Sub-Program Comments Provided by Reviewers

This Appendix includes reviewer comments on the sub-program overview presentations, including Hydrogen Production and Delivery; Hydrogen Storage; Fuel Cells; Manufacturing Research and Development; Technology Validation; Safety, Codes and Standards; Education; Market Transformation; Systems Analysis; and the American Recovery and Reinvestment Act.

Hydrogen Production and Delivery Sub-Program Comments

Hydrogen Production

1. Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year? (Include information presented in the plenary and/or session overview presentations of the sub-program if appropriate.)

- Progress in several areas was highlighted for this sub-program, which was adequately covered.
- The presentation gave an overview of all areas. The accomplishments compared to the previous year are clear.
- Yes, the Hydrogen Production sub-program sufficiently described the issues and current challenges. A diverse range of technologies is being developed to provide hydrogen gas from different sources. Recent efforts were clearly identified, along with progress made over the past year.
- The sub-program area was covered well. It was an excellent presentation.
- There was excellent coverage of the sub-program area. The issues, challenges, and progress were all covered in appropriate detail.
- The sub-program presentation was clear and concise. The progress was presented clearly. It was a well organized presentation.
- The sub-program was well described.
- Yes, critical issues and challenges were identified. The overview presentation was in line with plenary goals and objectives.
- Yes, the presenter did an excellent job gracefully presenting the material.
- The presentation was thorough and complete. Issues and challenges were identified, and progress was clearly shown with good comparisons to previous work.
- The presenter provided a good overview of the sub-program, including all of the approaches currently being researched for hydrogen production.
- Yes, the sub-program was adequately covered. Challenges were identified, but progress for specific funding periods was not covered clearly.
- This sub-program area had good overall coverage. This reviewer would be interested in available technology rather than projections. For example, the reviewer wants to know if large-scale electrolysis exists, and if there has been a concept comparison of biomass gasification principles.
- Yes; however, currently there are water electrolysis technologies that are being evaluated that operate, produce, and deliver hydrogen from 250–413 bars without the aid of any mechanical compression. The National Aeronautics and Space Administration's Advanced Energy Storage Program is actively developing these technologies for use in terrestrial applications.
- It was difficult to assess whether the sub-program was adequately covered. The funding and sub-topic breakdown, under distributed and central hydrogen production, was not presented; therefore, the reviewer was not aware of the specific types of projects that were funded. The specific sub-topic breakdown should be listed on an additional PowerPoint slide, as was done in the Delivery sub-program talk. Also, there was no mention of research into reforming and gasification technologies. Critical challenges to both of these technologies were clearly defined, and both were listed as being able to meet near- and longer-term goals of the sub-program. This reviewer wants to know if these technologies were funded under this sub-program. If they were not funded, the reviewer wants to know the rationale behind that decision. Assuming only hydrogen separation, electrolysis, and photoelectrochemical hydrogen production were funded, the issues and challenges were very clearly highlighted. However, there was no specific mention of the previous year's accomplishments to compare to the current year's achievements.

- The presenter did a very good job of describing the sub-program and the important issues and challenges. The presenter did not clearly identify progress, which would be hard to do in the five minutes allocated for that task. This reviewer did not attend the plenary, but has reviewed the slides. Progress was presented in a very anecdotal manner instead of through a comprehensive accounting approach.
- The progress in the biological hydrogen production section was not clearly presented. However, some projects in this field demonstrated substantial, if not considerable, progress. All of the other sections in the Hydrogen Production sub-program were adequately covered and basic achievements were presented.
- This was a nice summary of the sub-program area. The important issue of cost was presented, as well as how the U.S. Department of Energy (DOE) has put together plans for each of the technologies. The presentation nicely summarized the large amount of work in this portfolio.
- The projects that this reviewer reviewed were all related to biological hydrogen production, and this is a longer-term research and development (R&D) program compared with other routes to hydrogen production. It would have been beneficial to have seen more information from the DOE Hydrogen and Fuel Cells Program presentation on the goals and milestones for this specific sub-program. High-level technical barriers were identified for this sub-program, which was helpful.
- Yes, the technology was presented well; however, information on goals and performance versus goals was missing. It would be good to present cost and efficiency by year, as well as mention how that matches the goals for commercial viability. Renewable technologies are benchmarked against batteries, making the efficiency of renewable utilization a very important metric that needs to be monitored and reported. One way of reporting this would be "Renewables to Wheels."
- The sub-program area was adequately covered. Issues and challenges were identified, with the exception of the identification of necessary resources to support the totality of the feedback between theory, synthesis, characterization and device fabrication, and performance testing. This is a big job, and it is woefully underfunded for satisfactory integration of the four identified elements.
- This reviewer thinks that the current short- and long-term technology areas adequately cover the Program goals. Some projects have been active since 2003. Presenting a brief history, including timelines, goals, and milestones for each technology pathway, would be useful to reviewers as well as to (new) project teams. A budget breakdown by hydrogen production technology pathway would have been helpful.
- The presentation's slides were information dense and adequately covered much of the sub-program. Fifteen minutes, however, is not enough time to present that much material; consequently, the core messages might have been diluted. The "Challenges" slide and the timelines from the "Production Strategies" and "Summary" slides were effective in rapidly communicating status and direction. Progress highlights from individual projects were evident in the "Progress" series of slides, but their impact on their associated pathways was not immediately apparent.
- Challenges were listed for various production pathways. While progress in a few areas was shown, it is not clear if the effort occurred during the past fiscal year. The linkage of challenges to accomplishments was not clearly defined. For example, electrolysis has capital and efficiency challenges, but the progress chart did not mention efficiency; and the separations progress was not linked back to the challenges.
- [Note: two respondents replied "Yes."]

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

- Plans for addressing issues and challenges were clearly stated; there are no gaps in the project portfolio.
- There are no gaps in the portfolio. All of the basic challenges were clearly identified.
- The presence of a roadmap with plans for each of the technologies has been demonstrated. This reviewer did not see any gaps in the portfolio.
- The plans are very well identified and logically itemized.
- Plans are identified to address the challenges. Multiple paths are established to address the technology gaps, which lowers the long-term risk to industry.
- It seems that a lot of analysis goes along with the R&D portfolio, which allows for evolving prioritization and flexibility in developing portfolio milestones and mitigating issues as they arise.
- The plans are clearly identified for addressing the challenges.
- Plans addressing issues and challenges were adequately identified.

- Issues and challenges were presented. The sub-program seems to be well balanced in addressing these challenges.
- The critical challenges were clearly identified and the Hydrogen Production portfolio covers all of the relevant technologies.
- The future work for each area is well highlighted.
- The issues and challenges are well addressed. This reviewer wants to know if well-to-tank analyses for production and delivery pathways are conducted.
- Somewhat; there are some gaps between the DOE Hydrogen and Fuel Cells Program and other programs that are being developed by other agencies. The balance of plant (BOP) is a very important part of this sub-program and needs a lot of attention. Current hydrogen production technologies and chemistries are more advanced than the BOP. It is not clear how DOE is planning to bridge this gap.
- Brief summaries provided terse views of the future activities of several of the technologies. It appears that several projects are ending, while solicitations for new efforts apparently will not be issued until fiscal year (FY) 2013. There may be limited progress through joint efforts with the DOE Office of Fossil Energy and DOE Office of Science/Basic Energy Sciences (BES) Program, which may provide sufficient coverage.
- The plans are well laid out. However, researchers need to consider scaling up the polymer electrolyte membrane (PEM) electrolyzers to megawatt scale. This technology pathway should be added.
- The plans were identified only in terms of crosscutting issues and as references to the DOE Office of Energy Efficiency and Renewable Energy (EERE), Fuel Cell Technologies Program *Multi-Year Research, Development, and Demonstration Program Plan* (MYRDDP); it is hard to see how time would allow much more.
- The Program has identified areas of emphasis, but should consider moving approaches that are far from commercialization (e.g., photoelectrochemical and biological) to BES.
- This reviewer realizes that the plans for hydrogen production and delivery are challenging at this time, and not much detail was presented.
- The key challenges for each technology area were identified. However, it would be very helpful to state the progress made (or not made) with respect to all of the critical gaps in achieving the DOE targets for each of the seven technology pathways. For instance, it is clear that the biggest challenge in the photoelectrochemical pathway, which has existed for more than 25 years, is finding a photocatalyst with the right efficiency, stability, and cost. Accordingly, the bulk of the research effort and investment should be on breakthrough materials research. All other efforts such as photoelectrochemical system engineering, the H2A model, lifecycle assessment, or any economic or market analysis talks should be minimal at this stage of development. Otherwise, researchers risk being distracted from achieving real targets. Also, the stability and durability results for the two metal membrane systems were not stated in the same manner as the other critical targets.
- Some plans were apparent in the presentation. It was not apparent how many were not presented due to time constraints; therefore, it was not possible to identify gaps. Fifteen minutes is inadequate time to describe objectives, targets, budgets, progress, and plans for seven pathways.
- Some more fundamental work (science) on the stability of hydrogenases needs to be done, but this is more the domain of BES than EERE.
- The future plans are not as clearly defined as others in the session introduction package.
- There are gaps in the project portfolio. The plenary presentation and the sub-program presentation mentioned a highly cost-effective slurry approach to photoelectrochemical production of hydrogen. The project portfolio does not address the development of the isolated photoactive material necessary for slurry implementation.
- The plans for going forward were not clearly identified in this presentation. Most challenges are material based; therefore, the plans would have been expected to show more of a stage-gate approach to approaches with go/no-go decisions.
- Future planned research was not described at all. Some mention was warranted, although this seems less relevant to the sub-program overview presentations. Projections for decreased costs and long-term testing were only presented for the membrane research area. There was no mention of reforming or gasification technologies, which were both touted as near- and longer-term solutions. A balanced portfolio would include research into these as well.

3. Does the sub-program area appear to be focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program's needs?

- The sub-program is exceptionally well focused, well managed, and effective in its support of overall Program needs.
- The sub-program is well managed and effective at the current projected funding levels.
- Based on the available documentation, this sub-program seems very well managed and has the relevant goals to advance the field.
- The sub-program is focused and managed well.
- The sub-program is performing adequately with limited resources.
- The sub-program's focus on identifying appropriate challenges along with the emphasis on updating pathways costs and analysis modeling through H2A is consistent with DOE needs.
- The sub-program appears to be well run.
- The sub-program is focused on DOE EERE Fuel Cell Technologies Program R&D needs.
- The sub-program area is very focused and well managed, and it clearly addresses DOE needs.
- Yes, the sub-program is well organized and supports all R&D needs.
- The talk was clearly presented and shows how the portfolio is broad, yet provides adequate focus on technologies that are primarily renewable. The talk summarized some recent progress, which highlighted this work.
- Generally speaking, yes, but DOE needs to identify the current hydrogen generation technologies that are being developed by other agencies and try to leverage those programs—collaboration is the key.
- The sub-program is very focused on reducing capital costs and identifying robust and active materials. However, this reviewer does not think that the funded research is meeting overall Program needs, as reforming and gasification are clear near-term solutions that were omitted. Additional funding should be made available for those rather mature technologies. Although research into longer-term solutions such as photoelectrochemical and biological hydrogen production are necessary, these technologies are much further from realization, and therefore it seems most economically and developmentally responsible to limit any additional future funding to these programs until reforming and gasification are appropriately funded. Additionally, this reviewer wants to know what are the new projects slated for 2013 that the slides alluded to. The reviewer does not recall if they were addressed during the talk itself.
- Most of the performers currently funded have made excellent progress and are addressing key R&D needs for hydrogen production. However, there are a few projects that seem to be floundering a bit. With the current funding situations, there is not much luxury to allow these projects to continue, and difficult decisions will need to be made. There also needs to be more critical review of current technology so that DOE is not using its valuable research dollars to fund work at one institution that has already been done by another, and may even already be in production. For example, DOE could be funding the development of a demonstration unit that duplicates the capabilities of another company's existing commercial product.
- The topics of the sub-program enable key barriers to be addressed.
- Yes, a broad range of technologies to generate hydrogen from different materials and primary energy sources are included within the sub-program. However, the distribution and limits of available resources probably impact the scope and depth of projects. This sub-program remains a valuable effort without an overemphasis on any particular approach.
- As both the National Energy Technology Laboratory and EERE are working on hydrogen production, it would be helpful to have a more open exchange of information and collaboration in efforts.
- The sub-program addresses the cost and performance issues for the large-scale introduction of hydrogen, but does not clearly identify where current costs have been demonstrated. These could be modeled, but should show actual numbers that are based on the technology advances. For most technology, the presentation indicated that performance targets are being met and longer-term tests are needed, but there should have been more details presented.
- It is difficult to evaluate the effectiveness of a $15+ million sub-program that is developing seven technology pathways based on a 15 minute presentation. However, the progress that was described, the independent assessments completed, and the planned activities (e.g., MYRDDP update and R&D priorities workshop) are indicators of a well managed program that seeks input from diverse sources to identify and direct scarce resources toward the most critical developmental needs.
- [Note: six respondents replied "Yes," or similar.]

4. Other Comments:

- This is a first-priority program that requires substantial financial support.
- The nice, short presentation showed the effectiveness of the sub-program.
- This was a knowledgeable presentation of the topic and its issues.
- DOE should continue this stimulating review.
- Given the presentation time constraints, this was a very good overview.
- There is a well coordinated spectrum of program and sub-program areas.
- DOE's continued and meaningful support of renewal or non-conventional hydrogen production research is very important. Needless to say, the commercial timescale for these technologies will be longer without government support. Moreover, it is important to remember that demand for hydrogen will continue to grow with or without fuel cell automobiles. The chemical and oil and gas industries can always use additional volumes of hydrogen.
- This reviewer is a strong proponent of photoelectrochemical and biological hydrogen production, yet to most rapidly achieve more widespread centralized hydrogen usage in the near term, it is clear that those are not currently viable solutions.
- Infrastructure is becoming a key limitation in the implementation of fuel cells for fueling and backup power as fuel cells have come closer to commercialization. While the proposed budget is an increase over 2010, the production budget is still very small, especially considering the amount of funding that has been directed to fuel cells. In order to bring these technologies to fruition, appropriate funding levels must be appropriated to leverage the advancements being made in fuel cells and bring production to the same level.
- Regarding centralized hydrogen production, this reviewer does not see how wind and solar can ever be in sufficient quantity to produce 100,000 kilograms (kg) of hydrogen per day. Both are intermittent. On a good sunny day, solar is only available for about six hours. Wind may be more plentiful, but capacity factors are in the 40% range. The reviewer believes that solar and wind hydrogen production will be distributed, and recommends that the sub-program be amended accordingly. On the other hand, geothermal energy can provide centralized hydrogen production on the scale identified for centralized production. This is missing from the sub-program, and should be added. As per geothermal, this reviewer realizes that nuclear energy is under a separate program; however, it is an energy source that should be acknowledged. Photoelectrochemical (PEC) hydrogen production is listed under centralized production. This reviewer suggests that it be considered distributed production.
- It seems that more effort should be spent under solid oxide electrolysis. This pathway seems to be making little progress. Solid oxide electrolyzer cells (SOECs) operate in a favorable thermodynamic region where efficiency losses produce heat necessary for thermal splitting of water. As renewable hydrogen is often criticized for low conversion efficiencies in comparison to battery technologies, it would be prudent to focus efforts on technologies with the highest efficiency potential, such as SOECs. Production of hydrogen with low efficiency losses will allow buy-in of the energy carrier for other programs as well.
- Some graphics were too small or otherwise difficult to read. For example, reading words and symbols on slide three's technology maturity timeline was difficult. The inclusion of symbols for feedstock and energy source reduced the size of the words and symbols to the extent that both were unreadable from most locations in the room. The "Goals and Objectives" and "Challenges" slides were very readable. Some slides had multiple purposes that created some confusion. For example, the "Goals and Objectives" slide listed the cost target and emphasized clean, domestic resources. It also listed pathways and described current U.S. hydrogen production. The budget slide clearly showed the level and direction of funding by pathway, but also listed technical objectives (e.g., reducing the capital cost of distributed production by 10%). The "Challenges" slide, on the other hand, had a clear, focused message. Slides contained dense collections of information—too much to communicate during the presentation, but helpful to read outside of the session. The "Progress on Separations" slide contained the current status in the left column and the targets table to the right. It would have been helpful if the status and targets would have been juxtaposed. Having the red arrow from the stability and durability row of the table point to the "Performance targets…" statement (above the arrow) to which the arrow refers would have also been helpful.

Hydrogen Delivery

1. Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year? (Include information presented in the plenary and/or session overview presentations of the sub-program if appropriate.)

- The sub-program specifically highlighted the major research advances since the last DOE Hydrogen and Fuel Cells Program Annual Merit Review (AMR), and directly compared them to prior accomplishments for each sub-section. (It is unclear if these prior accomplishments were solely the previous year's advancements.) The broad overall challenges of each sub-section were clearly spelled out in the presentation slides.
- Yes—the issues and remaining challenges were laid out and specific progress from last year was reviewed.
- The presentation showed an overview of all areas. The accomplishments compared to the previous year are clear.
- Yes, the Hydrogen Delivery sub-program was adequately covered, and the major issues and challenges were summarized. The progress that had been made in the various projects that do not have very large total budgets was clear.
- There was excellent coverage of the sub-program area. The issues, challenges, and progress were all clearly presented.
- The sub-program was adequately covered, and all key challenges were outlined. Prior and recent accomplishments in different fields were clearly demonstrated.
- The sub-program was well summarized in a single slide, and the major issues were presented in another. Another slide presented a summary of progress during the past year. All of the information was presented very clearly.
- The sub-program areas goals and objectives were described in excellent detail. The presenter described the critical gaps and how government and industry are working together to address them.
- The sub-program was sufficiently covered, and the progress was adequately highlighted.
- The sub-program was well described. Reasonable progress was also described. Technologies with market pull from other applications (e.g., large compressed hydrogen tanks that can be used for natural gas) showed the most progress.
- The presentation did an excellent job of providing a comprehensive overview of the Hydrogen Delivery sub-program element, as well as describing the key challenges in specific terms around each delivery component. The progress that has been made was elucidated very well in terms of the individual delivery components and their targets. The overall delivery cost target was not explained well, nor was there a good link provided between that target and the individual component targets.
- The sub-program area was adequately covered. Important issues were covered, although funding challenges and stretch-outs were not. This reviewer wants to know if there will be any impacts on other sub-programs or codes and standards activities if this technology area is stretched out.
- The presentation was nicely done and very easy to follow. The progress made so far (both prior and recent), milestones, and techno-economic challenges for each pathway were clearly identified.
- There was excellent graphical portrayal of prior accomplishments, recent accomplishments, and future work by pathway. The status against targets was also clearly depicted. Given the available funding, the sub-program appears to have identified the most critical challenges and issues, and is pursuing solutions.
- Scott gave a good presentation covering the important elements of the Hydrogen Delivery sub-program: tube trailers, liquid hydrogen, pipelines and compression, and the forecourt.
- The research emphasis is well laid-out and the sub-program activities align with that emphasis, whether the activity is analysis (e.g., cost and emissions by Argonne National Laboratory and the National Renewable Energy Laboratory [NREL]), or actual project work such as reducing delivery cost through fiber-reinforced polymer (FRP) and alternatives to carbon fiber. The challenges and current status were clearly defined, as was the fit of the various approaches into the rollout of hydrogen infrastructure. The accomplishments achieved during the current year for each sub-area were also well documented.
- The sub-program area was mostly adequately covered. However, the following few points may be noted:
  - There is mention of a "carrier"—for example, in the bulleted description on slide two, the overview slide. However, there is no specific information provided on the status, progress, plans, etc. for this topic.
  - While the overall sub-program is pictorially represented in slide two, some of the information is insufficient or inadequate; for example, for large- or mid-scale hydrogen production, hydrogen output is shown at 200 pounds per square inch. While this may be appropriate for pipeline transportation, it is not

appropriate for truck, rail, or barge transportation—for which it needs to be higher (i.e., 350 or 700 bar). Similarly, "forecourt" production at 1,500 kg per day is shown connected with an arrow to liquid hydrogen storage. This reviewer wants to know if liquefaction at this scale is practical.
    - "Pipeline compressor" is somewhat of a misnomer—different terminology may be appropriate.
    - Important issues and challenges are adequately covered, and progress is clearly presented in comparison to the previous year.
    - The color coding on slide 10 is confusing; for example, it is unclear if blue is the pipeline or the compressor.
- Yes, although the residential refueling area was not addressed. The sub-program overview only identifies the transfer and delivery of large-scale hydrogen in either gas or liquid form.
- Station capacity requirements can be best served with gas delivery in the first years (i.e., 2015–2018), but after that larger stations are expected to require liquid delivery. Linde is aligning with liquid delivery for this reason. A workshop led by a researcher from the University of California, Davis with key stakeholders had the same finding. It appears that the delivery of gas spans a small time slice. This reviewer wonders if it makes sense to focus most of the development effort on gas delivery. In shipping, high-density materials are always preferable. It seems that there should be more focus on liquid stations for the post-2017 timeframe.
- This reviewer finds overview presentations very difficult to understand and follow. The reviewer much prefers to hear the most important details of the work so that he can judge the understanding and credibility of the R&D. The reviewer is a detail person and not a global person, such as required for high-level management; therefore, he cannot answer this question.
- [Note: six respondents replied "Yes," or similar.]

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

- This reviewer believes that there are no apparent gaps.
- The specific emphasis is well laid-out.
- The future work for each area is well highlighted.
- Milestones for the current hydrogen delivery projects were given, along with some planned activities. There was not much regarding any new efforts to improve cost issues with the various technologies, as most of the attention was on the capabilities and improving performance with respect to the DOE targets. Potential safety issues with high-pressure gas or liquid-phase hydrogen did not seem to be explicitly considered in any of these projects, although this reviewer is certain they are being considered.
- This reviewer did not see any gaps.
- The issues and challenges are well addressed. This reviewer wants to know if well-to-tank analysis for production and delivery pathways is performed. It would be great to have more demonstration projects of delivery pathways. International regulation, codes, and standards efforts are required.
- The plans for addressing issues and challenges were clearly stated. No gaps in the portfolio were identified.
- There are no gaps in the portfolio, and the sub-program seems to address the basic challenges. However, the plans were not clearly identified in the presentation.
- The portfolio clearly addresses the major issues related to hydrogen delivery. This reviewer does not see any gaps.
- The presentation identified key issues and challenges with a well defined path, if funding levels are maintained to eliminate gaps and challenges.
- The plans are in place for addressing the challenges.
- Yes, the plans are aimed at the right areas. Analysis would be helpful in identifying how much infrastructure already exists. For example, Air Products can already provide and dispense hydrogen. It is unclear how far that covers the infrastructure requirements. Increasing hydrogen dispensing in the near term to cover the 2015 roll-out is going to make a small dent in the current infrastructure capacity.
- Yes, nice organization and a path forward have been identified.
- The immediate challenge appears to be reducing the significant station or forecourt cost. The sub-program appears to address this gap with the appropriate allocation in the 2012 budget request.
- The sub-program appears to be addressing the most critical issues within funding constraints.
- Plans are laid out that cover the biggest technical hurdles identified.

- Plans for each sub-area are defined. It is not clear how the Air Products "hydrogen in a box" approach to early markets fits into the delivery components as defined.
- The plans to address the specific challenges for each delivery component over the short term are very clear. There was no link between the short-term component research plans and the long-term overall delivery cost target.
- In addition to the specific tasks described in "Future Plans," it would be helpful to describe the approach for addressing the critical issues and challenges. In terms of gaps, the current sub-program seems to depend on electrochemical compression as the only option for forecourt compression-storage-delivery—that may be expanded. Considering the current status and projections, the delivery cost target of $1 per gasoline gallon equivalent cannot be met. The pathway to reduce the delivery cost to $1/kg (goal) needs to be addressed, or the target needs to be revised.
- Yes, plans are presented to address the technical challenges. Yes, there are gaps associated with in situ, real-time monitoring of transport systems for leaks. This reviewer wants to know what technology will be used, and if there will be a visible indication of leakage in addition to more conventional practices. The reviewer also wants to know why there was not any discussion of mechanical fatigue due to hydrogen cracks in the metal tube trailers with overwrap.
- Gaps exist in the portfolio, but these are primarily due to the lack of funding.
- It only covers hydrogen transfer in large-scale volumes; it is as important to address small-scale residential hydrogen production units and on-site hydrogen generation and delivery to refueling pumps.
- Recent research advances aimed at targeting the emphasized topic areas were identified to meet the issues at hand. Specific plans for addressing future challenges were not addressed in the presentation slides, although this seems less relevant to the sub-program overview presentations. However, "next step" implementation pathways were described for the recent accomplishments. The project portfolio seems solid, although the crosscutting component of health and human safety was not expounded upon much.
- There are many challenges—this is not easy work.

3. Does the sub-program area appear to be focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program's needs?

- The goals are focused and well managed. Funding seems very small for the goals laid out, and it will be a challenge to achieve these goals with the minimal dollars invested.
- The topics of the sub-program enable key barriers to be addressed.
- Yes, a rather broad range of technologies are being supported in light of the limited resources for the funding of any prototype or demonstration tests. While system modeling and analyses are worthwhile, more efforts on experimental studies should be included—particularly with respect to the interface between hydrogen delivery and fuel stations.
- The Delivery sub-program appears to be focusing in on the critical areas necessary for cost-effective delivery in the near term and long term, even under challenging budgetary pressures.
- The sub-program area is very focused and well managed, and clearly addresses DOE needs.
- The sub-program is well managed, and is very effective in addressing the R&D needs.
- Although this sub-program has a broad focus, it addresses the major issues in hydrogen delivery. Summaries of several projects were given with past progress and current progress. This was well done and showed where the sub-program was going.
- The sub-program appears to be well planned and managed with some commendable collaboration. The funding appears balanced between incremental improvements in established, conventional technologies and longer-development, lower-cost technologies, such as metal versus composite pipelines.
- The sub-program is focused and well managed. The delivery technical team has been effective in working toward eliminating the technical barriers for hydrogen delivery to fuel cell vehicles within the funding provided.
- Yes, the sub-program objectives and strategic plan to bring technologies, standards, and codes to the marketplace is well thought-out and supported through a collaborated effort with other federal agencies.
- The sub-program area appears to be focused and well managed.
- Considering the changes in leadership, this appears to be exceptionally well organized and presented.
- Increased focus on the forecourt is a good change in the portfolio.

- This is a well managed sub-program relative to the individual delivery components and challenges, as well as the immediate research needs. There needs to be a more complete vision for hydrogen delivery research and accomplishments to meet the overall long-term hydrogen delivery cost target.
- Generally speaking, yes, but DOE needs to identify the current hydrogen generation technologies that are being developed by other agencies and try to leverage those programs—collaboration is the key.
- The sub-program area seems focused on two delivery technologies—forecourt storage and two areas of compression. These are indeed important to overall Program R&D needs, but this reviewer wonders if forecourt storage would have been more appropriately placed in the Hydrogen Storage sub-program.
- The plans do cover the right issues. The priorities may need to be aligned with projections from industry when high-volume dispensing is required (e.g., liquid, greater than 1,500 kg/day). Hydrogen in Hawaii, for example, is expected to require large stations as early as 2020, which would be difficult to serve with gas deliveries.
- The sub-program does address the Program needs, but there are so many related areas that need to be addressed, such as quality assurance and control during construction, in-line real-time leakage detection, embedded sensors for crack propagation, etc.
- Overall, this sub-program is focused on reducing the cost of delivery. However, it may be worthwhile to consider a more integrated approach to addressing the challenging goal of meeting the cost target, such as in the NREL modeling project. In other words, delivery options need to be presented as end-to-end solutions along the value chain, rather than discrete items.
- This reviewer would like to see more emphasis placed on return of investment. Some of the projects appear to be impractical. The reviewer realizes that EERE wants to coordinate with the BES Program, but the timeline for some of the work is impossibly long.
- [Note: six respondents replied "Yes."]

4. Other Comments:

- There appears to be a smooth transition between the team leader and the temporary replacement, and good coordination with other parts of the whole Program.
- The PowerPoint presentation style should be used as a model for other programs and projects. The sub-program could probably use more funding to address the forecourt challenges. (This reviewer may not have the right technical background to review this sub-program.)
- The presentation included a very good overview of the sub-program. All of the slides were well organized.
- This stimulating review should continue.
- Shortfalls in prior years' funding due to earmarks and other reasons have limited or delayed progress on the needed R&D.
- The modeling activities should be better integrated with vehicle modeling activities to obtain an overall optimum system. The problem with optimizing parts of the hydrogen system is that synergies are ignored. Integrated modeling could address this issue.
- DOE sub-programs should make sure that crosscutting technologies between sub-programs are well leveraged to maximize DOE's funding input. For example, several groups in the hydrogen production side are already doing electrochemical compression of hydrogen, in conjunction with the electrolysis reactions. Rather than funding duplicating efforts, utilizing the competencies of existing performers would enable the highest level of progress to be made.
- Compression is a major cost that needs to be addressed. The pathway has to be electrochemical hydrogen compression. The FRP pipeline can be used for both delivery and storage. This reviewer recommends an increased emphasis on this technology. Researchers need to develop more cost-effective liquefaction. The Prometheus technology shows a lot of potential.
- This reviewer wants to know if there is any ongoing development with regards to 500 bar trailers.
- The sub-program is only as good as the principal investigators who participate in its implementation.
- Some of the technology gaps and cost goals needed to bring cost-effective systems to market may need to consider other industries outside of fuel cells that are under development to the mass market. Examples include advancements in lightweight aircraft materials and aerospace jet engine designs and materials for the National Aeronautics and Space Administration and other U.S. Department of Defense agencies. Researchers may want to consider isotropic butane as a potential new fuel.
- It seems odd that HDSAM is being updated to 2007 dollars. Because the economic conditions changed so significantly in 2007 and 2008, this reviewer expected that a more near-term baseline would be necessary to

reflect today's costs in establishing infrastructure cost drivers (e.g., the cost of steel and energy has changed significantly in this period). The comment that FuelCell Energy has reduced compression energy for hydrogen by five times was noteworthy. The isentropic efficiency of compressors today is not five times the theoretical thermodynamic limit.

Hydrogen Storage Sub-Program Comments

1. Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year? (Include information presented in the plenary presentation of the sub-program if appropriate.)

- The presentation clearly stated the goals and objectives of the systems engineering and analysis and the materials technologies tasks within the Hydrogen Storage sub-program. The presenter identified the issues and challenges for the near-term and long-term options in the context of the current status. He described the strategy to meet the challenges and the areas of emphasis. The presenter also highlighted recent progress in cost reduction of the physical storage system, material discovery, storage engineering, cryo-sorbents, chemical storage materials, metal hydrides, and early market applications.
- The presenter did an excellent job of covering the sub-program, challenges, and progress.
- The sub-program was summarized clearly, methodically, and accurately, with careful balance given to the current and future priorities of the overall Program. The emphasis on hydrogen storage has shifted greatly over the past two years, and funding has been substantially reduced. These important issues were very directly and clearly addressed with the move toward emphasizing near-term engineering goals and the move away from recognizing materials discovery. Despite the reduction in funding for materials discovery, clear advances, particularly in physisorbed systems, were emphasized.
- The sub-program area was adequately covered, including the identification of important issues and challenges. The presentation clearly presented progress in comparison to the previous year, and showed near- and long-term options for efficiently storing an adequate amount of hydrogen in an acceptably small volume at a reasonable temperature, pressure, and cost.
- The introduction to the Hydrogen Storage session was very instructive and adequately covered the important issues and challenges. The progress in research in all of the major fields was presented in a very handy manner.
- The challenges were adequately addressed and the sub-program focus was well explained.
- The presenter gave an excellent overview of the sub-program objectives, challenges, and technical status. The technical progress in 2010–2011 was put in the larger context of overall progress that has been made on this sub-program. This provided a useful way to compare the progress made in this reporting period with previous work and DOE targets.
- The details of the sub-program were well described. Progress was also well described, but the remaining barriers were not clearly stated.
- Yes, the sub-program was covered well, including progress for the previous year.
- The sub-program area has been adequately covered, with good balance for both long- and short-term options. The short-term option has been focused on cost issues, while the long-term option focused on performance issues. Such different focuses represent good judgment on the important issues and challenges faced by hydrogen storage technology. The progress made is also adequate. The initiation of a new project on the use of low-cost, commercial, textile-grade polyacrylonitrile as a high-strength carbon fiber precursor, and the development of new sorbent materials with surface areas greater than 6,000 square meters per gram and material capacities exceeding 8 weight percent at 77 kelvin and less than 100 bar are examples of significant progress. Other noteworthy progress includes the demonstration of thermal control of alane decomposition, and the determination of the required material properties for the storage system to guide materials development efforts.
- Yes. The speaker demonstrated excellent command of the technology. The projections against the targets showed good progress.
- Yes, the presentation on the Hydrogen Storage sub-program sufficiently described the issues and current challenges. The presenter also described the status and issues for the technical aspects concerning both physical storage systems and materials-based storage technologies. However, little information was provided on what can be accomplished considering the 75%–80% reduction in funding over the past three years. Recent efforts and progress made over the past year were clearly identified.
- Yes. The presentation made clear that all DOE system targets must be met simultaneously—not just a few select targets. From a technical perspective, volumetric storage capacities were identified as one target that needs more attention. An annual progress plot showed that improvements leveled off in this metric, and emphasized the need to focus more on this issue.
- [Note: two respondents replied “Yes.”]

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

- The presenter listed the key milestones and future plans for FYs 2011–2013. He also listed the areas of emphasis and the breakdown of the FY 2012 budget request.
- The presenter did a good job of discussing the sub-program goals with the limitations placed on them by the uncertainty of the current budget.
- The plans for FY 2011 address important issues and challenges, and include projects on cost reduction of carbon fiber precursors as well as the hydrogen storage materials database.
- Details for continuing the work have been addressed.
- Issues and challenges were identified and are being addressed. There are no gaps.
- A reasonable plan was implemented last year, and the future plan is appropriate. The three-pronged approach of the future plan—(1) Small Business Innovation Research funding to reduce the cost of carbon fibers, (2) independent projects to improve performance and develop new materials, and (3) a Hydrogen Storage Engineering Center of Excellence (HSECoE) to determine the required material properties and identify technology and knowledge gaps—represents a good use of the available budget.
- The plans identified for addressing issues and challenges include providing at least one full-scale system design concept and down-selecting onboard reversible storage materials, including hydrogen storage approaches, with the potential to meet the 2015 targets.
- Currently planned activities for the hydrogen storage projects were clearly presented, and goals and expectations were identified. With the end of the three Materials Centers of Excellence in FY 2010 and most of the independent research projects on "new" materials in FYs 2010 and 2011, momentum is being lost for developing improved materials with the potential to meet the DOE performance targets for fuel-cell-powered vehicles. The just-closed funding opportunity announcement (FOA) may help to rectify this serious gap for hydrogen storage if adequate funds are available in FY 2011, FY 2012, and beyond.
- Plans were identified for addressing issues and challenges. This reviewer believes that there is now a substantial materials-discovery gap in the project portfolio.
- Future plans presented a milestone for the fourth quarter of 2013: down-select onboard reversible storage materials with the potential to meet 2015 targets. However, given the reduced funding, there seems to be a 2.5-year gap in the ability to address the challenges for meeting this milestone. In the current budget environment, there does not appear to be a stable plan for addressing this challenge. The need to strengthen coordination between basic and applied research within DOE and across agencies was identified as one stop-gap approach to addressing this issue.
- Issues for near-term applications were addressed, such as the cost of carbon fiber, and ongoing work to overcome this hurdle was explained. Issues with materials for long-term applications were also explained, and progress was communicated. The inclusion of non-automotive applications has been discussed for a couple of years but has not been implemented so far, apart from workshop information. This reviewer recommends accelerating this activity due to its relevance to the HSECoE work and near-market applications.
- Solid plans for addressing the major technical barriers were outlined. However, the conclusion or termination of the technical efforts by the Materials Centers of Excellence greatly diminishes the prospects of discovering a material that meets all of the DOE research, development, and demonstration objectives for hydrogen storage, especially reversible storage and delivery.
- The increased emphasis and targeting of heavier metallic hydrides for stationary and industrial vehicle (e.g., forklift) applications was not covered very well.
- Plans to overcome materials shortcomings were not clearly spelled out.
- There are no gaps.

3. Does the sub-program area appear to be focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program's needs?

- The sub-program appears to be focused and well managed.
- This is one of the best managed sub-programs in DOE.
- The sub-program area is focused, and the DOE Team Leader has successfully steered it away from materials discovery and toward more near-term engineering applications that are in line with current national priorities.

- Yes, the sub-program is well managed and flexible in meeting the challenges of an ever-changing Program.
- The sub-program area appears to be focused and effective in addressing overall Program needs.
- The sub-program is absolutely well managed and seems to be effective in addressing DOE needs and objectives.
- The sub-program area appears to be focused and well managed.
- The DOE sub-program manager is doing an excellent job of coordinating the sub-program activities and keeping sub-program participants apprised of Program needs. He has a strong technical background in hydrogen storage, and his recommendations (and criticisms) are considered and acted upon in a serious way by sub-program participants.
- The sub-program is reasonably well focused. The sub-program needs to continue to make hard decisions and focus on viable storage solutions.
- This sub-program has focused on three major technical areas, effectively addressing the critical needs of the hydrogen storage technology.
- The sub-program appears to be well focused and well managed.
- The Hydrogen Storage sub-program is using its resources very well in efforts to support improvements in physical storage systems, especially in lowering the cost of carbon fiber for high-pressure tanks, exploring alternative materials with better storage properties, and addressing the engineering issues for the three classes of storage materials. These projects are relevant and productive toward improving hydrogen storage systems. More attention could probably be directed toward developing reversible hydrogen storage materials for early market applications in which gravimetric capacity is not as demanding as the DOE targets for passenger vehicles.
- [Note: four respondents replied "Yes."]

4. Other Comments:

- The hydrogen storage team is doing an excellent job of adjusting to the changing landscape and reshaping the sub-program in line with the overall Program priorities.
- Despite the current funding difficulties in the Hydrogen Storage sub-program, the DOE Team Leader has continued to lead this sub-program effectively and move sub-program project members more toward engineering applications.
- This is a well managed and coordinated sub-program activity. It is imperative that higher-level DOE management fully understands that this activity will be in serious jeopardy if additional sub-program funding and new project starts are not approved. Without that support, there will be a serious and unfortunate loss of sub-program momentum and institutional knowledge regarding the important technical issues in the hydrogen storage field and the R&D strategies needed to address those issues.
- Going forward, this reviewer thinks that the new focus on reducing the costs of compressed gas cylinders is an excellent decision. The results of the sub-program on materials-based storage are outstanding and constitute excellent and fundamental contributions to the field. DOE should continue to preserve and further develop the knowledge base acquired through this sub-program.
- The very substantial decrease in funding to discover and develop new storage materials is greatly impeding the progress of better hydrogen storage systems. Furthermore, there has been no indication that either BES or the National Science Foundation (NSF) will make any real commitments toward supporting new research efforts in hydrogen storage materials. Hence, skilled and talented researchers are abandoning hydrogen storage materials, which is terminating progress and reducing expectations for making future advances. Looking at the projected FY 2012 budget for the Hydrogen Storage sub-program, very few (if any) of the proposals submitted to the storage FOA can be supported unless severe cuts are made to the HSECoE projects.
- Continuing new hydrogen storage material discovery R&D for advanced storage systems was clearly identified as a sub-program goal and challenge; however, the 2012 budget request shows a clear de-emphasis on this work compared with HSECoE work. The heavy focus on the engineering of systems seems premature without the existence of any storage materials that come close to meeting all of the storage targets. An increased emphasis on early market storage applications was presented on the budget slide. Commercial success in early market applications is needed for industrial support, social acceptance, implementation of codes and standards, and lessons learned. It is appropriate to shift some of the emphasis from vehicle to near-term applications. At-the-same-time government support of breakthrough materials R&D is essential for the United States to be a leader in this field.
- Close coordination with BES, NSF, the Advanced Research Projects Agency-Energy, and Energy Frontier Research Centers will be helpful to the Program.

- No information about the H-Prize was presented; it would be interesting to learn about its progress.
- Future hydrogen storage activities may be constrained by funding limitations.
- Not all of the slides were readable from the back of the room—for example, the spider plot on slide 13. This was a serious problem for most speakers in the large room used for the plenary talks on Monday.
- [Note: three respondents replied "None."]

Fuel Cells Sub-Program Comments

1. Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year? (Include information presented in the plenary and/or session overview presentations of the sub-program if appropriate.)

- The sub-program was adequately covered. The presentation identified the key targets for transportation, stationary, auxiliary power unit, and portable power applications. The presenter identified the key challenges and the strategies in three of the four application areas: catalysts, catalyst supports and membranes for transportation systems, and costs for stationary systems. The presenter also highlighted progress in cost projections for transportation systems, nanosegregated binary catalysts for activity enhancement, catalyst modifiers for startup and shutdown, non-platinum-group-metal (non-PGM) catalysts, perfluoro imid acid (PFIA) membranes, and improved performance and durability of solid oxide fuel cell (SOFC) systems.
- The Fuel Cells sub-program was covered well. Focus areas, critical issues, and challenges were presented. Progress from last year was presented along with goals for the future.
- The presentation clearly conveyed the status of the technology at the program level.
- The sub-program overview was well prepared and presented.
- The sub-program was adequately covered. Issues and progress were clearly identified.
- The sub-program area was adequately covered. Important issues and challenges related to fuel cell technology such as cost, durability, and efficiency were identified. The technology progress in comparison to the previous year was clearly presented.
- The solid performance of this sub-program was well presented.
- The main focus areas and accomplishments of the sub-program were successfully communicated.
- This reviewer believes that this introduction provided a very important overview about current and future DOE activities. It was great to see the progress that was made since the last AMR, and to get all of the highlights in this single presentation.
- The area was well covered. Issues and challenges were identified, and progress was well presented.
- The sub-program was well covered. The important targets were identified, and information was given on how these targets translate to issues to be solved. Progress over the last year was clearly presented using highlights from the individual teams in the context of stated DOE goals (progressing toward, achieving, or exceeding those goals).
- Yes, the sub-program area was adequately covered and important challenges and issues were identified. Progress was also clearly presented and compared to the previous year's progress.
- The sub-program area was adequately covered. The figures on slides 3 and 14 were particularly helpful to understand the organization of the area, given that it comprises several different sections. The most important issues and challenges in the sub-program were acknowledged, and notable progress in key areas of the sub-program was highlighted. This reviewer does not think that the progress was as detailed or long as it has been in the past, but believes that is a good thing.
- Yes, with the understanding that support for the SOFC area in the sub-program is limited.
- This reviewer's main concern with the sub-program presentation is that only selected successful projects were presented, which made it seem that DOE has either met or is very close to meeting most of the main targets. In reality, there is still significant work to do, and even the successful projects have issues that still need to be addressed that were not mentioned in the presentation. Someone not familiar with the details of the projects would infer that researchers are closer to meeting DOE ultimate targets than they really are.
- The sub-program was covered well, and the presentation included a good summary of the issues and challenges. Progress was properly summarized, and, in general, good examples of particular instances of progress were given. Regarding the Los Alamos National Laboratory non-platinum work (which does represent significant progress on an activity basis), better illustrative figures could have been chosen than the two figures from the *Science* article. (One improperly compares data for non-platinum in hydrogen/oxygen with data for platinum in hydrogen/air, the other shows durability at 0.4 volts [V], far below the minimum 0.6 V needed for adequate efficiency and plausible heat rejection.) Such non-platinum catalysts are less durable at the 0.6–0.9 V practical fuel cell operating range, a point that has been raised at several reviews of the project before the U.S. DRIVE's Fuel Cell Technical Team.

- Yes, although the budget for FY 2011 was missing.
- The sub-program was adequately covered. The 60,000 hour target for stationary combined heat and power (CHP) systems is questionable, as only one system (phosphoric acid fuel cell [PAFC]) has reached that target and all other systems have technical issues. The durability target for stationary fuel cells should be adjusted based on the maturity of the fuel cell types. The degradation targets should be identified. This reviewer wants to know if the efficiency targets are beginning-of-life targets, and what a good end-of-life target is for the four applications identified.
- The sub-program was well covered. The goals and objectives need to be revisited—some of the ones listed are unrealistic and inconsistent. It is important that the goals are realistic.
- Generally, the area was covered well. This reviewer noticed that only PEM and SOFC technologies were considered, despite a concurrent workshop on alkaline fuel cells. Nothing was said about molten carbonate fuel cells (MCFCs), PAFCs, or direct methanol fuel cells (DMFCs).
- The issues in PEM fuel cells were mostly characterized and covered in the presentation. However, it was not completely clear what progress has been made in the past year. Although new data was shown on catalytic activity, no cell data was presented to translate this into performance. Moreover, there was no lifetime data shown for cells or stacks. This performance parameter often seems to be passed over. Cost data was presented here, although without a supporting explanation of how the numbers were calculated. This reviewer wants to know what were the most significant variables and assumptions used to arrive at the conclusion of $51 per kilowatt (kW) in 2010.
- The sub-program area was adequately covered, Progress was clearly presented, and important issues were identified.
- [Note: seven respondents replied “Yes,” or similar.]

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

- The presenter listed the key milestones and future plans for FY 2011 through FY 2013. He also listed the areas of emphasis and the FY 2012 budget request breakdown.
- The key issues and challenges are being addressed. There are no gaps.
- Yes, the plans were identified. No, the major gaps have been identified.
- Plans for addressing critical areas related to fuel cell technology issues and challenges have been made. This reviewer did not notice any specific gaps.
- Plans are well placed for PEM, but this reviewer saw nothing regarding other technologies. Given the broader mandate of the sub-program these days, there still seems to be some inertial drag to stay focused on PEM fuel cell issues and challenges. The sub-program seems to still be focused on automotive applications.
- There are plans identified, but they may be limited by available funding.
- It seems that catalyst and membrane development are always at the top of the list. If the state-of-the-art materials continue to perform unsatisfactorily, the research focus should then center on developing new materials and demonstrating them in cells and stacks. The sub-program seems to develop new materials well, but the follow-up of demonstrating them in cells and stacks often seems to be left undone.
- General plans in the form of focus areas were presented. It is good to see BOP covered, as it has been overlooked in the past and is an area of concern for durability targets. While there are no overt gaps, it may be of interest going forward to see how DOE plans to either transition advances from a hydrogen-automotive focus to micro-CHP (mCHP) and stationary, or initiate projects relevant to mCHP and energy efficiency.
- Yes. Cost is still a big issue, so perhaps more effort can be put on non-PGM catalysts.
- Generally, there are clear plans for addressing issues and technology gaps. This reviewer would like to see increased emphasis on electrode performance and durability under dry operating conditions.
- Given the length of the talk, the plans were described in sufficient detail.
- The plans seem to be more of the same with no connection to developing the necessary novel materials. The connections between the sub-program and the Office of Science, NSF, and the National Institute of Standards and Technology are unclear. The reviewer wants to know how the sub-program’s needs are transmitted to the fundamental science agencies, and how their output is channeled into the sub-program. There is a danger of constantly repeating what was done before with only incremental advances, and without the necessary really big advances. It is not good that after all of this time, researchers are still working mostly with platinum and a Nafion-like membrane.

- The identified issues are addressed. Additionally, comparisons between the different system layouts (i.e., low-pressure versus high-pressure PEM, and operating temperature versus vehicle thermal management) could be addressed.
- The plans are reasonably comprehensive.
- Yes. More support for the reversible fuel cell area is strongly recommended, as it supports both DOE fuel cell and hydrogen objectives.
- Plans for addressing the identified challenges were outlined. There are gaps emerging in the portfolio, particularly in the areas of more fundamental research. More emphasis on developing manufacturing technology would also strengthen the portfolio. However, with the current funding situation, the distribution of projects in the portfolio seems balanced.
- Yes, and integrating projects for the current solicitation will fill a key gap.
- The sub-program is focusing on the right issues—cost and durability. The sub-program is on-target for fuel cell system development. It would be good to show any additional DOE developments for large stationary fuel cells in the same presentation—for example, the status of the Solid State Energy Conversion Alliance program. It would also be good to collaborate and leverage learning in these programs, regarding both fuel cell and electrolysis pathways. One area that seems to be a gap is that all stationary, reformer-based fuel cell manufacturers have to develop their own sulfur cleaning technologies. This effort is something that would be better suited as a DOE development project. When this reviewer was working in the industry and doing mCHP system development, his organization routinely evaluated desulfurization catalysts, and had to support expensive equipment and researchers. While sulfur management is common with all stationary fuel cells, it would help to put a single set of scientists on the problem and have them use the best instrumentation available. This type of work may be best suited to national laboratory settings, as their instrumentation and science base exceeds anything that individual fuel cell companies can accommodate. Given that sulfur is a leading cause of stack degradation across the technologies, it would benefit all fuel cell companies to have this research done in the public sector.
- Funding issues and out-year mortgages are affecting the breadth of the portfolio. The lack of membrane projects in 2012 is one example of a sub-program gap.
- It is not that the sub-program is not well managed. The problem is more that U.S. industry seems unwilling, perhaps unable, to move fuel cell technology into the marketplace. Other countries seem more able to create markets for government-supported new technology.
- Appropriate plans were reviewed. A possible gap is that the projects attempting to correlate vehicular fuel cell degradation with degradation in laboratory accelerated stress tests use only buses (heavy duty) as the source of the vehicular data and materials. While buses may be important as an early introduction point for fuel cells (due to simpler fueling infrastructure), automotive applications would have greater societal impact.
- There are some gaps for going forward and extending the sub-program in new directions.
- The challenges are not provided as specific targets; for example, the PGM content target and the performance and durability targets for support structures are unclear. The membrane challenges appear to address just low-temperature PEMs. This reviewer wants to know if an improvement in the matrix used in MCFCs will increase the durability of MCFCs. The reviewer also wants to know if the manufacturing scale controls the cost of perfluoro sulfonic acid (PFSA) membranes rather than the materials. The cost of bipolar plates should have been included as an objective for PAFCs. The BOP fails in most systems before the membrane or catalyst degradation for emerging fuel cell technologies. More emphasis on BOP would be beneficial.
- The plans for addressing the remaining challenges are not clear. For example, “membranes” was listed as a high-priority area, but hardly any funding is allocated for membranes in FY 2012. Plates and membrane electrode assembly integration are other listed areas of focus that have no FY 2012 funding. Even in the relatively heavily funded catalysts area, the high current density performance and durability of low-PGM-loaded electrodes is not listed as an area of focus. The total funding is insufficient to address the many remaining challenges.
- There are no gaps.
- [Note: four respondents replied “Yes,” or similar.]

3. Does the sub-program area appear to be focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program’s R&D needs?

- The Fuel Cell sub-program is the best run portion of the Fuel Cell Technologies Program.

- Given the funds available, the sub-program is well focused and managed. Barriers were identified, followed by strategy and R&D areas to address the barriers.
- The sub-program is highly focused and well managed, with an outcome-based evaluation of sub-program results. The use of universal targets and measurement of a contractor's performance against those targets is effective.
- The plan is showing very effective results. A considerable amount of progress (actually game-changing) has been made in the catalyst and membrane areas.
- Yes, the sub-program has an appropriate balance between component research (first priority) and product development (second priority).
- Yes, it appears to be focused. Program managers with more technical background in the area may be good for evaluating the progress of the projects.
- The sub-program appears to be well managed, and has ever-increasing relevance to R&D that is needed to either commercialize fuel cells or demonstrate that their commercialization would not be in the best interests of society in particular applications.
- In general, the sub-program area is focused on addressing Program needs and is well managed. Too many projects are funded that focus on oxide supports.
- Given the constraints with funding, it is well managed and effective.
- It certainly appears that the sub-program is focused and well managed. The sub-program should keep pushing the working groups to avoid redundant work.
- This reviewer was encouraged to see that SOFC technology is making progress (Acumentrics). This technology appears to be most promising for stationary CHP and combined heat, hydrogen, and power (CHHP) systems. Such systems leverage low capital cost components, and have the potential to provide high electrical efficiency and quality of heat.
- The sub-program is doing an excellent job with limited funds of continuing to progress toward cost, performance, and durability targets.
- Yes, the sub-program is focused, as demonstrated by meeting the technical and cost targets.
- The DOE fuel cell team continues forward with competence and excellence.
- The sub-program seems to be effectively managed, given the budget constraints. It seems focused on specific areas (e.g., oxygen reduction reaction activity and corrosion resistant catalysts) and ignores others (e.g., high current density performance and component interactions).
- The projected cost at low production rates should be harmonized with the actual cost of current fuel cell systems.
- It is clear that simultaneous materials development and system demonstration and deployment are needed to improve performance and maintain consumer interest in fuel cell technology. Unfortunately, because of the wide field of competing fuel cell technologies and their associated problems, in addition to the importance of attracting investors for near-term markets, it becomes difficult to address all of the issues consistently. The sub-program has done an excellent job balancing support to address these issues—all with a tight budget. What is needed now is an in-road into the open market. Perhaps the forklift will be the application that paves the way.
- The focus and management are good, but the effectiveness is in question. The shortcomings of present materials are clear, as demonstrated by the original equipment manufacturers. The sub-program needs to make provisions for new ideas and materials to be introduced that do not threaten the established workers, so that new concepts and ideas are welcomed.
- [Note: 14 respondents replied "Yes," or similar.]

4. Other Comments:

- The fuel cell team deserves kudos for running an excellent program and responding to changing priorities.
- This sub-program is well managed and appears to be making the best use of available funds.
- This reviewer applauds DOE's move to endorse a "fuel cell solution" instead of a specific fuel cell technology as a route to achieving energy efficiency.
- This is a great sub-program.
- There has been a great deal of progress made.
- It would be nice to see the FY 2011 budget.
- It would be good to spend more time evaluating the possibility of closing the gap of activation energy for fuel cells. As the presenter said, one-third of the potential energy of fuel cells is consumed at the bottom of the polarization curve. This is a very important barrier because it prevents fuel cells from showing very high

efficiency, which is possible for battery technologies. Renewable energy supporters are turned off from fuel cells because of the energy losses in energy conversion.

- There should be more focus on the tolerance to freezing of BOP components.
- It is not clear why there is a go/no-go decision to be made for stationary fuel cell R&D.
- The graphics used for the kickoff were not well done—many were impossible to read. Many slides presented more than one point. Even in this time of rigid cost controls, good graphics are essential.
- The high level of overlap between the slides shown in the Monday sessions and the sub-program summaries on Tuesday placed a bit of a burden on people who attended both. However, it was useful to be able to see both the broader overviews on Monday and the somewhat greater detail in the Tuesday introductory sessions.
- An analysis of incremental improvements of catalysts or membranes should be conducted to determine if the R&D will provide an acceptable return on investment.
- It is very unhelpful that the level of funding is declining when fuels cells are so close to commercialization. A little extra investment by the U.S. government at this time would be very helpful.
- Unsuccessful projects continue to receive funding. In general, a more rigorous go/no-go review process is recommended.

Manufacturing R&D Sub-Program Comments

1. Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year? (Include information presented in the plenary and/or session overview presentations of the sub-program if appropriate.)

- The sub-program area was adequately covered. Important issues and challenges have been identified. Progress was clearly presented in comparison to the previous year.
- The overall goals of the Manufacturing R&D sub-program were clearly outlined in the presentation and defined by the presenter. The presentation was well organized and highlighted the key areas of improvement in the past year. Specific examples of key improvements by various projects clearly show the progress being made in the manufacturing group.
- The sub-program was adequately covered, and issues and challenges were identified. A more thorough comparison to the previous year could have been presented.
- The objective to reduce the cost of fuel cell stacks from $1,500/kW to $15/kW is very aggressive. This reviewer wonders if the industry needs that level of cost reduction to be successful. This objective is consistent with large-scale production of automotive fuel cell stacks at production rates of 500,000 units per year or more. Objectives for stack costs should be established based on applications and volume production.
- Yes.

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

- The projects were impressive, with one exception, and the presenters highlighted a lot of progress. Regarding gaps, this reviewer suggests that presentations include a discussion of the technologies that would benefit from the particular project, not just the technology involved in the project.
- There are plans in place for addressing the key challenges to commercializing fuel cells for near-term markets. Specific focus on high-volume manufacturing of key membrane electrode assembly (MEA) components, bipolar plates, and BOP components is critical to bringing fuel cells to the market. The project portfolio covers most of the major areas, but some specific focus on integrating components and automated assembly of both MEAs and stacks would be helpful.
- The challenges are well founded and demonstrate the strong, positive interaction of DOE and national laboratories with industry. There is little, if any, support for the two most successful stationary fuel cell systems—PAFCs and MCFCs. The successful high-temperature PEM ultrasonic bonding technology is impressive, but it has no performance data to compete with PAFCs, its direct competitor. Automation is in an early stage for PAFCs and MCFCs; both manufacturing technologies would benefit from direct support.
- Automated stack assembly and metal bipolar plate stamping and quality are two areas that could be considered.
- Plans for addressing issues and challenges could have been presented in more detail. Gaps for high-volume manufacturing support are somewhat difficult to characterize because most manufacturers are some ways away from reaching high-volume production.

3. Does the sub-program area appear to be focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program's R&D needs?

- This sub-program is showing great progress toward meeting DOE targets for cost and volume manufacturing. The achievements shown from the past year indicate that the sub-program is well managed and clearly focused on addressing DOE needs.
- The sub-program is extremely well focused based on the very limited funding it has received. The progress by the National Renewable Energy Laboratory, RPI, and W.L. Gore is most impressive and should be identified as some of the best return on investment for DOE.
- The focus is on improving cost and providing diagnostics related to manufacturing. The projects can almost be separated into two categories: industry and academics. The projects are well managed and well run, but the overall benefit could be improved. The academic projects are good; however, they are useful only if used by the

industry component manufacturers. Incorporating the academic diagnostics into the existing manufacturing projects would be worthwhile.
- The reviewer would strongly suggest that the cost reductions be scaled to be aligned with the appropriate DOE cost targets. This would increase appreciation of the potential contribution of the projects to the achievement of the overall DOE cost targets.
- Yes, with one exception—in general, the assessment of potential cost reductions needs to occur earlier in many of the individual projects.

4. Other Comments:

- If fuel cells are going to be successful, more investment in these types of projects is critical. Reducing the manufacturing costs of key components and increasing the production volumes are the only ways to bring the costs down to support near-term fuel cell markets. More efforts should be spent to bring key component suppliers together to optimize the performance of low-cost, high-volume components to meet the needs of near-term markets. An improved understanding of how the components interact, how the manufacturing processes influence system and component durability, and how the overall quality can be improved will be critical to the long-term commercial success of fuel cells.
- A brochure should be produced identifying the successes that the manufacturing activities have achieved, and inviting industry to work more closely with DOE.

Technology Validation Sub-Program Comments

1. Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year? (Include information presented in the plenary and/or session overview presentations of the sub-program if appropriate.)

- The sub-program was covered reasonably well, and key challenges were identified. The sub-program is progressing as outlined, although it was not always clear what progress occurred in the last year and what occurred earlier.
- Yes to all.

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

- Issues and challenges have been identified and addressed. There are no gaps in the portfolio.
- The plans were generally well detailed. The vehicle demonstration projects seem to be especially well directed.

3. Does the sub-program area appear to be focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program's R&D needs?

- [Note: two respondents replied "Yes."]

4. Other Comments:

- The future activities should be focused on developing a hydrogen fueling infrastructure.

Safety, Codes and Standards Sub-Program Comments

1. Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year? (Include information presented in the plenary and/or session overview presentations of the sub-program if appropriate.)

- Yes, it was adequately covered. The issues, challenges, and progress were clearly defined.
- The sub-program areas were covered well.
- Despite the grim outlook for funding for these projects, there was much progress reported (e.g., forklift tank testing, international collaboration for codes and standards development, emergency response outreach and education, and safety).
- The sub-program presentation covered the sub-program well. Issues and challenges were identified well. Progress was discussed and compared to previous years. An improvement for the future might be to spend less time on budget issues and more time on technical progress.
- Yes, the presentation covered the platform adequately. More time should have been focused on issues and challenges, especially if a success story could have been provided to show how the sub-program's efforts improved the process.
- Yes.

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

- Plans were presented to address known challenges.
- Issues and challenges were discussed and plans for resolution were addressed.
- Yes. More focus should be placed on hydrogen fueling and advanced forms of hydrogen storage in the Safety, Codes and Standards sub-program.
- Yes. New, upcoming priority items, such as indoor refueling, have been identified and appropriate measures for addressing these priority items have been initiated. At present, this reviewer cannot make judgments on internal U.S. gaps. Gaps on the international level (i.e., lack of harmonization of international regulations and standards) have been identified, and people are working to address these in international fora.
- The largest gap is the lack of funding—zero for 2011, and a fraction of what was requested for 2012 in comparison to many other sub-programs' funding. As for specific projects, plans for addressing issues were presented; however, the resources must, of course, be available.
- The plans were identified, but there was no mention of whether funding issues were going to impact these plans and delay closing gaps. This could have been done in a broader sense and minimized specifics on budget sensitivities.

3. Does the sub-program area appear to be focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program's R&D needs?

- Yes. This is an enabling sub-program that supports other sub-programs. It positively contributes to its own objectives, but also facilitates the safe deployment of fuel cell and hydrogen technologies that incorporate the R&D progress achieved in other sub-programs.
- The sub-program is focused, with the exception of the hydrogen sensor work. This work appears to be slightly out-of-scope, as it is a hardware issue that might be better covered in another sub-program. The Safety, Codes and Standards sub-program would seem to include research supporting safety, codes, and standards instead of hydrogen sensor qualification that supports component design and qualification.
- There is now a need for some focus to shift from R&D to market implementation, which has happened in some projects as a natural progression. However, a more conscious effort could be made.
- [Note: three respondents replied "Yes," or similar.]

4. Other Comments:

- The sub-program appears to be well managed and productive.
- Due to its high priority, especially in light of the downside risk in these financial times, this element should be increased and provided more funding to accelerate some of these activities.
- This is no longer a distant, far-off technology. The progress shown in this sub-program and other sub-programs in general, along with the activity of the industry (including those that they do not report to DOE), demonstrate this early commercial phase. After making this much progress, not funding these programs would be a real waste of the taxpayer money. One huge need is for infrastructure development, so that the early commercial phase can be supported for a variety of applications.
- Researchers need to find ways to transport the hydrogen safety mock-up device training to all states with the pertinent information.
- This reviewer would like to see the amount of international travel reduced. The reviewer understands that the United States must maintain a presence within regulatory processes (e.g., Global Technical Regulations), but some of the conferences seem a bit out of place with the general belt-tightening the fuel cell industry is making.
- Safety, codes, and standards require accompanying R&D—known in Europe as "pre-normative research." International collaboration seems to be sufficiently implemented in the sub-program activity of contributing to the formulation of internationally harmonized regulations, codes, and standards through participation in international standards development organizations and regulatory bodies (e.g., the United Nations Economic Commission for Europe). However, the upstream pre-normative research activities could probably benefit from enhanced international collaboration. The role assumed by DOE—through the sub-program—in facilitating and hosting the Fourth International Conference on Hydrogen Safety is highly appreciated.

Education Sub-Program Comments

1. Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year? (Include information presented in the plenary and/or session overview presentations of the sub-program if appropriate.)

- This reviewer believes that the sub-program area was adequately covered. Important issues and challenges were identified, and many presentations addressed progress relative to the prior year's report. A few presentations specifically highlighted how they addressed concerns that were raised during the 2010 review.
- This reviewer did not serve as a reviewer last year, and therefore cannot make statements about relative progress. A variety of approaches to curriculum development were described, some less effective than others. The Michigan Technological University approach stood out.
- The goals, objectives, and barriers should have been covered in more detail. This would have helped the subsequent review of projects. Progress was presented, but overall it was difficult to discern the 2011 work from earlier work.
- [Note: three respondents replied "Yes," or similar.]

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

- Plans for addressing issues and challenges have been identified. This reviewer believes that the decision to focus more closely on reaching out to early market customers is a good addition to the sub-program. Raising the awareness of policy makers continues to be a concern, especially relative to the drop in sub-program funding.
- The biggest challenge is to keep this area funded.
- This sub-program is not funded for FY 2011 or 2012, so there were no plans presented. This definitely leaves a gap in the profile.
- There are plans, but they are dreadfully underfunded. This inherently means gaps are present.
- [Note: two respondents replied "Yes," or similar.]

3. Does the sub-program area appear to be focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program's R&D needs?

- There may have been a problem with the University of Central Florida project moving to the University of North Carolina at Charlotte that perhaps could have been managed a bit better to obtain a better outcome.
- The projects are pretty scattered. There is little "education" in the sense of academic programs. Most education is outreach to policy makers—which is needed, but insufficient for educating students.
- The sub-program appears to be focused, well managed, and effective.
- It is fairly well focused.
- Yes.

4. Other Comments:

- The work has been enthusiastically pursued in spite of funding problems. The people doing this work are very dedicated to getting the message out, having a credible message, and finding the best way to reach people. The collaborative efforts are good and recommended.
- This reviewer was especially impressed with the Connecticut Center for Advanced Technology and Carolina Tractor. The reviewer believes that their efforts stand out because they are able to deliver messages relative to the business case for various fuel cell products. As the education effort continues, the business case needs to be highlighted in the messaging. For example, fact sheets should focus on the potential for good paybacks for investments in these fuel cell products.
- Keep the area funded.
- It is unfortunate that education activities will not be funded in FY 2012.

- Universities that generate a set of courses for themselves are only, at best, a local win. Much higher funding precedence should be given to universities that form a curriculum that they then offer to other schools, along with training to execute it. This can be at a cost (though not at a profit), as it is unfair to expect the funded school to just give away teacher time or trainer time to other schools. The best spent money was in the independent groups that spread the value around, such as the Connecticut Center for Advanced Technology and the H2Educate program. This area is very badly underfunded, but the rest of the Program has no funds to spare, so increased funding to this sub-program should be directed from the EERE budget. This sub-program does so much for the nation in terms of education in technology, as well as for the future of alternative fuels, especially hydrogen.
- The least effective projects in terms of reaching large audiences appear to be the university projects. Those project teams seem so concerned with intellectual property that they are not forthcoming with the course materials that were developed with public funding and do not make them available to anyone outside of their universities. The result is that maybe 20–50 students would be reached in a year. The pre-college projects seem to be doing a far better job of widespread information dissemination.

Market Transformation Sub-Program Comments

1. Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year? (Include information presented in the plenary and/or session overview presentations of the sub-program if appropriate.)

- Challenges were presented and progress was communicated.
- The presentation was a great summary of the work done and going forward.
- As usual, the presenter did an excellent job in describing the parameters, goals, and objectives of the sub-program.
- The Market Transformation session overview provided an excellent summary of the fuel cell technology deployments resulting from the Market Transformation sub-program. Both Market Transformation and American Recovery and Reinvestment Act (ARRA) projects were addressed. Sub-program objectives and challenges were listed. However, the entries were not focused or easily understood. For some items on each list, the distinction between objectives and challenges was not readily apparent. This reviewer recommends refinement of the goals, objectives, and challenges of the sub-program's MYRDDP that is being updated this year.
- The content and progress were well presented. The strategic objectives could be explained in more detail. The DMFCs are not in line with the greenhouse gas reduction policy.
- The progress of the sub-program area was clearly presented, including the challenges researchers are facing. A good summary of the accomplishments, including the number of units deployed, was also presented. A graphic image of where each of the various projects fits in terms of technology readiness levels (TRLs) would have been useful. For example, the presentation could have shown that the projects were between TRL seven and TRL nine. A timeline showing how the sub-program element has evolved over the last 4–5 years would have given some useful historical background.
- Yes, issues and challenges were adequately covered. This sub-program element was not part of the review last year, so there is no basis for comparison. The highlights of accomplishments were well presented, but they could have been presented in a somewhat more categorized way.

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

- Challenges were addressed, and progress made toward overcoming them was communicated.
- At this point, there seem to be no significant gaps in the project portfolio, but the portfolio should be evaluated on a continuous basis to ensure consistency with R&D, market development, and technology advancement.
- The Market Transformation sub-program is a relatively recent initiative within the Program. The initial (current) portfolio of projects seems to be a bit of a hodge-podge. The overall decision rules and metrics that resulted in their selection are not clear. Individually, each project is helping to move hydrogen and fuel cells along toward more widespread deployment—some more than others. The upcoming MYRDDP update provides an opportunity to clarify priorities and sub-program metrics, and to build on the brief coverage of the Market Transformation sub-program in the 2010 draft *Hydrogen and Fuel Cells Program Plan* (pp. 49–50).
- The plan could be more precise. The projects are generally very good, but the general structure is not easy to find.
- Each project needs a bit more information regarding identifying the technical challenges.
- DOE should reconsider funding gas reformers for hydrogen generation. Commercialization has not really taken off for this technology, partly because there have been limited opportunities for field trials and performance evaluation under real-world conditions. Another area for potential inclusion could be bulk hydrogen storage; however, this might be better suited for other sub-program areas.
- One of the challenges that the Market Transformation sub-program identified—but does not appear to address—is insurance premiums. Someone should present real-world safety information and results from Market Transformation projects at a strategic insurance conference to expose that industry to the clean and safe history of hydrogen and fuel cell operation.

3. Does the sub-program area appear to be focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program's R&D needs?

- Management has done an excellent job in getting the Market Transformation sub-program underway. Major initiatives within the Market Transformation sub-program should spur increased interest, activity, and investment by the private sector. Examples include cost-shared Market Transformation projects that result in many fuel cells being introduced and used at multiple sites, such as DMFCs for material handling equipment, and fuel cells for CHP at commercial sites.
- The sub-program is a key component of the overall Program, as it addresses the real-world issues of deployment, commercialization, and market introduction. It has done a good job of implementing projects that cover a wide range of issues and applications relating to the technology.
- This is absolutely a great sub-program with a wide range of great, novel applications.
- The idea of the sub-program is absolutely positive, but the single projects should be more linked to one another.
- Obviously, more funding is needed in this area. A significant amount of funding in this area is divided among various national laboratories. DOE may wish to consider consolidating Market Transformation projects to one laboratory in order to maintain consistent adherence to overall Program objectives. Some laboratory program managers appear to have better collaboration with outside entities than others. This should be considered when directing funding to the national laboratories, especially for Market Transformation projects.
- Allowing public review and comment of the Market Transformation MYRDDP will allow the hydrogen community to see the details of how the sub-program will be focused and managed. This is the first time the sub-program has been reviewed, so the big picture of where Market Transformation is going and how it fits in with the other sub-programs (e.g., Safety, Codes and Standards; Technology Validation; etc.) is not fully clear.
- The sub-program appears focused.

4. Other Comments:

- The Market Transformation sub-program includes some very interesting projects that capture the imagination of the hydrogen community and do things that nobody else has been bold enough to try.
- As the Market Transformation sub-program evolves, it should identify and fund highly cost-shared projects that result in tens or hundreds of fuel cells being tested and evaluated. Conversely, it should steer away from projects that are strictly analytical or high-cost "one-off" demonstrations. For the latter, funding support should be sought from other DOE programs.
- Concentration on hydrogen fuel cell projects is preferable. Methanol fuel cells should not be promoted.
- One suggestion would be to clarify the role AARA is playing in overcoming the challenges identified. Most of the progress communicated is related to separate funds.
- Each project should identify particular technical gaps for that application.
- The AMR was well run this year, and it was less painful to be a reviewer than in years past due to the excellent computer resources and a well designed review format.

Systems Analysis Sub-Program Comments

1. Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year? (Include information presented in the plenary and/or session overview presentations of the sub-program if appropriate.)

- The sub-program area was adequately covered. Progress has been made compared to last year and especially the last couple of years regarding shifting from basic model development and a narrow focus on just transportation applications to more analysis results and a wider scope of issues investigated. Analyses have started to highlight more of the benefits and diverse applications of hydrogen and fuel cells such as energy storage, CHHP, and other applications. This year's presentation was organized better than last year's, and showed developments more in terms of key subject areas.
- The sub-program was adequately covered, including its issues and challenges. Examples of progress were presented.
- The important issues and challenges were identified and presented well.
- The sub-program area was adequately covered. The issues and challenges were covered, although some issues such as inconsistent databases were confusing throughout all of the presentations. Overall, progress was evident, but hard to see from last year.
- Yes.

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

- Future projects should continue to identify the various unique benefits of hydrogen and fuel cells, and aim to display results in terms of costs versus benefits and value propositions. Projects should also continue to include other alternatives (e.g., other alternative fuel and vehicle types and other energy storage technologies) in comparisons, and not look at hydrogen and fuel cells in isolation, but in the context of other applications and market realities. More emphasis could be given to policy implications. Looking at policy effects should be an important part of most projects. At the same time, results achieved from the portfolio of models, analyses, and projects should be considered together to determine overarching recommendations and market outlooks.
- Sub-program plans were presented. There do not appear to be gaps in the sub-program.
- There is no gap in the project portfolio. The plan for addressing issues and challenges is reasonable.
- The plans are somewhat unclear. There is a tendency to ignore the gaps and shortcomings of the technologies. For example, it is unclear how much new pipeline infrastructures will cost. Shortcomings in the technologies lead to significant gaps in addressing technology that is further out—in particular, regarding how these results help the DOE Office of Science to focus on the science needed for future generations.
- Yes.

3. Does the sub-program area appear to be focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program's R&D needs?

- The sub-program is effective and addresses the Program's R&D needs.
- Yes, the sub-program area is effectively following the needs of the Program by conducting analyses according to information on market realities and technological changes, while also closely coordinating with industry stakeholders to gain valuable real-world insights.
- The sub-program is well managed and is focused on understanding the issues and opportunities to achieve the Program's technical targets.
- The focus is on near-term applications. It is not clear if hydrogen generation and storage is the best way forward. Connections to the U.S. Environmental Protection Agency, NSF, and DOE's own Office of Science are lacking.
- Yes.

4. Other Comments:

- This is a high-quality sub-program, and it should be expanded.
- It would be nice to have a pictorial of all of the projects and how they relate to each other, as well as where they fit in the sub-program.
- It is very disappointing to see that the request for funding for this important activity is reduced from FY 2010 levels.

Comments on American Recovery and Reinvestment Act Activities

1. Were ARRA activities adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year? (Include information presented in the plenary and/or session overview presentations if appropriate.)

- ARRA activities are adequately covered, including the important issues and challenges. The progress shown in the summary is impressive, including the fact that more than 307,400 hours have been accumulated on ARRA-funded fuel cell lift trucks as of December 2010.
- It is unclear how much ARRA funding resulted in permanent increases in manufacturing jobs and facilities ($41 million for 48 jobs).

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

- These activities have produced valuable lessons learned for the acquisition and installation of fuel cell technology related to siting, permitting, and codes and standards.
- Plans are identified to reach the goal of 1,000 fuel cells deployed in commercial-scale applications.

3. Do these activities appear to be focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program's needs?

- The activities appear to be focused and effective in addressing the Program's needs.
- The activities appear well directed at the Program's needs. The expansion of the number of fuel cells deployed in commercial applications is impressive.

4. Other Comments:

- These activities are important to long-term economic growth.

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