reviewer acknowledged that there were good collaborations with universities, but added that it was not clear to what extent the original-equipment-manufacturer (OEM) collaborations influenced or benefited from this work.

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

Reviewer 1:

The reviewer commented that the future work was a good extension of the current work.

Reviewer 2:

The reviewer observed that the plan was a good continuation of current research, adding that the choice of piston bowl went hand in hand with injector design/protrusions, injection pressure, and operating strategy. The reviewer stated that, if Ford had already considered those issues, then great; otherwise, an injector with a different geometry should be considered. This reviewer added that DoE should be performed to reduce the number of test/modeling points and thus speed up the progress. It would also be helpful to put more emphasis on the cold start conditions, which are critical to meeting the Tier 2 Bin 2 emissions goal.

Reviewer 3:

The reviewer said that work would expand to other piston geometries (stepped-lip bowls) and higher loads, and added that modeling work might need to look closer at the injector characteristics.

Reviewer 4:

The reviewer mentioned that the squish flow should be measured and characterized, and correlated to CO and HC emissions.

Reviewer 5:

The reviewer asked if, given the discrepancies found in the simulation, there was a need for metal engine experiments. This person suggested this might be another collaborative opportunity, either with a university or an OEM, and added that this might also be a way to roll up all the progress every year and thereby show the net progress toward the stated targets.

Reviewer 6:

This reviewer looked forward to seeing the comparison of different bowl geometries, which would contribute to the data set. It was important to get these data sets to validate models with different bowl geometries, since that is how the models are used in the industry. This person added that the post-injection study plans were not well-defined and encouraged the PI to discuss this with industrial partners in AEC.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer asserted that this program was very strong and very valuable. It was making good progress in identifying and understanding the fundamental processes occurring in-cylinder and how they were impacted by changes in engine operation. This reviewer added that, to achieve the pending fuel-economy and emission standards, it would be critical to affect the manipulation of these in-cylinder phenomena.

Reviewer 2:

The reviewer emphasized that the project was relevant and uniquely focused on the LD diesel challenges.

Reviewer 3:

The reviewer affirmed that the project increased the potential to meet engine-efficiency targets by providing fundamental understanding of combustion and emissions formation processes in the cylinder.

Reviewer 4:

The reviewer explained that engine-out HC was clearly a barrier to fuel efficiency due to the negative impacts of calibration and aftertreatment actions.

Reviewer 5:

The reviewer agreed that this research would enhance the understanding of LD clean diesel combustion, which could potentially help to expand the use of high-efficiency and low-emissions diesel engines, which would in turn help reduce fuel consumption.

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

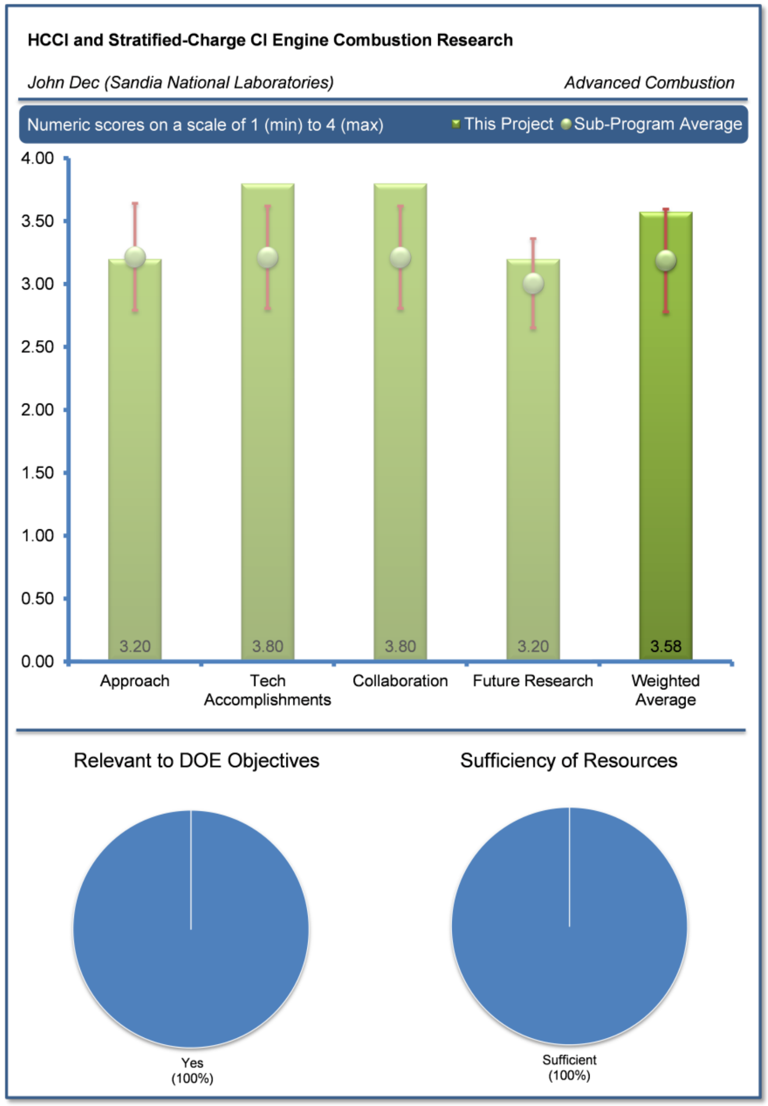
Reviewer 1:

The reviewer affirmed that there was no clear need to increase funding.

Reviewer 2:

The reviewer suggested that it might be important to evaluate what additional diagnostics could be applied to fully characterize the injector to help with model validation. The data set was meant to validate models, this reviewer continued, but the spray was critical to the model, so the better that spray was characterized, the better. This should be done soon, this person added, while the injector hardware was fully functional.

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



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer summarized that the work combined metal, optical, and computational approaches and was a good way to provide meaningful and realistic data for homogeneous-charge-compression-ignition (HCCI) combustion.

Reviewer 2:

The reviewer confirmed that a significant portion of this project addressed the DOE goals of improving engine thermal efficiency while ensuring engine-out emission levels were near regulated limits. In particular, a key focus area was the impact of fuel reactivity on the ability to push HCCI-like combustion to high loads within the limits of blending ethanol and gasoline. This effort showed the reactivity limits of gasoline under the speed and load conditions of this study, including the particular engine geometry. This person added that, though the results were limited to this particular engine, the project provided evidence concerning the impact of fuel reactivity on the ability to balance pressure rise rate, exhaust-gas-recirculation (EGR) level, and injection timing strategy on engine load limits.

Reviewer 3:

The reviewer stated that the project addressed barriers to high efficiency on a medium-duty engine.

Reviewer 4:

The reviewer noted that this was a good study of fuel reactivity on HCCI that was trying to isolate the influence of ethanol. This reviewer added that this was a good start looking at combustion noise, and that it confirmed that ringing intensity (RI) and combustion noise measured different things (i.e., knock versus noise). The next step should be to understand the sensitivity of efficiency to the noise. This reviewer went on to say that there may be an opportunity to better account for air path using an air path model to define appropriate exhaust pressure given the boost and exhaust temperatures.

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

Reviewer 1:
The reviewer noted that there was good progress towards understanding the effects of fuel reactivity, and added that the definition of the desirable fuel properties for HCCI appeared to be closer due to this work. The reviewer also thought that implementation of the noise calculation was a great step forward.

Reviewer 2:
The reviewer felt that the PI had done an outstanding job performing various parametric studies, including reactivity effects, boost effects, and some intake manifold temperature effects. This person added that one possible further parametric study could be a large intake manifold temperature sweep within vehicle design limits, not only at 1,200 revolutions per minute (RPM), but also at other key speed points.

Reviewer 3:
The reviewer remarked that the results provided a significant contribution to understanding HCCI combustion and efficiency potential. However, this person added that there was a need for a better understanding of why the indicated thermal efficiency (ITE) was so much lower than the results from some other HCCI research. This was a fundamental question as to the potential for HCCI to reach higher efficiency targets.

Reviewer 4:
The reviewer acknowledged the very impressive results in terms of efficiency and compression ignition load range, but went on to say that the results suggested significant implementation challenges regarding the boost system and engine control outside of a laboratory setting. This reviewer added that an estimate of brake thermal efficiency (BTE) or test results from a multi-cylinder engine would provide an assessment of the impact of the boosting system requirement on the overall engine efficiency.

Reviewer 5:
The reviewer commented that additional background on the tests, such as determining which exhaust backpressure and temperatures simulated the turbocharger, would have been helpful. This person suggested that, since the intake port was suspected for the fairly low peak efficiency, it might make sense to either slightly modify the flow field (to evaluate this possibility) or work with an outside partner for a complete revision.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed that there was good collaboration.

Reviewer 2:
The reviewer noted participation in AEC and added that the combustion noise information provided was improved relative to previous years.

Reviewer 3:
The reviewer said there was a good list of collaborators and went on to suggest that the PI might try to connect to Dan Haworth at Penn State, as he is doing interesting work on LTC combustion modeling.

Reviewer 4:
The reviewer mentioned that, although the PI ran out of time to discuss portions of their collaborations, it appeared that this element was present in the project. In particular, Cummins had been a key collaborator along with Lawrence Livermore National Laboratory (LLNL) in the chemical kinetics area.

Reviewer 5:

The reviewer affirmed that there was good interaction with the industry and good leverage of utilizing LLNL and universities for modeling work, but this person added that it was not clear how well-coordinated those activities were.

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

Reviewer 1:

The reviewer emphasized the project's good focus on efficiency evaluation and improvement.

Reviewer 2:

The reviewer agreed that the overall plan made sense, but asked about the compression ratio (CR) study and whether it was truly necessary to spend the money to design and install a new piston for high-load testing when one could simulate these conditions by properly choosing the intake manifold thermodynamic condition. This reviewer added that it was recognized that mixing could be a little different between the two cases, but a straightforward experiment with simulated conditions at higher CR could indicate the initial effects of such a change on the compression event.

Reviewer 3:

The reviewer warned that the current approach was to set combustion phasing based on knock limit, but that this might not be acceptable for noise. This reviewer added that it would be useful to look at the sensitivity of noise to combustion phasing and other things, as well as the sensitivity of efficiency to noise. The reviewer felt that this was as important as looking at the 16:1 CR and early direct injection (DI).

Reviewer 4:

The reviewer indicated that greater definition of the plans for Miller-cycle spark-assisted compression ignition (SACI) versus spark ignition (SI) would be helpful. This reviewer also asked about the lack of intake port revision plans.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer concluded that this project directly addressed thermal efficiency goals by exploring the limits of fuel reactivity over a broad range of operations under HCCI-like conditions and at ISFCs higher than today's engines. This person went on to say that the latter ISFC results had been a little disappointing, but nevertheless established insight into the limits of this type of combustion strategy.

Reviewer 2:

The reviewer reported that this work should help to answer the fundamental question of whether HCCI can lead to substantial efficiency gains over conventional diesel combustion. However, this reviewer added that there was a need to understand the differences with other work in this field.

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

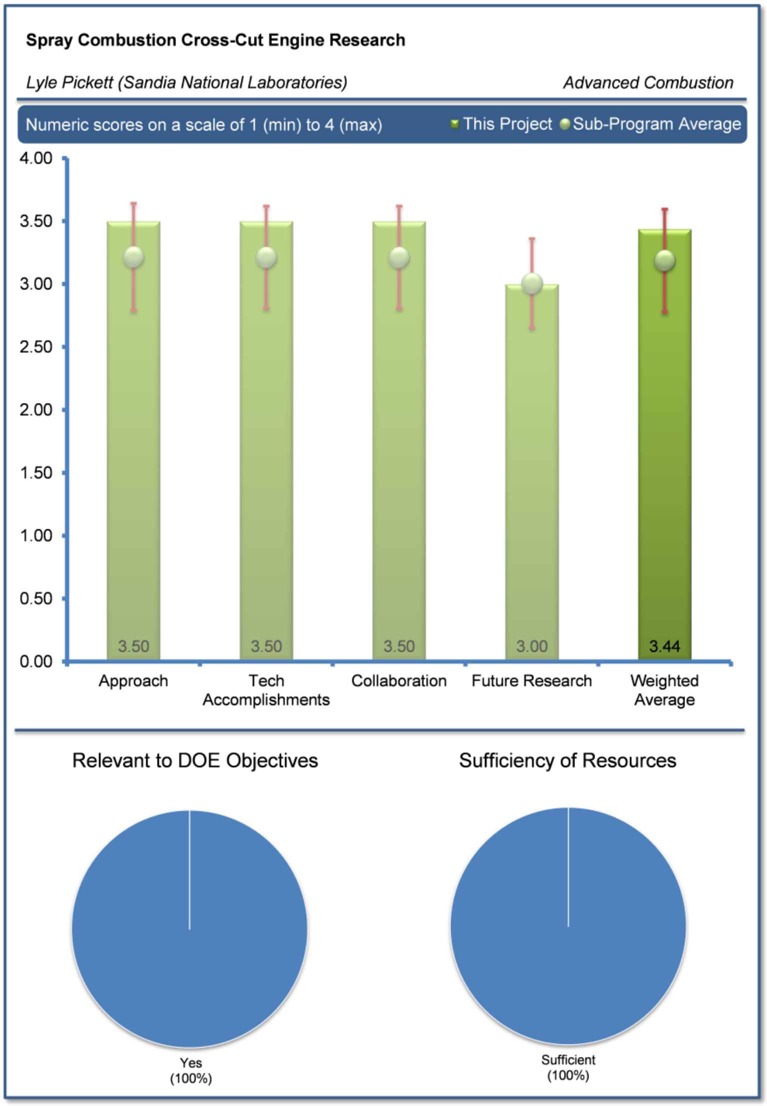
Reviewer 1:

The reviewer indicated that this project has been well-funded for many years.

Reviewer 2:

The reviewer simply noted $740, 000 in 2013.

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



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer summarized that this type of research was critical to developing fundamental knowledge to enable predictive spray simulations. A simple, well-controlled environment, as the PI had in his combustion vessel, was a good approach for this type of work. This reviewer added that the approach of engaging and aligning like work from various research institutions from around the world were also good.

Reviewer 2:

The reviewer confirmed that the project provided fundamental research to support the development of advanced engines and related technologies, and that the work identified the need to capture the interactions among spray, mixing, and chemistry for better future engine designs. The physics described here was to be integrated with better simulation tools. This person added that the experimental work proceeded with a well-controlled, constant-volume chamber, with consistent benchmarks across various facilities. The reviewer went on to say that this report had shifted the focus to gasoline-like systems, and asked if there were plans to continue with the diesel development. It might be worth capturing the impact the earlier diesel work had had on the capability to deliver more efficient systems. The impression of this reviewer was that there was much work that needed closure in the diesel world.

Reviewer 3:

The reviewer stated that it was good to see expansion into GDI, but asked how the injector-to-injector variability had been captured. In the images that were shown for the GDI analysis, the PI highlighted the asymmetry. The reviewer asked if this was characteristic of that injector or that family of injectors, as well as how the issue of injector-to-injector variability was captured by the Engine Combustion Network (ECN).

Reviewer 4:

The reviewer felt that this project was a good compliment to the optical engine test and modeling work, and that it offered a fundamental description of the spray behavior relatively undisturbed by other variables. This reviewer also acknowledged that, because things were not injected into real flow/temperature/pressure environments, the results were valuable only in close collaboration with other two-system approaches, which seemed to be happening.

Reviewer 5:

The reviewer noted that DI sprays would be a critical component of achieving enhanced performance of ICEs, yet they were still not well-understood. The work described here was an important contribution to advancing our understanding of combusting sprays, and the ECN was a good way to engage the international spray community in a focused effort. The comparison between the unified sets of spray data and simulation was a great way to advance the model development. This reviewer added that it would be interesting to ask the modelers to extend their predictions to an environment in which the pressure (and temperature) was (were) changing, as it did during engine expansion. It was known that predicting a fuel’s ignition delay in a shock tube or rapid compression machine did not necessarily validate the kinetic scheme for predicting auto-ignition of the fuel in an engine. This reviewer inquired whether if it was possible that the thermodynamic state history that the spray experiences in the constant-volume vessels used in the ECN, masked phenomena that influenced spray combustion in an engine. This reviewer emphasized that extrapolating the model predictions to include an expansion process might highlight important differences among the different models, and identify important subtleties associated with spray combustion during engine expansion.

Reviewer 6:

The reviewer acknowledged that high-temperature/high-pressure chambers provided good optical access and mimicked certain static conditions in the engine, thus providing a good flexibility to study fundamental phenomena. However, this reviewer added, it did have some limitations as well, and that a greater balance between diesel and gasoline work should be encouraged. This person noted that the ECN provided a good forum for experimentalists and spray modelers to collaborate to improve spray models.

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

Reviewer 1:

The reviewer stated that the PI’s work was very well done, and that the PI was able to draw valuable insights from his work. This person added that it was good to see the incorporation of GDI into this project.

Reviewer 2:

The reviewer felt that the inclusion of GDI sprays was a very good addition, as was the focus on particulates. This person also mentioned that the application of the array of diagnostics was very impressive.

Reviewer 3:

The reviewer noted great progress on adding GDI.

Reviewer 4:

The reviewer remarked that the optical diagnostics to date were providing excellent insights into spray behavior. The plotting of spray collapse with the use of plume plotting vectors was very interesting and visually very informative. The understanding provided regarding asymmetry among the plumes was very useful. This reviewer added that the outlet of GDI injectors should have been imaged to verify that the jet plume was or was not contacting the outer stepped hole, as it would greatly affect the downstream spray.

Reviewer 5:

The reviewer acknowledged that progress had been made with regard to Spray-A conditions in collaboration through the ECN. Liquid and vapor visualization provided insightful information. This reviewer also noted that the shot-to-shot variation in vapor penetration and plume interaction were good examples, adding that it would have been helpful to show the injector-to-injector variations. Testing some (if not all) of the 12 Delphi injectors could have provided a valuable data set on the scope of variability among production injectors. This reviewer added that such information could then be used by the testing and modeling community to study the impact of injector variability on the combustion process.

Reviewer 6:

The reviewer stated that, for the Spray-A DI, the present work highlighted significant differences in current models (as noted in errors in lift-off length and ignition delay, and sprays with similar lift-off lengths but very different OH profiles across the spray). This person added that the work had provided a new technique to quantify soot concentration based on high-speed extinction imaging, and it might have been of interest to explain how this could be integrated in the modeling efforts (such as soot formation and the location of the lift-off flame). This person asserted that the work had taken a deep look at specific challenges seen in GDI sprays, such as plume interactions, ignition in stratified environments, and injection-to-injection variability. The reviewer added that the work was very dependent on hardware (such as in the nozzle step geometry) and that it was difficult to understand how universal these findings might be, especially when the experiments were performed in a combustion vessel that differed greatly from the engine environment.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that the ECN was an excellent forum that maximized the group's ability to participate and share in this activity. It also represented a tremendous leverage of resources.

Reviewer 2:

The reviewer mentioned that the ECN was proving to be very productive and useful. Many institutions were participating and many measurements were being made. This reviewer further noted that appropriate connections with the industry existed to ensure that the relevant hardware and operating conditions were being selected.

Reviewer 3:

The reviewer affirmed that there was good representation comprised of multiple industrial partners, and multiple experimental and modeling capabilities through the ECN. The interactions have increased over the years, covering more technical ground across the combustion research front. This provided for the identification of future work areas.

Reviewer 4:

The reviewer emphasized that the ECN collaboration, with its over 100 participants, was outstanding, and further noted that the 26 types of experiments at Spray-A conditions across 10 different international institutions was an excellent example of coordination. A summary of the outcome would have been helpful, this reviewer added.

Reviewer 5:

The reviewer suggested that while the collaboration was good, the coordination appeared to be lacking. The reviewer asked about the types of information needed, the plan for getting there, and how progress was being measured. The reviewer also questioned if all the involved researchers were being utilized to their fullest potential, and if, once the various research institutions around the world had shown good agreement, it was possible to then coordinate each to look at different parts of the problem. The reviewer felt that it would be good to see this work occur at a faster pace, and asked about the limitations of going faster.

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

Reviewer 1:

The reviewer indicated that this was important work and that the plans for the future were good.

Reviewer 2:

The reviewer reported that the future work plan was sound and reflected the growing interest in the GDI engine and its challenges.

Reviewer 3:

The reviewer suggested that the gasoline spray measurements should be accelerated.

Reviewer 4:

The reviewer stated that the GDI injector performance could (and likely would) be different for each injector manufacturer, and asked how this would be addressed. The reviewer asserted that it was good to see Delphi involved. This reviewer asked whether other suppliers had been approached and if they were willing to supply multiple samples of their latest (best) injector design. The reviewer also asked how large the part-to-part and shot-to-shot variations for GDI were, how the injector design details impacted GDI performance, and how multiple GDI injections influenced the bulk spray. It would be good to see these types of results next year.

Reviewer 5:

The reviewer noted that the scope of work could be extended beyond LTC and HCCI to systems representative of current products that tended more toward hot-temperature combustion. This person added that the work could also explore kinetics of SI, flame-front propagation, and stratification.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer felt that this work was fundamental and pre-competitive, and addressed important phenomena that would be important for improved engine performance.

Reviewer 2:

The reviewer remarked that the project provided robust spray data for the development of spray models that were needed to analyze and design high-efficiency advanced combustion engines.

Reviewer 3:

The reviewer commented that findings from this project would enhance the understanding of fuel spray and guide the design of efficient combustion systems for both diesel and gasoline engines, which would reduce fuel consumption.

Reviewer 4:

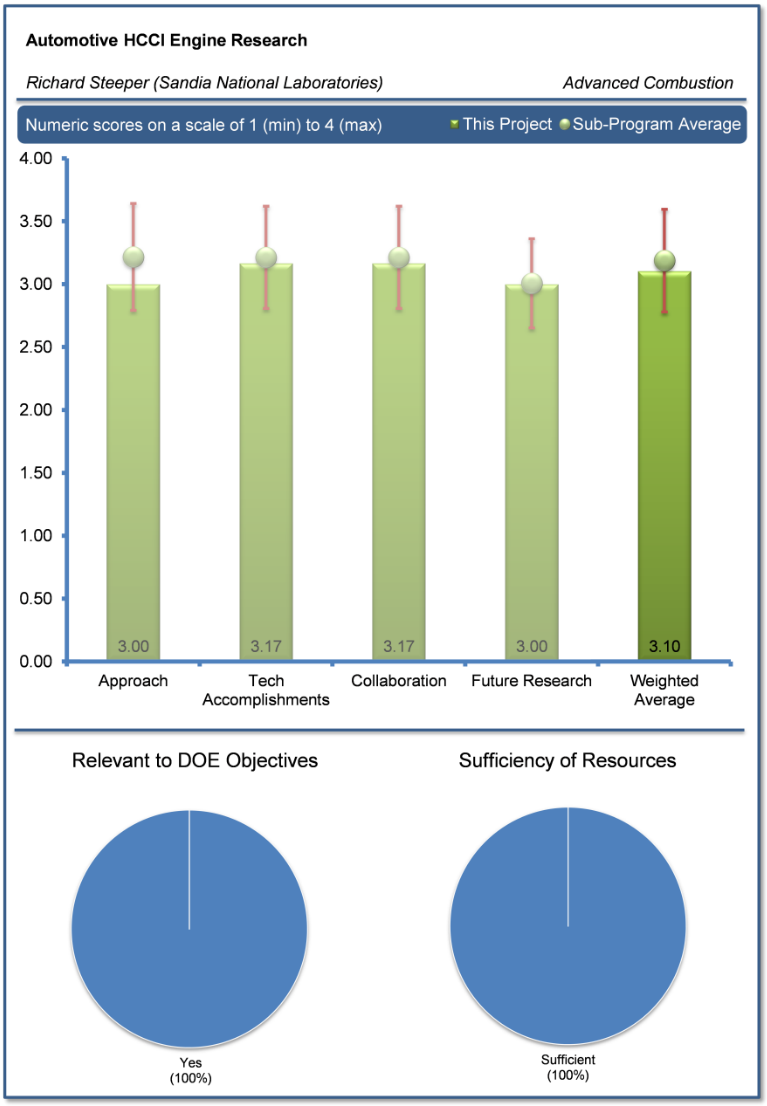
The reviewer pointed out that the fundamental understanding of sprays was clearly critical to our understanding of combustion and our ability to model it. This person went on to say that it would be helpful to better understand the true long-term objective of this project, so the project could be measured and tracked; this would help to ensure it remains relevant. This reviewer asked if the long-term objective was to establish the important performance characteristics of injectors, improve their design, or improve our ability to model them. If the goal was to improve the modeling, this person added, some evidence as to progress in this area should have been included in the presentation and work plan.

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

Reviewer 1:

The reviewer noted that there were nice facilities. As far as this reviewer could tell, the resources appeared sufficient.

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



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that this project had a very interesting approach to characterizing products of negative valve overlap (NVO) reactions.

Reviewer 2:

The reviewer pointed out that the new sampling valve test setup provided some interesting insight into the NVO chemistry.

Reviewer 3:

The reviewer said that coupling optical engine tests with in-cylinder sampling and computer modeling seemed to be a reasonable approach. This reviewer added that the in-cylinder sampling device and method that were developed seemed to provide a way to relate engine performance to in-situ chemical species and (potentially) chemistry effects.

Reviewer 4:

According to this reviewer, this project studied NVO species' influence on HCCI combustion, connecting NVO injection experiments with previous experiments in which trace species were introduced. This reviewer thought this was a very good use of a sampling system to characterize trace species and understand which species were most critical, and suggested expanding the focus to higher load conditions. The condition chosen was very low load (almost like an idle condition), which might become less relevant as engines are downsized and stop-start is introduced.

Reviewer 5:

The reviewer expressed that, even though it was not the focus of the work, NVO HCCI load challenges were not addressed, and it would have been nice to mention them.

Reviewer 6:

The reviewer affirmed that the work to date had been very good in assessing the impact of NVO fuel timing on combustion system response. However, the impact of ISFC was not clear to the reviewer, and thus more attention could have been paid to this detail. Also, mixing effects and reactivity effects could potentially be addressed at some point if it has not already been addressed sufficiently in the past.

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

Reviewer 1:

The reviewer emphasized that great progress on the sampling system appeared to be providing good information for understanding what was happening and what species were driving the process.

Reviewer 2:

The reviewer noticed good progress in both experimental and computational aspects.

Reviewer 3:

The reviewer cited the completion of the acetylene seeding study, a gas-sampling system for probing the chemistry of NVO, and model application. This reviewer also mentioned the nice isolation of chemical versus thermal effects on combustion phasing.

Reviewer 4:

The reviewer explained that the progress and accomplishments were good, but the timing and quantity were not outstanding. This reviewer added that the development and validation of the in-cylinder sampling method had enhanced the ability to determine fuel chemistry effects. This reviewer also noted interesting results on the impacts of the acetylene species on combustion phasing.

Reviewer 5:

The reviewer indicated that much effort had been spent this last year making sure good speciation measurements could be taken as well as studying the impact of NVO timing on combustion system performance. This reviewer added that it would have been nice to see the corresponding impact on ISFC through the various experiments.

Reviewer 6:

The reviewer cautioned that it was not clear how the CHEMKIN modeling could impact the conclusions or direction when the correlation to measured results was so poor.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer highlighted that there looked to be a very good collaboration set up with two automobile companies (Ford and, especially, GM) as well as with two National Laboratories (ORNL on parallel engine tests with NVO, and LLNL for the kinetic modeling).

Reviewer 2:

According to this reviewer, strong collaboration was apparent with GM, ORNL, and LLNL.

Reviewer 3:

The reviewer reported wide AEC participation.

Reviewer 4:

The reviewer noted that there was a strong connection to GM but not with the other OEMs. This reviewer also acknowledged interactions with ORNL and LLNL, but added that the extent and level of coordination were not clear.

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

Reviewer 1:
The reviewer pointed out that the PI intended to extend the operating range of the engine under NVO timing. This person added that it would have been helpful to see more details concerning targeted loads, possible fuel injection strategies, and any fuel reactivity studies. It is possible that these details had been developed and were simply not presented.

Reviewer 2:
The reviewer commented that the plans included a lot of activity. It would be interesting to explore how to enhance acetylene formation during NVO combustion. Also, it was not clear if the work was done with gasoline only or a 10% ethanol blend with gasoline (E10). E10 and higher ethanol blends should be more meaningful for high-output SI engines.

Reviewer 3:
The reviewer acknowledged that the plans to complete the work on elucidating chemistry effects during NVO seemed reasonable. The plans to shift the study to advanced ignition effects seemed a bit broad, with its focus on a large number of techniques (including cool plasma, microwave, and laser). This reviewer suggested some prioritization of techniques was needed there.

Reviewer 4:
The reviewer suggested a narrow focus on a short list of ignition technologies working specifically on spark-assisted HCCI. Otherwise, the ignition work area will be too broad for a meaningful deep dive. This person also suggested further collaboration with other DOE projects regarding the gas-sampling hardware and approach. The observed piston wetting and pool fires during NVO were likely drawbacks. This reviewer asked if there were other spray orientations (e.g., different injector) to assess reduced piston wetting.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer observed that expanding the fundamental understanding of LTC processes would lead to more efficient engines and thus better fuel economy, in turn displacing some petroleum.

Reviewer 2:
The reviewer said that, since high-output gasoline engines predominantly run at light load and low efficiency, this work should help to improve overall vehicle efficiency.

Reviewer 3:
The reviewer mentioned that this project did address DOE’s goal of improving the thermal efficiency of advanced gasoline engines. While progress to date had shown clear improvement in ISFC, there was potential for progress with the NVO fuel injection approach.

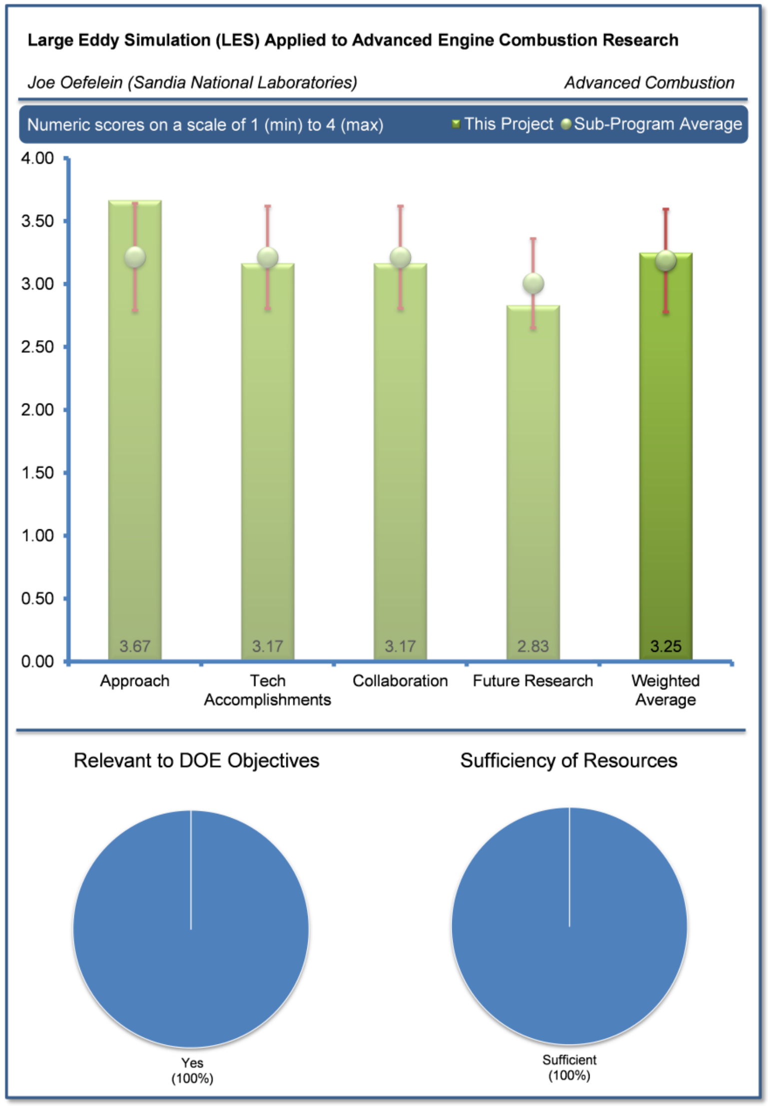
Reviewer 4:
The reviewer asserted that more work was needed at higher load regions of HCCI (5–10+ bar indicated mean effective pressure [IMEP]).

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

Reviewer 1:
The reviewer commented that the resources seemed sufficient, and cited that there was no indication that milestones were being missed due to a lack thereof.

Reviewer 2:
The reviewer indicated that the funding was very reasonable for this effect both in this fiscal year (FY) and in the past.

Large Eddy Simulation (LES) Applied to Advanced Engine Combustion Research: Joe Oefelein (Sandia National Laboratories) - ace007



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer affirmed that the three basic objectives of the project were well-aligned with the stated technical barriers, and that the high fidelity models would provide a useful tool to validate engineering models and the code used in the industry. This reviewer added that the validation of the model with the experiment was also very important and valuable.

Reviewer 2:

The reviewer expressed that it was hard to fault the approach.

Reviewer 3:

The reviewer rated the approach as very good, adding that the work was very fundamental and addressed the very essence of what was going on in fuel sprays. Consequently, it was very focused on important technical barriers to future developments. The interface with the ECN was an excellent and important collaboration. The reason this reviewer did not rate the approach as outstanding was that it was not clear what the pathway was for migrating this understanding into engineering-type models, or if this was being addressed. If this deficiency were due to the reviewer's lack of understanding, then this person would rate the approach as outstanding overall. This reviewer added that including GDI in the portfolio of topics was an important addition.

Reviewer 4:

According to this reviewer, LES appeared to be the only way that the industry could truly understand in detail the stochastic nature of combustion.

Reviewer 5:

The reviewer explained that the project used unique, powerful computational capabilities and advanced physical models like LES to evaluate spray and combustion calculations in advanced, high-efficiency engines.

Reviewer 6:

The reviewer indicated that the project focused on improved simulation capabilities using LES. The team had unique access to very powerful parallel codes and DOE computers to make this work possible. The work attempted to maintain a link between basic science and applied research, and promoted model development using thermodynamic principles with close coupling of experiments. This reviewer added that the project applied unique, high-fidelity simulation capabilities that complemented development of engineering models and codes. The main focus was the detailed simulation and analysis of direct injection processes with an emphasis on ECN experiments with target sprays of n-Heptane and n-Dodecane. The work included liquid-injection at high-pressure conditions.

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

Reviewer 1:

The reviewer reported that progress had been made on computing n-Heptane at supercritical conditions.

Reviewer 2:

The reviewer highlighted that the three focus points had progressed well. The emphasis on modeling of ECN experiments was important, as it was for the HCCI engine project work presented by Dec, et al. The LES simulations matched fairly well with Pickett's optical spray experiments (which was a good validation), and the quantitative description of high-pressure interface dynamics was impressive. The reviewer added that the high-fidelity models required long computation time. It was desirable to see this method be used to validate some simpler engineering models the automotive industry uses.

Reviewer 3:

The reviewer confirmed that the work continued to make progress towards a better understanding of the high-pressure fuel injection process. The project distinguished between low- and high-pressure environments, and it was impressive to see the correlations of simulations with experimental data. The work comprised unique descriptions of the spray interface. The reviewer added that the work yielded predictive diagrams separating the classical atomization and spraying regime from the diffusion-dominated mixing regime, with overlaid classical diesel injection. This reviewer went on to say that there could have been a better effort to represent and further explain the conditions modeled. It will be important to at some point tie the improvements in understanding these physical regimes to the capability of predicting combustion processes and what advantages these bring to applied teams.

Reviewer 4:

The reviewer confirmed that very good progress was shown, adding that it would be good to understand the nearness to an engineering-level LES solution, the path to get there, and the measurements of progress along that path.

Reviewer 5:

The reviewer noted that the enhanced understanding of the fundamental changes occurring at the liquid/vapor interface with changes in pressure and temperature [Knudsen number (Kn) and mean free path] was an important contribution to the knowledge base of the injection/spray community. It was not clear to this reviewer how this was being transitioned into an engineering analysis of the sprays.

Reviewer 6:

The reviewer felt that there had been great progress in leveraging the ECN results, and added that it would have been nice to see a prediction of when this type of computing could be used by the OEMs to develop combustion systems. This reviewer asked if, given that a certain level of detail is required to accurately represent the spray, the simulation cost or time would ever be low enough for it to be used by OEMs to develop combustion systems.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the work with the ECN seemed to be strong, adding that building a connection between DOE Basic Energy Sciences (BES), EERE, and industry stakeholders appeared to be in place as well.

Reviewer 2:

The reviewer pointed out that the presenter was making good use of the data generated through the ECN. This reviewer asked if there were additional data that the presenter needed to move faster and/or to further improve his models.

Reviewer 3:

The reviewer acknowledged good representation from National Laboratories and universities. This person added that the input from engine OEMs could bring very valued input, particularly to corroborate the value added to the modeling capability.

Reviewer 4:

The reviewer observed that there were significant collaborations within DOE labs, ECN, and university partners. However, this reviewer mentioned that direct collaborations with industry partners seemed to be lacking.

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

Reviewer 1:

The reviewer affirmed that the plans for the continuation of the research appeared to be very good.

Reviewer 2:

The reviewer emphasized that it was good to see GDI coming into the scope, as Lyle had done. This reviewer hoped to see more GDI detailed analyses (e.g., multiple GDI injections, shot-to-shot variability) next year from the PI. It would be good to see the PI influencing the types of tests run in the ECN to make sure the PI is getting the information the PI needs.

Reviewer 3:

According to this reviewer, the scope of work could be extended beyond LTC and HCCI to systems representative of current products that tend more towards hot-temperature combustion. This reviewer added that the work could also explore kinetics of SI, flame-front propagation, and stratification.

Reviewer 4:

This reviewer suggested that more gasoline sprays under GDI-like conditions should be calculated.

Reviewer 5:

This reviewer explained that continuation of the current three aspects was proper, but added that more emphasis on direct-injection-spark-ignited (DISI) injection would be timely and that more direct collaboration with industry partners would be desirable.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer claimed that the findings from this project would enhance understanding of fuel spray and guide the design of efficient combustion systems, which would in turn reduce fuel consumption.

Reviewer 2:

The reviewer indicated that the project aided in the predictive simulation of combustion in high-efficiency, advanced-combustion engines.

Reviewer 3:

The reviewer concluded that the project was relevant to developing the fundamental understanding of combustion, but noted the need to also be working toward an engineering LES solution if it is truly desired to impact the product being sold in the United States.

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

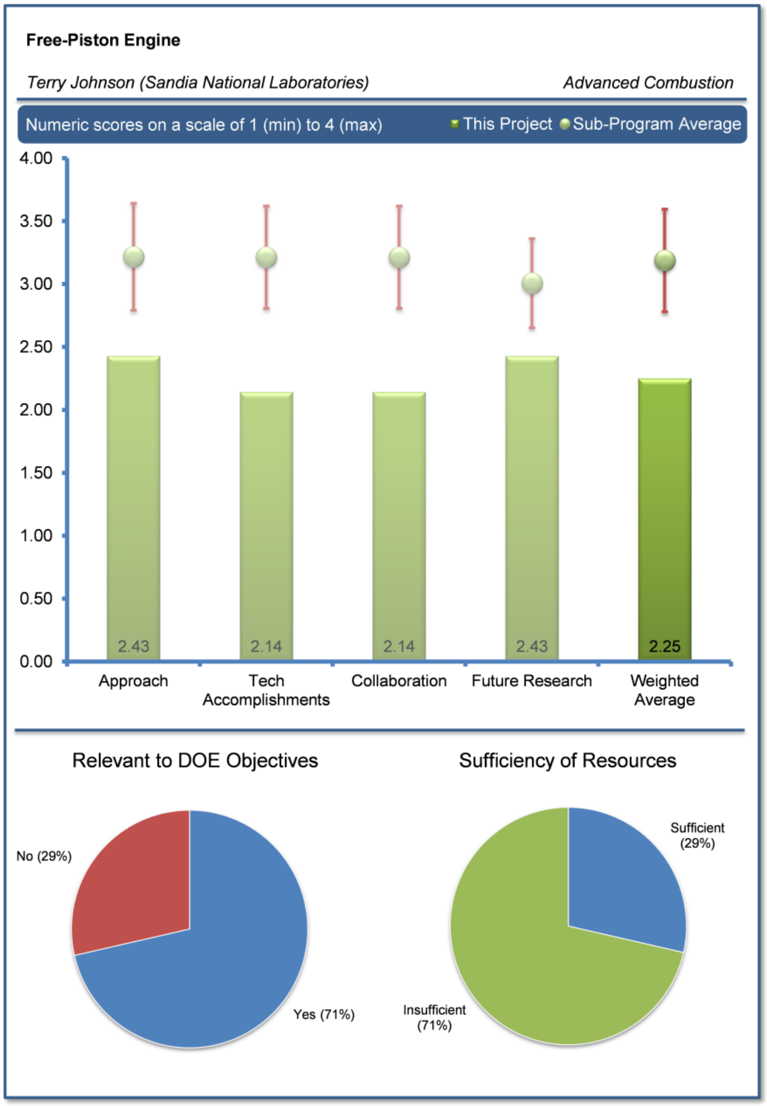
Reviewer 1:

The reviewer commented that the PI made great use of a modest amount of funding (relative to other projects).

Reviewer 2:

The reviewer stated that the resources appeared to be sufficient. This person assumed that the investigators were getting the computational access they needed.

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



Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

The reviewer asked if the plan was reasonable or too aggressive. It appeared that a parallel long-stroke mechanical solution combined with the free-piston engine (FPE) would be a powerful approach (versus FPE only).

Reviewer 2:

The reviewer stated that, while one could question the wisdom of an opposed-piston project, the presenter had a methodical approach to the execution of the concept.

Reviewer 3:

The reviewer remarked that, while the unique approach did not guarantee that the efficiency results would be better, a different approach was the first step toward realizing a different result.

Reviewer 4:

According to this reviewer, this project fell into the category of new engine concepts with the potential for improved efficiency and lower emissions. This reviewer added that, until this point, these characteristics have not been proven for this engine. The probability of success for such projects was likely to be low according to the reviewer, but it is important to investigate this with government funding. The lack of success in successfully proving the concepts in these types of projects is often not related or due to the approach taken.

Reviewer 5:

The reviewer commented that this project had made very slow progress throughout the last five years. The experiments were constrained and seemed to be transient-type versus steady-state experiments (e.g., the operating time was short and only one fuel was included [hydrogen]). The reviewer recognized that funding warranted only a part-time effort, but the limit on fuel type could be preventing further progress on this research project.

Reviewer 6:

Comments regarding the approach and scope of this project had been made over several years by this reviewer. The scope of this project has always been too large. As a result, progress toward goals has been less than satisfactory. Too many advanced features were combined altogether at once, which has clearly proven to be a huge challenge to make progress.

Reviewer 7:

The reviewer pointed out that this project was based on the concept that a very high compression ratio (20:1–40:1) was better for efficiency. The focus of the work had been to develop the engine, but the first step should be to verify the underlying hypothesis of the benefit of compression ratio. The reviewer asserted that this question should be answered before any more resources are put into anything else in this project.

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

Reviewer 1:

The reviewer observed that it was good to finally see some firing results and looked forward to additional tests.

Reviewer 2:

This reviewer was glad to see combustion data from the project before it closed, and added that estimates of the overall efficiency (including what energy was required to operate the bounce chambers, etc.) would be a good addition.

Reviewer 3:

The reviewer said that, compared to the progress made over the last six years, the progress made last year was commendable. Challenges to motoring the engine had been identified and were being fixed so motoring times could be extended. Also, some of the first useful firing tests had been conducted.

Reviewer 4:

The reviewer mentioned that there was significant progress on many subsystems, but added that it was not clear how much remained (in the high-level plan).

Reviewer 5:

The reviewer emphasized that, based on the projected 2012 Merit Review Future Work, the main effort of this year was to be on combustion studies. However, the reviewer indicated that only a few of these experiments had been conducted. The reviewer eagerly awaited additional experiments to determine if the efficiency made this approach worth pursuing.

Reviewer 6:

The reviewer explained that the rate of progress had historically been very slow. Even over the previous year, much of the work had focused on modifying the engine and setup in an attempt to reduce friction losses and improve the amount of time that the engine could be run before the motion was damped out (current run time was about 10-13 seconds, which seemed very short). The reviewer described that at the present time, the next step was to evaluate the success of a new piston design to significantly reduce friction losses so as to increase engine efficiency. The reviewer indicated that the slow progress was likely not due to poor performance of the PI, but rather the technical challenges of getting the FPE concept to work.

Reviewer 7:

The reviewer noted that one big accomplishment was having a running engine (although its operational capability was limited at this time), and appreciated that just ensuring the gas bounce system would work satisfactorily was an accomplishment in and of itself. Nevertheless, there was hope that more experimental work would have been completed by this time. The few experiments running very lean hydrogen were barely scratching the surface about what might be possible with this type of combustion system arrangement.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that the University of Michigan (UM) and GM had been added as collaborators. This person suggested OEM industry input on design details, especially on candidate piston and ring details.

Reviewer 2:

The reviewer reported that this project appeared to have included collaboration with UM in the overall modeling of the engine flows, but noted that the collaboration with GM was not clear.

Reviewer 3:

The reviewer concluded that the degree of collaboration seemed to be limited to Los Alamos National Laboratory (LANL) and GM/UM. It had been mentioned that the latter was set up in 2009 to help with modeling work in MATLAB/Simulink. It was unclear to the reviewer how effective that collaboration had been. This reviewer added that perhaps the modeling work could not be effective until a good quantity of experimental data was obtained.

Reviewer 4:

The reviewer confirmed that some collaboration existed. In retrospect, this person added that experts in the area of FPEs, hydrogen (H_2) combustion, and linear alternators (admittedly rare) should have been sought out early in the project.

Reviewer 5:

The reviewer voiced that there appeared to be a little collaboration with GM and UM, but it appeared to be minimal and it was not clear how it fit into the overall project.

Reviewer 6:

The reviewer stated that there was minimal collaboration.

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

Reviewer 1:

The reviewer felt that it would be good to fully characterize the performance of the engine given the investment to build it.

Reviewer 2:

The reviewer remarked that a combustion study (to answer the question about the premise of the study) should be the priority for the next year followed by a decision on whether to continue the project.

Reviewer 3:

The reviewer asked that the PI please mention the money needed for the various stages.

Reviewer 4:

The reviewer acknowledged that a lot of work remained if the project was to be completed in mid-2013.

Reviewer 5:

The reviewer commented that two key issues still had to be addressed: the ability to run the engine for more than 10 seconds before motion was damped out, and the reduction in friction losses to increase the engine efficiency. The latter issue depended on whether the new piston design successfully reduced friction losses. The reviewer asserted that if those two issues could not be addressed, the other proposed plans were not particularly relevant.

Reviewer 6:

The reviewer said that the proposed research plan was too vague, adding that little experimental progress had been made to date and that any future work needed a closer focus studying the combustion process with specific fuels and boundary conditions.

Reviewer 7:

The reviewer expressed that, in the time remaining, work should largely be focused on understanding efficiency potential and not on understanding any emissions characteristics. Work should focus on firing the engine repeatedly enough to be confident about the data so that efficiency estimates can be robustly made. This reviewer added that the project should be terminated this year and not continued unless totally rescoped.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer affirmed that this was actually a very relevant project, because it had very stretch goals for efficiency gains while using a very unique concept. This person added that this was just the kind of high-risk/high-reward work that a National Laboratory should be doing.

Reviewer 2:

The reviewer explained that if this concept were to be successful and an FPE having high thermal efficiencies could be commercialized, then the quantitative demand for fuel would be reduced. Also, this person added, the fuel could potentially be non-petroleum based.

Reviewer 3:

The reviewer suggested rescoping the project to include a mechanical approach to help accelerate the combustion portion of the project (thereby determining efficiency).

Reviewer 4:

The reviewer warned that the likelihood that this project would be successful in ultimately lowering petroleum consumption was low. This project provided a new engine architecture that takes advantage of hydrogen and HCCI. The reviewer indicated that there is a risk that both of these approaches might not succeed, and further that the new engine architecture would fail to be adopted.

Reviewer 5:

According to this reviewer, the experimental results showed that the concept engine had little chance of making progress towards meeting the DOE objectives focused on high efficiency engines. The reviewer explained that there were significant challenges in the alternator portion of the engine and in the potential ISFC capabilities of the engine using automotive-relevant fuels such as gasoline or diesel fuel (work to date has focused on lean-burn hydrogen).

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

Reviewer 1:

The reviewer acknowledged that the project needed minimal additional funding to complete testing and characterize the performance of the engine.

Reviewer 2:

The reviewer pointed out that there had been only $100,000 in funding in 2013. While this was certainly not sufficient, progress had been quite slow even in prior years with larger funding. This reviewer added that it was not clear where this project was headed, and that the PI had mentioned that Stage 3's financial need would be about $200,000.

Reviewer 3:

The reviewer said that the project should be funded just enough to focus on getting robust firing-efficiency numbers.

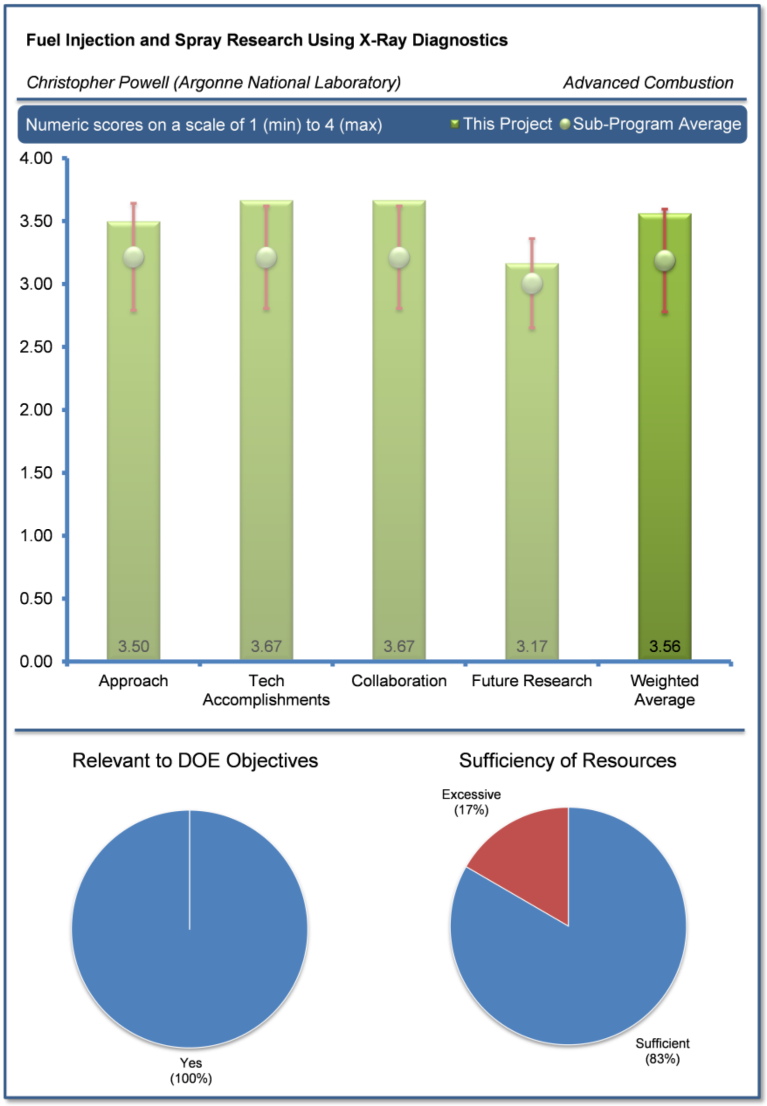
Reviewer 4:

The reviewer noted that the presenter had indicated that the funds allocated to the project in 2013 were insufficient for the proposed plans (especially Stage 3, which included broader emissions analysis). Specifically, the presenter estimated that an additional $150,000 to $200,000 would be needed. However, this reviewer added that given the state of the project, it was hard to justify the allocation of those additional funds.

Reviewer 5:

The reviewer expressed that it was apparent that the lower funding level had slowed down progress, but added that this project had very high risk, such that reduced or nil funding would be adequate in this case.

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



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the project had well-considered the use of X-rays in an appropriate application area.

Reviewer 2:

According to this reviewer, the use of X-rays to elucidate the fundamental spray structure and characteristics in the near-nozzle region was proving to be a very good approach.

Reviewer 3:

The reviewer felt that the development of a technique to measure cavitating flows would provide key information that were previously unknown. Citing the unique capability at Argonne National Laboratory (ANL), this reviewer added that it was important to continue active involvement in the ECN.

Reviewer 4:

The reviewer remarked that the PI and his predecessor had done a great job during the past decade to bring X-ray spray measurement from concept to reality. This reviewer added that the combination of modeling support and experimental evaluation of various nozzles had been very helpful throughout the years. The one area of weakness this person noted was the limited operating temperature for taking spray measurements, which made any evaporation effects difficult to assess.

Reviewer 5:

The reviewer acknowledged that the X-ray absorption technique, while capable of providing very useful information for certain types of problems, had the limitation of being limited to room-temperature conditions and only producing ensemble-average data.

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

Reviewer 1:

The reviewer commented that there had been great progress developing the technique for measuring cavitation, in both plastic tubes and injectors.

Reviewer 2:

The reviewer pointed out that there looked to be good progress in using the X-rays to view fuel flow near the nozzle. The project had seen the formation of bubbles near the nozzle, which are entrained back into the nozzle when closed and contribute to cavitation.

Reviewer 3:

The reviewer observed that new data on cavitation had been produced that will help understand the phenomena. The reviewer explained that different nozzle entrance effects had been studied, and droplet size data for gasoline sprays had been obtained.

Reviewer 4:

The reviewer said that it was good to see a better understanding of injector control and noise factors that influence spray. This person was looking forward to seeing how these factors influenced (or did not influence) spray and, ultimately, combustion.

Reviewer 5:

The reviewer mentioned the experimental cavitation results.

Reviewer 6:

The reviewer asserted that the recent work on cavitation was quite interesting and would be helpful for fuel suppliers in addressing methods for either minimizing the cavitation in a nozzle or exploring design changes to ensure that nozzles can withstand such conditions in future advanced designs. This person added that this tool would be very helpful for both fuel injector suppliers and engine companies in exploring spray formation phenomena, including cavitation in the combustion system designs. This reviewer concluded that the one downside of this technique was the temperature limit, which did not sufficiently include real-world evaporation effects.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer expressed that there looked to be a good number of collaborations with industry partners (including Delphi D, Infineum, and Chrysler) as well as the National Laboratories and universities (including via the ECN).

Reviewer 2:

The reviewer affirmed that it was good to see that various OEMs and suppliers were using this resource to better understand their products.

Reviewer 3:

The reviewer listed ECN and Chrysler.

Reviewer 4:

The reviewer reported that the project was leveraging simulations at ANL and the University of Massachusetts–Amherst to understand cavitating flows and suggest experimental improvements. This reviewer added that engagement with fuel-system suppliers would be useful.

Reviewer 5:

The reviewer reinforced that the existing collaborations were good, but encouraged more collaborations with the industry fuel-injector suppliers.

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

Reviewer 1:
The reviewer highlighted that the plan to address the temperature and pressure limitations would be a good step. This reviewer looked forward to the results of future application of cavitation diagnostics and continued involvement with the ECN.

Reviewer 2:
The reviewer summarized that the proposal to continue work on near-nozzle sprays with X-rays with various nozzles seemed reasonable.

Reviewer 3:
The reviewer confirmed that, generally speaking, the approach was logical and would yield further insight concerning two-phase flow in nozzles. This person added that it would be helpful if the PI could explore the possibility of increasing the chamber temperature to levels closer to reality in DI engines.

Reviewer 4:
The reviewer voiced that the move to diamond windows should be accelerated so that high-temperature measurements could be made. This reviewer asked whether something could be done to improve the X-ray flux to enable single-cycle imaging rather than ensemble-average.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that an improved understanding of the fundamentals of fuel injection and sprays, along with improved models, should lead to better designs and better engine efficiency. This in turn would lead to lower emissions and petroleum use.

Reviewer 2:
The reviewer noted that the trend toward high K-factor nozzles with lower cavitation indicated the importance of this phenomenon. This reviewer added that the importance was likely to increase with higher injection pressure.

Reviewer 3:
This reviewer remarked that the project provided fundamental data for understanding sprays and injector behavior.

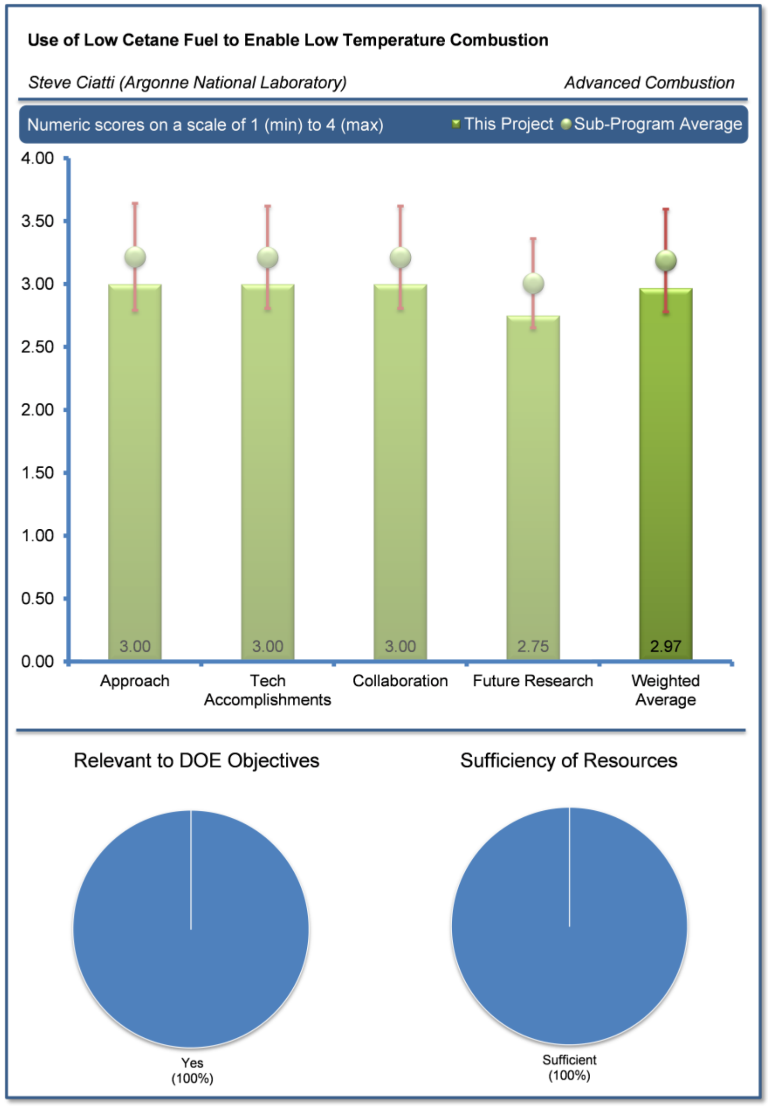
Reviewer 4:
The reviewer acknowledged that this project provided others with a tool to explore various combustion modes through an improved understanding of intra-injector and near-injector nozzle outlet spray formation.

Reviewer 5:
The reviewer commented that cavitation diagnostics were more useful at very high pressures.

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

Reviewer 1:
The reviewer indicated that the budget was very large for this project. This reviewer was not sure if the funding was excessive or not.

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



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer pointed out that there was excellent practical work with a clear focus and goals.

Reviewer 2:

The reviewer observed that the project was a good study of the potential for pushing up LTC operation to high loads using gasoline-like fuels.

Reviewer 3:

The reviewer mentioned that the approach taken was based on experimental work with the support of simulation, both from CFD (for in-cylinder operations) and Autonomie (for real-world impacts). Further, the presenter mentioned the supporting role of Argonne's Advanced Photon Source (APS) facility for injector performance characterization, as well as its rapid compression machine (RCM) for examination of ignition parameters. The latter two, however, had not yet been introduced to the project (the RCM may be part of another project). This reviewer additionally noted that the studies focused on gasoline-like fuels, combustion controls of ignition, and high power density. The low-octane and high-volatility fuels provided an increased ignition delay.

Reviewer 4:

The reviewer noted that this project addressed two of the three technical barriers directly (namely, the mechanism to control LTC timing and LTC high-load/high-speed operation). However, this person added that the approaches taken thus far had yet to show that true LTC had been achieved.

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

Reviewer 1:

The reviewer applauded the project's impressive progress toward low-load operation and low-emissions/high-efficiency operation.

Reviewer 2:

The reviewer emphasized that there was good progress demonstrating operation across the load range (going down to 1.5 bar brake mean effective pressure [BMEP]). This reviewer added that favorable fuel consumption compared to gasoline was good, but asked how this compared with a diesel engine (which was likely to be closer to the cost of this type of engine).

Reviewer 3:

According to this reviewer, the accomplished results were quite impressive, especially the power density (approximately 20 bar) and combustion stability (with a center of variation of IMEP less than 3%). However, this reviewer added that the NO_x level was still too high, which indicated that true LTC had not been achieved.

Reviewer 4:

The reviewer indicated that the work presented was a good step forward from last year's presentation. The project spanned a wide range of fuels at various operating conditions, and the load range that was run was very impressive. This reviewer added that it was not clear that the Autonomie selection of points was relevant at the present stage. It was disconcerting to the reviewer that the presentation provided fuel economy performance benchmarks with respect to the baseline hardware. The comparison should have been done at a much deeper level, taking into account the emissions levels, exhaust temperatures, exhaust makeup, and impact on aftertreatment. Other constraining factors would be important, such as pressure rise rate limits and coefficient of variation, and a consideration of steady state points was not sufficient for this type of engine. This reviewer went on to say that data of brake specific fuel consumption (BSFC) versus brake specific NOx (BSNOx) at fixed load would have better represented the trends, rather than overlying all the data at once across the load range. This reviewer asked what the expectation was from the KIVA work. The CFD work lacked direction and appeared as an afterthought to the experimental work. This tool should have been used to explore conditions beyond the experiments and provided useful direction to the project. The reviewer mentioned that the presentation emphasized the variation across cylinders as a major issue and that the tool should not be used in this context, but rather as directionally showing how the combustion system might be exercised for increased efficiency.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported that there were good collaborations with other institutions, and that the modeling collaboration with UW showed good synergy. This reviewer added that coordination with other DOE labs that have a similar LTC engine test program would be desirable (as indicated in the future work).

Reviewer 2:

The reviewer summarized that the work overlapped many other efforts currently taking place in industry and academia. The uniqueness of the work was running a multi-cylinder engine demonstrator. This person added that it might be good to frame the present work with the available reference data to illustrate the new ground gained from working with low octane number fuels.

Reviewer 3:

The reviewer noted that the project was working with UW for simulations, but that it was not clear how the modeling was being leveraged to further the goals of the project.

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

Reviewer 1:

The reviewer felt that the planned future work covered all the areas, but added that the major focus should have been to demonstrate that low BSFC/BSNOx was achievable with the proposed operating strategy. If not, then the transient study ought not to be performed.

Reviewer 2:

The reviewer remarked that it would have been useful to have identified all the issues that must be solved to provide a viable vehicle engine along with the work needed to address each.

Reviewer 3:

According to this reviewer, the project should continue to push toward low load and define what was needed to enable idle operation. Low emissions were critical to providing a cost benefit to this approach relative to diesel. The reviewer added that it was good to connect the work with John Dec's fundamental work. The noise (90-95 decibel [dB]) was high for LD. This reviewer further stated to explore LD as well as the tradeoff between efficiency and noise, trying to match the noise of the base diesel engine.

Reviewer 4:

The reviewer pointed out that last year's presentation had indicated the use of an endoscope, but this had not been carried out. The RCM work was also noted, but nothing had been reported. This reviewer added that caution must be taken to avoid this type of planning. It would be important to verify the feasibility to expand the low load limit with 93 Research Octane Number (RON) fuel. It would also be good to prove-out the feasibility and robustness of transients.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer observed that the work was clearly aimed at fuel savings for light-duty engines.

Reviewer 2:

The reviewer mentioned that low-cetane fuel could be one of the enablers for HCCI engines, which could reduce fuel consumption. Thus, this project supported the DOE objectives of using less petroleum.

Reviewer 3:

The reviewer explained that the project was working on improving efficiency with gasoline-like fuels running high-load LTC.

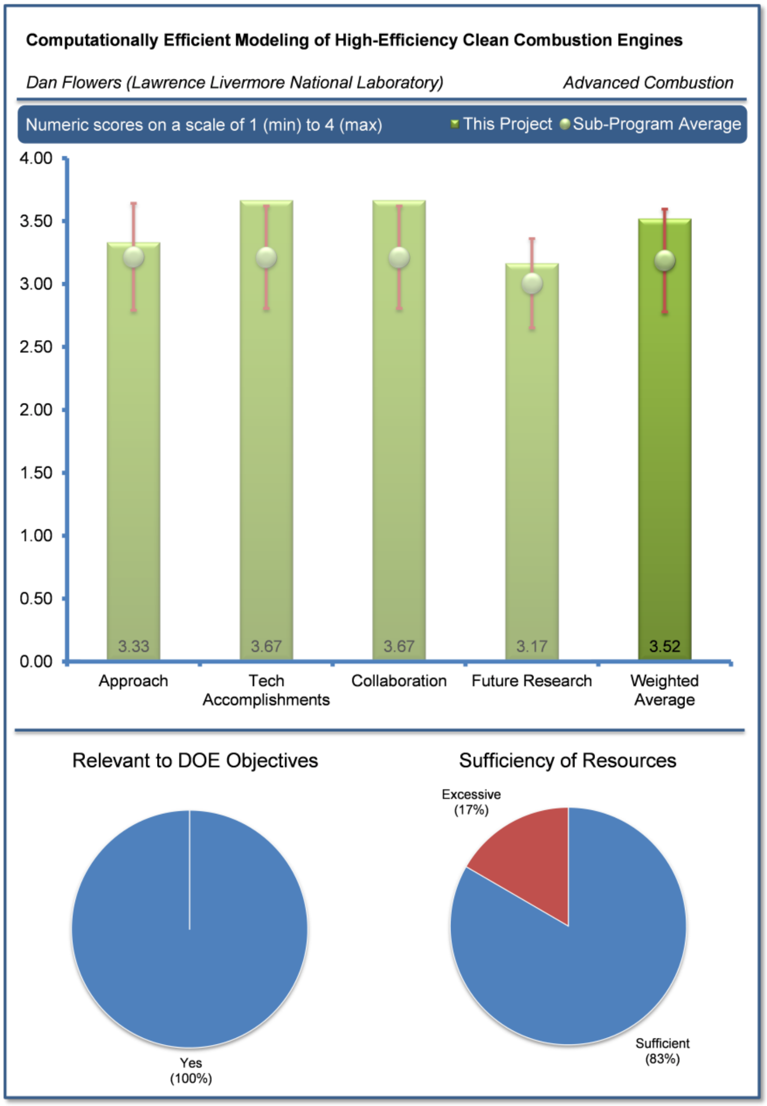
Reviewer 4:

The reviewer agreed that this project was relevant to the impact of fuel composition on future engine architectures and efficiency targets.

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

No comments were received in response to this question.

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



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer indicated that the project objectives were very well-aligned to the needs of the industry to thereby impact engine design.

Reviewer 2:

The reviewer reported that the approach taken to develop faster, more efficient computational combustion tools appeared to be reaping sizable benefits. This reviewer indicated not being an expert in this area and thus was unable to fully judge whether the approach and tools being used were the very best possible (i.e., outstanding. outstanding) or not.

Reviewer 3:

The reviewer summarized that the approach was to make CFD simulations of advanced combustion concepts available to the desktop computer. The approach was to validate new multi-zone schemes and advanced graphics-processing-unit (GPU) solvers, and incorporate enhanced features into commercial codes.

Reviewer 4:

The reviewer recommended investigating the sensitivity to various combustion system variables.

Reviewer 5:

The reviewer voiced that this ongoing project had demonstrated good progress in improving computational efficiency and time throughout the years, adding that this approach had included exploration in multi-zone modeling, techniques for performing chemistry calculations, and methods for speeding up processing time. The missing ingredient, according to the reviewer, is a lack of validation for engine operating conditions. The reviewer added that showing good results at one operating condition was not adequate.

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

Reviewer 1:

The reviewer noted lots of significant progress in a number of areas, including: validation of a new multi-zone scheme demonstration of a CFD multi-zone model for GDI SI and premixed charge compression ignition (PCCI) operation; a reduction by a factor of 25 in the chemistry computational time for multi-zone engine simulation with the latest LLNL solver; and the licensing of simulators to various companies.

Reviewer 2:
The reviewer acknowledged an amazing improvement in simulation runtime.

Reviewer 3:
The reviewer commented that the non-premixed reactor validation work was well-considered.

Reviewer 4:
The reviewer observed that the multi-zone scheme was working well and that orders-of-magnitude reductions in simulation runtime had been achieved with the advanced GPU-solvers. The new enhancements had been validated for a PCCI test case. This reviewer added that it seemed like progress on applying the models to real-world problems and the evaluation of models could be faster. This project had been ongoing for several years.

Reviewer 5:
The reviewer mentioned that there had been very good progress throughout the years improving computational efficiency and reducing simulation runtime, but the validation for engine use was really lacking within this project. It would have been very helpful to broadly compare predictions with numerous operating conditions, including single and multiple injections, varying intake conditions, and various nozzle sizes.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer asserted that there appeared to be lots of interactions with OEMs (including Cummins, Ford, Volvo, Bosch, Delphi, and General Electric Turbines), National Laboratories (SNL and ORNL), and universities (University of California–Berkeley, UW, and UM). It looked like the project team was serious about getting their simulation models/tools in the hands of end-users.

Reviewer 2:
The reviewer expressed that the collaborations with academia and industrial partners was great and helped advance the analysis tools.

Reviewer 3:
The reviewer affirmed that this project had supported many researchers throughout the country. The best collaborations had led to improved CFD codes and the use of specific solvers/models for internal use by different industry partners.

Reviewer 4:
The reviewer explained that several relevant collaborations existed with commercial code suppliers, industry, other labs, and academia.

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

Reviewer 1:
The reviewer indicated that there were excellent plans proposed to continue the work and to make further improvements to reducing the computational time for conventional-diesel and advanced combustion.

Reviewer 2:
The reviewer reported that parallel CFD with chemistry with a very large number of reactions was planned, and that multiple-operating-point simulations were also planned.

Reviewer 3:

The reviewer noted the diesel fuel model includes nine species.

Reviewer 4:

The reviewer summarized that the proposed approach was fair, but really needed to focus on much more detailed validation.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer confirmed that improving the accuracy and reducing the computational time of engine simulations should lead to the design of engines with improved efficiency and lower emissions; this was in alignment with DOE goals.

Reviewer 2:

The reviewer voiced that improved engine simulation tools would help the industry design engines with improved efficiency for the marketplace.

Reviewer 3:

The reviewer stated that this was another project that provided others with tools for pursuing combustion system approaches that address DOE objectives.

Reviewer 4:

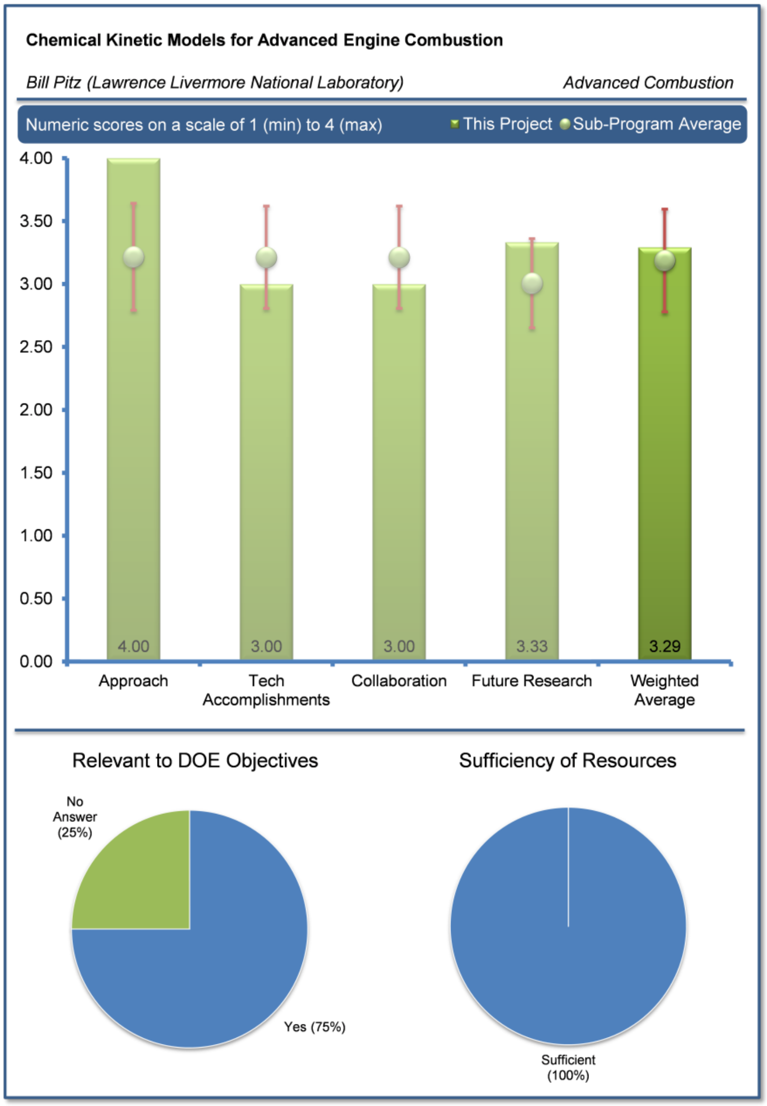
The reviewer noted that the project aimed to make high-fidelity CFD available to engine designers by reducing simulation time without sacrificing accuracy.

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

Reviewer 1:

The reviewer reported that the funding was very high for a software-focused effort, and this person was not sure where all the money was being spent.

Chemical Kinetic Models for Advanced Engine Combustion: Bill Pitz (Lawrence Livermore National Laboratory) - ace013



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer remarked that the scope was very clearly laid out in four steps, covering detailed mechanisms for diesel and gasoline components, and two-component mechanisms for diesel engine simulation tools. The reviewer thought the approach was comprehensive, transitioning between detailed individual components, combined mechanisms, and reduced mechanisms (for more practical use).

Reviewer 2:

The reviewer acknowledged that the approach was sound, and the end deliverable of reduced and accurate mechanisms for use in engine design would enable new, more efficient engines.

Reviewer 3:

The reviewer felt that the project's approach was well-considered, especially the validation process. This person added that it might be time consuming, but it was well worth doing it right. The chemical kinetic models established from this research would be very valuable to the research community as well as the industry.

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

Reviewer 1:

The reviewer pointed out that there was an excellent agreement between the bench tests and modeled results. This reviewer was looking forward to the gasoline/EGR validation that had been mentioned as proposed work in the project's 2012 presentation. Unfortunately, this reviewer did not see it in the 2013 presentation but hoped that it would be there in 2014.

Reviewer 2:

The reviewer observed that the presentation outlined four objectives clearly and that the numerical work was accompanied by experimental results. Objective 1 on the diesel side covered N-propyl and N-butyl benzenes in ranges covering shot-tube and RCM experiments. There was a good spread of pressure ranges between one and 50 atmospheres at an equivalence ratio (EQR) of 1.0 and 2.0. Objective 1 showed flame speeds for alkyl benzene and intermediate species for alpha-methylnaphthalene. Objective 2 revealed the maturity of the gasoline surrogate from LLNL and expanded this to gasoline-ethanol mixtures. Models were to be exported for comparison with single cylinder test engine (SCTE) data. Flame speeds were benchmarked with experimental data. Objective 3 considered large alkyl-cyclohexanes. The updated methlcyclohexane (MCH) mechanisms satisfied experimental species profiles in low-pressure flame experiments. Finally, Objective 4 outlined the reduction effort for the two-component diesel surrogate made out of m-xylene and n-dodecane. This reviewer would have liked the authors to have provided a picture, specifically arising from Objective 4, regarding the effectiveness of the work in the real applications. This might come from collaborations with academic or industrial partners.

Reviewer 3:

The reviewer commented that the objectives set out for the FY were mostly accomplished. The models were validated with results from experiments by other researchers on a fundamental level. Most comparisons yielded excellent results, except some cases with MCH, which deserved some further review. This reviewer added that it would be interesting to see the models perform in the actual engine modeling.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer affirmed an excellent lineup of resources, encompassing experienced numerical and experimental teams.

Reviewer 2:

The reviewer expressed that the collaboration and coordination with other institutions were well-handled.

Reviewer 3:

The reviewer affirmed good collaboration with other researchers. This person added that it would have been interesting to see a more tangible link to the industry, either by demonstrated use of the presenter's work or incorporation into commercial tools.

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

Reviewer 1:

The reviewer explained that the authors had set up an aggressive schedule to transition to a nine-component palette for diesel as well as the development of models for five Fuels for Advanced Combustion Engines (FACE) gasoline fuels. This reviewer looked forward to the results of these efforts.

Reviewer 2:

The reviewer agreed that the plan to finish modeling the rest of the three components was proper. This person added that the remainder of the two action items was also valuable.

Reviewer 3:

As for most other projects, this reviewer would like to see more work on gasoline. This reviewer asked about the long-term roadmap for the further development of gasoline surrogates, and whether the models had been fully validated over a range of equivalence ratios and EGR concentrations. This person went on to say that it was also not clear how the work was prioritized (e.g., which molecule was next, and why).

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that the development of kinetic mechanisms was essential to modeling advanced efficient combustion engines, which would in turn lead to reductions in fuel consumption.

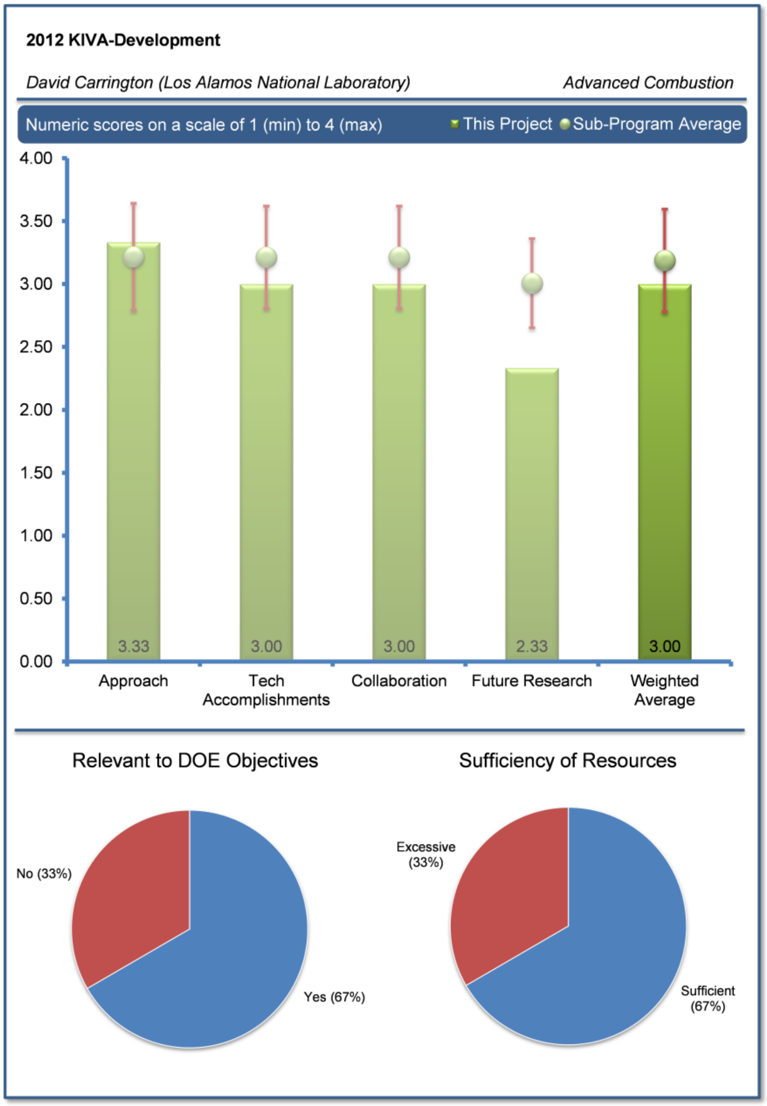
Reviewer 2:
This reviewer summarized that the work was very relevant and that fuel surrogate models for gasoline and diesel fuels enabled accurate engine simulations with fuel effects.

Reviewer 3:
The reviewer confirmed that simulation of advanced combustion concepts would not be possible without this type of work.

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

Reviewer 1:
The reviewer concluded that it was not clear how more funding, if it were available, would serve to expedite or expand this work.

2012 KIVA-Development: David Carrington (Los Alamos National Laboratory) - ace014



Reviewer Sample Size

A total of three reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the project was developing robust, accurate algorithms, and added that modular object-oriented code was a sound approach. Many aggressive goals were set. This reviewer went on to say that improving the KIVA's accuracy was very important for all of the users in the industry. The large number of KIVA licensees showed the general acceptance by the engine community.

Reviewer 2:

The reviewer confirmed that the work being done appeared to be addressing some of the shortcomings of the prior version of KIVA.

Reviewer 3:

The reviewer stated that the author emphasized the robustness and accuracy of simulation, based on a development process that emphasized physical modeling as well as validation and verification. The key was to provide modular object-oriented code. This reviewer added that the practical software improvements included a long list of wants, including faster grid generation, higher-order accuracy, and better turbulent modeling (Eulerian versus k-e). This reviewer noted that the author contended that this could be done with a new discretization and algorithms. The presentation seemed to lack depth on the verification side, especially in terms of real-world problems.

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

Reviewer 1:

The reviewer noted that the project went well against the objective and research plan. It was mostly going in the right direction, and there were good efforts in piece-by-piece validation. This reviewer went on to say that some of tests were just beginning, and that it would be interesting to see how the new KIVA would be proven to be more accurate in applications by the research community and industry.

Reviewer 2:

According to this reviewer, the author covered a wide range of material, focusing on numerical methods (finite element methods) and modeling approaches (e.g., k-omega and k-epsilon). This reviewer added that this was applied to airfoil geometries in subsonic flow regimes, boundary layer separation, and shock wave detachment. The present effort would have been more appreciated by this reviewer if the work presented here were incorporated into the simulation of an internal combustion engine where the present KIVA was being used to see the benefits of both modeling and numerical techniques. If this was already happening, the reviewer asked when it would take place and whether any issues were foreseen on valve pockets, recessed seat geometries, and so forth. This person also asked how the present effort compared with the work being carried out in other institutions, one example of which was the work being done by SNL and Convergent Science.

Reviewer 3:

The reviewer remarked that accomplishments were shown, but it was not clear how significant they were. This reviewer wanted to know whether the progress was ahead of or behind schedule.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the collaboration and coordination with other institutions were excellent, with contractors contributing 40% of the funding for this study and a significant number of KIVA licensees.

Reviewer 2:

The reviewer asked if this project would benefit from a broader partnership, particularly in the area of verification in industrial-like problems. This person further inquired about how this work related to that of SNL with Convergent, whether the effort should be plugged in with SNL, and how KIVA compared with Convergent over the short and long term.

Reviewer 3:

The reviewer pointed out that the collaboration appeared to be limited to three universities and LANL. This was surprising to this reviewer, who expected to see more universities involved given that KIVA was said to have many users and that its open source enabled researchers to make code improvements.

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

Reviewer 1:

The reviewer observed that the tasks planned for this project were quite aggressive. Since a modular approach was taken, prioritizing the tasks was necessary.

Reviewer 2:

The reviewer said that the work proposed was piecemeal but was scheduled to roll out to the public in a year or so.

Reviewer 3:

The reviewer criticized that it was not clear what tasks remained and when this activity would be done. This person would have liked to see a clear (and independent) comparison of the features and capabilities in KIVA and how they compared to commercial codes available today.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer asserted that KIVA was widely used in the auto industry for developing new high-efficiency engines that would reduce fuel consumption.

Reviewer 2:

The reviewer expressed that it was important to upgrade a long-standing tool used in combustion development.

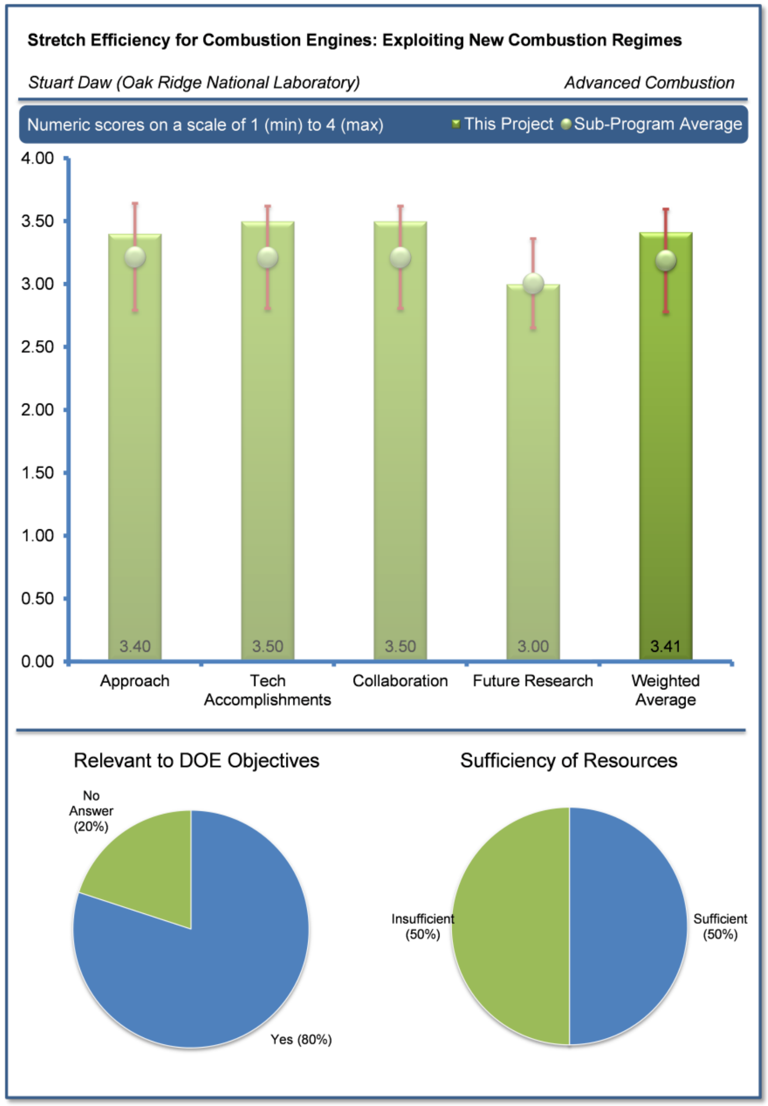
Reviewer 3:

This reviewer questioned the relevance of KIVA the more time went on. Because this person had to pick between yes and no, this reviewer picked no to make a point. This reviewer asked how many true users there were. This should be tracked annually, and not as a flat list of licensees since the beginning of this work. If the list of users were significant, this reviewer would change the relevance rating to yes. Given the fact that other researchers were partnering with commercial code providers, this reviewer asked if there was a similar opportunity here, and whether any of the commercial code providers would be willing to grant free licenses to universities and open up their system to enable code enhancements. This reviewer further asked whether DOE had approached them, as this would be a more direct, quicker way to get the code improvements into the hands of the OEMs.

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

No comments were received in response to this question.

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



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the project pursued thermodynamic strategies and technologies that could provide an increase in efficiency that would be revolutionary rather than evolutionary. The project focused on high-risk, high-reward technologies that could have a real-world impact over a longer-term timeframe. Thermochemical recuperation was the lead technology pursued. It is an attractive path to exhaust heat recovery (using one conversion device), where reforming may increase the lower heating value and exergy of fuel through endothermic reactions, driven by exhaust heat. This was evaluated via two pathways. The first was in-cylinder non-catalytic, for which the authors were considering the feasibility of the in-cylinder process via a six-cycle process. The second was catalytic reforming in an EGR loop. The reviewer indicated that here, the authors were identifying catalysts with sufficient activity and durability for future engine experiments and were building on work previously carried out at the Gas Technology Institute (GTI).

Reviewer 2:

The reviewer stated that this was exactly the type of project that the DOE should be supporting, as it had a high risk of failure but also a potentially high reward if successful.

Reviewer 3:

The reviewer remarked that this project was a result of previous years' brainstorming sessions on aggressive, high-risk strategies to noticeably improve LD engine thermal efficiency. This was an exploratory research project and there were many unanswered questions concerning whether reforming in some manner could dramatically impact thermal efficiency. This research will evolve as the research team learns on a day-to-day basis. There were many unknowns with this project and thus the direction will evolve with time.

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

Reviewer 1:
The reviewer acknowledged very interesting results regarding speciation of NVO products.

Reviewer 2:
The reviewer commented that most of the work focused on the first path (non-catalytic). The authors provided an organized report based on the experimental investigation of in-cylinder thermochemical recuperation with iso-octane, methanol, ethanol, iso-butanol, and hydrous ethanol, across various NVO durations and timings. The work was dependent on NVO settings, injection timing and oxygen (O_2) concentration, and fuel type. This was well-documented in the work published here. The reviewer added that H_2 and co-trends were shown for the fuels tested, which, when combined with fuel timing, were the main drivers. The conversion of fuel carbon to CO and shorter-chain hydrocarbons was recorded and did not compare well with the kinetic mechanisms used in the modeling exercises. The H_2 production was predicted more accurately by a temperature integral method. The reviewer explained that the authors needed further work to confirm if thermochemical recuperation was feasible, that is, that the fuel energy that resulted was greater than the input fuel energy. This reviewer also noted that work along the second path (catalytic) encompassed comparisons between fresh and used catalysts. Here, sulfur appeared to be the likely cause of the shift recorded in the experiments.

Reviewer 3:
The reviewer pointed out that much effort had been spent setting up and performing initial experiments in a single-cylinder engine (SCE). These initial experiments confirmed that reformation was possible, at least, but much work needed to be done to show the pros and cons of this approach. This reviewer reemphasized that much work still needed to be done.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that the project leveraged a good team, including SNL, GTI, Cummins, Sturman Industries, and various universities. The work was being shared through the U.S. Council for Automotive Research (USCAR) colloquium.

Reviewer 2:
The reviewer mentioned that the history of this project had included various researchers at multiple National Laboratories and universities, as well as industry input. This reviewer added that this project connected well with Dick Steeper's work.

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

Reviewer 1:
The reviewer explained that the work of in-cylinder and EGR reforming would continue. The present work indicated that the effort might be successful. It was viewed as a good idea to extend the work from the single- to multi-cylinder engine platform.

Reviewer 2:
The reviewer indicated that the comparison between different reforming approaches would be interesting.

Reviewer 3:
According to this reviewer, the proposed future work was very general. The reviewer explained that it would be helpful to have seen a more detailed plan, including any work that might focus on using reformation to enable combustion modes that had shown promise toward improving engine thermal efficiency. The reviewer recognized that there was initial upfront work required to ensure the reformation process was somewhat optimal and worked well within an engine system, but that eventually other portions of this research effort needed exploration.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reinforced that this project was a result of a DOE-supported effort to explore ways to theoretically improve engine efficiency. From its inception, it had been addressing DOE fuel-economy objectives.

Reviewer 2:

The reviewer noted that the effort was high risk but also high reward if successful at improving engine efficiency.

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

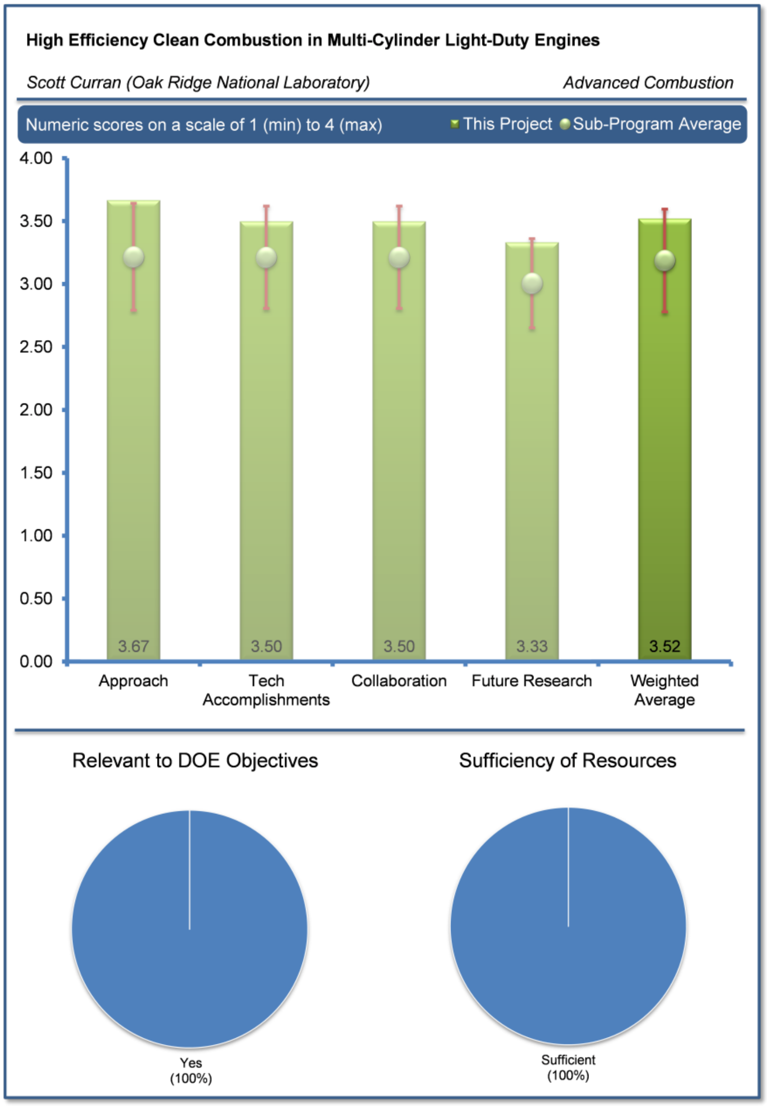
Reviewer 1:

The reviewer suggested that, given the range of interesting ideas presented, it seemed like more work could be done to evaluate them and understand the opportunities and tradeoffs.

Reviewer 2:

The reviewer explained that the budget could become insufficient depending on how the reformation experiments progressed toward exploring that possibility (leading to advanced combustion strategies that have shown promise for improving engine thermal efficiency). For example, this reviewer added that if the PI needed to modify the engine setup, then the budget could become insufficient.

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



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the data and analysis generated in this project had been needed for a few years. It pointed out the pros and cons of dual-fuel combustion systems for practical automotive use. This reviewer added that the combination of engine testing and zero-dim vehicle analysis was very fruitful for this project.

Reviewer 2:

The reviewer felt that this project provided an understanding of RCCI combustion on a more real-world multi-cylinder engine. This project was a critical step in providing efficiency and emissions data so that the barriers to advanced combustion modes could be better understood and therefore better addressed.

Reviewer 3:

The reviewer remarked that the valuation of the RCCI technology in a multi-cylinder engine with real aftertreatment was critically important to determine the commercial feasibility of the RCCI approach.

Reviewer 4:

The reviewer acknowledged that it was a good idea to investigate the potential vehicle-level fuel economy impact of the RCCI approach.

Reviewer 5:

The reviewer commented that it was good to see a systems-level project in the portfolio. This reviewer added that dynamometer measurements of efficiency could easily be lost when implemented on a vehicle.

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

Reviewer 1:

The reviewer pointed out that there was excellent progress in assessing the benefits and challenges of RCCI technology in real multi-cylinder engines with real aftertreatment systems. The project had mapped the performance of RCCI as well as validated the high efficiency and low NOx and smoke emissions on the multi-cylinder platform. This reviewer added that the project had identified several challenges, which included high HC and CO emissions coupled with low engine-out temperatures, which made the current aftertreatment systems ineffective. The project had also extended the engine maps to the Urban Dynamometer Driving Schedule (UDDS) drive cycle.

Reviewer 2:

According to this reviewer, excellent progress had been made. Within the limitations of the stock turbo, the multi-cylinder engine had been mapped and BSFC and emissions data had been obtained, providing a much clearer picture of the potential of RCCI. Further, the map had been used in Autonomie predictions and compared to some baselines to get an idea of the potential on the Federal Test Procedure (FTP) cycle.

Reviewer 3:

The reviewer observed that there was very good work to date demonstrating the capability of RCCI in a practical multi-cylinder engine. The vehicle analysis work was also very good and at least provided the community with a feel for what sort of fuel economy gains were reasonable with RCCI engines.

Reviewer 4:

The reviewer said that there was great progress. The project addressed many important aspects of implementing an LTC strategy. The PI should attempt to estimate the cumulative TP emissions to see how close the project was to a Tier 2-Bin 2 or partial-zero-emissions-vehicle (PZEV) TP emissions standard. By the early part of the next decade, OEM fleet averages will need to be at these levels. If their standard catalysis is not an option, then alternatives such as HC traps will be required.

Reviewer 5:

The reviewer noted the Quarter Three Milestone (high-efficiency RCCI mapping) and Quarter Four Milestone (drive-cycle evaluation).

Reviewer 6:

The reviewer asserted that the project needed to compare vehicle fuel economy on an equivalent performance basis. It was not fair to compare fuel economy for an 8-bar BMEP engine with an 18-bar BMEP engine because vehicle performance would be so different.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer expressed that very good collaborations with very relevant organizations over several areas existed. These collaborations would ensure that the relevant data and results were obtained to understand the potential of RCCI combustion.

Reviewer 2:

The reviewer affirmed that the project showed good collaboration between the PI, UW, GM, and other minor partners in both performing experiments on the small diesel and modeling the RCCI combustion events.

Reviewer 3:

The reviewer explained that a number of collaborations were mentioned, including those with MAHLE, GM, MECA, CLEERS, Diesel Engine Research Consortium (DERC), and UW.

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

Reviewer 1:

The reviewer indicated that there were very reasonable plans to continue to assess the benefits and challenges of RCCI technology (including transient performance) as well as aftertreatment integration options to address the challenges of high HC and CO emissions coupled with low engine-out temperatures.

Reviewer 2:

The reviewer reported that the project proposed to replace the stock turbocharger with a bigger one (and perhaps a supercharger as well) to enable the completion of the RCCI map at higher loads and speeds. This person added that this was a very appropriate next step.

Reviewer 3:

The reviewer reinforced that, overall, the objectives for FY 2014 were solid. This person's only suggestion was to also work on transient response during load transition, especially within the RCCI operating regime.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer claimed that this work directly supported the DOE's objectives of improving vehicle fuel economy, adding that this project had shown the potential of one type of engine combustion strategy at steady-state conditions to improve over diesel and port-fuel-injection (PFI) type technology.

Reviewer 2:

The reviewer summarized that this was exactly the kind of work that was needed to bridge fundamental single-cylinder research in the area of advanced low-temperature combustion to more real-world-like multi-cylinder evaluations.

Reviewer 3:

The reviewer voiced that RCCI was an advanced combustion approach that had the potential for higher efficiency, lower fuel consumption, and lower NOx and soot emissions than current engines. The ORNL project was assessing what the technical benefits and challenges of this technology were in realistic engine and vehicle system setups.

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

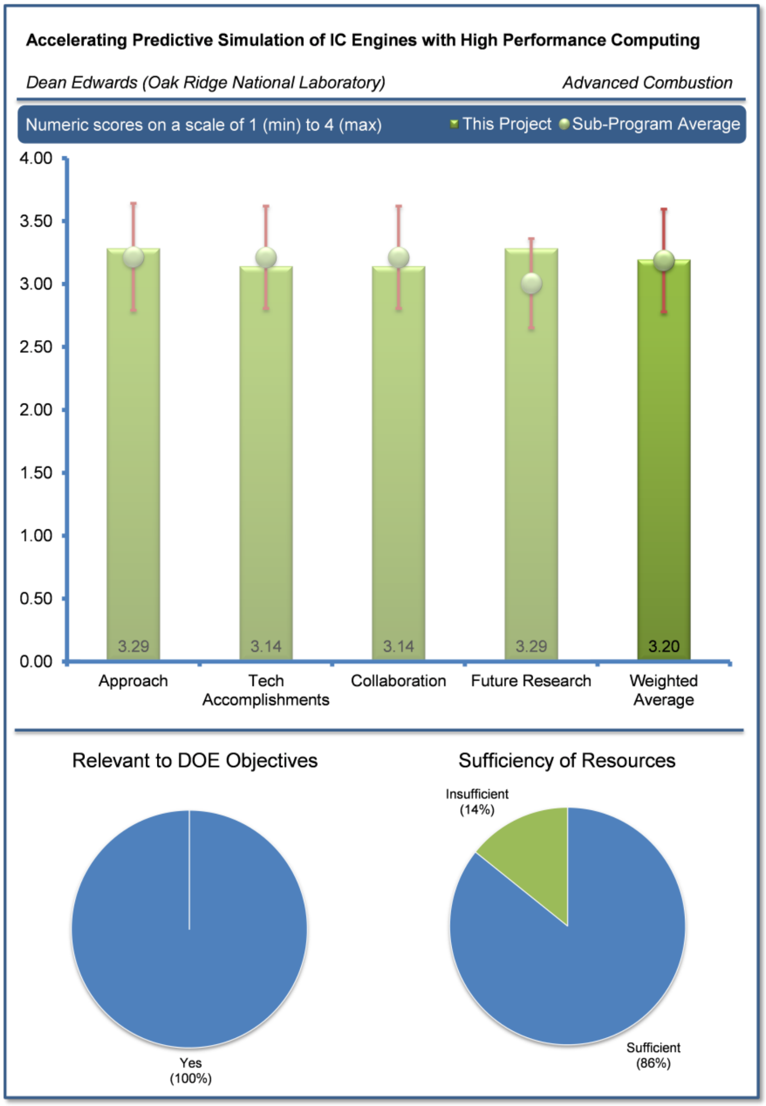
Reviewer 1:

The reviewer indicated that the milestones were being met, so it appeared that resources were sufficient.

Reviewer 2:

The reviewer reported that the project had been supported for years at consistent funding levels and continued to produce useful results.

Accelerating Predictive Simulation of IC Engines with High Performance Computing: Dean Edwards (Oak Ridge National Laboratory) - ace017



Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the project was very focused in two areas of interest to OEMs: combustion stability and GDI injector design optimization. This looked like a very useful approach of using meta-models to greatly speed up the simulation.

Reviewer 2:

The reviewer noted that the lack of fundamental knowledge of advanced engine combustion regimes, and the lack of modeling capability for combustion and emission control, were cited as the technical barriers this project tried to address. The approach this project had taken was in general alignment with the goals by reducing the computing time. The methods were innovative and seemed feasible. The two cases where the methods were applied were very important to the industry. The ultimate validation of the method would be the degree to which that predication matched the test results, as the authors recognized (here the reviewer referenced page 22).

Reviewer 3:

The reviewer remarked that the project aimed to reduce engine design and simulation time from months to weeks. This person added that high-performance computing schemes and meta-models (models of models) were being used to optimize and speed up calculations. Two real-life applications were being studied as test cases.

Reviewer 4:

The reviewer commented that, for the injector spray optimization, it would have helped to provide the measures of success for optimizing. This reviewer assumed one measure was the set of control factors that provided a minimum in the response variables. The other would be robustness to noise factors (such as injector-to-injector spray variability).

Reviewer 5:

According to this reviewer, the approach to make use of large-scale computing was good. This reviewer was not sure if the meta-model approach being used for the Ford project would work. Given the approach to closely partner with two OEMs, this reviewer asked if all of the details of the approach would be open and publicly available, since it was being developed with public funds.

Reviewer 6:

The reviewer observed that this was a potentially valuable project. Using the most current simulation models and the massive computing power of Titan, the researchers were exploring the extent to which processes currently viewed as stochastic might actually be deterministic. If successful, it would shed light on the extent of current understanding of the details of phenomena that ultimately controls ability to maximize engine efficiency with reduced emissions. The second part of the reported effort involved using the extensive computing power of Titan to implement a very comprehensive injection system optimization. It was not clear what the new knowledge would be if this aspect of the work were successful. This reviewer concluded that it seemed that this part of the work was more the use of impressive computing capability to develop a more comprehensive optimization process.

Reviewer 7:

The reviewer said that CFD modeling was an excellent approach to studying the issues with the combustion system. Specifically, this reviewer thought that using CFD in an optimization loop was an excellent step forward in how injector design could be better optimized and matched to the engine's combustion system. This reviewer was admittedly not convinced that there was good value to studying cycle-to-cycle combustion variation in CFD, as it was not clear what could be done with this information. This person added that some explanation or theory on how understanding cycle-to-cycle variations could be used to improve overall engine efficiency would have been helpful.

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

Reviewer 1:

The reviewer mentioned that getting the codes ported and running was a significant accomplishment.

Reviewer 2:

The reviewer asserted that there looked to be good initial progress in setting up the meta-models and initial validation/calibration runs.

Reviewer 3:

The reviewer emphasized that the work was in its early stages and the results were basically the establishment of techniques and approaches. This reviewer went on to say that good progress had been made in doing this.

Reviewer 4:

The reviewer explained that the progress on this program seemed good, with most of the progress being made on the combustion-stability task.

Reviewer 5:

The reviewer asked, for the DI injector spray optimization, how some of the findings from Chris Powell and Lyle Pickett (on the asymmetries that existed in fuel sprays and their influence on the mixing) would be incorporated.

Reviewer 6:

The reviewer agreed that some progress had been made on both fronts. For the Ford study, the meta-model approach had been demonstrated with simple model and LES simulations in progress. For the GM study, the automation and optimization framework had been developed. This person added that it would be beneficial to verify the model prediction at an early stage with some test results from industry partners.

Reviewer 7:

The reviewer indicated that the project was in its first year, but the concept had been demonstrated to some extent and the framework had been established. It seemed like this was yet another project on using supercomputers to model mixing and combustion. This reviewer went on to add that every effort should be made to test the models on real-world industrial applications to prove its worth.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project was working very closely with Ford on the real-life combustion stability test case and with GM on the real-life injector pattern optimization.

Reviewer 2:

The reviewer reported that there appeared to be close collaboration with GM, Ford, and Convergent Science, as well as collaboration with other groups within ORNL. This person added that hopefully the results and tools that were developed were not only beneficial to GM and Ford, but also useful and made available to the other OEMs (and ultimately would result in interactions with them as well).

Reviewer 3:

The reviewer concluded that there was good collaboration among the stakeholders, and that the stakeholders would also be significant beneficiaries if the work were successful.

Reviewer 4:

The reviewer confirmed that both ongoing efforts had direct industry involvement. This reviewer added, however, that coordination with institutions and labs outside of ORNL seemed to be lacking.

Reviewer 5:

The reviewer voiced that the collaboration with only two OEMs appeared to be limited.

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

Reviewer 1:

The reviewer noted that the plans for upcoming work were good.

Reviewer 2:

The reviewer felt that the plans to complete validation of the various model components and then running the full models were important and reasonable.

Reviewer 3:

The reviewer stated that the work on matching injector design and optimizing this to the combustion system was an outstanding objective, and the work in this area should have value to many in the industry and represented a good step forward in state-of-the-art combustion CFD. (This reviewer added that this was assuming this could be done in a good, linked manner, ideally including an automated optimization method.)

Reviewer 4:

The reviewer remarked that, given the approach, the future work appeared to be reasonable.

Reviewer 5:

The reviewer commented that the final results that would prove out the concept and approach were to be expected in the next phase of the work.

Reviewer 6:

The reviewer observed that the proposals were fine in their general direction. This reviewer pointed to an item that the authors have recognized (model validation with experimental data is vital during each phase) and added that this task was not defined in future work.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that this project had the potential to accelerate advanced GDI engine development to meet future efficiency and emissions goals, which supported the objective of the DOE in reducing petroleum consumption.

Reviewer 2:
The reviewer observed that this project focused on the development of tools to reduce the time it took to run simulations and thus presumably decrease the time for design and commercialization of advanced combustion equipment and technologies. These support the DOE goals of high-efficiency, cleaner-combustion engines.

Reviewer 3:
The reviewer mentioned that this work was designed to help optimize engine combustion system design, which was directly relevant to improving engine performance.

Reviewer 4:
The reviewer expressed that advanced combustion concepts needed to be tried and tested via simulation and that, currently, the computing time was prohibitively large. Concepts and approaches like this were needed to hasten the development of advanced combustion concepts.

Reviewer 5:
The reviewer asserted that making use of high-power computing to impact engine design was very relevant. This person added that the time to run simulations needed to be short enough so they could be used in real product development cycles where time is finite and limited.

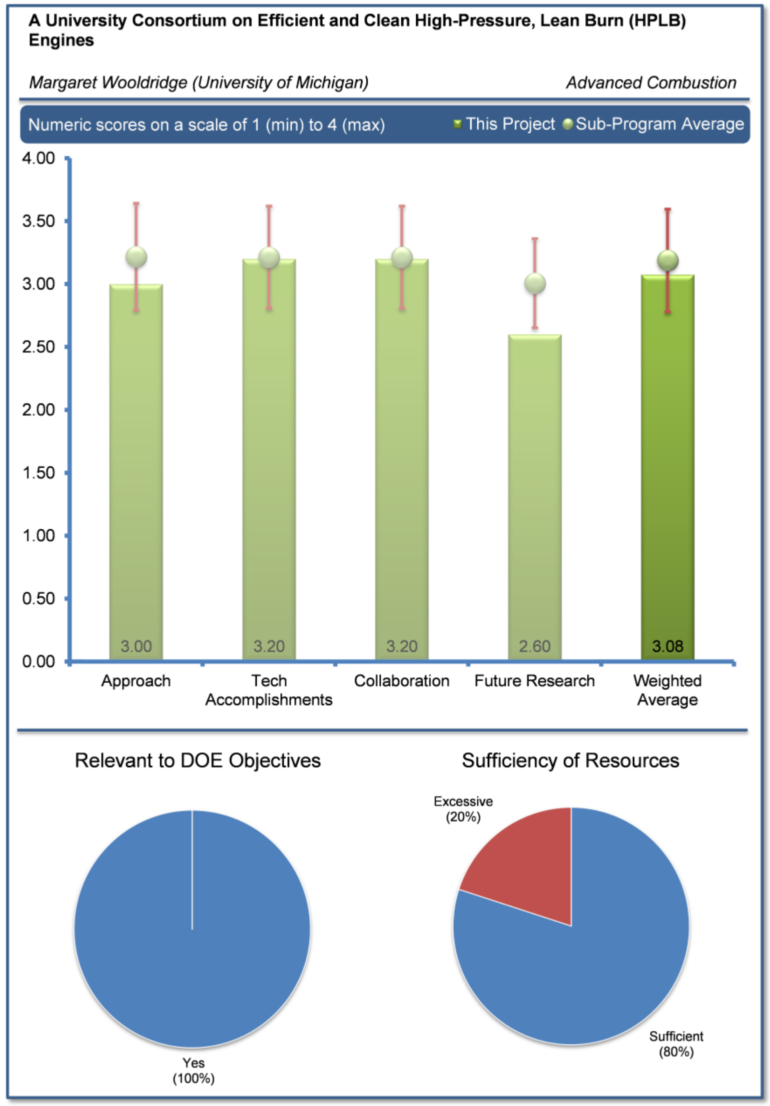
Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer voiced that it would be good to see this work expanded.

Reviewer 2:
The reviewer summarized that it appeared that milestones were being met, which would suggest that resources were sufficient.

Reviewer 3:
The reviewer confirmed that the resources appeared sufficient for the proposed scope of work.

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



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that there was excellent work to collaboratively develop significant data sets and to characterize opportunities with advanced combustion modes.

Reviewer 2:

According to this reviewer, there had been quite a bit of fundamental combustion research within this project exploring the intricacies of SACI and partially homogeneous spark-assisted modes. The modeling portions of this effort, especially in the multi-dim arena, were developing as more data was generated from optical engine experiments to further refine the UM flamelet model. The piece missing in this work revolved around integrating new knowledge gained about these lean-burn combustion modes into either a thermodynamic engine simulation and/or a simple vehicle model to project the potential fuel-economy/thermal-efficiency gains.

Reviewer 3:

The reviewer remarked that this project provided a comprehensive approach to exploring the advancement of dilute, high-pressure combustion for LD gasoline engines. It proposed to focus on four areas: the development of analytical tools to link engine and vehicle fuel economy; stratification; SACI; and novel fuel properties. This person added that, whereas the approach proposed was clearly identified, the presentation failed to show how these areas impacted the goal to attain the 45% engine efficiency. In fact, it was unclear if this goal would be realized.

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

Reviewer 1:

The reviewer acknowledged that the key goals had been achieved as the project was now near completion.

Reviewer 2:

The reviewer commented that the key technical accomplishments have occurred at a fundamental level in assisting the physics associated with various facets of lean-burn, spark-assisted-combustion modes. This person added that this knowledge must eventually be integrated into a form that could be used to assess fuel economy gains and thus address DOE goals in this technical area.

Reviewer 3:

The reviewer asked how stratification impacted efficiency and emissions, what power level and input power were used for the microwave system, and if there were any results for engine-out emissions. This reviewer further noted interesting rapid compression machine results where SI was included.

Reviewer 4:

This reviewer wanted to know why it was not shown why load extension was critical to minimizing the friction-mean-effective-pressure (FMEP) percentage of BMEP, and added that the FE results versus the base SI engine were not shown.

Reviewer 5:

The reviewer pointed out that the work was near completion, but felt that the presentation could have provided a better comprehensive review of their overall efforts and success in achieving the goals proposed here. Task 1 addressed the overall fuel efficiency goal of the project (only one slide was dedicated to it). This was done via the development of a quasi-D model that combined multiple combustion modes (SI, HCCI). This reviewer added that no dynamometer demonstration was provided. Task 2 pursued the impact of stratification, which can be used to mitigate high-pressure rise rates. The work reported improvements of an integrated spray-interactive flamelet (SIF) model over the simpler Reynolds-Averaged Navier-Stokes (RANS) model. This was explained by turbulent fluctuations affecting the heat release under stratified conditions. Mitigation of pressure rise rates was explored by adjusting the timing of the direct injection gasoline. Additionally, the authors embarked on interesting tests with SACI in Task 3. New work included KIVA-3V predictions, with temperature distributions accompanying earlier heat release traces. The task then added the contributions of EGR across a wide range of O_2 ratios. The dilution method affected the tradeoff between flame heat release and ignition delay, and could be used to manage heat release. Work included the impact of spark- versus microwave-assisted spark plugs, though few details were given about the physical arrangement. This reviewer went on to say that the work could have shown a detailed analysis of the energy distribution, comparing the SACI with conventional combustion. This comparison would have been used to assess the progress towards the 45% efficiency target. Unfortunately no assessment was made here. Task 4 presented data across fuel properties based on various Primary Reference Fuels (PRFs). The data was not accompanied by basic energy balance analysis. The reviewer added that it was unclear if there was any particular direction that the authors were taking or if they had chosen a set of conditions to benchmark towards the efficiency goal. It was also unclear why the authors focused on n-heptane rather than more comprehensive surrogate formulations. As the authors indicated, the data available for n-heptane was very large and the tests the authors had run overlapped with existing data already available.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that this project from the onset had demonstrated very good university-level collaboration between UM, the Massachusetts Institute of Technology (MIT), and the University of California–Berkeley in exploring the intricate details of lean-burn gasoline engines. This reviewer added that it appeared that certain industry partners had also been involved in this project to help ensure progress was made from an OEM perspective.

Reviewer 2:

The reviewer observed a wide collaboration, almost too much to organize.

Reviewer 3:

The reviewer said that this section was vague, and suggested that more detail might be given as to the contribution of the partners.

Reviewer 4:

The reviewer mentioned that broader industry involvement might have been useful.

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

Reviewer 1:
The reviewer asserted that the project was wrapping up.

Reviewer 2:
The reviewer affirmed that the main effort remaining was wrapping-up and reporting.

Reviewer 3:
The reviewer emphasized that, overall, the proposed future research was sound. This reviewer's suggestion was to consider adding additional work concerning the impact of ethanol blends on fuel efficiency gains in Task 4, and to consider developing reasonable thermodynamic engine or vehicle models to assess the fuel economy gains of the various combustion modes under study. This person added that starting with a purely steady state in Item 2 was reasonable. The transient controls work was important, but understanding what was possible from a fuel-economy point of view was very important as well.

Reviewer 4:
The reviewer explained that the work was expected to complete in June. This reviewer added that, as in the accomplishments section, the outline was rather vague. The authors could have been more specific as to the expectations or milestones that were sought.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer indicated that this project was relevant for future engine designs and high-efficiency targets.

Reviewer 2:
The reviewer highlighted that it was important to compare various combustion processes for efficiency potential.

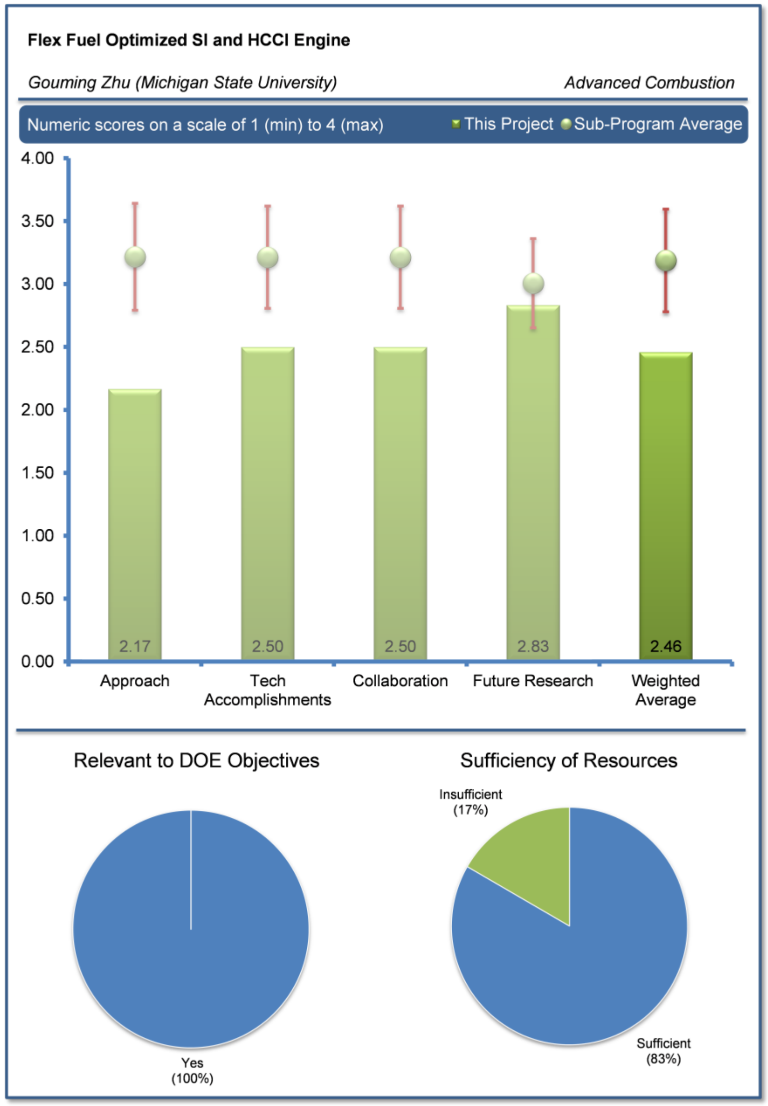
Reviewer 3:
The reviewer concluded that this project was another one that explored advanced combustion modes for improving the fuel economy of today's PFI engines. Eventually, this project should provide DOE with a sense of what is possible in comparison to other projects (including LTC, RCCI, and advanced diesel combustion modes).

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

Reviewer 1:
The reviewer commented that no cost extension was noted.

Reviewer 2:
The reviewer indicated that funding had been a little lower this year, but the PI stated the project was 90% complete. It was not clear if that budget cut would affect a subproject within this effort, such as a graduate student.

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



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that transient control of SI-to-HCCI transitions was clearly a barrier, and that this project's approach addressed this challenge. This reviewer still had some concern that the results would be very engine specific and identified a need to strive for a general understanding of the approach and how it applied to other applications.

Reviewer 2:

The reviewer stated that the delays in the project, which had led to a delay of one year, suggested that the approach had some shortcomings. The PI mentioned that, in hindsight, it would have been better to use an existing engine rather than to build one from scratch.

Reviewer 3:

According to this reviewer, the work had been to develop a model-based control for transition between SI and HCCI; yet the effort had devoted most of its time to facilities development. In the opinion of this reviewer, there was not much reported on the actual development of the control strategy or the model that drove it. It also seemed that the project would be dependent on the specific engine configurations being used, so it was not clear to this reviewer what new knowledge for general use would be generated. This reviewer thought that this would be especially true for transient operation.

Reviewer 4:

The reviewer felt that there was clearly a need to be able to transition from HCCI mode to SI mode and vice versa, but the approach being used to handle this was a bit questionable. This person was at a loss for why optical rig testing was needed to address this transition mode, and the reviewer believed it would be better to focus the program's resources on the multi-cylinder engine and controls. Also, it was not clear what criteria would be used to determine acceptable versus unacceptable transition between the operating modes.

Reviewer 5:

The reviewer remarked that this project was focused on the HCCI engine control, which was one of the major technical barriers. The methodology was generally sound; however, to control a multi-cylinder engine on a cycle-to-cycle basis, the computation time of the model had to be very short without sacrificing the accuracy of the output (control parameter). This reviewer thought that efforts in this area were lacking.

Reviewer 6:

The reviewer commented that this project had always suffered from an unsatisfactory approach, which had been described at length in previous reviews by this reviewer. The project still continued to be bogged down by the lack of a multi-cylinder engine that was capable of running HCCI. Thus, the main objective of the project, to develop and validate a controls model of SI-to-HCCI transition, would not be satisfactorily addressed.

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

Reviewer 1:

The reviewer pointed out that some progress had been made according to the plan despite a delay in the build-up of the four-cylinder engine.

Reviewer 2:

The reviewer observed that considerable time had been spent setting up the single- and multi-cylinder hardware. The project appeared to be poised to begin generating results just as it came to a close. The future value would be for ongoing projects for graduate students.

Reviewer 3:

The reviewer said that the accomplishments reported were primarily those of the facilities build-up. The basis for the two-zone mixing model that was important to the control algorithm was not well-described, yet it seemed that this was a critical component of the overall project. This reviewer was surprised that a two-zone mixing model would work. An explanation of why this would work would be a significant addition to the knowledge base for developing control algorithms.

Reviewer 4:

The reviewer mentioned that, overall, progress on this project seemed to be fairly slow, although progress on getting the multi-cylinder engine up and running was good. However, this reviewer added that, given all the time and effort spent on the optical engine and analyzing the images taken, it was not clear what value this would have to the overall program goals. Also, there seemed to be no data shown on the transitions between SI and HCCI modes, the issues being uncovered, and the actions being taken to overcome these issues. Thus, developing the controls was good, although more focus needed to be added to taking and reporting data during combustion mode transitions.

Reviewer 5:

The reviewer criticized that progress had been slow on this project, resulting in a one-year extension. It looked like the progress had been accelerated over the past year, but it was still not clear that the project could achieve its ultimate goal of developing an effective transition control model in the remaining four months.

Reviewer 6:

The reviewer asserted that progress had been made in the areas of the multi-cylinder build-up and testing, as well as more optical engine tests. But none of these efforts provided any new knowledge, and certainly none regarding control of SI-to-HCCI transitions, which was the aim of the project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer affirmed that there were good collaborations with Chrysler and the University of Minnesota.

Reviewer 2:

The reviewer emphasized that the collaboration appeared to be with a single OEM. This reviewer stated that it appeared as though the frequency and effectiveness of that collaboration had improved over the past year.

Reviewer 3:

The reviewer indicated that the collaboration was just with Michigan State University (MSU) and Chrysler, but added that perhaps this was enough in this case.

Reviewer 4:

The reviewer reported that it seemed that the collaboration was limited to Chrysler, the research partner. The PI claimed interaction with Ricardo relative to the wave-disk-engine project at MSU, yet it seemed that they were using the GT-POWER simulation tool.

Reviewer 5:

The reviewer highlighted that the help provided by Chrysler with all the multi-cylinder issues was recognized and greatly appreciated. However, this reviewer added that Chrysler was solicited late in the program to help. Also, what was really needed in this project was collaboration with an appropriate partner right from the beginning, a partner who could supply an HCCI-ready engine so that the project could focus on the primary objective, which was to understand and develop controls for SI-to-HCCI transitions.

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

Reviewer 1:

The reviewer claimed that the project had a reasonable plan to complete their activities.

Reviewer 2:

The reviewer concluded that the research was close to the end.

Reviewer 3:

The reviewer summarized that focusing the future work on mapping the engine in SI and HCCI mode and validating the controls during transition mode was good, but there should have been a clear (quantitative) criteria on what defined an acceptable transition between the modes.

Reviewer 4:

The reviewer specified that there was some uncertainty as to whether the multi-cylinder engine would be able to run HCCI over the relevant load range, given the fact that the compression ratio of 11.5 might have been too low. As a correction, this reviewer added that the intake charge should have been heated to promote HCCI operation, and that work should have been focused on understanding and controlling SI-to-HCCI transitions.

Reviewer 5:

The reviewer voiced that it was not clear that the goals of completing the mapping of the metal engine (for SI and HCCI combustion) and validating the mode transition control on the metal engine could be successfully completed by the project end date of September.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the HCCI engine could reduce fuel consumption, which supported the DOE objectives of using less petroleum.

Reviewer 2:

The reviewer noted that incorporating LTC modes (such as HCCI) into vehicles could provide significant fuel-consumption reduction.

Reviewer 3:

The reviewer remarked that if the project were successful and resulted in the development of an effective controls model for the transition from SI to HCCI modes, it would advance the development and commercialization of part-time HCCI engines. This would have improved efficiencies and resulted in cleaner combustion than conventional engines, supporting DOE goals.

Reviewer 4:

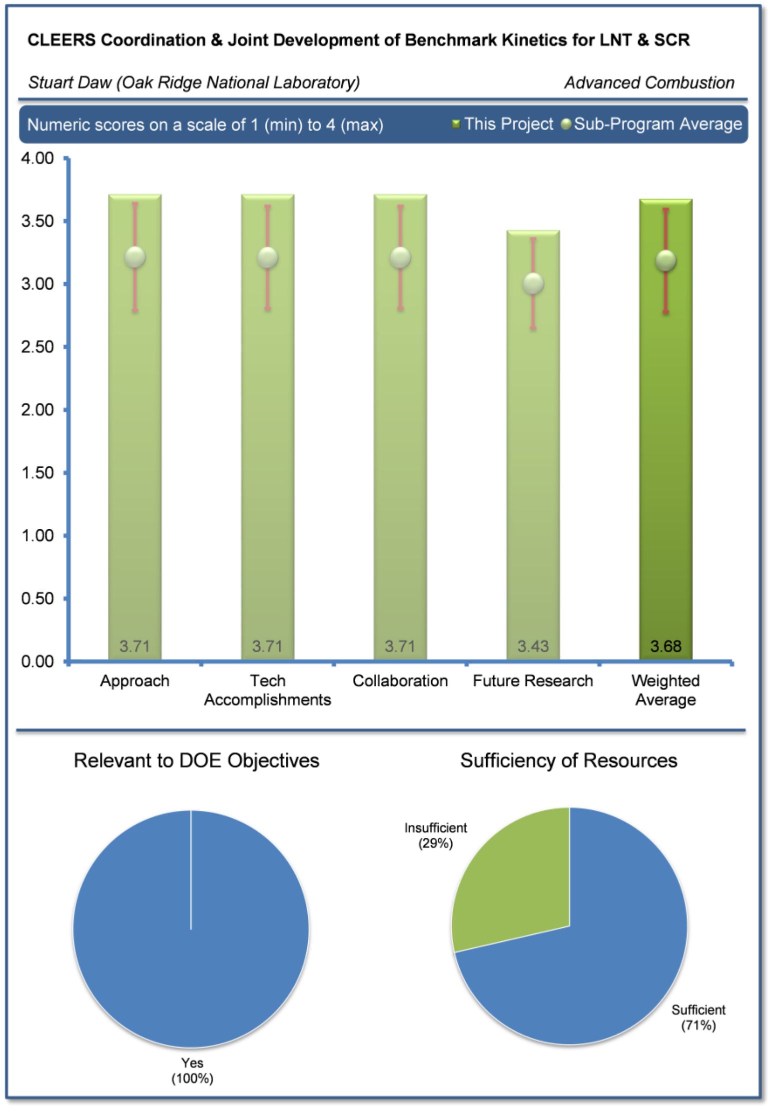
The reviewer acknowledged that HCCI was an important low-temperature combustion concept that provided significant efficiency and emissions benefits but whose main barrier was the lack of good controls.

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

Reviewer 1:

The reviewer had some concerns that the remaining tasks of completing the engine mapping for SI and HCCI combustion, and completing the validation and revision of the mode transition control model, could be completed by the project deadline of September. Despite that, this reviewer did not favor further extension of the project.

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



Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that this project had an excellent approach, with a broad range of topics and a clear set of goals for improving the modeling of aftertreatment systems. The way the project was set up with access for industry and academia allowed the findings to be used widely. It can be used in universities to assist in the training of students learning how to model emissions control technologies.

Reviewer 2:

The reviewer said that the approach was very comprehensive through its use of advisors, website, technology focus groups, and workshops. There was very good leverage of other domestic and international funding resources.

Reviewer 3:

According to this reviewer, the approach of this project had provided a very positive outcome in the aftertreatment community, and that all activities under this program served to help many researchers in both the industry and academia engage and work together in the advanced aftertreatment area.

Reviewer 4:

The reviewer asserted that these simulations were critical to guiding the development of future aftertreatment applications, especially in regard to NOx. The focus on lean aftertreatment systems was consistent and supportive of more efficient engine technologies that the industry was pursuing. In addition, the included emphasis on low-temperature catalyst reaction mechanisms would be an area of growing industry interest, as tighter emissions standards must be achieved. This reviewer added that having a central database of modeling simulations of pertinent catalyst systems was important to resource redundant efforts and to better coordinate academic and industry activities.

Reviewer 5:

The reviewer expressed that the CLEERS coordination project had been a well-constructed support of a clear and ongoing need: “the collaboration and dissemination of industry, university, and National Laboratory pre-proprietary simulation and data for emissions controls technologies.” While it was challenging to separate the pre-proprietary and proprietary activities in this industry segment, the CLEERS coordination leadership continued to seek and leverage outside resources such as universities. Limiting membership to a manageable level, hosting monthly calls, and facilitating events (e.g., industry priority survey) were examples of the excellent approach. Continued dialogue with industry was strongly recommended. It was also suggested to publish aggregated results of the industry priority survey and to add a CLEERS use/feedback survey, as this would be a valuable addition to confirm the excellent approach. CLEERS use surveys could be done at monthly meetings, at workshops, or once a calendar year to gauge industry/researcher interest and value, and to provide feedback.

Reviewer 6:

The reviewer emphasized that the technical barriers were addressed for the NOx control strategies, but added that the particulate kinetics should have been included in this work. These were not separate problems, and the interactions between the PM and NOx (and components) were best studied together. CLEERS seemed heavily focused on simulation, which was great, but the simulations must be developed from experimentally determined data; again, these things did not stand alone. The proposed database would be an excellent resource and a fantastic way to disseminate data. This was truly an exemplary program that showed the benefit to DOE (and an excellent use of resources) when industry, laboratories, and academia worked together.

Reviewer 7:

The reviewer explained that CLEERS provided the aftertreatment modeling community with a forum to share ideas and approaches. However, this reviewer added that most OEMs already had models for commercial catalyst systems for the key parameters (i.e., selective-catalytic-reduction [SCR] conversion and ammonia storage).

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

Reviewer 1:

The reviewer strongly emphasized that the results were excellent. The project provided an excellent mechanism for sharing measured and simulated data from engines and aftertreatment.

Reviewer 2:

The reviewer explained that this project facilitated effective information exchange and dissemination, and added that the kinetics modeling accomplishments were significant as well.

Reviewer 3:

The reviewer indicated that the excellent participation during the April 2013 workshop demonstrated CLEERS’ value. The venue choice was also excellent. This reviewer further noted results in key focus areas that should be of interest to industry, adding that SCR, lean NOx trap (LNT), and oxidation catalysts were completed.

Reviewer 4:

The reviewer reported that advances in the understanding of ammonia storage for SCR and the performance of modern LNT catalysts were excellent. The improvement of models was very noteworthy. This reviewer further noted the demonstration that nitric oxide (NO) oxidation appeared not to be involved in the mechanism of standard SCR reaction.

Reviewer 5:

The reviewer said the project made good progress and demonstrated synergy (via working with external groups such as the modeling group at Pacific Northwest National Laboratory [PNNL]). Additional transient engine-out data from both LD and HD engines would add more information for the CLEERS library. The 2013 CLEERS workshop had been pretty successful; however, this reviewer added that the monthly teleconference did not seem to bring more attention. The monthly teleconference would provide a unique opportunity for both presenting and participating members to interact with ideas and suggestions. This reviewer suggested arranging a full list of speakers among the National Laboratories, universities, and OEMs for each year. External publication seemed to be light compared to the amount of work they had done, although there were many oral presentations.

Reviewer 6:

The reviewer specified that better understanding of commercial catalysts and how they functioned was helpful. However, this person added that it was a bit more of a stretch to look at pre-commercial catalysts and really support next-generation powertrain development. There was the issue of proprietary catalyst formulations that inhibited the testing of pre-commercial catalysts, and this would always be an issue with CLEERS. This reviewer further noted that the move into low-temperature oxidation catalysts with some exploratory research was interesting.

Reviewer 7:

The reviewer voiced that BMW LNT technology might be a good reference, but it was not leading-edge technology. The problem was to obtain a supplier's newest formulations to make sure the catalyst community was working on and heading in the correct technical direction. Maintaining a database of modeling activities relevant to the automotive industry was very important to understanding catalyst behavior. However, this reviewer added that consistent and uniform modeling conditions had to be used to ensure technologies were being compared fairly. This reviewer went on to say that including low-temperature materials was an excellent expansion of the modeling activities.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer emphasized that the collaboration was excellent. There was a fantastic cut across industry, academia, and the labs, as well as international collaborations.

Reviewer 2:

The reviewer stated that CLEERS activities were among the best collaborative venues for bringing together government, university, and industry participants to more efficiently address aftertreatment needs.

Reviewer 3:

The reviewer noted significant collaboration with industry partners, National Laboratories, and universities (domestic and international).

Reviewer 4:

The reviewer felt that this project was widely collaborative in several respects, but mainly in all of the people participating in the CLEERS web calls with speakers from industry, academia, and the National Laboratories.

Reviewer 5:

The reviewer remarked that the CLEERS community consisted of a nice cross-section of National Laboratories, university, and industry participants.

Reviewer 6:

The reviewer acknowledged the project's excellent collaboration from leveraging the effort with other entities such as U.S. DRIVE, the industry survey, PNNL, Politecnico di Milano, and others listed. This effort might improve by mentioning or disclosing some of the other partners' contributions and use. (If only to reviewers, this would be okay.) This reviewer asked about the feedback and involvement of the DOE Advanced Engine Crosscut Team, the U.S. DRIVE ACEC Team, and the CLEERS Focus Group members. Lastly, this person noted that there were 10 engine/vehicle manufacturers, 11 component/software suppliers, and 10 universities.

Reviewer 7:

The reviewer pointed out that there was a very well-coordinated collaboration with world-renowned groups. This person added that one concern would be the mechanism between ORNL and international partners; collaboration often requires balanced contributions and face-to-face interaction to facilitate scientific discussions as well as to update the scope of the project. With the given travel restrictions, it would be more difficult.

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

Reviewer 1:
The reviewer said that the incorporation of low-temperature aftertreatment modeling activities was agreed upon by many in the community as a research area of intense interest. This person added that initiatives to improve the CLEERS database in terms of content, accessibility, and modeling specifications was essential to its adoption as a repository of shared catalyst knowledge.

Reviewer 2:
The reviewer noted appropriate topics for investigation under CLEERS kinetics and further coordination improvements.

Reviewer 3:
The reviewer mentioned that the project's inclusion of low-temperature emissions catalysts and the modeling thereof was a wise look to the future.

Reviewer 4:
The reviewer expressed that the low-temperature aftertreatment need gave CLEERS an opportunity to do more exploratory research on new pre-commercial materials.

Reviewer 5:
The reviewer indicated that the collaboration was very good, and added that it was more of the same with continuous improvement. This person went on to note that it was good form to always show a brief rationale connected to the industry partners and other users when setting priorities for future work, such as a statement like CLEERS is focusing on low-temperature ammonia storage mechanisms because x% of manufacturers and x% of researchers surveyed in 2013 indicated having a need for this.

Reviewer 6:
The reviewer highlighted that future work should (and did) include some focus on the mechanistic details lacking in the current models as well as great focus on low-temperature aftertreatment, demonstrating a timely response from the labs. This reviewer would like to see the PM work integrated into the ORNL program.

Reviewer 7:
The reviewer voiced that the fundamental catalyst characterization paired with vehicle/lab experiments was not scoped. This person added that there would be some activities under NSF/DOE projects starting in 2013; however, looking into domestic academic partners for catalyst characterization was recommended.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated yes, and expressed the belief that this program was one of the most important activities for DOE's aftertreatment portfolio.

Reviewer 2:
The reviewer emphasized the work was excellent and highly relevant to current, near-term, and long-term issues.

Reviewer 3:
The reviewer stated that this project supported DOE objectives because the improvement in lean NOx catalysts and emissions control allowed the engine (especially in the HD environment) to run with better fuel economy but higher NOx emissions. As such, excellent catalysts allowed these fuel savings to occur.

Reviewer 4:

The reviewer noted that CLEERS provided the data and strategies needed to model and evaluate advanced technologies for improving engine efficiency.

Reviewer 5:

The reviewer remarked that a cost-effective, productive, and durable new aftertreatment emission technology was critical to enabling many advanced fuel economy improvement techniques to become productive. Examples were advanced low-temperature combustion and lean engine operation. Basic research and pre-competitive modeling could accelerate the development of solutions to enable the near-term implementation of these fuel economy improvement technologies in a cost-effective way.

Reviewer 6:

The reviewer acknowledged that aftertreatment could be an enabler for more highly efficient powertrains.

Reviewer 7:

The reviewer commented that the work was very supportive of current and proposed catalyst technologies, adding that a well-organized database with commonized testing and modeling protocols should enhance the throughput of catalyst testing to shorten the timeline of industry products.

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

Reviewer 1:

The reviewer expressed that the project had done admirable work with the resources given. This reviewer would like to see more money directed here. In particular, the addition of the low-temperature catalysis work would require more funding to deliver results at the same level of quality that one expected from ORNL. This person said to increase funding for this work.

Reviewer 2:

The reviewer affirmed that there had been a general consensus that there would be more low-temperature challenges in emission control for advanced combustion, and CLEERS activities captured the key areas pretty well. More resources for this project would help and facilitate all existing activities in this direction.

Reviewer 3:

The reviewer explained that the speaker said there were sufficient resources to take on the new area of low-temperature catalysis while still possibly keeping current in the SCR and LNT areas. This reviewer thought that more resources might be needed, especially at the beginning, when the project was being defined and the best systems to study and model were being chosen.

Reviewer 4:

The reviewer indicated that funding was okay for now, though exploratory research on new materials might require more funds.

Reviewer 5:

The reviewer reported that the project might have insufficient resources to accomplish all the projects and activities planned unless in-kind work was provided through industry or universities.

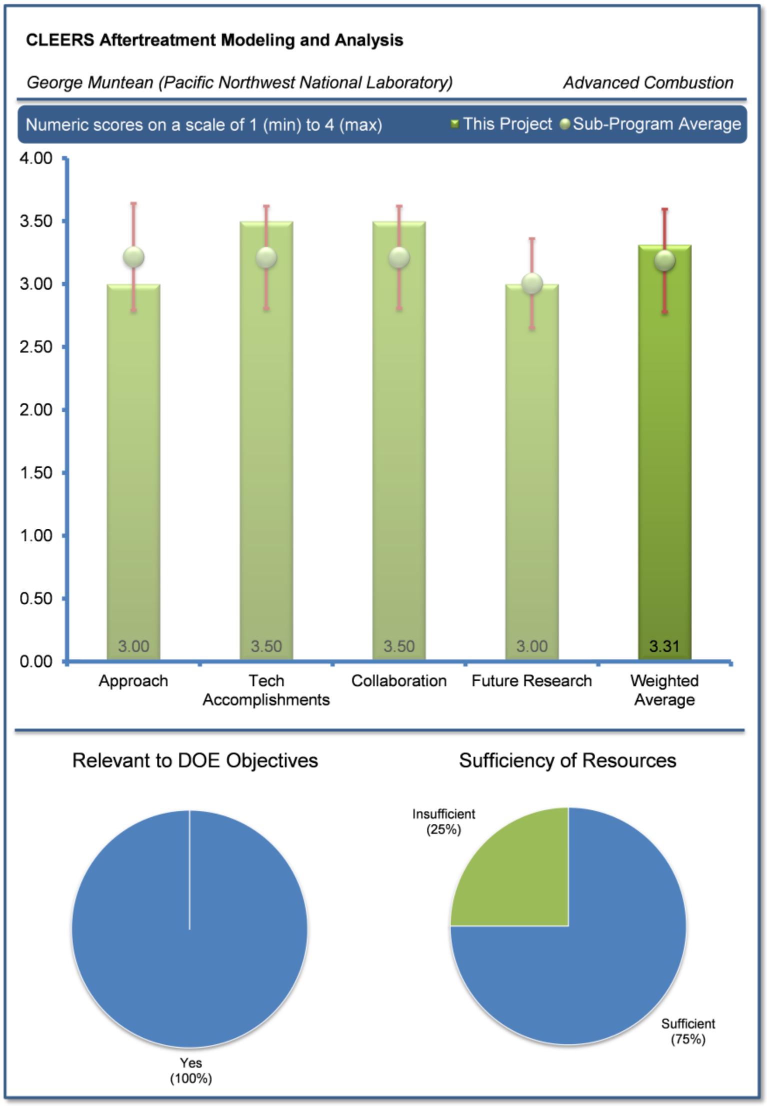
Reviewer 6:

The reviewer commented that the project could be more placed in this area; however, it might be more efficiently placed in Consortium-focused research to enhance the pre-competitive work.

Reviewer 7:

The reviewer indicated that there was appropriate annual funding for coordination and kinetics modeling because this had been an ongoing project since 2000.

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



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that the focus on catalyst aging was preferred over lots of testing and modeling of fresh catalysts. The topic areas of SCR and diesel particulate filter (DPF) were reflective of industry priorities. This reviewer added that potassium (K) LNTs were not preferred for durability reasons.

Reviewer 2:

The reviewer said that PNNL's approach on fuel-efficient engine emission control was very well-balanced, and the fundamental approach from real-world problems had demonstrated great potential to achieve the goals that DOE was targeting. This CLEERS activity was very well-paired with existing Cooperative Research and Development Agreements (CRADAs) on which PNNL was working with industry partners, which would help them bring science to solutions. However, this reviewer added that the approach on LNT subtasks was not very lined up with their portfolio with CRADAs.

Reviewer 3:

The reviewer mentioned that the emphasis of the work presented here was on SCR technologies for lean exhaust systems, which would be increasingly important going forward as automotive OEMs tried to meet emissions and corporate average ruel economy (CAFE) standards. The presentation did not emphasize NOx storage catalyst (NSC)-based technologies and the challenges those catalysts faced if applied to low-temperature aftertreatment. It was premature not to explore newer formulations and blending of technologies to improve performance at low temperatures. The reviewer further noted significant CRADA activities at PNNL to improve the connectivity to OEMs and universities, and to cost share/use resources effectively and address technical barriers.

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

Reviewer 1:

The reviewer asserted that understanding how small-pore copper (Cu) zeolites aged was very important for industry, and added that longer aging times and/or higher-temperature aging would be interesting. The development of model formulations was helpful to understanding commercial formulation behavior. This reviewer went on to say that it was good to see the NO-plus-ammonia (NH_3) mechanism explained without nitrogen dioxide (NO_2) formation.

Reviewer 2:

The reviewer affirmed good SCR characterization, as well as Cu zeolite characterization of Cu species and high-temperature K-based NSC materials. NH_3 storage and SCR reaction model were very pertinent. With respect to NSCs, the work was mostly looking at high-temperature stabilization. This reviewer added that it must also include low-temperature applications and their associated reaction challenges to help enable lean GDI systems.

Reviewer 3:

The reviewer emphasized that the PNNL team had made excellent progress and a very impressive external publication list, adding that the team had made a great contribution on elucidating the reaction mechanism of the state-of-the-art SCR technology. However, this person noted that the LNT work did not seem to have made as good of progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted many CRADAs showing good support, resources, and relevance.

Reviewer 2:

The reviewer emphasized significant CRADA activities with a number of light- and heavy-duty OEMs and suppliers.

Reviewer 3:

The reviewer explained that PNNL had been very active in collaborating with other institutions under CRADA; however, there was not very much under the CLEERS program.

Reviewer 4:

The reviewer indicated that it would have been good to see more direct industry involvement, if only as guidance. This was not explicitly shown in this project, but did happen to some extent through CLEERS and the annual priority survey.

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

Reviewer 1:

The reviewer indicated that it was good to see low-temperature materials were playing a larger role in research and development (R&D). This reviewer was not so sure the lack of NSC research was reasonable, adding that it would be appropriate to benchmark the newer NSC technologies coming out of Europe. Characterization activities were well-founded and important to OEM industry, but the project needed more supplier interaction.

Reviewer 2:

The reviewer reported that the future activities on SCR and DPF were very well-scoped, but the planned work on NOx storage-reduction (NSR) (LNT) was not very clear to this reviewer. The focus needed to be revised around how the market and industry moved forward. For example, LNT was having difficulties in the U.S. market due to nitrous oxide (N_2O) and durability problems. There were new efforts that suppliers were making to resolve those issues.

Reviewer 3:

The reviewer recommended moving away from LNT for diesel to passive NOx adsorption at low temperatures (for diesel/new powertrains) or high-temperature LNT (for lean gasoline). This reviewer also suggested moving away from things like K and titania due to lack of durability.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer highlighted that CLEERS provided data and strategies that are needed to model and evaluate advanced technologies for improving engine efficiency.

Reviewer 2:

The reviewer summarized that the studies further enabled aftertreatment for fuel-efficient powertrains.

Reviewer 3:

The reviewer confirmed that the work was very supportive of many industry aftertreatment needs. The person added that, if possible, it should start to address combined catalyst technologies to achieve super ultra-low emission vehicle (SULEV)-30 and U.S. Environmental Protection Agency (EPA) Tier standards.

Reviewer 4:

The reviewer said that PNNL contributions were absolutely directly linked to DOE’s goal of reduced petroleum usage via the development of aftertreatment technologies for fuel-efficient engines. One concern this reviewer had was that LNT technology had not been a viable solution for lean aftertreatment for both LD and HD vehicles in the United States, so the scope on LNT needed to be modified to be more relevant to U.S. applications.

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

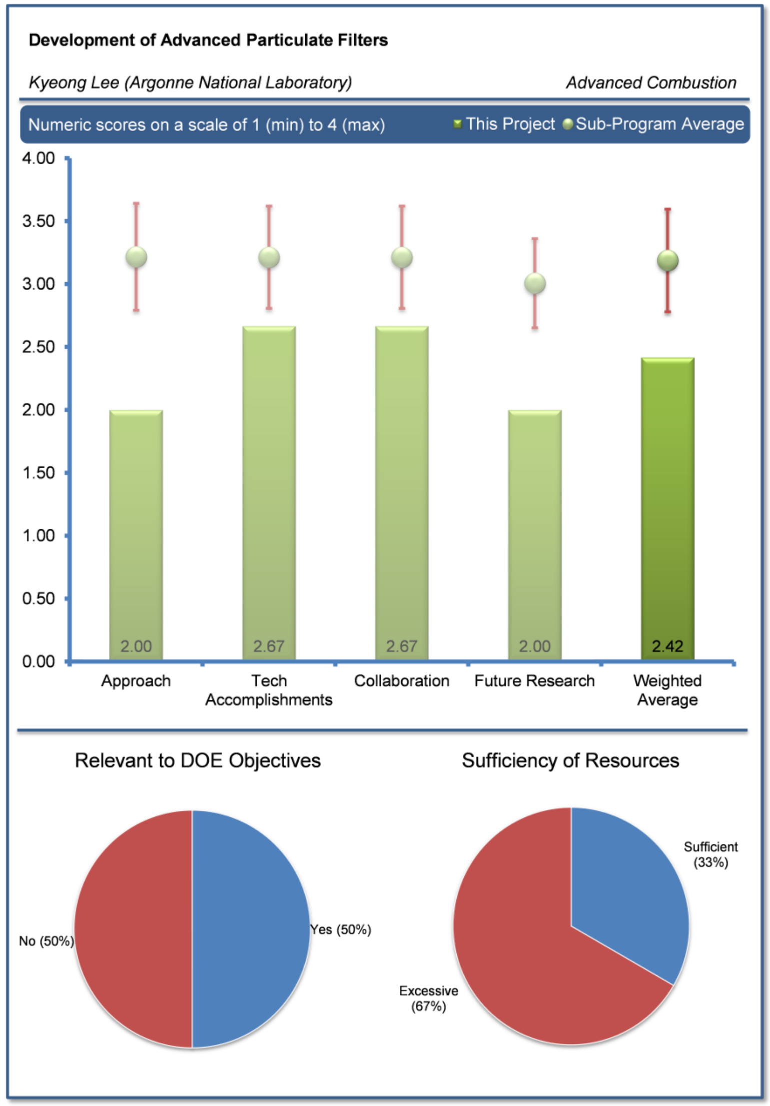
Reviewer 1:

The reviewer reported that funding was probably sufficient, but noted that there were many projects. This reviewer wondered if there were adequate resources to make the required progress.

Reviewer 2:

According to this reviewer, it was explained that funding was delayed for this program.

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



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer voiced that the approach was good as it included engine experiments as well as numerical modeling.

Reviewer 2:

The reviewer stated that the research was proposed because of insufficient information about GDI particle emissions, filters and filter materials, and regeneration strategies. These were all excellent reasons for the research; however, there might be improvements possible in the approach for addressing each of these issues. For example, for GDI engines, there were many parameters that could be varied to generate larger or smaller amounts of soot (injection pressure, injection angle, injector spray, air- versus wall-guided spray, injection angle, EGR percentage, piston design, etc.). While the single engine sweep of injection angle did generate more and less PM, it was not clear that the results of this sweep would generate the only results that were valid for GDI particle size and chemistry. The approach should consider, at least peripherally, other reasonably varied parameters in engine control for variations in PM/soot formation to insure more broadly applicable results. The formation and regeneration of PM accumulations on a filter may also vary depending upon the underlying reason for the formation of PM material. The remainder of the approach was very good: to apply the filter in the correct location before or after the three-way catalyst, and to identify regeneration approaches such as fuel cutoff.

Reviewer 3:

The reviewer noted that the ANL group had unique capabilities in particulate-filter-related research, and the project team’s expertise had been excellent. The PI mentioned that the gasoline particular filter (GPF) needed to be designed differently; however, all of the project team’s experiments were not different from what had been done for the previous DPF project. This reviewer opined that the project team has focused too much on fundamentals and morphology that were previously reported elsewhere.

Reviewer 4:

The reviewer commented that substantial instrumentation had been developed for this project. Apparently both an engine test cell and a laboratory test bench were available for this project, and integrating the results from both was a definite positive, especially since the flow from the dynamometer was routed through the test bench with filtration samples. This reviewer added that the work seemed to be a bit of a hodgepodge of techniques. Other than a focus on flow characteristics, there did not seem to be a unifying goal. It seemed as if this project was at least two years behind where the rest of the technology was headed.

Reviewer 5:

The reviewer remarked that very nice characterization and analysis equipment were available for soot filtration studies. However, this reviewer added that nothing had been shown on filtration efficiency, which was a key parameter for filter performance, especially for gasoline where there was no expected soot cake buildup. The first bullet on Slide 3 mentioned PM being a major problem for GDI. It was actually particle number that was the main problem. Particulates from GDI had been evaluated by many other groups. This reviewer concluded that the only element of the approach that was correct was the emphasis on lower backpressure, but not at the sacrifice of filtration efficiency, mechanical strength, etc.

Reviewer 6:

The reviewer pointed out that this was an extremely interesting and timely topic with a fantastic set of tools at hand. However, this reviewer believed that the approach being undertaken by this group was completely disorganized and uninformed. Therefore, a lot of effort was being expended in areas that would likely turn out to be dead ends. A more thoughtful approach to the project should have been undertaken. It currently seemed disorganized and was based on the PI's poor understanding of how GDI differed from diesel. For example, more work needed to be done on characterizing the GDI PM before the design of a GPF could be undertaken. It was clear that the PIs did not understand how the concentration (particle number density) and size differed between diesel and GDI. Also, the project team did not seem to understand the exhaust temperature differences between diesel and GDI. Most importantly in any filtration system, this reviewer strongly emphasized, filtration efficiencies must be measured. This was especially true since we know the soot cake to be the work horse for the filtration work in a DPF. And in a GDI, we know that there would not be enough PM in GDI exhaust to form a soot cake. Therefore, we would nearly always be in a clean filter regime and the filtration efficiency would be related to the substrate. Instead of parallelizing the entire project (certain parts could be done in parallel without going down blind alleys), this reviewer thought it would proceed better in a more linear fashion. The 2012 reviewer comments were not at all addressed, and the PI argued with (industrial) reviewers when they tried to explain that there was a misunderstanding regarding the GDI exhaust characterization.

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

Reviewer 1:

The reviewer commented that the project was just getting started. Much of the equipment was installed and there was some initial analysis and data. The preliminary (DPF) data presented showed good activity; however, there was some concern about making analogies between DPFs and GPFs. This reviewer added that there was a good start on models for various filter configuration types.

Reviewer 2:

The reviewer pointed out that no actual GPF results had been presented yet, but an optimal filter design had been proposed based on experimental data findings of the virtual concept.

Reviewer 3:

The reviewer observed that particulates from gasoline engines had been known to be different from that of diesel engines, and the approach needed to be revised accordingly. The first thing that needed to be investigated would be how much gasoline particulates were different from those for diesel.

Reviewer 4:

According to this reviewer, there had been too many directions taken that were not relevant to GPF and were more applicable to DPF. Additionally, nothing had been done to lower the backpressure of GPFs, which had been a main objective.

Reviewer 5:

The reviewer criticized that most of what was shared in this presentation were discoveries by others that were already in the literature. This returned to the point that there was not a unifying discovery goal for this project.

Reviewer 6:

This reviewer expressed that, again, the rating in this category was related to the approach. No significant progress in any one area could be made when one parallelized efforts. It was clear that last year's reviewer comments had not been taken into account, and it became obvious during the questions that the PI was not even aware of them. Therefore, what progress had been made was not geared to be relevant to the DOE/industry needs. Again, the lack of understanding of the system they were designing for was problematic.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer explained that the collaborations included an OEM (Hyundai), supplier (Corning), and universities (UW, MIT, and Tokyo Institute of Technology).

Reviewer 2:

The reviewer indicated that an excellent mix of industry, university, and National Laboratory partners were identified during introduction, but that the presenter should have clearly communicated what roles each of the partners would have in the work.

Reviewer 3:

The reviewer reported that there was a solid range of partners on this project. However, it was extremely difficult from the presentation to know which partner contributed to what studies in each section of the presentation.

Reviewer 4:

The reviewer highlighted that there was industry involvement by Corning and Hyundai, but added that there was no indication that these collaborators were offering any research direction.

Reviewer 5:

The reviewer voiced that it was not clear how the substrate manufacturer would contribute to this program. The scope listed on the relevance and objectives focused more on soot and the filter regeneration; however, this work needed to lead on how to improve and develop better filters and higher filtration efficiency with lower backpressure.

Reviewer 6:

The reviewer stated that, while the project had good industry and university partners, the project apparently did not coordinate well with the partners that were participating in the work. As evidence, this reviewer noted that the project team had missed some very obvious important issues and did not seem to understand the system within which the project team was working.

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

Reviewer 1:

The reviewer noted that GPF systems still had technical questions to be resolved. Future evaluation of various filter models and characterization of PM emissions were very relevant and appropriate. This reviewer added that the emphasis should have been placed on GPF filtration efficiency, as the soot cake buildup for gasoline engines was much different (slower) than for that of diesel engines.

Reviewer 2:

The reviewer felt that there was a solid plan except that additional base GDI PM formation variables should have been included to insure that PM formulation had been thoroughly characterized.

Reviewer 3:

The reviewer recommended that the PI needed to look into the thermal signature of gasoline engine aftertreatment systems compared to those for diesel engines.

Reviewer 4:
The reviewer remarked that this group said that they were looking at GDI technology; however, it was clear that filtration was the crucial issue for GDI and that all this work was focused on regeneration. This was way behind the technology curve.

Reviewer 5:
The reviewer asked a series of questions about the project. The reviewer asked why the project developed filter models if the researchers did not understand or demonstrate basic concepts like filtration and what catalyst would be applied to GPF, and if a three-way-catalyst (TWC) chemistry was expected. The reviewer continued to ask why the project evaluated soot oxidation when GPF was not expected to build much soot loading and there was no close contact between the soot and catalyst and also why the project characterized the physical properties of GDI-engine PM further when many other groups were already doing so. The reviewer asked why the project evaluated soot cake formation via environmental scanning electron microscopy (ESEM) when no soot cake was expected on the GPF, and why the project modeled GPF regeneration when it was expected to be almost always passive. Lastly, the reviewer wanted to know why there was no future work planned on lowering the backpressure of GPFs, which was a main objective of the program as indicated in Slide 3.

Reviewer 6:
The reviewer remarked that it was clear that there were holes in this plan. Current and past reviewer and industrial guidance had been ignored to the detriment of the work.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer remarked that GPF enabled PM emission control from high-efficiency GDI engines.

Reviewer 2:
The reviewer commented that this was one of the very few GPF projects out of the VTO-funded projects, and it was very important to understand the challenges and to develop a better gasoline particulate technology for fuel-efficient advanced gasoline engines.

Reviewer 3:
The reviewer observed that GDI particulate formation and aftertreatment mechanisms were important, as GDI was an enabler of higher power density powertrains for downsizing engines. DI provided greater injection accuracy and improved thermal efficiency and fuel economy, but GDI had higher engine-out PM due to limited fuel mixing in the combustion chamber. This reviewer added that this could possibly lead to fuel enrichment around the spark plug, and combustion chamber wetting through reduced droplet evaporation. This, combined with the fact that gasoline particulate emission standards were being proposed in Europe and the United States (citing European emission limits [EURO 6] and U.S. emissions standards [Low Emission Vehicle (LEV) III]) along with industry pull to meet these standards demonstrated support of DOE objectives.

Reviewer 4:
The reviewer said that this work was potentially relevant but fell short due to misplaced priorities.

Reviewer 5:
The reviewer mentioned that the focus on GPF was very appropriate. The application of lean or dilute gasoline combustion would continue to dominate the LD transportation market, but the work was so far behind that it did not appear to be relevant.

Reviewer 6:
The reviewer criticized that there had been no discussion regarding how this research fit into the DOE objectives, nor were there discussions about how to make this work relevant at all were considered or addressed.

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

Reviewer 1:
The reviewer expressed that there was good leverage of DOE VTO funding (citing a 50% cost share from an OEM and supplier).

Reviewer 2:
The reviewer emphasized that more funding and research in the area for GDI PM would be required, as there was no clear solution presenting itself near-term to meet Euro 6 and (California Air Resources Board [CARB]) LEV III PM proposed targets. All major OEMs would have interest in finding a cost-effective, reliable solution. This project was well-funded for its scope.

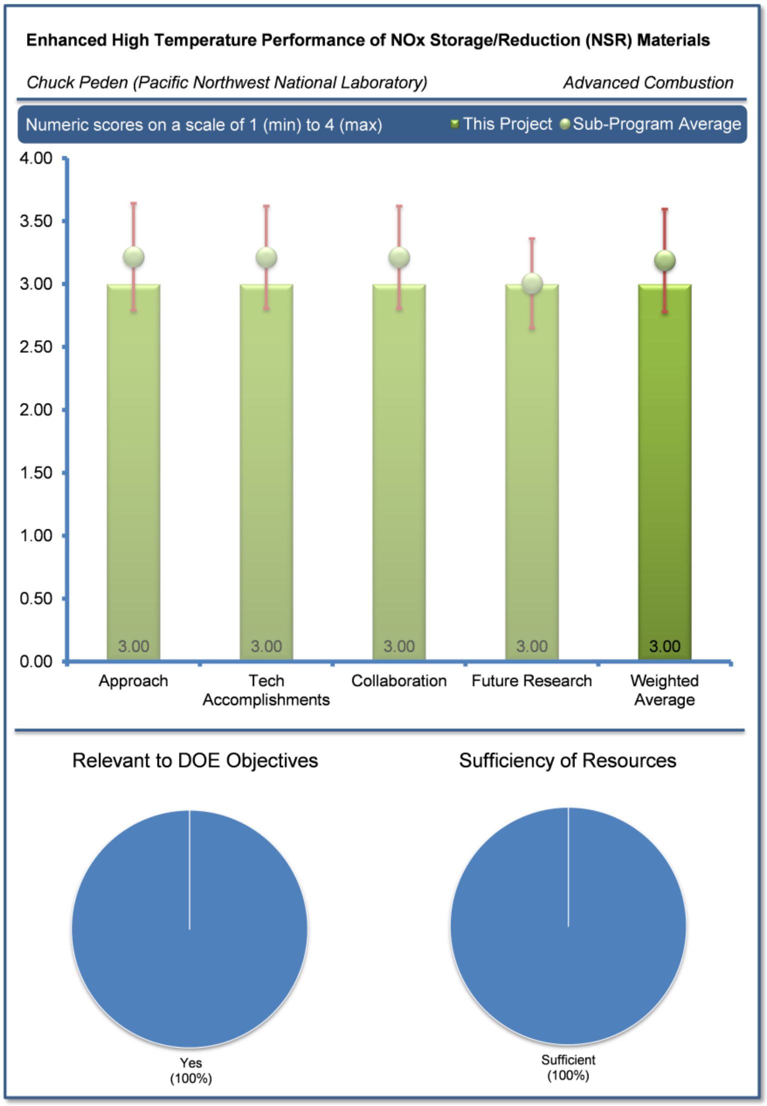
Reviewer 3:
The reviewer explained that the ANL team generated a lot of data and high-quality results but added that ANL was not well-focused, probably due to the large resources.

Reviewer 4:
The reviewer indicated excessive resources directed toward low-priority objectives.

Reviewer 5:
The reviewer reported poor payback. This work had been consistently reviewed low in the past and nothing seems to have changed. This reviewer did not understand why the project had been renewed in 2012, and added that just because there was industrial interest was not a justification for the project.

Reviewer 6:
According to this reviewer, the researchers had an amazing amount of tools at their disposal, which were completely misused. This reviewer recommended cancelling the project or moving it to another group with better potential for results.

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



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

This reviewer stated that the project currently targeted valid research needs (low-/high-temperature NOx, modeling) and had followed standard methods for modeling, material selection, and deactivation (thermal, poisoning).

Reviewer 2:

The reviewer remarked that significant synthesis activity of materials occurred in this project. This reviewer added that it did highlight the conundrum of requiring a National Laboratory or academic institution to produce materials that might be a common process for one of the catalyst suppliers. This reviewer wished that closer collaboration could have been generated with the suppliers so that the National Laboratory could have focused on the instrumental and kinetics studies where the National Laboratory was the most expert.

Reviewer 3:

The reviewer acknowledged a good use of CLEERS and industrial partnerships to solve relevant and timely problems. The integration with the industry and, now, two universities was helpful. This reviewer asked why the researchers used K in the NOx trap material, as it was known to exchange with the substrate and weaken the structure. If there had been (bench-scale) studies on substrates instead of powder studies only, these effects would have likely already been noted. This reviewer further added that the Cu-CHA work for SCR was interesting, and that there was lots of room to continue working in.

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

Reviewer 1:

The reviewer acknowledged that there was very good progress on LNT NOx, as evidenced by multiple publications on performance. This person added that the low-temperature results were also good, considering the CLEERS-sponsored synthesis of CU zeolite catalysts, hydrothermal aging results, and the identification of solid-state ion exchange (for the addition of Cu to enable reproducible catalysts with varying Cu loading).

Reviewer 2:

The reviewer commented that the progress was very good.

Reviewer 3:

According to this reviewer, the investigation of the correct copper substitution approach was quite interesting.

Reviewer 4:

The reviewer pointed out that the group had identified solution ion exchange as not being optimal, and added that solid-state ion exchange generated more active catalysts.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed appropriate collaboration with an OEM and a supplier since this was a CRADA. Also, the project leveraged relevant information from CLEERS activities.

Reviewer 2:

The reviewer said that the CRADA collaboration with an OEM, supplier, and National Laboratory was a good equation, and added that the partnership results were still proprietary.

Reviewer 3:

The reviewer asserted that the new NSF-DOE project was quite exciting. This reviewer would have liked much more work on the zeolite characterization, which may come via Purdue University.

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

Reviewer 1:

The reviewer affirmed that the proposed future research seemed appropriate as it built on recent findings.

Reviewer 2:

The reviewer indicated a well-contained scope of future work, with a targeted budget to focus on K-titanates and continued SAPO-34 work.

Reviewer 3:

The reviewer still had questions about the focus on high temperature (when the trends in exhaust temperature seemed to be going lower) as well as the use of the K component, which was likely to exhibit problems when one coated it on a cordierite substrate. This person added that there had still been no discussion of sulfur poisoning.

Reviewer 4:

The reviewer voiced that the evaluation of exchange, loading, performance, and aging of copper chabazites was appropriate for the industry. This person continued to be concerned by the thought that much of this had been examined in the supplier laboratories and was not publicly available. This reviewer thought that a more extensive analysis of the morphological character of the PNNL chabazites was warranted. The project team has had a long and storied history, and the comments in this work were reminiscent of studies done on other zeolites as many as 20 years previous. This reviewer was not sure that the focus on the potassium NOx storage continued to be useful. With new generation exhaust temperatures dropping and LNTs going more and more into under-floor positions, it was not clear that the high-temperature functionality was such a crucial issue.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer voiced that SCR and LNT technologies were enablers for the use of lean combustion strategies, which provided significant potential to improve fuel consumption and displace petroleum.

Reviewer 2:

The reviewer stated that copper chabazites seemed to own the SCR technology right now. This work to a large degree fit into that direction.

Reviewer 3:

The reviewer noted that the low exhaust temperatures of future, more efficient engines would create major challenges for exhaust aftertreatment systems.

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

Reviewer 1:

The reviewer reported that there was no evidence that any projects were being delayed by funding issues.

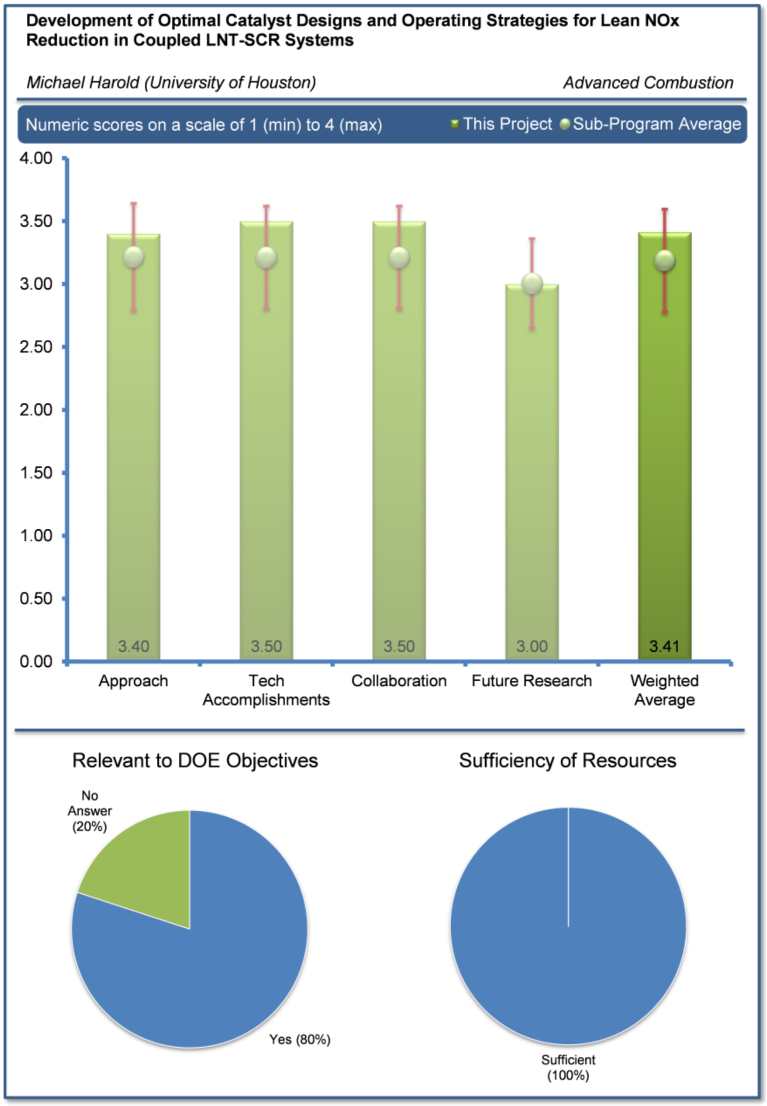
Reviewer 2:

The reviewer reinforced that the resources seemed adequate as this was a 50% cost-shared CRADA with Cummins.

Reviewer 3:

According to this reviewer, the funding was reasonable for a scope of activities limited to base characterization and deactivation mechanisms.

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



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the goal was non-urea passive NOx reduction systems for lean aftertreatment systems, which was desired by the industry. Investigating combined LNT and SCR technologies to achieve high NOx conversion was very relevant to OEMs that must also consider cost and packaging requirements for many vehicles. Investigating the role of HCs as a reductant, not only for NH_3 generation but as a source of reduction over the SCR as well, was an important topic and could help overcome the limitations of NOx reduction and address HC slip in lean systems. This reviewer added that the use of reactor data to help model activity provided a good feedback mechanism for optimizing this approach.

Reviewer 2:

The reviewer noted a pragmatic approach to catalyst modeling that focused on computational methods that could be done in a reasonable timeframe.

Reviewer 3:

The reviewer remarked that this was the final year of the project and the approach was appropriate for completion of the remaining work.

Reviewer 4:

The reviewer pointed out that the University of Houston led this team effort. The approach that the project had taken was to combine experiments with modeling to lean and optimize the performance of LNT and SCR catalysts separately. Subsequently, the project had combined both the models to study and optimize the performance of various LNT-SCR configurations. The overall idea was to have a viable NOx reduction aftertreatment system while reducing the precious metal content. The reviewer went on to say that the approach that these researchers had taken not only assured an optimized end product, but also provided insight into the chemical processes associated with catalysis to result in tractable modeling. The latter had long-term value. The reviewer added that it was advisable to integrate some sulfur-poisoning studies, as it could impede transformation of this technology into practice.

Reviewer 5:

The reviewer observed a great approach to the project goal of optimizing the performance in LNT/SCR systems, since LNT for this system was different than a stand-alone LNT. Diffusion issues in both catalysts were well taken care of and helped guide the approach. The project used data as the material to model and then used the models to suggest new experiments and reaction areas of interest. Although useful for studying the mechanism of the layered catalyst and the importance of diffusion, it would be difficult to put such a catalyst into production, unless there was diffusion of the metal species in the catalyst.

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

Reviewer 1:

The reviewer pointed out that significant progress had been made in the accuracy of kinetic models.

Reviewer 2:

The reviewer observed a broad range of work covering SCR (both iron and Cu), LNTs, and LNT/SCRs, with very good modeling and characterization of each configuration.

Reviewer 3:

According to this reviewer, isocyanates shuttling back and forth from support to metal was important. Water was the most reactive species with cyanate to make ammonia. When water was not present, there was another mechanism. Showing the reaction of propylene with NO to form ammonia commented on other chemistries in lean conditions.

Reviewer 4:

This reviewer mentioned that, judging by the fact that two successful models could be developed for LNT and SCR and then integrated for the prediction of the LNT/SCR catalyst, significant progress had been achieved. While this was progress in the right direction, the reviewer added that prototyping and testing in practical systems was a few years away.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer asserted that this was a highly coordinated and collaborative project with multiple partners from the university, supplier, and industry realms. This was the right mixture of participants to help ensure the results were applicable to an end product.

Reviewer 2:

The reviewer expressed good collaboration among academia, industry, and National Laboratory researchers.

Reviewer 3:

The reviewer affirmed that the team working on this effort worked in concert while leveraging each other’s capabilities and core strengths. However, this reviewer added that no reason had been given as to why the industrial partner Ford dropped out, and yet Ford’s name was still being touted.

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

Reviewer 1:

The reviewer emphasized that the scope of work identified before the completion of this project was very relevant and appropriate.

Reviewer 2:

The reviewer explained that this was the last year for the project, and added that an award had recently been received from DOE/NSF to continue some of this work.

Reviewer 3:

The reviewer indicated that this was the last year, so the work would be ending under this project. Still more characterization was needed to determine the benefits and challenges of layered LNT/SCR technology, especially for denitrogenization and desulfurization regenerations. This reviewer was not completely convinced that flow and temperature conditions over an FTP cycle were compatible with layered technologies.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that the technology pursued here could facilitate advanced combustion engine cycles that could potentially yield higher efficiencies. This would, as a result, lead to petroleum displacement.

Reviewer 2:

The reviewer noted very relevant work and support of effective lean aftertreatment applications toward achieving CARB LEV III and U.S. EPA Tier 3 emissions standards. This reviewer said that the investigators must also consider the effects of sulfur poisoning and desulfurization requirements in determining the viability of layered technologies.

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

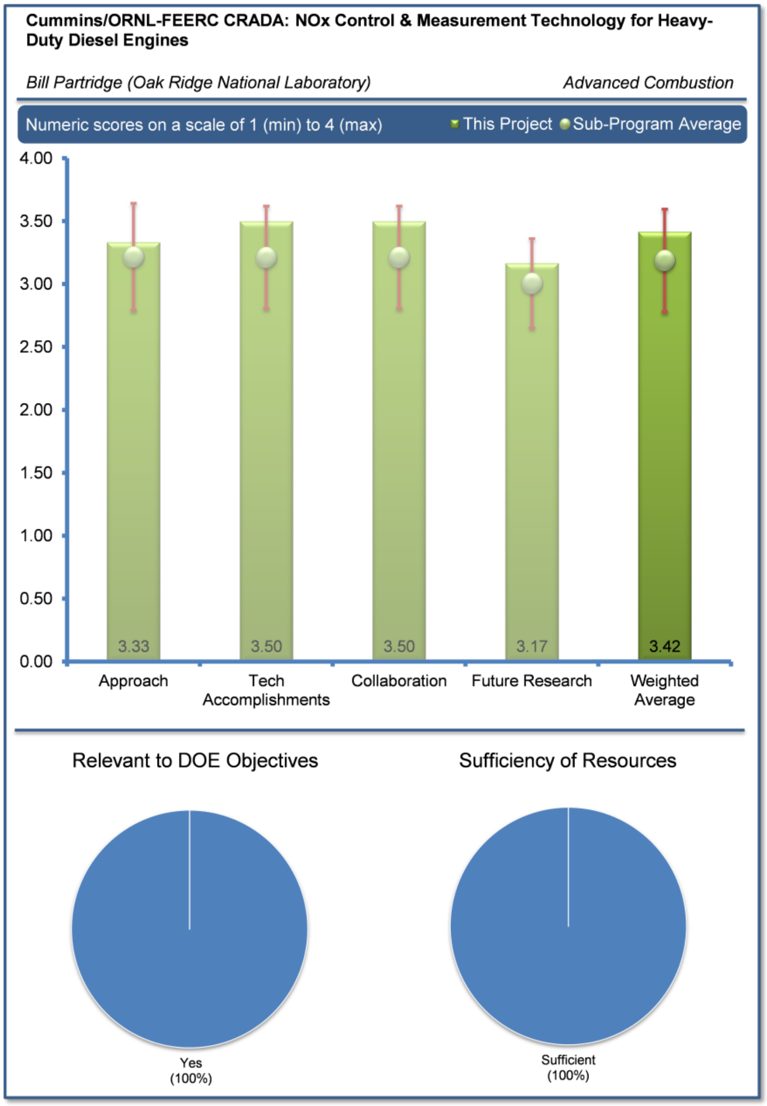
Reviewer 1:

The reviewer confirmed that this was a well-funded and productive project, and added that it was a very nice set of work.

Reviewer 2:

This reviewer noted that the project had received a no-cost extension for Year 4, noting that it was originally a three-year project.

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



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the instrumental work in this project was very good, especially since the ammonia storage behavior is spatial in nature to a large degree. The reviewer noted that doing spatially resolved capillary inlet mass spectrometer system (SpaciMs) measurements allows kinetic development of the ammonia storage in an almost non integral behavior. Effectively fitting the kinetics as a function of position, it is as if the experiments are being done on a decreasing set of segments of catalysts. This approach was used previously on the similar kinetic effects of a diesel oxidation catalyst (DOC) catalyst, which has no significant storage. The reviewer concluded that doing the kinetic analysis spatially on a LNT catalyst allows a much better description of the kinetic interaction between storage and direct surface kinetics.

Reviewer 2:

The reviewer observed a very good and comprehensive approach, which covered a broad spectrum of real world challenges.

Reviewer 3:

The reviewer noted that the strong collaboration with the industry partner keeps the work sharply focused on the technical barriers most impacting industry. This reviewer acknowledged excellent techniques and tools available at ORNL and pointed out that the PI was particularly talented in developing instrumentation. This reviewer felt that the combination of laboratory and field studies makes this project very strong and noted a really sharp approach.

Reviewer 4:

This reviewer stated that characterizing the nature of catalysts was well-laid out in the approach.

Reviewer 5:

The reviewer stated that characterizing catalysts with the intent of gaining insight on how to control and diagnose activity is an important on-board diagnosis (OBD) topic that is required by the EPA. This is OBD-related research, which is necessary for future emission control systems for lean applications. The reviewer said that focusing on ammonia (NH_3) storage dynamics as a function of catalyst length and temperature may be the basis of a good monitor system. The reviewer added that it was critical to know this to diagnose catalyst health and utilization. The reviewer felt that some of the NH_3 has been performed already by others in terms of NH_3 storage as a function of temperature, but not the dynamic capacity.

Reviewer 6:

The reviewer would like to see more catalyst aging up front.

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

Reviewer 1:

The reviewer indicated that good progress was made on associating NH_3 storage and gas phase concentration over the length of the catalyst to provide a way to measure the NOx activity of a SCR and how well the SCR volume was being utilized. The reviewer noted that using SpaciMS/Fourier Transform Infrared Spectroscopy (FTIR) techniques for mapping concentration as a function of SCR length was a very good tool for characterization and should be employed more. The reviewer concluded that the project provides a tool to monitor catalyst activity for OBD and control.

Reviewer 2:

The reviewer stated that the project team accomplished a good correlation between SCR kinetic models and experimental data associating with a function of NH_3 storage. The project team's unique SpaciMS tool seemed to be mature and fine-tuned for better interpretations.

Reviewer 3:

The reviewer explained that there was a nice comparison of the kinetic behavior between a beta zeolite and a new generation chabazite. The reviewer added that it seemed fairly clear that the kinetic mechanism for the two different zeolites were quite similar and may differ primarily between the density of active sites.

Reviewer 4:

The reviewer expressed that good progress has been made to date towards the project goals.

Reviewer 5:

The reviewer mentioned good leverage of ORNL analytical tools to better understand a commercial SCR catalyst.

Reviewer 6:

The reviewer stated that more work on catalyst aging would be really nice.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that clearly significant work was done at the Olsson group in addition to ORNL. That was strong evidence of good collaboration. The reviewer remarked that since Cummins was a major partner in this CRADA that the voice of the industry was being heard. The reviewer applauded the number of visiting scientists on this project and pointed out that that was great collaboration.

Reviewer 2:

The reviewer indicated excellent collaborations with industry and universities and international partners. Good participation in CLEERS, DEER, etc.

Reviewer 3:

The reviewer noted a very good collaboration portfolio; however, not much results from the collaboration partner especially from universities.

Reviewer 4:

The reviewer indicated that there was narrow formal collaboration, but broad informal collaboration to better characterize SCR NH_3 activity and to develop a Cu sensor for detecting NH_3.

Reviewer 5:

The reviewer stated that in addition to CRADA collaboration, this project also involves several universities (domestic and international) and provides data and findings for CLEERS.

Reviewer 6:

The reviewer stated that Cummins is clearly an equal partner. Additional informal collaborations enhance the overall program.

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

Reviewer 1:

The reviewer noted that the 2013 plans are a clear continuation of the good work. There is nothing revolutionary. The reviewer felt that the work is primarily evolutionary and that 2014 plans in the presentation are pretty bland.

Reviewer 2:

The reviewer would like to see more defined future work to characterize NH_3 utilization of SCR catalysts as a tool for OBD.

Reviewer 3:

The reviewer noted that the proposed future experiments and modeling seemed appropriate.

Reviewer 4:

Although only verbally mentioned, more work on how aging affects the correlation between SCR efficiency and NH_3 storage was recommended by this reviewer.

Reviewer 5:

The reviewer noted that the incorporation of laboratory and field aged catalysts was critical to understanding the real behavior on the road.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that this was effectively industry support and the industry is very good at that. Industry support ultimately improves fuel economy.

Reviewer 2:

The reviewer stated that OBD strategies are a required essential component of lean aftertreatment systems to meet CARB LEV III emissions. Any method should be cost-effective and practical as well. The reviewer concluded that this work provides a possible way to perform this function.

Reviewer 3:

The reviewer noted that this work increases catalyst knowledge which reduces catalyst costs, enabling higher efficiency engines.

Reviewer 4:

The reviewer indicated that the ORNL team's unique SpaciMS expertise has helped in many applications related to meet DOE's objectives.

Reviewer 5:
The reviewer expressed that better understanding of lean aftertreatment systems supports higher fuel efficiency.

Reviewer 6:
The reviewer stated that improving the catalyst allows the combustion efficiency to shift in a positive direction.

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

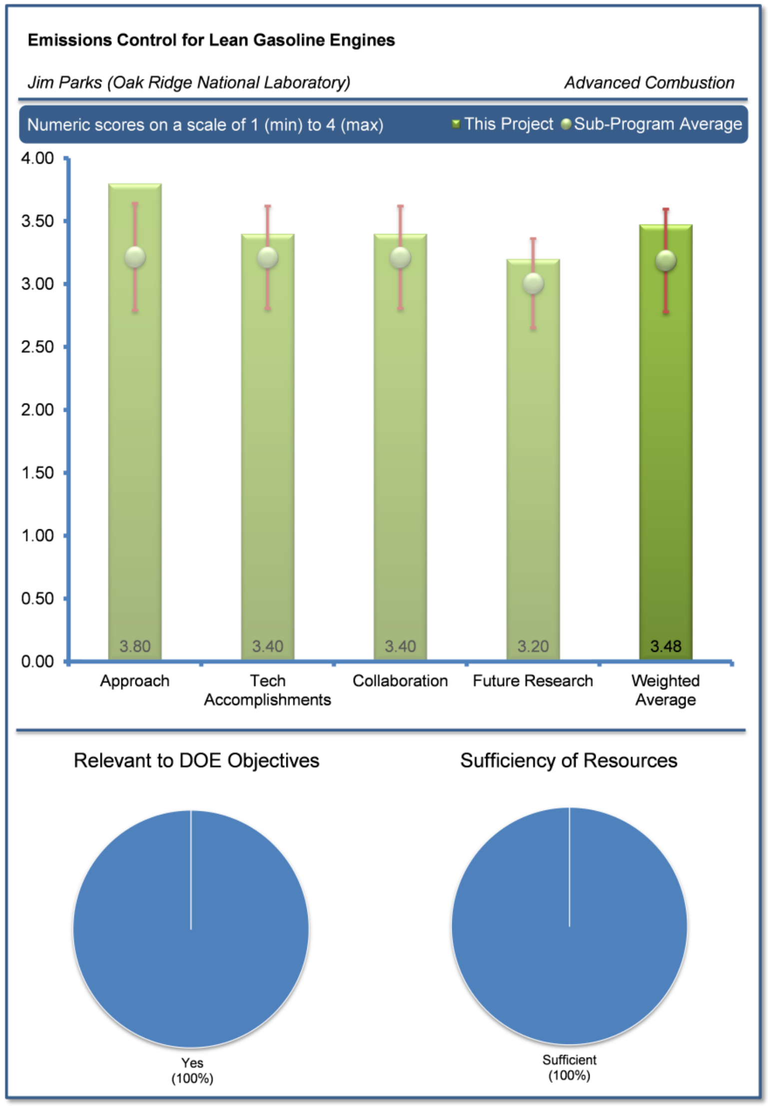
Reviewer 1:
The reviewer stated that the resources seemed sufficient.

Reviewer 2:
The reviewer stated that resources appeared to be sufficient to accomplish future work.

Reviewer 3:
The reviewer indicated that the funding level seemed appropriate for this work.

Reviewer 4:
The reviewer noted a very well-defined scope for the provided resources.

Emissions Control for Lean Gasoline Engines: Jim Parks (Oak Ridge National Laboratory) - ace033



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the area of research that is the focus of this work is very important for lean gasoline and diesel aftertreatment systems. Targeting Tier 2 Bin 2 emissions by testing various TWC/SCR/LNT configurations using only passive approach is an important and challenging area of research and development for OEMs. The reviewer noted that using both bench and engine testing is a good approach, but should try to draw a better correlation between the two. The reviewer added that including a catalyst supplier in this work is highly desirable to make sure the newest technologies are characterized.

Reviewer 2:

The reviewer indicated a comprehensive approach to enabling Tier 2 Bin 2 emissions compliance of high efficiency lean gasoline engine vehicles.

Reviewer 3:

The reviewer noted that this project has a well-balanced approach between the reactor and dyno work, and no one else can do both in-house as the ORNL team does. Also, the team scoped a wide variety of aftertreatment architectures that would enable the tight U.S. emission regulation such as Tier 2 Bin 2.

Reviewer 4:

The reviewer felt that the engine and laboratory bench studies are complementary to each other.

Reviewer 5:

The reviewer commented that the project was sharply focused on the technical barriers (aftertreatment) to lean gasoline combustion, which if solved, could lead to significant reductions in petroleum use, which is in line with DOE goals.

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

Reviewer 1:

The reviewer stated that there was a good approach. The project relies on more current technologies, but no aging effects of the system operating at different operating points. Investigations at a system architectural level should include FTP testing and aging effects to ensure an accurate assessment of system performance and a better estimate of the fuel penalty associated with passive NSC and SCR technologies. The reviewer felt that at some point PM should also be included because of its regulatory requirement.

Reviewer 2:

The reviewer observed a tunable ammonia generator for passive SCR and noted that TWC was shown to be effective. A rich air fuel ratio is needed for ammonia generation.

Reviewer 3:

The reviewer observed that the laboratory-scale results demonstrated more than 99% NOx conversion without using urea; TWC produced NH_3 was stored in SCR and was able to reduce engine out NOx during the lean operation. The project team also investigated the NH_3 production efficiency under various catalyst technologies. The Drivven-based controller seems to have provided a full control capability for the BMW lean-gasoline engine in the ORNL dyno.

Reviewer 4:

The reviewer stated that there was great bench data so far and was looking forward to results from the engine.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed very good collaboration and cooperation to achieve meaningful initial results. Having input from industry OEMs and suppliers is a significant element for deriving relevant information. The reviewer noted that the use of leading catalyst formulations is also important. However, the combined catalyst technologies may also be an important element of future systems to achieve SULEV standards.

Reviewer 2:

The reviewer stated that there was very well-coordinated interaction with OEMs, a catalyst supplier, and universities.

Reviewer 3:

The reviewer indicated that the proactive approach of ORNL with OEMs was good, but it was not clear how effective this approach has been.

Reviewer 4:

The reviewer observed that the project was sharing data and findings with all three domestic light-duty OEMs, a catalyst supplier, several universities, and CLEERS.

Reviewer 5:

The reviewer said it would be nice to see collaboration with (university) partner for catalyst characterization. The reviewer also suggested adding a university partner for the PM work (in collaboration with PNNL).

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

Reviewer 1:

The reviewer remarked looking forward to data from the engine platform and comparison to bench studies.

Reviewer 2:

The reviewer stated that the project must look at aging and poisoning effects. Also, the reviewer added, to include challenging FTP cycle points in testing and optimal regeneration strategies for DeNOx and DeSOx events to minimize the fuel penalty associated with passive lean systems.

Reviewer 3:

The reviewer noted that consideration should be given to a different metric for measuring reduction in aftertreatment cost since Pt-equivalent loading does not account for potential addition of SCR.

Reviewer 4:

The reviewer expressed that dyno work will need more sophisticated control capability; it may be too early to judge how far the Drivven can do. The OSC effect along with aging condition for NH_3 generation will need to be investigated. The reviewer also stated that ORNL has all the capabilities to investigate how aging would impact the passive SCR system; however, that the aging related study is not well-explained.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that there was very relevant work that can help characterize lean aftertreatment systems and which will enable more fuel efficient GDI and diesel engine strategies.

Reviewer 2:

The reviewer remarked that cost-effective and durable emission control systems are enablers for use of high efficiency engines.

Reviewer 3:

The reviewer noted that for LD applications, improving fuel efficiency in gasoline vehicles via lean combustion is so critical to meet DOE's near term objectives; however the lean aftertreatment has always been one of the biggest hurdles; therefore this project will help in developing the game changing aftertreatment technology that harmonizes the effort on advanced fuel efficient combustion.

Reviewer 4:

The reviewer indicated that enabling lean gasoline penetration into the U.S. market, with new lean, low-cost aftertreatment would allow for a significant efficiency improvement and impact petroleum usage.

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

Reviewer 1:

The reviewer stated that funding appeared to be sufficient.

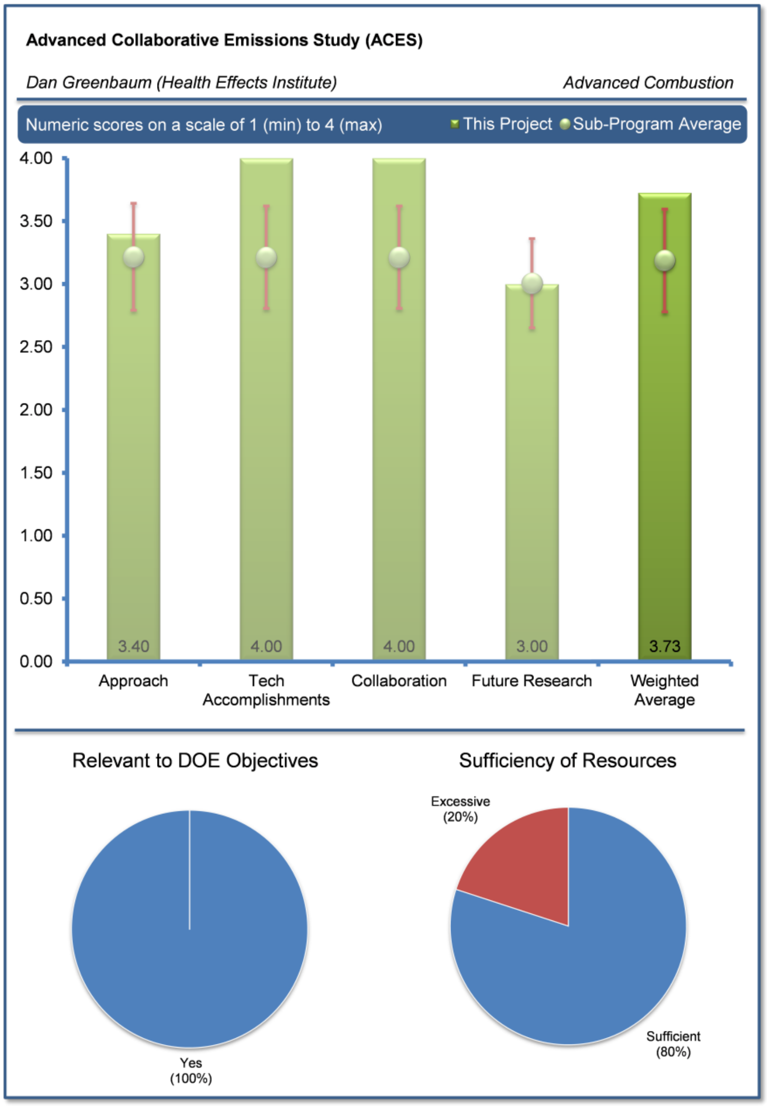
Reviewer 2:

The reviewer indicated that there was an appropriate increase in funding for the second year of the project.

Reviewer 3:

The reviewer described project resources as well-balanced and sufficient.

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



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the development of appropriate test cycles with the industry and other stakeholders is well done. Careful characterization of potentially harmful emissions has been outlined in a consistent and repeatable way. The project discussed in review the possibility to consider real world variability in emissions/regeneration cycles which can potentially be significantly worse than a standard test protocol. The reviewer noted that although the study is aimed to evaluate the regulatory levels of criteria pollutants on health, the application of real world measured data corrections /estimates for real world degradation factors would add value.

Reviewer 2:

The reviewer noted a very comprehensive approach, including a vast array of stakeholders.

Reviewer 3:

The reviewer stated that the main focus on heavy duty diesel reflected the higher diesel fuel usage by that segment versus medium or light duty diesel. It is important to understand the health effects, if any, of new aftertreatment applied to heavy duty diesels.

Reviewer 4:

The reviewer said that it seemed fairly clear that improvements in aftertreatment have made appreciable improvements the detrimental effects of diesel emissions.

Reviewer 5:

The reviewer noted the following: heavy duty diesel based, worthwhile work with contributions from many partners (industry, DOE), heavily-funded, looking specifically at diesel emissions effects on cancer rates, and diesel has a bad image. The reviewer asked what about gasoline (lean GDI) with particulate matter and what about light duty diesel effects.

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

Reviewer 1:

The reviewer remarked that engine studies found that emissions were well below standard. The project focused on regeneration and cold start. The reviewer noted it would have been nice to have a final Phase 2 report prior to the meeting. The reviewer added that there was a very broad range of species and experiments to determine if PM, NOx or other exhaust component should be considered a human toxin. The reviewer commented that engine testing was very well-thought out to keep an even comparison and noted that there was important insight and conclusions with respect to NO_2 and PM toxicity that should be considered by regulatory agencies in their policies.

Reviewer 2:
The reviewer stated that this work has made it clear that present day diesel aftertreatment should no longer be viewed as a carcinogen.

Reviewer 3:
The reviewer indicated that the project was interesting and had important findings that validated early assumptions.

Reviewer 4:
The reviewer stated that it was wonderful that the results showed little or no health effects. NO_2 effects were observed from 2007 engines. The reviewer indicated that NO_2 production is typical of a passively regenerated filter system. SCR downstream will reduce the amount of NO_2 emitted out the tailpipe for 2010+ engines.

Reviewer 5:
The reviewer commented that the project had a defined test schedule, identified emission results, conducted animal testing, and concluded no significant risk to human health (extrapolated from rodent studies) with 2007 emission levels.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that the excellent list of university, industry and government laboratory collaborations with names shows significant credibility.

Reviewer 2:
The reviewer felt that the project was well-coordinated with very good collaborations through organizations and OEMs.

Reviewer 3:
The reviewer indicated that there was successful collaboration between Coordinating Research Council (CRC), Lovelace Respiratory Research Institute (LRRI), DOE, and EPA, as well as the advisory board.

Reviewer 4:
The reviewer indicated that there was very good collaboration with industry, university, and government agencies.

Reviewer 5:
The reviewer noted that this was an industry wide accepted standard.

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

Reviewer 1:
The reviewer stated that the project team was sharing the results with the industry and the regulating bodies. That was the optimum need.

Reviewer 2:
The reviewer noted that the project was coming to a conclusion. Most of the work had been completed.

Reviewer 3:
The reviewer indicated that almost all of the testing has been completed. The future work of test data analysis and publication of results is very important.

Reviewer 4:
The reviewer wanted a budget to look at health effects of medium-duty diesels where the duty cycle and aftertreatment were different.

Reviewer 5:
The reviewer stated that although the results showed the regulatory approach was sound for public health, there should be the possibility to consider real world variability in emissions/regeneration cycles which can potentially be significantly worse than a standard test protocol. An understanding of real world measured in use data or at least estimates for real world degradation and subsequent consideration relative to animal studies can confirm real world health risk expectations.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer noted that evaluating the impact of increasingly sophisticated aftertreatment on health assists in determining the level of sophistication of aftertreatment that is necessary for a healthy environment. Since aftertreatment comes with a fuel economy tradeoff, this work helps to indicate where the tradeoffs occur.

Reviewer 2:
The reviewer stated that health effects are an important aspect to emission control technologies. Diesel image has been poor due to PM in the past. The reviewer indicated that this work supports the industry position that diesel engines are not the source of significant human toxins. There was very helpful information for regulatory agencies in developing their diesel policies and provides a pathway for greater acceptance of diesel engines into the automotive market to achieve increasingly difficult fleet cafe standards.

Reviewer 3:
The reviewer stated that this project indirectly supports the petroleum displacement by examining the emissions of new commercial technology engines and their health impacts.

Reviewer 4:
The reviewer stated that lower emission standards continue to be pursued in a regulatory environment and can constrain the fuel economy possibilities for combustion engines. It is important that there is justification for these standards in terms of public health and the environment. The reviewer indicated that this study provides evidence for this decision making. By understanding levels of exposure versus the risk of health issues, regulators and the industry can make effective choices balancing public health, the environment, and the methods to achieve fuel efficiency.

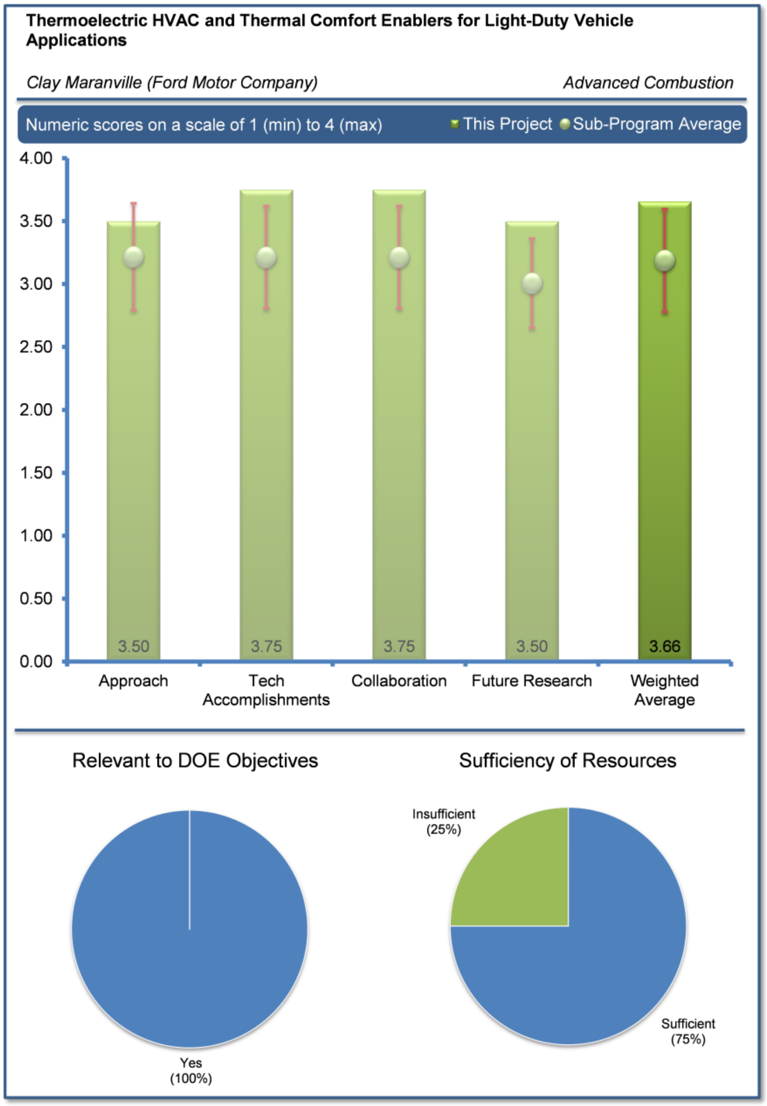
Reviewer 5:
The reviewer concluded that the project team studied the health effects of aftertreatment on highly efficient diesel engines.

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

Reviewer 1:
The reviewer described the project as expensive, but very needed.

Reviewer 2:
The reviewer indicated that there was more than sufficient funding due to the relevance of this work to OEMs; well-placed funds.

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



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that this project has been very well-designed. All the engineering details have been addressed, and the feasibility of employing thermoelectric (TE) heating ventilating and air conditioning (HVAC) system in vehicles have been demonstrated.

Reviewer 2:

The reviewer reported that the project proceeded by using a methodical approach that involves system-level modeling, materials development and fabrication, bench scale and vehicle testing, and an economic study. Additionally, the reviewer opined that the zonal approach for climate control was interesting, nothing that it has been in progress for several years now.

Reviewer 3:

The reviewer noted that four barriers were presented and that there appeared to be an overall effective approach to overcoming them. There was an abundance of modeling and simulation resources devoted to this effort, which is critical for most of these barriers. The reviewer felt that the presentation appeared to present a logical method for both the packaging and the scale-up barriers presented. The cost barrier is a particularly difficult barrier in that a balance remains most of the time between cost and performance. The reviewer stated that there should be some further effort in order to ensure that cost targets are met. The reviewer stated that durability is the other barrier that was not fully focused upon. There appears to be some work done in the future of the effort on durability, but at the present time, there was not a lot of focus on this barrier.

Reviewer 4:

Maranville clearly laid out the issues, and explained the approaches that Ford was taking to address those. The project team has partnered with valuable collaborators. It is a good mix of materials-devices-systems-analysis.

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

Reviewer 1:

The reviewer stated that the approach includes a range of activities that cover a lot of bases, and is reasonable. The relevance of TE for automotive is cast in terms of fuel economy or efficiency. The reviewer indicated that the results were presented for the most part in terms of coefficient of performance COP. In the future, it would be helpful to present the results in those terms as they will be most relevant to DOE's interests and its ability to sustain funding in this area.

Reviewer 2:

The reviewer stated that while nearing completion of the project, there still seemed to be quite a bit of work that still needs to be completed before the end of the period of performance. With the delay that was mentioned, there may need to be resources diverted from other portions of the project, increasing the risk of not overcoming all of the barriers. The reviewer reported confusion with discussing the target in terms of a 30% reduction in fuel and then only using COP for measurements during the presentation was a little discontinuous.

Reviewer 3:

The reviewer indicated that the Ohio State (porous materials) results were somewhat disappointing, but that is what university-level research is all about. The Ohio State collaborator is at the leading edge of credible research, and the reviewer had no doubts that there would be value and contributions. The reviewer added that the other collaborators have had excellent progress.

Reviewer 4:

The reviewer noted that the HVAC related tasks were carried out and completed with very good results. The Ohio State University (OSU)/ZT-plus effort on porous materials seemed to be not as well-planned. The basis for porous materials to have better ZT than dense materials was not very strong. The reviewer explained that usually the power factor loss due to high electrical resistivity can be compensated by lower thermal conductivity; but the improvement in ZT has not been shown to be significant. The reviewer indicated that it was a good indication of proper project management to terminate the effort when the potential of porous materials was not confirmed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that there was a good range of academic and industrial partners.

Reviewer 2:

The reviewer noted that there appeared to be a sufficient amount of partnership in this effort. Each partner had a specific function; even though some of the Ohio State information was not used as part of the project, it was useful information to know what was out of the scope based on test results.

Reviewer 3:

The reviewer stated that Ford's team was at the cutting edge of their respective fields and felt that this was excellent.

Reviewer 4:

The reviewer reported that this project assembled a strong team. Ford has been very successful in coordinating the research efforts among various partners.

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

Reviewer 1:

The reviewer indicated that wind tunnel tests were mentioned but it was unclear precisely what would be obtained from them. The reviewer indicated that more details would have been appreciated. It was stated that at the end, or near the end, of the project an assessment will be made on more conventional metrics of performance (i.e., fuel economy improvement based on TE). The reviewer felt it would be preferable to engage in such projections during the period of funding (and not the end of the project) because (for better or worse) fuel economy is the benchmark that is understood by a wider audience.

Reviewer 2:

The reviewer offered that it would be helpful to show at least progress on the cost portion, as this could potentially be one of the more critical barriers to overcome, and there is only a report at the end of the study. Overall, the plan is well-laid out and has the required output mechanisms to show comparison against the barriers. The reviewer noted that there seems to be a number of steps still in need of completion before August.

Reviewer 3:

The reviewer observed that the project is on track to be complete by 2013. The completed and remaining milestones have shown that the team will achieve the original goal of assessing the feasibility of TE-based HVAC system in vehicles.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that this project was obviously very relevant. It was unclear if the ultimate outcome would be a car on the market with Thermoelectric Generators (TEGs) that could have a significant impact on fuel economy. The reviewer noted that perhaps the project team will be successful, though the presentation was not clear on that forecast.

Reviewer 2:

The reviewer stated that thermoelectric technology was a beneficial technology which in this case was taking a significant load off of the primary HVAC system and using a zonal approach to cabin cooling. The target of 30% reduction in fuel use for the system is a direct correlation to the goal of DOE objectives.

Reviewer 3:

The reviewer mentioned going a step further and acknowledged that Ford uses the profitability metric, meaning that Ford will work to field a system that can be profitable. If Ford succeeds, then everyone will win. If something is not profitable, then it will not go into cars.

Reviewer 4:

The reviewer stated that improving the efficiency of the HVAC system is part of the solution for petroleum displacement. This project has shown that the thermoelectric system is a viable alternative.

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

Reviewer 1:

The reviewer indicated that given the large team, the resources are about what one would expect for a major automotive manufacturer developing a new technology for the market.

Reviewer 2:

The reviewer stated that there seemed to be sufficient resources. Again, there is a risk from a schedule perspective with the identified slip already in the schedule with minimal months remaining in the project.

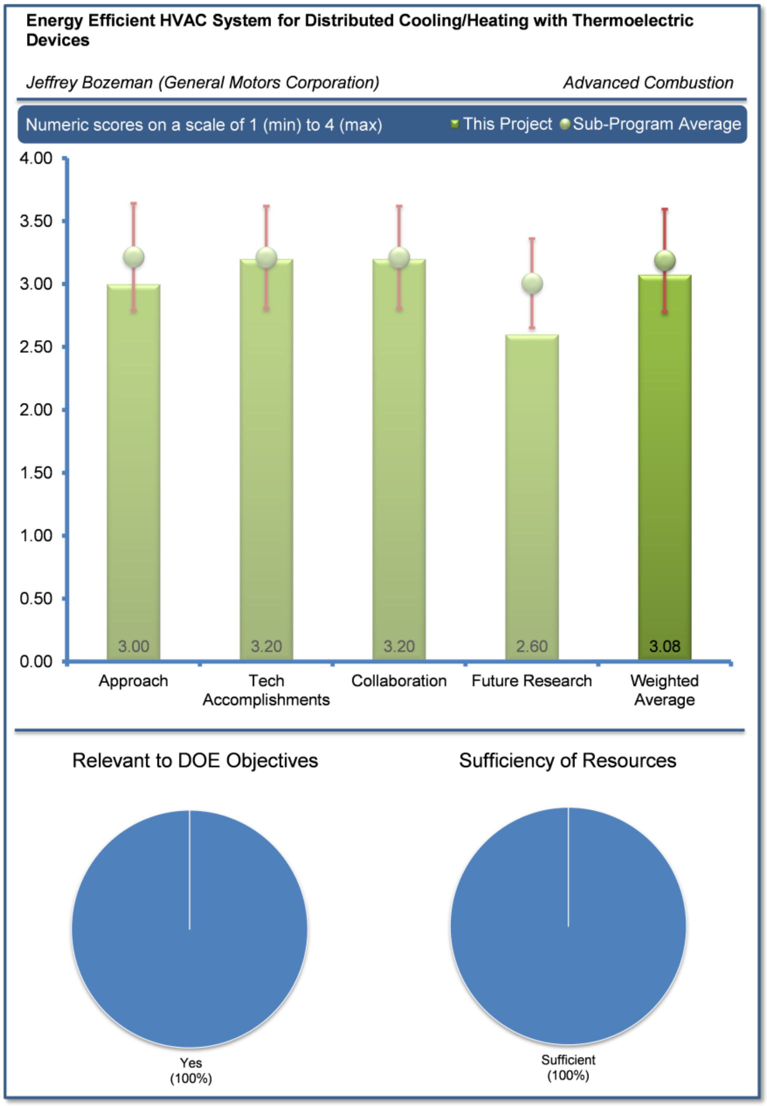
Reviewer 3:

The reviewer stated that the project team could use a plus-up.

Reviewer 4:

The reviewer noted that the team has shown sufficient use of resources to achieve program goals.

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



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that this project is focusing on the engineering design and testing of automotive HVAC devices to achieve a targeted COP. The team has made significant progress and is on track to complete the project by Spring of 2014.

Reviewer 2:

The reviewer found this talk to have good results, but noted that in an overall sense it was somewhat disconnected and inconsistent. The reviewer criticized that the focus is on cooling systems, yet the materials research was a summary of the power-generation work, and the supporting theory was focused on lead-telluride, which is not a material in either the cooling or the power generation.

The reviewer emphasized that not all three were irrelevant and there is overlap, but recommended to re-focus the theory component to work on either better cooling materials, or to a systems thermodynamics analysis. The reviewer also suggested the researchers devote some of the materials work towards better cooling materials, better device integration or something. All of the topics were done well, but the reviewer felt there was not a glue or an overall goal that tied everything together.

Reviewer 3:

The reviewer stated that the project is organized around a range of tasks that include thermal comfort, HVAC prototype development and developing new TEG material systems. It was hard at times to understand how the individual parts of the project fit together as a directed effort to achieve an overall goal. The reviewer felt that future work should endeavor to communicate a greater degree of synergy of the components, perhaps with some sort of a flow chart that feeds into a grand target goal. Then, the presentation could speak to the individual elements. The reviewer noted that, as it stands, the presentation seemed like a communication of unrelated elements. Also, the connection with Ford's effort (and vice versa) would help.

Reviewer 4:

The reviewer stated that although the overall approach was discussed, the presentation did not address critical air conditioning (A/C) design criteria, particularly fast cool-down from hot interior cabin environments. The current thermoelectric (TE) HVAC system design cannot handle the fast cool-down transient requirements; consequently, the system design actually appears to keep the original A/C system and integrates the TE HVAC system with it to handle steady-state conditions (as explained by the presenter). The reviewer added that this creates an element of complexity that was not immediately clear in the presentation or the approach. The focus on WHR integration also adds an element of complexity and it is not clear that the power generated from any WHR system would be enough to power the TE HVAC system. The reviewer indicated that there was no discussion of synchronizing the power generation from WHR with the power demands from the air conditioning system. This could require energy storage in some operational scenarios/conditions and this does not appear or is discussed as part of the Technical Approach. Without a well-thought out integration plan there is no reason to be doing TE materials research on WHR materials in a program designed and advertised as a TE HVAC program.

Reviewer 5:

The reviewer noted three goals/targets to performing the work (i.e., reliability, COP, and energy reduction). While initial test results showed a solid approach to meeting, if not exceeding, both COP and energy reduction targets, it still needs to be completed in a vehicle with the final design. The reviewer criticized the project for not integrating cooling in the front passenger seat. The reviewer suggested that the project should use a similar technology that indicates that a passenger needs to buckle their safety belt in order to activate cooling in the zone. It did not appear that there was enough focus on the reliability aspect of the project barrier. The reviewer stated that while it was beneficial to show performance measures, it was also important to show repeatability when identifying reliability as one of the targets. The reviewer was not sure if this barrier would be achieved with the present project plan.

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

Reviewer 1:

The reviewer noted that the overall approach appeared to be well-thought out. Much of the work seemed to be directed toward climate control strategies.

Reviewer 2:

The reviewer indicated that significant progress has been made toward two of the target barriers. With only the virtual environment with specified test conditions, a measured savings of 29.5% versus the 30% goal was promising; also the COP of 1.4 for cooling and 2.4 for heating both exceeded the performance targets of 1.3 and 2.3 respectively. The reviewer warned, however, that based on the limited number of devices being developed, it may be difficult to conduct enough tests in order to meet the reliability concern target. There did not appear to be a clear path forward in order to meet that barrier.

Reviewer 3:

The reviewer stated that this project has been very well-designed and executed toward program objectives. The study using Volt is an excellent example of utilizing the unique advantages of both heating and cooling functions of TE devices. The reviewer indicated that the results have shown the HVAC devices meeting the DOE program target.

Reviewer 4:

The reviewer observed good results in each of the separate, disconnected focus areas. The reviewer added that to keep up the good work was in order, but the effort should be re-adjusted to succeed on the one area for which the project receives funding (i.e., cooling systems).

Reviewer 5:

The reviewer felt that this presentation left out key pieces of information (e.g., air inlet temperatures and coolant temperatures were not specified for the COP greater than 1.4 claim). There was no discussion on how TE design optimization was integrated with thermal design optimization to achieve COP and cooling capacity requirements. The reviewer stated that the unity cooling design was effective. Integration of the VC system with the TE HVAC system was effective in handling all varied requirements, but it was a complex, brute-force approach. There also was no discussion of the heat exchanger design approach, heat exchanger sizing, or design optimization to produce compact, lightweight systems that can fit within headliners and door pillars. The reviewer indicated that it was not clear what progress had been made and what challenges remained in this part of the system design. The reviewer asked if this team could really remove the necessary heat transfer at the required heat fluxes with low pressure drops, low fan powers, and low noise levels. The reviewer noted that this presentation did not discuss any of these important system design aspects, nor the integration with the TE cooling system design. It was therefore difficult to judge and evaluate the progress in this particular design area.

The reviewer stated that the human comfort modeling was strong and effective in helping to meet requirements.

The reviewer indicated that WHR materials performance was too low to be effective in meeting DOE goals for power generation to operate the TE HVAC system. There was no discussion of integration of the WHR power generation performance with the power requirements of the TE HVAC system. The reviewer offered that this team needed to discuss and consider integration of the TE waste heat power output and synchronize the TE power output to the TE power input for the TE HVAC system. This will likely require energy storage to properly integrate these two sub-systems, but there was no discussion of this in the presentation. The reviewer then asked how the team was going to accomplish that integration. The reviewer felt that without a well-thought out integration plan there was no reason to be doing TE materials research on WHR materials in a program designed and advertised as a TE HVAC program.

The reviewer reported that this team did claim that there was progress on a control strategy for the TE components, but there was little or no specific information or discussions of this in the presentation. It was therefore difficult to evaluate the progress in this area.

The reviewer also criticized that in some cases, the presentation chart was so poorly done that one could not even read the text, labeling and language on the Figures (e.g., Slide 7). It was therefore not possible to evaluate this work and the system design message being portrayed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the team was large and covered a lot of expertise. Not much was discussed on how the partner objectives were related.

Reviewer 2:

The reviewer remarked that there was a good team, but the results and accomplishments so far were not clear or impressive.

Reviewer 3:

The reviewer stated that it appeared there was well-qualified collaboration with partners that would allow the breadth of knowledge needed in order to successfully complete the project. The interdependency shown between the collaborators was encouraging on coordination.

Reviewer 4:

The reviewer observed good collaborations.

Reviewer 5:

The reviewer noted that the project team was well managed. It was not very clear that the University of Nevada-Las Vegas (UNLV) effort was directly related to HVAC or the waste recovery. The materials the project team investigated, PbTe and $Cu_{2-x}Se$, did not appear to be the selected materials for HVAC and waste recovery.

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

Reviewer 1:

The reviewer noted that the lack of a fuel efficiency target should be addressed in future work. DOE projects upwards of a 5% improvement. The reviewer noted to commercialize the design of new components (i.e., enhance imperative tradeoff and consider configuration in mainstream, hybrid, and EV applications).

The reviewer stated that some of the future targets were a bit vague (i.e., what did developing a localized strategy for Chevrolet Volt mean). More specificity in future work would be appreciated.

The reviewer noted that the performance was generally cast in terms of COP and was not preferred compared to how the DOE program has been presented, namely in terms of a fuel economy improvement (or percent improvement).

The reviewer commented that casting the performance in other terms was not always understood by high-level management, and this was the crucial selling point that needed to be accomplished to sustain the program. Also, an economic analysis was crucial to potential profitability.

Reviewer 2:

The reviewer stated that this team discussed their high-level plans, but did not discuss many important system design aspects as discussed above. Once again, there appeared to be a large focus on TE materials research (for high-temperature WHR of all things), with little focus on TE materials research directed to improve the lower temperature TE HVAC system. No mention was made of this in the presentation.

Reviewer 3:

The reviewer felt that the final deliverable appeared to fulfill a bulk of the requirements, including time for optimization of the system. The only barrier the presentation lacked was how this project was going to attack the reliability barrier. The reviewer observed that there did not seem to be much of the tasks targeting module consistency, lifetime testing or other durability studies associated with increasing confidence in this barrier.

Reviewer 4:

The reviewer suggested that the effort be re-adjusted to succeed in the one area for which the project receives funding (i.e., cooling systems).

Reviewer 5:

The reviewer noted that the remaining tasks have been well-planned. The integration of TE devices into the Chevrolet Volt seems to have overcome more challenges to become a component in future EVs.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the overall project was quite relevant to DOE's interests. The performance targets were reasonable.

Reviewer 2:

The reviewer stated yes, but it was not clear to the reviewer that this project was well-focused on the DOE objectives. The team did not provide any analyses on how much fuel savings or performance improvement their system could produce in their selected vehicle applications (i.e., Buick LaCrosse).

Reviewer 3:

The reviewer indicated that the specific barrier to reduce HVAC consumption by 30% was a clear indicator that this project supported the overall DOE objective of petroleum displacement.

Reviewer 4:

The reviewer stated that the project team would have a positive impact on waste-heat recovery even if the miles per gallon (MPG) targets were not exactly met. Whatever improvement was averaged over millions of cars, and that was a huge deal.

Reviewer 5:

The reviewer reported that the TE HVAC devices in vehicles, especially in EVs, directly supported DOE objective in petroleum displacement.

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

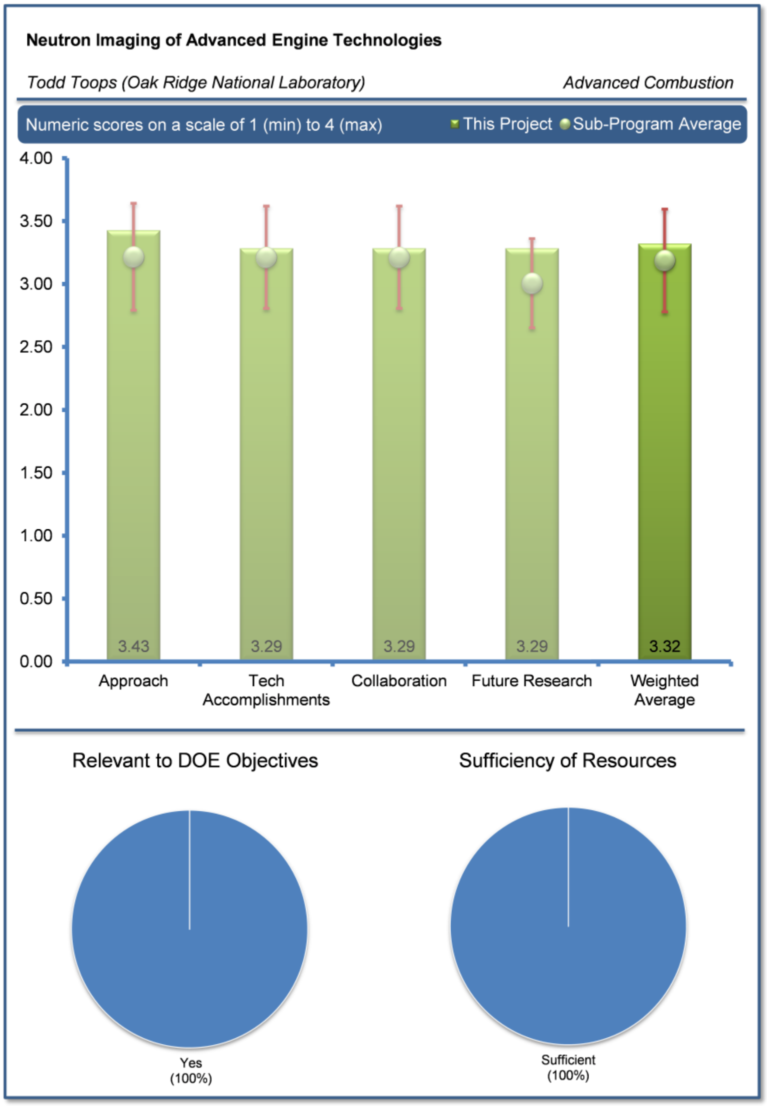
Reviewer 1:
The reviewer stated that the resources were adequate for the project.

Reviewer 2:
The reviewer felt that as structured, it appeared that this project would be able to complete the tasks presented. The risk of the project was to ensure that the reliability barrier was addressed to a sufficient level, as resources may need to be diverted in order to place more focus in an area that may not achieve the barrier.

Reviewer 3:
The reviewer stated to keep up the good work.

Reviewer 4:
The reviewer stated that the GM team had been very efficient in utilizing resources in this project.

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



Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the use of neutron imaging as a non-destructive, non-invasive technique seemed like an excellent approach to study a number of aspects related to combustion and emissions.

Reviewer 2:

The reviewer noted that this is a worthwhile project and has the potential to provide information that is not available by other means. It should be continued. Since it remains to be seen just what information can be obtained, the work should be continued to find out what can be done. The reviewer rated this work as outstanding if its potential is fully realized. Once the potential of this technique is understood it will be able to more tightly focus the work on specific areas of relevance to DOE's mission.

Reviewer 3:

The reviewer stated that the project still feels like a technique in search of a use for fuel injection. The reviewer felt that this was worthy work though for $200,000 of funding.

Reviewer 4:

The reviewer stated that the approach is sound. It will be important to understand the unique capabilities this facility provides, as compared to other DOE facilities (e.g., ANL and APS).

Reviewer 5:

The reviewer felt that this program was looking into a very interesting area of study, allowing valuable insight into the detailed functions within both fuel injectors and diesel particulate filters.

Reviewer 6:

The reviewer stated that the neutron imaging technique has very unique capabilities and is worthwhile exploring. It is capable of non-destructive testing of certain engine components. The reviewer indicated that the technique also has some barriers, especially for fuel injector diagnostics; low neutron flux is one and resolution is the other. The reviewer suggested that more work be focused on exploring the removal of these shortcomings in order to make this technique more useful. The reviewer concluded that it seems like the technique will do well in imaging a large static component like a particulate filter.

Reviewer 7:

The reviewer noted that non-destructive techniques offered a unique opportunity for multiple study of a single device. It provides insight into intra-nozzle fluid dynamics for improved simulation and design. The reviewer pointed out that the negative slow response makes dynamic injection imaging challenging. DPF application provides the thickness of the soot layer as well as porosity of the layer, which allow the soot mass to be calculated. This reviewer also noted ash deposit. The reviewer reported that the neutron flux is low and that higher resolution is desirable, such that the opening and closing behavior of the injector can be studied.

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

Reviewer 1:

The reviewer stated that there was good progress. The project team designed a spray chamber to study flow injectors. The reviewer indicated that the initial proof of concept tests demonstrated could detect a denser fluid profile for fuel injected at a higher pressure. The project team obtained interesting results on soot cake density changes during DPF regeneration.

Reviewer 2:

The reviewer stated that the initial results were very encouraging and that the investigators have identified, and are working on, improvements/modifications that need to be made to enhance the value of the data and the extraction of the maximum information from the analysis.

Reviewer 3:

The reviewer asked if the resolution available will allow enough fidelity to detect the internal flow characteristics of the fuel injector that matter.

Reviewer 4:

The reviewer noted that results for GDI and DPF were interesting. The conceptual model for DPF regeneration was also good.

Reviewer 5:

The reviewer indicated that the program has made good progress and that the results presented on the DPF were of great interest. The reviewer also suggested that the one potential recommendation would be to get a better understanding of why soot layer density was changing during the regeneration process; if the packing density changing was, if the porosity changing, and to get a good fundamental explanation of how and why the packing factor (and porosity, pressure drop, etc.) changes through the regeneration event.

Reviewer 6:

The reviewer noted that a fair amount of work remained before the technique could yield results that would provide new understanding. In order to prove the usefulness of the technique, more work should tie in with ongoing particulate filtration work at ORNL or other institutions. The reviewer felt that the soot regeneration work was very interesting and was providing new knowledge. The reviewer asked if the density of the liquid within the injector discerned by the imaging could be correlated to the pressure as a function of distance along the injector passages. It seems like this data would be useful in the design of better injectors and nozzles.

Reviewer 7:

The reviewer stated that good progress had been made for both DPF and injector fronts, including that a measurement of sequential soot distribution changes in diesel particulate filters as a function during a series of partial regenerations had been completed. The determination of temporal and spatial resolution of neutron imaging with respect to fluid density and flow in fuel injectors was on target. The reviewer stated that the potential usefulness of neutron imaging had been demonstrated.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that very good collaboration existed with several key partners. The reviewer suggested that more collaboration with Navistar and others on particulate work should be pursued. The reviewer also recommended that a partnership of collaboration with a Tier I fuel injector supplier like Bosch, Delphi, Conti, etc. should be pursued, as the suppliers would be able to point to areas of interest that the technique could help with regarding designing better injectors.

Reviewer 2:

The reviewer noted that collaborations have been setup with a few industrial collaborators (NGK and Navistar) that have provided materials for proof-of-concept tests. Presumably the number of collaborations can be expanded if/when other industry members have materials they would like to have evaluated by this technique. The reviewer indicated that collaborations have been setup with other government and university laboratories.

Reviewer 3:

The reviewer observed that there was good collaboration with universities, industry, BES and the technical community at large. There appeared to be significant interest about this project from the technical community at large.

Reviewer 4:

The reviewer indicated that there was a good mix of collaborators, including academics and industry.

Reviewer 5:

The reviewer stated that the program had the right parties involved to address the program objectives.

Reviewer 6:

The reviewer noted that there was good collaboration with the industry and university partners.

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

Reviewer 1:

The reviewer noted that there were plans to adapt the system to have the capability to investigate GDI injectors and stated that the incorporation of ash-laden and gasoline particulate samples into the particulate filter studies seemed reasonable.

Reviewer 2:

The reviewer indicated that the investigators have responded well to suggestions on applying this diagnostic to applications such as GDI. This reviewer added that the most immediate future work is being directed to technique improvement, as it should be.

Reviewer 3:

The reviewer expressed interest in the results from the GDI spray measurements, to see how the results compare to the ANL's APS. The reviewer indicated interest for the impact of multiple injections, over a range of ambient densities.

Reviewer 4:

The reviewer stated that another item that could be included is the studying of deposit formation on DI gasoline injector nozzles.

Reviewer 5:

The reviewer noted that the continuation of the current aspects was proper. The reviewer expressed the need to further improve the technique in terms of resolution to better understand of the injector. More emphasis on GDI injector would be timely according to this reviewer. The summary on page 21 lists only diesel injector, and the reviewer hopes it was an oversight. More focus could be put to study the injector behavior during the opening and closing phase of the operation.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer suggested that an improved understanding of fluid flow inside injectors should lead to better injector design and modeling and more efficient engines. Also, better understanding of particulate regeneration processes should lead to more effective regeneration procedures which are tied to emissions abatement which are related to DOE goals of clean combustion.

Reviewer 2:

The reviewer felt the project provides added insights in a non-destructive way.

Reviewer 3:

The reviewer indicated that this work would give good insight into the operation of both fuel injectors and particulate filters, both of which were directly relevant to improving engine performance.

Reviewer 4:

The reviewer stated that this project was developing a non-destructive diagnostic technique that would help develop enabling technologies for high efficiency engines like fuel injectors and particulate filters.

Reviewer 5:

The reviewer commented that any techniques which provide a better understanding of the devices which could improve the fuel economies would indirectly support the overall DOE objectives of reducing petroleum consumption.

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

Reviewer 1:

The reviewer stated that it appeared that the resource allocation was sufficient.

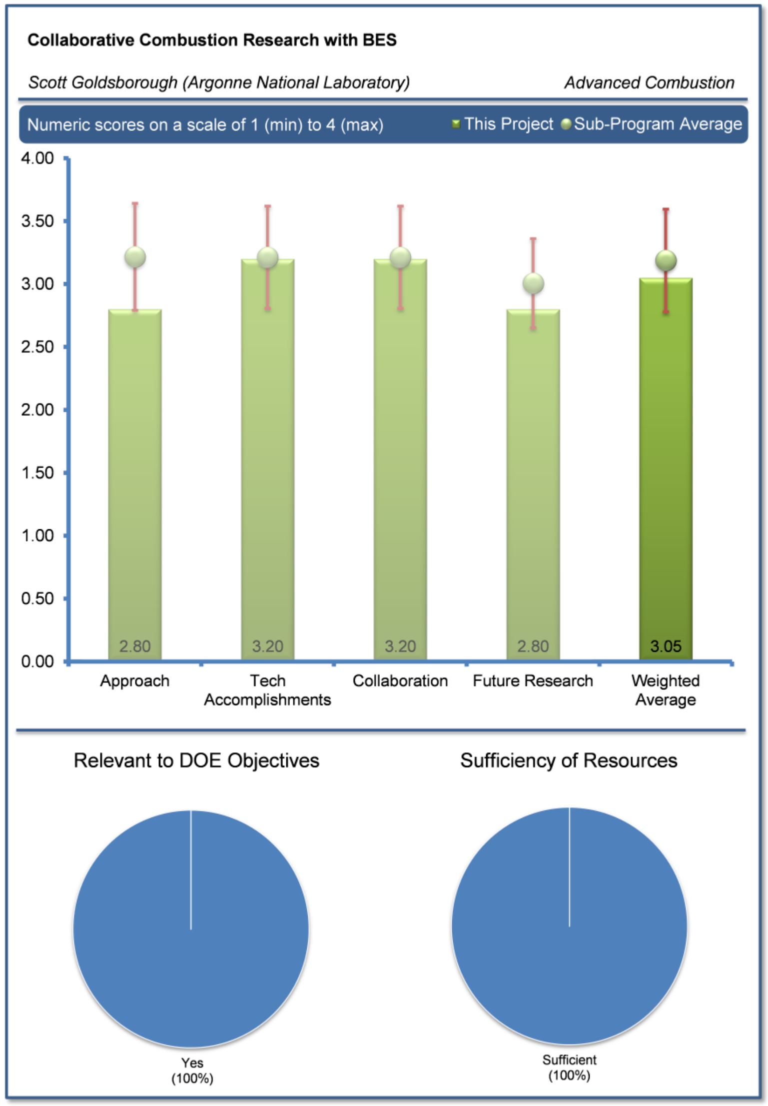
Reviewer 2:

The reviewer stated that the funding was sufficient for now, but may need to expand in the future, depending on how significant (and unique) the GDI findings are.

Reviewer 3:

The reviewer noted that this program was doing very good work on a relatively small budget.

Collaborative Combustion Research with BES: Scott Goldsborough (Argonne National Laboratory) - ace054



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer summarized that this project seeks to provide fundamental research to support DOE and industry advanced projects. It attempts to build fundamental knowledge of combustion in advanced combustion regimes, and to improve the predictability capability of today's modeling tools. The reviewer indicated that the project does not give adequate description on how this work is tied up to engine efficiency or pollutant reduction. Furthermore, the reviewer felt that the connection with the industry was unclear.

Reviewer 2:

The reviewer stated that the RCM work provided a good addition to the work done via other methods.

Reviewer 3:

The reviewer noted that adding model of RCM test was a great idea to help improve the accuracy of chemistry results.

Reviewer 4:

The reviewer indicated that this project was an enabler for others as a new experimental facility for exploring the reactivity of various possible transportation fuels. The RCM is operational but still was undergoing maturation steps. The reviewer commented that more data, especially on fuels of interest to DOE and its partners were possible for next year.

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

Reviewer 1:

The reviewer stated that the effort shown here appeared scattered. Studying the effect of crevice volumes seems outside the scope of this work. The reviewer asked what was expected by this work. There was much dedicated to the crevice geometry but it did not seem tied up with any specific goal. The authors asked if some configurations were better than others. The reviewer felt that the authors could provide the foundations for selecting these reactivity modifiers and justify the effort in the long-term development of fuel chemistry. The reviewer asked if the industry both from supplier to engine manufacturers were in line with this effort and if so, what their input was. The reviewer stated that the authors planned detailed measurements for FACE fuels with reactivity modifiers and asked how this fit in with the expectation from manufacturers and fuel suppliers. The reviewer continued to ask, how the work on phase change, the histories of pressure, temperature and EQR, got incorporated in the models. The results did not appear to be followed through. The reviewer indicated that the experimental work across several ranges of 2-ethylhexyl nitrate (EHN) percentages was a good fundamental set of data. The reviewer wanted to know that the long term plans for this project were.

Reviewer 2:

The reviewer observed nice work to better characterize fuels and additives.

Reviewer 3:

The reviewer commented on good results with RCM, and that it was good to identify shortcomings of the chemistry model to know where to focus efforts to improve the model.

Reviewer 4:

The reviewer stated that the RCM was operational and had generated some initial data including comparison to kinetic calculations. The next year should generate significantly more data and an understanding concerning fuel reactivity of various fuels under consideration by DOE.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated there was an excellent goal with standardized tests among 14 RCM laboratories

Reviewer 2:

The reviewer suggested that more detail may be given as to the contribution of the partners.

Reviewer 3:

The reviewer stated that it was good to see the International RCM workshop.

Reviewer 4:

The reviewer stated that it was good to see collaborations with both academic partners and industrial partners.

Reviewer 5:

The reviewer indicated that there was good collaboration between ANL, Akron, and possibly UM. It would be interesting to eventually compare data generated in this RCM with data from UM for the same fuels or comparable fuels.

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

Reviewer 1:

The reviewer stated that the outline was rather vague in the accomplishment section, the outline was rather vague. The authors could be more specific as to the expectations or milestones that the authors were seeking.

Reviewer 2:

The reviewer felt that the proposed research was logical and should yield good data. One suggestion was to consider taking measurements of ethanol-gasoline blends for comparison with other facilities as both validation and learning steps.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that basic fuel combustion data was needed for advanced modeling of combustion.

Reviewer 2:

The reviewer noted that improving the understanding of chemistry would help improve the engine combustion models that could be used to improve engine efficiency.

Reviewer 3:

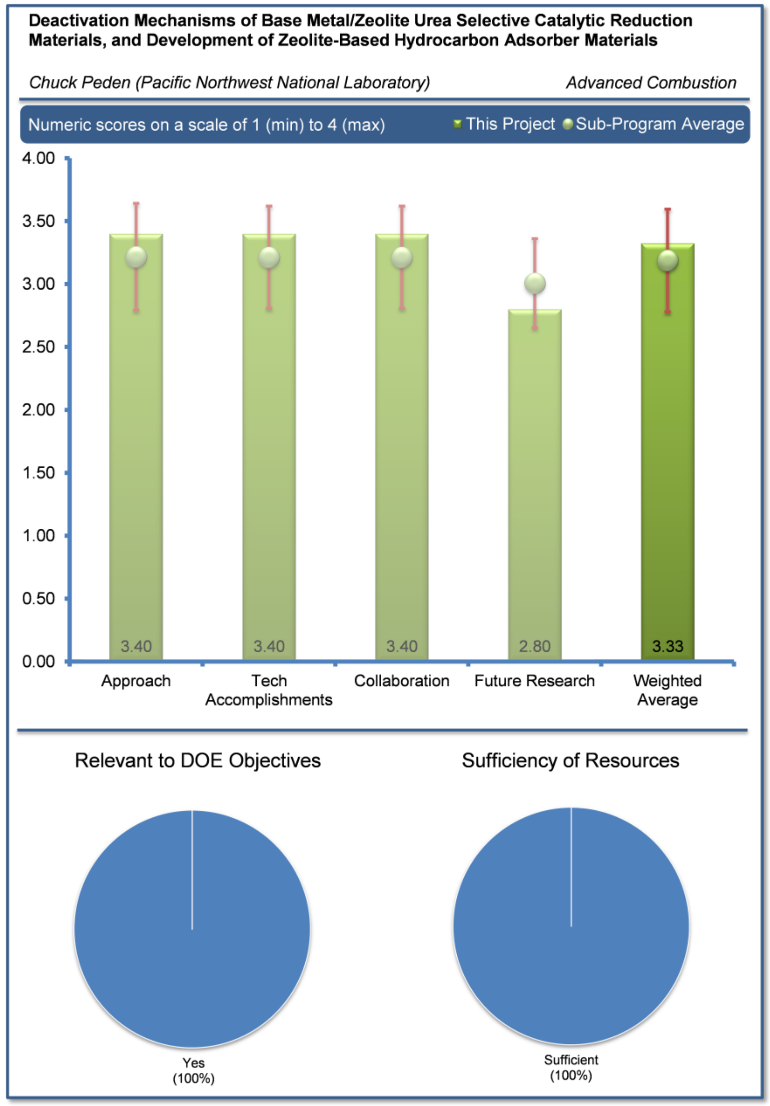
The reviewer stated that this project could support others working on advanced homogenous combustion models that are focused on improving engine thermal efficiency.

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

Reviewer 1:

The reviewer indicated that funding appeared adequate for the PI to execute future thrusts given that the bulk of the RCM set-up was complete.

Deactivation Mechanisms of Base Metal/Zeolite Urea Selective Catalytic Reduction Materials, and Development of Zeolite-Based Hydrocarbon Adsorber Materials: Chuck Peden (Pacific Northwest National Laboratory) - ace055



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the approach was reasonable and led to interesting results.

Reviewer 2:

The reviewer stated that the deactivation mechanisms for lean SCR systems were an important area of research. This supported efforts to enable lean engine systems to meet emissions standards as well as OBD and durability requirements. The reviewer summarized that the project also supported laboratory-based aging protocols to simulate in-field use. It was a very useful study to help meet durability requirements at OEMs.

Reviewer 3:

The reviewer indicated that there was a good delineation of tasks between the OEM partner and PNNL.

Reviewer 4:

The reviewer stated that the development of aging protocols helped accelerate the testing of new catalysts, saving time and money and enabling a greater number of catalysts to be evaluated. The project looked at different ethanol contents of current gasoline blends. The reviewer stated that it would have been helpful if the presenters had been mindful that some audience members were not experts in catalyst chemistry.

Reviewer 5:

The reviewer stated that the technical barrier is to develop realistic laboratory based rapid aging protocols, which effectively simulate engine based catalyst deactivation methods. Characterizing dyno aged parts and correlating laboratory aged parts to be industry standard method. Thermal and poisoning mechanisms are typical candidates and were selected for evaluation (hydrothermal), also to identify HC adsorber materials.

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

Reviewer 1:
The reviewer noted that the project team developed an improved understanding of the catalyst aging/deactivation processes and mitigating strategies.

Reviewer 2:
The reviewer noted that the project consisted of very useful SCR work related to deactivation mechanisms and how poison type and location can affect activity. Also, this reviewer reported that a wide range of poisons and how they interacted with SCR catalysts were examined.

Reviewer 3:
The reviewer stated that experimental data and catalysis insights have enabled the OEM partner to develop realistic laboratory aging protocols for SCR catalysts. Unusual hydrothermal aging of SCR catalysts was observed. The reviewer emphasized the very relevant work on HC adsorber materials for fundamental understanding of HC Trap characteristics.

Reviewer 4:
The reviewer observed that parts were characterized as proposed and important findings were identified. This reviewer further noted that loss of zeolyte crystallinity is a proposed mechanism to loss of performance with urea having some influence on catalyst aging; SO_3 poisoning was impacting low temperature performance, but being removed at high temperatures; SO_2 was having no impact; and approximately 1-inch at the front of brick has Cu sintering/poisoning with remainder of the catalyst not impacted.

Reviewer 5:
The reviewer stated that HC progress was minimal due to the departure of previous PI.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer indicated that there was very good government/industry interaction on an important topic.

Reviewer 2:
The reviewer stated that there was good, close collaboration with the OEM partner, typical for a CRADA.

Reviewer 3:
The reviewer noted that the appropriate division of tasks between Ford (practice) and PNNL (fundamental understanding) was based on respective expertise.

Reviewer 4:
The reviewer noted a good collaboration with Ford as proposed.

Reviewer 5:
The reviewer indicated good collaboration with industry.

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

Reviewer 1:
The reviewer stated that this was not applicable as the projects are complete.

Reviewer 2:

The reviewer commented that there is no further funding and the project has ended. However, new projects should continue with investigating the mechanisms of urea, SO_3, and P poisoning pathways.

Reviewer 3:

The reviewer stated that this project ended in September 2012.

Reviewer 4:

The reviewer indicated that the team was ending the project as planned.

Reviewer 5:

The reviewer noted that the project was ending so there is no future work.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated, yes, by working to develop and understand more effective and durable catalysts, and procedures for accelerated aging of sample catalysts to speed laboratory evaluations of them.

Reviewer 2:

The reviewer noted that the project was very relevant to enabling lean engines to enter the marketplace and meet emissions standards. In-use durability, now at 150, 000 miles for CARB LEV III systems, must be met. Deactivation mechanisms associated with common exhaust poisons were important to understand, to avoid long-term exposure to field failures.

Reviewer 3:

The reviewer noted that the rapid aging of catalysts allows optimization of materials, lower costs of aftertreatment which is critical to allow technologies which enhance fuel economy and petroleum reduction to be implemented.

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

Reviewer 1:

The reviewer indicated that there was an excellent collaboration and use of resources.

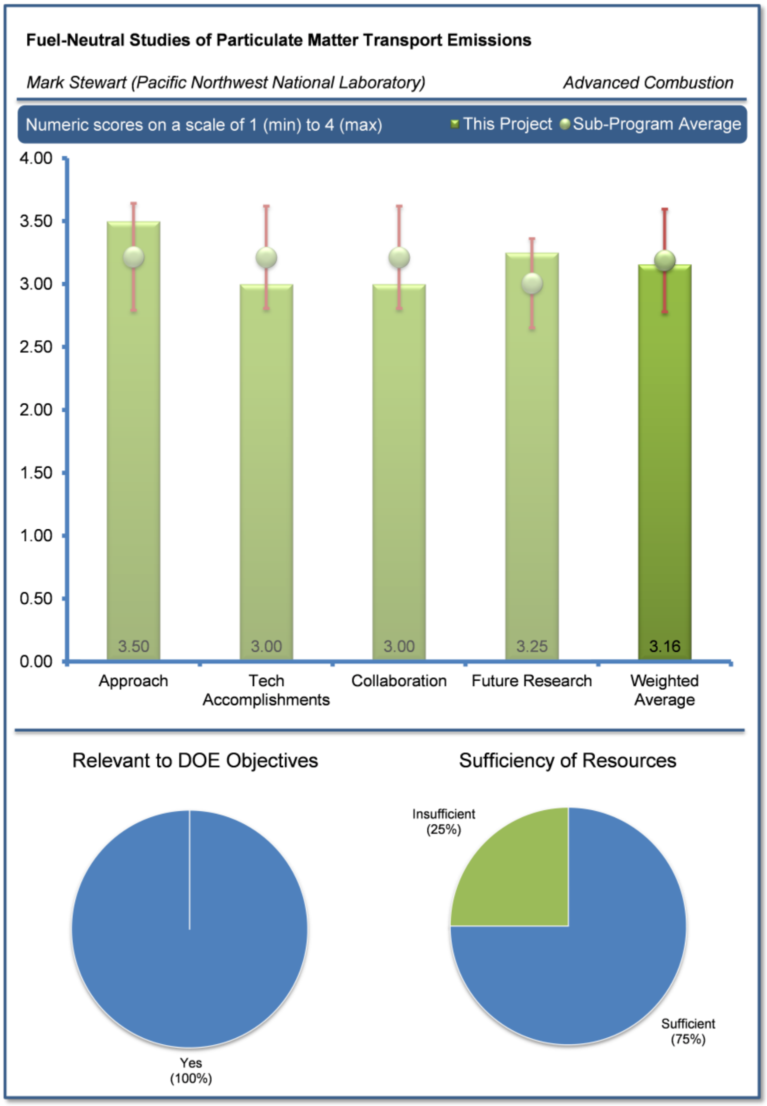
Reviewer 2:

The reviewer noted that this was a relatively low effort, but the funding was appropriate because objectives were accomplished.

Reviewer 3:

The reviewer stated that the project is complete.

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



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that this work is great as always. It has a well-directed goal for GDI filtration. The reviewer criticized that the glaring weakness is generating or reproducing a membrane filtration technology which limits backpressure drop and has a high filtration efficiency for the small GDI particles. This presentation did not raise the reviewer's confidence in the model materials produced for this project.

Reviewer 2:

The reviewer indicated that the project was a very nice study to determine the composition and size of PM under different operating conditions and fuels.

Reviewer 3:

The reviewer stated that the approach included a good combination of filtration experiments and evaluations as well as modeling.

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

Reviewer 1:

The reviewer expressed that after grumbling about the character of the model materials, this project has been marvelously successful in extracting the maximum information with the least resources.

Reviewer 2:

The reviewer reported that the project identified PM composition and property differences associated with load and operating conditions as well as fuel type. This was important for OEMs to know and understand for incorporating filter technology into exhaust aftertreatment systems. The reviewer noted that some of the data and information had been performed already.

Reviewer 3:

The reviewer indicated that this project had generated a lot of exhaust particulate data and the analysis resulted in a very large dataset including many characteristics of advanced gasoline particulate populations.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported that there was very good collaboration and effort between the university, National Laboratories, and OEM. There was very good interaction and feedback during project.

Reviewer 2:

The reviewer noted that there was good collaboration with GM and UW-Madison.

Reviewer 3:

The reviewer stated that there is no supplier involvement preventing the rating of outstanding. The UW work was great. The integration was great between the UW and PNNL. The reviewer expressed confidence that the membrane coated filters were a good representation of what might ultimately be obtained from the filter suppliers.

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

Reviewer 1:

The reviewer noted that there were good future plans with the available resources.

Reviewer 2:

The reviewer noted that the proposed future experiments and modeling would focus on the characterization of particulates from subsequent generations of lean, high-fuel efficiency engines.

Reviewer 3:

The reviewer indicated that the proposed future activities appeared reasonable. However, efforts should be made to include new filter materials such as membrane coated filters for PM studies and the effects of fuel sulfur and HC composition of E10 and E85 fuel blends.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the GDI particulate filtration was the high impact approach to make lean or dilute gasoline possible from an aftertreatment perspective.

Reviewer 2:

The reviewer indicated that the research in this presentation was important to perform and understand in order to characterize regulated PM, which is associated with more efficient direct injection engines and the fuels that will be used.

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

Reviewer 1:

The reviewer felt that this work is well directed to addressing the issue of adequate filtration for GDI systems. The reviewer stated that it is believed that more could and should be done on this project. The PI has been exceptionally effective in leveraging limited funding for good technical gain.

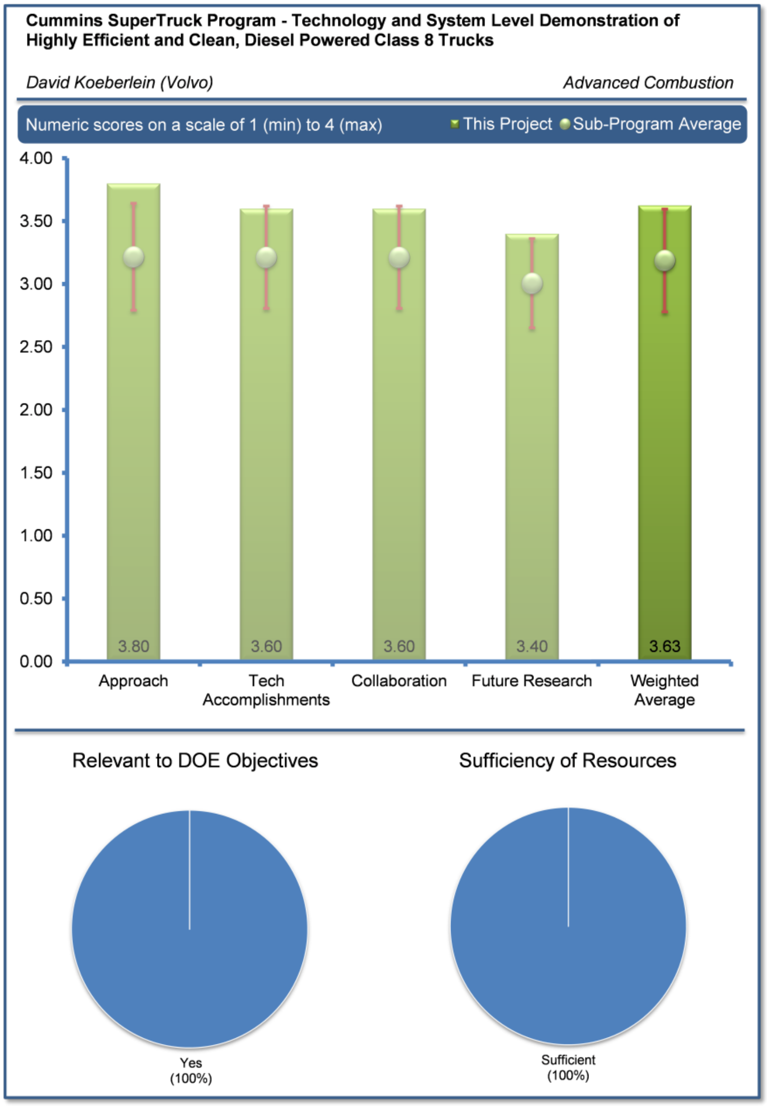
Reviewer 2:

The reviewer noted that funds appeared to be adequate to accomplish project goals.

Reviewer 3:

The reviewer reported that good progress had been made for a relatively low level of funding.

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



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed an exemplary approach with solid analytical and experimental work, and noted involvement of all the key suppliers and research base. The reviewer added that Cummins approach here, as well as elsewhere, does a great job of leveraging various research and supplier capabilities.

Reviewer 2:

The reviewer noted that the project approach is excellent as it focuses on priority technology advances, which will provide the largest improvements and are practical (at least technically) to implement at an engine and vehicle level. Additionally, while modeling and analysis have played key roles, the focus has been to quickly integrate the technologies on an engine and a vehicle to demonstrate real results and identify real system benefits and costs. The reviewer stated that generally, the technologies were also building block technologies that appeared to be aligned with a truck product plan so that the technologies can be implemented individually or as a whole when the value proposition for production is high enough.

Reviewer 3:

The reviewer indicated that there was an extremely excellent approach; focused on the appropriate components, from a fundamental thermodynamic approach, without having to rely on hybridization (which adds cost and weight).

Reviewer 4:

The reviewer stated that this was now the classic piece by piece approach. However, Cummins had done it well reaching 51% BTE at this point which was the best result of the SuperTruck competitors.

Reviewer 5:

The reviewer indicated that the achievement of 50% BTE goal was the most impressive technical improvement, which can be attributed to the integrated engine system approach, heavily relying on WHR with fine tuning on other technologies. The approach to 55% goal seemed to rely on homogeneous charge compression ignition (HCCI) and dual fuel, where these two technologies have not been experimentally proved to be BTE improvement friendly technologies. The reviewer warned that while dual fuel showed some promising feature, high pumping loss and stability control for transient operation was too tough to overcome. Both technologies suffered high HC emissions. The contractor should demonstrate the technical feasibility with preliminarily convincing data at the current level.

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

Reviewer 1:
The reviewer noted that the engine friction losses seemed to be the lowest of the SuperTruck competitors. The project team seemed to have gotten the Rankine cycle WHR running with a fluid other than ethanol and was projecting a 2.8% improvement with a low global warming potential (GWP) fluid. If commercially successful, this could be a significant breakthrough.

Reviewer 2:
The reviewer commented that it is amazing to see the targets exceeded. This is great work.

Reviewer 3:
The reviewer reported that the project has met a challenging 50% BTE with an island of high efficiency engine points, not only one single breakpoint. Emissions have been appropriately considered and addressed with data. The reviewer commented that the 50% freight efficiency target has also been met with the engine technology and that many of the vehicle technologies were now on a demonstration truck. The demonstration truck has been compared to a conventional truck with data and showed a real world fuel economy of 55%. BTE analytical work had also been completed with an excellent look at advanced combustion technologies such as HCCI, PCCI, RCCI and alternative fuels. The real world data measured approximately 9.2 to 10.1 MPG.

Reviewer 4:
The reviewer reported that the project had accomplished objectives on time to date.

Reviewer 5:
The reviewer noted that the contractor not only achieved the technical goal for 50% BTE on the engine side, but also achieved the vehicle goal, thanks to the project team's comprehensive and beyond-state-of-art technologies.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer felt that this appeared to be primarily a Cummins in-house project. The reviewer had no objection to that. The reviewer noted that the project utilized both Purdue University and ORNL but it was a bit difficult to see how involved ORNL and Purdue are in the project.

Reviewer 2:
The reviewer commented that Cummins seemed to do a wonderful job of developing solid relationships with key people and really leveraging abilities effectively. This is a consistent pattern for Cummins and is a good example to others on how to develop high technology.

Reviewer 3:
The reviewer indicated that the collaborators and key technological accomplishments or functions were identified. ORNL advanced sensing methods for combustion studies and Purdue University worked on variable valve actuation (VVA).

Reviewer 4:
The reviewer observed a large project team, incorporating laboratories, the industry, and universities.

Reviewer 5:
The reviewer commented that Slide 20 only showed two key partners for technical progress (i.e., ORNL and Purdue University), while Slide 7 showed a large number of partners. The information was kind of misleading in terms of collaboration and coordination.

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

Reviewer 1:

The reviewer stated that project team is on track for the evolutionary improvements that should give the project team a chance to reach the 55% goal.

Reviewer 2:

The reviewer expressed looking forward to seeing the results.

Reviewer 3:

The reviewer reported that the proposed future research follows the plan and is investigating auxiliary power unit (APU) options for improving 24-hour cycle with non-solid oxide fuel cell (SOFC) technology.

Reviewer 4:

The reviewer stated that the program was on schedule and meeting Recovery Act goals. This was clearly on track with the future work proposed to achieve objectives.

Reviewer 5:

The reviewer noted that the future plan was solid, which could further refine the impressive achievements. This reviewer cautioned that relying too much on dual fuel was risky for a 55% goal, partially due to high HC and CO emissions for cold start.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer explained that on the road (OTR) diesels probably consumed over 60% of U.S. oil imports. These improvements, if rolled out commercially, would significantly reduce dependence on foreign oil.

Reviewer 2:

The reviewer asserted that this was a direct response to efficiency needs.

Reviewer 3:

The reviewer stated that the suite of technologies could improve fuel efficiency and fuel economy by about one MPG so far. The reviewer's concern was that due to value proposition, the cost versus benefit of technologies, that many may not make it to production in five years. The Rankine cycle is one where there is still a clear constraint. Goals were to show what is possible, but with an eye toward production must improve costs to increase probability of near term production.

Reviewer 4:

The reviewer reported that the project clearly met SuperTruck goals.

Reviewer 5:

The reviewer noted that development of realistic technologies, many of which could be production-intent, leads to a reduction of petroleum consumption in the truck market. The results showing the achievement of the program goals demonstrated this purpose.

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

Reviewer 1:

The reviewer indicated that the project was moving on track and had sufficient resources.

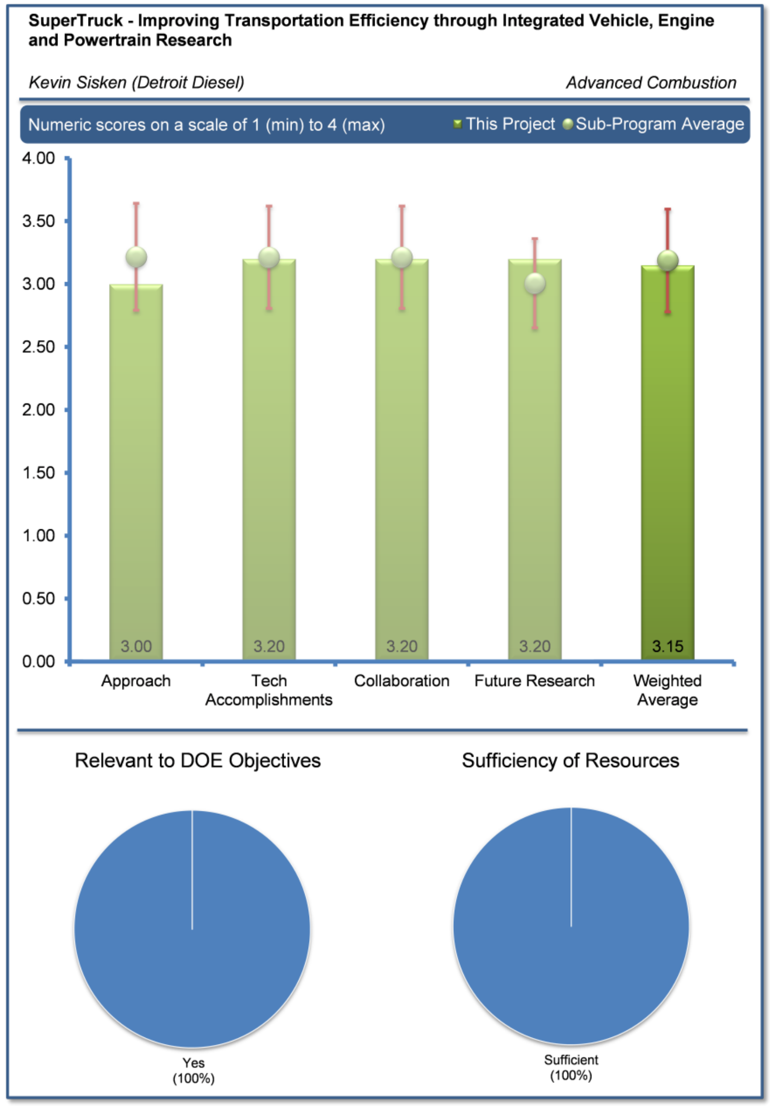
Reviewer 2:

The reviewer said that it seemed like resources were at the right level.

Reviewer 3:

The reviewer stated that the program was on schedule. With seven million funding remaining from DOE, resources should be adequate to reach all program milestones.

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



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that this project had a solid approach with analysis to define needs, followed by design toward objectives and testing for confirmation and validation.

Reviewer 2:

The reviewer observed that the engine control in Slides 10-11 was kind of innovative, and really wanted to see if this technology could be implemented into vehicle demonstration.

Reviewer 3:

The reviewer said that this project was moving along steadily. Detroit Diesel had a vision of where this project should go and were solving the problems steadily. The project team exuded a sense of confidence in its direction and ultimate success. The reviewer reported that this project initiated major changes in the engine design and approach. Downsizing the displacement and increasing the RPM seemed to be the correct approach for higher fuel efficiency. The reviewer indicated that the WHR was crucial and that the technology appeared to be having success. However, practical implementation of that technology was quite far in the future.

Reviewer 4:

The reviewer stated that the goals were standard for SuperTruck: 50% BTE for engine; and 50% freight efficiency improvement. Overall, the technology list was appropriate (i.e., WHR, turbo-compounding, and downsizing) and added hybrid. The reviewer voiced some concerns with the communication of the approach for downselection and the integration of technologies. The systematic selection, and possibly some de-selection of technologies had not been presented in a crystal clear way. The reviewer indicated that the data based prioritization of key fuel economy improvement technologies was only brought out in a limited way in the Q&A, and would improve the score. The expectation is also that there may be some possibility to leverage hybrid technology for the powertrain (downsizing) or to discuss the reasons it was not practical and why hybrid functions were de-selected for the powertrain.

Reviewer 5:

The reviewer stated that this was a brand new, from the ground-up approach and was not based on existing technologies. The reviewer asked if there was nothing in the Daimler arsenal to leverage for this. This reviewer was given the impression that either Daimler did not have the confidence in anything it already had or was not comfortable about leveraging what it had. The reviewer further noted that the use of hybridization and WHR relied on immature thermoelectric technology.

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

Reviewer 1:

The reviewer stated that Detroit Diesel seemed to be solving problems steadily. However, it appeared as if the efficiency of the engine technology was lagging the original expectations.

Reviewer 2:

The reviewer indicated that there was good progress with a nice movement approaching the targets.

Reviewer 3:

The reviewer noted that some of the data presented on engine activity are 1.9% away from the 50% BTE goal. Some data plots could be presented in more standard ways to improve communication. For example, BSFC plot versus RPM and load, BSNOx versus speed and load, brake-specific particulate matter (BSPM) versus speed and load are important standard plots. The reviewer indicated a further tie of the improved engine torques back to standard test and functional operating conditions would improve scores. Higher BSNOx number by 3-5x is large. Changing non-quantitative statements like more demand on SCR to SCR size is projected to increase by X%, DPF consumption by Y% and overall cost by Z% for the aftertreatment are examples. The reviewer criticized that language like DOC and DPF met expectations should be clarified. The reviewer asked if the system met 2010 emissions or another expectation. The pressure drop data is good to clarify design requirements. The reviewer felt that the use of neural network controllers over physics based control systems is a concern. For limited operation, the data can be good and fast, however, for many vehicles and operating conditions, it is not reliable or defensible. The reviewer offered that small system changes generally require full recalibration runs. Good progress on WHR system with collaboration at ORNL and with MIT for friction reduction.

Reviewer 4:

The reviewer stated that the generational improvement on the aftertreatment represented significant improvement in aftertreatment conversion efficiency. The reviewer expressed concern about what had been accomplished with controller training and the recalibration issues mentioned; and if the project team would be able to move on to the next step.

Reviewer 5:

The reviewer indicated that the 48.1% thermal efficiency was good. The 49.1% achievement in the verbal presentation was even more impressive.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the integration of the suppliers with Detroit Diesel seemed to be very successful.

Reviewer 2:

The reviewer indicated a good set of collaborators and suppliers. It seemed that some of the suppliers were not directly involved as participants as thoroughly as might be possible.

Reviewer 3:

The reviewer noted many collaborations listed in the presentation with some good examples about actual contributions such as ORNL and MIT.

Reviewer 4:

The reviewer said that it sounded like there may be issues with some of the hardware suppliers.

Reviewer 5:
The reviewer noted that it seems that the contractor only mentioned ORNL on WHR and MIT on friction reduction for the engine related development, and no other partners were mentioned in terms of result presentation. It appears that some of other partners were also involved, such as Johnson Matthey and Corning in aftertreatment. The reviewer felt it would be helpful if individual partners could be acknowledged in those slides that utilized their works and technologies.

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

Reviewer 1:
The reviewer noted that the project team was moving step-by-step to reach the goal. The reviewer was not quite sure if the project would be successful; if not, the project would be very close.

Reviewer 2:
The reviewer noted that a solid plan seemed set to reach the objectives in an implementable way.

Reviewer 3:
The reviewer said that the project was continuing on the specified path.

Reviewer 4:
The reviewer stated that controller training and recalibration issues mentioned were concerning as to what had been accomplished and if the project team would be able to move on to the next step according to plan.

Reviewer 5:
The reviewer stated that there was still a 0.9 efficiency to go in order to reach the 50% goal and felt that it was achievable with the current plan.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer noted that major reductions in oil imports can occur with improvements in the fuel economy of the over the road diesels. This project will go a long ways to achieving those improvements.

Reviewer 2:
The reviewer stated that there is direct relevance to vehicle efficiency.

Reviewer 3:
The reviewer felt goals for SuperTruck were clearly identified for petroleum reduction. Class 8 Truck improvements to 50%, 55% engine BTE. A 50% improvement in freight efficiency while meeting 2010 emissions will provide pathways for reduced fuel consumption for an application that consumes 17-20% of the national fuel in MD/HD applications.

Reviewer 4:
The reviewer reported that the most valuable part of this program is to use many production-intent or refinement of the current production technologies to achieve the program goals. This road map will have an immediate impact on the current truck market in just a few years to go, thus achieving the reduction of petroleum consumption immediately.

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

Reviewer 1:
The reviewer said that resources seemed to be appropriate for accomplishing the goals.

Reviewer 2:

The reviewer stated resources seemed like an appropriate level to reach the goals.

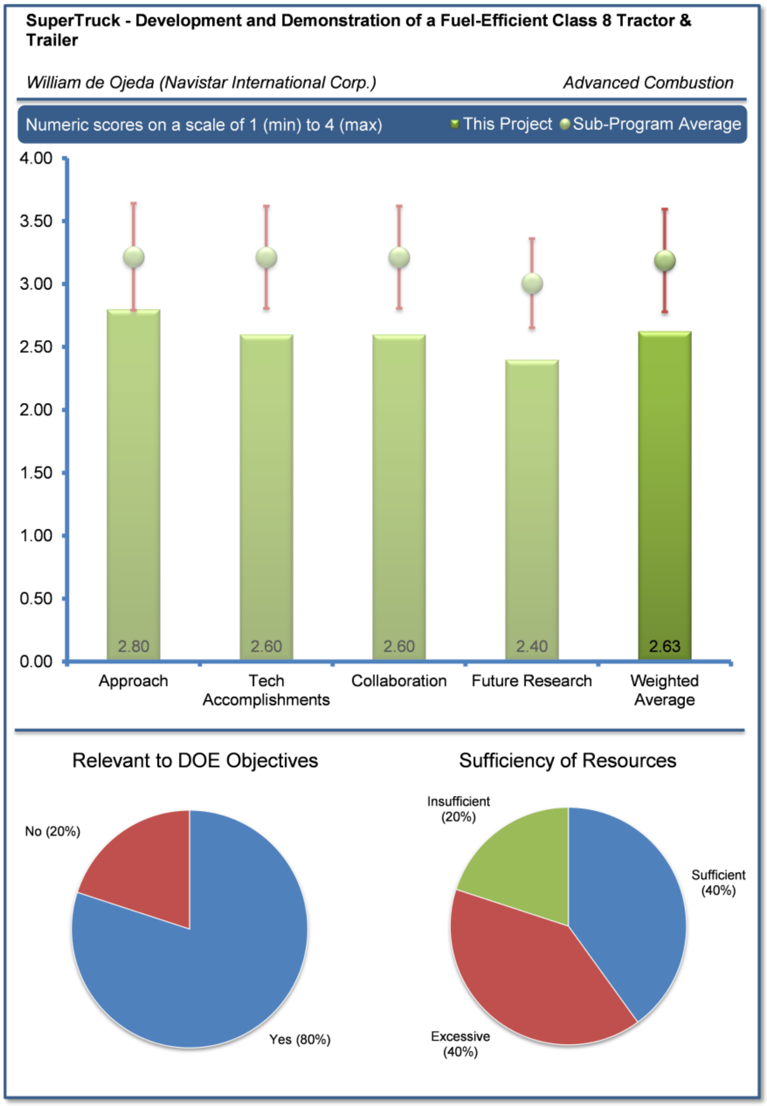
Reviewer 3:

The reviewer indicated that the resources were large, as was the task and the possible benefits.

Reviewer 4:

The reviewer pointed out that the contractor showed 60% completion in Slide 2, but it was not clear whether it was against technical achievement or budgeting.

SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer: William De Ojeda (Navistar International Corp.) - ace059



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer reported that there were standard SuperTruck targets for the engine, a 50% BTE, a 55% technology roadmap. The approach showed a clear plan, prioritization, and the roadmap with expected contribution of technologies and the progress to goals. The reviewer indicated that the gold star was to estimate payback or to show some indication of current value proposition to customers. This indicated a clear plan to consider the implementation of the technologies considered at some date based on value proposition.

Reviewer 2:

The reviewer offered that switching the SCR system from a non-workable high EGR solution was a significant step toward achieving the program goal in this year development. However, the project needed more description of how the SCR was integrated into system in such a late game, specifically, introduction of SCR into the program will require new system tuning when it works with WHR, VVA and other advanced systems. The reviewer criticized that the use of dual fuel approach for 55% thermal efficiency goal was questionable, due to its high pumping loss and high HC emissions. At this time, all potential improvements of this RCCI or dual fuel concept are demonstrated in an SCE or simulation. The reviewer pointed out that this high efficiency combustion concept had not been demonstrated in a multiple cylinder platform, not even close to the targeted 50% goal. No WHR with Rankine cycle would be a big issue of whether the program can meet the goal.

Reviewer 3:

The reviewer mentioned that this program had a pause. That did not seem like an appropriate approach.

Reviewer 4:

The reviewer felt that the original approach was very weak on aftertreatment. Now, aftertreatment seemed to be properly considered as part of the project. Navistar would do well to aim for higher aftertreatment efficiency and gain more fuel efficiency in the engine. Otherwise, the reviewer felt that there was solid work on the engine systems.

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

Reviewer 1:

The reviewer stated significant progress was made so far. The temporary break from program work, while understandable in the general business climate of the company, was troublesome.

Reviewer 2:

The reviewer recognized that there was good progress from the National Laboratory collaborator, while the OEM was in pause mode due to a production launch. The reviewer felt that the project did not really seem to be on track for efficiency numbers with still almost 2% away, with limited work planned by the OEM.

Reviewer 3:

The reviewer stated that achieving the 48.2% efficiency was the key milestone achieved. However, it was not clear if the engine would meet 2010 emissions at the tailpipe out NOx emissions of 0.2 g/hp-hr, since the engine may not be completely optimized with new introduction of SCR. The reviewer commented that the pause due to corporation decision was not acceptable considering a huge DOE investment.

Reviewer 4:

The reviewer indicated that the program was on hold for a large part of the year due to current product engineering effort needed near term. The project team proactively put to use engines for dual fuel work at ANL with Wisconsin Research Consultants. The reviewer said that dual fuel BTE and especially NOx/PM reduction with dyno engines was exciting indeed. This reviewer also noted BTE improvement with emission technology reduction. The base program had progressed well and was 1.8% away from 50% BTE goal. The reviewer added that the score would be higher without a pause.

Reviewer 5:

The reviewer noted nothing much. ANL has been doing some modeling for them.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted good coordination with partners such as ANL to continue activity with the main program on pause, and to leverage hardware for next generation possibilities.

Reviewer 2:

The reviewer observed that there was solid interaction with the ANL group. Other collaborations were less clear and perhaps less integrated than with some other programs.

Reviewer 3:

The reviewer observed that much of the project was turned over to ANL.

Reviewer 4:

The reviewer stated that the only meaningful contribution from the partners is ANL for 55% thermal efficiency related to work due to the company pause decision.

Reviewer 5:

The reviewer asserted that Wisconsin Engine Research Consultants (WERC) was not a university partner, but rather a consulting firm operated by the UW faculty. The reviewer believed that the call was looking for an integrated university-lab-OEM team and this project did not meet that. Also, it seemed like ANL had to take the lead in this work.

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

Reviewer 1:
The reviewer observed an excellent plan to maintain the path for diesel only technology for the 50% BTE goal while considering advanced combustion regimes using gasoline/ethanol and diesel with improved BTE than current diesels and significantly lower engine out emissions.

Reviewer 2:
The reviewer stated that with a clear history of management putting this project off, it was hard to be upbeat about the proposed future research.

Reviewer 3:
The reviewer noted that there was a good technical plan, but the program delay was troublesome.

Reviewer 4:
The reviewer stated that the OEM planned a break through 2013 into 2014 depending on partner contributions.

Reviewer 5:
The reviewer said that the future plan toward 50% goal was to rely on turbocompound, which was much less efficient compared to Rankine cycle at the DOE-designed operating point.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that the full system modeling was not the same as making hardware.

Reviewer 2:
The reviewer indicated a direct contribution to vehicle efficiency.

Reviewer 3:
The reviewer stated that SuperTruck goals to develop technology with 50%, 55% BTE Engine targets and 50% improvement in freight efficiency with 2010 emissions for Class 8 trucks clearly could contribute to significant petroleum reduction.

Reviewer 4:
The reviewer reported that many key technology developments under this program could be viewed as production intent. A demonstration of 48.2 % efficiency was already a major step to reduce petroleum consumption in the truck market.

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

Reviewer 1:
The reviewer indicated that the delay of the program for one year will have an impact on the final program funding level while achieving the program goal.

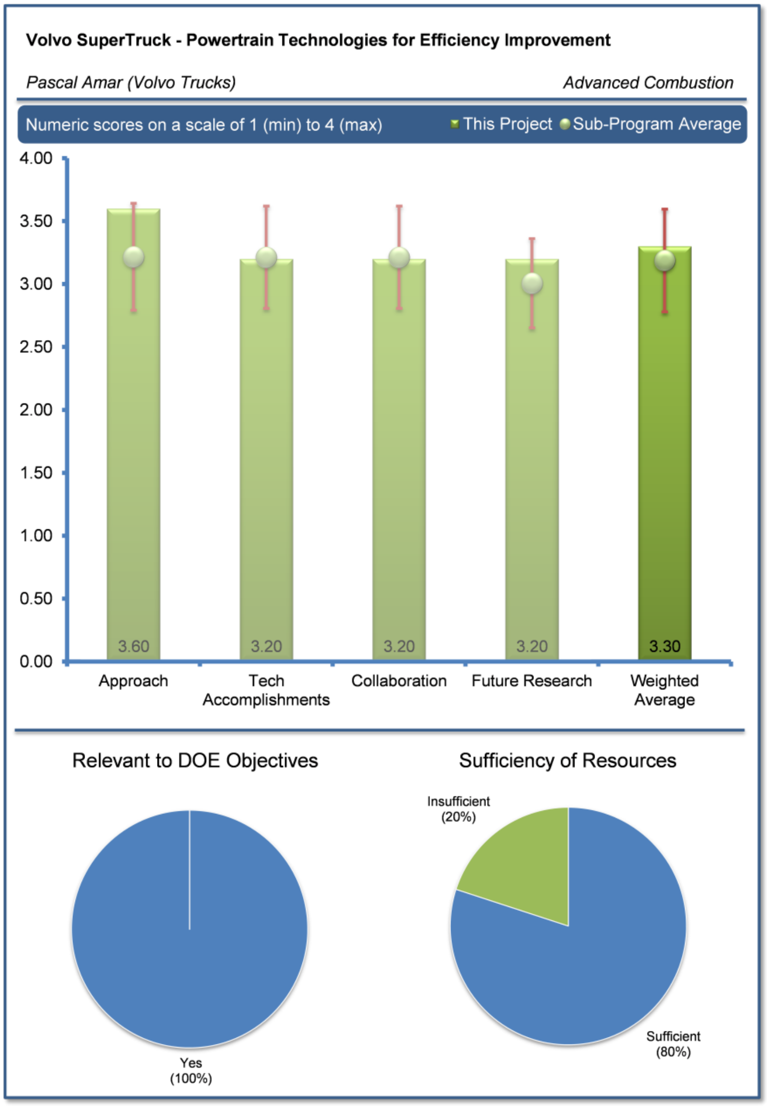
Reviewer 2:
The reviewer reported that the DOE resources were sufficient but the company was not able to do its part in the short term. The program scale as appropriate even though it was delayed.

Reviewer 3:
The reviewer said that there are large resources and that there are high expectations.

Reviewer 4:

The reviewer stated that this project should be terminated and prior funds into the project should be recaptured.

Volvo SuperTruck - Powertrain Technologies for Efficiency Improvement: Pascal Amar (Volvo Trucks) - ace060



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer reported that there was a clever approach on half the budget of the other projects.

Reviewer 2:

The reviewer indicated that there was a good approach with a comprehensive technology list.

Reviewer 3:

The reviewer noted that project team should be able to learn from the Detroit Diesel Corporation (DDC) and Cummins work. They are doing a mixed mode PCCI; however, the project team was using 20% DME and 30% propane. The reviewer was not very excited about that. The DME is a major enabler for PCCI and it is unlikely to be in any future diesel blend at those concentrations.

Reviewer 4:

The reviewer commented on the solid combination of analytical and experimental work on a reasonable set of technologies.

Reviewer 5:

The reviewer stated that SuperTruck project goals have clearly been embraced and the building block technologies (Rankine Cycle, Turbo Compounding, Cooled EGR) integrated into the product development plan for possible production implementation. The Rankine cycle was discussed with a clear communication of possible production use of the SuperTruck level technology. The reviewer indicated that other technologies such as robotized automatic, consideration for advanced RCCI combustion and next generation fuels such as DME were exemplary. Prioritization of key technologies and contribution were identified. There was a clear planning timeline for implementation with plans for engine and vehicle integration tests starting early.

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

Reviewer 1:

The reviewer stated that the project team seemed to be doing well with the Rankine WHR. The project team is using ethanol as the fluid and made it clear during the question and answer session that the system could be safely commercialized. From the presentation, the reviewer assumed that the 48% BTE was using this unrealistic fuel.

Reviewer 2:
The reviewer stated that the amazing engine efficiency seemed to be approaching program goals rapidly and ahead of schedule.

Reviewer 3:
The reviewer observed that the team started much later than the other teams and had demonstrated very good results with the data even without that consideration. The project delivered a powertrain to a truck chassis with 48% BTE with many new technologies implemented. The reviewer commented that the team has designed WHR system with an eye toward production. The reviewer recognized that vehicle level data was shown for Rankine Cycle on a vehicle with a transient cycle. All efficiency improvements claimed were integrated into the full system and demonstrated as a powertrain system.

Reviewer 4:
The reviewer felt that the project was exceeding BTE goals ahead of schedule.

Reviewer 5:
The reviewer stated that the 48% achievement with a comprehensive technology list was impressive, giving such a shorter time compared to its competitors.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that the integration of partners and collaborators seemed to be quite good. Slide 16 was an excellent summary.

Reviewer 2:
The reviewer indicated a very good cross-section of partners from the industry and universities. The reviewer thought that the integration of a fuel supplier Exxon Mobile was an exemplary idea, as the expectation for the next generation systems with PCCI, RCCI will require fuel supply industry involvement for success.

Reviewer 3:
The reviewer reported a reasonable set of collaborators. Volvo seemed to do more of the work in-house than some others; not a bad thing. The collaboration Volvo is doing seems effective and appropriate.

Reviewer 4:
The reviewer stated that it was not clear how the various partners contributed to the program with the way it was presented by the contractor; even with one slide to show the list of participants.

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

Reviewer 1:
The reviewer commented that there was a solid approach toward the program goals with a high confidence of success.

Reviewer 2:
The reviewer indicated that there was an excellent plan for future work. The integration and production use of technologies was clearly the focus. Plans to implement PCCI DME/propane were exemplary. Significant benefits from these systems have been demonstrated from both BTE and an emissions standpoint. Some more detail on the truck/trailer integration could improve the score.

Reviewer 3:
The reviewer felt that it would be good to provide a more detailed plan of how the future work would be done in achieving the final program goals.

Reviewer 4:

The reviewer would have liked to see more discussion of the aftertreatment component.

Reviewer 5:

The reviewer went back to the fuel issue. The reviewer did not see that the path forward avoided the use of DME. If DME was required, then the reviewer was not comfortable with the path forward.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that even though the Volvo work appeared to be done with unrealistic fuels, the reviewer thought that it had long term relevance.

Reviewer 2:

The reviewer felt that the work had a direct contribution to vehicle efficiency.

Reviewer 3:

The reviewer stated that the SuperTruck objectives to develop technologies for 50% BTE, 55% BTE and 50% improvement of freight efficiency at 2010 emissions were clearly aligned with reduction of petroleum. The project had a strong focus on key technologies to achieve the goals and also showed a very strong predisposition to implement the technologies on production trucks as soon as possible.

Reviewer 4:

The reviewer summarized that the program was to develop some production intent technologies that could reduce the petroleum consumption.

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

Reviewer 1:

The reviewer offered that the project team seemed to be accomplishing solid results with the available funding.

Reviewer 2:

The reviewer stated that it seemed to be an appropriate level of effort.

Reviewer 3:

The reviewer noted that funding was sufficient to meet goals. Volvo was contributing a majority percentage of the budget as cost-share. This demonstrated the level of commitment to productive implementation of the technologies demonstrated on SuperTruck.

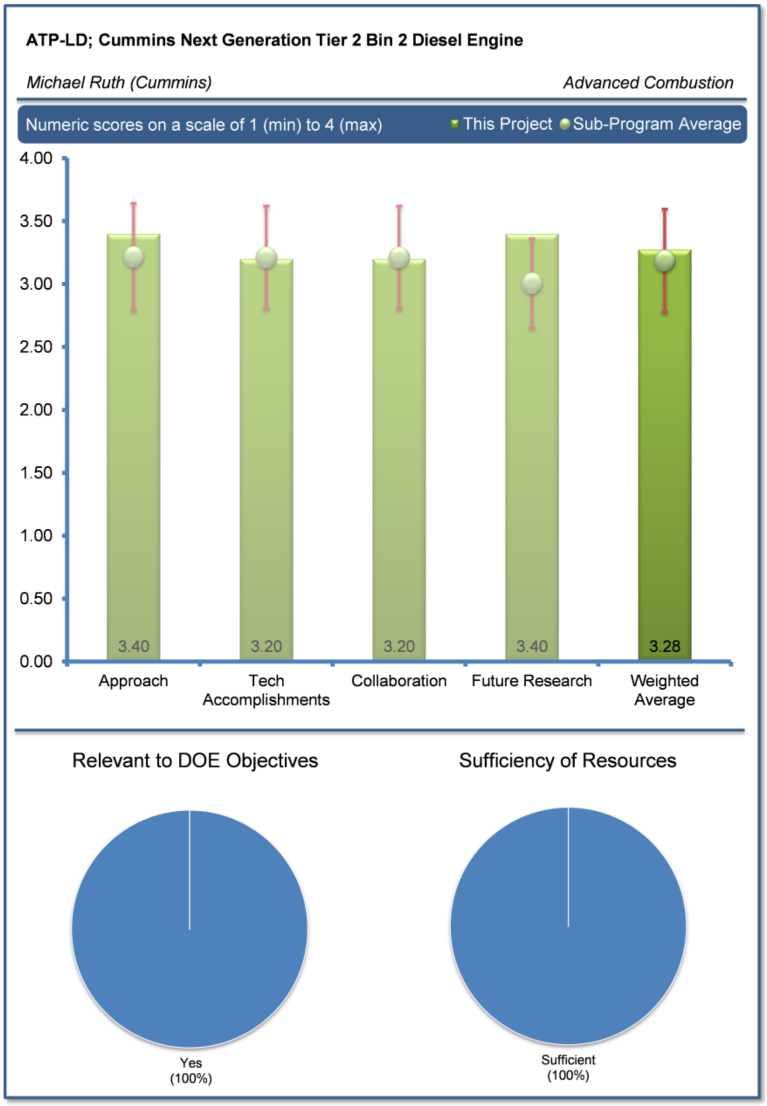
Reviewer 4:

The reviewer observed that this project had about half the budget of the others and had already achieved more than certain others, with a much higher probability of success.

Reviewer 5:

The reviewer indicated that the total funding was much less than their competitors, while achieving the same goals in a much shorter period.

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



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that this work was an interesting project. It represented an effort to simultaneously integrate the next level of advanced technology for combustion systems, control, manufacturing, and aftertreatment into a vehicle all at the same time, while maintaining a viable and affordable product.

Reviewer 2:

The reviewer said that this was a very interesting program to make a comparison of a diesel replacing a gasoline engine in the pickup truck application. The product targets were very aggressive, and had been tackled with solid engineering approaches.

Reviewer 3:

The reviewer commented on the excellent use of aluminum block supported by steel for durability. The reviewer thought that eliminating the need for any studs into Al was excellent. The downsizing approach was good. A 40% FE improvement target with Tier 2 Bin 2 emission was very good.

Reviewer 4:

The reviewer stated that this project was the only LD diesel program with a goal of 28 MPG for a half-ton truck. The project achieved Tier 2 Bin 5 in a vehicle. The new engine uses a lot of Al and represents at least a 30 pound lighter engine when compared to original, allowing for more aftertreatment. The aftertreatment included a cold start catalyst. The reviewer noted good partnership with Johnson Matthey.

Reviewer 5:

The reviewer indicated that the extensive use of aluminum material for a diesel engine was something new, where the weights saved can be used to emissions upgrade. Using Model Predictive Controller (MPC) for an air system control is challenging but great for the future of OBD development. The reviewer felt that it was not clear why gaseous NH_3 is used for the program, since there was no production future with Amminex's solid urea. Maybe this was due to the fact that the aftertreatment system had very short mixing area if the liquid urea was used. The reviewer felt that justification of using solid urea would be helpful in this program. The use of a NOx absorber was an interesting concept, but it would definitely increase the cost, thus less competitive than gasoline engine in terms of the package cost.

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

Reviewer 1:
The reviewer commented that the progress and accomplishment were on or ahead of schedule.

Reviewer 2:
The reviewer stated that the project to date had come up with solid designs that seemed to be accomplishing the aggressive project targets. The innovative solutions to problems like low exhaust temperature during cold starts seemed to be working.

Reviewer 3:
The reviewer reported that the engine was running and showing necessary torque with significant weight reduction and was on track to meet emission standards Tier 2 Bin 2. The cold start concept was showing some promise and if it was sorted out could enable a production engine near term. The weight reduction was large enough to leave an allowance of about 152 pounds for the emission control system.

Reviewer 4:
The review indicated that 60% of goals were accomplished; the project has about 1.5 years left and is on target.

Reviewer 5:
The reviewer stated that the first shot on the mule engine seemed to show the promising features. Hopefully, the new engine to be built should be more competitive. However, whether it can meet a 40% improvement goal remained to be seen, since the progress made so far were mainly on the aftertreatment side as far as this presentation was concerned.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that the attempt to integrate the Rose Hulman Institute of Technology into the project was admirable.

Reviewer 2:
The reviewer noticed that Cummins seemed to do an excellent job of integrating quality suppliers and researchers into their programs.

Reviewer 3:
The reviewer commented on the good use of partners and observed that a difficult gate decision was made on technology readiness from the Rose Hulman Institute of Technology on the NOx sensor. Nissan-confirmed interest in productive application would make collaboration outstanding.

Reviewer 4:
The reviewer highlighted partnerships with ORNL, Johnson Matthey, and universities.

Reviewer 5:
The reviewer stated that working with Johnson Matthey, Nissan, and ORNL is good.

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

Reviewer 1:
The reviewer stated that it appeared that the project team was on track to meet the program goals on schedule.

Reviewer 2:
The reviewer noted that the plans addressed the open issues and seemed likely to be successful.

Reviewer 3:
The reviewer felt that the project was in good shape with a status similar to some carryover engines when aggressive emissions targets were ratcheted down. The engine design appeared nearly complete with the possible exception of EGR loop optimization. The reviewer noted that the project started, but must sort out cold start NOx CSC and SCR/filters.

Reviewer 4:
The reviewer pointed out the following regarding the project: controls work, new castings, and glow plugs.

Reviewer 5:
The reviewer stated that the future plan seemed solid. However, it would be helpful if a production road map was shown. At this time, it was still challenging to put this engine in production due to high potential cost.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that the learning obtained during this project should accelerate the introduction of more advanced fuel consumption and emission reduction technologies throughout entire powertrain into near-term products.

Reviewer 2:
The reviewer noted the large improvement in fuel efficiency of a large class of vehicles (pickup trucks) that use a lot of fuel.

Reviewer 3:
The reviewer indicated that the engine targeted 40% improvement in fuel economy when compared to a traditional gas engine and appeared commercially viable in the near term. Technical roadblocks were very difficult (durability, aftertreatment cost/durability) but were not insurmountable. The calculation is 1.5 billion barrels today if all light trucks and SUVs achieved 40%.

Reviewer 4:
The reviewer felt that the reduction of the fuel consumption was always part of overall DOE objective. A 40% reduction compared to gasoline engine is a big improvement.

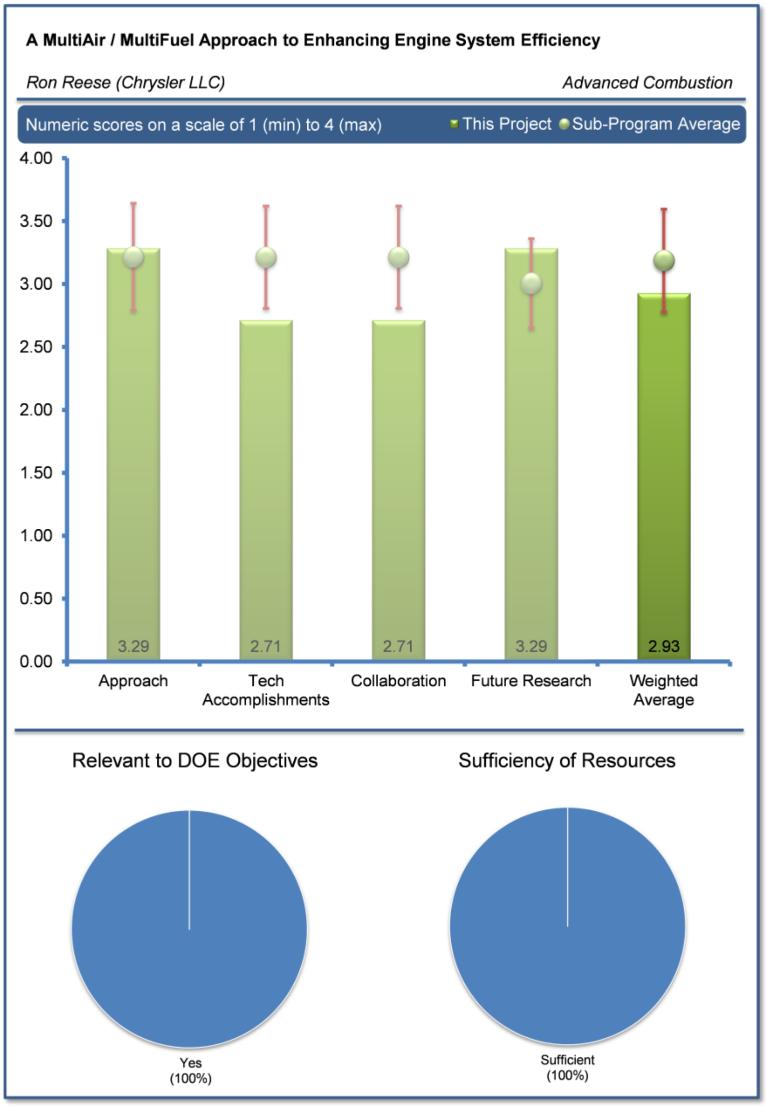
Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that the resources appeared to be sufficient.

Reviewer 2:
The reviewer noted that resources seemed to be appropriate for the levels of work taken on.

Reviewer 3:
The reviewer summarized that the technology methodology had been developed through a mule engine. The 40% remaining funding should be adequate to complete the program goal.

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



Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the dual path approach on combustion systems reduced risk. The reviewer noted that there was an interesting multi-plug approach, though not entirely new. Other vehicle and engine features added were reasonable. The reviewer felt that BSG was a nice addition, but similar systems in mild hybrids were already commercial; could have been in the baseline vehicle. The reviewer added that multi-loop engine and transmission cooling was not really new.

Reviewer 2:

The reviewer stated that the overall approach was very good. The use of high dilution in a stoichiometric package gave very good confidence of low emissions with high efficiency. The focus on two alternate means of ignition was unique.

Reviewer 3:

The reviewer reported that the outline of technologies list and contribution is good, however, both current technologies pathways SI Ethanol/Gas, CI Diesel/Gas are dual fuel making the production implementations much longer term and less likely to see the light of day. The reviewer noted a good list of technologies (high dilution cooled EGR, ignition) but no mention of cost/value analysis path to production reduces score when technologies are available as pathways to nearer term production. The reviewer felt that aftertreatment is not clearly addressed and WHR should be removed as not practical. Excellent work to use nine-speed transmission with low lockup. This could provide significant savings even without engine downsizing.

Reviewer 4:

The reviewer expressed that the chosen approach is somewhat conservative in that it employs stoichiometric operation with high EGR and downsizing. On the other hand, there is some novelty in the base engine design. The reviewer pointed out that the alternate approach using diesel and gas dual fuel appears to have hit an end so it was not entirely clear why so much of the presentation was spent describing the effort.

Reviewer 5:

The reviewer stated that the project looked at two combustion approaches and is downselecting to one (SI) for the vehicle demo. Both approaches (CI and SI) were of merit and aimed at higher efficiency engines. In addition to the engine efficiency gains, other engine components and vehicle drivetrain efficiency gains were also critical in the overall vehicle design choices.

Reviewer 6:

The reviewer commented that the project did really nice work, but was still concerned that the dual fuel approach would not be an adoptable path forward.

Reviewer 7:

The reviewer remarked that the project had a kitchen sink approach with downselect at appropriate times. The project had a mix of risky and not-so-risky technology. The reviewer felt that the Stoich with TWC was safe and smart but was not pushing the envelope.

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

Reviewer 1:

The reviewer noted that there was good progress on SI engine development and vehicle development. Not much engine data on Diesel-Assisted Spark Ignition (DASI) or Diesel-Micro-Pilot Ignition (DMP), but perhaps downselection was being made. Not much discussion of aftertreatment. The reviewer added that TWC is low risk, but there was not much proof at this point that Tier 2 Bin 2 would be achieved.

Reviewer 2:

The reviewer stated that the results presented solid progress in fuel efficiency with a good understanding of the issues and solutions available to them.

Reviewer 3:

The reviewer indicated that there were good results for BSFC versus power. The drawback is no emission numbers or targets were reported. The reviewer added that there was no identification of how emissions would be handled except to say stoichiometric. The reviewer said that many pathways were still active which indicated that more work needed to be done. The data presented from boost/EGR and air system and crankshaft balancing was good but limited data from some other critical path items were needed demonstrating value. For example, the ion sense feedback control system capability was indicated as a key technology, but limited supporting data for actual control was presented. The reviewer commented that the WHR also was a key technology identified, but was not discussed in the main presentation data or during Q&A that it was removed from consideration.

Reviewer 4:

The reviewer noted that significant benefits seem to be had from downsizing and the use of the nine speed transmission. Neither of these strategies would seem to have been enabled by DOE funding, rather these are normal product development exercises. The reviewer stated that it seems awkward to take full credit for these approaches in the 25% fuel reduction target.

Reviewer 5:

The reviewer stated that a lot of progress has been achieved, and there is still much to be done toward a vehicle demonstration. Overall, it was obvious that progress had been made on a number of fronts (that add up together to achieve greater system efficiency).

Reviewer 6:

The reviewer indicated that progress has been good, despite a break in continuity.

Reviewer 7:

The reviewer reported that there was good progress on the downselected approach, but the DMP progress was disappointing.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer expressed not being clear how or whether the research tools at ANL were being systematically applied to advance the DMP or SI approach or if it was just applied to individual experiments with interesting capabilities.

Reviewer 2:
The reviewer noted good use of ANL capabilities, and a couple vendors for components.

Reviewer 3:
The reviewer noted that there was good collaboration including leveraging ANL.

Reviewer 4:
The reviewer indicated that the collaborations with ANL and Ohio State did not seem to be very integral to the main effort at Chrysler. Rather, the collaborations appeared to be separate and parallel efforts that did not really add to the Chrysler main product selection.

Reviewer 5:
The reviewer stated that there are a number of collaborations on the project. The ANL spray diagnostics work appears to be beneficial to the project. The dual fuel CI work at ANL was decided to not go forward in the project vehicle demo, but it was not clear all of the reasons for that choice or what exactly was determined from those studies. The reviewer reported that Bosch and Delphi are contributing to the various hardware in the project; the Ohio State part of the project is providing benefits for some of the sub-system energy benefits, which seems like a good modular scope for the university partner.

Reviewer 6:
The reviewer noted nice variety of collaborators and with some roles seeming well-coordinated.

Reviewer 7:
The reviewer indicated that collaboration between institutions appears to be adequate. The reviewer suggested that perhaps the category should be asking for performance of collaborators, not how well collaborators coordinated with one another.

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

Reviewer 1:
The reviewer said that the project was on path to build demonstration vehicles.

Reviewer 2:
The reviewer noted that it would be very interesting to see how this work translated into the vehicle. The downselect of technologies seemed to need to be made soon.

Reviewer 3:
The reviewer stated that the plan to finish out work in dyno and on vehicle was a good typical plan.

Reviewer 4:
The reviewer noted that the path forward looks solid. The combustion approach has been narrowed which should enable good progress on the vehicle demo.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer reported that there were some innovations here that could contribute to reduced fuel consumption.

Reviewer 2:
The reviewer observed a large gain in vehicle fuel efficiency.

Reviewer 3:

The reviewer stated that the 25% fuel economy technology improvement target was a good one. Some technologies could produce results in the near term such as nine speed transmission.

Reviewer 4:

The reviewer said that this project could enable petroleum displacement particularly for larger size passenger vehicles. It is important to note that the project aimed to improve large vehicle fuel efficiency as even small gains there can lead to significant petroleum savings.

Reviewer 5:

The reviewer noted a good blend of near-term technology. It was disappointing to the reviewer, that for a $30 million program that DMP could not be implemented on a demonstration vehicle.

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

Reviewer 1:

The reviewer stated that resources seemed to be about right for this large effort.

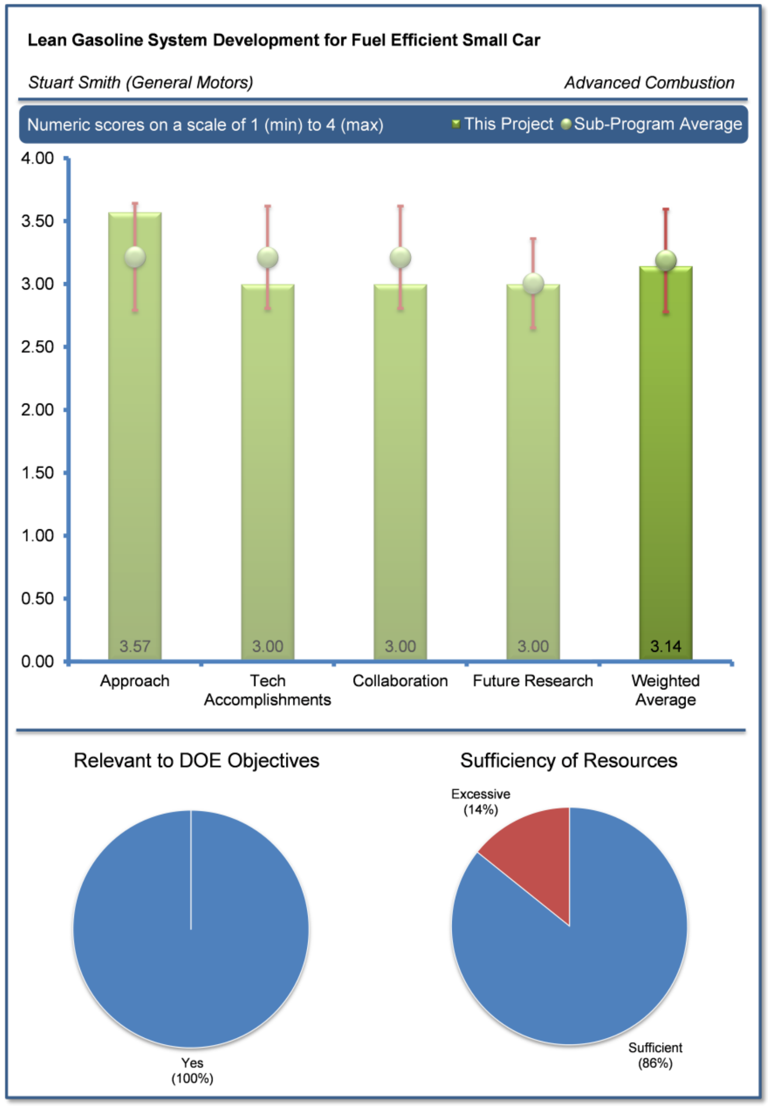
Reviewer 2:

The reviewer said ARRA funds.

Reviewer 3:

The reviewer stated that the budget was the largest seen, but appeared appropriate for the scope of the study.

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



Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the technical plan was very sound and was expected to reach the project goals of 25% improvement. The lean-burn system represented a major development and appeared to prove an alternate path forward for combustion systems. The reviewer indicated that another contributor to the fuel economy goal was a start-stop system. Similar systems were already available on U.S. specification vehicles. It would be better if the goals were more aggressive or the baseline was at a higher level.

Reviewer 2:

The reviewer reported that a logical pathway was identified and subsequently followed to achieve the stated goals. The combination of lean-burn, passive/active ammonia SCR, along with the needed controls appeared a viable pathway to achieve the goal of 25% fuel efficiency improvement.

Reviewer 3:

The initial approach did not meet the FE target although it met simulations; the need for lean downsized boosted (LDB) should have been recognized sooner.

Reviewer 4:

The reviewer stated that the approach to further develop lean, boosted, downsized engine and work for mature lean aftertreatment was a reasonable strategy toward a 25% FE improvement goal. Lean stratified technologies have been worked through thoroughly in the past 20 years with the limitation being aftertreatment. SCR may be acceptable to customers, and passive SCR was an excellent goal. The reviewer felt that there was a good approach to characterize the test speed and load points and to estimate real test improvement with real data. The reviewer identified that the 12 volt start/stop had concerns with customer acceptance due to NVH issues.

Reviewer 5:

The reviewer noted that the lean burn gasoline approach was relevant and appropriate for this program. It has general applicability, a good amount of risk (especially with the emission control) and good potential.

Reviewer 6:

The reviewer stated that this project uses an approach heavily focused on lean gasoline engine and emission control (+ controls) technologies. Such technologies are very appropriate for this government-industry collaboration as the technology is challenging but with research and development, and further development worth considering for commercial applications. The reviewer reported that the progress in the move from naturally aspirated lean combustion to boosted and downsized lean combustion is significant. Greater fuel economy gains at low and moderate loads (versus stoich) were shown. The lean emission control system is novel and cost-effective (relatively speaking). The reviewer identified that urea is being utilized to make up for NH_3 needed that is not produced with the passive (over TWC) approach. It was clear that the passive NH_3 production is lowering overall urea tank/refill frequency requirements. Overall, the reviewer felt that there is a very promising approach with excellent progress shown and the reviewer is looking forward to the vehicle results.

Reviewer 7:

The reviewer said that there was a good approach and noted good application of 2.2-liter naturally-aspirated engine experience to a 1.4 liter GTDI engine.

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

Reviewer 1:

The reviewer stated that the lean-burn aftertreatment system and combustion system developments were highly significant. The overall progress toward vehicle demonstration was excellent.

Reviewer 2:

The reviewer reported that earlier in the program, a naturally aspirated engine was converted to lean burn to determine potential benefits. As it yielded only 13% improvement, an LDB engine was developed. The LDB engine in turn achieved the 25% FE improvement while meeting the Tier 2 Bin 2 emissions target. This team is on the pathway to demonstrate the LDB engine in a vehicle after integration with vehicle controls.

Reviewer 3:

The reviewer noted that good BSFC results were achieved in a short development time on the LDB engine.

Reviewer 4:

The reviewer stated that the initial first generation engine achieved only a 10% fuel economy with lean combustion. This was not a large base engine technological feat. Leaning out traditional stoichiometric engines can yield close to 10% improvement. The reviewer described that the SCR passive ammonia generation did not produce significant ammonia to eliminate urea tank and the passive amount was not quantified. The first generation gasoline SI engine requires 1.4 times the urea as a comparable diesel. The second generation LDB engine: downsized, with cooled EGR, close coupled TWC integrated into the turbine housing was projected to have nearly a 21% fuel economy improvement which was better than traditional lean stratified but it also was projected to consume even more urea than the first generation engine and significantly more than diesel technology (approaching 2x). The reviewer noted that the PI indicated that gasoline SCR aftertreatment cost was significantly lower than diesel fuel injection system and was therefore an implementable, competitive solution. The reviewer felt that the technology could be ready in a few years.

Reviewer 5:

The reviewer stated that it was good to see that the program has now moved on to a boosted engine platform. The work on passive versus active ammonia systems for the SCR is intriguing although it was no surprise that the final design would employ some active system. What is surprising was the ability to meet current particulate standards without a filtration system. The reviewer concluded that it would be good to see verification that this was the case.

Reviewer 6:

The reviewer commented that it was excellent to see the results from the downsized lean boosted engine this year. The new engine is showing significant advancements in efficiency over both the PFI baseline and the previous naturally aspirated lean engine. Good progress on the emission control system and the calibration/controls work was also shown.

Reviewer 7:

The reviewer indicated that there was an impressive mastery of quasi-passive ammonia SCR. The engine out NOx was 10x that of diesel but only 1.4x the urea consumption.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the partner selection was sound and effective; the OEM and key suppliers, including a leading aftertreatment company.

Reviewer 2:

The reviewer noted that the GM (PI) was collaborating with partners with needed expertise to ensure the success of the present project.

Reviewer 3:

The reviewer noted a use of good suppliers rather than a thorough integration of partners.

Reviewer 4:

The reviewer indicated good partners including Bosch, Umicore, and Ricardo. The third-party modeling, evaluation, and testing at a National Laboratory could improve the score.

Reviewer 5:

The reviewer felt that the team had all the right skill sets. Ideally, the aftertreatment expertise at Umicore coupled with the systems expertise at Ricardo and Bosch would be hard to beat. The reviewer criticized that it was difficult, however, to know exactly how well the team was collaborating and how much each brought to the project specifically.

Reviewer 6:

The reviewer reported that the calibrations with Ricardo, Bosch, and Umicore appeared to be beneficial to the project. However, there was no university or National Laboratory partners mentioned and asked if such partners would add benefit to the project.

Reviewer 7:

The reviewer noted that collaborators all appeared to be pulling their weight. The reviewer noted that there was a good team.

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

Reviewer 1:

The reviewer stated that the project was in its final stages, so the future plans were moderately a relevant rating area. The reviewer asked if there was a path to commercial use. The reviewer presumed the final demonstration of goals would be based on chassis dyno and road tests, and not the steady-state mode simulation used in development.

Reviewer 2:

The reviewer stated that as a next step, the installation of the LDB engine and integration of its controls with that of the vehicle was proposed. Finally the vehicle would be tested for performance evaluation. This was a logical extension of the effort pursued so far.

Reviewer 3:

The reviewer expressed concern about real world fuel economy and thus the customer acceptance of these technologies. The reviewer suggested that the project team needed to look at higher loads and real-world driving cycles.

Reviewer 4:

The reviewer indicated that the improvements planned should result in the achievement of the 25% goal. All technology should be achievable in a few years on the vehicle and the value proposition was reasonable. The concern was consumer acceptance of urea consumption and the 12V Start Stop.

Reviewer 5:

The reviewer stated that future plans seemed reasonable.

Reviewer 6:

The reviewer reported that the future work was appropriate and focused in the right direction (vehicle integration and demo).

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer felt that yes, the proposed development could lead to fuel efficiency improvement by 25%. This can potentially wean the nation off its petroleum dependence.

Reviewer 2:

The reviewer observed a direct relevance.

Reviewer 3:

The reviewer reported that a 25% fuel economy improvement goal can be met with technology that is possible to implement in the near term.

Reviewer 4:

The reviewer noted that this project had the potential to impact the gasoline fueled passenger car market and significantly reduce petroleum from that fleet in the United States.

Reviewer 5:

The reviewer indicated that this was a very relevant demonstration. There is a high risk, high payoff approach. This is the type of demo project DOE should be funding.

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

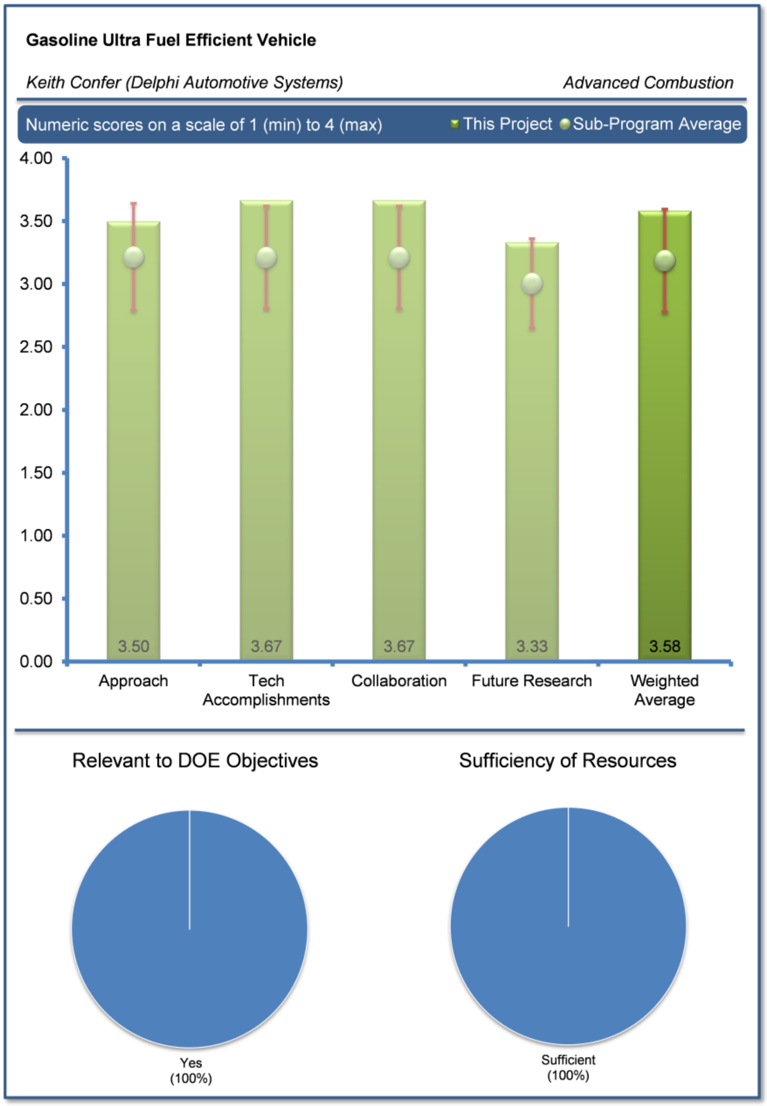
Reviewer 1:

The reviewer commented that it seemed okay.

Reviewer 2:

The reviewer stated that the funding was high for the activity. Significant technological stretch was not pursued. The work is valuable and well done, but the funding required for this activity could be less than $15 million and achieve goals, especially if the technology was in the product plan for production.

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



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer reported that there was a well-thought out, well-orchestrated effort at a very good value. Overall the gasoline direct compression ignition (GDCI) concept stood out as a very promising technology that can lead to significant fuel savings. The other two technologies (i.e., friction reduction via down speeding, and ePhasers) appeared promising with long term value.

Reviewer 2:

The reviewer stated that the overall plan included some high-risk stretch technology (good for a DOE project) as well as well-understood near-term solutions. The GDCI system was worth the exploration at the vehicle level to help determine the viability of low-temperature combustion methods and would be an important outcome. The reviewer reported that the strategy and discussion on achieving emissions goals such as Tier 2 Bin 2 were not really complete. Engine-out PM and NOx were very low in engine tests, but it was unlikely that Tie 2 Bin 2 was achievable without integrated aftertreatment system. The reviewer recalled that this was a criticism in a prior year.

Reviewer 3:

The reviewer indicated that a large number of technologies have been included in this project -- almost a shopping list rather than a concept. However, the project appropriately includes downselect and analysis of which technologies are synergistic and which are not. The reviewer stated that the method has the advantage of potentially pulling some successful ideas into production sooner, without waiting for the whole package to mature. The reviewer expressed concern that the in-use fuel variability will be a difficult problem for the CI concept, especially when the full range of cold operation is included.

Reviewer 4:

The reviewer said the project was aggressive, risky, and innovative; everything that one would look for in a DOE-funded project of this sort.

Reviewer 5:

The reviewer stated that the approach focused primarily on the GCDI technology which enables gasoline combustion with diesel-like efficiency but at gasoline scale equipment cost. The advancements made in GCDI are substantial and the team has moved away from multimode operation with HCCI. The reviewer noted that the injector technologies developed were importantly demonstrating low

PM emissions. Also, apparently NOx emissions were controlled in-cylinder. While the project has made excellent progress with the GCDI approach, the project would benefit from more research results on the novel injector technologies shown (more sharing of the mechanisms and sprays that are enabling progress). The reviewer felt that more information on in-cylinder NOx control mechanisms would also be beneficial. HC and CO emissions also need to be characterized and an appropriate control mechanism shown.

Reviewer 6:

The reviewer reported that the project was attempting to demonstrate a risky, advanced combustion approach.

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

Reviewer 1:

The reviewer noted outstanding progress was made on base vehicle improvements and GDCI mulitcylinder engine builds and tests. The reviewer cannot assign an outstanding mark because the emissions question was not resolved as the vehicle phase was starting.

Reviewer 2:

The reviewer indicated that in Phase-I of this effort, two vehicles were built and tested, each with a different combination of advanced technologies. Out of these two technologies - friction loss reduction through downspeeding, and use of ePhasers - proved promising. The reviewer reported that in the Phase-II of this program, that was executed so far, the hardware configuration for GDCI was optimized to result in an engine that offered significant (greater than 25%) improvements in fuel efficiency, while meeting the emissions target. Subsequently, a multi-cylinder engine has been built and is currently being optimized before installation in a vehicle. Overall the progress achieved is very impressive.

Reviewer 3:

The reviewer noted that there was solid progress on a number of interesting technologies. Good progress in defining the ultimate package of features and integrating the concept.

Reviewer 4:

The reviewer stated that the concept of gasoline direct injection, compression ignition is very interesting indeed. This has the potential to bring many of the benefits of traditional diesel engines along with the benefits of traditional gasoline engines. Conversely, the potential exists to blend the deficiencies of both approaches. The reviewer felt that the progress made with the E' and E" test configurations is impressive. The reviewer added that it would have been nice to hear more details of the hardware but it is understandable that this is sensitive information. It will be exciting to see how this work proceeds towards addressing full transient operations.

Reviewer 5:

The reviewer stated that the project has shown excellent progress in the GDCI combustion approach utilizing the injector technology. Clearly, benefits are being attained from advanced injector design. The reviewer reported that it would be better if there were more information shared on the injector mechanisms that are the underlying source of the benefits achieved since this is a public project. The emissions are low as observed to date; it will be interesting to observe the emissions for transient drive cycles. The reviewer also indicated that the project should show more specific data related to the oxidation catalyst approach since that is identified as the emission control requirement (specifically, what temperatures were observed on the oxidation catalyst, what HC species were present, and where light-off occurred, and etc.)

Reviewer 6:

The reviewer said that although it seemed somewhat secretive, the projected appeared to have mastered GDCI.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project has brought together outstanding participants from the industry and universities.

Reviewer 2:

The reviewer reported that this team effort has the right elements of partnership between a parts supplier like DELPHI and vehicle manufacturer like Hyundai. This was supplemented by modeling and testing efforts by WERC. The involvement and contribution from Wayne State was not clear from this presentation.

Reviewer 3:

The reviewer stated that close relations with Hyundai America Technical Center Inc. (HATCI) and others seemed to be well integrated in the project.

Reviewer 4:

The reviewer felt it was a good team with Wayne State University (WSU), WERC, and HATCI, but that it could be made stronger with a U.S. OEM involved. However, this was an understandable result given the awards to the three major U.S. OEMs and the conflict of interest which would arise.

Reviewer 5:

The reviewer noted that the collaborations looked good with a mix of universities and private sector entities.

Reviewer 6:

The reviewer commented that there was a good team and all members appeared to be pulling their weight.

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

Reviewer 1:

The reviewer noted that full emission compliance strategy was not fully addressed.

Reviewer 2:

The reviewer felt that a logical extension of the progress was achieved so far.

Reviewer 3:

The reviewer commented that the vehicle build and demonstration will be most interesting.

Reviewer 4:

The reviewer expressed excitement to see how the technical challenges are addressed in the coming year, and incorporated into the demonstration vehicle.

Reviewer 5:

The reviewer stated that much progress was needed on the vehicle demo part of the project, but the combustion footing is solid, and a good plan for moving forward was presented.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reported an emphatic yes. The concepts investigated have long term value in terms of fuel savings for the nation and reduction of GHG for the environment.

Reviewer 2:

The reviewer stated this was a big, fuel efficiency vehicle.

Reviewer 3:

The reviewer said, yes, the project has potential to substantially reduce petroleum via the GDCI combustion approach.

Reviewer 4:

The reviewer indicated the project was a high risk, high payoff approach. This was the type of demonstration project DOE should be funding.

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

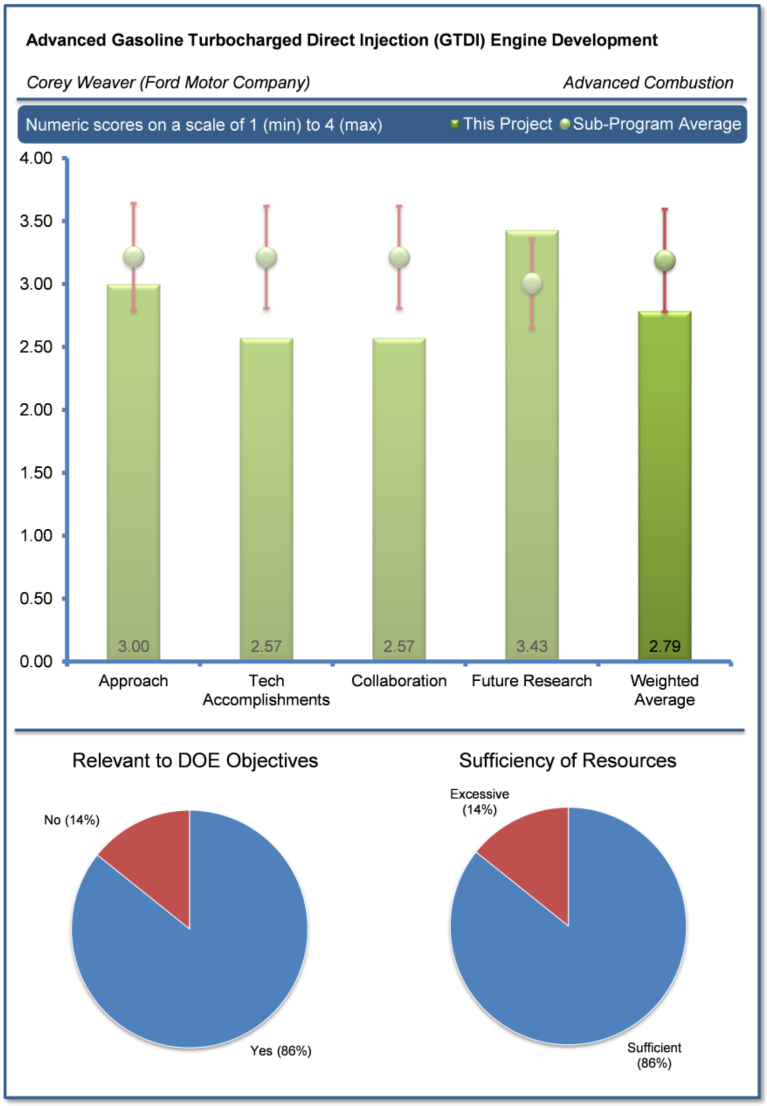
Reviewer 1:

The reviewer indicated that the project team executed a well-thought out project plan and had delivered the promised deliverable at a very good value.

Reviewer 2:

The reviewer said resources seem to be appropriate.

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



Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

The reviewer felt that the effectiveness of the overall approach to meeting goals was solid and on target. The approach lacked any major technology leap forward, but what was proposed will likely meet the goals set by the sponsor, and the commercial viability was high.

Reviewer 2:

The reviewer stated that the presentation material is not very clear and that a very limited amount of information is being shared. But judging by the content, one has to guess that in addition to trying out a variety of advanced technologies, two technologies were primarily focused upon: stoichiometric burn with turbocharging and three-way catalyst; and lean burn with turbocharging and lean NOx/ SCR catalyst. The reviewer reported that all of these were pursued in addition to the main effort of downsizing. At the heart of any research program is a solid concept. The reviewer said that in this case, one gets the impression that the project is not well-designed, and facing a myriad of pathways, Ford downselected based on engine testing far down into the program.

Reviewer 3:

The reviewer felt that this is clearly a program designed to take current EcoBoost technology and move it to much higher efficiency; the project will develop a very production-ready concept likely to have a real impact on national fuel consumption. A solid approach is taken with modeling, laboratory tests, and engine tests appropriately combined.

Reviewer 4:

The reviewer indicated that the plan to meet the target of 25% fuel economy with downsized, boosted, lean combustion is a reasonable approach. This has been pursued in various forms in the past years in the industry, with limited success due primarily to lean aftertreatment. The reviewer described a well-integrated plan including single-cylinder, modeling, dyno and aftertreatment. Novel ignition system and passive ammonia generation appear as key enablers. The reviewer noted a great additional list of technologies ready for implementation in addition to downsized boost: roller bearings on front of cam journals; electric power steering; electric Twin Independent Variable Camshaft Timing (TiVCT), variable displacement oil pump; and torque converter dampener.

Reviewer 5:

The reviewer observed that there was a very conservative approach. The reviewer was not clear how this work was much afield from standard product development activities.

Reviewer 6:

The reviewer stated that this project aims to improve gasoline engine vehicle fuel efficiency via a turbocharged GDI engine and accompanying efficiency gaining technologies. However, the project lacks sufficient risk to enable large impacts in this area. The reviewer reported that there are two primary problems with the approach. The first is that a relatively large engine was chosen for the baseline point to reference progress. A 3.5-liter V6 is a very large engine for a mid-size sedan vehicle and not a true representation of a commercially available baseline sedan (a 2.0- to 2.5-liter I4 engine would have been more appropriate). The reviewer noted that this baseline engine choice causes the project's accomplishments to appear greater than they are. Secondly, the project has dropped the lean approach due to the difficulties associated with lean emission control. While the decision may be valid to drop the lean combustion approach, no other significantly advanced combustion approach was pursued in place of the lean approach. The reviewer asserted that the nature of the DOE-funded projects should be to take risks that the industry cannot justify spending their own resources on, and the project does not now have an approach with enough risk to enable the associated high reward. Therefore, it is unclear how this approach will achieve major increases in efficiency over what would normally be achieved by the industry without DOE funding.

Reviewer 7:

The reviewer stated that there was a good approach, but looked like something Ford would do anyway. The reviewer felt that this seemed not terribly risky for a $15 million DOE investment.

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

Reviewer 1:

The reviewer noted excellent progress on base engine development, boosting system, and EGR system. This reviewer also noted many engine builds. The reviewer added that the integration in the vehicle appears on schedule.

Reviewer 2:

The reviewer stated that the project pathway was identified to be modeling from SCE testing to multicylinder engine testing to vehicle testing. System evaluation along with aftertreatment was performed ultimately at the multicylinder engine level. But the selection of the aftertreatment was performed towards the end. The reviewer indicated, however, the final goal of 25% FE improvement appears viable. Per the path identified, adequate progress has been shown.

Reviewer 3:

The reviewer reported that there was solid progress in all activities. The reviewer observed that good BSFC results while meeting all the other constraints was needed for a product. The decision to avoid lean aftertreatment seemed very appropriate; being coupled with high EGR dilution to maintain efficiency with a simpler and lower cost aftertreatment system.

Reviewer 4:

The reviewer indicated that there were very good results including a no-go gate assessment of passive ammonia generation technology and refocus on high dilution EGR with three way catalyst. There were good findings on multi-strike ignition sweet spot. The reviewer felt that the larger number of engines (12) and vehicles in the build plan demonstrated confidence in designs for possible production application of the technology. The partial data shown in the presentation indicates success in meeting fuel economy goals (min-map points) and a return to stoichiometric removes a degree of risk from aftertreatment. Some data for engine out and three-way aftertreatment system reality is desired.

Reviewer 5:

The reviewer commented that the decision of Ford to abandon lean combustion was a significant disappointment. The level of risk and innovation in the chosen path forward was minimal and brought into question the legitimacy for DOE investments.

Reviewer 6:

The reviewer noted that there was good progress in building the 2.3-liter engine and collaboration studies on the ignition process and control. However, it was unclear how the new engine was substantially increasing efficiency. The reviewer reported that the downsize versus baseline was approximately a third, and without any combustion improvements, a significant gain from operating at a higher load on the map should occur. So, it was unclear how the engine improvements were specifically increasing thermal efficiency.

Reviewer 7:

The reviewer stated that the project looked successful so far.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer felt unclear where Michigan Technological University (MTU) research would be integrated into a demo vehicle and contribute to goals.

Reviewer 2:

The reviewer stated that though MTU has shown steady progress in their tasks, most of it is of academic importance. One can hardly find any significant findings transitioning towards the final product. The reviewer noted, on the other hand, no effort has been made in the review presentation to list any publications by MTU that have resulted out of this program. So, one has to assume that this project has not resulted in any knowledge building either.

Reviewer 3:

The reviewer reported that the Michigan Tech interface was solid. There was no other major collaboration. However, given the strength and breadth of in-house expertise, this did not present a problem. Indeed, the reviewer felt that it may be a strength since Ford retained the knowledge in-house.

Reviewer 4:

The reviewer stated that only MTU is given credit for collaboration. Ford may be doing all the work in house. However, it seemed to this reviewer that there may be some key suppliers not named. To improve the score, a National Laboratory or other third-party development house could be included to verify work and key supplier credits.

Reviewer 5:

The reviewer noted that the two strike ignition work done at MTU looked intriguing, but it was not clear whether Ford was actually going to employ the strategy. Now that the project team has gone away from lean burn, the reviewer asked if this ignition work would be as meaningful with a high EGR stoich engine platform.

Reviewer 6:

The reviewer reported that the MTU collaboration was solid and was providing beneficial results to the project and adding to ignition and controls development. However, there was little mention of other collaborations.

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

Reviewer 1:

The reviewer indicated that the path forward to complete the project is clear and achievable.

Reviewer 2:
The reviewer reported that during the final year, twelve mule engines, and four vehicles were being built to complete the carpet bombing of the available technologies.

Reviewer 3:
The reviewer expressed interest in seeing the results. The reviewer observed a very solid plan with ambitious testing and development schedules.

Reviewer 4:
The reviewer stated that the homework had been done on the single-cylinder, modeling, and multi-cylinder engines to achieve a 25% fuel economy improvement with a clear eye on production applications using these technologies.

Reviewer 5:
The reviewer stated that the project was on track to reach the vehicle demo stage of the project.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer reported that the project could be argued as mostly evolutionary engineering, but achieves sponsor targets and has high probable commercialization.

Reviewer 2:
The reviewer summarized that the ultimate goal of this project was to develop a vehicle that could surpass a 25% improved fuel efficiency while meeting emission targets. The improved FE supports DOE's goal of petroleum displacement.

Reviewer 3:
The reviewer noted that the high fuel efficiency was being moved toward production in a useful way.

Reviewer 4:
The reviewer stated that the 25% fuel economy target was on track to be met and technologies appeared to be possible for production in the near term, in terms of value proposition and technical readiness; performance, reliability and cost.

Reviewer 5:
The reviewer reiterated concerns about the choice of baseline engine for comparison and the lack of aggressive combustion approach that may limit this project’s ability to displace petroleum versus already commercialized technologies.

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

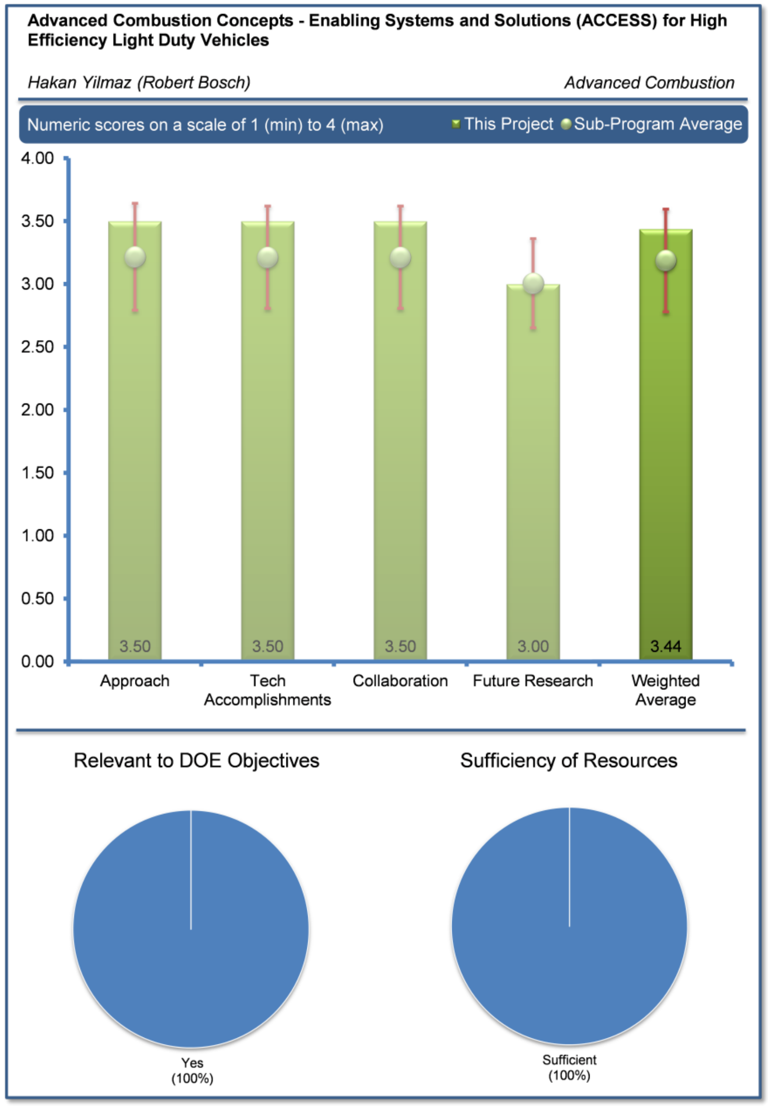
Reviewer 1:
The reviewer reported that this was a well-funded project.

Reviewer 2:
The reviewer stated that it seems to be appropriate.

Reviewer 3:
The reviewer indicated that a broad range of technologies have been researched, designed, and integrated, with an eye for production. The engine and vehicle build levels support funded technology to production focus.

Reviewer 4:
The reviewer noted this as one of the largest budgets. The reviewer added that it seems high given the relatively low-risk approach.

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



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that this project is utilizing an advanced combustion approach (i.e., SACI) and pursuing a multimode operation to achieve performance over the engine map. The reviewer affirmed that the level of risk in this approach is appropriate by taking risks to achieve a high reward. The reviewer said that the project utilizes a team approach and has good coordination and collaboration.

Reviewer 2:

The reviewer affirmed that utilization of multi-mode combustion from HCCI to SACI to standard SI is relevant and of value.

Reviewer 3:

The reviewer said that this research team is trying to use a combination of technologies to bring a mixed mode combustion strategy comprising of SI, HCCI and SACI. This reviewer proposed density high boosting to offset the loss in power. The review noted that with internal and external EGR the overall equivalence ratio is being maintained at 1.0, so as to able to use a standard three way catalyst. The reviewer summarized that overall the project is well-designed to evaluate the potential for the implementation of HCCI and associated combustion strategies.

Reviewer 4:

The reviewer stated that the multimode combustion approach with SI would ensure robustness and also compliment other types of combustion systems in other contracts. The reviewer added that the project had the appropriate level of stretch and risk, low-risk aftertreatment and emissions strategy, and a strong R&D team. The reviewer pointed out that significant effort would be required for controlling mode transitions in and out of HCCI. This reviewer was unsure what fuel efficiency is lost if HCCI mode (small part of operating map) is deleted and what is the value proposition of HCCI.

Reviewer 5:

According to this reviewer, the project, based on the EcoTech 2.0L, started with a downsized platform in a Cadillac. Regarding the engine, the cylinder head was changed for a central injector, electric cm phasing, 2-step cam profile, cooled EGR, and mixed-mode combustion. This reviewer went on to say that the project is developing integrated technology for drop-in OEM use.

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

Reviewer 1:

The reviewer stated that the collaboration and coordination of this project is excellent and that multiple entities are working closely together on the project with contributions coming from all. The reviewer said that the organization of across university and industry teams is impressive.

Reviewer 2:

The reviewer stated that this project has achieved significant progress in integrating the hardware, control strategies and software. The reviewer noted that the researchers do acknowledge the challenges associated with aftertreatment due to the low exhaust gas temperatures, but are pursuing efforts through external electrical heating. The reviewer went on to say that efforts the researchers have made to optimize control strategies are somewhat delayed, but are likely to have minimal impact on the next step of demonstrating the engine in a vehicle. The reviewer noted that no data have been presented on engine emissions verses fuel efficiency trade-off in comparison to a baseline engine during the review. The reviewer stated that the researchers will assure that this is of no concern as compared to the challenges associated with combustion control and switching between combustion modes. The reviewer remarked that as model-based-control is proposed in conjunction with in-cylinder pressure sensing, some comments on the impact on engine cost would be helpful.

Reviewer 3:

The reviewer noted that very good progress was shown on the combustion research relative to HCCI and SACI and that controls development and compression ratio selection also demonstrated progress and accomplishments.

Reviewer 4:

According to this reviewer, the majority of innovation and effort appears to be in the successful implementation of the SACI combustion approach, yet it is shown to account for only about 20% of the efficiency gain. This reviewer also wondered whether the effort is worth the benefits and asks why not implement all the other approaches, forgo SACI and yield 80% of the benefits.

Reviewer 5:

The reviewer reported switching from HCCI to SI, high compression ratio (CR), and controls works.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that this project consists of a well-coordinated team of independent labs and universities. The reviewer pointed out that the overall project would be a bit stronger with full participation by an OEM, yet the current approach may aid tech transfer to a large number of OEMs.

Reviewer 2:

The reviewer commented that the collaboration and coordination of this project is excellent. Multiple entities are working closely together on the project with contributions coming from all. The reviewer found that the organization across university and industry teams is impressive.

Reviewer 3:

According to this reviewer, the project has a very good team assembled. The team shows U.S. OEMs are involved in information exchange and technology alignment, but it would be helpful to understand in greater detail how this is actually occurring.

Reviewer 4:

The reviewer said that the project comprises of various centers of expertise that adequately leverage each other’s capabilities.

Reviewer 5:
According to this reviewer, there were collaborations with Bosch, AVL, University of Michigan, Stanford, and Emitec.

Reviewer 6:
The reviewer said that the project has a really large team and budget.

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

Reviewer 1:
The reviewer stated that the project team has a good plan forward for their technologies and technology integration. The reviewer added that there is a lot of work to perform to reach the vehicle demonstration.

Reviewer 2:
The reviewer affirmed that HCCI is essential to meet its future goals.

Reviewer 3:
The reviewer said that the project appears on path and on schedule.

Reviewer 4:
The reviewer noted that focus on emissions system and vehicle integration is appropriate.

Reviewer 5:
According to this reviewer, future activities identified for combustion control, software integration and overall hardware integration are adequate.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that this project can impact petroleum use by reducing gasoline consumption in the light-duty sector. The reviewer affirmed that the SACI approach is a key enabler for petroleum reduction.

Reviewer 2:
According to this reviewer, the project is an important indicator of how and how much advanced combustion modes and strategies can improve fuel economy at the vehicle level.

Reviewer 3:
The reviewer affirmed that the proposed concept evaluates HCCI and associated modes of engine combustion that have the potential to improve fuel efficiency of passenger cars by 25% and that this is likely to lead to support DOE's goals of petroleum displacement.

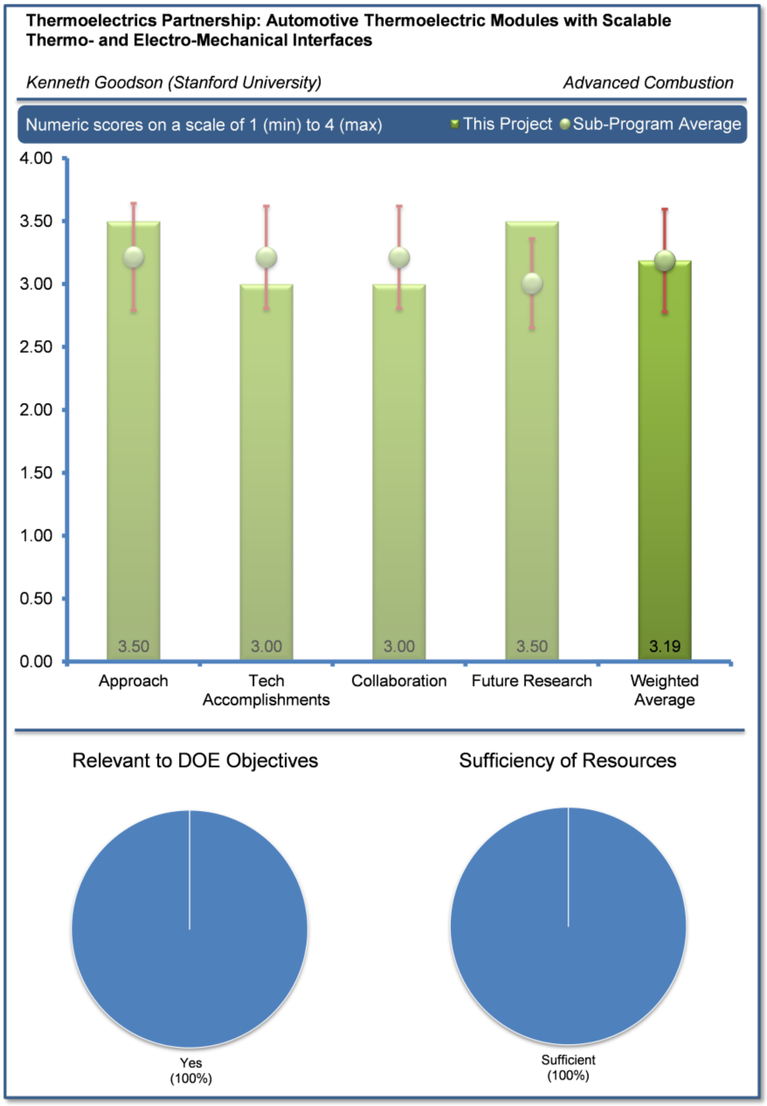
Reviewer 4:
The reviewer stated that multi-mode combustion is relevant.

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

Reviewer 1:
The reviewer states that the project has a large team and budget, and that the program has made great progress.

Reviewer 2:
The reviewer commented that the project resources are adequate.

Thermoelectrics Partnership: Automotive Thermoelectric Modules with Scalable Thermo- and Electro-Mechanical Interfaces: Kenneth Goodson (Stanford University) - ace067



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

This reviewer observed that for a DOE NSF project, this team has done an excellent job to address fundamental issues in thermoelectric: improving thermoelectric figure of merit (ZT) and improving interface contact resistance.

Reviewer 2:

This reviewer stated that overall, the approach appears to have a very solid approach to overcoming the barriers presented and that the system packaging barrier did seem to be the barrier with the least amount of focus and innovation. The reviewer went on to say that from the presentation, it appears that a flat nominal wafer approach will be taken, suggesting that a bit more investigation into alternative modes to potential assemble the bridges may lead to greater advantages in the system. The reviewer noted that the remaining approaches to overcoming the barriers are focused and comprehensive in the coordinated approach.

Reviewer 3:

The reviewer said that this approach has a good focus on thermal interface materials, techniques, and solutions. The approach of using multi-physics modeling and unique experimental facilities of novel thermoelectric metrology, high sensitivity electro-thermal interface characterization, Micro-Electro-Mechanical Systems (MEMS)-based electro-thermal and mechanical characterizations, and high-temperature infrared (IR) microscopy to attack thermal interface challenges and create better interface understanding and solutions is quite good and useful in supporting DOE goals. The reviewer added that the work with reactive bonding work is quite interesting and useful. The reviewer remarked that, however, the focus on gas-liquid simulations using ANSYS & FLUENT and novel cold side heat exchanger microfluidics is redundant with other programs and does not add anything new to the DOE program. The reviewer added that the approach to work in system specifications and multi-physics codes/simulations to predict transient TEG system performance is also redundant and basically re-inventing the wheel and that DOE funds could be better spent attacking other material developments and system challenges and approaches. The reviewer said that the project’s work with high-temperature TE materials (Half-Heuslers and skutterudites) is less impressive and really is not raising the bar. The reviewer stated that the project’s outreach and engagement programs are useful and helpful to the future of this technology.

Reviewer 4:

The reviewer remarked that Goodson's approach has good intentions, and admirable progress. There are some issues that the reviewer thinks could be improved, such as the understanding about emissivity from the many different materials and surface finish, and how its temperature dependence can affect the measurements. The reviewer asked how the researcher can measure the temperature of a composite structure, and everything else in the field of view of the microscope, without very precise data for temperature dependent emissivity values. The reviewer pointed out that this problem is very hard, and Goodson has made truly excellent attempts to get that under control, but suggested that more work is needed. The reviewer was happy to see that the project team migrated away from carbon nanotubes and on to metal nanotubes. This reviewer was somewhat disappointed with Nolas' approach, recalling that he was systematically removing antimony from mixed pnictides and chalcogenides, in the hope of obtaining materials with low sublimation. But, the chalcogenides themselves are sublime, in many cases more than the pnictide. The reviewer stated an example that selenium has a higher vapor pressure than the respective antimony compound, and did not see value to this approach.

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

Reviewer 1:

This reviewer stated that the project's technical achievement is very impressive. The number of publications generated is a proof of the project quality. The reviewer observed that on the NSF side, the education elements of the project also involved graduate and undergraduate students and even high school science programs.

Reviewer 2:

The reviewer said that this project has made good measurements, given the limitations, and has leveraged the measurements to extract useful information for the other performers.

Reviewer 3:

The reviewer stated that the project's work in characterizing nano-scale thermal interfaces and materials (thermal and structural properties) and their equipment is quite impressive. The team's work with metal nanowires and carbon nanotubes (CNT) to create better thermal interfaces is quite helpful. However, it concerns this reviewer greatly that these materials may be quite limited in their temperature capability and these may not work well at temperatures relevant to automotive WHR. The reviewer added that the researchers appear to be performing good work in characterizing CNT interfaces after thermal cycling and this is critical information. The project team's work with CNT mechanical simulations and experimental data are quite useful. The reviewer pointed out that this team's work on TE materials work with different skutterudites and Half-Heusler materials is unimpressive. There appears to be little work in thermal cycling of these materials and that is a serious requirement which these materials must pass to be useful in this automotive WHR application. One could easily envision any automotive TEG system cycling approximately 800-1,000 cycles each year. Any TE materials that cannot tolerate this environment should not be pursued. High Seebeck coefficients have been demonstrated in some cases, but this reviewer did not see data on the other key thermoelectric properties (electrical resistivity, thermal conductivity). The team is working with TE materials exhibiting ZT less than one. TE materials with ZTs this low will not lead to TEG WHR systems satisfying DOE's objectives. This presentation also showed no results, current work or planned work, on the mechanical/structural properties of their TE materials. In this particular automotive application, the mechanical/structural properties are just as critical as the fundamental TE properties. The reviewer noted that this is a serious deficiency in the TE materials work of this project.

Reviewer 4:

This reviewer stated that this project, having a primary focus to investigate ways to improve the interface efficiency is a significant challenge, but one worth delving into for better solutions. The project screen captures and graphical representation of the data was well-laid out and easy to follow. This reviewer also said that it appears that this effort has already accomplished some of the goals, while the remaining goals are well within reach.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that it appears that the project partners are fairly well-coordinated and that there is a solid collaboration between each entity. Even with the vast capabilities of the participants, it may be beneficial to potentially add other participants to increase the capabilities even further.

Reviewer 2:

According to this reviewer, collaborations are good, although each member is doing its own study and the overlapping of work seems not enough to generate collaborative publications that are co-authored by two or three team members.

Reviewer 3:

The reviewer said that Goodson is pursuing a very challenging approach for non-contact measurements. However, the reviewer expressed that Goodson does not have everything under control at this point, but is confident Goodson can and will gain control. Goodson has an army of excellent graduate students with very novel ideas. The reviewer also expressed a need to see more innovation from Nolas' end.

Reviewer 4:

This reviewer said that the project has exhibited and demonstrated close collaboration amongst its team members. This reviewer noted that, however, in the case of the team’s TE materials research work, the team is collaborating in the wrong area. TE materials with ZT less than 1.0 will not lead to TEG WHR systems satisfying DOE’s objectives.

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

Reviewer 1:

The reviewer observed that the project’s integration of thermal interface resistance progress and accomplishments with TE materials and potentially devices is quite good. The project demonstrated solid progress with its Time Integrity Modules (TIM) and the team’s plans to extend its work with TIMs and that experimental /analytic modeling of TIMs is sound. This team will have challenges in implementing their TIMs at high temperatures (i.e., 600ºC) and it is good that the team will focus on this in its future work. The reviewer affirmed that the team’s work on metal nanowires is a good choice and approved of the team’s approach for next year's efforts. The reviewer went on to say that the team’s planned TE materials work is less impressive and it is not clear how that work will extend/expand upon current state-of-the-art. The reviewer said that the team should re-think its plans in this area.

Reviewer 2:

According to this reviewer, directions for future research are focusing on the program goals.

Reviewer 3:

The reviewer noted that the project proposed work appears to build on past progress and potentially lead to overcoming the remaining barriers that remain on the project. The bulk material area presents the most risk as the metal nanowire array technology, while showing promising data, may be difficult to integrate in a higher rate process for demand.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer observed that the project is approaching thermoelectric with multiple solutions at material and device levels and that these fundamental studies support DOE's petroleum displacement objective.

Reviewer 2:

The reviewer stated that this project is investigating how to improve upon thermoelectric technologies. According to this reviewer, thermoelectric technology can be used on vehicle platform applications to improve fuel economy, which supports the overall DOE objective of petroleum displacement.

Reviewer 3:

The reviewer noted that the project is attacking a critical problem and barrier (i.e., improving thermal interfaces) in applying thermoelectric technology in automotive WHR applications. This work will benefit all TEG systems in automotive applications and is required to allow these systems to reach their full performance potential in satisfying DOE's objectives. The reviewer questioned whether this team's TE materials work will lead to major advancements towards satisfying DOE's objectives. The reviewer pointed out that DOE funding can be better utilized in developing and transitioning higher-performing alternative TE materials to achieve its objectives.

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

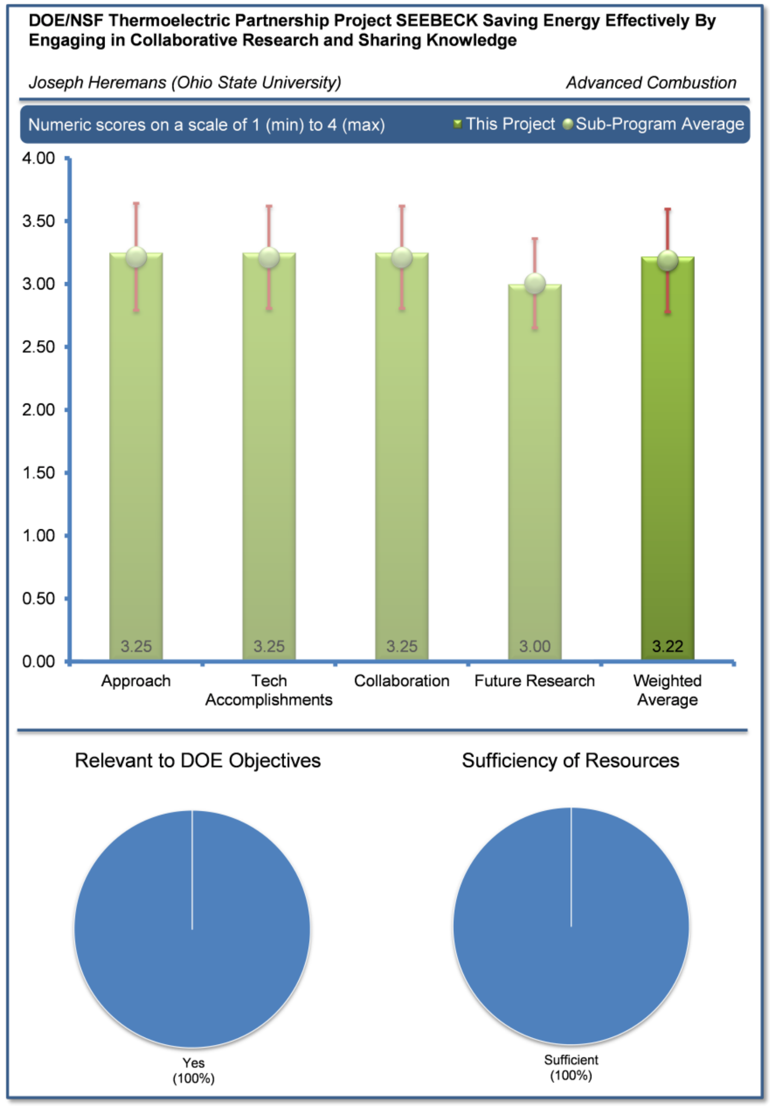
Reviewer 1:

The reviewer said that the project appears to have sufficient resources in order to complete this project within the stated duration of the project. The scope of the remaining work seems to justify the 34% funds remaining in the last eight months. The reviewer added that the leveraging of other work has allowed this project to get more bang for the buck.

Reviewer 2:

This reviewer affirmed that the project team is utilizing sufficient resources from its institutes for this project.

DOE/NSF Thermoelectric Partnership Project SEEBECK Saving Energy Effectively By Engaging in Collaborative Research and Sharing Knowledge: Joseph Heremans (Ohio State University) - ace068



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that the basic research approach to solve these barriers is very solid. Even though all of the team's objectives are based on the science of thermoelectric technology, the reviewer expressed a need to know if all of these objectives should be the focus of this effort. According to the reviewer, one of the deficiencies of the project appears to be that there were only efforts on the basic combinations without much focus on doping or other novel approaches to increase ZT while keeping cost low.

Reviewer 2:

The reviewer expressed that Professor Heremans' work is quite impressive. Ohio State seems to have an excellent approach to investigate lightweight, abundant magnesium/manganese based device technologies. Although the results were not as anticipated, or hoped, this is the very definition of pure academic research. The reviewer commented that if there were more Heremans, the scholastic world would be a better place.

The reviewer expressed a little more disappointment in the approach from Kanatzidis, whose approach to the project seems to be to blindly mix together several materials and hope for the best. The reviewer pointed out that the explanation of the team's approach to the project comes later, even when it is a PowerPoint illustration that qualitatively proposes a mechanism, or phonon blocking, with no analysis or extra experiments to support that. The reviewer added that examining samples in the transmission electron microscope (TEM) without analysis, theory or even energy dispersive analysis of X-rays (EDAX) is somewhat empty and lacking.

Reviewer 3:

According to this reviewer, the project is focusing on high-ZT and low-cost thermo-electrics. The materials studied by the team followed this objective and they have been quite successful in gaining fundamental understanding of the issues.

Reviewer 4:

The reviewer affirmed that the project is focusing on developing thermoelectric materials with ZT greater than 1.5 while minimizing electrical and thermal contact resistances, materials metrology and durability. Of the three TE materials that this team is investigating, only one, PbS, has shown any capability to get ZT greater than one. The team achieved ZT equal to 1.3 at 923 thermal conductivity

(K). However, the reviewer pointed out that this particular material has a peak performance at around 900°K, which is too high for the automotive WHR applications on this DOE program. Many presentations have shown that automotive exhaust temperatures are less than 600ºC (873°K) and that the TE materials in optimized TEG designs will only see temperatures less than about 450-500°C (723-773°K). The reviewer added that at these temperatures, it is clear that PbS has ZT of approximately 0.8 which is not high enough to create high performing TEG designs that will meet DOE's objectives. The reviewer opined that PbS may be cheap and inexpensive, but so is dirt TE devices and systems out of it. The reviewer also stated that the team has already dismissed Mg_2Sn materials because its ZT value of approximately 0.25 is not at all relevant. Zinc antimonide (ZnSb) materials presented by this team, presumably their starting point materials, has only produced ZT approximately 0.8 at 600°K, which is well below 1.0 and quite inferior to other established and characterized TE materials in this temperature range. The reviewer also said that this is not an Excellent ZT as claimed by this team in their presentation (i.e., Slide 15) and will not lead to high performing TEG systems that satisfy DOE's objectives. The ZT of the ZT plus ZnSb materials, after thermal cycling, is only 0.9 at 300ºC, and appears to be less than 0.9 at 400ºC. There were no TE property results presented for ZnMgSb materials, so it is unclear how well these materials might perform. The reviewer added that it is unclear why this team is investigating silver (Ag) & titanium (Ti) interfaces for bismuth telluride-based materials. At the temperatures that bismuth telluride (Bi_2Te_3) is useful, there are already effective diffusion layer materials, for example, nickel (Ni).

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

Reviewer 1:

The reviewer noted that based on the information presented, there has been significant progress in achieving the barriers. The nano-silver interconnect is an interesting accomplishment. While it initially appears to solve some of the technical issues, there may be a concern of cost based on the use of silver as an element. On a small scale, data was recorded and showed to demonstrate reliability, but at a very low level. The reviewer remarked that it would be beneficial to begin a scale-up of some of the accomplishments and see how the data compares with model predictions and initial data collected.

Reviewer 2:

The reviewer stated that the project has completed planned tasks and met the milestones. The reviewer noted, however, that the project has listed no publications as accomplishments. For DOE and NSF project this should be a focus area in the following year. The reviewer, recognizing the project is just 31% complete, would not give the highest score in this category. The reviewer questioned the project Slide 1, noting that the same slide can be found online in Applied Power Electronics Conference (APEC) 2011 annual meeting's Slide 14. The only differences were some temperature parameters and Assembled TE device was added to the AMR review slide. The reviewer noted that the question was if there are the three devices shown in the picture really thermo-electrics from the project. The devices seem more like light-emitting diode (LED) devices.

Reviewer 3:

According to this reviewer, this team may have shown a ZT of 1.3 at 923°K in PbS materials, but the ZT at temperatures relevant to automotive applications, for example, less than 750 K, is less than 0.8. Repeatable ZTs appear to be 1.1, and the repeatable ZT at 750 K are less than 0.8, as well. The reviewer pointed out that this is not particularly high and will not produce high-performing TEG systems that satisfy DOE's objectives. The ZT approximately 0.8 for the team's starting ZnSb materials is not high either and will not produce high-performing TEG systems that satisfy DOE's objectives. The reviewer added that ZT of the ZT plus ZnSb materials after thermal cycling peaks are at only approximately 0.9 at 300ºC and appears to be only 0.7 at 200ºC and less than 0.9 at 400ºC, which is simply not an impressive TE material performance. There are better TE materials available than this. The reviewer commented that there were no TE property results for their ZnMgSb materials, so at this point, no progress that can be claimed these results.

The reviewer added that thermal cycling consisting of only 50 cycles is not sufficient. High performance TEG systems for automotive WHR can easily reach approximately 800-1,000 thermal cycles per year. The reviewer pointed out that the project needs to perform many more cycles on their TE materials before they begin to satisfy DOE's objectives.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

According to this reviewer, there seems to be good collaboration between the team members and partners.

Reviewer 2:

The reviewer noted that there is good collaboration among team members.

Reviewer 3:

The reviewer observed that for this project, it appeared that some of the objectives were being conducted almost independently of others. While being fairly well-coordinated with each other, the presentation had the appearance of almost four separate efforts being combined into one as a roll-up at the end. The reviewer pointed out that based on the barriers that were being worked on, it makes sense for the project to have a bit of independence, but it would be beneficial to have a capstone that focuses on leveraging all of the advancements under the project.

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

Reviewer 1:

This reviewer observed that there was no slide for future research, although it is implied in the summary slide.

Reviewer 2:

The reviewer commented that even though there is a substantial bit of information in back-up relating to the future effort, there did not appear to be much conversation & review over the plans during the next period of time. While the effort is more than 50% completed with respect to schedule, only 31% of the funding has been utilized. The reviewer added that this raises a small concern as to how this funding will be utilized when most of the objectives have a recommendation moving forward. The assumption is that more refining and optimization will be conducted on each of the objectives.

Reviewer 3:

The reviewer stated that it is not clear from the team's presentation that future research plans are aimed at overcoming the mediocre TE materials performance that is presented in this work. The team seems to be quite impressed with their materials, even though the team has lower ZT values than other available TE materials at temperature relevant to automotive WHR applications. The reviewer also remarked that there were no concrete band structure or alignment engineering plans presented to improve the fundamental ZT performance. The team simply stated that it will be done. The reviewer expressed a need to know how the team will do this and what exactly will be done.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer observed that the project is working towards the DOE's goal on petroleum displacement by improving TE material and device performance.

Reviewer 2:

The reviewer noted that the thermoelectric technology is being developed in order to recover waste heat from the vehicle, reduce HVAC demands, and other applications to save on fuel usage. The reviewer observed that this is a fundamental research project that could act as a foundation to increase any existing system.

Reviewer 3:

This reviewer answered yes to this question, but according to the reviewer there were serious questions about the TE material performance levels exhibited in this presentation and review.

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

Reviewer 1:

This reviewer stated that the project has used sufficient resources for this project.

Reviewer 2:

According to this reviewer, Heremans probably deserves a plus-up and that Kanatzidis probably does not.

Reviewer 3:

The reviewer observed that based on the spend plan to date, there is a risk that there will be excess funding at the end of the project. The reviewer added that for the project there was no clear path showing use of funds. The majority of the presentation focused on the multiple barriers that the project is focusing on and giving status, leaving the use of funds portion lacking.

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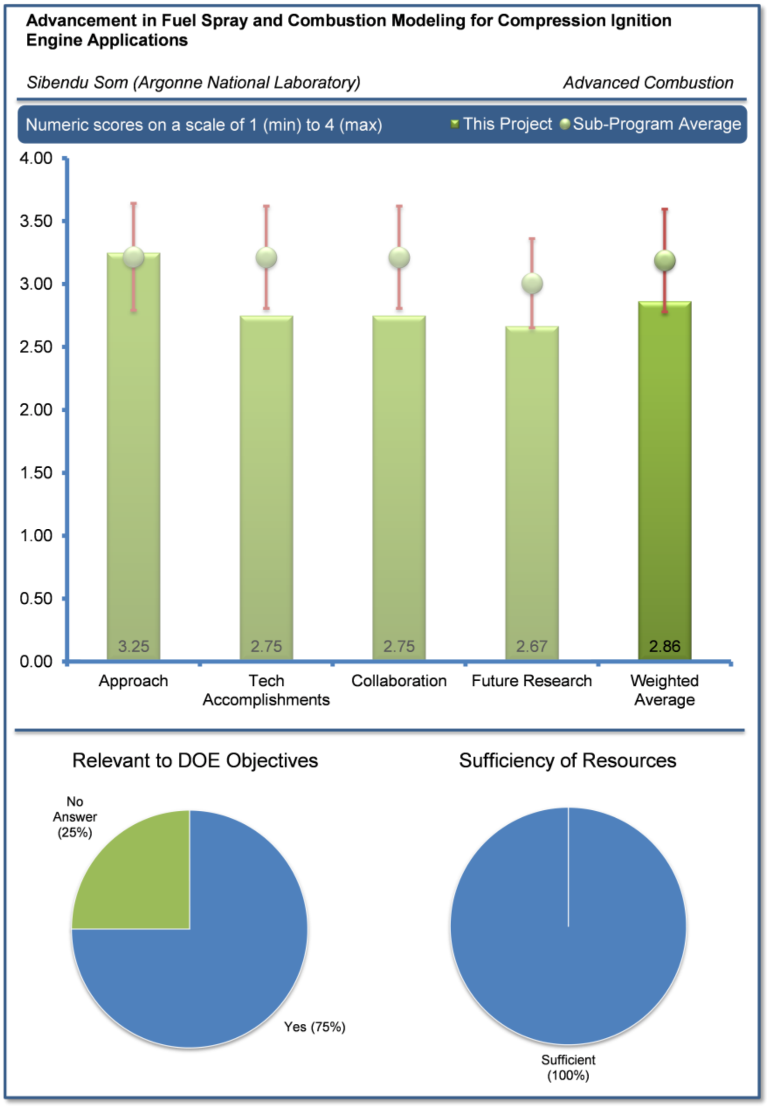
Advancement in Fuel Spray and Combustion Modeling for Compression Ignition Engine Applications: Sibendu Som (Argonne National Laboratory) - ace075



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that the project is doing very good work on both spray and combustion modeling. The reviewer said that the project focus is on both computational and modeling displays inputs confound accurate modeling.

Reviewer 2:

The reviewer said that this project is well-designed to address the four technical barriers in fuel spray and combustion modeling. The feasibility of the method has been demonstrated to a certain degree. The reviewer found it encouraging noting that future work includes validation against constant volume combustion data from SNL and engine data at Argonne National Laboratory.

Reviewer 3:

The reviewer said that this project is particularly interesting as it represents a serious attempt to improve the simulation capabilities of combustions systems. The project attempts to make an impact on the predictive capability for future engine designs. The reviewer strongly emphasized that one thing that often lacks in these programs however is coupling the work with validation in real applications. Possibly this coupling of the work with validation in real applications is something for future efforts, but it would be important for the project to introduce this coupling early on to see indeed if the work at hand has a positive influence on engine designs. The reviewer added that the project is disappointing in that the engine benchmarks are not being shared with the public.

The reviewer noted that the project could benefit from clear milestones & benchmarks. For example, authors could establish a target to arrive at a combustion system that limits soot in low O_2 concentration environments. Effectively, it is unclear how successful the high fidelity approach is towards becoming more predictive. The authors could rank the individual contributions of their research as to the impact in the overall effort, such as spray, combustion modeling and computing capacity. The reviewer added that in the milestones for 2013, the use of high performance computing (HPC) tools to capture cylinder-to-cylinder variations seems disconnected from the other more fundamental work. The reviewer also noted that the figures on Slide 6 require labeling for proper understanding. The reviewer said that is not clear what the timeline of the project is, as no end date was presented.

Reviewer 4:

The reviewer stated the project work uses much more complex and expensive combustion and turbulence models than those used today for engine design. While the work could provide insight into combustion processes, it did not appear that this was what was done. The conclusions were more around the benefits of the high grid resolution, LES and detailed chemistry. The reviewer also stated that it is unclear what the plan is to transfer the findings of this work to engineering models that can be used for engine design.

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

Reviewer 1:

The reviewer noted that the project has made good progress against milestones. Grid convergences in spray modeling and engine simulations have been demonstrated. The reviewer noted that the improved load balancing algorithm has been implemented, Cycle-to-Cycle variations in fuel spray have been captured by a grid-convergent LES approach and the effect of needle off-axis motion quantified with in-nozzle simulations using X-ray data.

Reviewer 2:

The reviewer said that this project is making good progress in identifying important modeling parameters and it will be important to apply and compare with more experimental data.

Reviewer 3:

The reviewer observed that a lot of this project’s model demonstration has been done showing the benefit of this high fidelity approach, but the main conclusion appears to be that this approach works reasonably well. The reviewer stated that it is not clear what the project long term vision of this activity is.

Reviewer 4:

The reviewer said that this project is particularly interesting as it represents a serious attempt to improve the simulation capabilities of combustions systems. The project attempts to make an impact on the predictive capability for future engine designs. The reviewer strongly noted that one thing that often lacks in these programs however is the coupling of the work with validation in real applications. Possibly this coupling of the work with validation in real applications is something for future efforts, but it would be important for the project to introduce this coupling early on to see indeed if the work at hand has a positive influence on engine designs. The reviewer added that the project is disappointing in that the engine benchmarks are not being shared with the public.

The reviewer noted that the project could benefit from clear milestones or benchmarks. For example, authors could establish a target to arrive at a combustion system that limits soot in low O_2 concentration environments. Effectively, it is unclear how successful the high fidelity approach is towards becoming more predictive. The authors could rank the individual contributions of their research as to the impact in the overall effort, such as spray, combustion modeling and computing capacity. The reviewer added that in the milestones for 2013, the use of HPC tools to capture cylinder-to-cylinder variations seems disconnected from the other more fundamental work. The reviewer also noted that the figures on Slide 6 require labeling for proper understanding. The reviewer said that is not clear what the timeline of the project is, as no end date was presented.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the project has close collaboration with industry, academia, and National Laboratories in the United States and through the Engine Collaboration Network (ECN) with researchers world-wide. The reviewer pointed out that some coordination with other ongoing DOE supported LES modeling projects would be beneficial.

Reviewer 2:

The reviewer remarked that the project has an impressive lineup of teams. The reviewer added that it is however unclear about what role the OEMs (Slide 18) outlined have on the project. The reviewer would like to know whether any of these interactions can be described. The models are said to be provided to them for implementation, yet the consortium and public are not able to gauge the significance of this work. The reviewer pointed out that the project team should engage a facility that would be able to corroborate the impact of the work because by not doing this leaves the work heavily deficient.

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

Reviewer 1:
The reviewer stated that the project focus on Eulerian-Eulerian approach for near-nozzle spray modeling is proper. The development of realistic diesel surrogate chemical kinetic model is also well-planned. The reviewer remarked that the project validation with experimental data is vital to show the value of this research.

Reviewer 2:
According to this reviewer, the presentation mentions plans to incorporate Cummins hardware. The reviewer was unsure of the scope of work planned and wonders whether these plans will be limited to X-ray or will there be plans to do engine validation.

Reviewer 3:
The reviewer noted that the project path for this work to transfer into models used by industry is not clear, as there is significant work with Converge, which provides an avenue to get into engineering models. The reviewer added that the project's vision of that transfer process should be shared.

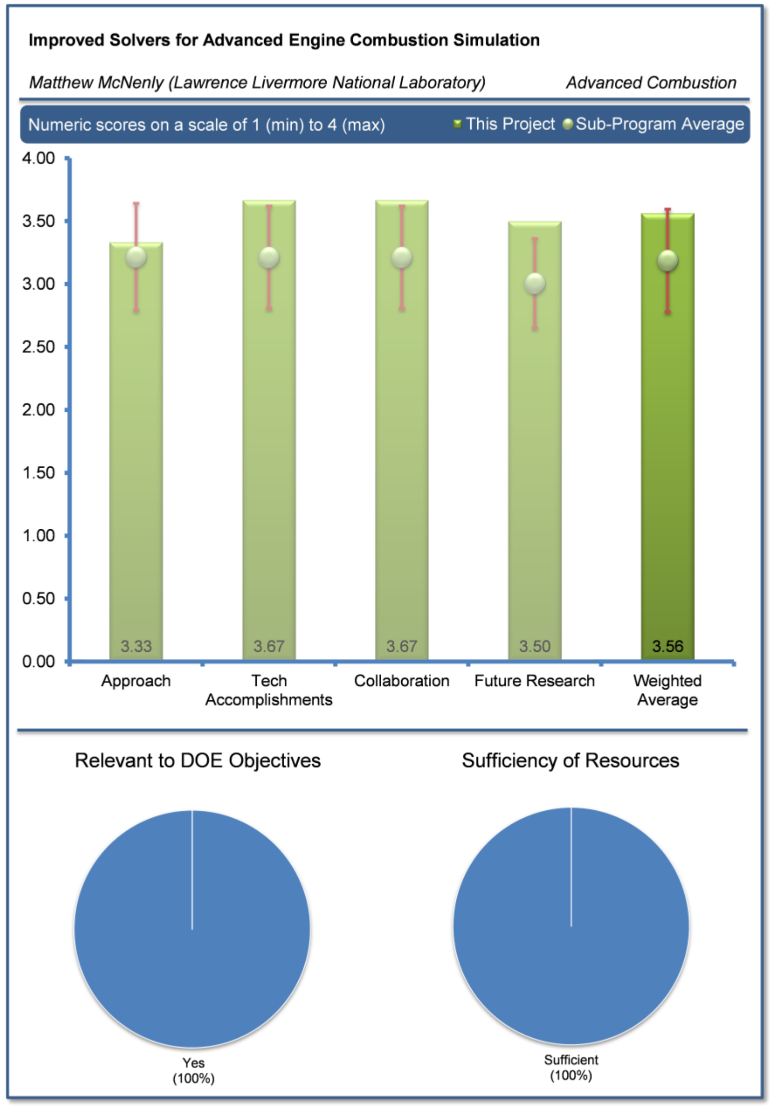
Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer noted that the project's work is aimed at working towards predictive modeling, which is critical to optimizing engines.

Reviewer 2:
The reviewer observed that the project could improve simulation and predictive capabilities of fuel spray as well as combustion processes which support the development of high efficient engines with lower emissions. The reviewer added that the project study supports the DOE's objective of reducing fuel consumptions.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
No comments were received in response to this question.

Improved Solvers for Advanced Engine Combustion Simulation: Matthew McNenly (Lawrence Livermore National Laboratory) - ace076



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that this is another project that will enable others to explore advanced combustion system development toward meeting the DOE's objectives. Speeding up multi-dimensional chemically reactive simulations will further enable engineers to more quickly assess and design new combustion systems.

Reviewer 2:

The reviewer noted that the goals have direct application to improving engine design tools.

Reviewer 3:

The reviewer noted that the approach of developing better algorithms coupled with new computing architecture and improved physical models seems to be on target to develop simulation solvers that can be used by industry to speed up the design and commercialization of high efficiency, clean combustion engines. The reviewer was unsure if there is a lack of expertise in this area, and if the project approach and tools being used are the very best to merit an outstanding rating.

Reviewer 4:

The reviewer remarked that the project is not focused on technical barriers, but focused on cost and time barriers for conducting simulations of combustion. The reviewer added that this project will not have immediate benefits, but will in the long term help in the analysis and design of engines faster and more accurately.

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

Reviewer 1:

According to this reviewer, the project continues to show amazing improvements in clock time for chemistry solvers for engine simulation.

Reviewer 2:

The reviewer noted that the project demonstrated a number of significant accomplishments, such as the following: the development of an adaptive pre-conditioner to remove least important reactions that significantly speeds up chemistry solver time without loss of accuracy; improvements to GPU algorithms to speed up thermo-chemical functions; and licensing of the solvers to Convergent Science.

Reviewer 3:

The reviewer observed that the project has made progress in the area of faster algorithms, better architectures, and improved physics; the adaptive pre-conditioner has sped up calculations by 10 times to arrive at the same solution; and the new solver has brought a typical gasoline-type calculation to about one day, which puts it in the realm of a design tool. The reviewer was unsure whether the project has achieved the objective of speeding up calculations, and wondered if the team knows whether it now has a design tool, and whether the team knows that the calculations are correct.

Reviewer 4:

According to this reviewer, this project has shown a noticeable decrease in computational time by about an order of magnitude through careful development and application of a clever scheme to perform chemistry reduction on the fly. The reviewer added that at some point, someone from the project has to validate these new schemes on a real world engine problem. The reviewer wondered if possibly Dan Flower's project can aid in validation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that the project's team working with Convergent Science is great as this will have a direct impact on the engine modeling tools used by industry to design and improve future engines.

Reviewer 2:

The reviewer noted that this project has been pretty well-coordinated with other engine combustion researchers and with a software development company. In particular, the later software company has been very involved and is the recipient via licensing of new solver software.

Reviewer 3:

The reviewer observed that the project has collaboration with a number of industry organizations including Ford, GM, Cummins, Bosch, and Convergent Sciences. The goal is to get these improved solvers in the hands of the team as well as having interactions with other National Laboratories including, SNL and ORNL, and also universities including University of California at Berkeley, UW, and University of Michigan.

Reviewer 4:

The reviewer noted the good collaboration exists with industry, other National Laboratories, universities, and working groups, and that the project is working closely with Ford, Bosch, and Covergent Science Inc.

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

Reviewer 1:

The reviewer said that the plans to further identify CFD bottlenecks, development of a turnkey chemistry solver for testing by MOU partners, and acceleration of other aspects such as multispecies diffusion are important.

Reviewer 2:

The reviewer observed that the multispecies diffusion and advection problems will be accelerated using the new solver. The reviewer added that other common applications like computing flame speed and ignition delays are also very relevant project needs.

Reviewer 3:

The reviewer noted that the proposed approach to target a few of the current time consuming algorithms is a good logical approach. The reviewer added that as stated above, at some point in time, these new solvers must be validated against engine data.

Reviewer 4:

The reviewer was unsure if, given the extraordinary results over the past few years speeding up the chemistry calculations, there is anything the project can do to speed up the fluid dynamics computations. The reviewer pointed out that rather than the chemistry, it seems like the CFD is now becoming the bottleneck in the project simulation time.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the improvements in the accuracy of detailed chemical reactions and physical models in engine combustion simulators coupled with significant reduction in computational times, will lead to design of engines with improved efficiency, lower fuel consumption, and lower emissions and that all of these are in alignment with DOE’s goals.

Reviewer 2:

The reviewer noted that this project enables others to address DOE’s efficiency goals by allowing engine researchers to develop future fuel efficient engine combustion systems. Acknowledging that such a tool will allow developers to more quickly develop combustion systems that could meet DOE’s efficiency goals.

Reviewer 3:

The reviewer remarked that the project focuses on improving and speeding up the underlying solvers that take advantage of the latest computing platforms, and that these improvements will speed up simulation of combustion in internal combustion engines that focus on achieving high efficiency.

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

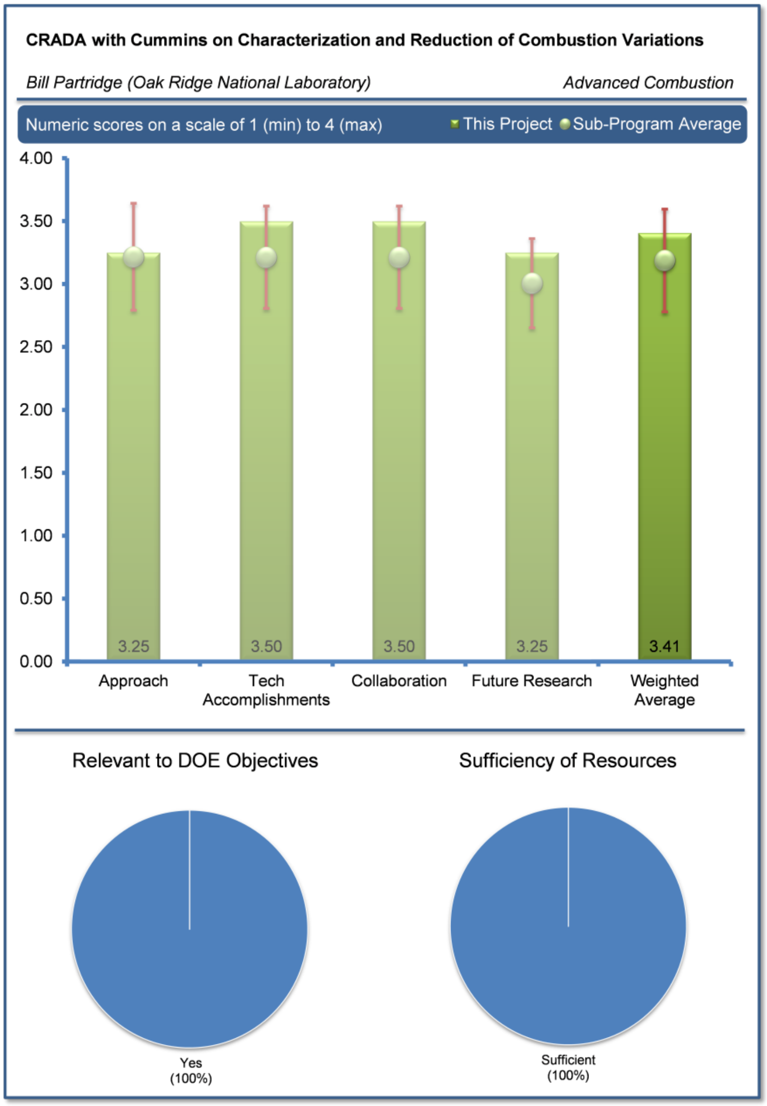
Reviewer 1:

According to this reviewer, the project resources seem sufficient.

Reviewer 2:

The reviewer noted that the project funding seems commensurate with the effort spent by the PI’s past output.

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



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that the project has a very unique approach to investigating model validation on the EGR, and a very systematic approach to identifying the efficiency barrier.

Reviewer 2:

The reviewer notes that the project has a good approach supporting work on achieving the SuperTruck Program's 55% brake thermal efficiency target.

Reviewer 3:

The reviewer expressed this work is likable because it gets down to the nitty-gritty issue of charge distribution, and that the work is a big deal, but not very glamorous. However, the reviewer also expressed that there is truth that variations in charge distribution and subsequent cycle to cycle variation, cause more fuel economy loss and emissions than is gained from going to a more complex combustion approach.

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

Reviewer 1:

The reviewer said that the project is making very good progress on updating both hardware and map, for example, having multiple probes at various locations.

Reviewer 2:

The reviewer opined that being able to make these measurements in real engine situations is the major accomplishment.

Reviewer 3:

The reviewer observed that this project, based on the new scope, is in very early stages, but good progress has been made to date.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that Cummins had the project team come in and install all the sensing equipment in the project test cell, which is a very strong collaboration. The reviewer added that if there is any weakness in the program, it is that the project is apparently not making this technology available to the other participants in the SuperTruck program.

Reviewer 2:

The reviewer remarked that the project has good, close collaboration with an OEM partner; typical of a CRADA. The project also supports the Cummins SuperTruck program.

Reviewer 3:

The reviewer noted that the project team has a very strong relationship with Cummins, but once the project information is publicly available, the validation of the design tools with other hardware available at ORNL is recommended.

Reviewer 4:

The reviewer said that the project has a good link to Cummins SuperTruck program.

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

Reviewer 1:

The reviewer observed that the future work is very relevant to supporting the SuperTruck program efforts.

Reviewer 2:

The reviewer noted that this project is very well-defined and planned.

Reviewer 3:

The reviewer observed that this project has moved very quickly. The reviewer said that instead of deciding what new thing to do, the reviewer would like to see this project technology be rolled out to other HD engine manufacturers.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that the validation of numerical design tools for emission control is important for accelerating development of high efficiency engine technologies.

Reviewer 2:

The reviewer noted that the EGR uniformity is important for engine-out NOx control of highly efficient powertrains.

Reviewer 3:

The reviewer noted that the basic engine intake improvement has a major effect on the fuel economy. This project makes this improvement a refined engineering possibility.

Reviewer 4:

The reviewer affirmed that the project work will support the overall DOE objective on developing advanced fuel efficient engines.

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

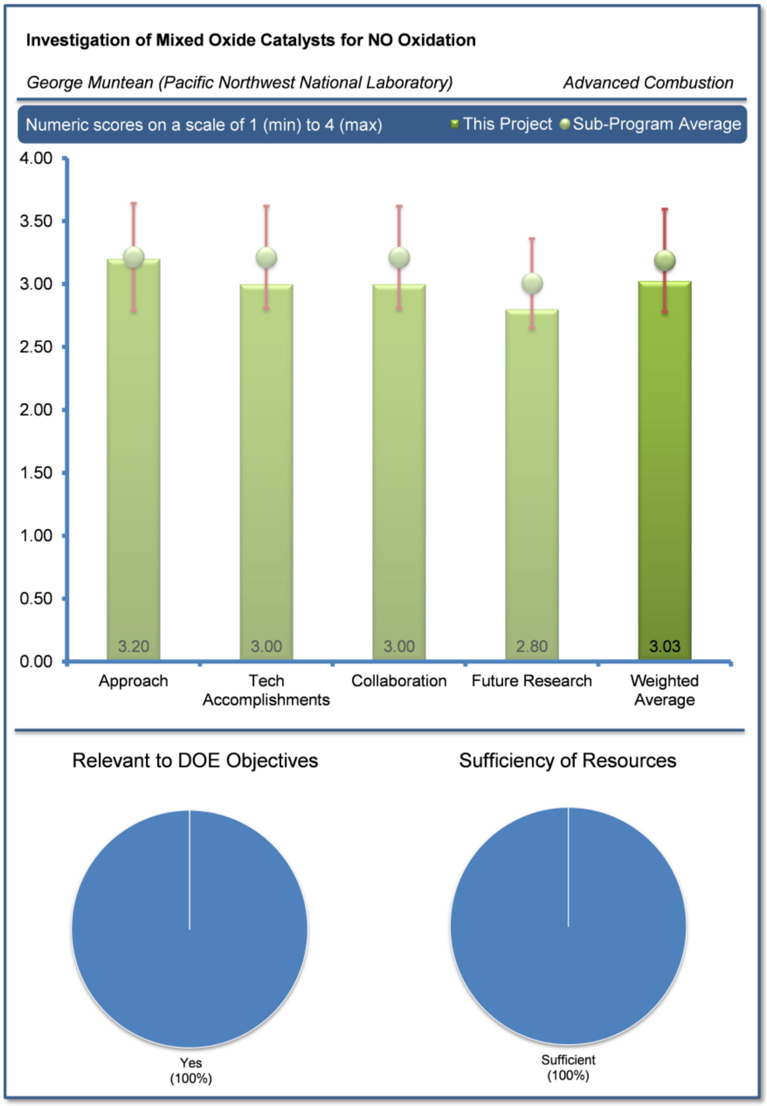
Reviewer 1:

The reviewer noted that the project is moving quite fast and that additional funds are not necessary.

Reviewer 2:

The reviewer noted that the funding seems appropriate.

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



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer remarked that the approach is an important area of interest to enable cost-effective lean aftertreatment systems. The reviewer said that the low-temperature focus is appropriate, but high temperature stability and survivability are equally important.

Reviewer 2:

The reviewer noted the project's approach leverages excellent catalyst characterization resources available at PNNL. The reviewer pointed out, however, that manganese (Mn) is not known for its durability in exhaust gas systems. Issues are hydrothermal and sulfur and these were not mentioned.

Reviewer 3:

According to this reviewer, the project's approach is fundamental science work on improved catalysts.

Reviewer 4:

The reviewer affirmed that this close collaboration with an OEM is evident in the approach.

Reviewer 5:

The reviewer affirmed the project's common need and approach is to evaluate and characterize methods to reduce Pt content from the DOC and LNT.

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

Reviewer 1:

The reviewer noted that the very good characterization progress for the different mixed metal oxide formulations has a fresh approach. The reviewer said that the lab aged samples should be checked earlier in the process to make sure the material survives potential higher temperature conditions that would be experienced in different portions of vehicle drive cycles.

Reviewer 2:

The reviewer noted this project has made good progress to date given the funding amount it received.

Reviewer 3:

The reviewer stated that the project, as planned, prepared and evaluated catalysts and reported some interesting findings (e.g., that CeO2 can stabilize Mn, and MnOx can lower temperature of conversion nitrites).

Reviewer 4:

The reviewer said that the project appears to have made reasonable progress since last year.

Reviewer 5:

The reviewer affirmed the project's high technical content, but the reviewer added that the projected gave no information on catalyst durability.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the project has good scope, and noted collaboration with PNNL, GM, and GM China.

Reviewer 2:

The reviewer noted that the project has an appropriate and effective partnership with GM in formulating and aging catalysts, and PNNL in performing fundamental characterization.

Reviewer 3:

The reviewer noted the project has close collaboration with an OEM and the involvement of an international university.

Reviewer 4:

The reviewer noted that the team has nice cooperation with GM, but is unsure what was done with Tianjin University.

Reviewer 5:

The reviewer is unsure of the role of GM's university partner at this time and recommended a clarification.

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

Reviewer 1:

The reviewer commented same plan, more data, and concluded good idea.

Reviewer 2:

The reviewer commented continued optimization.

Reviewer 3:

The reviewer observed that the proposed future research seems appropriate for addressing the overall project objective.

Reviewer 4:

The reviewer noted that the stated areas of future work are appropriate. However, the reviewer noted that aging effects and stability are not mentioned, and that lab aging protocols and analysis should be started earlier to determine the limits of the technologies.

Reviewer 5:

The reviewer noted that it is not clear how the catalyst will lower use of platinum group metal (PGM) and how the catalyst will be scaled up from powder and made more durable.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

According to the reviewer, it is very important to reduce catalyst cost and improve effectiveness, particularly at lower temperatures.

Reviewer 2:

The reviewer said that DOC LNT precious metal content reduction can significantly reduce costs of catalysts and possibly improve performance, enabling wider use of fuel economy, improving combustion strategies, while meeting emission regulations.

Reviewer 3:

The reviewer stated that lower cost and better performing catalysts are desirable to enable high efficiency powertrains.

Reviewer 4:

The reviewer pointed out that this project needs both themes of lean NOx aftertreatment and low temperature functionality to support proposed future engine combustion strategies.

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

Reviewer 1:

The reviewer stated that there are no indications that project resources are inadequate.

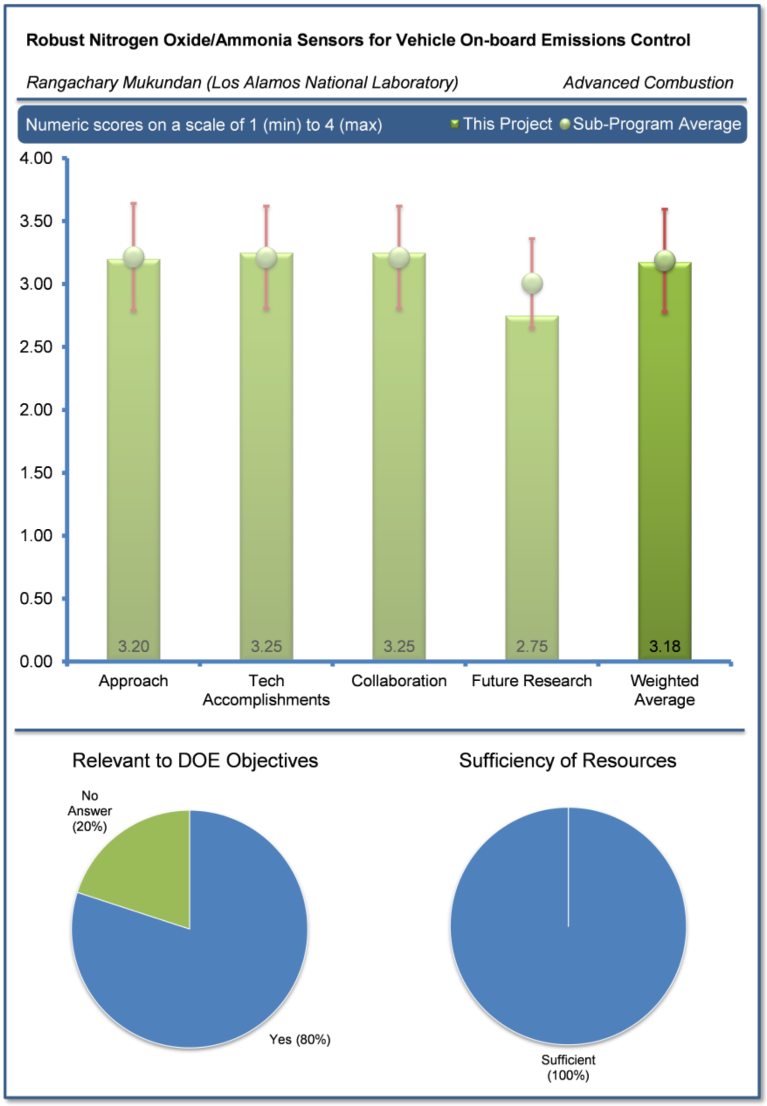
Reviewer 2:

The reviewer stated that the project expressed no issue.

Reviewer 3:

The reviewer noted that funding for this project is relatively low, but considering it is a CRADA, the overall funding seems appropriate.

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



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that this project has a good approach to try a known base sensor technology but used in a different way for NOx sensing for potential lower cost.

Reviewer 2:

The reviewer said that the approach seems to be good. The reviewer added that right now, the upper temperature limit for this sensor appears to be 400°C, and finds that limiting, since an excellent application for this sensor would also be lean and highly dilute gasoline engines, as 400°C is a bit low for that application. The reviewer noted that the heater positioning on this sensor seems to cause some gradients down the sensor, which sounds like a possible calibration issue.

Reviewer 3:

The reviewer noted that the approach is focused on maximizing NOx sensor sensitivity while at the same time improving its robustness.

Reviewer 4:

The reviewer remarked that the approach is very interesting, but the mixed potential sensors will not work at temperatures above the heater temperature.

Reviewer 5:

The reviewer noted that the need for simple, cost-effective sensors that support lean aftertreatment diagnostics OBD are important to enable catalyst technologies and higher efficiency engines. Being able to uniquely monitor multiple species would be very beneficial for control and monitoring. The reviewer added that the NOx and NH_3 sensors are central to this need. Also, detection of these species at low concentrations and with interfering species present is essential to meet Tier 2, Bin 2 emissions standards.

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

Reviewer 1:

The reviewer observed that the project has produced a sensor that seems to work with a reasonable response time and decent potential for manufacturability. The team has already tested the sensor on an engine system and is refining the design, an extremely comforting approach. The reviewer affirmed that because the project sensor is responding faster than the FTIR is very encouraging because FTIRs are slow. The engine results confirm that this sensor can work under engine conditions.

Reviewer 2:

The reviewer pointed out that the developed sensor response voltage tracks the Nitric Oxide (NO) concentrations well at steady state conditions. The sensor can also track total hydro carbons when in HC sensing mode. The reviewer noted that in transient operation during cold start, improvements are needed to isolate reaction to HC and NO (interference).

Reviewer 3:

The reviewer noted that the project's researchers have addressed many of the barriers including interference, time response, and reproducibility. However, responses to poisons such as sulfur and effects of very high temperature have not been explored. These responses should be addressed sooner to make sure the materials are appropriate. The reviewer added that the Tier 2 and SULEV standards leave little room for error in detecting breakthrough species.

Reviewer 4:

The reviewer observed that the FTIR response could be more time-averaged depending on the internal volume and sample line length, and that the exhaust gas sensor is a more direct measurement. The reviewer added that not much is shown on the ammonia sensor. The reviewer was not clear if the project sensors are durable in real exhaust gas and can survive filter regenerations.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the integration of suppliers and collaborators is very good and that the project team utilizing ORNL for the engine testing is great. The reviewer said that hopefully, the project time available to piggyback the sensor testing on the engine will be sufficient.

Reviewer 2:

The reviewer noted that this project has a good supplier and academic collaborative, but only minor interaction with an OEM (Ford).

Reviewer 3:

According to the reviewer, collaborations exist with ORNL for engine testing and with ESL ElectroScience for sensor prototype development. While LANL acknowledges that upon successful prototype tests, a commercialization partner will be sought (Caterpillar showed initial interest but is currently talking to EmiSense), it would likely be beneficial to involve potential commercialization partner(s) earlier in the project.

Reviewer 4:

The reviewer remarked that this project would benefit by having an OEM formally offering direction to the project, and a commercial alliance with a sensor manufacturer would be beneficial to determine mass production potential.

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

Reviewer 1:

The reviewer observed that the project is on a strong pathway for validation of the device. The reviewer added that it seems that program estimates of the costs of manufacturing are now needed.

Reviewer 2:

The reviewer noted that the project must more quickly address the continued issues related to HC, NO/ NO_2 ratio, NH_3, water (H_2O), interfering species, and sulfur as well. The reviewer added that high temperature is also still a concern.

Reviewer 3:

The reviewer said that details of next steps were not very clearly presented.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the use of sensors for OBD at a reasonable cost is a huge industry need for aftertreatment on highly efficient powertrains.

Reviewer 2:

The reviewer said that the NOx sensor is required for effective and efficient monitoring of advanced emission aftertreatment devices (SCR), which enable high-efficiency clean engine technologies of the future.

Reviewer 3:

The reviewer noted that the lean GDI and diesel aftertreatment systems need these sensors for OBD and control of catalyst activity. The project team must, however, be selective to the species of interest.

Reviewer 4:

The reviewer observed that the cost of NOx sensors has somewhat limited their application in the commercial market. NOx sensors and ammonia sensors can improve the efficiency of the aftertreatment system and subsequently lower the fuel penalty of the aftertreatment system. The reviewer affirmed that given that background, this work has strong relevance for the DOE's objectives.

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

Reviewer 1:

The reviewer said that this project is in its first year of a three-year follow-on project (two-year previous project) and that annual funding for the three years has been appropriately increased from that of the initial project.

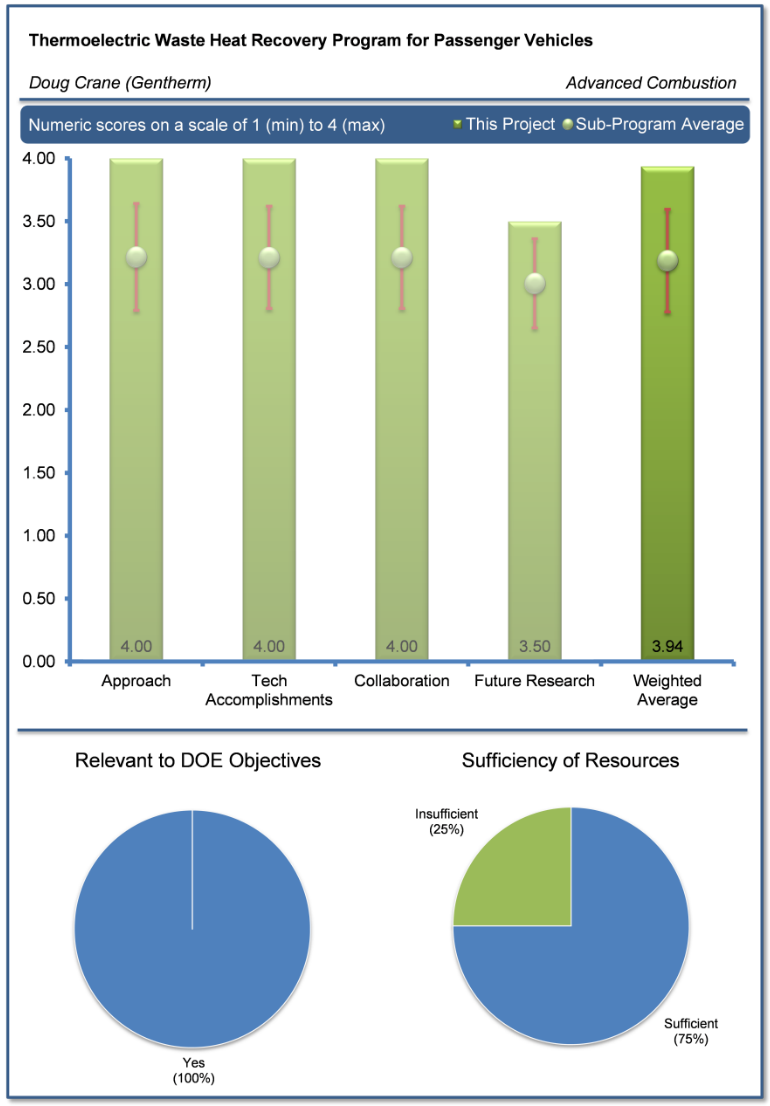
Reviewer 2:

The reviewer noted that with the exception of ensuring that there is sufficient engine testing time at ORNL, this project seems to be sufficiently funded.

Reviewer 3:

The reviewer observed that this project appears to have adequate funding to carry out its work along with contributions from partners.

Thermoelectric Waste Heat Recovery Program for Passenger Vehicles: Doug Crane (Gentherm) - ace080



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that the overall objective of improving the cost-effectiveness of its unique TEG design is well-thought out. Evidence of the efficacy of the design is its integration into a BMW product line, and the decision to move to a new design was made on issues that were identified that could be improved of cost, versatility, and etcetera. The reviewer added that this sort of evolutionary approach was nice to see, for example, the team was not married to a specific design. The cylindrical TEG seems to be unique. The reviewer also said that the project approach to incorporate net shape manufacturing in the TEG is novel. The evaluation of its designs involved a range of bench-scale tests and detailed numerical modeling. The reviewer commented that the modeling was a nice complement to the hardware development.

Reviewer 2:

The reviewer said that Crane described a large shift in the project's approach from a holistic self-contained converter that is applicable for one platform, to a general approach based on TE cartridges. The cartridges could be integrated onto any mobile platform, or sedentary heat source. The reviewer noted that this integration is a truly big step in the field. Now, the DOE-funded work can be transitioned to anything. The reviewer felt that Gentherm is really going to make a difference, not only on success of the present program, but generally in the future.

Reviewer 3:

The reviewer observed that this project has shown a strong approach in developing its TEG design, integrating well-performing TE materials, and implementing innovative approaches in the system design. Although the team's cylindrical design approach is not that unique, for the National Aeronautical and Space Administration (NASA) Jet Propulsion Laboratory (JPL) has been using this approach for 20 years, this team has tailored it to its application quite well. The reviewer also noted that the team has demonstrated a strong use of system modeling to guide system design. This team is also solidly leveraging past accomplishments to strive for modular, scalable designs that could fit various applications.

Reviewer 4:

The reviewer observed that the project is using knowledge obtained in WH1 to investigate the scale-up potentials of thermoelectric. The approaches on using multiple smaller units and material selections are reflections on the team's focus.

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

Reviewer 1:

The reviewer noted that the project team has been excellent in engineering the designs of the TEG. With the new material (SKU), the team is investigating a series of issue, such as sublimation prevention. The reviewer noted that Slide 9 showed ZT of n-type Ytterbium (Yb)-filled material. There is no mention of p-type material and expected performance. The reviewer also noted that it will be good to have a target ZT target in order to achieve the program goal of 3-5% fuel economy saving.

Reviewer 2:

The reviewer commented that a range of accomplishments was presented. The project developed an approach to mitigate the sublimation issues associated with the TE material the project team is employing. The reviewer also commented that the TEG architecture (Slide 12) seems quite novel. The packaging and integration of the team’s TEG designs into the Ford and BMW vehicles seems to be underway. The reviewer added that the bench scale testing on a TEG building block is well developed. The model predictions from the bench scale testing are apparently being used by the team to guide further development and design.

Reviewer 3:

The reviewer noted that Gentherm & BMW team has demonstrated great TE system modeling capabilities, which have helped to guide the project system design. The reviewer added that the TE materials development work is still lagging and the team’s ZT values are not that high. However, the team appears to have compensated for this with their effective system design, and is looking for coatings for Skutterudite materials. The reviewer observed that it appears that the team is not as yet successful at identifying these yet. The project team is investigating and developing pathways to develop cost-effective systems, understand cost verses performance tradeoffs, and combine cost analyses with performance analyses, and this pathway approach appears to be on track.

The reviewer commented that the project is making reasonable progress on developing the cartridge TE design. However, the project presenter did indicate that the team is working through electrical contact resistance issues, for no details were provided in the presentation. The reviewer observed that there was no discussion on how this system and design is increasing fuel economy in light-duty vehicles. The team provided no real answers from fuel economy analyses and discussion emanating from last year’s review (2012). The reviewer added that even with the very good performance and power production from the Gentherm system, BMW is only projecting a 1.3% increase in fuel economy in the project’s selected vehicle application. This approach is quite far below DOE's program objective and the Gentherm team was unable to provide a good pathway to achieving DOE's fuel economy goals, beyond stating that the DOE program goal is quite challenging.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that the project is very strong and showed excellent collaborations in the initial approach and design.

Reviewer 2:

The reviewer noted that the collaboration with BMW that involves the integration of the Gentherm TEG module is very strong.

Reviewer 3:

The reviewer noted the project has a strong team and good collaboration in achieving some noteworthy TEG system performance for this application.

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

Reviewer 1:
The reviewer observed that the future research plan is good. The work with Tank and Automotive Research, Development and Engineering Center (TARDEC) is another example of the team's approach being recognized by potential users.

Reviewer 2:
The reviewer noted that the project Gentherm team has a good plan for future research work and has a good track record of implementing their plans on time and delivering a quality product. The reviewer stated that the Gentherm team was unable to provide a good pathway to achieving DOE's fuel economy goals, beyond stating that the DOE program goal is quite challenging.

Reviewer 3:
The reviewer noted that the future work will involve vehicle-level performance by National Renewable Energy Laboratory (NREL), continuing the modeling effort, TEG testing and evaluation, materials development, and consideration of scale-up of the TE material and TEG manufacture. The reviewer pointed out that the performance would preferably be presented in terms of efficiency going forward and MPG improvement, for example, with a TEG compared to conventional operation with an alternator. The reviewer commented that the mention of net shape manufacturing is interesting, for example, rapid prototyping. The reviewer was unsure if net-shape manufacturing will apply to the materials, housing, and etcetera. The reviewer expressed the need to look forward to seeing how the PI's team would further develop this approach.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer noted that the Gentherm team is progressing and performing the best of any of the current program teams. The project’s systems will likely have the biggest impact in supporting DOE’s objectives.

Reviewer 2:
The reviewer remarked that this project is very relevant and probably the top TE project in the DOE portfolio.

Reviewer 3:
The reviewer commented that this work is very relevant to DOE's petroleum displacement goal. Moving from a demo phase to scale-up phase is critical to take this technology to the market and make a real impact.

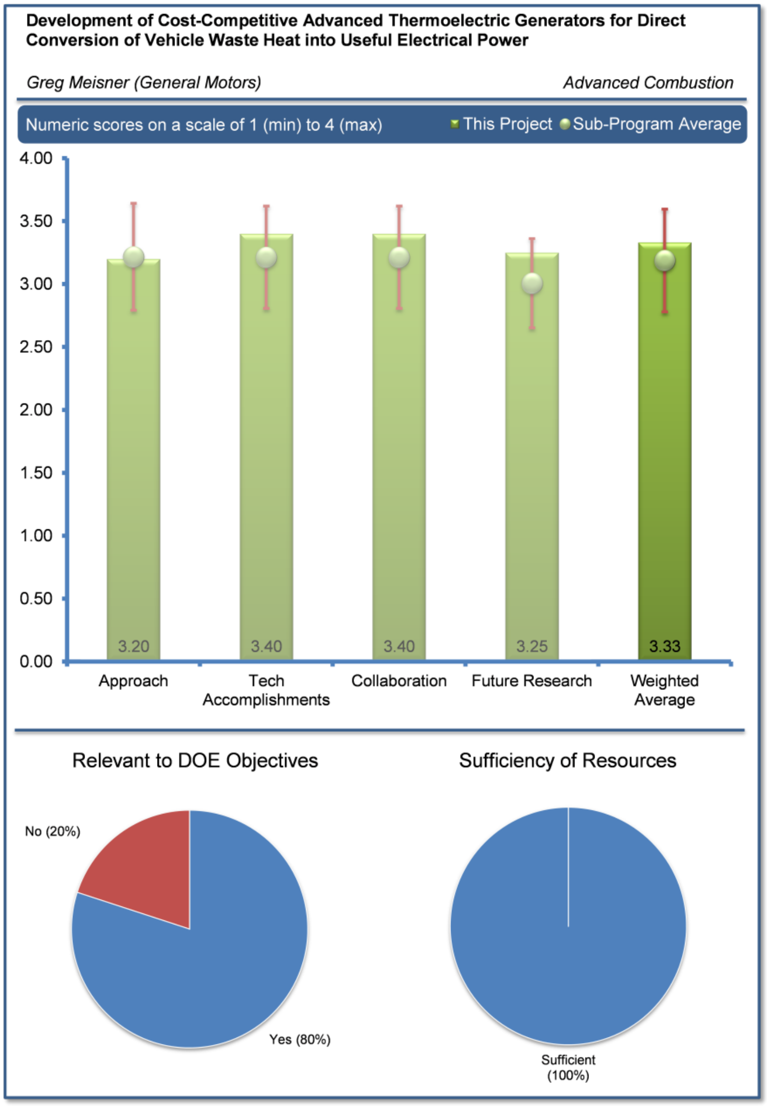
Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented to give Gentherm a plus-up.

Reviewer 2:
The reviewer noted that the project is using sufficient resources toward project goals.

Reviewer 3:
The reviewer noted that the resources are adequate for what is being done.

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



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that that much of this project's effort concerns materials processing and development, specifically improving p-type material development. The recognition that contact resistance is important is appropriate. The reviewer mentioned a target of 5% over US06, but not much was discussed in how this number would be achieved. The reviewer pointed out that the approach involves a range of tasks that are all relevant. The list is quite long. The reviewer noted that what seems to be lacking in the team's approach is a clear connection of the various tasks to performance targets that is at the heat of the DOE program. If 5% is a target, it was not clear beyond a broad perspective, how what the team will do would provide the information needed to assess how close the PIs will be to the performance target. Basically, a closer connection is needed between what will be done and how achieving a task would assist in allowing the PIs team to know what the actual percent improvement is, and how the work could be altered to be modified accordingly.

The reviewer affirmed that the approach to platform selection is quite good. As noted by the PI, certain product lines will be amenable to improved fuel economy, and others will not.

Reviewer 2:

The reviewer commented that GM has made impressive performance advances over their previous accomplishments. The project team is showing better materials and is now showing device technologies that can make a difference for DOE interests in waste-heat recovery. The project showed a high-efficiency device, but in all honesty, if the material ZT were as good as their ZT plots showed, then the efficiency should have been over 10%. The reviewer believed there is an issue with the materials and/or the measurements, but considers this a side issue. The project team has made excellent progress, but should focus on the fundamental device and materials measurements. The reviewer concluded by commenting great work.

Reviewer 3:

The reviewer commented that this project is aimed at scale-up of thermoelectric generators for mass production vehicles. The TEG involves not just materials but a multidisciplinary engineering team. The large team of expertise assembled showed the understanding of a team approach in this project.

Reviewer 4:

The reviewer noted that overall approach to overcoming the barriers is effective, since the project is fairly early on in the process it is critical to have a comprehensive approach to solving complex barriers. The reviewer said that as of now, the project foundation is in place to address the challenges; for these challenges have not been enacted, but appear feasible.

Reviewer 5:

The reviewer commented that this project has had significant problems in achieving any meaningful progress for several years. The presenter described that p-type materials have been and are still a problem for the project, where thermal and electrical interfaces and bonding and diffusion barriers are both a huge problem for the project. The project team did not properly anticipate the huge challenges they had and are having in these areas. The reviewer also expressed the need to know why this team had to go all the way to Fraunhofer Institute to do the required testing. The reviewer noted that there are plenty of other organizations in the United States that could have helped with that problem to solve these problems much quicker and more efficiently than this team started to realize.

The reviewer commented that the module fabrication and TE materials research has not been well-coordinated.

The reviewer added that this team is also not completely addressing the thermal system design. The presentation shows no results or indication of accomplishments in heat exchanger design, integration of the thermoelectric and heat exchanger sub-systems, and the necessary power electronics to control the TEG system power output to integrate it with the vehicle electrical systems. The reviewer stated that there is no mention of the thermo-structural analyses to identify thermally induced stresses in the TE modules, and within the overall TEG system. There seems to be no clear integration of these design efforts within the team, either by way of this presentation or the accomplishments from this and prior efforts.

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

Reviewer 1:

The reviewer said that this project showing of a Skutterudite device is really a big step forward. These devices are not available in commercial off-the-shelf (COTS) form, so it is a huge deal.

Reviewer 2:

The reviewer remarked that this project team understands the importance of scale-up. The large batch melt-spin of skutterudite and follow-on characterization are important steps toward large scale production of TEGs. The team recognized the significance of interface heat loss and its impact on system performance. Although a 3-5% fuel economy saving is achievable based on the selected materials, minimizing the temperature drop and heat loss will be the key to realize the potential energy conversion efficiency.

Reviewer 3:

The reviewer pointed out that, again, this project is fairly early on and there has not been time to address all of the barriers; however, for the barriers that have been addressed, there appears to be significant progress in module development and material selection.

Reviewer 4:

The reviewer remarked that this project is comparatively new. The team has done some work, though, in ZT measurements, vehicle platform selection materials fabrication and developing an understanding of issues (e.g., the role of interfaces), which is all good.

Reviewer 5:

The reviewer commented that, after five years working on this project, the project team has some accomplishments, but it has taken many years and many ineffectively used funds to show any significant progress. The team is still heavily involved with TE materials research to try to achieve project goals. The team presented limited system design and system test data, which makes is difficult to assess whether this design can achieve performance goals and calls into question the progress of this team in meeting its project milestones/deliverables.

The reviewer added that this GM team is finally (after five years) starting to get the TE device and system design information needed to be successful. However, the team did not demonstrate in this presentation how they are interpreting and using this data to achieve their system design. The team presented no evidence of an integrated thermoelectric-thermal-structural design approach to their TE module design or their overall TEG system design. The team did not discuss critical heat exchanger designs or simultaneously optimizing thermal system and thermoelectric system design.

The reviewer said that the team did not discuss within this presentation of system testing protocols, and is only just now looking into thermal design optimization within the TE sub-system design optimization process. The reviewer observed that this project discussed the need to provide 130 pound per square inch (psi) compression to produce the 7-8% TE conversion efficiency in the tested TE modules. This large pressure and module crush is an issue and how the team will respond to repeated thermal cycling under these rather large pressures is another issue. The team provided no discussion on how it would provide such high compression pressures in its design or the weight penalties associated with this design approach.

The reviewer also observed that this project presentation gave no discussion on the production yields to produce the good test results on the three modules that were actually tested. The presenter claimed that all the modules produced were within expected tolerances on alternating current (AC) resistance testing. The reviewer remarked that this, however, is not the only diagnostic metric to examine in evaluating a TE module's health and potential performance. The presenter provided no additional elaboration on TE module diagnostic monitoring.

The reviewer noted that the GM team indicated their analyses showed their TEG system would provide a 2.5-3.0% improvement in fuel economy using their TE materials as measured on their test stand. The reviewer observed, however, that the team’s power estimate was analytically derived at with no system testing data substantiating the power output required to produce that level of fuel economy improvement. There was also no comprehensive explanation of the team’s analytic approach or fuel economy improvement calculations. The reviewer stated that it is troublesome that the team’s fuel economy improvement levels are so far below DOE program targets and objectives and that GM should better explain these fuel economy estimates and how they are arrived at.

The reviewer pointed out that the project’s thermal stability of carbon nano-tube interfaces is not necessarily good at high temperatures. This instability is going to limit the long-term system performance in this system, but the team did not discuss how it would address that design problem.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that it appears that the project Marlow collaboration is really paying off.

Reviewer 2:
The reviewer noted that the largest team on TE devices is assembled in this project. The team’s work so far has shown a detailed evaluation and study on all aspects of building a TEG that is scalable.

Reviewer 3:
The reviewer observed that although it appears that not all partners are highly active at this point of the project, it appears the foundation and team that has been assembled for this effort is sufficient to accomplish the objectives. The reviewer states that the concern is about how the multiple material developers will be coordinating to ensure that there is not redundant work being conducted.

Reviewer 4:
The reviewer noted that the project is large with wide-ranging collaborations. The reviewer’s rating of fair speaks to a difficulty to understand specifically how the team is integrated, so that what they do fits into a needed piece of information to achieve the overall objective of an efficiency improvement.

Reviewer 5:

The reviewer observed that the project has a potentially strong team, but noted that it has many team members, which creates severe coordination and component and system design challenges for a TEG system and vehicle integration design, with as many multidisciplinary aspects as this project has. The project loss of GE Global as a team member was a huge setback. However, the reviewer commented that it is not clear how well-coordinated this team is. There is certainly is some on-going collaboration, but the team's progress has been painstakingly slow by any standard. The reviewer noted that this slow progress calls into question of how well the project system design will perform ultimately in satisfying DOE's program goals.

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

Reviewer 1:

The reviewer affirmed that the project team keeps up the good work.

Reviewer 2:

The reviewer observed that the range of future activities seem to be directed toward TEG development and improvement, selection of TE materials and targets of TEG performance, and etcetera. The reviewer commented that it was good to hear from the team and that this emphasis is only for the upcoming year of work. The reviewer pointed out that vehicle integration, experimental protocols to measure what is needed to determine an efficiency target, and etcetera, are important to consider in parallel with the listed future work.

Reviewer 3:

The reviewer commented that this project, based on the strategy laid out in the project, the proposed work for the next quarter appears to be logical and will be effective to complete a solid prototype system that will provide a portion of the fuel economy savings objective.

Reviewer 4:

The reviewer affirmed that the proposed future research tasks are following the original plan and focused on overcoming the technical barriers.

Reviewer 5:

The reviewer noted that the project's proposed future work basically appears to be a re-do of work that should have been completed in the prior DOE OVT Waste Heat Recovery project that GM led. The project currently plans to select its TE materials in the third quarter, which indicates that the team still has significant TE material challenges to overcome. The reviewer stated that once again, the project made painstakingly slow progress for such a team. DOE appears to be considering alternate development pathways, but they are slow in implementing them.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer pointed out that the project will have a positive impact on water-heat recovery, even if the miles per gallon (MPG) targets are not exactly met. The reviewer added that whatever the MPG improvement is averaged over millions of cars, it is a huge deal.

Reviewer 2:

The reviewer stated that this project is providing a practical answer of fuel economy improvement and directly supports DOE's petroleum displacement objective.

Reviewer 3:

The reviewer said that the thermoelectric technology is an approach to take energy that is wasted in the vehicle and recovered to increase vehicle fuel economy, which supports the overall DOE objective of petroleum displacement.

Reviewer 4:

The reviewer affirmed that this project is of course relevant to DOE's objectives. The reviewer stated that it was unclear how the various elements specifically addressed the 5% target. The reviewer provided as an example what specifically would allow reaching this target that is a current problem.

Reviewer 5:

The reviewer noted that it is quite difficult to ascertain whether this project is supporting DOE’s objectives, because so little system design information and so little information or backup data on fuel economy improvement projections have been provided in this presentation. In addition, all of the system design concerns discussed above call into question whether this project is supporting DOE’s objectives. The reviewer commented that, unfortunately, this reviewer cannot answer yes to this question based on this presentation and review.

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

Reviewer 1:

The reviewer observed that the resources from each partner are being utilized to make the project a success.

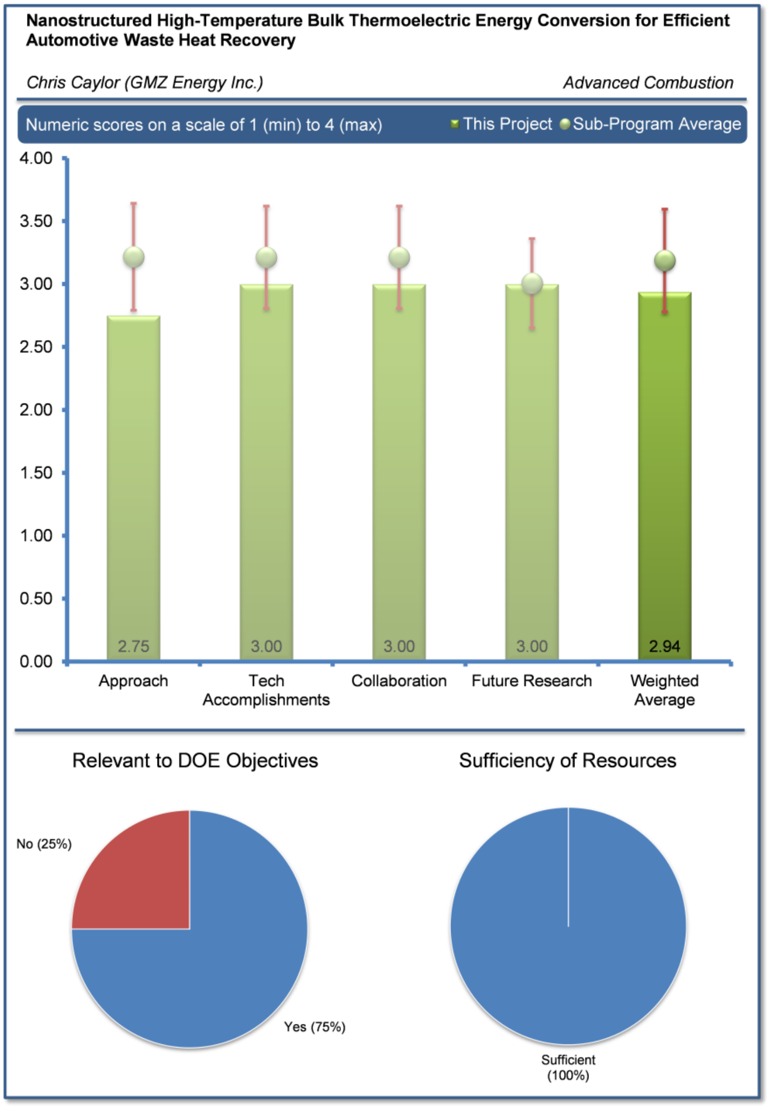
Reviewer 2:

The reviewer observed that the resources seem sufficient, but would prefer if GM had a higher internal investment to this area and not rely so heavily on the DOE. After all, it is GM that stands to gain profile, on the bottom line, as the ultimate outcome of this effort.

Reviewer 3:

The reviewer noted that while this project started in September, there has only been 4% of the budget expended to date. Based on the discussion, there appears to be sufficient resources for this effort. But cost and schedule are both risks this early on in a project and should be monitored closely to ensure that they stay at appropriate levels based on projected status.

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



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer affirmed that the approach is well-thought out and that its performance is admirable, commending it as an excellent project.

Reviewer 2:

The reviewer observed that the approach is good to achieve the DOE's program goals. The element of scale-up and mass production is not as strong. The reviewer noted that without a committed automotive partner, the approach must be very general.

Reviewer 3:

The reviewer stated that the TEG system to be developed will employ Half-Heusler materials in the first, high thermal (T) stage, and Bi_2Te_3 materials in the low T stage. The materials are nanostructured (Half-Heusler) with apparently low cost compared to competing materials.

The reviewer said that the effort includes materials production, device fabrication and testing, system level modeling, and a cost assessment. The TEG designs have also been developed based on a hermetically sealed configuration that integrates a multichannel heat sink with the TEG modules. Furthermore, the reviewer noted that vehicle testing is included to provide a baseline for fuel economy. The reviewer also noted that this vehicle testing is an activity that is crucial.

Reviewer 4:

The reviewer commented that this project is not particularly well-designed. This project is focusing on Half-Heusler (HH) materials in designing its TEG system. These TE materials were shown to have ZT values of approximately 1.0 and less at relevant temperatures by the GMZ Energy group, and this does not represent high material performance as claimed by the GMZ Energy team. The reviewer stated that there was little evidence presented that these materials perform at a high enough level to achieve DOE's targets. This team has shown that the material ZT temperature dependency exhibits a pronounced reduction at 300°C at ZT approximately 0.6. In fact, the reviewer noted that past experiences and knowledge of this reviewer and other performers on this DOE program would clearly indicate that ZT values of approximately 1.0 will not achieve a system design satisfying DOE's program requirements. No design information was presented by this project on how to deal with the rapid ZT degradation at temperatures that are still well within the required operating range associated with this automotive WHR application.

The reviewer went on to say that there was little evidence presented that this team is performing the needed thermoelectric design optimization and thermal system optimizations necessary to produce an effective design. The reviewer added that according to the presenter, the team has just now obtained some capability in its TE modeling and analysis software and algorithms.

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

Reviewer 1:

The reviewer observed that this is truly impressive, having gone from essentially a University-level demonstration of a nanostructured Half-Heusler device, to a working device having excellent performance.

Reviewer 2:

The reviewer affirmed that the project has used good approach to draw-on lessons learned from the WH1 teams. It is important that the team recognized both the material challenges and engineering challenges of building TEGs for mass production, and that the Half-Heusler (HH) material has shown great potential. The reviewer noted that the team's use of p-type materials still lags and could impact the overall system performance. If HH reduction could not achieve targeted ZT, the reviewer commented that an alternative approach will be helpful.

Reviewer 3:

The reviewer noted that GMZ Energy is now fabricating Half-Heusler hermetically sealed TEG modules, which is an interesting concept. The heat exchangers are a layered flat configuration, with plate fins in between, and the heat exchangers are hermetically sealed. The reviewer noted that the cost assessment was well done and found to be in the range of $4 per watt down to its $3 per watt target.

The reviewer added that the project group has also done actual measurements showing the influence of removing the alternator on a Chevy van. This activity will provide a baseline preformation target that TEG integration would work toward. The reviewer said that these sorts of measurements are crucial to assessing the performance of a TEG and benchmarking the results to know what the actual limits are.

Reviewer 4:

The reviewer pointed out that this project has demonstrated TE module efficiencies of only 4% at temperatures of relevance to this application. This is not high enough to produce enough energy to meet DOE's program goals, further verifying that that focusing on Half-Heusler materials alone will not achieve DOE's goals. There does not seem to be a strong plan on how their TE device and system design will produce enough power, 480 watt (W), to achieve even the modest light-duty fuel economy improvement targets the project team proclaims of 2.9%, which are well below the DOE's program goal of 5%. The reviewer stated that as a result, the project final fuel economy improvements will likely be much less than 2.9%.

The reviewer described that that this program is supposed to be a system design deployment program, but once again, this supposedly TE application program has morphed into focusing on TE material development. The team showed little or no thermal/TE design integration information or data. The reviewer added that the team did not discuss thermal interface challenges, and how the team is addressing and solving thermal interface challenges in either the TE device design or the TE system design.

The reviewer added that the team's presentation of the thermal cycling information was incomplete and did not give a strong sense on how the team's TE materials and modules will perform in the actual automotive waste energy recovery environments anticipated. In this automotive application, the devices could easily see nearly 1,000 cycles per year, and the 50 thermal cycles shown so far by this team is unimpressive. This reviewer recommended that more attention be paid to this derived design requirement.

The reviewer noted that the project is working on a sectioned TEG design whereby lower temperature Bismuth Telluride materials and modules would be employed in a downstream, in the lower temperature region of the exhaust stream, in order to recover more energy and increase power production. However, there was no design data presented on how the team was optimizing this sectioned design. The presenter indicated that the team was concluding that this downstream, lower temperature section was not cost-effective and was considering eliminating it. This reviewer simply believed that the team has not or cannot properly design or optimize such a design. Other teams on this program have shown this approach effective.

The reviewer noted that this project is working on mass production of TE modules. However, very little progress was demonstrated on that mass production. The reviewer opined that 15 modules per month was not impressive. That fact does not represent much progress toward the high volume production levels needed to support DOE's objectives.

The reviewer observed that the TE device encapsulation system design is not optimized, and the team has not quantified heat losses, heat transfer rates, or thermal fluxes for given encapsulation design, nor has the team addressed any design issues surrounding thermal interfaces associated with this design. The presenter indicated that this encapsulation design could potentially be dropped into existing TEG designs, and according to the reviewer that is simply not true. Finally, the reviewer stated the this project design information on the plate fin heat exchanger and pin fin heat exchanger design is quite simplistic. The team does not appear to have any type of sophisticated thermal design capability based on this GMZ team AMR presentation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that Robert Bosch is a major industrial partner for vehicle integration. ORNL is pursuing the dynamometer testing, Houston is working on materials development, and Boise State is pursuing heat exchanger design. The reviewer also noted that Honda is apparently also involved, but its contribution was not especially clear (e.g., Honda is providing an automotive OEM, commercial perspective on system cost and production volume, which seems a bit vague).

Reviewer 2:

The reviewer observed that the project team seems to have experienced multiple leadership changes. The reviewer noted that it is important to maintain the leadership role to make sure the project can be carried out with no major interruptions.

Reviewer 3:

The reviewer noted that there is some instability in personnel. The reviewer opined that it is fine that the work seems to be following the people, but there are inherent time delays and inconsistent focus on the work. In some cases, the people have left the field (Caylor) and no doubt that is a drag on progress. The reviewer affirmed that the project results are obtained on-time and are impressive. The reviewer was sure that it was not easy to attain these results.

Reviewer 4:

The reviewer noted that although the project does seem to have some on-going collaboration between partners, this team is the weakest of the three teams performing on this VTO WHR. There is no real strong TE design or thermal design partner on this team.

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

Reviewer 1:

The reviewer commented that the project will have a positive impact on waste-heat recovery even if the MPG targets are not exactly met. Whatever improvement is averaged over millions of cars will be a huge deal.

Reviewer 2:

The reviewer stated that the future research plan is good and that the project has met all the planned milestones.

Reviewer 3:

The reviewer noted that this future work will include pursuing a range of topics, including finalizing the heat exchanger for incorporation into a vehicle, vehicle testing with TEGs providing electricity to determine baseline performance metrics, a cost study for the materials and TEGs being developed, and partnering with TARDEC to integrate a TEG into a Bradley fighting vehicle. The reviewer pointed out that the inclusion of a study of bismuth telluride devices may not be advisable even though it is apparently proposed in the two-stage TEG devices. In the long term, tellurium will probably not be preferred in an automobile (e.g., rare earth, limited supply, etc.).

Reviewer 4:

The reviewer observed that there was no real discussion about how this team will overcome the performance weakness of the Half-Heusler TE materials. This team's continued focus on Half-Heusler materials, with no real plan to overcome its performance weaknesses, will not produce acceptable power production performance, eliminate performance barriers, or advance the program. The reviewer added that the proposed future work plan is sufficiently vague and that is it is unclear how this program will reduce the risks that this reviewer sees.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer notes that this project will have a positive impact on waste-heat recovery even if the MPG targets are not exactly met. Whatever improvement is averaged over millions of cars is a huge deal.

Reviewer 2:

According to this reviewer, the project is relevant to DOE's petroleum displacement goals.

Reviewer 3:

The reviewer affirmed that this project is highly relevant to DOE's objectives. The tasks are all directed toward developing the ingredients to allow evaluation and determination of the efficiency metrics of the TE integration. The reviewer added that the vehicle testing with and without TEGs to establish benchmarks is important.

Reviewer 4:

The reviewer elaborated that many of the reasons for arriving at this conclusion are stated above: focus on mediocre performing Half-Heusler materials; no plan to overcome Half-Heusler performance deficiencies in achieving the required power levels; little demonstrated progress on the system TE design, system thermal design, and multi-disciplinary integration; and serious TEG/thermal system design deficiencies.

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

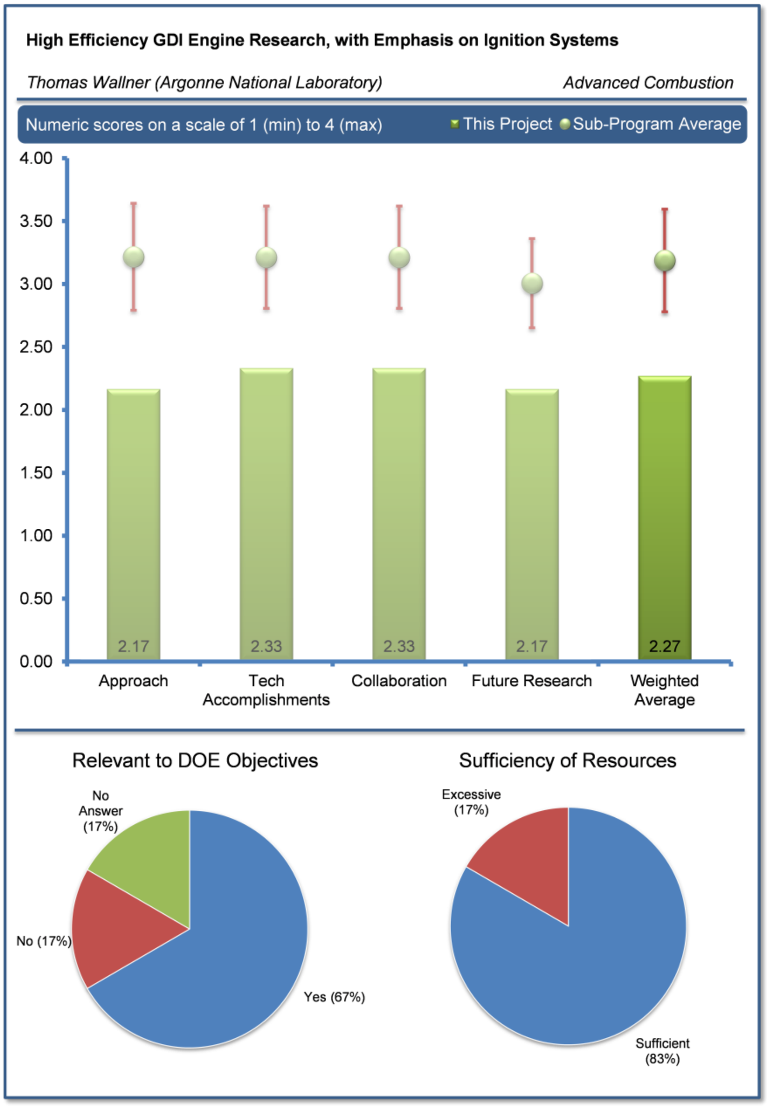
Reviewer 1:

The reviewer remarked that the project funding level seems sufficient for the tasks proposed.

Reviewer 2:

The reviewer observed that the project team is using sufficient resources from each member.

High Efficiency GDI Engine Research, with Emphasis on Ignition Systems: Thomas Wallner (Argonne National Laboratory) - ace084



Reviewer Sample Size

A total of six reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that the single-cylinder work and simulation is good. The reviewer was unsure whether there would be an optical dimension to this as well, potentially using Lyle Pickett's lab. The reviewer added that an optical dimension would make this project more valuable and provide more in-depth insights.

Reviewer 2:

The reviewer commented that the project focus is on two of three technical barriers, for example, the lack of systematic assessment of ignition systems and their potential in combination with lean/dilute combustion; and the absence of robust modeling tools. The approach to task is technically sound in general.

Reviewer 3:

The reviewer commented that the approach of an integrated assessment of combined effects of ignition system and combustion on engine efficiency and NOx seems reasonable. The reviewer noted that it is important to focus on aspects not already well investigated already by the OEMs.

Reviewer 4:

The reviewer commented that the project work is just starting. However, it seems that this work is focused on current technology and known approaches to extending the lean limit and EGR tolerance. The reviewer was not clear what new fundamental learning will result from this work.

Reviewer 5:

The reviewer observed that the approach involves using tools, methodology, hardware and concepts that industry is already familiar with and has been for about 15 to 20 years. This approach is very hardware and apparatus dependent and is best done on a competitive level by individual industrial entities and will offer little precompetitive knowledge.

Reviewer 6:

The reviewer observed that this project did not seem to present anything really new and unique, perhaps because of the team’s presentation style. The team’s approach for tackling lean burn GDI is fine, but it does not seem to be entering into a new area of understanding, for example, charge air motion, stratification, and etcetera are not really new areas.

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

Reviewer 1:

The reviewer noted that this project is only six months old so most of its accomplishments are related to engine setup, baseline testing and CFD tools validation for lean premixed combustion.

Reviewer 2:

The reviewer noted that this project is progressing with milestones: single-cylinder work established homogeneous lean combustion limit; 4% gain in indicated thermal efficiency (ITE); detailed chemistry CFD simulation yield good information on cyclic variability on intake flow; combustion simulation; quantify the ignition energy to be (current and voltage) 25 to 30 millijoule (mJ); and ignition system suppliers identified. The reviewer added that at this stage of the project, the team has made no significant progress towards any barriers.

Reviewer 3:

The reviewer noted that the engine is set up and running, but that no significant results have been shown thus far beyond what has been shown by other researchers doing like work.

Reviewer 4:

The reviewer remarked that again, the project work is just starting; however, to date, things that have been accomplished are fairly routine characterizations and analysis. It also seems that the results will be dependent on the engine configuration being used. The reviewer added that it seems that the team is not going to investigate anything particularly novel in terms of ignition systems, and perhaps laser ignition systems applied to smaller engines could be considered new.

Reviewer 5:

The reviewer observed that some relevant engine data has been obtained, but that this data is of little or no value. The reviewer noted that the team has not yet studied any effects of ignition energy or ignition concept. The effect of swirl plate position is very hardware dependent and does not offer value out of its local context. The reviewer noted that the same is true of the team’s CFD calculations.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

According to this reviewer, the project demonstrates good collaborations with industry and with universities and DOE labs.

Reviewer 2:

The reviewer noted that the collaboration on this program is good, and meets the program needs.

Reviewer 3:

The reviewer remarked that the project had very limited collaborations. The reviewer pointed out that the team could partner with Lyle Pickett as one option to improve this communication, adding that it would be good for the team to acknowledge other research in this field, and potentially gain additional partners. It would also help the project to focus this work on areas that are fruitful and have not already been explored.

Reviewer 4:

The reviewer commented that some collaboration exists. However, the reviewer added that collaborations should be established with organizations that have prototype laser ignition or other novel ignition systems. The reviewer also pointed out that the effect and value of conventional inductive or capacitive ignition systems is well-known and need not be revisited.

Reviewer 5:

The reviewer noted that this collaboration seems to be mainly with the participants. The reviewer opined that it would be nice if a metric of the level of interest from the community at large could be shown.

Reviewer 6:

The reviewer remarked that the number of collaborations seems limited, primarily restricted to obtaining some equipment from Ford and Altronic and some input, with no real details given, from ACEC members.

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

Reviewer 1:

The reviewer affirmed that the planned assessment of directed energy ignition system (DEIS) system and laser ignition seems to be the logical path.

Reviewer 2:

The reviewer said that the future research plans seem reasonable.

Reviewer 3:

The reviewer commented that only laser or other novel ignition systems should be pursued. The reviewer noted that a spray guided combustion system is also very hardware dependent and should not be entertained within the scope of this project as it will defocus from the main ignition system part of the project.

Reviewer 4:

The reviewer noted that the project should be clear about what innovative approaches will be used in this program. The laser ignition source is interesting, but even that is not really ground breaking. The reviewer would like to see something added to really try and advance the state-of-the-art, either in the approach or improving the understanding of how/why the combustion behaves as it does.

Reviewer 5:

According to this reviewer, the project appears to lack of originality in its work. If this project is to be successful, Thomas needs to explore something new and unique in his work.

Reviewer 6:

The reviewer commented that the project does not seem to have planned any novel future research.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that GDI lean-burn combustion is a growing trend in reducing fuel consumption, which is DOE's objective. The reviewer added that a robust ignition system for such a combustion concept is essential.

Reviewer 2:

The reviewer noted that lean burn GDI SI engines have the potential to improve fuel economy which leads to lower petroleum-based gasoline consumption which is in line with DOE’s goals.

Reviewer 3:

The reviewer was unsure.

Reviewer 4:

The reviewer commented that the research is relevant, but the relevance of the current plan is questionable.

Reviewer 5:

The reviewer pointed out that the bulk of what the project has planned and what has been accomplished is ground that has already been ploughed.

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

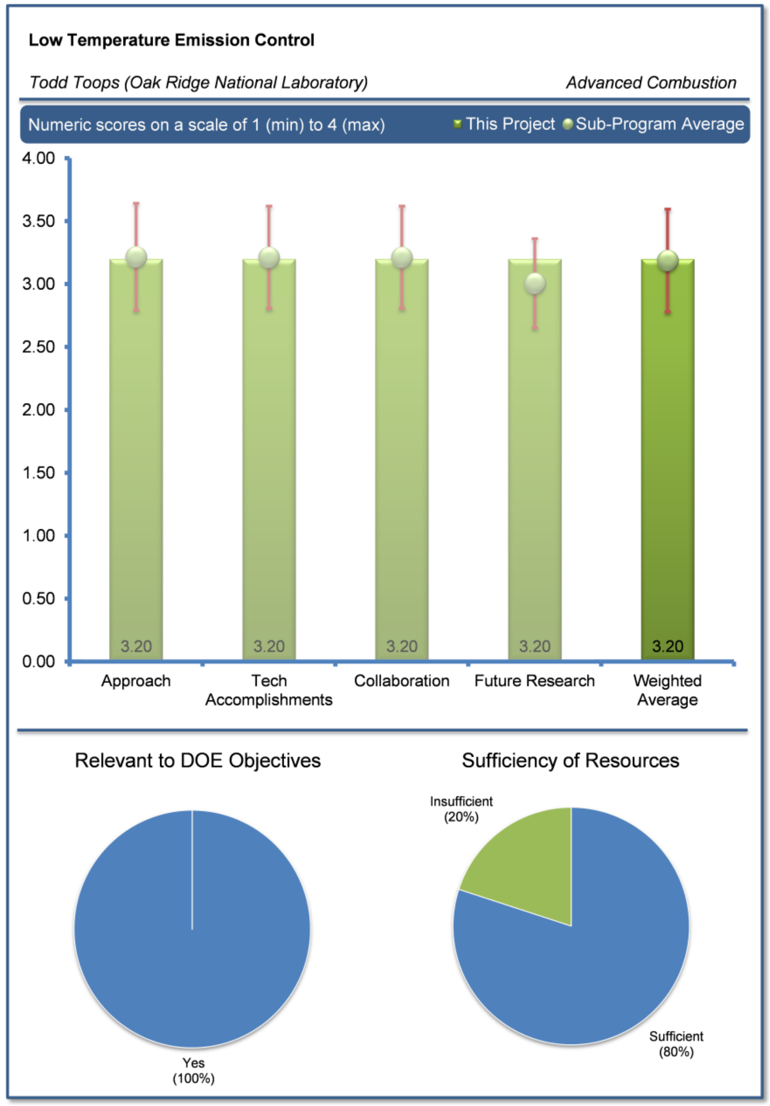
Reviewer 1:

The reviewer affirmed that this project funding is sufficient for the moment. The reviewer expressed that there is a need to give Thomas another year to prove that he can find something new and unique. If he cannot do this in the coming year, the reviewer recommended a reduction in the project funding.

Reviewer 2:

The reviewer stated that unless this project is redirected in a major way, this project should not be continued to be funded.

Low Temperature Emission Control: Todd Toops (Oak Ridge National Laboratory) - ace085



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

This reviewer expressed that it was very good to see that low temperature technologies are being actively pursued to deal with more efficient engines and Tier 2 Bin 2 emissions standards. The reviewer stated that this is a necessary and critical area for future aftertreatment development. This reviewer expressed an interest in knowing why the researchers chose CO instead of HC or NOx as the team's first area to explore in the low temperature area. Most of the industry need is in the area of HC and NOx remediation, however, this interesting novel approach is worth exploring further in combination with other PGM metals.

Reviewer 2:

This reviewer stated that collaboration with DOE BES to translate fundamental science to useful, applied systems is a great example of an integrated approach. The approach is definitely contributing to the knowledge base on catalysis, and hopefully, in turn, the project will contribute to overcoming the low temperature activity barrier.

Reviewer 3:

This reviewer observed that the approach is ideal; the idea is to bring the results from BES-funded project to the vehicle level catalyst technologies with required elements such as sulfur and hydrothermal aging requirement. However, using gold (Au) as a commercial catalyst may not be practical as the cost impact will be big.

Reviewer 4:

This reviewer thanked the project team for listening to the ACEC and the goal of 90% conversion at 150°C. The reviewer added that the project had good alignment with BES for new materials. At first, the reviewer wondered why there should be concern about low temp CO oxidation, but upon further contemplation, expressed that it would be good to remove CO as interference to other light off reactions. In addition, the reviewer pointed out that there should be more emphasis placed on realistic aging.

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

Reviewer 1:

This reviewer stated that, especially considering a lot of the initial work was unfunded, there has been exceptional progress.

Reviewer 2:

This reviewer expressed a need to forward to future results from this project.

Reviewer 3:

This reviewer said that there was very good technical progress, for just starting the project. It is important to recognize early on, through appropriate testing, to determine the viability and limitations of the technology. The reviewer remarked that if a technology is poisoned by HCs in an exhaust stream, then it severely limits its applications. The reviewer added that HCs and NOx activity at low temperature is more critical than CO.

Reviewer 4:

This reviewer pointed out that it may be too early to make judgment, as the project just started a few months ago. However, the evaluation condition and durability measurements need to be scoped appropriately.

Reviewer 5:

This reviewer commented that the catalysts studied show promise in increased durability and effective conversion at low temperatures, but challenges remain.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that this is one of very first attempts to work with the BES Community, and the project will be a great synergy if coordinated right.

Reviewer 2:

This reviewer observed that the project had active collaboration with basic energy sciences researchers, CLEERS, USCAR and U.S. DRIVE.

Reviewer 3:

This reviewer stated that all the ORNL projects have a sharp focus on the industry goals and nice collaboration with other researchers.

Reviewer 4:

This reviewer observed that the project collaborations with U.S. DRIVE, including OEMs and Tier 1 suppliers, will be the key in moving forward with this work.

Reviewer 5:

This reviewer stated the project consisted of mostly internal ORNL activity, and asked if the project had any partnerships.

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

Reviewer 1:

This reviewer said for the project team to keep up the good work.

Reviewer 2:

This reviewer remarked that the future work is sharply focused on the low-temperature catalysis that will be the key to enabling future research.

Reviewer 3:

This reviewer observed that the project had a very well outlined, vehicle level, and validation plan.

Reviewer 4:

This reviewer stated that this was the first year of this project and future work seems appropriate.

Reviewer 5:

This reviewer commented that the project team must know the operating conditions and limitations of the Au and copper (Cu) system better, and in combination with Pt and Al_2O_3. The reviewer added that if HC poisoning will be an issue, it will limit its usefulness.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer pointed out that low temperature emissions control technologies are greatly needed to meet future emissions standards and to enable more efficient lean GDI engines.

Reviewer 2:

This reviewer stated that low temperature catalysts will be the key to enabling novel efficient combustion strategies.

Reviewer 3:

This reviewer indicated that this project is very important for low temperature aftertreatment that harmonizes the advanced combustion.

Reviewer 4:

This reviewer said that improved engine efficiency leads to lower exhaust gas temperatures, which causes issues for effective emission control. The reviewer added that this project investigates aftertreatment technologies for low exhaust gas temperature operation.

Reviewer 5:

This reviewer remarked that aftertreatment that is active at lower temperatures is going to be needed for highly efficient powertrains.

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

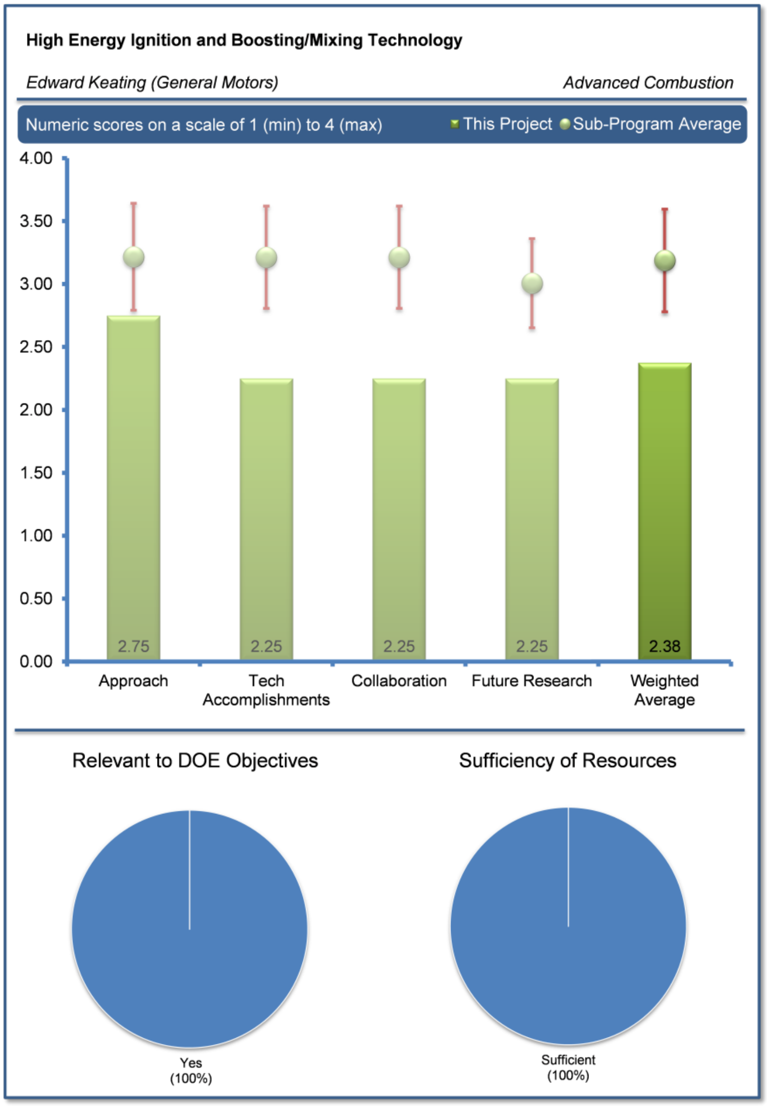
Reviewer 1:

This reviewer commented that low temperature materials are a broad research area that will require additional funding to support a larger effort to pursue these materials and technologies.

Reviewer 2:

This reviewer observed that the project has had impressive work to date considering this started as unfunded work. The reviewer added that the project team did an excellent job in leveraging DOE/BES resources.

High Energy Ignition and Boosting/Mixing Technology: Edward Keating (General Motors) - ace086



Reviewer Sample Size

A total of four reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed that this project plans to evaluate a plan to achieve high efficiencies by using boosting, high levels and EGR and improved ignition system. A clear path to implementation and success is somewhat muddled per the presentation. However, it merits pursuing due to the novelty and difference from other efforts.

Reviewer 2:

This reviewer stated that it is good to have a vehicle manufacturer assess the viability of this novel concept being pursued at Southwest Research Institute (SWRI).

Reviewer 3:

The reviewer stated that this is an enabling technology project and not a full vehicle system development. The reviewer added that the ignition system and dedicated-Exhaust Gas Recirculation (D-EGR) technologies are interesting and have high potential. The reviewer indicated that this is known from a number of presentations and public papers from the SWRI High-Efficiency Dilute Gasoline Engine (HEDGE) program. The reviewer indicated that it is unclear why the DOE needs to carry this this next step to commercialization. The reviewer noted that there is limited new discovery and technology development in this project.

Reviewer 4:

The reviewer stated that this project aims to improve fuel efficiency by the application of advanced ignition systems and boosted combustion. While technically, the project’s plans may address barriers, the approach taken appears to be inconsistent with the purpose of a publically-funded project. Specifically, the reviewer said it appears that GM is subcontracting the majority of the work to SWRI and pursuing only technology evolving from SWRI's consortium. Thus, it is not clear why DOE funding is need to perform such tech transfer. Furthermore, the reviewer indicated that some questions were not addressed based on proprietary limitations from GM's involvement in the consortium. Thus, the reviewer added that there are concerns about intellectual property limiting the benefits from this project to the public research community.

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

Reviewer 1:
This reviewer pointed out that the project was a recently awarded (i.e., July 2012). So far the baseline engine tests with cooled EGR and an improved form of ignition have been conducted. The reviewer commented that in the future, the presenter should share a table that gives a timeline of different phases of the program.

Reviewer 2:
This reviewer stated that it is still early in the project and the accomplishments were planning and evaluation.

Reviewer 3:
The reviewer said that the project has taken steps to make the D-EGR more robust and controllable.

Reviewer 4:
This reviewer noted that the project is in the beginning stages and that there is not much to evaluate the project on in this category yet.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer indicated that this work is between SWRI and GM. However, the other members of the consortia at SWRI are also considered as part of the collaboration, so the learning gained in this project should be disseminated within that group.

Reviewer 2:
This reviewer observed that SWRI has developed most of the concepts proposed under this effort under the HEDGE program. The reviewer added that SWRI is an ideal partner with GM to evaluate these concepts.

Reviewer 3:
This reviewer stated that SWRI seems to be doing the project and that there is too much overlap with HEDGE.

Reviewer 4:
This reviewer stated, as mentioned in the approach section, GM is utilizing only one primary subcontract, and that is SWRI, which has already pursued these technologies via industry consortia. Given that, the reviewer asked what additional benefits this project will provide in technology advancement. The reviewer added that it would be much better if a university or National Laboratory partner was involved. Then, further research could be applied to the SWRI technologies with potential to either better understand the technologies or advance the technologies with the aid of experts external to the original development team.

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

Reviewer 1:
This reviewer noted that the program appears to be on track in terms of planned modifications and the effort to incorporate this concept into a vehicle.

Reviewer 2:
This reviewer said the pursued effort follows a logical train of thought.

Reviewer 3:
This reviewer opined that future work should be more focused on a vehicle demo and full transient dynamometer (dyno) evaluation, yet appears to be repeating part of HEDGE in a different engine, which is not a criticism of GM.

Reviewer 4:

This reviewer indicated that the future research plan does not include any new technology tasks or collaborators that can further develop the technologies beyond the progress already made by SWRI.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer stated that if successful, the approach can lead to improved fuel efficiency via the advanced combustion proposed.

Reviewer 2:

This reviewer said the technologies have potential for fuel savings.

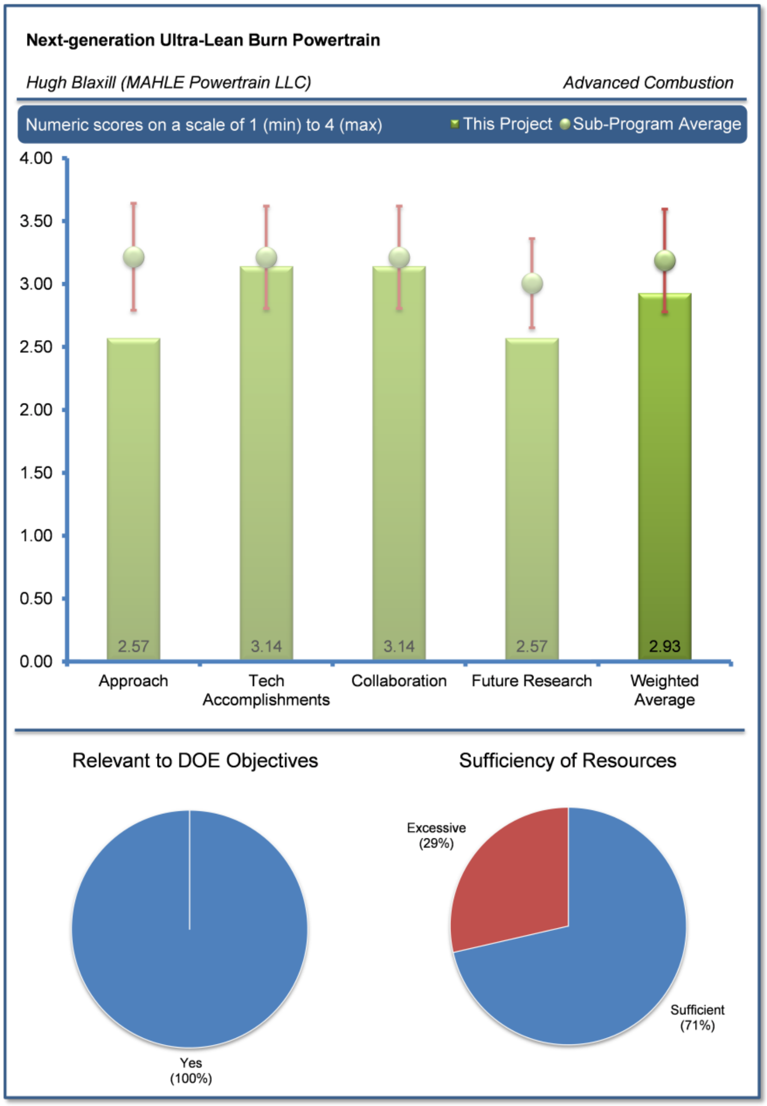
Reviewer 3:

This reviewer observed that the proposed concepts may offer fuel savings through improved engine efficiency. However, high levels of EGR will reduce engine specific power and improved boosting may not be sufficient for typical vehicle use. The reviewer added that future efforts need to address this issue along with efficiency improvement and emissions reduction.

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

No comments were received in response to this question.

Next-generation Ultra-Lean Burn Powertrain: Hugh Blaxill (MAHLE Powertrain LLC) - ace087



Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

This reviewer observed that this project had interesting enabling technology. Not the first time a pre-chamber has been attempted, but preliminary results published last year were promising. This reviewer indicated that some work and reports on this technology pre-date the contract start. The reviewer also said that this project is a good contribution in optical engine studies and that it appears boosted engine work will be new data compared to prior work.

Reviewer 2:

This reviewer remarked that the approach is good. However, the reviewer expected some issues and the program should address issues such as: low temperature cold start, which has been problematic for previously proposed pre-chamber systems; heat losses where pumping hot gas, whether flaming or just hot, through orifices with enough velocity to make ignition jets is bound to cause high heat transfer. A careful heat balance needs to be done, as the reviewer asked if the system fuel efficiency gains enough to offset increased heat loss to coolant; similarly, forming jets requires pumping work to be done on the gasses. The reviewer commented that a careful thermodynamic analysis is needed. If the engine runs ultra-lean, then the residual gas trapped in the pre-chamber may be mostly air, and adding fuel may achieve stable ignition. The reviewer added that under conditions like higher or lower load and cold start when main chamber mixture cannot be that lean, the high residual content in the pre-chamber may cause problems.

Reviewer 3:

This reviewer stated that this team is investigating the use of fueled pre-chamber with an objective to achieve 45% engine efficiency. With the use of pre-chamber, high velocity combustion jets issue into the main chamber and ignite an overall lean fuel-air mixture. The reviewer added that such an arrangement for ignition offsets the reduction in flame velocity, thereby enabling the use of ultra-lean mixtures, and hence higher engine efficiency.

Reviewer 4:

The reviewer thought that this turbulent jet ignition approach has potential to impact fuel consumption by enabling lean combustion. There are several challenges that will need to be overcome to achieve impact. The reviewer noted that one current weakness is the lean limit anticipated by the technique (lambda equals 2.2), which is not much leaner than what conventional ignition approaches can achieve for (DI systems. A leaner combustion goal may be more appropriate or, perhaps if the NOx emissions are lower with this approach, versus lean stratified GDI, and then more data demonstrating that would be good.

The reviewer said additional experimental approaches are recommended as well. While the optical engine and CFD tools are valuable for this project, the project needs further application of research tools to characterize the internal jet pre-chamber and in-cylinder exhaust chemistry and net air to fuel ratio (AFR). Likewise, the reviewer said that the engine out emissions characterization would be beneficial to characterize any benefits compared to more conventional ignition approaches. The reviewer noted that it is recommended to add these tools to further characterize the complex processes occurring and to validate CFD results.

Reviewer 5:

This reviewer thought that the jet injector pre-chamber design is novel and claims to have significant advantages such as being able to run lambda 1.0 (stoichiometric) at wide open throttle (WOT) or full load with less spark retard and power enrichment (PE). The reviewer stated this could be interesting in that downsized engines running at full spark and at lambda 1.0 at WOT may provide fuel economy benefits from significant downsizing. Typically, power enrichment (rich Air Fuel Ratios 11:1-13:1) is needed to protect engine hardware. This reviewer added that the data presented to justify this approach is not compelling. This reviewer stated that more detail on the hypothesis would be helpful for higher marks. Additionally, the reviewer expressed some concerns with cold start and warm-up operation as well as emissions with pre-chamber from many years of industry experience. If initial experiments are promising warm, cold start performance must be added to the approach.

Reviewer 6:

The reviewer opined that this is a been-there-done-that approach. The reviewer stated that all the OEMs and just about everybody else has tried some variation on jet ignition for ultra-lean mixtures. There was no real identification of anything new in this approach.

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

Reviewer 1:

This reviewer thought that the progress on optical engine and modeling work are excellent.

Reviewer 2:

This reviewer said that it is early on in the project and that there was good progress to date.

Reviewer 3:

This reviewer indicated that there is good progress in the initial phases of this work particularly related to the optical engine and CFD work. This reviewer added that advancements in progress related to understanding the AFR and chemistry in jet are needed in the next phases of the studies.

Reviewer 4:

This reviewer said that the initial results show expected pre-chamber results.

Reviewer 5:

This reviewer commented that the project is just getting underway and that no quantitative performance data was presented.

Reviewer 6:

This reviewer observed that the team appears to be making steady progress per the proposed schedule. However, with the data presented so far, undue importance was given to optical engine testing. The reviewer indicated that the pre-chamber geometry optimization could have been performed with just tests on a thermodynamic engine and by using CFD simulations. Other combinations of ignition technologies that ignite lean mixtures and piston designs that improve turbulence at the end of the compression stroke could have been tested instead.

Reviewer 7:

This reviewer opined that the accomplishments were nothing special, except there was a lot of hardware building. The reviewer stated that perhaps the six jet pre-chamber injection system is new, but the reviewer is not sure that it is a particular technological accomplishment.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer said the project had excellent collaborations and interested parties.

Reviewer 2:
This reviewer said the project team was a comprehensive team and that there was not much to improve on in a project on enabling technology.

Reviewer 3:
This reviewer expressed that the team members complement each other's capabilities to result in a high quality program with a tangible hardware deliverable, and that there is also benchmarking of the potential gains associated with that technology through tests and CFD simulations.

Reviewer 4:
This reviewer pointed out that this project seems to be primarily an in-house effort, with engine help on components from Ford and Delphi, which seems like a reasonable approach.

Reviewer 5:
This reviewer indicated that there were lots of subcontractors for this project.

Reviewer 6:
This reviewer indicated that collaborations with Ford and Delphi appear valuable. However, it is unclear what contributions are being made by WERC.

Reviewer 7:
This reviewer expressed a need to see more university collaboration, where WERC is a consulting firm.

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

Reviewer 1:
This reviewer observed that there was a reasonable transition from single-cylinder to multi-cylinder. However, there was very limited data provided to justify future work.

Reviewer 2:
This reviewer said that the experiments and studies in boosted engines will be important contribution and expansion of knowledge. The reviewer added that the project team needs to consider or discuss costs.

Reviewer 3:
This reviewer said that previous work performed in (stationary) natural gas engines has resulted in the use of a non-fueled pre-chamber that offered similar results but with far simpler hardware complexity. The reviewer stated that it is worth the effort here to conduct tests comparing the performance of a non-fueled pre-chamber with a fueled pre-chamber.

Reviewer 4:
This reviewer indicated that the plan seems to be appropriate to define normal operating modes like FTP. However, the reviewer thinks there are more severe conditions like very cold starting that may make the concept unworkable; the work plan needs to address such issues.

Reviewer 5:

The reviewer commented that at this stage, the project appears too narrow in the approach for the next phases of the project. The reviewer pointed out that it appears that more research will be needed in the next phases to better characterize and understand the jet chemistry issues to maximize the feasibility of this approach. The reviewer recommended adjusting the proposed next steps to include more research versus the proposed development and testing.

Reviewer 6:

This reviewer expressed that the project is just moving along in a predetermined direction with no clear indication that there is anything new in the approach.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer indicated that the technology being developed in this project can potentially increase the efficiency of light-duty gasoline engines to 45% from the current level of 36%. In other words, the improved engine efficiency facilitated by this technology supports the DOE objective of decreasing gasoline consumption.

Reviewer 2:

The reviewer noted that this project has good potential enabling technology for dilute combustion engines.

Reviewer 3:

This reviewer commented that significant downsizing and related fuel economy benefit may be possible if WOT lambda 1.0 can be achieved at full spark advance and no cold start issues. The reviewer added that this project could be an enabler for dual fuel applications as well with a very controlled pilot.

Reviewer 4:

This reviewer stated that if the project works, the project would be a contributor to a very lean and therefore high efficiency engine.

Reviewer 5:

This reviewer said the project aims to enable lean combustion which can reduce petroleum use.

Reviewer 6:

The reviewer expressed that a project is only relevant if there is something new. The reviewer commented that there is not anything new in the presentation.

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

Reviewer 1:

This reviewer commented that the resources are sufficient for the initial evaluation and that more funding may be needed if initial results are promising.

Reviewer 2:

The reviewer noted that this seems like appropriate funding, although more might be needed to cover the expanded boundary conditions that the reviewer thinks are important.

Reviewer 3:

This reviewer pointed out that the resources at this stage are sufficient. However, the optical engine appears to have adsorbed most of the resources; other diagnostics related to plume and engine out emission characterization would be valuable to add.

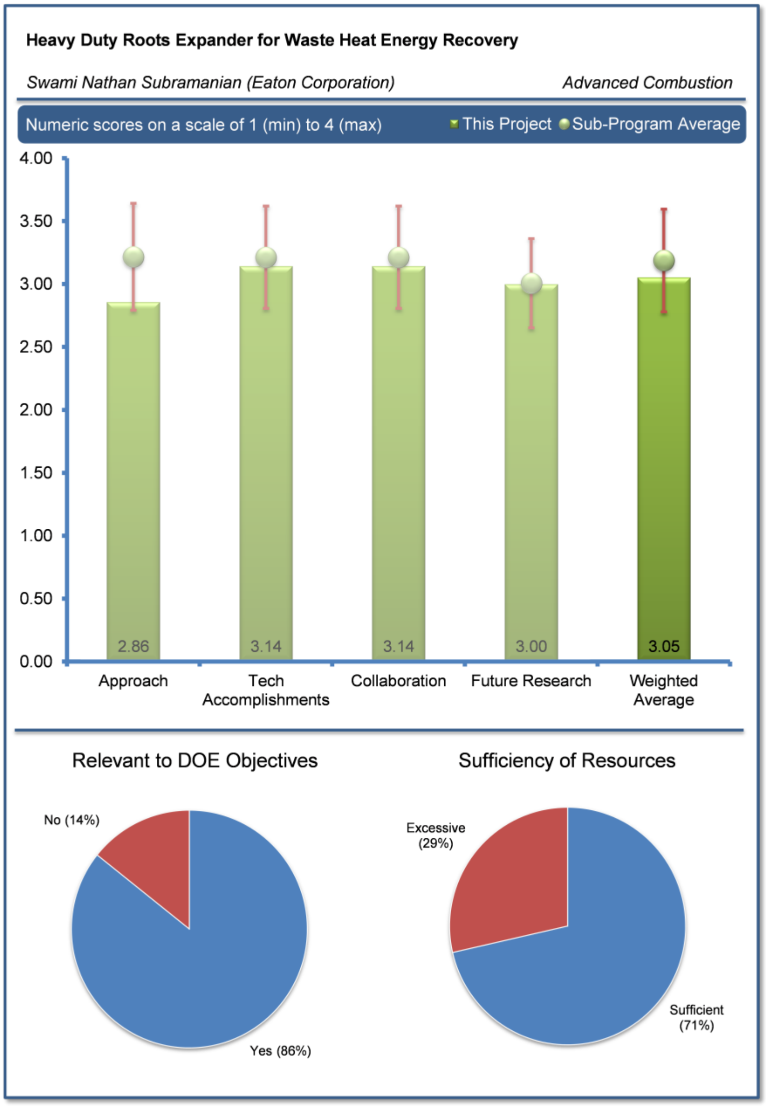
Reviewer 4:

This reviewer expressed that the project received a lot of money to build engines without any clear, unique application.

Reviewer 5:

This reviewer observed that the allocated funds are somewhat excessive. The reviewer added that the insight obtained with the optical engine development and tests yielded very little information. The pre-chamber geometry optimization could have been performed without this task being performed.

Heavy Duty Roots Expander for Waste Heat Energy Recovery: Swami Nathan Subramanian (Eaton Corporation) - ace088



Reviewer Sample Size

A total of seven reviewers evaluated this project.

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

Reviewer 1:

This reviewer said that this appears to be a very well developed commercial development project. The reviewer lauds Eaton for putting this together. This reviewer added that the project has a solid chance of success and that the project is weak on safety technologies for a catastrophic event.

Reviewer 2:

This reviewer observed that the project had a very good technical approach with simulation and planned experiments. A comparison of cost and performance with other types of expanders would have been beneficial.

Reviewer 3:

This reviewer stated that given the initial assumption that the roots device is the right one, this seems to be a good approach to configuration and design.

Reviewer 4:

This reviewer pointed out that the project is in the beginning stages, but there are plans for the approach to achieve potential benefits relative to more conventional approaches. Specifically, the Roots Expander can potentially offer greater efficiency and the ability to manage multiphase flow.

Reviewer 5:

This reviewer observed that the basic idea of using Rankine Cycle, to harvest waste heat and transform it to useable shaft power, is being pursued by various companies. However, the present effort aims to develop a novel Roots expander which has the primary advantages over the other competing technologies of operating at 10-times lower speeds, and having the capability to withstand two phase flow during the expansion process.

Reviewer 6:

This reviewer indicated that it was a good approach to make use of expander, but it seems that the decisions regarding materials selection and working fluid selection are not quite as fully developed as they could be yet. In particular, the reviewer expressed concern about the ethanol (EtOH)/oil separator for which no details were given.

Reviewer 7:

This reviewer thought that the re-use of roots blower in reverse is a creative idea. However, significant concerns arise relating to applying an air based system to exhaust gas. The reviewer indicated that the main re-use is engineering for flow across the device. The materials, bearings, seals all need to be re-evaluated and re-designed. The reviewer said that the project must at a minimum compare the proposed device to other current solutions in terms of cost, weight, complexity, functionality, and packaging. The reviewer stated that one of the key attributes must be that there is an advantage to pursue a roots expander. These attributes were not conveyed clearly. Also, the reviewer thought that the project should have considered leveraging the other SuperTruck evaluations of WHR for modeling effort and may still consider plugging in roots type expander to other models. The approach should discuss design changes needed if working fluid were changed in the future. Additionally, the reviewer said the design does not have to accommodate other fluids, but could package protect for other possibilities.

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

Reviewer 1:

This reviewer expressed that the approach that is being followed is very logical, and the progress is on schedule. Through engine tests, the base engine performance was established and potential available energy in the EGR stream and in the exhaust streams was estimated to result in appropriate estimates for the size of the roots expander. The reviewer indicated that these estimates were further substantiated through 1-D computer simulations. A prototype expander was designed and built. The reviewer added that problems associated with sealing, high roots impeller mass, etc., were adequately addressed though design innovations. This reviewer indicated that the prototype single-stage expander will be integrated with an engine and tests will be conducted as a part of future effort.

Reviewer 2:

This reviewer commented that this project appears to be well on its way to producing a quality product.

Reviewer 3:

This reviewer remarked that the project was a very comprehensive analytical exercise. The reviewer said the project had a good start on hardware design and development. The reviewer added that multiple expander stage design is good.

Reviewer 4:

The reviewer was not completely sure how much is simulation and how much is test result. The reviewer added that it seems that there are good preliminary results in the first program year.

Reviewer 5:

This reviewer observed that the initial progress of the project has focused on analytical and design studies. The reviewer added that the progress is fair at this stage, with more progress expected in the next year with prototype building commencing.

Reviewer 6:

This reviewer said that there was good progress to perform modeling and initial prototyping of single stage device. The reviewer also stated that there are concerns with using engine oil and ethanol oil separator. The reviewer recommended using separate lubrication loop, and to consider alternate designs as risk to engine oil is a significant concern. It is understood that the additional complexity and losses of a separate pump will reduce the value of the system.

The reviewer is unsure about the increase of EGR from base engine calibration for WHR efficiency. The reviewer inquired whether it was possible to increase EGR on the base engine without WHR, or is the presence of the WHR improving EGR tolerance in some way. Also, the reviewer expressed surprise to find NOx and HC improvement with exhaust restriction. Understanding the mechanism causing this improvement is important.

Reviewer 7:

The reviewer stated that there are insufficient details to fully assess progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer indicated that each of the team partners' expertise is being adequately leveraged to result in a high quality product.

Reviewer 2:

This reviewer said the project has solid collaboration with partners, especially John Deere.

Reviewer 3:

This researcher remarked that collaboration with an engine manufacturer, John Deere, is good. Also, collaborations with Modine and seal suppliers are notably valuable.

Reviewer 4:

This reviewer commented that excellent for credibility is the identification of a good cross section of partners and their roles, with the inclusion of key suppliers, which are not necessarily official project partners.

Reviewer 5:

This reviewer said the project had a very complete and comprehensive team. The reviewer said that a possible improvement would be adding an on-highway engine OEM.

Reviewer 6:

This reviewer said there seems to be an appropriate choice of suppliers and that it is not clear how integrated they are in the design process.

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

Reviewer 1:

This reviewer said that the proposed future research was an overall solid plan and has some go/no-go points.

Reviewer 2:

This reviewer indicated that the project is on track to a decision point in 2015 for a possible commercial product. The reviewer believed that this is an acceptable timeline.

Reviewer 3:

This reviewer said the future plans are well established at this early stage in the project.

Reviewer 4:

This reviewer indicated that the project had a solid approach to the design and evaluation of this device.

Reviewer 5:

The reviewer observed that the base engine used is one typical of off-road equipment and as a result steady-state tests are being conducted here. This reviewer added that it may prove effective to evaluate the performance of the roots expander for vehicular application by performing some transient tests.

Reviewer 6:

This reviewer stated that the future research plan is reasonable. The reviewer indicated that the plans to lightweight and harden first prototype design and to develop multistage system is good. Also, the project should include alternate lubrication schemes and be sure to show concept selection approach. The complexity and content of multistage system is very high. The reviewer pointed out that there is a need to provide some kind of value proposition and advantages for roots design over other designs. The reviewer asked if the balance of the system is made simpler/less-costly at all with roots expander. The reviewer commented that the project should provide some idea about benefits of a roots type expander and system as well as cost or at least cost target range.

Reviewer 7:

This reviewer had concerns about the oil/EtOH separator. The reviewer would like to know which direction (or both) is the separation. This does not seem trivial and could be a big deal for the lubricating oil if there is residual ethanol.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said WHR for Class 8 trucks and associated 6% estimated fuel economy improvement, if realized and implemented, can provide significant petroleum reduction potential for Class 8 trucks which consume 17-20% of the fuel for Medium duty/Heavy duty trucks in the United States.

Reviewer 2:

This reviewer commented that this project could contribute to several of the SuperTruck programs since several are using EtOH fluid WHR systems.

Reviewer 3:

This reviewer indicated that the project addresses WHR technologies, which are a worthwhile approach to reducing petroleum displacement by recovering heat energy in the exhaust that would otherwise be wasted to the surrounding atmosphere.

Reviewer 4:

This reviewer stated that this project would be stronger with an OEM that is a premier on-highway manufacturer. The reviewer added that it was good to see projects pertaining to HD trucks.

Reviewer 5:

This reviewer expressed that there are a number of commercial entities attempting to commercialize Rankine WHR. The reviewer asked why not let the market take care of this development.

Reviewer 6:

This reviewer indicated that the proposed invention could potentially improve the efficiency of diesel engines by 5-6% thereby reducing our petroleum consumption significantly.

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

Reviewer 1:

This reviewer observed that at this stage, the resources are appropriate.

Reviewer 2:

This reviewer said that the allocated funds are sufficient.

Reviewer 3:

This reviewer said that there are generous resources for project objectives.

Reviewer 4:

This reviewer stated that the total resources seem appropriate. The reviewer noted that it was surprising that DOE accepted much less than 50/50 matching.

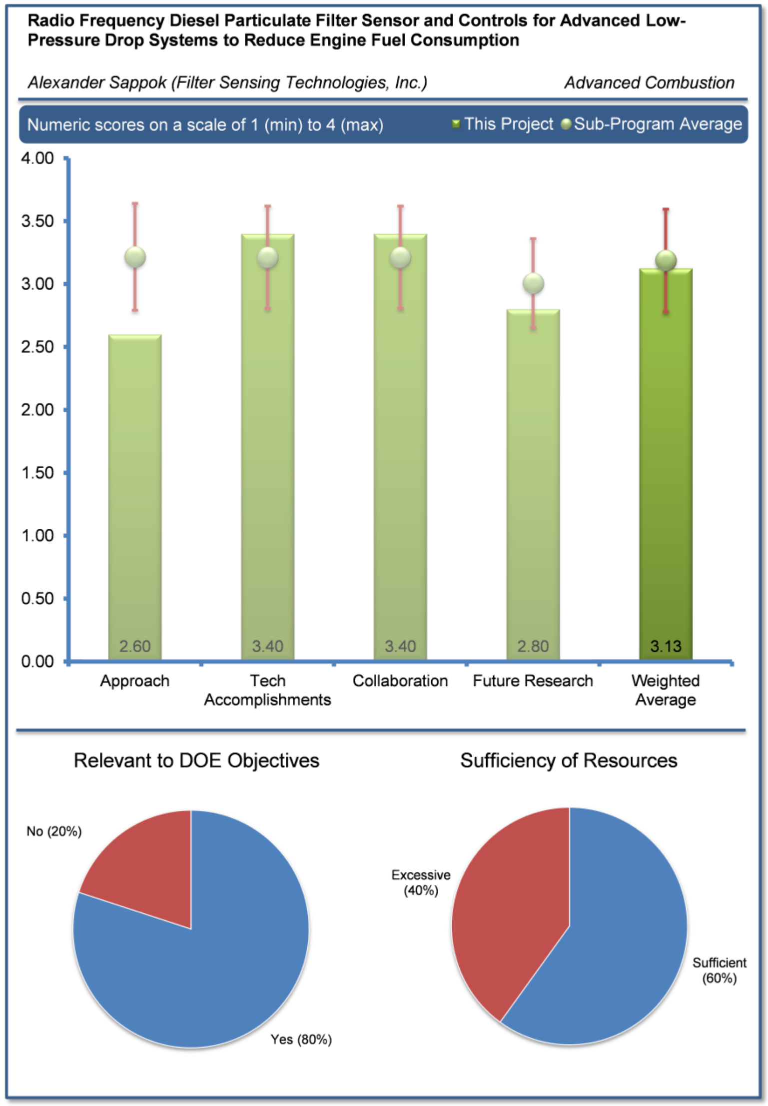
Reviewer 5:

This reviewer said that considering that Eaton is developing a proprietary device that they hope to commercialize, the reviewer feels that the level of DOE funding is truly excessive (2:1).

Reviewer 6:

This reviewer is unsure if the DOE should fund this project.

Radio Frequency Diesel Particulate Filter Sensor and Controls for Advanced Low-Pressure Drop Systems to Reduce Engine Fuel Consumption: Alexander Sappok (Filter Sensing Technologies, Inc.) - ace089



Reviewer Sample Size

A total of five reviewers evaluated this project.

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

Reviewer 1:

This reviewer stated that this project had an excellent, well-integrated approach that leverages previous DOE-funded work at MIT to develop a real world OBD device. The project makes good use of industrial and National Laboratory partners; however, there should probably be some parametric testing of fuel/lube oil effects, especially as they relate to soot and ash composition. The reviewer asked how will engine wear (metal components that become part of the ash) impact the sensor calibration over time.

Reviewer 2:

The reviewer said that this technology was developed as a diagnostic during the PhD. program of the PI. It appears that the intent of the proposed effort is to reduce this diagnostic to practice, so as to be able to measure particulate loading in Diesel Particulate Filters (DPFs) of trucks. The advantage of this technique is that it yields a direct measurement of the soot loading in DPF as compared to the standard technique of measuring the pressure drop and thereby estimating the soot loading. From a controls point of view, one just needs a feedback signal so as to initiate a regeneration cycle for the DPF and the necessity of having to know the exact DPF particulate loading is overkill. Also, the reviewer stated that the pressure drop across the filter is a better feedback signal as it has a direct impact on backpressure and the overall engine efficiency.

Reviewer 3:

This reviewer observed that the use of low-cost Radio Frequency (RF) sensor technology with the possibility of use for sensing DPF loading is an interesting approach. Many barriers have been identified for the use of such sensors. The reviewer indicated that the top priority barrier, which is being pursued in parallel to sensor development, is to characterize soot and ash accumulations. A key element in this activity is to identify a reasonable metric and verifiable laboratory grade test/ sensing equipment to identify the percent filled, percent plugged or other appropriate proxy for DPF loading across many products and engines. The reviewer noted that the current plan includes a DPF loading device, but it is the correlation and characterization of dyno, and actual in use vehicle loading that will be critical to end use. Once the proxy for loading is identified, which is somewhat universal across devices and engines, then the RF sensor value proposition can truly be established. The reviewer added that without a standard method to clearly identify the loading, or plugging, of the devices, each device, DPF material, truck, and possibly duty cycle may require a characterization or calibration implying at least a cursory set of tests and possibly an extensive study being required. The reviewer said that if a characterization or calibration is required for each DPF device (and possibly truck application) and the characterization is not very straightforward or very standardized then it will be difficult to take advantage of the low cost sensor universally. The reviewer said that it appears that the goal of the project is to sense DPF loading inexpensively and universally to avoid detailed characterizations of specific applications each time. A clear test process with metrics for what constitutes DPF loading is the first step and can become an extensive activity by itself. Critical Assumptions and Issues (part to part, durability, OBD) are key barriers and should be formally reflected as such.

Reviewer 4:

This reviewer indicated that the approach is clearly and well-thought out. The reviewer's recollection is that changes in the RF cavity (i.e., DPF) caused changes in the calibration. This was very cavalierly swept under the rug. The reviewer expressed that this was a serious omission. The reviewer indicated that this approach has been considered before. The reviewer does not see any reference to the other attempts, these references would be relevant.

Reviewer 5:

This reviewer noted that the project was an interesting approach to DPF monitoring. It should help in monitoring loading, but the reviewer asked is it able to perform OBD sufficiently. The reviewer answered probably not, since it may not detect all modes that might cause soot leakage.

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

Reviewer 1:

This reviewer said that in spite of the short time period from the date of award to the first review, considerable progress has been achieved. The reviewer said that through relevant tests the effects of frequency and temperature on the signal response were determined. Subsequently, adequate modeling and validation were conducted for various levels of particulate loading. Also, the reviewer indicated that the necessary engine test setups have been readied in order to conduct the performance tests.

Reviewer 2:

This reviewer commented that the project has made impressive progress and accomplishments to date. The reviewer added that the project had impressive facilities commissioned and were running tests.

Reviewer 3:

This reviewer pointed out that the project made very good progress in the first year, apparently including commissioning an engine test cell. The reviewer added that the means of translating resonant frequency into an output signal is not explained.

Reviewer 4:

This reviewer stated that initial tests showing proof of concept to measure loading on a single DPF with a single loading device have been shown. Also, the reviewer noted that the design is progressing well from previous work; however, results must focus on common metric which can be easily characterized in a simple test or which requires no characterization at all. For the goal of the project, the reviewer said that production use of this type of sensing is paramount and is not a trivial task. Priority focus on this technical barrier should be stated and worked on aggressively with top priority.

Reviewer 5:

The reviewer stated that there was nothing new here except the instrumentation. There was no evidence of self-correcting approaches to fix the calibration. The reviewer added that swap out as fixes are not good, way too much warranty costs.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer stated that the integration of very disparate working groups seems to be successfully handled, and that the project team did a good job.

Reviewer 2:

This reviewer said that the collaboration is a good buy-in from DOE, industry, and the labs.

Reviewer 3:

This reviewer noted that the contractor seems to have built a strongly leveraged team of competent people and organizations.

Reviewer 4:

This reviewer commented that there was a very extensive list of collaborators. This reviewer suggested considering a “loaded return part" program from multiple fleets to confirm capability of the sensors across a range of products.

Reviewer 5:

This reviewer expressed that the team appears to have more players than necessary. Also, the reviewer pointed out that the roles DDC and the City of New York Department of Sanitation (DSNY) were not clear and appeared superfluous.

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

Reviewer 1:

This reviewer indicated that there were solid future plans for a technology that could be implemented. The reviewer added that the project needs a better definition of durability and repair.

Reviewer 2:

This reviewer stated that the proposed future activities comprise the necessary tests to validate the performance of the technology under development.

Reviewer 3:

This reviewer said the project has a solid approach, assuming the intermediate points are successful. The reviewer also expressed that it would be nice to have a clearer picture of what success would look like and how the sensor would be used in a vehicle system, leading to an estimate of its value in the system.

Reviewer 4:

This reviewer remarked that the project needs to focus on characterization of a common metric to overcome barrier of part to part and ash formation capabilities before looking at alternative fuels.

Reviewer 5:

The reviewer said to see previous comments.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer observed that this project could possibly reduce maintenance cost of DPF devices.

Reviewer 2:

This reviewer indicated that this project is part of the potential means for meeting emissions.

Reviewer 3:

This reviewer said if the damage/wear problem is well addressed.

Reviewer 4:

This reviewer stated that it is not clear to the reviewer how this technology would lead to fuel savings, if any.

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

Reviewer 1:

This reviewer said the recourses seemed to be appropriate. The reviewer is surprised the DOE required much less than 50/50 matching. This may be appropriate for a small company such as this.

Reviewer 2:

This reviewer stated a recommendation that a Go/No-go decision be made after Phase-II (FY 2013-2014). If the relevance of the program to DOE goals cannot be justified, the subsequent phases should be curtailed.

Reviewer 3:

This reviewer expressed that the project could use a value proposition for pay back.

Reviewer 4:

This reviewer expressed that there is too much money in this project for the possibility of success.

Acronyms and Abbreviations

Acronym	Definition
3D	Three Dimensional
AC	Alternating Current
A/C	Air Conditioning
ACEC	Advanced Combustion and Emissions Control
AEC	Advanced Engine Combustion
AFR	Air to Fuel Ratio
ANL	Argonne National Laboratory
APS	Advanced photon source
AMR	Annual Merit Review
Au	Gold
Bi_2Te_3	Bismuth Telluride
BES	DOE Basic Energy Sciences
BMEP	Brake Mean Effective Pressure
BNL	Brookhaven National Laboratory
BSFC	Brake-specific fuel consumption
BSNOx	Brake-specific NOx
BSPM	Brake-specific Particulate Matter
BTE	Brake Thermal Efficiency
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board
CE	Coulombic Efficiency
CFD	Computational Fluid Dynamics
CI	Compression Ignition
CLEERS	Cross-Cut Lean Exhaust Emissions Reduction Simulations
CNT	Carbon Nanotubes
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COP	Coefficient of performance
COTS	Commercial-Off-the-Shelf
CR	Compression Ratio
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council
Cu	Copper
dB	Decibel
D-EGR	Dedicated-Exhaust Gas Recirculation
DASI	Diesel-Assisted Spark Ignition
DDC	Detroit Diesel Corporation

Acronym	Definition
DEIS	Directed Energy Ignition System
DERC	Diesel Engine Research Consortium
DI	Direct Injection
DISI	Direct Injection Spark Ignited
DMP	Diesel-Micro-Pilot Ignition
DOC	Diesel oxidation catalyst
DOE	U.S. Department of Energy
DoE	Design of Experiment
DPF	Diesel particulate filter
DSNY	City of New York Department of Sanitation
E10	10% Ethanol blend with gasoline
ECN	Engine Collaboration Network
ED/AX	Energy Dispersive Analysis of X-Rays
EGR	Exhaust Gas Recirculation
EHN	2-Ethylhexyl Nitrate
EPA	U.S. Environmental Protection Agency
EQR	Equivalence Ratio
ERC	Engine Research Center
ESEM	Environmental Scanning Electron Microscopy
EtOH	Ethanol
FACE	Fuels for Advanced Combustion Engines
FE	Finite Element
FE	Fuel Economy
FMEP	Friction mean effective pressure
FPE	Free-piston engine
FTP	Federal Test Procedure
FTIR	Fourier Transform Infrared Spectroscopy
FY	Fiscal year
GDI	Gasoline Direct-injected
GDCI	Gasoline Direct Compression Engine
GM	General Motors Corporation
GMZ	GMZ Energy Inc.
GPF	Gasoline Particulate Filter
GPU	Graphics Processing Unit
GTI	Gas Technology Institute
GWP	Global Warming Potential
$\mathbf{H_2}$	Hydrogen
$\mathbf{H_20}$	Water
HATCI	Hyundai America Technical Center Inc.
HC	Hydrocarbon
HCCI	Homogeneous Charge Compression Ignition

Acronym	Definition
HD	Heavy-Duty
HEDGE	High-Efficiency Dilute Gasoline Engine
HH	Half-Heusler
HPC	High Performance Computing
HPLB	High-pressure, lean burn
HVAC	Heating, ventilation and air-conditioning
ICE	Internal Combustion Engine
IMEP	Indicated Mean Effective Pressure
ISFC	Indicated Specific Fuel Consumption
ITE	Indicated Thermal Efficiency
JPL	Jet Propulsion Laboratory
°K	Temperature in degrees Kelvin
K	Potassium
Kn	Knudsen Number
KIVA	Computational Fluid Dynamics Modeling Software
LANL	Los Alamos National Laboratory
LD	Light-Duty
LDB	Lean Downsized Boosted
LED	Light-Emitting Diode
LES	Large Eddy Simulation
LEV	Low Emission Vehicle
LII	Laser Induced Incandescence
LLNL	Lawrence Livermore National Laboratory
LNT	Lean NO_x Trap
LRRI	Lovelace Respiratory Research Institute
LTC	Low Temperature Combustion
MATLAB	Numerical Analysis Software
Mg	Magnesium
Mn	Manganese
MCH	Methylcyclohexane
MD	Medium-Duty
MEMS	Micro-Electro-Mechanical Systems
MIT	Massachusetts Institute of Technology
mJ	Millijoule
MOU	Memorandum of Understanding
MPC	Model Predictive Controller
MPG	Miles Per Gallon
MSU	Michigan State University
MTU	Michigan Technological University
N_2O	Nitrous Oxide
NH_3	Ammonia

Acronym	Definition
NASA	National Aeronautical and Space Administration
NO	Nitric Oxide
NO_x	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
NREL	National Renewable Energy Laboratory
NSC	NO_x Storage Catalyst
NSF	National Science Foundation
NSR	NO_x Storage Reduction
NVO	Negative Valve Overlap
O_2	Oxygen
OBD	On-Board Diagnostics
OEM	Original Equipment Manufacturer
OH	Hydroxide
ORNL	Oak Ridge National Laboratory
OSC	Oxygen storage capacity
OSU	Ohio State University
OTR	On the Road
PCCI	Premixed Charge Compression Ignition
PE	Power Enrichment
PFI	Port Fuel Injection
PGM	Platinum group metal
PI	Principal Investigator
PM	Particulate Matter
PNNL	Pacific Northwest National Laboratory
PPC	Partially Premixed Combustion
PRF	Primary Reference Fuels
Pt	Platinum
PZEV	Partial Zero Emissions Vehicle
R&D	Research and development
RANS	Reynolds-Averaged Navier Strokes
RCCI	Reactivity Controlled Compression Ignition
RCM	Rapid compression machines
RF	Radio Frequency
RI	Ringing Intensity
RON	Research Octane Number
RPM	Revolutions Per Minute
SACI	Spark assisted compression ignition
SCE	Single-Cylinder Engine
SCR	Selective Catalytic Reduction
SCTE	Single Cylinder Test Engine
SI	Spark-ignition

Acronym	Definition
SIF	Spray-Interactive Flamelet
SIDI	Spark-ignition direct-injection
SKU	Skutterudite
SNL	Sandia National Laboratories
SpaciMs	Spatially Resolved Capillary Inlet Mass Spectrometer System
SULEV	Super Low-Emission Vehicle
SWRI	Southwest Research Institute
TARDEC	U.S. Army Tank and Automotive Research, Development and Engineering Center
TE	Thermoelectric
TEG	Thermoelectric Generator
TEM	Transmission electron microscopy
TIM	Time Integrity Modules
TiVCT	Twin Independent Variable Camshaft Timing
TWC	Three-Way Catalyst
UDDS	Urban Dynamometer Driving Schedule
UHC	Unburned hydrocarbons
UM	University of Michigan
UNLV	University of Nevada-Las Vegas
USCAR	U.S. Council for Automotive Research
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability
UW	University of Wisconsin
UWM	University of Wisconsin-Milwaukee
VCT	Variable camshaft timing
VTO	Vehicle Technologies Office
VVA	Variable Valve Actuation
WERC	Wisconsin Engine Research Consultants
W	Watt
WH	Waste Heat
WHR	Waste Heat Recovery
WOT	Wide Open Throttle
WSU	Wayne State University
ZT	Thermoelectric Figure of Merit