7. Combustion Research

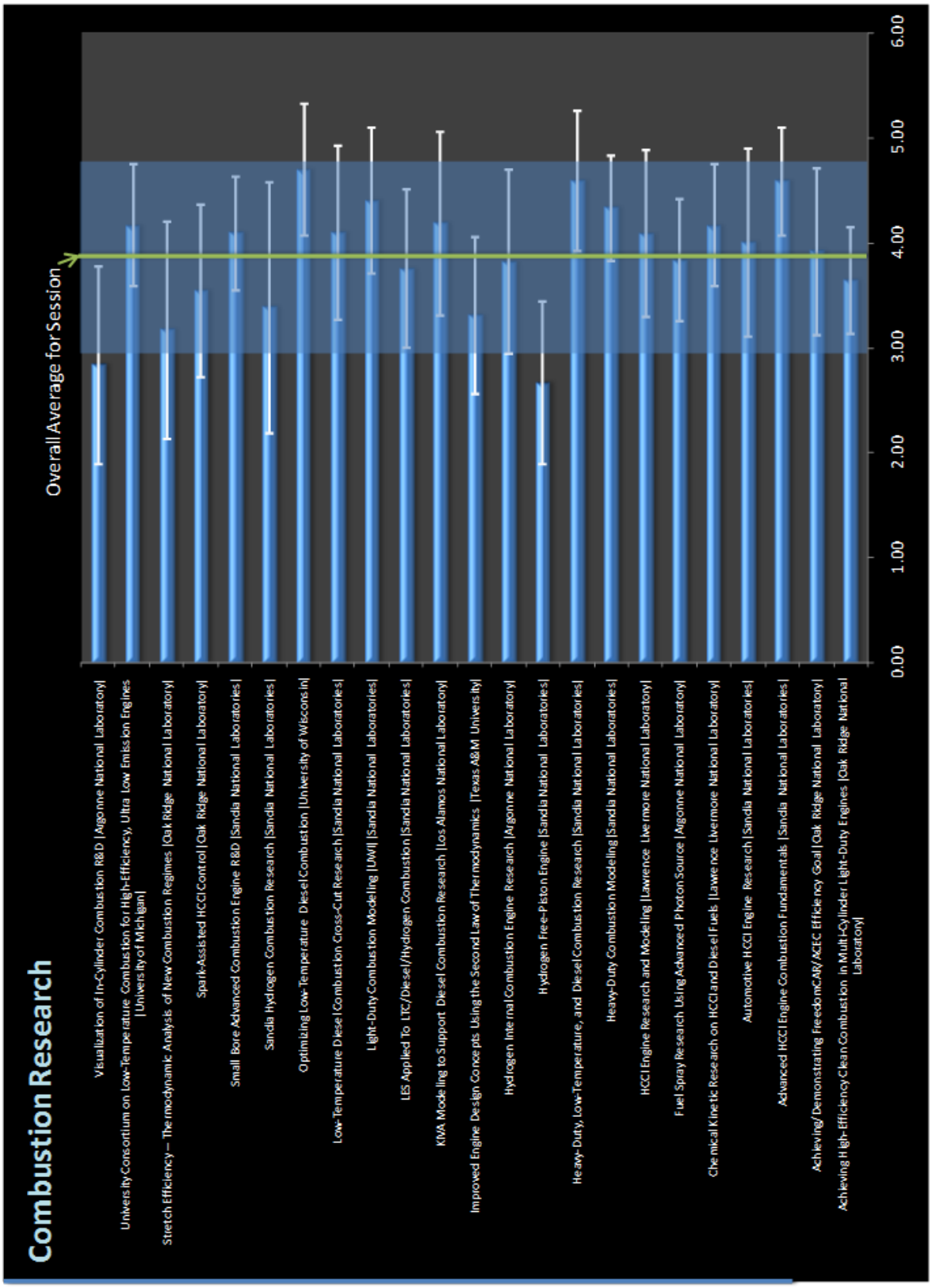
Introduction

The U.S. Department of Energy's Advanced Combustion Engine research addresses critical technical barriers to the commercialization of more efficient advanced internal combustion engines in light-, medium-, and heavy-duty vehicles. Specific goals are to improve, by 2012, the efficiency of internal combustion engines for (1) light-duty applications from 30% to 45% and (2) for heavy-duty applications from 40% to 55% – while meeting cost, durability, and emissions constraints. The research seeks to advance fundamental combustion understanding to enable design of engines with inherently lower emissions, and eventually advanced engines operating predominantly in low-temperature or HCCI combustion regimes. The resulting technological advances will reduce the size and complexity of emission control devices and minimize any impact these devices have on vehicle fuel efficiency. A fuel-neutral approach is being taken, with research addressing gasoline-based LTC engines as well as diesel-based advanced engines. In addition, the work seeks to increase overall engine efficiency through fundamental improvements such as advanced combustion processes, reduction of parasitic losses, and recovery of waste heat.

In this merit review activity, each reviewer was asked to respond to a series of six questions, involving multiple-choice responses, expository responses where text comments were requested, and one numeric score response. 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 pictorial form in eight graphs as the last page of each project, and the expository text responses will be summarized in paragraph form for each question. A table and graph presenting the average and standard deviation for each project relative to the overall average and standard deviation for this session is presented below.

Page	Project Title and Principal Investigator	Project Average Score	Project Score Standard Deviation
7-4	Achieving High-Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines (Robert Wagner, Oak Ridge National Laboratory)	3.64	0.50
7-7	Achieving/Demonstrating FreedomCAR/ACEC Efficiency Goal (Robert Wagner, Oak Ridge National Laboratory)	3.92	0.79
7-11	Advanced HCCI Engine Combustion Fundamentals (John Dec, Sandia National Laboratories)	4.58	0.51
7-14	Automotive HCCI Engine Research (Richard Steeper, Sandia National Laboratories)	4.00	0.89
7-17	Chemical Kinetic Research on HCCI and Diesel Fuels (Bill Pitz, Lawrence Livermore National Laboratory)	4.17	0.58
7-20	Fuel Spray Research Using Advanced Photon Source (Christopher Powell, Argonne National Laboratory)	3.83	0.58
7-24	HCCI Engine Research and Modeling (Dan Flowers, Lawrence Livermore National Laboratory)	4.08	0.79
7-27	Heavy-Duty Combustion Modeling (Mark Musculus, Sandia National Laboratories)	4.33	0.50
7-30	Heavy-Duty, Low-Temperature, and Diesel Combustion Research (Mark Musculus, Sandia National Laboratories)	4.58	0.67

Page	Project Title and Principal Investigator	Project Average Score	Project Score Standard Deviation
7-33	Hydrogen Free-Piston Engine (Peter Van Blarigan, Sandia National Laboratories)	2.67	0.78
7-36	Hydrogen Internal Combustion Engine Research (Thomas Wallner, Argonne National Laboratory)	3.82	0.87
7-39	Improved Engine Design Concepts Using the Second Law of Thermodynamics (Jerry Caton, Texas A&M University)	3.31	0.75
7-42	KIVA Modeling to Support Diesel Combustion Research (David Torres, Los Alamos National Laboratory)	4.18	0.87
7-45	LES Applied To LTC/Diesel/Hydrogen Combustion (Joe Oefelein, Sandia National Laboratories)	3.75	0.75
7-48	Light-Duty Combustion Modeling (UWI) (Paul Miles, Sandia National Laboratories)	4.40	0.70
7-51	Low-Temperature Diesel Combustion Cross-Cut Research (Lyle Pickett, Sandia National Laboratories)	4.09	0.83
7-54	Optimizing Low-Temperature Diesel Combustion (Rolf Reitz, University of Wisconsin)	4.69	0.63
7-57	Sandia Hydrogen Combustion Research (Sebastian Kaiser, Sandia National Laboratories)	3.38	1.19
7-61	Small Bore Advanced Combustion Engine R&D (Paul Miles, Sandia National Laboratories)	4.09	0.54
7-65	Spark-Assisted HCCI Control (Dean Edwards, Oak Ridge National Laboratory)	3.55	0.82
7-68	Stretch Efficiency -- Thermodynamic Analysis of New Combustion Regimes (Josh Pihl, Oak Ridge National Laboratory)	3.17	1.03
7-72	University Consortium on Low-Temperature Combustion for High-Efficiency, Ultra Low Emission Engines (Dennis Assanis, University of Michigan)	4.17	0.58
7-75	Visualization of In-Cylinder Combustion R&D (Steve Ciatti, Argonne National Laboratory)	2.83	0.94
	Overall Session Average and Standard Deviation	**3.87**	**0.91**


Combustion Research
Overall Average for Session
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Visualization of In-Cylinder Combustion R&D |Argonne National Laboratory|
University Consortium on Low-Temperature Combustion for High-Efficiency, Ultra Low Emission Engines |University of Michigan|
Stretch Efficiency – Thermodynamic Analysis of New Combustion Regimes |Oak Ridge National Laboratory|
Spark-Assisted HCCI Control |Oak Ridge National Laboratory|
Small Bore Advanced Combustion Engine R&D |Sandia National Laboratories|
Sandia Hydrogen Combustion Research |Sandia National Laboratories|
Optimizing Low-Temperature Diesel Combustion |University of Wisconsin|
Low-Temperature Diesel Combustion Cross-Cut Research |Sandia National Laboratories|
Light-Duty Combustion Modeling |UW|| Sandia National Laboratories|
LES Applied To LTC/Diesel/Hydrogen Combustion |Sandia National Laboratories|
KIVA Modeling to Support Diesel Combustion Research |Los Alamos National Laboratory|
Improved Engine Design Concepts Using the Second Law of Thermodynamics |Texas A&M University|
Hydrogen Internal Combustion Engine Research |Argonne National Laboratory|
Hydrogen Free-Piston Engine |Sandia National Laboratories|
Heavy-Duty, Low-Temperature, and Diesel Combustion Research |Sandia National Laboratories|
Heavy-Duty Combustion Modeling |Sandia National Laboratories|
HCCI Engine Research and Modeling |Lawrence Livermore National Laboratory|
Fuel Spray Research Using Advanced Photon Source |Argonne National Laboratory|
Chemical Kinetic Research on HCCI and Diesel Fuels |Lawrence Livermore National Laboratory|
Automotive HCCI Engine Research |Sandia National Laboratories|
Advanced HCCI Engine Combustion Fundamentals |Sandia National Laboratories|
Achieving/Demonstrating FreedomCAR/ACEC Efficiency Goal |Oak Ridge National Laboratory|
Achieving High-Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines |Oak Ridge National Laboratory|

Achieving High-Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines (Robert Wagner, of Oak Ridge National Laboratory)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Light-duty low temperature combustion was seen, by one reviewer, as an important area of study for fuel economy improvement. Another reviewer felt that HECC will enhance the performance / emissions tradeoff of the engine. Another reviewer saw the project as supporting light-duty diesel with understanding and implementing LTC. Another reviewer viewed the project working toward improving fuel economy and reducing emissions.

Another reviewer was concerned that the program needed to be careful that engine testing doesn't lose focus on fundamental combustion issues. Much time can be spent diagnosing engine design specific issues (such as EGR cycle-to-cycle distribution due to a sub-par intake manifold) rather than addressing the fundamental combustion questions. Also, separating the impact of strategy and calibration robustness from fundamental combustion is difficult.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer saw the program as taking a laundry list approach to LTC in LD diesel and was concerned how much of the project is merely a "voyage of discovery" for ORNL rather than getting the job done. Another reviewer found the general subject matter as good, but was unclear what the actual objective of the project is. The same reviewer felt the team should pick an aspect of LTC and focus on it, for example, expanding the LTC operating range. Another reviewer did not feel that a good explanation was provided for what the barriers are and how they are addressing them. The reviewer also wondered is noise a primary focus?

A reviewer found that the program goals are well-defined in terms of objectives, task interactions and collaborations. The key goal is to enable and expand HECC boundaries in a multi-cylinder light-duty diesel engine. Another reviewer spoke of collaboration with industry partners.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer felt that progress was slow due to the large list of areas of interest being studied. Another reviewer felt the tools were now in place to move forward and wondered how well is modeling integrated with this project?

Another reviewer saw the program as making steady progress toward goals. The reviewer saw good interaction with industry partners and expressed the key accomplishments as characterizing performance (including noise) with mixed-source EGR and controls strategies. One reviewer viewed the project as looking at a systematic characterization of several different efficiency improvement techniques. The reviewer also commented that the project had done a good job combining modeling and experimental work. The project was seen, by a reviewer, as having shown some good results comparing low-pressure and high-pressure EGR as well as combined EGR systems, but did not provide any insight about why low-pressure EGR appears to have benefits. A reviewer felt it was a good idea to run FACE diesel fuels on the GM engine to look at cetane and other fuel property effects,

especially at low load conditions. The reviewer also felt that it would be very interesting to also run the FACE fuels on the Mercedes engine before shutting down work on that engine.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

One reviewer saw good collaboration with industry and academics, but wondered how much if this was technology transfer from other organizations to Oak Ridge National Lab instead of the other way around. A reviewer felt the project needed to communicate with industry partners to make sure they (ORNL) are looking at practical methods for implementing the various HECC technologies.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

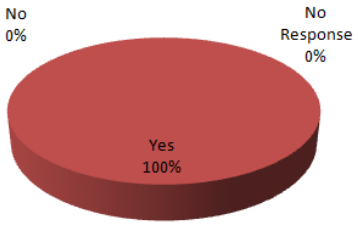
A reviewer felt that progress seems to match the budget, but a much larger budget could be consumed to fully explore these areas. Another reviewer felt that resources appear to be adequate. One reviewer felt closer industry ties were the key to support access to more state of the art hardware.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

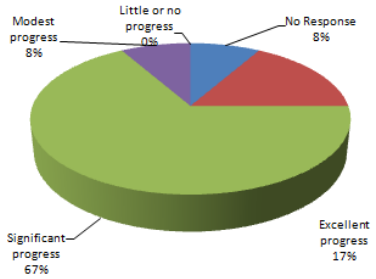
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Achieving High-Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines

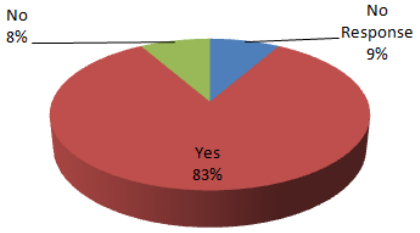
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



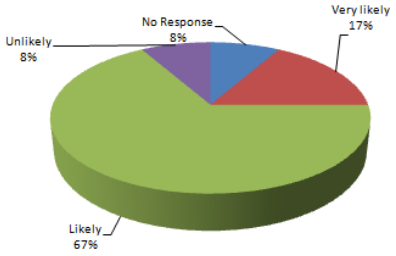
Question 3: Characterize the technical accomplishments and progress toward goals.



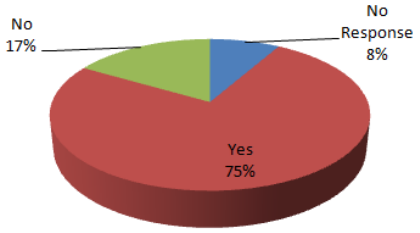
Question 2a: Are the goals of the project technically achievable?



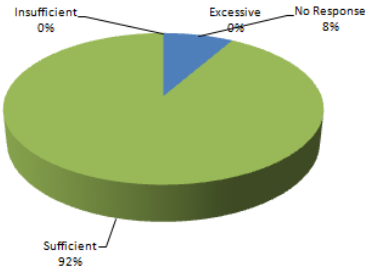
Question 4: How likely is the project team to move technologies into the marketplace?



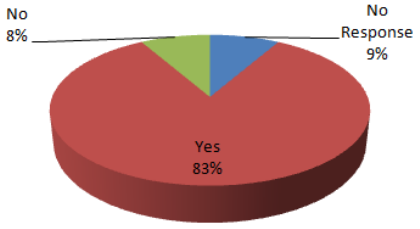
Question 2b: Have the technical barriers been identified and addressed?



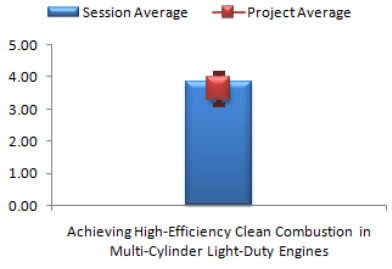
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Achieving/Demonstrating FreedomCAR/ACEC Efficiency Goal (Robert Wagner, of Oak Ridge National Laboratory)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
A reviewer commented that improving light-duty diesel fuel economy is an important step along the way to further improve the fuel cost benefit of dieselization. Another commented that the program supports DOE goals because it aims to provide physical understanding and predictive capabilities for high efficiency combustion systems. Another saw the program as sharing the same goal for brake thermal efficiency as defined in the DOE objectives. Another reviewer saw the project as intended to bring technology together to demonstrate efficiency and emissions improvements on a light-duty diesel engine. Other reviewers saw the project as aiming at improved engine and fuel efficiency.

Another reviewer stated that integration of controls into a systems approach to LTC is needed for a timely implementation of this technology, but added that they would have liked to see more of the interaction between engine research and after treatment.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
A number of reviewers questioned if waste heat recovery was practical for light duty vehicles. One reviewer was not sure if using the organic Rankine cycle to capture available exhaust energy would be likely to yield a significant amount in light duty applications where exhaust energy is relatively low. The reviewer felt it was important to balance energy recovery with aftertreatment function, which is difficult given the low exhaust temperature in light-duty, and hoped the transferability of what is done to achieve efficiency and/or emissions on this engine to other engines would be addressed.

A reviewer would have like to known the emissions levels at 42% BTE, but the reviewer realizes that this target is set elsewhere. The reviewer asked if anything would be gained by focusing on the areas of the engine map where the duty cycles spend the most time. The reviewer also wondered how waste heat recovery fits with aftertreatment, especially with light-duty off-road trucks. Another reviewer commented that availability, analysis and advanced combustion and waste heat recovery are being evaluated, but felt there should be more effort focused on improving part-load efficiency and emissions.

A few reviewers commented on the project as having good connections with several industry partners. A reviewer thought it was smart to use availability analysis to identify areas to go after energy. Another reviewer saw the project as having a good systematic approach to the problem, but waste heat recovery especially is a very large potential area of investigation, and it needs to be approached in a goal-based fashion. Another reviewer saw baseline measurements of performance on two light-duty diesel engines and studies of opportunities for improved efficiency as a key accomplishment. A reviewer commented that the slide showing exhaust energy over engine map was good for focus on where the most “bang for the buck” is to improve BTE.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.

A reviewer's belief that waste heat recovery is not feasible for light duty vehicles was reiterated. Another reviewer felt the program needed to progress beyond using available engines with varying calibrations. Another reviewer stated that the program needs to show how the 42.2% efficiency was accomplished, adding it is more important to learn the path then the numbers. One reviewer felt there should be a focus on an operating point for efficiency: the reviewer also wondered about emissions and cycle efficiencies. Yet another reviewer felt there should be a focus on part loads, stating that modest gains had been made at peak or near-peak loads. A reviewer found the project very interesting to assess the practicality of an organic Rankine cycle on a light duty engine. The reviewer added that the investigators also need to look at efficiency improvements over a real drive cycle and not just at the peak BTE point. The reviewer realized the DOE objective is 45% BTE at the peak efficiency point, but felt they should also report a drive cycle efficiency improvement too. The reviewer also commented that it was a good job working with Bosch to try and overcome the controller problems they have had.

Another reviewer felt the program is making steady progress towards goals. The reviewer saw interaction with industry partners as good. The reviewer saw baseline measurements of performance on two light-duty diesel engines and studies of opportunities for improved efficiency as key accomplishments.

A reviewer also noted this was one of the few DOE projects on light duty waste heat recovery, and hence an important project. The reviewer also noted that progress has been slow.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

It was reiterated, by a reviewer, that waste heat recovery is not economically feasible for LD vehicles. Another reviewer was concerned that it was not clear that anything new has been done yet. How was the 42% achieved? Advancing the timing? What other things can be done? Close analysis of where improvements can be made will be some of the key contribution, but how does this overlap with some other projects?

Another reviewer found waste heat recovery as a very attractive approach for fuel efficiency improvement, but wondered if ultimately the low grade of the energy available reduces the benefit to only a couple of percentage points at best. Another reviewer found that the program is yielding valuable insights into performance of light duty diesel engines. The team was able to demonstrate 42% thermal efficiency with two modified OEM engines, but the reviewer felt they did not state if these changes compromised consumer acceptance (life, operability, noise, etc)

A reviewer saw the question as whether an organic Rankine cycle is practical. The reviewer expect that if this project does an excellent job of characterizing and quantifying an organic Rankine cycle (which the reviewer believed it will), then the project was worthwhile even if the technology doesn't make it to the marketplace. Another reviewer stated that work is being performed on a relevant light-duty engine is so is easily relevant and transferable.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

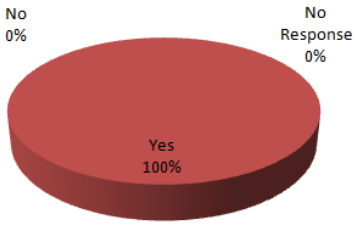
One reviewer felt that progress is slow but steady on the project. One reviewer found resources to be adequate. Another reviewer wondered if additional funding would allow the work to be expanded to looking at energy recovery from coolers.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

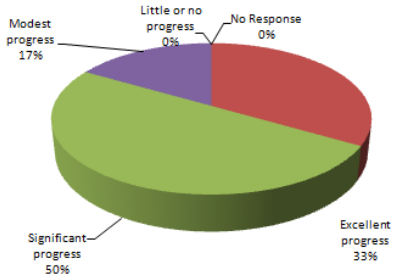
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Achieving/Demonstrating FreedomCAR/ACEC Efficiency Goal

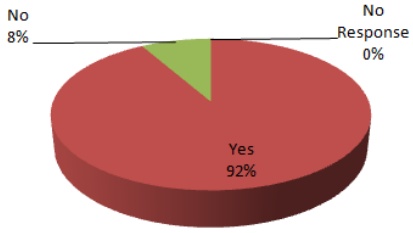
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



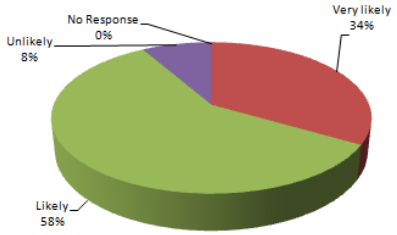
Question 3: Characterize the technical accomplishments and progress toward goals.



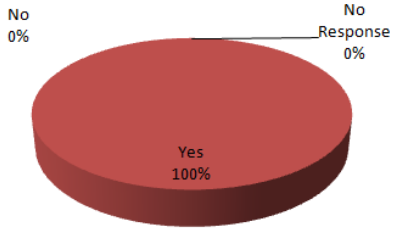
Question 2a: Are the goals of the project technically achievable?



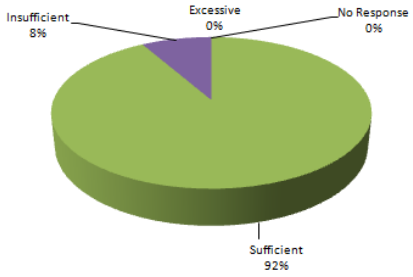
Question 4: How likely is the project team to move technologies into the marketplace?



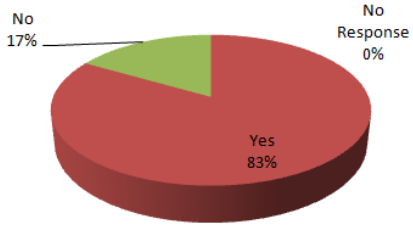
Question 2b: Have the technical barriers been identified and addressed?



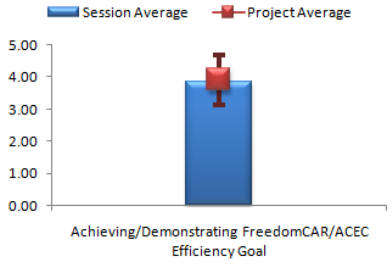
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Advanced HCCI Engine Combustion Fundamentals (John Dec, of Sandia National Laboratories)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Many reviewers felt that HCCI study will lead to real fuel savings, and is important because HCCI is already being implemented in test vehicles. The current study was also seen, by a reviewer, as being important to future engine design, and another reviewer said that extending the limits of HCCI would enable efficiency at part load on gasoline engines. The research was also seen as addressing fundamental barriers to implanting low temperature combustion, as expanding the LTC/HCCI operating regions.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
The program's goals were seen as well-defined and the approach as good. Improvement was seen in chemical kinetics and CFD models, based on increased understanding obtained from the program. One reviewer saw the program's key accomplishments as the studies of fuel types, EGR levels, and valve actuation systems. The program goals are well-defined in terms of objectives, task interactions and collaborations. Key accomplishment is investigation of HCCI including fuel type, EGR levels and valve actuation schemes. A good connection was seen with industry and working group partners. One reviewer wondered if cooled EGR would lead to different results.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
The work was seen as having an excellent approach with systematic progress. The program's plan was viewed as good, and the program was seen as achieving its goals. One reviewer went on to state that the work is having an impact on a number of programs at national labs, with good interaction among partners. One reviewer noted that the work showed a correct understanding of the issues, and that progress was being made in understanding the relative merits of injection retard versus EGR on IMEP, NOx and efficiency is important information. The reviewer added that going forward, studies in thermal stratification (TS) will be important in extending the high-load limit of HCCI and should continue to be pursued. The installation and operation of the VVA system is a key step. It will make this work more relevant to practical implementation of HCCI by the auto industries. Going forward, VVA strategies should be the grid upon which understanding of SOI, EGR and other parameters should be developed. Investigating boosted conditions to extend high-load limits will also be interesting. The information on the impact of EGR and thermal efficiency was viewed as good, by a reviewer, but the reviewer would have liked to hear more about the exhaust gas speciation and how that information will help better understand advanced combustion fundamentals. A reviewer felt that the mechanism of low temperature combustion still needed to be analyzed.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
The program was seen as yielding valuable information towards making HCCI combustion material. The work was seen as the early stage basic science approach, which is important to the ultimate commercialization of the technologies. The plan was seen as being good to date, and another reviewer

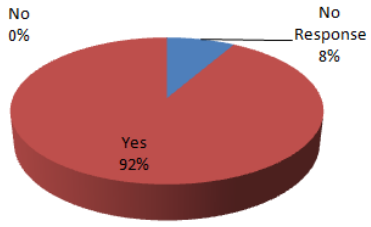
added that industry needs a high efficiency and low emission engine and the study shows it can fit the solicitation.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
Responding reviewers felt that there was a need to consider additional funding for the program.

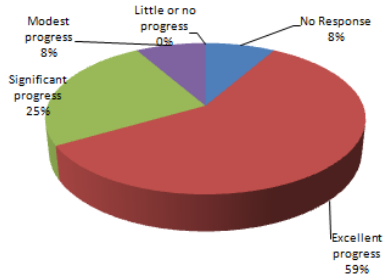
Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Advanced HCCI Engine Combustion Fundamentals

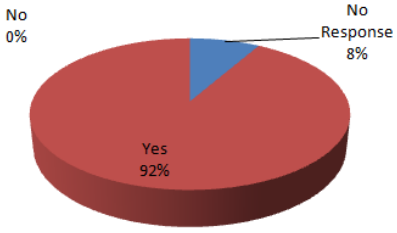
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



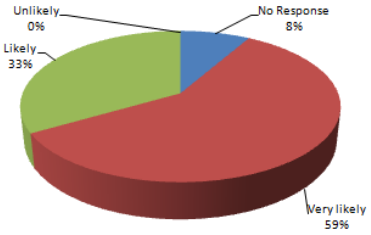
Question 3: Characterize the technical accomplishments and progress toward goals.



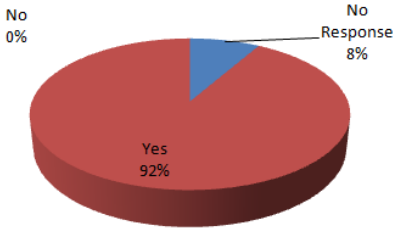
Question 2a: Are the goals of the project technically achievable?



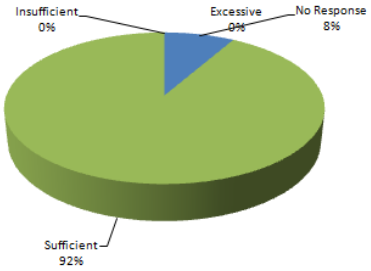
Question 4: How likely is the project team to move technologies into the marketplace?



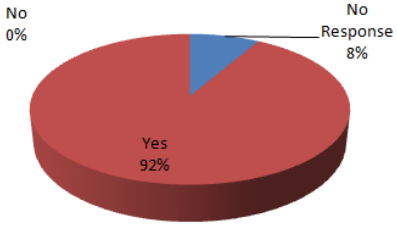
Question 2b: Have the technical barriers been identified and addressed?



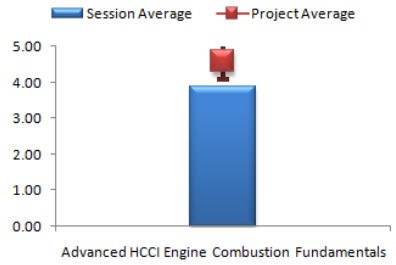
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Automotive HCCI Engine Research (Richard Steeper, of Sandia National Laboratories)

Reviewer Sample Size
This project had a total of 11 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Most reviewers who responded found that automotive research was important for fuel efficiency improvement. One saw the program as understanding HCCI combustion using advanced optical diagnostic techniques.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
A number of reviewers found the project goals as good and well defined. One reviewer saw the key accomplishments as the investigation of negative valve overlap applied to gasoline engine and PLIF diagnostic applied to optical engine.

Collaboration with industry partners was also observed by a reviewer. Another reviewer saw that there had been collaboration on chemical kinetic and CFD modeling work. One reviewer noted that understanding is being transferred to numerical models at UW and LLNL and industry. There was also a comment by a reviewer that the technique of looking at equivalent ratio and temperature simultaneously will provide incredibly useful data.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer stated that the program had saved a lot of time by using fixed cams for the NVO study instead of trying to implement a VVA system, which has allowed focus on doing work instead of implementing a VVA system. The program's systematic approach to try and understand the effects of temperature and EGR concentration throughout the cylinder was seen as positive. Another reviewer did not understand why VVA systems (which the reviewer saw as readily available) had not been incorporated.

A key accomplishment was viewed, by a reviewer, as the investigation of negative valve overlap applied to gasoline engine and PLIF diagnostic applied to optical engine. A reviewer also saw the development of experimental/analytical tools for HCCI investigation as interesting and to be encouraged. The prove-out of the technique was seen as a great accomplishment by another reviewer, while one reviewer found mixing observations as a key to successful development of LTC and HCCI.

The 2-wavelength PLIF diagnostic to simultaneously measure EGR concentrations and temperature was seen as exciting by a reviewer. The reviewer added this diagnostic should now be brought to bear on negative valve overlap and fuel injection parametric studies aimed at understanding the HCCI combustion process.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
The program was seen by a reviewer as yielding valuable insights. Another reviewer noted that the program was seeking to improve collaboration. One also felt that the development of the Stanford technique was useful. Another reviewer expressed concern that the program continued to be too

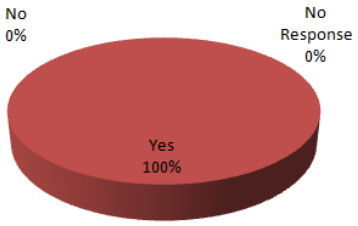
focused on GM, while another reviewer did not see how the program's results will help to develop engines with better efficiency.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
All reviewers who responded found resources to be sufficient.

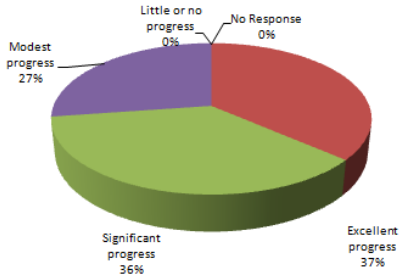
Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Automotive HCCI Engine Research

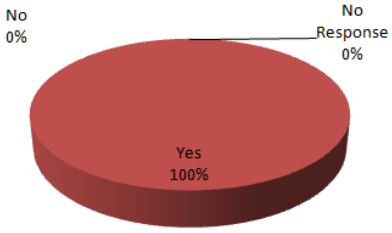
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



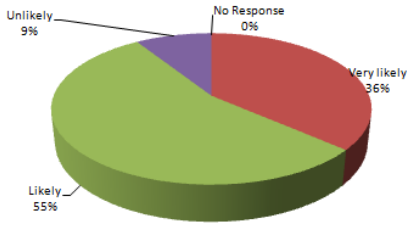
Question 3: Characterize the technical accomplishments and progress toward goals.



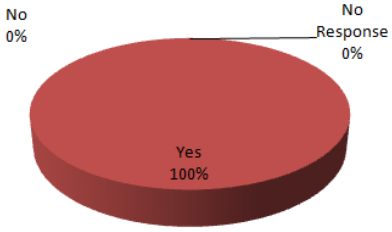
Question 2a: Are the goals of the project technically achievable?



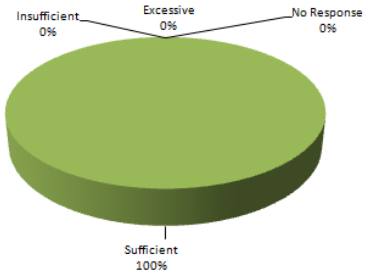
Question 4: How likely is the project team to move technologies into the marketplace?



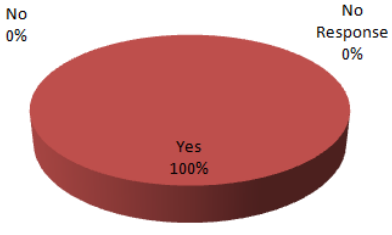
Question 2b: Have the technical barriers been identified and addressed?



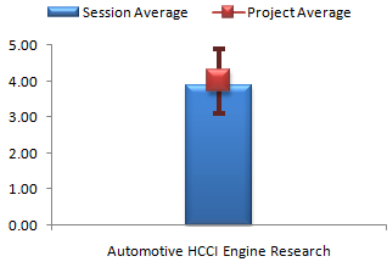
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Chemical Kinetic Research on HCCI and Diesel Fuels (Bill Pitz, of Lawrence Livermore National Laboratory)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
A number of reviewers stated that better chemical kinetic models are critical for improved modeling and ultimately engine design, especially for low temperature combustion. Other reviewers commented on generating surrogate fuels and alternative fuels which will lead towards bio-based fuels and alternative fuels with petroleum use.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
It was commented by a reviewer that this project is well connected to industry, universities and other labs through the distribution of mechanisms. Another reviewer stated that the modeling was vital for advancing combustion technology, and found the modeling of RME as new and valuable. One reviewer stated that simplified models, as discussed, are important in that they will allow a broader group of researchers to use the techniques in a broader range of projects. The reviewer added that simplification is not a substitute for complete understanding of detailed kinetics. A reviewer mentioned that LLNL has a unique capability, which is being used wisely in the project.

A reviewer said that the strategy seemed good overall and solid. The reviewer added that it was good to see modeling backed up with experiments. It was said, by another reviewer, that the focus on biodiesel, while understandable from a DOE perspective, seems premature given the current relative lack of knowledge about the chemical kinetics of more conventional diesel-type fuels. One reviewer cited the project as having a nice approach to develop the full reaction and then simplify to a usable number of reactions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer described the modeling of RME as new and valuable. A number of reviewers commented favorably on the model development for useful fuels, citing n-hexadecane and methyldecanoate. A reviewer felt that program had a pretty good apparent understanding of the tradeoffs between simplification and accuracy. A reviewer felt that the development of mechanisms for several fuels that are of key interest to industry. The reviewer added that the program needs to be sure to acknowledge that “diesel fuel” and “gasoline” can vary significantly and insure that the surrogates can address these variations.

A reviewer stated that reduced-order chemical kinetic models are required by industry, and the project stands to provide those. The reviewer wondered whether matching fuel combustion properties through reduced order reactions or through the use of surrogate compounds would be the better approach. A reviewer felt that the project was pretty good work, with good feedback and validation mechanisms. Another reviewer wonders how many more fuel components for diesel and gasoline will be necessary to provide good HCCI/LTC predictive capability.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

A reviewer commented that modeling is important for the engine to reach the market: the reviewer considers bio-fuel as a high priority. A reviewer stated that LLNL and DOE have established a very good technology transfer mechanism for this and related programs. Another reviewer added that most people are using the LLNL mechanism. A reviewer stated that good fuel models will likely be picked up by industry for their modeling work, and felt the program had an excellent amount of publications and industry collaboration. Another reviewer felt there was a need for more direct contact with industry.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

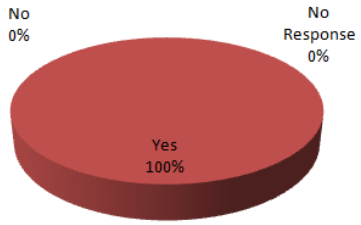
Two of the commenting reviewers felt that the budget was appropriate for the broad array of work being performed. Another reviewer saw evidence of widespread collaboration among worldwide peer group; the reviewer also saw evidence of feedback from experimentalists.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

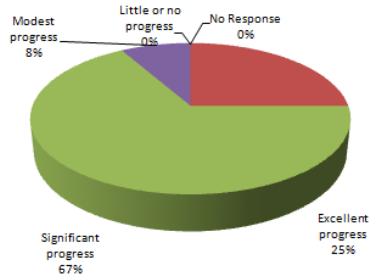
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Chemical Kinetic Research on HCCI and Diesel Fuels

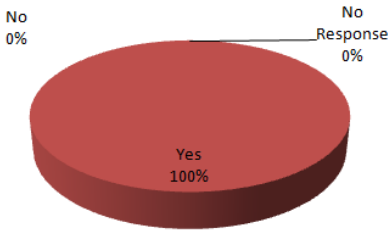
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



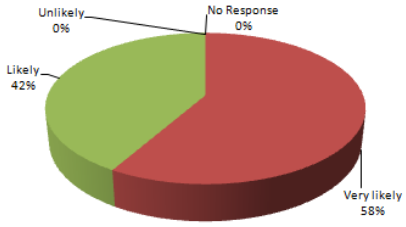
Question 3: Characterize the technical accomplishments and progress toward goals.



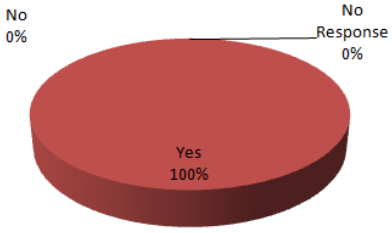
Question 2a: Are the goals of the project technically achievable?



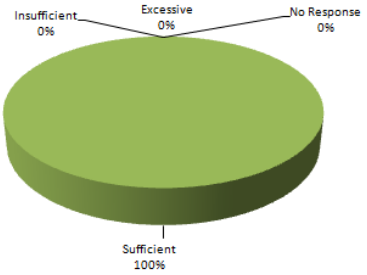
Question 4: How likely is the project team to move technologies into the marketplace?



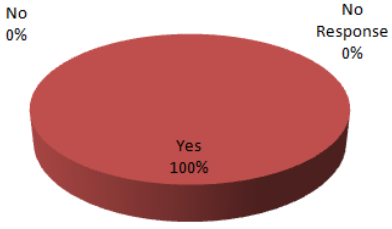
Question 2b: Have the technical barriers been identified and addressed?



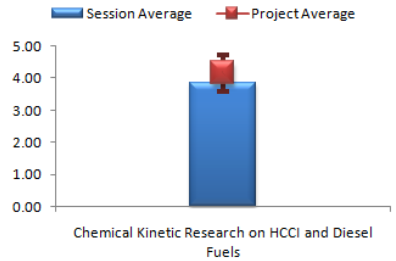
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Fuel Spray Research Using Advanced Photon Source (Christopher Powell, of Argonne National Laboratory)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
A reviewer stated that fundamental fuel spray research is potentially important for diesel combustion research. Other reviewers added that improved understanding of fuel spray will lead to improved engine performance. Another added that the study provided great data sets model validation which compliments those provided by Sandia. The goals were described as clearly stated, by another reviewer, and the role of the project clearly defined.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
A reviewer felt that quantified spray data was not available, but added that this work is very valuable for model improvement and that good models are vital for engine development. A reviewer stated that there was insufficient information on how this technology will find its way into the industry, other than Bosch's interest. The reviewer added that collaboration with Bosch seems to be too one-sided (as is always the case). Another reviewer question industrial partnerships. One reviewer wondered if Argonne had made industrial collaboration a top priority, and wanted to know if this would be measured and later evaluated versus metrics. A reviewer felt the project was straightforward with obvious benefits. The reviewer added that the x-ray technology for spray measurement seems to be a significant step forward in this technique. Another reviewer felt that some interesting results could be achieved. Another reviewer stated that GDI work would be very useful, and that the effect of orifice shapes and finishes a la Bosch would be a good extension.

One reviewer wondered if it would be possible to look at the interaction of multiple injections. The reviewer added that the closer to real engine conditions the project can get the more useful the data. The reviewer stated it is worth working toward these goals.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer stated that it was good to see the program was moving to higher ambient pressure, which was seconded by another reviewer. Another reviewer felt that interesting results had been achieved. A reviewer felt that the project was making progress towards goals with completion of modeling studies of real sprays, etc.

A reviewer stated that the X-ray window selection was not yet finalized - this is a necessary prerequisite, but it seems far from the DOE's actual goals. The reviewers understand that good windows for high-pressure, high-temperature studies are needed, but their interest is really in the results which seem far removed from this.

Another reviewer said it was good to see the collaboration with Caterpillar and implementation of the Cat injector into their rig. The reviewer felt it was good that they had gotten Bosch involved in some of the testing. The reviewer would like to see more quantitative results from the measurements. The reviewer added that most of what has been shown are 2-D pictures of fuel density in the spray plume. The reviewer wondered what these pictures can be used for, and if there are modeling results that can

be compared to the spray measurements. Since one of the stated goals is to improve spray models, is it possible to investigate the end of injection leaning out demonstrated at Sandia?

One of the reviewers commented that the emphasis is on describing what happens in the spray, and felt there was a need to expand to define what we want the spray to look like and how different spray characteristics affect emissions and performance. The reviewer felt that to do this there has to be a second, deeper level of collaboration that may exist in pockets, but is not as widespread as it could be. The reviewer added that there is some evidence this is happening from the discussion, but wondered if Argonne could do more here.

A reviewer felt that significant progress was made to improve the facility to test at diesel like ambient pressures. The reviewer felt it would be useful to continue to push this limit up so that the entire operating range can be captured.

Another reviewer felt that the productivity of the project can be increased, that the output has not been commensurate with the amount of time that this project has been active.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

Two reviewers commented that the program was well-connected with industrial partners; another said that it was good to see the collaboration with Bosch and a reviewer was encouraged that Bosch had agreed to non-competitive research. A reviewer felt that this was good, valuable work but wondered if there was as much technology transfer here as at other labs.

A reviewer stated that it was fundamental work to understand the spray patterns, and the project seemed responsive to industry partners. Another reviewer felt it seemed the technology was near term available (5 years or so), so that it could very likely be picked up by industry. The reviewer added that it seemed like the project could provide an excellent measurement technique for fuel system suppliers. Another reviewer stated that the study can directly apply into different injectors' evaluation, if the authors can develop a general empirical equation based on X-ray founding. The reviewer also suggested testing multiple injections to see the effect of jet to jet interaction

A reviewer felt the results are potentially important for the industry, but did not feel the technology transfer plan (to industry) was well formed (other than Bosch's interests). The reviewer also wonder if the researchers were up to date with work done at Chalmers University and elsewhere.

One reviewer answered modeling, support, and that the modeling work was close to the final stage of combustion development.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

A reviewer stated that the amount of funding seemed appropriate, considering the hardware and testing involved. Another reviewer felt that testing at high temperature and pressure is of value, and the replacement of windows should be expected and considered as a consumable for this sort of work. Another reviewer said the Caterpillar dyno engine sub project was important and should be funded.

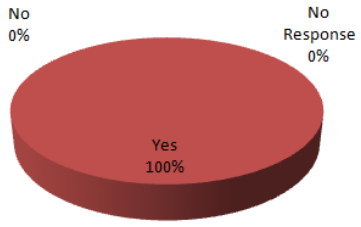
A reviewer felt the program made good use of existing national laboratory resources (X-Ray source). One reviewer expressed concern about getting Bosch to share proprietary information.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

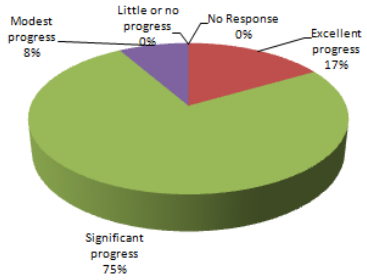
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Fuel Spray Research Using Advanced Photon Source

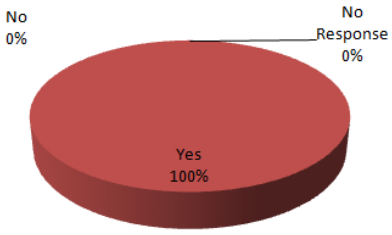
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



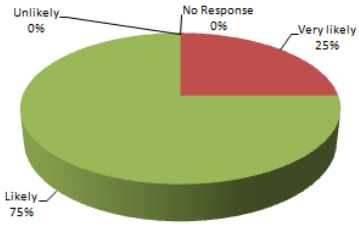
Question 3: Characterize the technical accomplishments and progress toward goals.



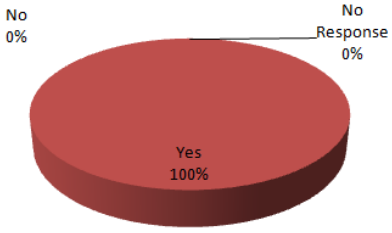
Question 2a: Are the goals of the project technically achievable?



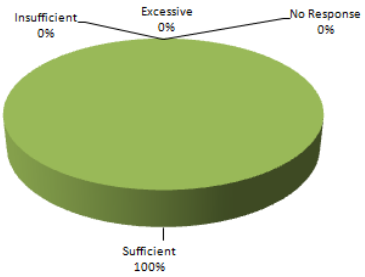
Question 4: How likely is the project team to move technologies into the marketplace?



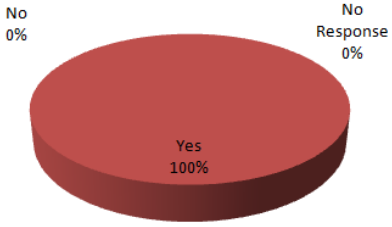
Question 2b: Have the technical barriers been identified and addressed?



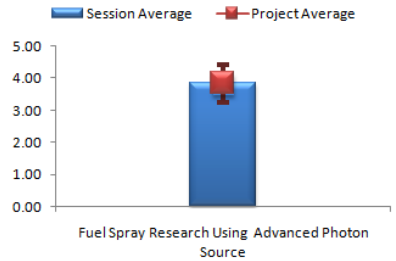
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



HCCI Engine Research and Modeling (Dan Flowers, of Lawrence Livermore National Laboratory)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Overall increased understanding of the HCCI engine modeling methods was mentioned by one reviewer as being very important for reducing the cost and effort to develop HCCI and mixed mode engines, which will reduce fuel use in the US. Another reviewer felt efficiencies would be increased in both diesel and gasoline engines. One reviewer felt that overall increased understanding of the combustion process through extensive advanced modeling should lead to identification of key adjustable parameters within advanced combustion processes which should lead to opportunities for efficiency improvement.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
A reviewer stated that CFD is crucial for advancing engine combustion. Another reviewer was glad that the work has been expanded beyond just HCCI. Another reviewer noted a well-laid out set of project plans.

A reviewer felt the return on this project seems low. More engine configurations and data need to be modeled to identify the model's deficiencies and improve the model. The reviewer wondered who in industry are using the models being developed. One reviewer felt the project needs to mention during the description of different projects and tool applications which opportunities for improvement are being pursued. The presentation highlighted the great tools being used but didn't get into the goals for their application.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer felt that CFD is crucial for advancing engine combustion. A reviewer commented that the program had a good systematic approach to the multiple problems and challenges that lie ahead, with a good plan in place for future progress. There were a number of positive comments concerning the progress in software and modeling work. A reviewer felt the program's application and what it will provide need to be highlighted.

A reviewer felt the project needs to be more focused. The reviewer did not see what the project was adding to its collaborations with Sandia, ORNL, and LANL. The reviewer felt that all of the results shown are matching the models to existing data, and that it would be nice to see this effort lead the experimental effort in some areas by developing ideas to be validated. The reviewer stated that it was good that the program was working on partially stratified combustion, but it that it would be nice to see more than just matching the existing experimental data. Another reviewer questioned why the project gets such a large dollar amount.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
A reviewer cited the program's good history of technology transfer, and a cross fertilization between industry, national labs and academic institutions. The program's good industry and university

collaboration was also mentioned by other reviewers. A reviewer felt the program supported other work that is likely to reach the market. Another reviewer felt that if the technology progresses it will be due in part to work done under this funding. It was also expressed by a reviewer that there were a large number of interested parties within industry. It was also commented by a reviewer that the next generation of CFD codes would make this work extremely useful, and that the program had implementation in existing codes used throughout industry.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

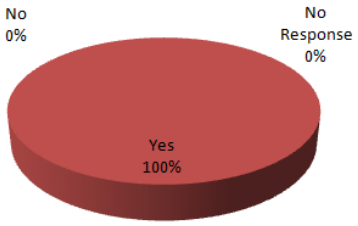
Two reviewers felt the funding level seemed high, and one of those reviewers wondered if the computers or computer time (for the modeling) was that expensive. Another reviewer cited difficulties in accessing persons from the project for support of other projects, leading the reviewer to believe the program was understaffed. The reviewer added that the program does great work and has a good understanding of what is required to progress to the state of the art. Another reviewer felt the program had good use of resources for a national lab.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

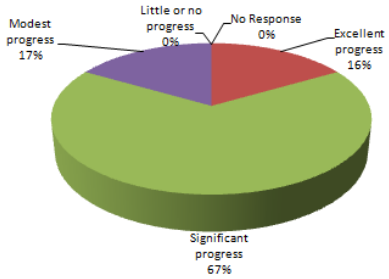
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: HCCI Engine Research and Modeling

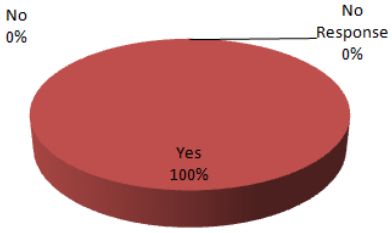
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



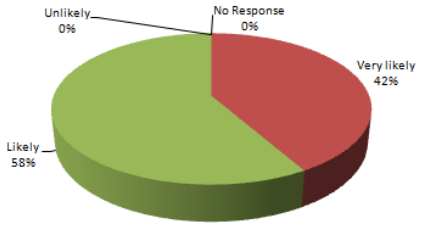
Question 3: Characterize the technical accomplishments and progress toward goals.



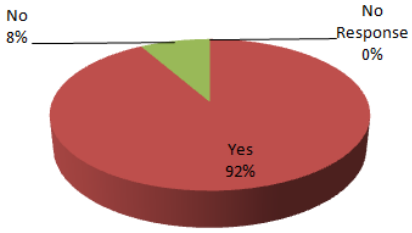
Question 2a: Are the goals of the project technically achievable?



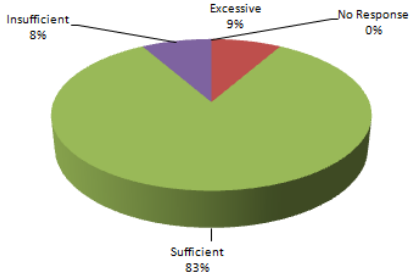
Question 4: How likely is the project team to move technologies into the marketplace?



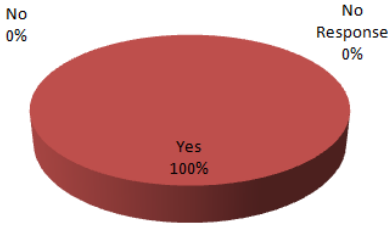
Question 2b: Have the technical barriers been identified and addressed?



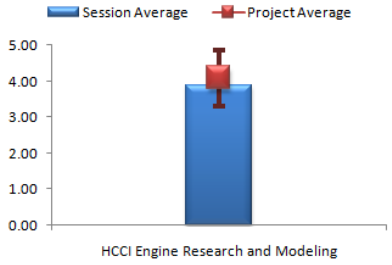
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Heavy-Duty Combustion Modeling (Mark Musculus, of Sandia National Laboratories)

Reviewer Sample Size
This project had a total of 10 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
It was commented by a reviewer that the program supports DOE goals for petroleum displacement because it aims to provide physical understanding and predictive capabilities for high efficiency combustion systems. HCCI was seen by a few reviewers as important to the future of fuel economy improvements. It was also stated, by another reviewer, that the study will be good for reducing soot.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
It was said by one reviewer that this was very useful fundamental work that is necessary for the future deployment of HCCI technologies. Another reviewer went on that the program goals are well-defined in terms of objectives, task interactions and collaborations. Key accomplishment is developing a model to explain the behavior of unsteady sprays and the resulting in-cylinder fuel-air distribution. The program was also described as an excellent blend of experimental and model development, a view held by another reviewer.

One reviewer also felt that it would be good to have that the same students do the optical and modeling work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
The modeling program was found to be making steady progress towards goals, by a reviewer. The modeling program was the topic of another reviewer, that the project had successfully addressed some of the physical parameters and then applied modeling or developed models to match the observations. The unsteady 1-D jet penetration model had the attention of a another reviewer, who saw it as being very useful in understanding details of optical engine data and encouraged continued development of this model.

Another reviewer felt that it was still early days in the progress of this modeling project, while another commented that more fundamental analysis will be necessary to further improve the model.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
A reviewer stated that technology transfer is more appropriate than market transformation. Good interactions with industry and academics. Good tech transfer to engine designers is possible. Another reviewer commented that this program is contributing to understanding and predictive models that is necessary to commercialize low temperature combustion. One reviewer felt that the work was a model of what these programs are envisioned to be. "Observe, understand, model." The models and understanding developed here will be what goes to market. Another felt that the diesel engine industry would benefit from the study. It was also wondered by a reviewer when the model will be predictive with high enough confidence to be used for engine design and development.

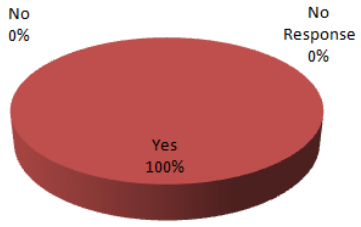
Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
Those who responded noted that funding was adequate.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

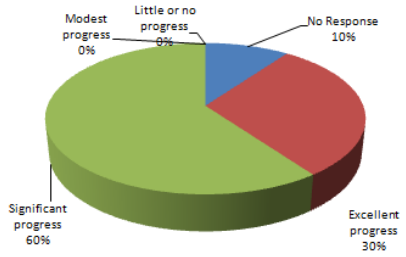
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Heavy-Duty Combustion Modeling

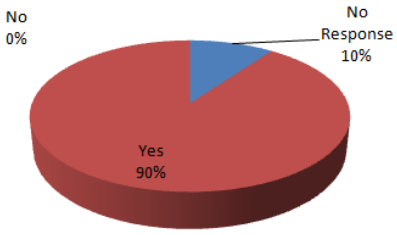
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



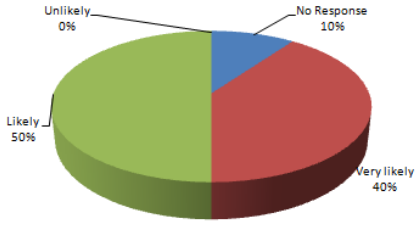
Question 3: Characterize the technical accomplishments and progress toward goals.



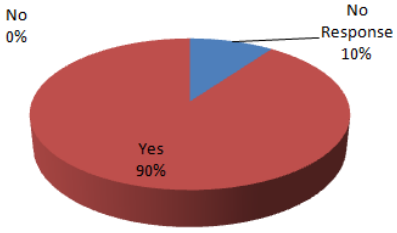
Question 2a: Are the goals of the project technically achievable?



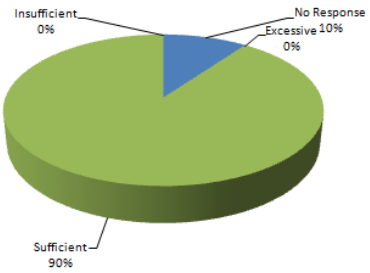
Question 4: How likely is the project team to move technologies into the marketplace?



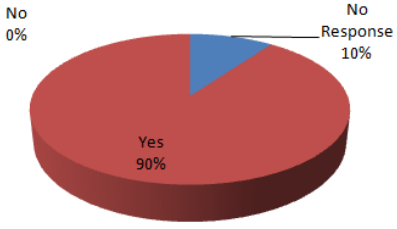
Question 2b: Have the technical barriers been identified and addressed?



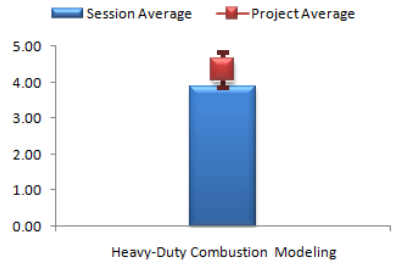
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Heavy-Duty, Low-Temperature, and Diesel Combustion Research (Mark Musculus, of Sandia National Laboratories)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One reviewer notes this program supports DOE goals for petroleum displacement because it aims to provide physical understanding and predictive capabilities for high efficiency combustion systems. It was also stated by a reviewer that the project is well aligned with the goal of developing a fundamental understanding of LTC - and what are its fundamental limitation in providing a higher efficiency combustion mode.

It was felt by other reviewers that barriers defined correctly would be of interest to industry. It was also felt that HD LTC would be important in the future and key to creating clean and efficient diesels engines.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
HD LTC was seen as an important area of research, as long as the fuel economy benefits outweigh the disadvantages. Another reviewer stated that the new focus on the influence of engine design parameters is producing valuable data and insights. The program goals are well defined in terms of objectives, task interactions and collaborations. A key accomplishment is using an optical engine to understand how engine design choices influence low temperature combustion. The work was seen, by a reviewer, as being good and systematic. The reviewer added that understanding of combustion process is to be transferred to numerical models. Another reviewer had a more specific comment, saying that the entrainment wave concept helps to explain gaps in one dimensional modeling, which should help KIVA model grid dependencies, which should help in designing HCCI operation at various bowl/swirl configurations. A reviewer also commented that there was good coordination with industry.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer states that good steady progress has been made. The reviewer adds that in-cylinder visualization is an important but potentially very large experimental field. The reviewer asked if the team considered design of experiments to reduce the bowl diameter/spray angle/injection timing matrix down to a manageable size. The reviewer continues, saying that this program is making significant progress toward goals. There is good interaction with industry and university partners. Key accomplishment is using an optical engine to understand how engine design choices influence low temperature combustion.

A reviewer praised the project for doing a good job using a systematic approach to investigate the effects of the bowl and nozzle geometry, adding that they don't need to run a full design-of-experiment -just look at known relevant conditions. The things that are being measured in the engine (toluene, formaldehyde, OH, PAH) are tied to a fundamental understanding of the mixing, ignition and combustion.

A reviewer stated the project team needs to make sure they stay on the task of developing the picture of LTC and not get too tied up looking at variations in hardware and operating conditions.

The unsteady jet model is a great innovation. This reviewer finds simple models like this to be very useful for increasing understanding of a problem. A reviewer also felt that physical interactions will require fundamental understanding in order to model effectively. Good results were shown.

Another responder commented that the project should continue to work on ways to overcome the HC and CO issues associated with LTC. It was felt by a reviewer that significant progress has been made on understanding effect of engine design variables on LTC. Looking forward to the data from the 80% bowl to complete the understanding gained from the 60% and 70% bowls, as well as the spray targeting and swirl variations.

Can CO and UHC emissions measurements also be made (a la Paul Miles) to complete our understanding of emissions formations? A reviewer stated that counter intuitive results seem well explained. This reviewer wondered what we do about the lean condition around the injector.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

A reviewer stated that this program is contributing to understanding and predictive models that is necessary to commercialize low temperature combustion. One reviewer stated that the work is focused on the right issues; engine design variables, fuel injection, numerical and conceptual modeling. Close collaboration with University of Wisconsin to update numerical models is ongoing.

Technology transfer was also commented on by a number of reviewers. One stated that these techniques are well-suited for technology transfer, rather than market introduction.

Another reviewer stated that the transfer is likely to be in the form of a model. Bringing in a modeler to help set up the test plans is a great idea that should be utilized in other projects. The project's good connection with industry was also commented upon.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

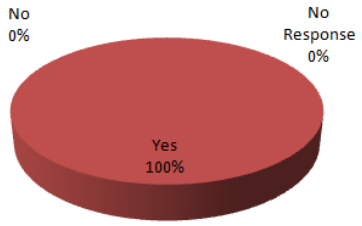
Progress seems commensurate with resources, according to a reviewer, while another felt that resources were adequate. One respondent added that the project needs to Needs to incorporate multiple injections and work towards solutions, in addition to "understanding".

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

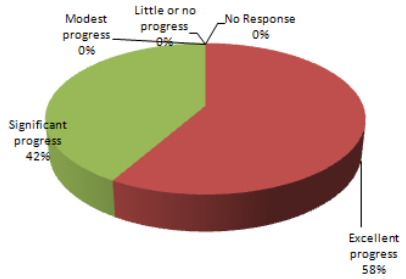
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Heavy-Duty, Low-Temperature, and Diesel Combustion Research

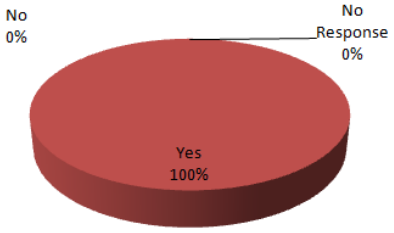
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



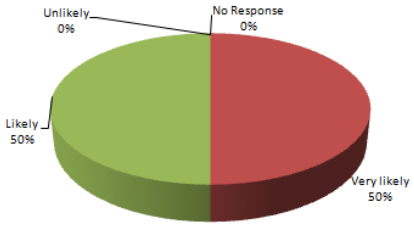
Question 3: Characterize the technical accomplishments and progress toward goals.



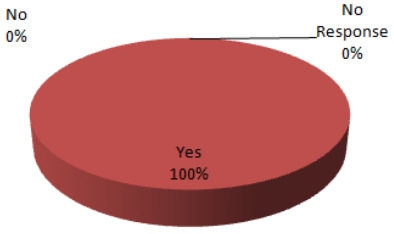
Question 2a: Are the goals of the project technically achievable?



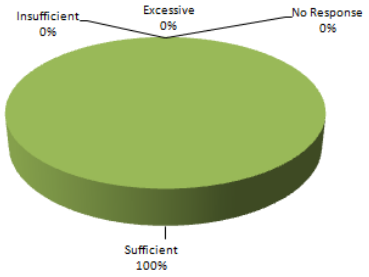
Question 4: How likely is the project team to move technologies into the marketplace?



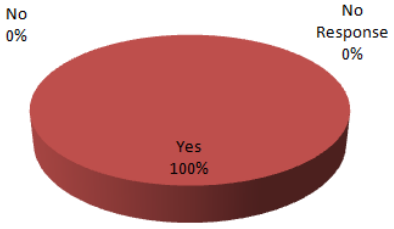
Question 2b: Have the technical barriers been identified and addressed?



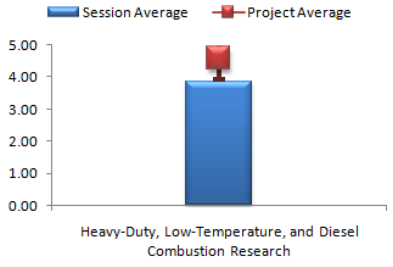
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Hydrogen Free-Piston Engine (Peter Van Blarigan, of Sandia National Laboratories)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
A reviewer saw that the modeled or calculated efficiency of the free piston engine is potentially very good, but this is still theoretical. Another reviewer felt that the link to implementation in a vehicle was not defined. The same reviewer saw a need to expand on the systems approach to implementing the technology in a vehicle. Another reviewer did not see enough evidence that free piston engines are going to be a viable solution for transportation in the short to mid-team.

Another reviewer saw the program as supporting DOE goals for petroleum displacement because it aims to develop a novel engine configuration that incorporates a hydrogen-based combustion system. It was stated by reviewer that the project was investigating a method to potentially make a significant improvement in the efficiency of internal combustion engines. A reviewer said that it was a high risk project, but one that supports advanced engine concepts and hydrogen. Other reviewers saw the project as potentially increasing efficiency.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
The project faces difficulties, in the words of a reviewer, with its broad scope and the essential re-engineering of the internal combustion engine. Another reviewer saw the project's goals as being well defines, but as having two significant barriers, including the availability of hydrogen as a fuel and the performance (in terms of efficiency, cost, operability and reliability) of the free-piston concept versus current or competing new technologies. The reviewer saw achieving competitive performance as the biggest barrier for implementation.

Other reviewers suggested technological concerns. One reviewer saw many potential problems in the scavenging system. Another reviewer saw limits to the benefits of increasing compression ratio in conventional engines caused by heat transfer and friction. The same reviewer saw significant noise as being caused by auto-ignition at all loads as loads increase, and there was no clear path to addressing emissions issues, since it was not clear that the exhaust temperature would support catalyst usage. Another reviewer was left unsure by the presentation, if the almost certain technological barriers that will arise on implementation of the technology can be overcome. One reviewer would like for the hardware and goals to be demonstrated on a laboratory scale, so that the barriers can be well understood.

A reviewer hoped that industry interaction would be maintained, while another thought there was good efficiency analysis.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer saw the project as having struggled with fairly limited physical accomplishments. The reviewer, among others, awaits the operation of a real steel engine with interest. Another was interested in seeing what the efficiency and emissions will be achieved with the upcoming demonstration engine.

One reviewer expressed concern that controlling the free piston engine had not been addressed in the current project. Two reviewers expressed concern that there was focus on the electric components at the expense of the combustion capabilities. Another simply wanted more attention placed on combustion capabilities and demonstrating motion control. A reviewer saw high risk with combining the dual linear alternators with a combustion system, which contributes to the apparent slow progress. The same reviewer wondered whether assumptions of the efficiency of the linear motor/generators been validated, as well as whether sufficient control of linear motor/generators been demonstrated to achieve target operability, control of compression ratio and control of work extraction. This reviewer suggested the program focus on verifying multi-cycle combustion operation with pistons controlled by simpler means, verifying control of the linear motors without combustion and combining the two.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

There was widespread concern about commercial application of this technology. It seems unlikely that industry will embrace this kind of technology - not that this means that this should not be pursued - but that it should be approached with realism. Concern was expressed, by a reviewer, if the project would deliver the efficiency that is claimed and that battery energy storage costs and transfer would cause unattractive pricing. The project was seen, by one reviewer, to be a fundamental experiment to look at the thermodynamic problem of using a very high compression ratio. Another saw it as a very unique approach which faces a number of hurdles. One reviewer was certain that if the demonstration was successful interest will pick up significantly.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

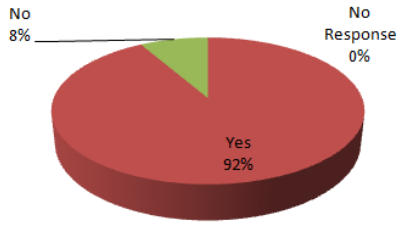
One reviewer saw the project as having shown good promise, even while on a starvation budget. Another felt that funding should only increase if the fuel efficiency advantage is demonstrated and if a path to market is defined.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

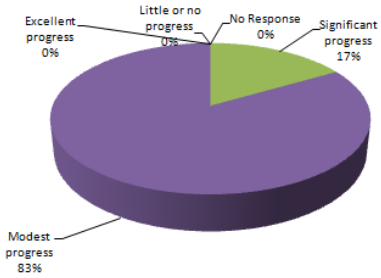
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Hydrogen Free-Piston Engine

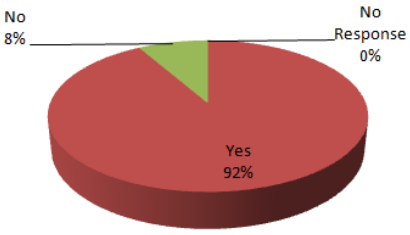
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



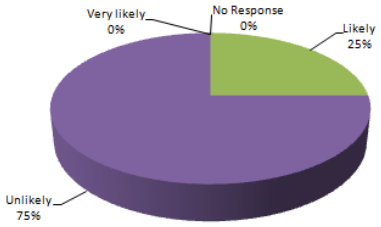
Question 3: Characterize the technical accomplishments and progress toward goals.



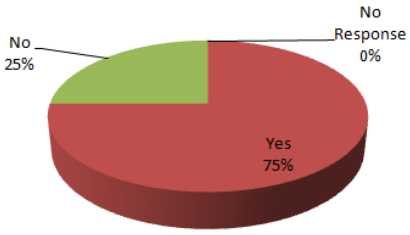
Question 2a: Are the goals of the project technically achievable?



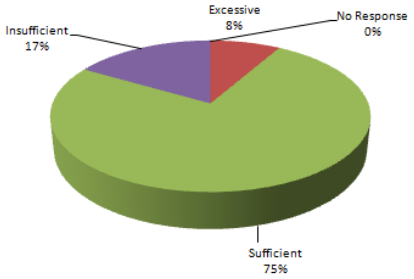
Question 4: How likely is the project team to move technologies into the marketplace?



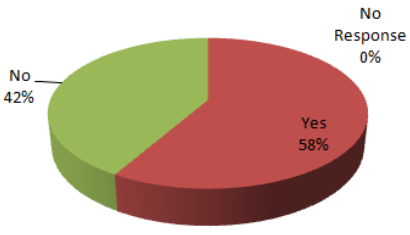
Question 2b: Have the technical barriers been identified and addressed?



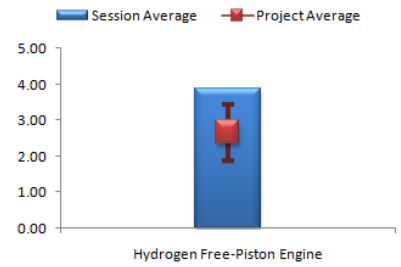
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Hydrogen Internal Combustion Engine Research (Thomas Wallner, of Argonne National Laboratory)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One reviewer saw the project as offering both improved fuel efficiency and alternative fuel utilization, but felt that hydrogen internal combustion engines research was moving out of favor with DOE. Two reviewers saw the hydrogen internal combustion engine approach as making sense, with hydrogen as a gap technology to establish a hydrogen infrastructure until fuel cell vehicles become commercially available. A reviewer saw the program as supporting DOE goals for petroleum displacement because it aims to provide physical understanding and predictive capabilities for hydrogen-based combustion systems (comparing direct injection with port injection).

Another reviewer did not see hydrogen as an ideal fuel for a vehicle. A reviewer expressed concern that a hydrogen fueled engine would not have enough added efficiency over a gasoline or diesel engine to make it worthwhile and wondered how this would compare to low temperature diesels or advanced lean gasoline engines.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer found the program's goals as being well defined. The same reviewer saw accomplishments as the study of direct injection hydrogen internal combustion engine by investigating different injector configurations (comparing direct injection with port injection).

Two reviewers expressed concern about NOx emissions, one of whom did not find water reduction as practical. The other was curious what guided the testing, and how the various injector locations were chosen. The same reviewer also wanted to know if modeling was a factor.

Another reviewer saw direct injection hydrogen internal combustion as the only reasonable path for the technology that would enable high efficiency and power density. Concern was expressed that the goals were not comprehensive, and the reviewer blamed this on the project being in response to Ford, not out ahead leading the work. Other reviewers saw good industry cooperation, but one expressed concern the hydrogen was not an ideal vehicle fuel.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer saw the program as making progress towards the goal of studying hydrogen combustion in internal combustion engines. The reviewer saw a key accomplishment as the study of direct injection hydrogen internal combustion engine by investigating different injector configurations (comparing direct injection with port injection). A different reviewer saw the program as useful work aimed at overcoming technological barriers to hydrogen internal combustion engine deployment. A reviewer considered the program as doing an excellent job examining various nozzle configurations and helping understanding how best to mix the fuel and air. Another reviewer commented on the good brake thermal efficiency results. One reviewer saw the program as assisting development of an engine that achieved the milestone 45% peak thermal efficiency as a key accomplishment for 2007.

A reviewer suggested that the project choose a future emission standard, such as Tier 2 Bin 5 or lower and then estimate the NOx PPM level required to meet it. The reviewers impression was that the NOx measurements presented are very high. A different reviewer commented that NOx emissions should be normalized (e.g. g/kg-fuel) and plotted against advanced gasoline and diesel engine NOx emissions to see where this engine technology stands.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

Concern was expressed by several reviewers about the lack of a hydrogen infrastructure, while one reviewer also felt the technology was competitive with fuel cells. Another reviewer saw interest in hydrogen as fading, but found the information on reformer gas as valuable. Some reviewers saw the industry partnership with Ford as important, but urged the project to stay ahead of Ford rather than follow.

One reviewer saw the program as yielding valuable public domain data on hydrogen combustion in internal combustion engines, and felt the technology would be a valuable transition to fuel cell vehicles. One reviewer felt that industry was looking at this approach very closely, and that more fundamental investigations might be recommended.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

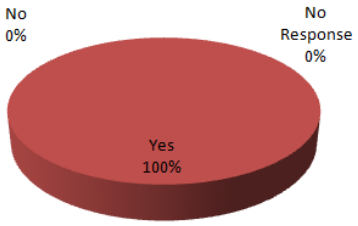
One reviewer found the project as having a low budget compared to the amount of work required to commercialize the technology. Another reviewer felt that funding was currently adequate, but should increase if sources of hydrogen become more competitive with other fuel options. A third reviewer felt this was the kind of project that was best kept small.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

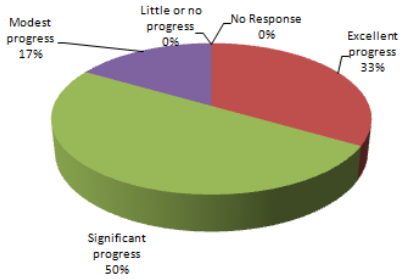
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Hydrogen Internal Combustion Engine Research

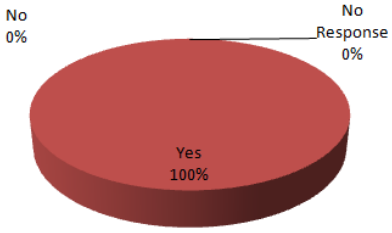
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



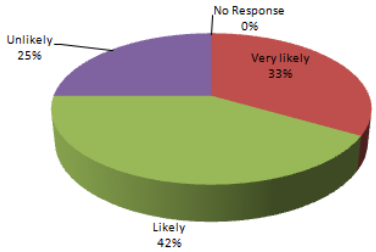
Question 3: Characterize the technical accomplishments and progress toward goals.



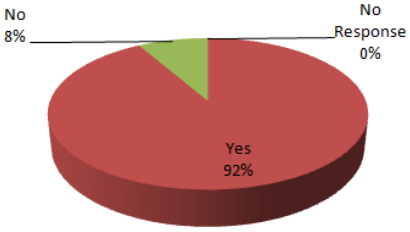
Question 2a: Are the goals of the project technically achievable?



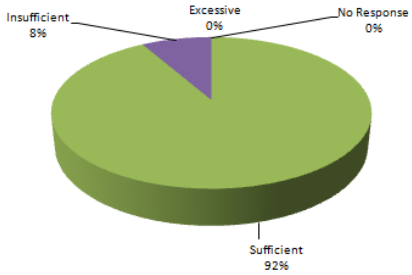
Question 4: How likely is the project team to move technologies into the marketplace?



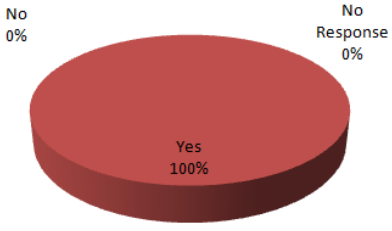
Question 2b: Have the technical barriers been identified and addressed?



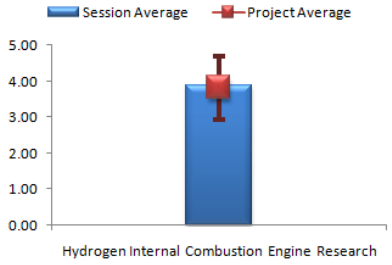
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Improved Engine Design Concepts Using the Second Law of Thermodynamics (Jerry Caton, of Texas A&M University)

Reviewer Sample Size
This project had a total of 13 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
The program was seen by a reviewer as a good, well-targeted use of DOE's limited basic science budget. The goal of the project was seen to improve the efficiency of internal combustion engines by understanding fundamentals of thermodynamic losses, and the program was viewed as supporting DOE goals by another reviewer. A reviewer noted the first principles look at ways to improve efficiencies in internal combustion engines, which the reviewer felt would provide insight to DOE and industry. Another reviewer found that using the second thermodynamic law to analyze the thermal efficiency of internal combustion is a very interesting topic. A reviewer thought the work is good, keeping a sanity check on other programs, so indirectly it contributes to the overall objective of reducing petroleum consumption. One reviewer was concerned that there was no link to experimental data and perhaps the program was too ideal to be of practical use in the real world.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
A reviewer found the project to be a good generic study, and useful. Another saw the project as computational and open-ended with readily achievable goals. A reviewer saw the program goals as well-defined in terms of objectives, task interactions and collaborations. This program team is making good progress leveraging their respective facilities and capabilities to meet the goals of the program.

A number of reviewers urged the program to increase collaboration with industry partners in order to implement new technologies. One reviewer felt that that analysis should be expanded to include turbocharger, charge air cooling, EGR cooling, etc. The reviewer added that the approach should be expanded beyond in-cylinder, and wondered what other paths to improvement could be seen using this analysis.

A reviewer was unsure what engine design concepts can emerge from the analysis and felt that some thought should be devoted to actually incorporating the results into possible engine designs that would spell out the hardware needed. Another reviewer felt that analysis at partial load might help with understanding in this part of the engine map, even if unlikely to help overcoming any technical barriers. Another reviewer felt that some practical things need to be considered during simulation, such as the length of the stroke.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer stated that this was a good, solid study that will aid future engine design. The reviewer added that this is a fundamental study, but better rooting in 'reality' would be of greater value - for example, multi-cylinder exhaust manifold tuning will improve exhaust breathing in an over-expanded engine. Another reviewer stated that this program is making reasonable progress toward goals, but that the program can add more value by extending the analysis method to assess the relative contributions to irreversibility of friction, turbo-machinery, heat exchangers, etc. Another reviewer felt the program should focus more on diesel engines for best fuel consumption potential, although

attention to (alternative) cycles for paper studies is thought provoking. Another reviewer thought that this was interesting work, and that it may be a good idea to do more.

A reviewer stated that progress is good, and agreed with the suggestion to look at indicated efficiencies, rather than brake at this stage of the project. Another reviewer found the work to be interesting, but felt it would be a good idea to do more comparison between the different combustion modes (SI, HCCI, diffusion controlled diesel, or PCCI diesel) to look at combustion availability destruction for these different processes. The reviewer went on to suggest separating the combustion process from the reciprocator device if this is possible. The reviewer felt that a useful outcome of this work would be a set of guiding principles for engine developers - which direction should various parameters be pushed, i.e. is longer vs. shorter combustion duration beneficial or is it path independent and so it doesn't matter?

Another reviewer urged a tie to industry and suggested working with indicated and pumping efficiencies rather than brake. The reviewer feels a few statements that explain the significance ("what does this mean?") of some of the Second Law Analysis results should be included for discussion.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

The project was seen as having technology transfer predominately via graduate students employed by industry and through academic publications. Reviewers found that to be appropriate for a fundamental project. Reviewers felt that the project was investigating a very fundamental question, and that understanding and quantifying the results are worthwhile, even though there is not a marketable component. One reviewer added that a benefit of the program was adding a lot of graduate students to industry. One reviewer felt that while a lot of analysis work is being done, the significance of these needs to be better explained.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

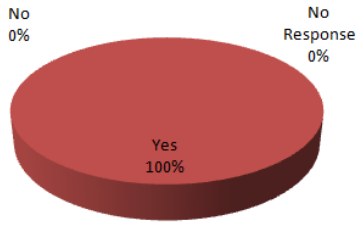
Several reviewers felt that resources were appropriate for a project of this size. One felt that there was good use of a low budget, while another reviewer felt that lots of work being done with very little funding, especially when consider having to customize software to use on their project. The reviewer wondered would it be beneficial to expedite EGR studies if there were increased funding available.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

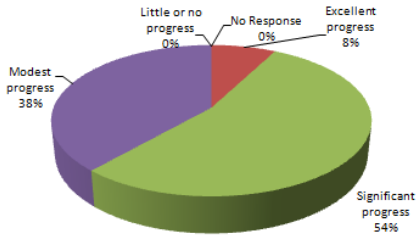
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Improved Engine Design Concepts Using the Second Law of Thermodynamics

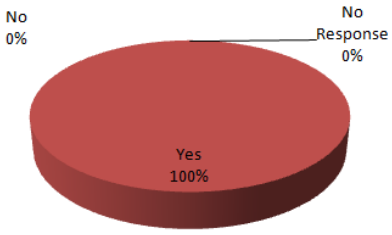
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



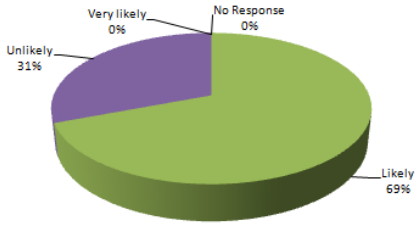
Question 3: Characterize the technical accomplishments and progress toward goals.



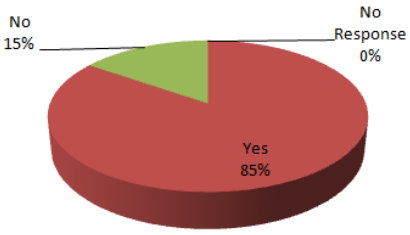
Question 2a: Are the goals of the project technically achievable?



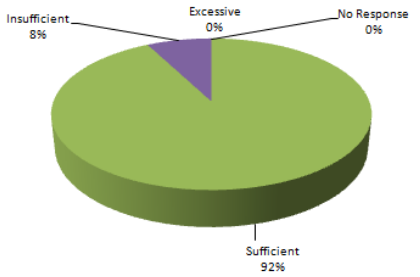
Question 4: How likely is the project team to move technologies into the marketplace?



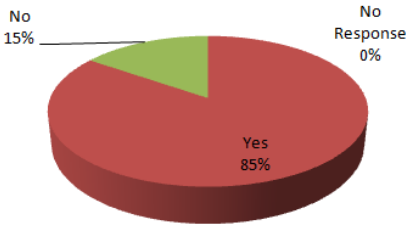
Question 2b: Have the technical barriers been identified and addressed?



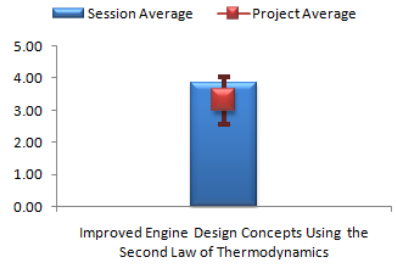
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



KIVA Modeling to Support Diesel Combustion Research (David Torres, of Los Alamos National Laboratory)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
A reviewer commented that combustion CFD progress is need for HCCI development. Another reviewer felt there was support for diesel combustion work. A reviewer stated that the program should lead to improved combustion event understanding leading to opportunities to improve efficiency.

A reviewer felt that improved computational modeling is required for both conventional and advanced engine combustion studies and design. A reviewer added that the project establishes the modeling tools for efficiency improvements. Another reviewer stated that the numerical modeling supported the study. Another reviewer stated that developing an unstructured parallelized KIVA code will help improve diesel and gasoline engines by improving the tool used to develop them.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
A reviewer felt that multi zone and parallelization do add the necessary modules. Another reviewer stated that KIVA updates would find their way into industrial and academic research in an expeditious manner. A reviewer saw collaboration with the labs and industry. One reviewer commented that the project looks like its applying other's models and examining their inner workings. The reviewer added this seems to be trying to identify one model's ability over another. The reviewer wondered will the study's examination of ability and quality of results be significant given the overall resolution ability of the models to start with.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer commented that combustion simulation is the next step after diagnostics. It supports the implementation part of implementing the low temperature combustion in the engine. A reviewer felt that increased focus on industry relevant applications is good, giving the example of four valve geometrics. A reviewer said to keep up the good work. A reviewer said that the work seems to be looking at the work of various users of KIVA3 and 4 and looking at model results and trying to see which method had better results. The reviewer believed the model implementation of KIVA4 here was presented by others, and was unsure what the new work was here.

A reviewer would have liked to have seen more quantitative comparisons, feeling that the comparison show was just comparing pictures on a 3-D mesh which the reviewer considered qualitative only. The reviewer felt it would be useful to see a 2-D plot of a variable across the cylinder diameter or a histogram showing mass fractions at different equivalence ratios, for example. The reviewer added that on the whole, it seems they have made better progress this year.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

Reviewers commented favorably on the technology transfer, one citing the open-source nature of the updates as helping this. One reviewer would like to have seen reporting on the results of the industry collaboration.

A reviewer felt that improvements developed here will likely have to be implemented in other codes to gain more use by industry. Another reviewer felt that there may be value in the determination of which methods have superior results when applied in a specific manner, the reviewer added that this should be useful information to industry.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

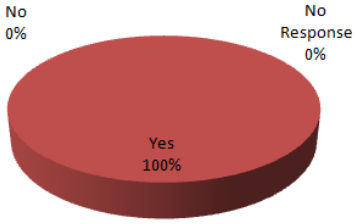
A reviewer commented that the budget is low, but progress was good nonetheless. Another stated that this was great basic work developing tools for use by engine designers. The reviewer added the team has good collaboration with its peers.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

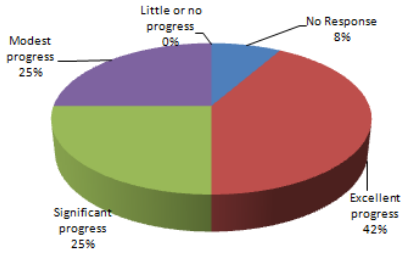
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: KIVA Modeling to Support Diesel Combustion Research

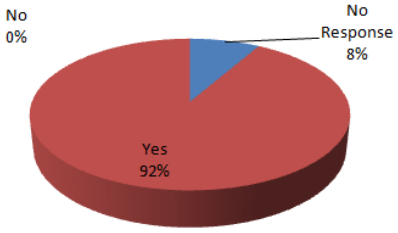
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



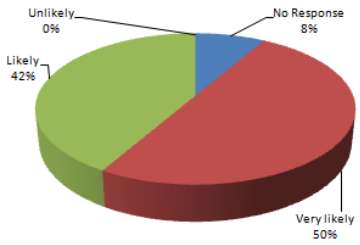
Question 3: Characterize the technical accomplishments and progress toward goals.



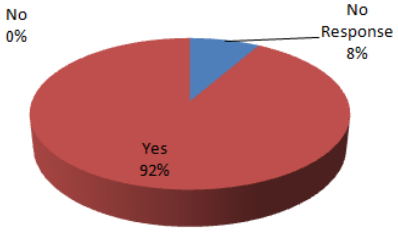
Question 2a: Are the goals of the project technically achievable?



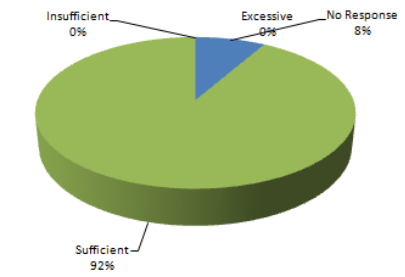
Question 4: How likely is the project team to move technologies into the marketplace?



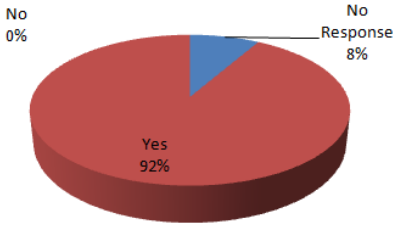
Question 2b: Have the technical barriers been identified and addressed?



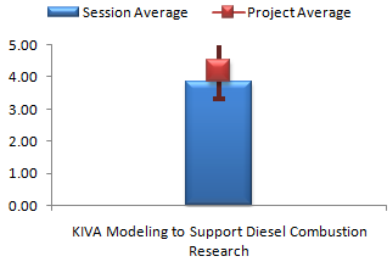
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



LES Applied To LTC/Diesel/Hydrogen Combustion (Joe Oefelein, of Sandia National Laboratories)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
The project was seen by a commenter as providing the next generation LES models to assist with the development of direct injection LTC/advanced diesel and hydrogen engines. All those engines are consistent with DOE's objectives in enhancing conservation of conventional fuels, as well as promoting the use of alternative fuels. Another reviewer felt that high-fidelity simulation of engine combustion is a very necessary adjunct to the experimental and analytical research conducted elsewhere under DOE funding. The program was also seen by a reviewer as supporting DOE goals for petroleum displacement because it aims to provide physical understanding and predictive capabilities for high efficiency combustion systems. One reviewer saw the goal of the project being model development, but also felt this would untimely lead to advances which support the goal of petroleum displacement.

A reviewer said that high-end numerical models capture the understanding from the engine experiments. They can be applied over a range of products design and development. The project was seen as high risk by a reviewer, but as representing the future of modeling with high fidelity predictive models. Another reviewer saw the basic work as valuable, and the hydrogen work's relation to diesel low temperature combustions as well explained. The reviewer did add an interest in reversing the role, i.e. doing the diesel first, then applying the hydrogen.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
The goals of the project were seen as appropriate, by one reviewer. The goals were also seen as well defined. A number of reviewers commented positively on the computer modeling, seeing that as a study to confirm experimental and analytical results obtained elsewhere. The project was seen as being primarily about model development, and the numerical model was expected to contain the necessary physical processes. One reviewer saw the project as a tremendous undertaking, which could not be handled by industry and beyond the means of academia, and hence left to government.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
The project was seen, by a reviewer, as having being realigned from an emphasis on hydrogen, to a more general diesel and LTC approach, which the reviewer saw as a good modification. A reviewer stated that the LES direct injection model can provide insight to develop hydrogen engines, but added that the hydrogen research does not appear to be technical barriers for the near to intermediate future. The reviewer also added that the program provided a bridging technology toward a future transition to a hydrogen economy.

One reviewer said that they liked the project and thought it was a good idea to take a small part of the resources and use then to look at a simple combustion problem with a very powerful computer in order to get an idea of the long term capabilities and usefulness of modeling. The reviewer added that they felt the program was in transition from hydrogen to looking at gasoline fueled engines, the reviewer hoped that the original objective of using LES in a detailed model would not be lost.

The project was seen as a tremendous task, by a reviewer. Another reviewer found the main impact as being to explore computationally-intensive methods for transient fuel injection and combustion related to reciprocating engines. This is useful for industry because it shows what is possible as computer resources become available. The reviewer expressed concern that the work is still very fundamental and is not having an impact at the design level. To be more valuable to the community, it is desirable to include two phase flows and perform a design-of-experiments set of calculations to assess the impact of engine geometry variations. The reviewer also cautioned that the group needs to make faster progress developing a validated suite of benchmark simulations.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

One reviewer felt the project would have more immediate impact if the simulation models were transferred to multiple manufacturers working on the development of diesel engines, with more near term potential, giving the examples of other gaseous fuels beyond hydrogen, advanced direct injection gasoline, advanced direct injection diesel. Another reviewer felt that the program was limited by the focus on hydrogen engines, which also limited the number of collaborators. Another reviewer saw the transition of results to Ford as assisting in the company's research and development of hydrogen engines, which would slowly transition to niche markets as long as the infrastructure issues are overcome.

Another reviewer found that there had been a useful transfer of knowledge back and forth from modelers, experimentalists and computational specialists. A reviewer also saw the technology as transferring to modelers and eventually transition to the marketplace. One reviewer commented that the fundamental research and modeling provides the understanding necessary to design and develop production capable combustion systems.

Two reviewers felt that in addition to the focus on hydrogen, the program indirectly supported the building of hi-level combustion, and that the modeling would allow a look at more complex fuels.

One reviewer felt the models would not have an impact for some time, until there is sufficient computer power, but felt that those models would eventually change the way engines are designed. Another reviewer felt the program was pioneering the use of advanced computational tools, but that the impact of the program remains to be seen.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

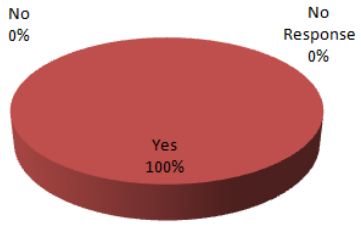
Most reviewers felt that funding was sufficient. Two reviewers added that with more focus on diesel or LTC, more funding would be desirable. The team's leveraging of other program resources received positive comments from two reviewers, and the computer time grant as encouraging.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

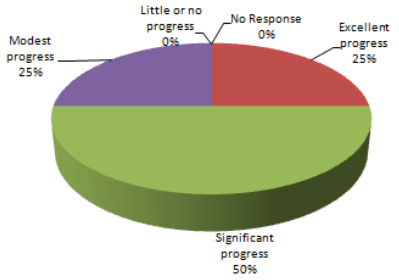
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: LES Applied To LTC/Diesel/Hydrogen Combustion

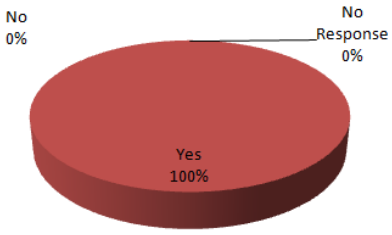
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



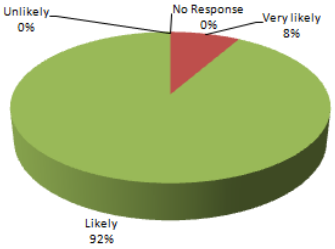
Question 3: Characterize the technical accomplishments and progress toward goals.



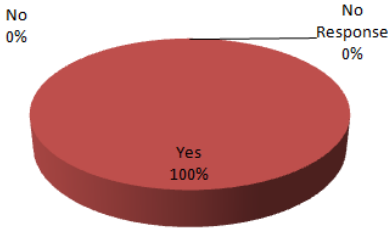
Question 2a: Are the goals of the project technically achievable?



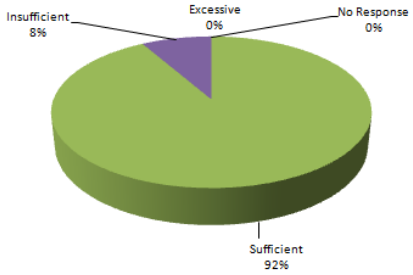
Question 4: How likely is the project team to move technologies into the marketplace?



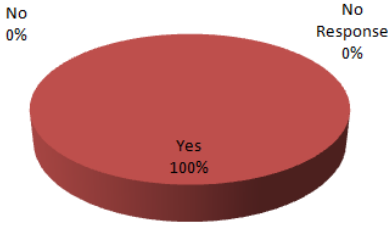
Question 2b: Have the technical barriers been identified and addressed?



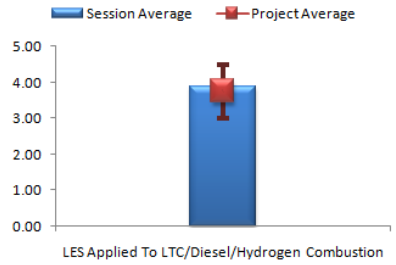
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Light-Duty Combustion Modeling (UWI) (Paul Miles, of Sandia National Laboratories)

Reviewer Sample Size
This project had a total of 11 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
The reviewers had universally positive responses. One reviewer stated that HCCI/PCCI will save significant amounts of fuel, if it works out to its full potential. Another felt this program supports DOE goals for petroleum displacement because it aims to provide physical understanding and predictive capabilities for high efficiency combustion systems. Another reviewer commented that the modeling component of the activity would improve fundamental understanding of LTC. It was commented by a reviewer that fundamental understanding and translation into useful models should enable faster development of diesel engines. The numerical simulation was seen, by a reviewer, as being an effective tool to study unknown effects in LTC engine research. Another reviewer commented that the project aimed to improve efficiency.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer saw the project as having a sound strategy in place. The reviewer found the project to be well-coordinated with the industrial partners. Another reviewer found the program goals are well defined in terms of objectives, task interactions and collaborations. A key accomplishment is modeling of in-cylinder CO and unburned hydrocarbons and examining the influence of turbulence. A third reviewer found good cross-industry, national laboratory and university collaboration.

It was also suggested by a reviewer that the model needs to be improved. Maybe the effect of swirl ratio on fuel distribution in cylinder needs to be considered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer found that the modeling program is making progress toward goals. Good interaction with industry and university partners. Good effort to interpret the experimental results. It was stated, by another reviewer, that the kinetics studies are innovative - more detail than this reviewer had seen anywhere else. They are doing a good job trying to couple the optical measurements to the kinetics modeling results. They are focused on combining the modeling work with the experiments to develop a complete picture of LTC. It was also noted by a different reviewer that the model need be improved to predict CO at different injection timing and a reviewer also commented that a large area of work remains to be done in this area.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
All responses were positive in this area; one reviewer commented that this program is contributing to understanding and predictive models that is necessary to commercialize low temperature combustion. One reviewer saw potential benefits to the entire industry if the improved model can be embedded into KIVA. It was also observed that the project was well-connected with an industrial partner. The modeling work being done here will ultimately help improve the fundamental understanding and engine designs. It was also noted, by a reviewer that there was good industry involvement in this (and related) project(s).

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

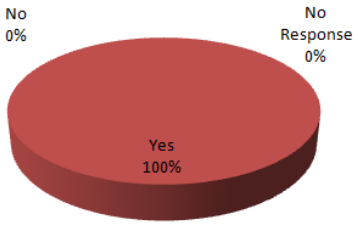
Overall the funding was found to be sufficient, with one reviewer stating that compared to the experimental program, the modeling portion of this work does not appear to have critical mass. It may be better to increase funding of this task, or more closely link this task to one of the larger modeling efforts at SNL.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

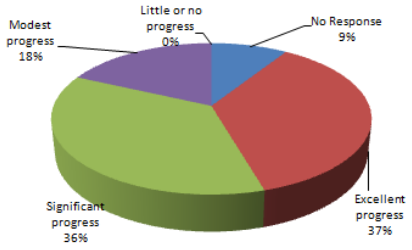
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Light-Duty Combustion Modeling (UWI)

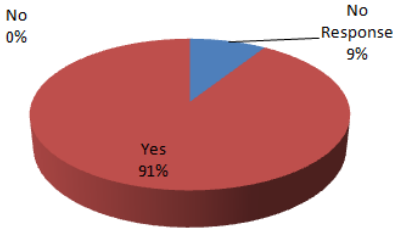
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



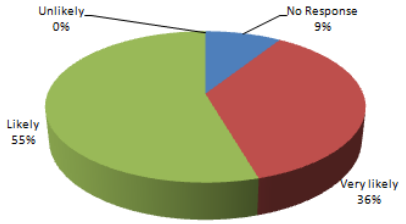
Question 3: Characterize the technical accomplishments and progress toward goals.



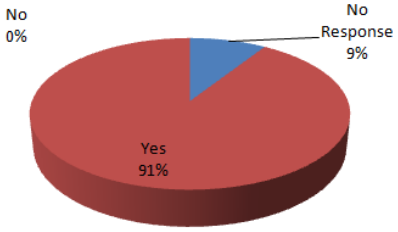
Question 2a: Are the goals of the project technically achievable?



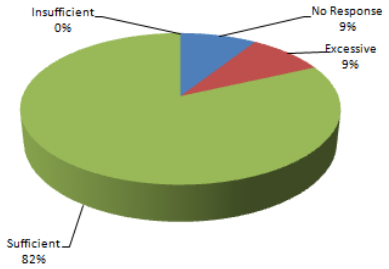
Question 4: How likely is the project team to move technologies into the marketplace?



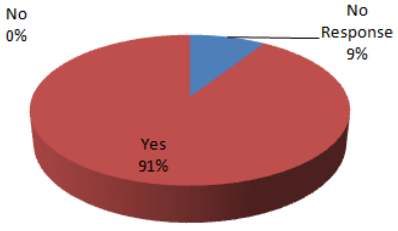
Question 2b: Have the technical barriers been identified and addressed?



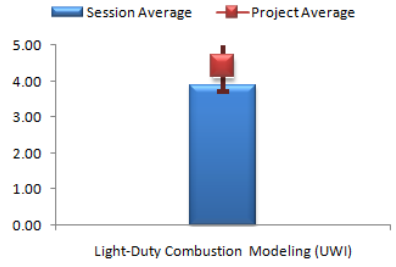
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



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

Reviewer Sample Size
This project had a total of 11 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
The study was seen, by one reviewer, as a development of a toolkit of methods to be used by others in HCCI engine design and development. Another reviewer commented that understanding which addresses the barriers of low temperature combustion was being developed. One reviewer stated that the program was providing a fundamental understanding of diesel sprays as they relate to combustion and emissions formation, which will help improve both heavy- and light-duty diesel engines. The fundamental transfer of data to universities will support model improvement, according to one reviewer. Another reviewer saw this as a welcome study on multiple injections. One reviewer said that Lyle seems to have really reached out to industry for collaboration. The reviewer added good "rub off". One reviewer stated that although this work is done in a constant volume vessel and not an engine, this kind of work is very much needed because well-controlled experiments, unconfounded by engine complexities, can be conducted specifically to isolate and understand physical and chemical process for injector design as well as spray modeling. The program was seen, by a reviewer, as supporting DOE goals for petroleum displacement because it aims to provide physical understanding and predictive capabilities for high efficiency combustion systems.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
The project was seen by a reviewer as providing a good systematic approach to a wide set of fundamental and applied problem areas in HCCI engine design. The program's goals are well defined in terms of objectives, task interactions and collaborations. Key accomplishment is imaging of spray in optical chamber showing spray behavior as a function of injection shape and ambient temperature, yielding useful information for spray model development. One reviewer said that the project seems to be working cross functionally, i.e. building on work of others (Paul, Mark) well! Another reviewer stated that the project is well connected to several industry partners and to other labs and universities through the Engine Combustion Network.

One reviewer said the project should aim to quantify the size (volume or mass) of the lean region during the end of injection as a percentage of the total mass injected, and see if this correlated with the amount of unburned HC in engine experiments. Another reviewer commented that there was good fundamental information for liquid phase residuals from spray patterns. Researcher indicated four projects using information but unclear as to how much this will impact deployment technologies.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer said the project was a useful development of a number of engine design technologies that will be invaluable to other engine developers. Another reviewer stated that this program is making steady progress toward goals. There is good interaction with industry and university partners. Key accomplishment is imaging of spray in optical chamber showing spray behavior as a function of injection shape and ambient temperature, yielding useful information for spray model development. Another reviewer commented that project had done a good job relating the conditions and results of the vessel to those in a real engine. It was added that improving the understanding of the phenomena

which occur at jet shut down (EOI) is very useful. This has been identified as a source of hydrocarbons and combustion inefficiency and an improved understanding is needed.

The laser ignited jet was a great idea. The reviewer would like to see more of this. This is a project for which the combustion vessel is ideally suited. This reviewer thought this kind of work will quickly lead to an improved understanding of lifted flames. Another reviewer found the understanding of liquid penetration in transient sprays as useful in enabling early or late fuel injection without wall wetting, which is important for LTC as well as dealing with diesel after treatment. It was commented by a reviewer that the barriers to LTC combustion and how this facility can help is well understood by these researchers. The collaboration with Musculus and his observations and understanding of the lean region at the end of injection is good. Why was an in-house rate-of-injection meter developed? Why not use available off-the-shelf rate-of-injection meters?

One reviewer felt the focus was on a resolution of problems commons to others and wished to know what the process would be, to the projects findings to more basic modeling.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

Three reviewers spoke highly of the engine combustion network web site. One reviewer found the technology transfer with other research groups to be good. Collaboration with the Musculus project, on both the 1-D jet model and on the imaging of the leaning effect near the injector at the end of the injection, was seen to be good. The collaboration beyond the traditional organizations who work on DOE programs was also pointed out as good. The program was seen as yielding valuable insights required to make HCCI combustion commercial. Publication of the results was also seen as prompt and widespread by a reviewer.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

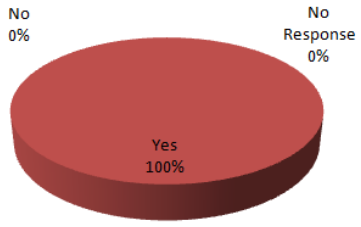
One reviewer stated that greater budget was always better, but noted the project seems to be efficient in its budget per unit work output. The other responding reviewer felt that resources appear to be adequate.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

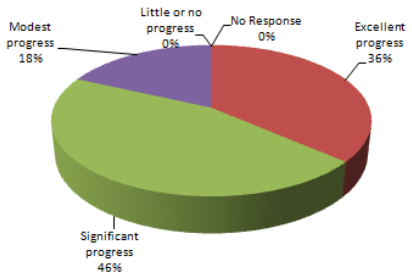
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Low-Temperature Diesel Combustion Cross-Cut Research

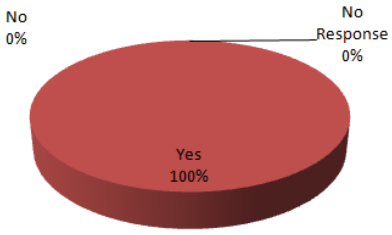
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



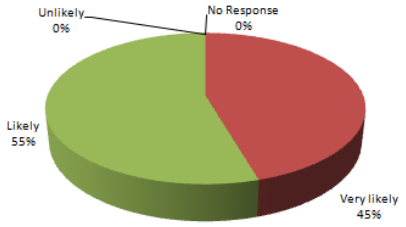
Question 3: Characterize the technical accomplishments and progress toward goals.



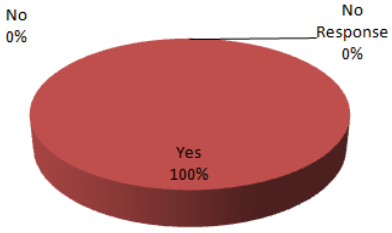
Question 2a: Are the goals of the project technically achievable?



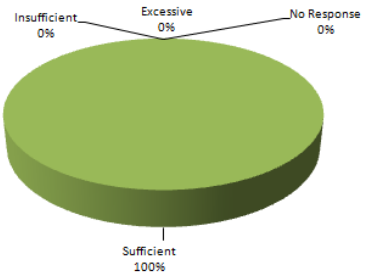
Question 4: How likely is the project team to move technologies into the marketplace?



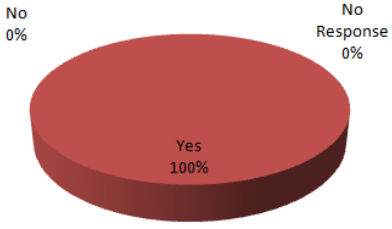
Question 2b: Have the technical barriers been identified and addressed?



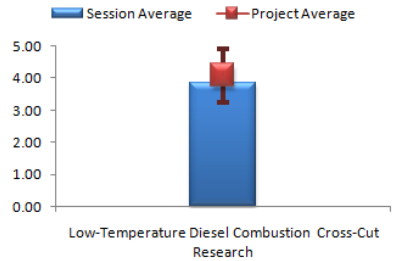
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Optimizing Low-Temperature Diesel Combustion (Rolf Reitz, of University of Wisconsin)

Reviewer Sample Size
This project had a total of 13 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
A reviewer found that numerical simulations are an effective tool for HCCI study. Others saw low temperature combustion as an important potential adjunct to conventional diesel combustion for reducing aftertreatment costs while maintaining efficiency. Program goals were seen as improving the understanding of diesel LTC as well as reducing exhaust emissions while preserving efficiency. A reviewer said that the research was consistent with other LTC research and has the long term potential to accomplish the projects goals. A reviewer saw the program as supporting DOE goals for petroleum displacement because it aims to provide physical understanding and predictive capabilities for high efficiency combustion systems. Another reviewer saw good synergy with industry and good communication.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
A reviewer felt that in-cylinder FTIR measurements of exhaust species are exciting and should provide a much deeper understanding of the combustion process. Another saw the program as doing a lot of fundamental work the supports other projects with very efficiently used money. The projects strategy was seen by a reviewer, as a good strategy for project success.

Reviewers commented favorably on the modeling, one viewing it as a key accomplishment. Reviewers also noted the collaboration between the various labs and universities. A reviewer commented that involvement with two will provide opportunities for deployment, but it would be nice to see more specifics on how this will be achieved. A reviewer stated that variable spray geometry has been "on the table" for decades with little or no visible progress in developing hardware. Dual injectors as used in this program are a satisfactory tool, but someone needs to develop a path towards a production solution. The reviewer added that focus and scope were well defined.

A reviewer felt a good job had been done identifying barriers and addressing them with results. However, another reviewer felt the need for a second injector should be clarified, and wondered whether this would be a practical approach. A reviewer found the improvements in exhaust emission prediction and model calibration have been carried out, but felt that accuracy needed improvement.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer stated that the program had an excellent systematic approach to this large project and experimental matrix. Another said that the program is making strong progress toward goals. There is good interaction with industry and national lab partners. There are numerous advances aimed at retiring risk with low temperature combustion. Another reviewer felt that a very impressive amount of work completed. A reviewer also stated that the project is well coordinated and wide in scope, while another reviewer added that a lot of relevant results had been shown.

Another reviewer said that this is a big program with a wide range of activities. The activities address many different aspects of optimizing LTC in diesel engines. They are looking at some novel techniques such as grouped nozzles and multiple injectors which are good. The reviewer added that

the title of project is "optimization", but need to also focus on developing a fundamental understanding of the various strategies they are studying.

One reviewer felt the model needed to be further improved.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

The program's technology transfer plan and results with consortium partners were seen as good by a reviewer. Technology transfer, in general, from Wisconsin, was described as historically excellent by a reviewer. The program was seen as yielding valuable insights into mixture preparation and low temperature combustion in internal combustion engines by a reviewer. The collaboration was described as good by a number of reviewers, and the work was described as widely published by a reviewer.

One reviewer stated that developing fundamental understanding and model development/improvement will be crucial to future efficiency and emission improvements. The model was described as good for HCCI study in both diesel and SI engines. A reviewer stated that the project would be moved forward by others. A comment, by another reviewer, was that this project is coordinated and leveraged with the ERC's other funding sources. Good interaction with the two consortiums (LTC & DERC). The significant number of industrial partners should provide a high probability of tech transfer in this project.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

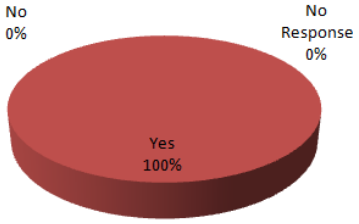
The project was seen as good use of available funding by a reviewer. Another felt that this was a very productive program and that it should be considered for increased funding. These types of projects were described as extremely cost effective, by a reviewer, who added that universities are a good area to fund. One reviewer questioned if the funding was too high. The reviewer states that in spite of the wide range of objectives with good progress that the funding level was significantly higher than at other universities. The reviewer was also concerned that generating patents at universities could hinder the availability of new technology tech transfer. The reviewer gave the example of will the model enhancements being developed be available to others wanting to collaborate and run their own models, or will these only benefit future work at UW-Madison?

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

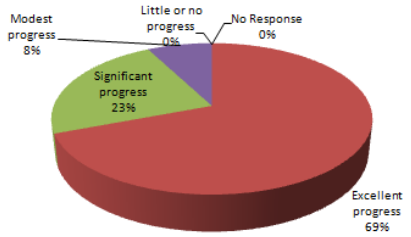
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Optimizing Low-Temperature Diesel Combustion

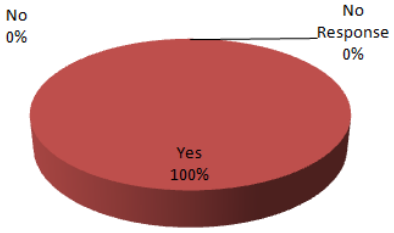
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



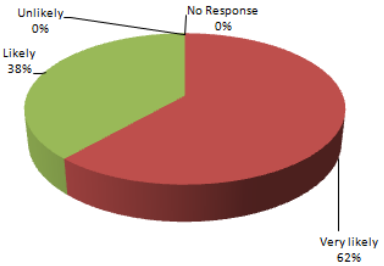
Question 3: Characterize the technical accomplishments and progress toward goals.



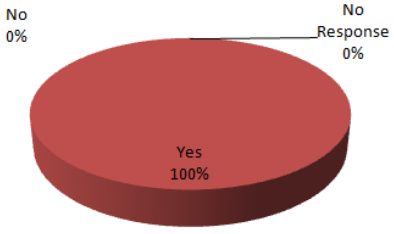
Question 2a: Are the goals of the project technically achievable?



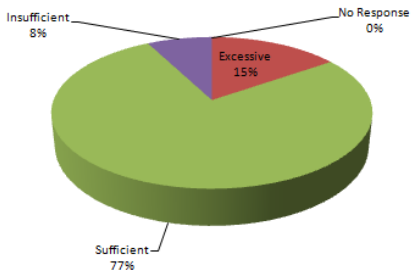
Question 4: How likely is the project team to move technologies into the marketplace?



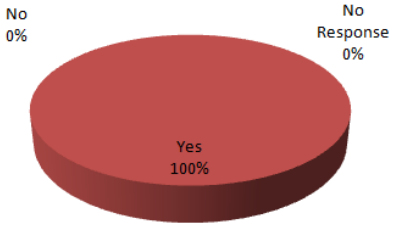
Question 2b: Have the technical barriers been identified and addressed?



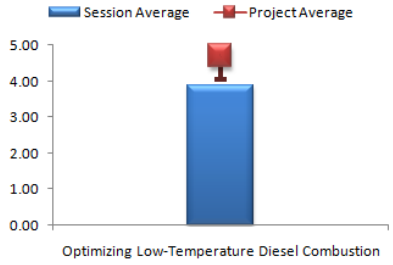
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Sandia Hydrogen Combustion Research (Sebastian Kaiser, of Sandia National Laboratories)

Reviewer Sample Size
This project had a total of 13 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Concerns were expressed by a variety of reviewers about the program's hydrogen focus. One reviewer felt that hydrogen was not a viable short- to intermediate-term technology. Another commented that with DOE's apparent move away from hydrogen the reviewer was unsure where these "orphan" projects fit into the scheme of things. One reviewer was curious where the hydrogen would come from.

Another reviewer saw the program as providing fundamental measurements, such as composition and velocity fields, on mixture of a gaseous fuel (hydrogen) with air in an optical engine. The reviewer added this activity is needed to support model development for hydrogen injection to develop direct-injection hydrogen engines. One reviewer saw the program as supporting the goal of transitioning away from a fossil fuel-based transportation sector. The reviewer added that hydrogen internal combustion engines are a valuable bridging technology that can use the existing IC engine infrastructure. The hydrogen internal combustion engine approach was seen as making sense to two other reviewers as a gap filling technology to the establishment of a hydrogen infrastructure. One reviewer saw the in-cylinder fuel/air ratio as a benefit to combustion studies.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
The program's strategy was seen as appropriate for the goals of the investigation by one reviewer. Another reviewer stated that there was a clear and systemic layout of the obstacles facing the direct injection hydrogen internal combustion engine work. It was felt by a reviewer that the direct injection hydrogen optimization was in its infancy, and that understanding will enable fast progress.

The program's key accomplishments, according to another reviewer, are acquiring data for understanding of hydrogen operation and data for validating advanced computer models. The reviewer added that the program goals were well defined. One reviewer also expressed that the program had a good method for combustion study.

A reviewer expressed concern that the barriers of production, transportation, and storage of hydrogen fuel were not being addressed. Another reviewer saw the optical engine flow field study as good, but time consuming and the reviewer felt that it the study was combined with 3D modeling the effects will be better.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer saw the optical diagnostic measurements as providing insight to assist LES model development, which in turn will assist the development of hydrogen engines. Another reviewer saw useful developments of hydrogen related tools and experiments. One reviewer stated that this program is making progress toward goals of studying hydrogen combustion in an optical internal combustion engine. A key accomplishment is the study of direct injection hydrogen internal combustion engine, as well as the acquisition of unique data for understanding hydrogen operation and data for validating advanced computational models. One reviewer saw the information helping understand how to

optimize fuel spray and fuel-air mixing in direct injection hydrogen. A reviewer commented that the program included the same combustion system as 45% BTE demonstrated at Ford.

One reviewer describes the program as "useful"; another described the program's results as confirming the intuitive thoughts.

The program was seen by a reviewer as showing more results then in the past, with PIV results that have proved very useful for this gas jet based system. The reviewer added that a lot of progress had been made in understanding hydrogen internal combustion engines, and the reviewer suggested that the program chooses a future emission standard, such as Tier 2 Bin 5 or lower and then estimate the NOx PPM level required to meet it. The reviewer has the impression that the NOx measurements presented were very high.

One reviewer expressed concern that hydrogen research no longer appears to be on the critical path in overcoming the DOE program's key technical barriers for near to intermediate use. The same reviewer saw this as the bridging technology for a future transition to a hydrogen economy. Another reviewer was concerned that the number of experimental conditions was limited and would have liked a closer connection to industry so that the engine was being developed while the project focuses on basic understanding. A reviewer would like to see more fundamental mechanisms analyzed, so results can be applied to other engines and fuels.

One reviewer did not see the hydrogen projects as having a lot of value.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

Concern was expressed by some reviewers that the project would only be relevant with developments in hydrogen storage and infrastructure. The project was seen by a reviewer as being competitive with fuel cells, and another saw the technology moving to the marketplace once the infrastructure was in place.

The program was seen by a reviewer as yielding valuable public domain data on hydrogen combustion in an internal combustion engine. Another reviewer felt that future work planned on advanced direct injection of hydrogen, if simulations/modeling pan out, may enable hydrogen engine deployment into the marketplace. This reviewer was skeptical that the current level of research will assist deployment of a hydrogen internal combustion or fuel cell vehicle.

The project's partnership with Ford was mentioned. One reviewer saw the collaboration with Ford as good, but another wondered if the project was merely trying to keep up with Ford, rather than stay ahead. One reviewer was concerned that there was only one industry partner.

A switch in technology focus from hydrogen to hybrid and biofuels was mentioned by one reviewer, while another reviewer saw the project as well connected to industry and other national labs.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

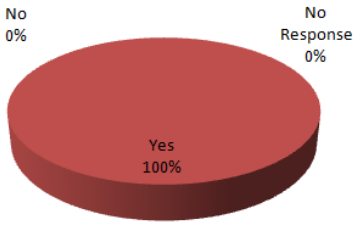
Resources were considered adequate by some of the reviewers, while others felt more funding was needed if hydrogen was to be made mainstream. One reviewer felt the funding reflected a low level of interest from DOE in hydrogen. A reviewer also said that the initial goal of the program had been met.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

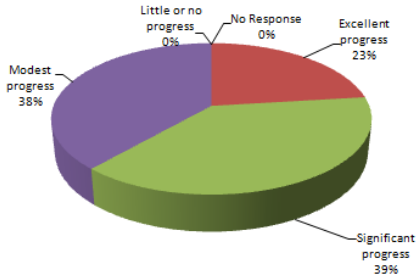
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Sandia Hydrogen Combustion Research

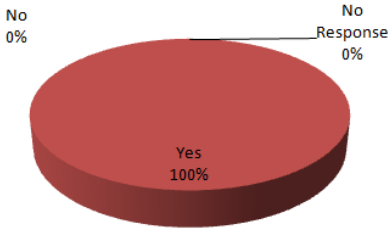
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



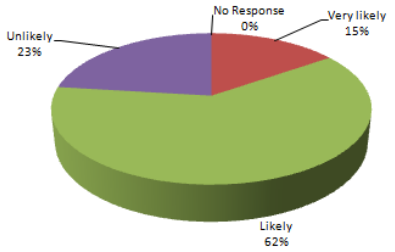
Question 3: Characterize the technical accomplishments and progress toward goals.



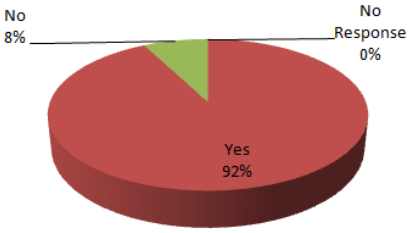
Question 2a: Are the goals of the project technically achievable?



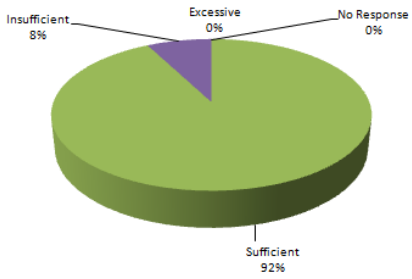
Question 4: How likely is the project team to move technologies into the marketplace?



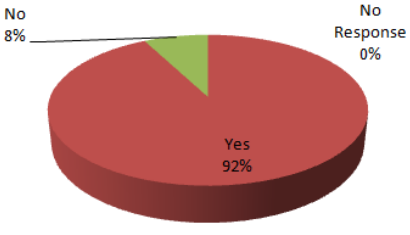
Question 2b: Have the technical barriers been identified and addressed?



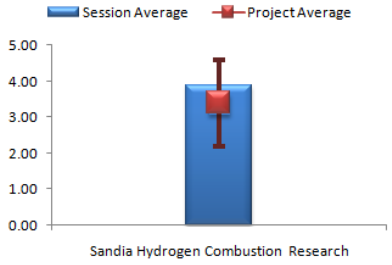
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Small Bore Advanced Combustion Engine R&D (Paul Miles, of Sandia National Laboratories)

Reviewer Sample Size
This project had a total of 11 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Many of the reviewers commented on low temperature combustion. One reviewer felt that better understanding of LTC would likely help in achieving emissions targets with better fuel economy. Another reviewer said that Paul is working in the right area. Controlling HC and CO in LTC is a key barrier to diesels being brought to the US market. This project's goal, stated a reviewer, is to improve the fundamental understanding of diesel LTC and the mechanisms by which the combustion efficiency can be improved. Another reviewer saw CO and unburned HC as two fundamental issues that need to be dealt with in the commercialization of LTC. CO and HC issues were also touched on by a reviewer who saw the aims as being improving thermal efficiency indirectly by understanding sources and mechanisms for CO and HC emissions. Another reviewer saw CO and HC distribution maps as filling the gap in emission study, which can direct the study of LTC engines. A reviewer saw HCCI or LTC as having the potential to reduce fuel consumption in both LD and HD engines - probably only for select engine and cycle applications. The full potential of these technologies will require significant levels of basic and applied efforts such as these.

While a reviewer saw the program supporting DOE goals for petroleum displacement, aiming to provide physical understanding and predictive capabilities for high efficiency combustions systems they would have liked to have seen more work looking at ways to overcome GC and CO problems. Another reviewer stated that engine-out emissions are the key roadblock to implementing low temperature combustion with reduced after treatment costs. The presentation was also seen as a nice visualization of relevant combustion processes.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
Among positive reviews, one saw the project as a good high level collaboration across the board. The reviewer added this project should be an example or model for industry-laboratory-university collaboration. Deployment of these technologies in the commercial arena will undoubtedly follow if these technologies turn out to be useful. Another reviewer saw the program, overall, as doing valuable scientific work. The program goals are well-defined in terms of objectives, task interactions and collaborations. A key accomplishment is measurement of the regions in the cylinder where CO and UHC is formed, and how formation depends on engine operation. A reviewer also saw the strategy as sound, with good coordination with the industrial partners. Another stated the project goals are largely to increase understanding of combustion processes. The key is optical experiments aimed at looking at in-cylinder spatial and temporal sources of HC and CO emissions. This understanding is designed to be transferred to numerical models that simulate the combustion process. One reviewer stated that modeling and validation on an engine seems a good approach. It was also commented, in another review, the combination of experimental test and numerical simulation can save time and cost, and also can fundamental understanding engine combustion.

One reviewer saw the collaboration between National Labs and universities to get a comprehensive look with simulations, optical engine data and metal engine data as excellent, but added that using the fast FID may enable some interesting speculation, but may not yield many conclusive results. Another reviewer expressed doubts that full advantage was being taken of Paul's work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.

Among the several positive comments, one reviewer found the project to be very good, with its widespread collaboration between energy, auto, engine companies and universities. Another reviewer commented that they have a good plan in place to address the key technical problem they are working on. They have been making steady progress against the plan. The timeline clearly showed the plan and progress. The topic is very relevant and useful. The same reviewer added the kinetics studies are innovative and they are doing a good job trying to couple the optical measurements to the kinetics modeling results.

It was also commented, by another reviewer, that the program is making significant progress toward goals. Improvements have been shown in interactions with industry and university partners. The reviewer had a positive response to the production of useful data for CO and UHC showing the in-cylinder distribution, and that optical engine behavior is correlated with metal engine behavior.

A mixed review advocated that this project is showing good correlation between metal engine and the optical engine, but not perfect correlation. To what extent are more questions than answers being exposed? This is obviously a highly complex area, and achieving good experimental-analytical-model correlation is extremely important.

Concerns were also expressed, one reviewer stating that the work was relevant, and focused on the right issues. The commenter continues by noting that sources of unburned hydrocarbons have been identified to be from the injector and from quenching along the bore walls. CO sources are also identified to be in the squish region, associated with lean fuel air mixture. The behaviors of these sources, with start-of-injection and engine load, are being identified.

A reviewer thought that understanding the formation of HC and CO within the bowl could be a key factor. The model predicts high CO and HC within the bowl, while the optical diagnostics could only probe the clearance and squish regions. What about CO and HC sources in the jet-to-jet interaction regions within the bowl. Model results should already be available. Could it be that we are looking the wrong region for the original sources?

PLIF experiments at 355 nm to probe HC sources within the bowl should be given high priority.

One reviewer saw the model as still having weaknesses to predict CO at certain injection timing. Another reviewer felt that additional industry interface would accelerate the progress, suggesting regular quarterly reviews, which would have a more universal attendance.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

A reviewer saw the program as contributing to measurements and predictive models of in-cylinder processes that are necessary in order to commercialize low temperature combustion. Partnership with GM is a plus. Another felt the program was well connected to OEM. A reviewer stated that there was good collaboration with UW, which will transfer knowledge into useful models.

One reviewer felt that identifying and describing the problem is the first step. As the problem with CO and HC is described better, solutions to address these problems will follow. There is close collaboration with industry and the results are being widely published. Another imagined that some

form of this modeling work will be useful for industry, while another felt that the study will benefit for LTC engine design.

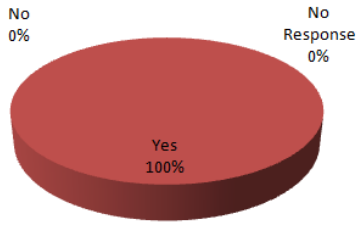
Concern was expressed by one reviewer that the program was based away from the industry center and hoped that there would be more proactive interaction with industry.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
All responding reviewers found funding to be adequate. Additional reviewer comments were that progress is good, albeit slow and that cross-collaboration makes good use of the available funding. "Great work" was the comment of another reviewer.

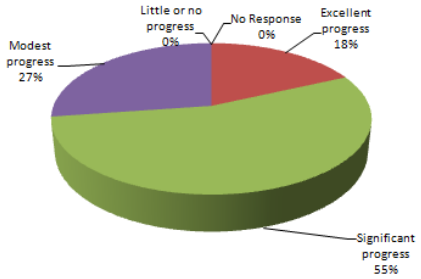
Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Small Bore Advanced Combustion Engine R&D

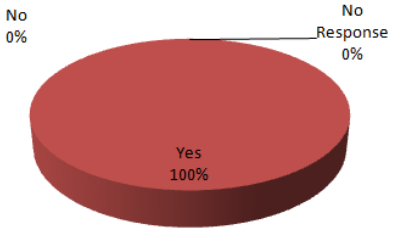
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



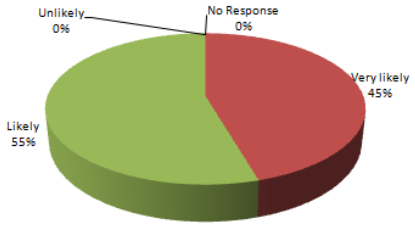
Question 3: Characterize the technical accomplishments and progress toward goals.



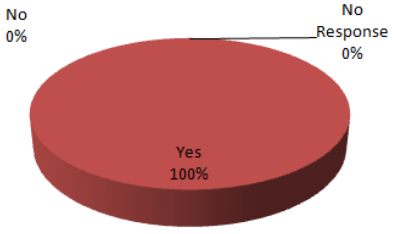
Question 2a: Are the goals of the project technically achievable?



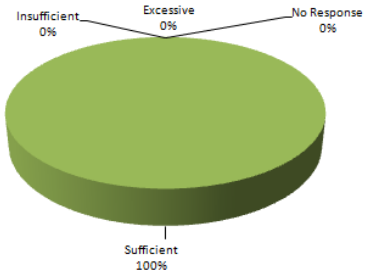
Question 4: How likely is the project team to move technologies into the marketplace?



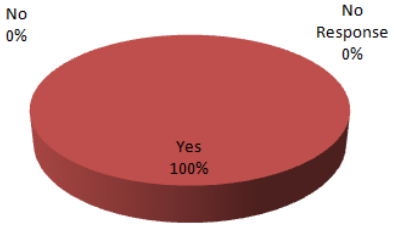
Question 2b: Have the technical barriers been identified and addressed?



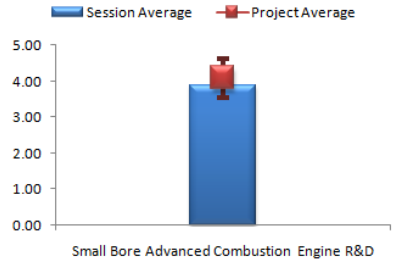
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Spark-Assisted HCCI Control (Dean Edwards, of Oak Ridge National Laboratory)

Reviewer Sample Size
This project had a total of 11 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One reviewer felt that spark-assisted HCCI might be an important aspect of light duty fuel economy. Another reviewer said that the goal is to use HCCI combustion mode to improve the efficiency of an SI engine. Another saw the program as aiming at understanding LTC combustion for higher part load efficiency a reviewer felt the program supported gasoline efficiency improvement through HCCI by addressing one of the main barriers, control.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
A reviewer felt the program was based on scientific results. Another saw the program as being open-ended in its scope, which the reviewer did not view as a bad thing. One reviewer saw the program goals as well in terms of objectives, task interactions and collaborations. The reviewer saw the key goal as demonstrating HCCI in a production-level engine platform for improved fuel efficiency and reduced emissions.

A reviewer saw well-defined project goals, but would like to have seen a rigorous analysis or sensitivity study of what boundary conditions impact stability and to what extent. The reviewer went on that variability is mapped, and it looks like that work is the next planned. Bottom line is: How do we control the instability? Is there a path or is this a dead end as far as implementing the technology? The reviewer added that this is a huge undertaking

A reviewer felt that a single-cylinder engine would be a good tool to use for a program like this. Another reviewer expressed that spark-assisted HCCI is being understood and developed, and wondered if this would be a possible solution to extending the HCCI load regime.

One reviewer felt it was still not clear that the integrated control approach will allow spark assistance to improve HCCI operation stability. The reviewer wondered if this would just improve the transition between SI and HCCI, or if it will actually increase the operating range of HCCI mode. Another reviewer felt the program needs to address the tailpipe emissions capability. A link between "use of advanced LTC modes to reduce the formation of emissions in-cylinder to reduce aftertreatment system requirements and associated costs" is not clear. Another reviewer felt that further development of the combustion mode prediction model will be key. The reviewer wondered what other improvements can be made?

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer felt that the program is making steady progress toward goals. There is good interaction with industry partners. Key accomplishment is characterizing performance with variable valve and advanced sensors and controls. Mixed mode operation and understanding cycle-to-cycle variation are key contributions. Other reviewers seconded that there was good collaboration. A reviewer stated that the researchers have a good overall view of the problems facing them. Another reviewer felt that they are investigating a novel approach to extend the operating range of HCCI and to improve stability. The modeling part of the effort is very useful in trying to understand the details of what is going on in-cylinder. The reviewer added that it would be good to focus more on the control aspect

of the program and try to understand how to control the combustion, not just to understand the instability but to be able to control it.

Progress in 2007 was seen to have improved by a reviewer. Another reviewer felt that modeling strategy and controls seemed well thought out. Another reviewer felt the question could not be answered accurately yet. The reviewer found the project very interesting and wondered how to control HCCI.

A reviewer expressed a number of concerns. The reviewer would have liked a more detailed description of the combustion chamber, adding that injector and spark plug layout is needed. The reviewer felt that the project operated on a knife's edge between SI and HCCI modes. The reviewer added that the present cycle combustion mode is being influenced by the prior-cycle combustion efficiency, which does not inherently seem like a good idea to begin with. The reviewer wondered if this concept will prove to be robust. The authors themselves admit to this in slide #13. Now the work is migrating towards a controls focus. The reviewer added this could be "throwing good money after bad." It should be shown that efficiency gains and emissions reductions are well worth the while before continuing on this path. The reviewer continued by stating that going to a multicylinder at this early a stage with only partial understanding seems premature. A lot of work and energy is being expended in acquiring and setting up this multicylinder engine with not much real progress in understanding the combustion concept. The reviewer ended that in all likelihood there will be cylinder-to-cylinder differences in the multicylinder engine that will confound spark-assisted HCCI phenomena being studied.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

A reviewer found that the technology transfer seemed sound, and the results of this project would be of interest to OEMs, if it works. Another reviewer felt the program was yielding valuable insights that are required in order to make HCCI combustion commercial. The connection with Delphi provides a path to market. Another reviewer stated that the project seems to be well connected and cross functional. Another reviewer felt a lot more work needs to be done.

One reviewer felt that it might be problematic to control transients. The reviewer expressed concern that there might be patent problems, believing that the technology was discovered by the Ford group long ago and that there are patents. A research stated that the approach of predicting misfire may work in a lab, but was unsure if this approach would be robust to sensor and engine variability as well as external noise factors such as ambient temperature and humidity? If not, said the reviewer, OEMs won't be able to use it.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

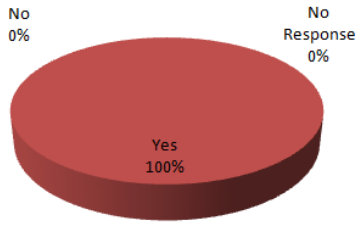
Collaboration with Delphi was seen as good for the tools. Another reviewer felt that this project, among others, would benefit from a single cylinder engine readily available at a reasonable cost. A reviewer commented that making the project goals and expectations to fit the budget is the important balancing act.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

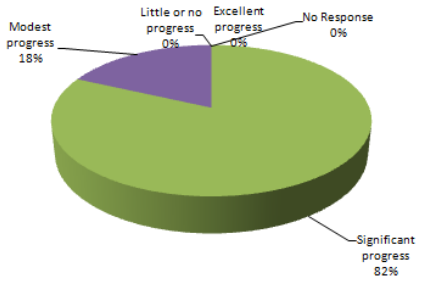
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Spark-Assisted HCCI Control

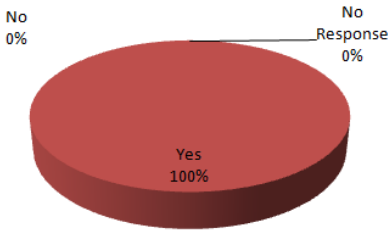
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



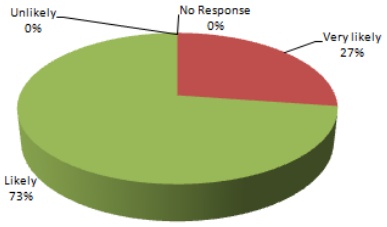
Question 3: Characterize the technical accomplishments and progress toward goals.



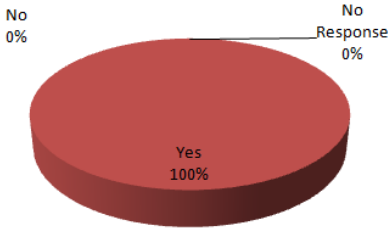
Question 2a: Are the goals of the project technically achievable?



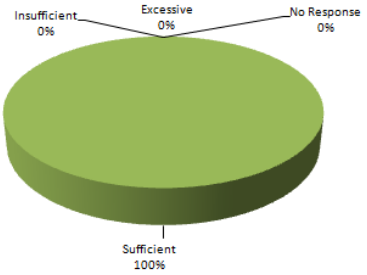
Question 4: How likely is the project team to move technologies into the marketplace?



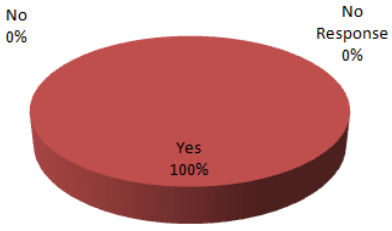
Question 2b: Have the technical barriers been identified and addressed?



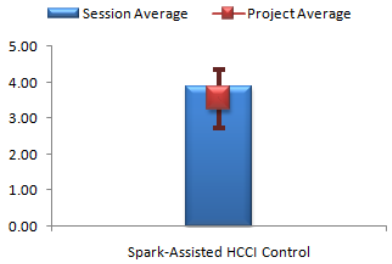
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Stretch Efficiency -- Thermodynamic Analysis of New Combustion Regimes (Josh Pihl, of Oak Ridge National Laboratory)

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
The program is seen, by a reviewer, as supporting DOE goals for petroleum displacement because it aims to provide physical understanding and predictive capabilities for high efficiency combustion systems. Another reviewer stated that this is a good advanced project, and little funding was required, but findings will help define future on engine projects, i.e. compound cycles. Another reviewer stated that the project was a good fundamental investigation of efficiency. Another reviewer saw the goals as improving the efficiency of internal combustion engines by understanding fundamentals of thermodynamic losses. A reviewer stated that combustion irreversibility study is a fundamental research, which will benefit for both diesel engine and SI engine combustion efficiency improvements. A reviewer said that using first principles to look for opportunities to improve efficiency, which will both provide DOE and OEMs direction for future projects.

A reviewer said that recovering combustion availability is directionally correct for supporting DOE objectives. The reviewer would like to see more practical implementation ideas. Another reviewer found the work very speculative.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
The strategy was seen by one reviewer as very speculative, another as not being included in the project. Another reviewer felt that there was no clear path to extend the information to internal combustion engines, which was echoed by another reviewer. A reviewer felt that the technical barriers of improving the energy efficiency of an on-board reformer, using a real-world fuel, are beyond scope of this work. Another reviewer stated the program's goal of demonstrating reduced combustion irreversibility with a constant-pressure combustion (CPER-TCR) is not well-connected to goal of improving internal combustion engines.

One reviewer warned that the project needs to stay connected with industry partners. A reviewer felt that the project, in its first stages, fundamentally works. A reviewer felt that there was good understanding of the program's objectives and hurdles, and that this was obviously a long term project. Another reviewer commented that understanding combustion availability destruction is a very interesting subject that could potentially open a lot of avenues for improving efficiency. I will be keen to see future results.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A reviewer saw slow progress and wondered how the low pressure combustion will add to knowledge (we know about combustion availability but it is a fundamental limitation that low pressure combustion studies will not allow us to break). Another reviewer said that the thermodynamic analysis failed to show the benefits of constant-volume combustion over constant-pressure combustion. Since other programs within DOE are dedicated the study of constant pressure combustion (for gas turbines) the value of the proposed experiments to VT is not clear to the reviewer.

One reviewer felt that the second law analysis of IC engines is a very important topic and it could lead to improvements in engine cycles, but was concerned that the current experiment uses constant pressure, steady combustion which is the basis of today's Brayton cycle even though a key thermodynamic advantage of IC engines is constant volume combustion (IC engines are typically ~5% more efficient than gas turbines at similar output power).

A reviewer felt that the program should focus on using availability analysis to improve the efficiency of IC engines through constant volume combustion. Another reviewer saw the project as having a very lofty goal, but thought it a good idea for at least some part of the DOE program to be looking at very fundamental things like this. The reviewer found the project very interesting and was curious to see what they will be able to show. They need to make sure to stay connected with reality. It would also be good to see them run the experiment over a range of conditions (if possible) to see how the results are affected. The reviewer wondered is there a modeling component of the project? If not, then why?

A reviewer saw the progress as good, considering that it is a proof of principle project. Another felt that the work could be relevant for external combustion engines, but perhaps not for internal combustion engines? Another reviewer felt the project shows the potential from stoichiometric engine plus waste heat recovery. One reviewer found the project to be in its first stages.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

A reviewer questioned where the technology transfer would go from this project, and how other than high level academic papers. Another reviewer commented that this was not a well-thought-out plan. The technology transfer path for IC engines is not clear. This program will provide much more value to the community if it addresses reducing irreversibility in the context of cyclic, unsteady, constant volume combustion processes. Another reviewer felt the project was in its very early stages, and that the path to practical implementation in an internal combustion engine was not clear. One reviewer felt that even if the principle of the experiment was proven to be possible it would not enable a fuel reformer as a commercial solution to improve fuel efficiency. A reviewer found the project as very risky to look for ways to avoid availability destruction caused by combustion. The reviewer felt it unlikely to give usable solutions since the gradients enable internal combustion engines to generate power; however, the risk is worth the gain in understanding and the potential gain in avenues to improve efficiency.

One reviewer felt the project was investigating a very fundamental question. Understanding and quantifying the results are worthwhile even though there is not a marketable component. Another reviewer felt it was too soon to rate the project, and that the program could use some industrial partners. The program was seen as very long term, by another reviewer. A reviewer stated that the technology could be applied to both diesel and SI engines.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

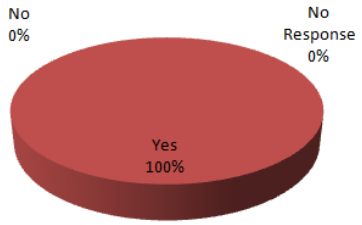
A reviewer questioned if the potential payoff was there, for a project the reviewer described as potentially open ended with high risk. Another reviewer stated that the project appears to be relatively low cost for a demonstration project, and that current funding was sufficient until proof of concept is achieved. Another reviewer stated that funding should continue if the focus becomes reducing irreversibility in the context of cyclic, unsteady, constant volume combustion processes.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

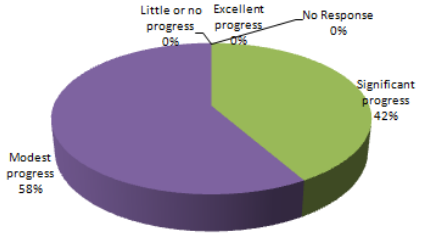
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Stretch Efficiency -- Thermodynamic Analysis of New Combustion Regimes

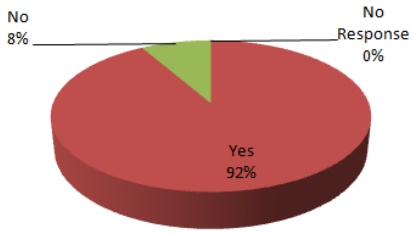
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



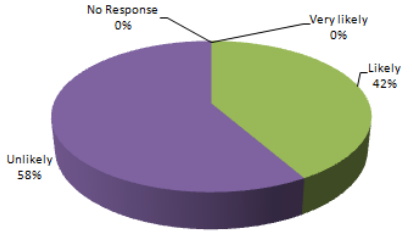
Question 3: Characterize the technical accomplishments and progress toward goals.



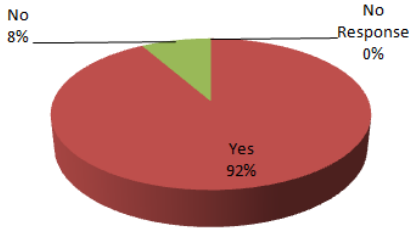
Question 2a: Are the goals of the project technically achievable?



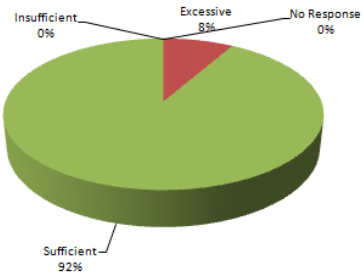
Question 4: How likely is the project team to move technologies into the marketplace?



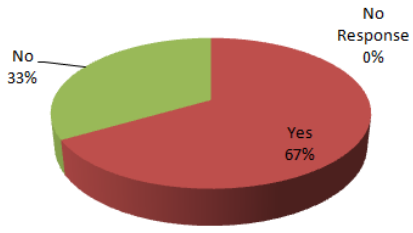
Question 2b: Have the technical barriers been identified and addressed?



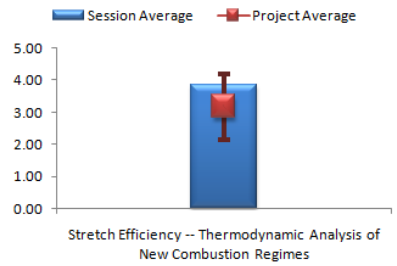
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



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

Reviewer Sample Size
This project had a total of 12 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
A reviewer saw the program as having a good holistic, multi-group approach to LTC research. The goal was seen, by a reviewer, as to expand the operating range of LTC combustion in order to improve emissions and efficiency. Another reviewer added that the program supported model development to improve engine development in the future. A reviewer stated that the program supports DOE goals for petroleum displacement because it aims to provide physical understanding and predictive capabilities for high efficiency combustion systems. A reviewer felt that the program had the long-term potential to accomplish its objectives.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
A reviewer was happy to see that this project is working on the issues of transient engine operation. The reviewer believes this will be one of the key barriers to overcome in order to deploy LTC in the marketplace. Another reviewer saw this as a comprehensive, multi-front attack on the problem. The reviewer added that there were many barriers still remain but the program had a competent approach to the problem.

A reviewer felt that program focused on important problems like how to extend the HCCI regime and transient control. The reviewer added that the project supported other projects and was cost efficient.

Some of the reviewers spoke highly on the industrial collaborations and the collaboration between the various labs and universities. A reviewer felt that the program goals are well defined in terms of objectives, task interactions and collaborations. The reviewer added this program team is making good progress leveraging their respective facilities and capabilities to meet the goals of the program.

One reviewer added that they would like the gasoline HCCI programs to have a closer association with the diesel projects, in order to help or transfer knowledge from diesel to gasoline and vice versa.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
The program was seen as making good progress towards its goals, by a reviewer. Good interaction with industry and national laboratories was also cited as well as numerous advances aimed at retiring risk with low temperature combustion. A reviewer said there was a good blend of modeling and experimental work

Some reviewers found the boosted HCCI work as interesting and would like to see more modeling and bar work on that. The program was seen as big with many subtasks, with the goal of expanding HCCI. The control of HCCI based on wall temperature was also seen as interesting by a reviewer. A reviewer was glad to see the inclusion of biofuels in the program. The reviewer added there was good collaboration with LLNL on the chemical kinetics of methyl-butanoate. A reviewer saw VVA control to extend HCCI operating range as a key development that may assist in overcoming technical barriers for low temperature combustion.

One reviewer felt that good progress had been made, but that there was still no evidence of good transient control methodologies. The reviewer added that tough problems always seemed to be listed under 'Future Plans'.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

The program's collaboration was widely praised. It was noted that there was good technology transfer from the consortium to industry as well as from industry to consortium. A reviewer felt there was excellent involvement of universities and labs to develop important tools. The primary method of technology transfer was seen, by a reviewer, as being through publications and students who graduate from the program. One reviewer expressed concern that the discussions seemed to all be with GM or Ford. The reviewer hoped this would be widened, perhaps including overseas companies.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

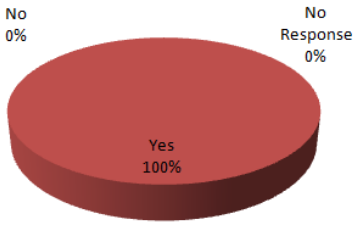
Reviewers found a good level of available resources. The work was seen as well distributed amongst the consortium. One reviewer felt the funding levels were high, but appropriate when considering the project. A reviewer would have liked to know how the funding was distributed amongst the consortium participants.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

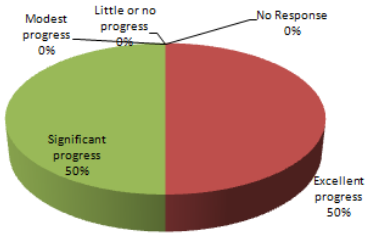
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: University Consortium on Low-Temperature Combustion for High-Efficiency, Ultra Low Emission Engines

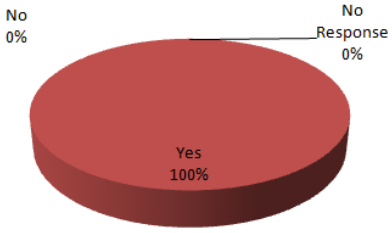
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



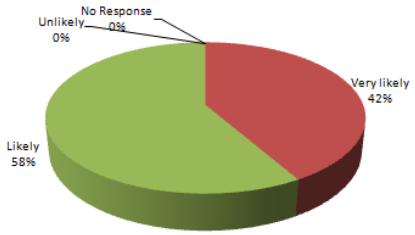
Question 3: Characterize the technical accomplishments and progress toward goals.



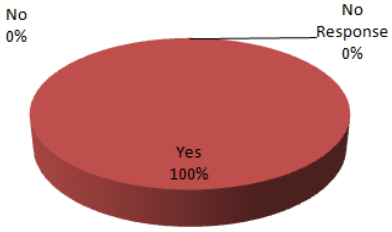
Question 2a: Are the goals of the project technically achievable?



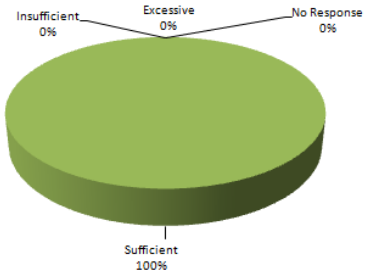
Question 4: How likely is the project team to move technologies into the marketplace?



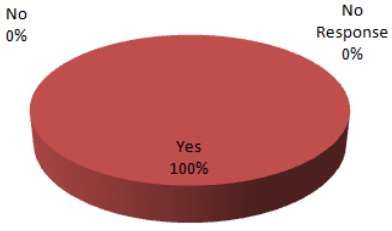
Question 2b: Have the technical barriers been identified and addressed?



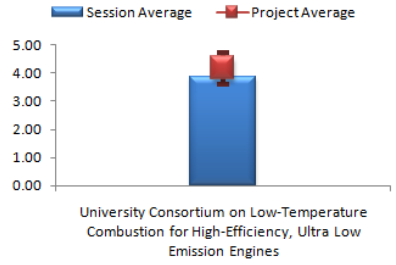
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



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

Reviewer Sample Size
This project had a total of 13 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
A reviewer felt that improving power density of LTC/HCCI concepts is important to support DOE objectives. A number of reviewers saw the goal as being to improve understanding of the combustion process in order to improve efficiency. A reviewer felt that a study of alternative fuel utilization at low emissions and high efficiency was DOE compatible.

One reviewer felt the objective was noble, but the path unclear. The reviewer added that the actual testing program was undefined, although the reviewer found the application of chemical luminosity as interesting. The reviewer wondered if this work wouldn't be better handled in a fuels program. A reviewer felt the testing process was sketchy and another was struggling with this project.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
A reviewer stated that focus on improved power density strategies could be a technology transfer enabler to bring high load HCCI to market. The reviewer added it will be interesting to see how this can be achieved with a fuel resembling gasoline (in a diesel like engine) without reducing the octane value of the fuel below what is currently available as a low-sulfur, real-world gasoline blend stock. The reviewer wondered if the Sturman digital fuel injection system would be a better fit for a low lubricity fuel like this.

A reviewer felt the goal of the project was not completely clear, but felt that it would be useful to examine both high and low cetane fuel as well as other properties such as volatility and their impact on diesel LTC to understand why one OEM says low cetane is better and another says high cetane is better.

Other reviewers felt that the project requires more definition on what may be obtained with multi-injection. A reviewer felt that there didn't seem to be much new with the project.

Another reviewer felt the imaging technique and spectroscopic measurements are useful, but the project needs to define carefully the experimental plan, select design changes and LTC strategies, and also differentiate them from work done in industry. A reviewer felt there was not enough experience with this type of project at Argonne to run this type of program, and the reviewer wondered if the laboratory had relationships with Wisconsin, for example. One reviewer felt this type of work more suitable to an OEM, and was unclear what specialty Argonne brought to the study.

One reviewer thought it would be interesting to look at formaldehyde formation and emission from LTC and HCCI combustion, to see if there is any? Another reviewer stated that it was still early for this project and the plans are still fluid, which the reviewer described as good.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
A number of reviewers stated that this is a new project and no progress was expected. Some reviewers saw engine set up and benchmarking as the only progress so far. Another reviewer was unclear how well-thought-out the project is, and though the described work sounded similar to work published by

Shell. The reviewer felt a need for a more detailed plan, which would answer what the purpose of the visualization measurements is and what specific quantities are going to be measured. Another reviewer felt that no new technology was used in the production engine, and that the test cell was built up for a low temperature combustion study. One reviewer stated that seven months to get the engine running seems like a long time, and is indicative that progress is going to be slow. Another reviewer stated that potential is there for significant progress in a timely manner, now that the test cell has been set up.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

A number of reviewers commented that the project was not well explained. Another reviewer felt the plan for technology transfer was not fell formed with respect to collaboration with industry, universities or other national labs. The reviewer added that market pull for LTC would depend on power density goals being met. A reviewer felt that the lack of consensus over which direction to take cetane, would make it unlikely that the research would result in a fuel change. The reviewer added that the wide range to cetanes seen in the field in the US is already a major barrier for bringing diesel to North America, and that pushing for lower cetane fuels will make this issue worse.

Some reviewers expressed concern that even if the results indicate a benefit to using a low cetane, other issues, such as cold starts, will prevent change of fuel. One reviewer commented that there was slow progress, but the technology being used is known. Reviewers also felt that if a benefit to using low cetane fuel can be established there will be interest from industry partners.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

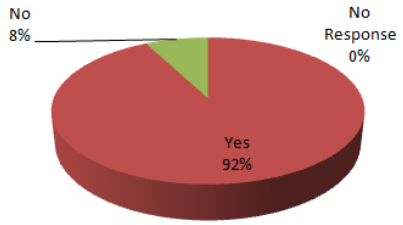
A reviewer stated that funding was appropriate for the objectives, while another reviewer felt that the project made good use of other Argonne National Laboratory diagnostic's techniques with good cross-fertilization potential.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

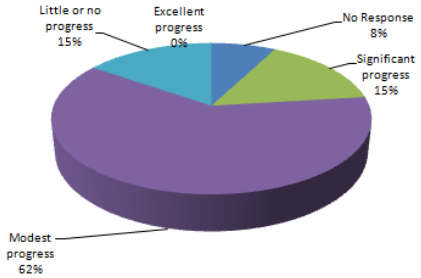
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Visualization of In-Cylinder Combustion R&D

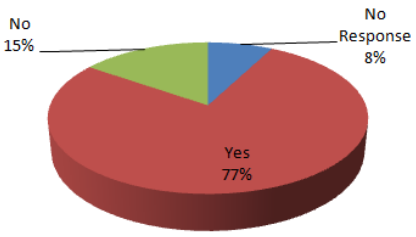
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



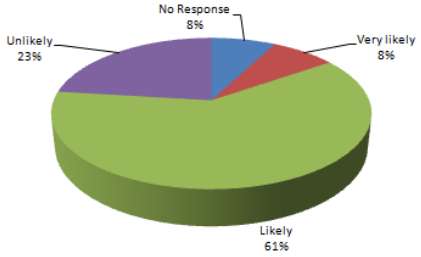
Question 3: Characterize the technical accomplishments and progress toward goals.



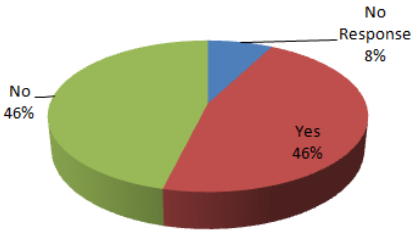
Question 2a: Are the goals of the project technically achievable?



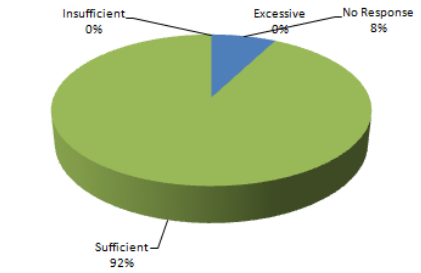
Question 4: How likely is the project team to move technologies into the marketplace?



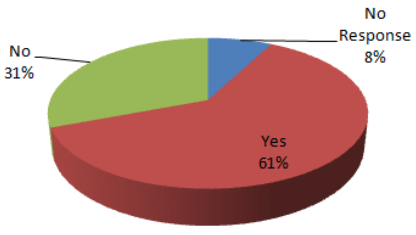
Question 2b: Have the technical barriers been identified and addressed?



Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating