Program Comments Provided by Reviewers

Hydrogen Production and Delivery Program Comments

Hydrogen Production

1. Was the 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 program if appropriate.)

- The Hydrogen Production program area was very well covered—the important issues (including material performance and capital costs for all production pathways) and challenges were clearly described and progress was shown on examples for all research fields (including novel hydrogen production methods) within the program.
- The program area seemed to be adequately covered; however, based on a review of the PowerPoint slides, important issues and challenges were not clearly identified. Progress was reported, but there was little mention of previous years' successes, which would have served as a useful baseline.
- Yes to all of the questions. The progress was usually presented as a status, which made it impossible to judge the progress in comparison to the previous year.
- There has been some good work on perovskite compounds; this work is novel and may be a breakthrough.
- Yes, issues and challenges were highlighted. It is not clear how progress was made compared to 2012 during the introduction; the main focus was on current achievements, which is good.
- Yes, the program area did adequately addressed program goals and objectives. Current market cost analysis and near-term and long-term market cost expectations were clearly identified. Program technical goals and expectations were also clearly identified.
- The program area was adequately covered, with important issues identified pathway-by-pathway. Not only were the previous year's accomplishments and progress covered, but they were covered in a multi-year context. Slides showing quantitative progress over an extended period of time juxtaposed with targets are more valuable than single-year snapshots and are appreciated.
- Project benchmarks were well defined and adequately covered during the presentation. Challenges were defined in materials performance and capital cost with future targets established on electrolyzer and photochemical economic pathways. Progress over the past year's efforts were identified and analyzed. However, gaps identified across the three near-term areas may need additional work to be completely addressed. Use of the Small Business Innovation Research (SBIR) program to advance the basic research appears to be an excellent use of funds. Budget constraints may result in longer-term projects to address the identified issues and challenges.
- The sub-program on biological hydrogen production using photobiological organisms and enzyme development seems to represent the core of the efforts. As such, the program has a dynamic group of investigators who have expertise in molecular biology, enzyme kinetics, and organism development. Progress has been made since the previous year. However, the group lacks concerted efforts and efforts on scaling reactions beyond bench scale. The group also lacks chemical engineering expertise. Also, the Fuel Cell Technologies Office (FCTO) is encouraged to broaden the investigation of organisms that can produce hydrogen biologically beyond photosynthetic bacteria and algae. There are other microbial organisms that have the potential to produce hydrogen at commercially relevant titers, including the archaeon *Thermococcus kodakaraensis* (see Thomas Santangelo's work at The Ohio State University). Such organisms are becoming more genetically tractable and may use mechanisms to generate hydrogen other than photobiological, which have the potential to reduce the capital costs involved with vessels, such as enclosed photobioreactors.
- It is unclear if any of these technologies have been adopted by any of the demonstration projects in the United States to show that they can achieve some validated production cost targets.
- This presentation seemed to be more of the same—same challenges, same barriers, and the same amount of progress. It would have been better to show, for example, what the capital cost and production cost of hydrogen is based on the electrolysis funding opportunity announcement (FOA) run in fiscal year (FY) 2007 with a $300 cost goal. There was brief mention of progress made by Proton OnSite and Giner, Inc.,

but the description of the component improvements seemed short compared to the catalyst loadings. It is unclear if they made the $300, if the operating cost came down with the capital, and if the production cost broke the relationship between electricity and hydrogen cost. If the catalyst loading came down, it is unclear what the yield was per plate. It is unclear if the energy efficiency improved or whether it was reduced.

- The photobiological work is not making much progress. It is good science, but even a five-fold increase in hydrogenase activity is minor and not much of an accomplishment considering the amount of time spent. There was no clear path presented for how to achieve the 2020 cost targets.

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

- The program overview addressed current technology, cost, hydrogen production methods, and challenges.
- Gaps are defined. However, the plans and pathways to address the issues and challenges within the identified gaps appear to be jeopardized by projected budgets constraints. The project portfolio appears to be aimed at addressing the gaps.
- Plans are in place for more research and development (R&D). There do not seem to be many gaps in the long-term portfolio, but one could argue that small steam methane reforming (SMR) technology is currently very weak and the potential for small tri-generation (combined heat, hydrogen and power, or "CHHP") systems for home use is undeveloped due to the low demand for hydrogen vehicles. The U.S. Department of Energy (DOE) should consider providing support for small CHHP systems.
- The projects address the main issues and challenges very well. However, to achieve the DOE goals for hydrogen production costs, there seems to be a gap in demonstrating promising technologies. Budgets for such demonstrations seem to be limited. Joint actions as proposed by the International Partnership for Hydrogen and Fuel Cells in the Economy some years ago might help to achieve progress. Partners from abroad might be able to create synergy by bringing in infrastructure and knowledge that is presently not available within the program.
- The presentation clearly identified movement from distributed natural gas production to renewable distributed production and longer-term technologies, which is appropriate. The FY 2014 request has a significant amount of additional funding for distributed renewable production; the presentation did not indicate the direction of this funding (pyrolysis, aqueous reforming, or other). One assumes that other areas of major funding (high-temperature solar thermochemical, photoelectrochemical, biological) will continue the ongoing efforts reported in the presentation.
- Issues and challenges are expected to be addressed through FOAs issued over the next fiscal years. Overall gaps in project portfolio are not completely clear.
- The Hydrogen Production program area should consider more practical technologies for production of hydrogen. Due to near-term and long-term specific targets and goals, the program should focus more on practical technologies than "science projects." Solar-thermochemical technology is one of those technologies that perhaps is very attractive on paper but in reality is not very practical. Solar energy generation technology can be coupled with water electrolysis stack technology to produce hydrogen at a much higher rate and smaller footprint. The program needs to reevaluate some of the technical approaches and spend funds on technologies that already have demonstrated hydrogen production in a large scale and are commercially available.
- It is unclear what the following statement in the presentation means: "Nearer term technologies being transitioned to Tech-Val portfolio and continue to be supported by SBIR Program." What about near-term electrolysis development with regard to dynamic operation and capital cost decrease? Is DOE satisfied with current electrolyzer performance? It is unclear if there are considerations for new projects on upscaling electrolyzers for centralized production.
- While analysis is important to ensure the correct approaches are being taken, it was not clear which technologies or systems have been eliminated or reduced in priority due to funding constraints or limited R&D results. It seems the sub-element already has an approach for the next 7–10 years—improved SMR with lower greenhouse gas emissions and higher efficiencies—but there are not enough projects to jump start the applications. The biggest gap is how the individual program elements are coming together to meet the well-to-wheel expectations.
- The sub-program on biological hydrogen production could benefit from reactor engineering efforts. R&D to improve photobioeactor designs is being pursued in the DOE Energy Efficiency and Renewable Energy

(EERE) Bioenergy Technologies Office, the Defense Advanced Research Projects Agency (DARPA), U.S. Department of Defense/Air Force, and the National Science Foundation. The FCTO could be well-served by collaborating with these entities to share insights on R&D progress as well as techno-economic modeling analyses in terms of understanding the current progress toward cost barriers and remaining challenges specific to hydrogen production.

- No specific plans were shared, although vague key milestones and general future plans were presented. The portfolio seemed to have a glaring gap in electrolysis funding/research. The production goal and pathway strategies indicate that electrolysis is a significant near- and mid-term distributed and central technology, along with biomass; however, the hydrogen production budget for FY 2013 funds little research in biomass and electrolysis and the FY 2014 request is even smaller. This does not make sense based on the prior slides indicating that these are target near-term research areas.

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

- The Hydrogen Production program area appears to be effective, well focused, and well managed.
- There was a good overview of focus; more information could be given about management and effectiveness, although the individual project presentations did show the results.
- The program area appears to be well managed and focused, but focused on longer-term efforts (i.e., solar thermochemical, photoelectrochemical, and photobiological). The program would better suit its near- and mid-term goals if electrolysis was more heavily funded.
- The sub-program area on biological hydrogen production is very focused and well managed. The sub-program area could benefit from more funding in order to broaden the portfolio and lower risks associated with the single focus on cyanobacteria and microalgae.
- Yes, the program overview was focused and effectively addressed DOE Hydrogen and Fuel Cells Program (Program) needs. However, the Hydrogen Production program management team should consider looking into similar programs that are currently under development in other federal agencies—in particular, the National Aeronautics and Space Administration (NASA). NASA has a long history and extensive expertise on electrolysis technologies, cryogenic hydrogen, and oxygen storage and delivery.
- The work appears to be focused and well managed. Technical barriers and the scope of work to address the barriers and gaps are clear and well defined.
- The program area appears to be well managed, but it is not effective in addressing the overall Program's needs. If there are critical dates in 2015, more emphasis should be on the technologies needed to achieve those targets and less emphasis should be placed on pathways that require over 15 years to achieve any significant improvements. If there are no critical dates in the near term, such as to commercialize fuel cell vehicles, standalone auxiliary power units, or other applications that determine the success or failure of the Program, then working on incremental improvements is fine and will produce some good science and engineering.

4. Other Comments:

- The presentation featured good use of the rule of thumb of 1 minute per slide—it fit well into the 15 minutes available for the session introduction and the presenter did not appear rushed.
- Very good progress has been made on the scope of work. Validation testing may need to be considered. It is unclear what the table on slide 10 from the University of Colorado is showing. It is unclear if future SBIR grants are a viable option.
- The requested budget for FY 2014 shows funding decreases for electrolysis technology but significant increases for photoeletrochemical and solar thermochemical technologies. Does DOE think that these two technologies will be ready to meet hydrogen production and cost targets by 2020? Is it feasible for solar thermochemical technology to reduce the cost of hydrogen production by 75%—from $14.80 in 2015 to $3.70 in 2020, or for photoelectrochemical technology to meet its 2020 cost targets?
- The DOE goals for hydrogen production cost are very ambitious. This is the right strategy and important to accelerate the fast and sustainable introduction of hydrogen in the economy. However, it seems to be difficult to achieve the goals based on the carried-out projects alone. Because this is an issue all over the

world, there might be synergy with other R&D programs that could be leveraged to improve the program area's output through joint efforts.

Hydrogen Delivery

1. Was the 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 program if appropriate.)

- The presentation was well done, but there was far more material than could be adequately covered in the time allotted.
- Definitely yes to all of the questions. The progress was usually presented as "status 2013" compared to targets (see the table on slide 3). It was not possible to judge the progress in comparison to the previous year in most cases.
- The Hydrogen Delivery program area was presented very well. The important issues and challenges were identified and discussed clearly. Progress was also described. Measuring the progress was rather difficult—it might be more appropriate to evaluate this only at the end of the projects.
- The presentation adequately addressed program goals and objectives. Current market cost analyses along with near-term and long-term market cost expectations were clearly identified. Program technical goals and expectations were also clearly identified.
- The program area was adequately covered and key challenges to addressing future targets were addressed up front. The 2013 progress reports were described, including major accomplishments and highlights, but there was little comparison to previous years' accomplishment besides the 2012 status table. It would have been nice to include this information so that the recent accomplishments could be put into perspective.
- The Hydrogen Delivery program area was adequately covered, apparently incorporating content of the new *Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan* and workshop learning. Key issues and challenges were identified. Single-year accomplishments were presented, but of greater value were the descriptions of progress over time relative to targets. For example, commendably, slide 14 graphically portrayed progress on current density from 2007–2013. It was not as apparent on slide 14 the period over which parts the count was reduced; this could guide expectations regarding further reductions.
- The presentation was very good and the program was well covered and important issues and challenges were identified. The high cost of hydrogen compression is identified as an area were more research is needed
- Central delivery targets were well defined and adequately covered during the presentation. Critical issues and challenges were identified and discussed. Advancements in technology through analysis and modeling were clearly presented and future work necessary to meet program goals and objectives were presented.
- All projects within this program area were covered; however, the time available for the introduction is so short that DOE Hydrogen and Fuel Cells Program Annual Merit Review (AMR) management should consider advising introductory speakers (overall, including this presentation) to avoid getting into details about session projects due to time constraints. Instead, they should mention the project title, the presenter, and one sentence about highlights of a specific presenter/project, and then move on. This would also leave the opportunity for the principal investigators to share their key findings with the reviewers and audience during their session presentations. Important issues and challenges were identified, but they could be presented in a more general way for all projects as a group since specific project presenters will get into more detail. Specific 2013 progress compared to 2012 was not clearly identified.
- The presentation identified all of the barriers as it has in the past, but it did not clearly address which issues do not have adequate solutions or resources available to address them in the R&D plans. Progress was addressed only marginally and, other than talk about high market penetrations needed for cost reduction, a clear path for improving the near-term market was not identified. Most of the information presented was only analysis and it was not clear how it was validated or if industry agrees with the assumptions and conclusions. For example, with regard to compression, storage, and dispensing cost (CSD) reduction by using tube trailers and a cascade system, it is unclear which current hydrogen delivery companies reviewed the results and agreed this was a reasonable approach for focusing limited research and development funds.

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

- The plans are satisfactory.
- The projects carried out under the subtopic are clearly within its key areas and are able to achieve the goals.
- There are good plans to address the roadblocks identified in the new roadmap.
- Plans and funding described in the presentation indicate that the Hydrogen Delivery program area has prioritized its challenges and directed 2013/2014 funding accordingly. The prioritization seems appropriate given the issues and their time frames (i.e., the nearer-term, higher-priority issues, such as forecourt CSD, are receiving relatively greater emphasis).
- Yes, but there was not enough time to get into each item. For example, metering has extensive challenges, but there was no time to mention it, much less get into detail.
- There was minimal coverage due to time limitations, which occurred because too much detail was presented about each project. Gaps are hard to identify due to the significant amount of information presented during the session introduction.
- Yes, a coherent plan appears to be in the works, although funding for a planned funding opportunity announcement (FOA) needs to be allocated, and federal support for early stations that deploy 700 bar fueling systems for the first 1,000 fuel cell electric vehicles (FCEVs) from each manufacturer appears to be essential because the commercial business case will not exist until there are many hundreds of stations.
- Plans are identified, although there appears to be a lack of projects/activities aimed at near-term R&D topics (e.g., reliability and cost of gaseous compression). Maybe some new projects will develop as a result of the CSD workshop. Also, the topics of hydrogen quality and hydrogen metering should be addressed.
- Technical targets are well defined along with the plans necessary to address the challenges. Scientific gaps and the metrics necessary to reach the gaps were included in the discussion and slides. The lack of discussion on collaborative research by other federal agencies was not discussed regarding transmission/delivery/storage and distribution. Some work appears to be more focused toward a paper-based study on cost analysis to meet the targets instead of a research-/data-based analysis.
- Yes, the program overview did address current technical, cost, and hydrogen delivery methods challenges. The program should consider looking into high-pressure electrochemical electrolysis technology; although it was briefly mentioned in the program overview, it needs more consideration. Currently, NASA's high-pressure static feed electrochemical water electrolysis SBIR program is developing an electrochemical system that can produce hydrogen or oxygen up to 413 bar without any mechanical compression. This technology currently is being developed for production of high-pressure oxygen for NASA's life support program.
- There are plans to achieve the targets identified in the *Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan*, but the relationship of the plans to what has been experienced already, for example, in the California Fuel Cell Partnership, was not explained. The program funding is limited, so even if a FOA is released in late 2013, it is unclear what anticipated achievements will be made and if there are any plans to use the existing demonstrations as real test beds. While analysis is a good tool, fuel cell cost has not been reduced as the analysis indicated, so it is unclear why the forecourt should also reduce as drastically, especially if reliability and product liability are key for new systems and components.
- Specific plans are not identified, but general short- and long-term goals and strategic plans are described. The portfolio seems solid; however, three of the six key milestones from "today -2015" are focused on liquid hydrogen delivery yet only one liquid delivery seems to be funded. More projects that investigate liquid storage and pumps seem to be in order.

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

- Yes, the work is targeted at the biggest hurdles to reduce the cost of delivered hydrogen at the forecourt.
- The Hydrogen Delivery program area appears to be appropriately focused, well managed and effective. It has a good balance between support of analysis and component development, as well as between emphases on forecourt CSD versus delivery.
- The program area is focused on addressing what the researchers' analysis indicates are the major cost barriers. It is managed as well as could be expected with limited resources.

- The Hydrogen Delivery program area is very well managed and focused on the key issues and challenges that need to be addressed.
- Yes, except for liquid hydrogen storage and pumps.
- Yes, although a key metric going forward should be the actual deployment of these technologies. That would be the real test of success.
- The program area appears to be focused, well managed, and effective, but this mainly becomes clear when listening to individual project presentations. The program introduction should focus more on management, highlighting the impact on progress toward goals and future steps to address the goals from a project management perspective.
- Yes, the program overview is focused and effective in addressing the overall Program's needs. However the Hydrogen Delivery program management team should consider looking into similar programs that are currently under development by other federal agencies—in particular, NASA. NASA has a long history and extensive expertise in cryogenic hydrogen and oxygen storage and delivery.

4. Other Comments:

- The learnings from the recent CSD workshop at Argonne National Laboratory were reflected in the presentation.
- It will be good to attend the international workshop on infrastructure topics at the end of June in Berlin.
- The presentation used a lot of abbreviations that were not always explained. For the unfamiliar listener, this may have led to confusion. Overall, it was a good presentation.
- Overall this was a good presentation, but presenting 21 slides within 15 minutes is too much. A good rule of thumb is 1 minute per slide, with a limited and concise amount of information on each slide (which appears to be a challenge for all DOE presenters).
- There is good progress toward the goals...on paper. However, it is not clear if the solutions are practical for real-world deployment. Many of the technologies developed are not in day-to-day use nor are there plans for them to be so in the foreseeable future. It is unclear why this is the case and whether this throws doubt on the actual results.
- Connections with other funding opportunities were mentioned (e.g., European Union programs). It would be helpful for the participants to know more precisely what these possibilities are because it is very complicated to find the right links in Europe without a deep knowledge of the various programs, but the benefit especially in codes and standards are immense if work could be carried out jointly.

Hydrogen Storage Program Comments

1. Was the 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 program if appropriate.)

- Yes, the presentation gave a good overview of the program area.
- This program area continued its tradition of having a very good presentation that describes issues, challenges, and progress related to moving forward toward achieving the program's RD&D goals in hydrogen storage.
- The program area is comprehensive and carefully planned. The presentation was well organized and provided sufficient detail to allow a good understanding of approaches, progress, and plans in each technology area.
- The program area was well covered with enough breadth and depth to clearly understand the challenges, degrees of progress, areas of priority, and the reasons for the priorities. The degree of barriers were shown clearly (with the help of spider charts) to allow qualitative comparisons among the various projects.
- The Hydrogen Storage program area was well covered. The presentation stated that its main goal is to develop and demonstrate viable hydrogen storage technologies for transportation, stationary, material handling, and portable power applications; clearly identified the volumetric density limitation and cost challenges of the near-term incumbent compressed gas technology; and identified the need for better materials for the longer term technologies to enable them to meet all of the technical targets. The results from the Hydrogen Storage Engineering Center of Excellence (HSECoE) were very valuable in identifying the issues and challenges of material-based storage and will help direct and focus materials development. The progress relative to the previous year was clearly presented via spider chart illustrations and pathways via waterfall charts.
- The program area was well covered by presenting well-refined charts and emphasizing and re-emphasizing important points and takeaways. Important issues and challenges were identified, such as the following, which is difficult to categorize but was mentioned as "Note: there are ~20 specific onboard storage targets that must be met simultaneously."
- The program area was covered in a concise and very clear manner. Progress in individual projects, and the program as a whole, were clearly presented and are being well managed by the program managers.
- The approach to divide the program area into "near-term" and "long-term" options is very productive and will likely, soon, lead to applications using hydrogen. It may likely prove highly relevant to focus on improving the more "low-tech" solution, i.e., high-pressure gas storage, by reducing the cost for carbon fiber and increase the tensile strength to be used to develop new high-pressure storage tanks. There is clearly significant progress within most programs and several solutions fulfill most of the targets set by DOE; only a few out of the 20 targets need to be further improved. The focus in the research program is broad, covering engineering and materials science with a focus toward the most challenging target, mobile applications. But, also, shorter-term applications are covered, such as materials-handling forklifts, single-use portable applications, and stationary applications.

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

- Yes, plans were identified for addressing issues and challenges.
- There are no gaps in the project portfolio.
- The portfolio does a good job of covering gaps. The program has made good use of limited funding.
- Plans for addressing challenges have been presented and are being managed within the limitations of the program's current budget.
- Plans with key milestones were presented for physical storage and material-based storage: mainly, to reduce the cost of carbon fiber precursors, improve materials properties, and prove design concepts and feedback materials development. The addition of non-automotive storage activities filled a gap in the storage portfolio.
- The issues and challenges related to attaining appropriate materials properties were well discussed and described. While there are no glaring gaps in the materials strategy, the upcoming funding opportunity announcement (FOA) may be able to address any small adjustments in the portfolio.

- Plans were identified for addressing issues and challenges both on a detailed and generalized scale: general motivation was provided in the "Goal and Objectives" slide followed by specific quantitative metrics, followed by strategies, then overviews of projects to address challenges, and finally how the discussed approaches would translate in a solution.
- The plans going forward were described to provide a general understanding; deeper plan descriptions are necessary within the specific project presentations.
- There is clearly a need to discover novel materials that could come closer to fulfilling all of the DOE targets. Increased focus on fundamental materials science within hydrogen-containing materials would be good. Liquid hydrogen is previously known to have low energy efficiency. It would be very interesting to obtain an estimate of the energy efficiency for the liquid cryopump technology, which allows the direct fueling of supercritical hydrogen.
- The HSECoE is facing serious challenges in the development of a prototype engineering system that meets or exceeds DOE targets. Those obstacles were not described in much detail in this presentation. Consequently, it is difficult to fully assess the status of the project/program. The ever-increasing complexity that seems to be accompanying the development of a prototype engineering system based on ammonia borane (AB) is especially disconcerting. In addition, efficient, cost-effective off-board regeneration of the AB system is highly problematic. If AB is going to serve as a surrogate material for prototype system development, it seems that a more careful examination of the many issues that impact the regeneration process must be considered.

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

- The Hydrogen Storage program area appears to be very focused, well managed, and effective.
- The program area is as focused and well managed as it ever has been. Every year, the focus on addressing DOE needs is improved.
- The program area is very well managed and is focused on critical technology issues. The DOE management team is doing an excellent job of interacting with all program participants and informing the technical community in a timely and straightforward way about the overall status of the program and upcoming funding thrusts and opportunities.
- The storage team continues to be very focused on the RD&D needs and goals of the program. The program area is well managed by the DOE Headquarters/Golden Field Office team, as is the tradition.
- The program area is compellingly focused, as is DOE's approach. The program is also well managed by a program manager and a team that is thinking critically, yet aimed at moving forward. The team comprises an effective leader and members who are experts in addressing DOE Hydrogen and Fuel Cell Program's needs.
- The Hydrogen Storage program area is well focused on achieving the program's targets, and it appears to be well managed. It is well balanced; however, the level of funding may not be sufficient to advance the technologies performance in a timely manner to achieve DOE targets.
- There has been a realignment with the inclusion of near-term niche markets, which are in the purview of the DOE Hydrogen and Fuel Cells Program and is an important addition for program continuity and success in reaching longer-term hydrogen storage goals.
- The program area clearly has strong and visible coordination and organization. The Hydrogen Storage program manager appears to stay in close contact with all programs and is a very competent leader. The speaker mentioned in his presentation that the ideal hydrogen storage material should meet 20 specific onboard storage targets defined by DOE, simultaneously, to meet the demands for a broad range of vehicles. This is clearly challenging. Therefore, it may be fruitful (as proposed in the *Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan*) to put some focus on the more "low-tech" approaches of high-pressure hydrogen gas storage. This is possibly the most focused and efficient research program dedicated toward hydrogen energy storage, worldwide. A major focus is technological and engineering aspects and improving known technology, but there is still room for some fundamental science research as well, which may provide completely new approaches for hydrogen storage and novel "long term" solutions.

4. Other Comments:

- The Hydrogen Storage program area is very focused on automobile applications and targets for automobile applications.
- The program manager is effective in fostering an encouraging yet sobering environment to present and discuss ongoing research with him and his team. Each team member appears to work independently but with common goals to help SBIR researchers remain focused on DOE metrics. The responsiveness of the program manager and his team supports constructive and iterative feedback.
- The attention to non-automotive applications is a welcome improvement. Real commercialization will see evolution of these technologies within both automotive and nonautomotive applications. DOE's focus on both is consistent with how technical products actually evolve in the marketplace, which can only benefit the overall storage improvements for both.
- During the course of a research program, it usually comes out that some materials or systems may not fulfill the defined targets. These materials or systems might still have potential for other applications but cannot be investigated any more. Such a program should leave 0%–20% of the budget to be spent in the second half of a project or program on promising materials or systems for spin-offs in order to increase the probability of finalizing developments for potential applications.
- High-pressure hydrogen gas storage (tank) has some advantages compared to known solid-state storage materials (e.g., fast refueling). It was suggested that perhaps materials may be developed that could be introduced into the storage tank and improve the volumetric storage density.
- In future reviews, it is suggested that all presenters be required to explicitly state the major problems and challenges in their specific approaches and then discuss a plan for mitigating those risks. Without that information, it is very difficult for the reviewers to fully understand the context in which the future plans are being formulated (it also forces the principal investigator [PI] and team to be brutally honest about the status of their project).
- In materials discovery programs of the future, ensuring the proposers have the equipment or will have the equipment in very short order to achieve their proposed goals needs to be closely examined. Two projects in the Storage program did not have the critical high-pressure characterization equipment in year-one to carry out the R&D proposed. Another project did not have the laboratory capability to study pressure reactions at a pressure relevant to DOE requirements after a two-year project. The results of the latter project are of little value to the Storage program. Good progress is being made in most projects, and the community in attendance at the DOE Hydrogen and Fuel Cells Annual Merit Review (AMR) was, in general, an attentive audience. Attendance was good, and those in attendance asked good questions indicating that the general level of interest is still high within the storage community. There are a few outlier projects that are struggling, but those are likely to be identified through the AMR peer review process. One project that will be perceived to be failing is indeed not likely to meet its goals. But the project is really a success, because it set out to validate a very unusual claim in the literature that, if true, could provide a breakout opportunity for hydrogen sorption. The PI on this project is very meticulous and well respected and cannot repeat the literature claims. This is highly valuable information for DOE to obtain, even if it is negative evidence, because now the community knows that this is a direction that does not need to be revisited. The PI is to be congratulated on his candor. The two post-doctoral programs appeared to result in an excellent multidisciplinary experience for the post doctorates. DOE should track their careers to examine its return on investment.

Fuel Cells Program Comments

1. Was the 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 program if appropriate.)

- Yes, the Fuel Cells program area was adequately covered, important issues and challenges were identified, and progress was clearly presented.
- The presentation was excellent. It gave a complete overview of past progress and what important challenges need to be addressed.
- Important issues were identified and progress was reported in a clear and concise way.
- The program area was well covered with a clear view of and approach for addressing the different challenges that need to be overcome. The template for each project presentation enables reviewers to understand the targets aimed for and evaluate the progress made. The program was well covered with a clear view and approach of the different challenges to overcome, in particular for the program presentation. The template enables, for each presentation, to evaluate with a clear positioning of the subject addressed, the target to reach and the progress made.
- There was a good overview and discussion of a few specific examples of technical progress. More comparison to the previous year would be interesting. More detail on the upcoming year would be useful, if possible.
- The main issues were covered well. There was a lot of emphasis on modeling and analysis and not much on research thrusts for the upcoming year, as is typically heard at this AMR meeting. Perhaps this is because DOE is in a period of transition as a new Secretary is being selected.
- The program area was well covered. The presentation was very well structured and combined messages of the approach and examples of detailed research very well. The presentation made the idea behind the program very clear. The progress was adequately presented as far as it is possible in such a short time frame.
- The presentation was well done and described the current fuel cell technology program well. The targets are totally clear, and the overall program is focused and well managed. The emphasis tends to be on the light duty automobile applications, but it was also clearly stated that other commercial applications are also moving onto the DOE screen.
- The presenter did an excellent job with a complex subject in a short period of time. The reviewer learned a lot and will distribute the presentation to his company. Important issues and priorities were well described for the past year. The presenter's knowledge and thoroughness were evident.
- The Fuel Cells program area was fairly accurately covered. The stated emphasis did not completely match the projects presented, with little or no membrane, membrane electrode assembly (MEA) integration, and balance of plant projects. Also, several of the catalyst projects seem to have overlapping scopes. With most projects ending in 2013, it will be a short fuel cell session next year. Also, cost projections are leveling off, with no clear path presented to bridge the gap.
- Yes, the program area was well covered, including the important issues and challenges. Progress in this area was not explicitly compared to where things stood in 2012, but the sweep of program progress was clearly presented.
- Basically, yes; but the current cost breakdown and technical scenario with a bar chart to achieve the future target should be shown in the slides, as was presented at the 2012 AMR. That can be quite helpful for the reviewers.

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

- Yes, plans were identified for addressing issues and challenges, and there are no gaps in the portfolio.
- The proposed plans are appropriate. The project portfolio and the budget allocation are adequate with the main cost drivers identified, particularly for the stack. Nevertheless, regarding the cost breakdown, a new focus on metallic bipolar plates may be needed because they represent the second highest cost component for high-volume production. Actually, developing durable stamped metallic bipolar plates (with a lifetime of more than 10,000 to 20,000 hours) might open the material handling equipment (MHE) market, or even

some stationary markets. This may then lead to manufacturing and operation feedback for R&D actions to overcome issues in automotive applications

- The focus areas have been identified; however, the details of the plans are vague.
- The present projects were explained and plans for these were clear. Plans for innovation were not dealt with. Perhaps this is because DOE is in a period of transition as a new Secretary is being selected.
- Forward funding is causing a temporary gap in the project portfolio's robustness.
- Several projects need to have the roles reversed, with industrial partners taking the lead and the national laboratories providing the needed resources, as R&D developments transition into actual products and systems.
- Plans were properly addressed. One possible gap is that more attention needs to be given to problems that are appearing at high current density in hydrogen/air at low platinum loadings. Better fundamental understanding of possible interfacial oxygen transport problems may be needed to allow the progress that has been made in increasing kinetic oxygen reduction reaction (ORR) activity with lower platinum loadings to be realized in practical fuel cells.
- The Fuel Cells program area does an exceptional job; however, there are constant challenges that arise due to funding limitations and changes in priority. Currently, the projects on membranes have largely been completed but underrepresented in the portfolio; further materials advances could be beneficial. Work in portable power, while not a significant part of the current portfolio, is not particularly valuable and could be even further de-emphasized.
- The presentation described plans for addressing issues and challenges well. One gap is the reduced focus on transportation. Other than batteries, fuel cells can provide propulsion for vehicles on a basis that is very similar to today's convenience and flexibility. It is recommended to sharpen the focus on transportation, especially on propulsion of vehicles.
- Some of the biggest challenges are not even listed and were not addressed at all in the future plans. One of the biggest gaps was between the status and the target in the thermal heat rejection (Q/delta T) requirement. This was not highlighted as an issue and no projects are specifically addressing it. New materials for stacks and humidifiers will be required to achieve this. Cost projections, for the third straight year, are based on nanostructured thin film (NSTF), which is an extremely risky technology. Also, addressing the challenge of high current density performance of low-loaded electrodes requires a much greater focus. There are also major gaps with a complete lack of membrane, gas diffusion layer, plate, and seal projects. The challenge remains: encouraging automotive original equipment manufacturers to market technology in direct competition with their present commercial base. In other places, Japan, for example, the government facilitates such a transfer. For instance, Osaka Gas, a huge utility, sells both natural gas and "appliances" that burn natural gas (e.g., water heaters). It was natural to add a new appliance, a combined heat and power (CHP) fuel cell system, to that market. The program might search for similar opportunities in the United States. Fuel cells have admirable low emissions. The evidence about particulate matter/human health is overwhelming. It seems like a strong emphasis on "clean air now" might add strength to the fuel cell technology message [cancer and heart disease costs hundreds of billions each year] -- fuel cells in urban environments are game changers.

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

- Yes, the Fuel Cells program area is focused, well managed, and effective in addressing the DOE Hydrogen and Fuel Cells Program's needs.
- This program area is very well focused, well managed, and effective compared to other government programs. The program manager clearly has a good sense of where the value points are and how to spend the taxpayers' money most efficiently.
- Yes to all; this program is a role model for DOE.
- The program area is very well managed. The high technical competence of the DOE project officers is key to this success.
- The entire activity is exceptionally focused and driven by targets. The management team is fully functional and exceptional as well.
- The program area appears to be well focused, well managed, and effective in addressing the Hydrogen and Fuel Cells Program's needs. However, some points may be addressed:

  - MEA studies appear too focused on the same manufacturer. A potential risk is that not all of the associated project outcomes will be applicable for other types of MEA production.
  - System modeling is done well, but stack data used for performance and near-future durability are actually only single-cell data. This may have an impact on the results' accuracy. Therefore, some single cell/stack data comparison will be welcome.
- The program area manages its existing project portfolio well. However, it seems that little vision is applied to the innovation that will be needed to meet the DOE Hydrogen and Fuel Cell Program's needs. The Program did some reaching out to stakeholders for inputs on future areas of R&D needs, which is good.
- The program area is fairly well focused. Many of the less productive and poorly managed projects from last year have been cancelled, which is very encouraging. Most remaining projects have proven valuable or still have the potential to provide value.
- Because many systems are hybridized with batteries, it could be interesting to introduce this hybridization into the system modeling. Actually, the system control balance will significantly impact either the fuel cell system's durability or the global system's efficiency. Many of the projects are at the point where they need critical evaluation as to their potential for commercialization. If ready, the projects should be turned over to industrial partners; if not, a decision should be made to further develop or drop the project.
- There is room to improve the management of the Annual Merit Review. Many project presentation files about the programs seem to have almost the same slides as those of previous year, depending on the programs. If you instruct the PI to show what is updated/changed compared with the previous year, then it would be easier to understand and review the programs.
- The program area is not adequately focused; the ratio of money spent does not seem to proportionally match the focus areas. Further, new projects are being funded using proposals submitted three years ago, and new learnings in areas such as membrane durability and system mitigation for start-stop means that projects on improving membrane and carbon support durability are irrelevant.

4. Other Comments:

- The DOE Hydrogen and Fuel Cells Program has helped accelerate progress in automotive fuel cell technology significantly over the last decade.
- The Fuel Cells program area has exhibited typically fine performance over the past year.
- This was a good, concise summary of a good program.
- A new "scorecard" may be useful, detailing DOE fuel cell projects that have enabled commercialized products.
- Overall, this is a tough job at this time. It seems that a lot of projects are wrapping up, and the next steps are not clear. Hopefully new solicitations and finalizing the selection of DOE's top leadership at the top of DOE will get things back on track.
- The unaddressed issue is that, despite all the progress of the Fuel Cell program area, DOE seems to be ignoring the fact that the cost projections are becoming asymptotic at about $45/kW and there are not any projects on the horizon to bridge the gap to $30/kW. New step-out ideas and funding are needed to keep the momentum going.
- As shown on slides 4 and 5, given that catalyst costs are 46% of the cost of making a polymer electrolyte membrane (PEM) fuel cell stack at a production rate of 500,000 units per year, it is imperative that DOE continue fundamental work in catalyst development. The promise afforded by the 3M roll-to-roll processing technique will set the stage for the next generation of high-performance, low-cost catalysts. The Ni_7Pt_3-NSTF materials show what promise can be realized by a first-principles materials design approach. The outstanding kinetics of the Ni_7Pt_3 alloy are unfortunately combined with a nickel-dissolution rate that will prevent them from being deployed on a large scale. The advantage of the 3M approach is that complex multicomponent alloys can be synthesized in a large-scale commercial setting. This technique can be applied to non-NSTF high-surface-area supports. Advanced alloys with high ORR kinetics and low-platinum loadings and that are also stable in acid electrolytes have been developed by the Jet Propulsion Laboratory, and these new alloy classes could set a new paradigm for future fuel cell catalysts. None of these achievements would have been made possible without the DOE Office of Energy Efficiency and Renewable Energy (EERE) funding targeted to catalyst development. Therefore, it is hoped that DOE will continue to support this area, either in the EERE or the DOE Basic Science offices, because these new materials are key to the future.

- The fuel cell activity is now approaching a transition between development and commercialization. Most R&D money in the private sector is spent in the commercialization phase; however, much of that R&D is typically proprietary. Getting the correct balance in a public R&D program is challenging, but doable. The Fuel Cell program team needs to think more about market creation. Right now, some of the Japanese and Korean combined heat and power (CHP) units should be evaluated in U.S. laboratories. The question should be, "Given these 'components,' how can such hardware be integrated into a new system?" For example, given a clean sheet of paper, what would a house look like with a CHP system? How would you manage a group of CHP-deployed houses to form a mini-grid? And so on, with all other commercialization opportunities.

Manufacturing R&D Program Comments

1. Was the 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 program if appropriate.)

   - Yes, the Manufacturing R&D program area was adequately covered. However, it is unclear if the key issues have been identified yet.
   - The program area was well described. Prior successes were also described, helping attendees to appreciate the program's value.

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

   - It was helpful to learn about the Manufacturing R&D program area's funding opportunity announcement (FOA) and the Clean Energy Manufacturing Initiative. The future plans were clear.

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

   - Yes, the program appears to be focused, well managed, and effective.
   - The objective of the Manufacturing R&D program area should focus on manufacturing cost, enabling the design of choice, and reducing the cost of producing the design.

4. Other Comments:

   - The funding should focus on alternate manufacturing and quality control techniques that lower the cost of producing any design of choice.
   - DOE should consider the addition of support for improved design for manufacture and assembly (DFMA) that is directly relevant to PEM and SOFC fuel cell stacks and advanced stack assembly methods. Hopefully the FY 2014 appropriation will be the same as the DOE request.

Technology Validation Program Comments

1. Was the 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 program if appropriate.)

- The Technology Validation program area was adequately covered, important issues and challenges were identified, and progress was clearly presented.
- The program area was well presented and complete. The structure of the Fuel Cell Technologies Office, as shown on slide 2, can be readily understood and the placement of the program within the Office is clear. Slide 3, in combination with the rest of the program manager's presentation, provided a succinct summary of the program's goal to assess technologies and provide feedback for the benefit of other DOE Hydrogen and Fuel Cells Program areas. Slides 6–11 provided an excellent summary of progress and set the stage well for the individual project reviews. It is unclear whether the specific objectives listed on slide 3 comprise all of those associated with the program or whether they are a selected subset; that should be clarified in the slides and/or oral presentation. Some of the equipment included in the program (e.g., buses, MHE, and backup power) is not reflected in the objectives cited. On slide 4, another challenge could be: "Determining priorities for expenditure of Technology Validation program resources."

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

- Yes, plans were identified for addressing issues and challenges. No, there are no gaps in the portfolio.
- The bulk of fiscal year (FY) 2014 Technology Validation program resources will evidently be for projects resulting from proposals submitted in response to an upcoming funding opportunity announcement (FOA). Given the topics identified on slide 12, it appears that ongoing "core" program activities, such as data collection on light-duty-vehicle and bus performance, will continue with FY 2013 funds, however, this was not (to this reviewer's knowledge) stated directly during the program manager's oral presentation. Reviewers should be assured that new topics planned for the portfolio, such as fuel cell hybrid-electric medium-duty trucks and rooftop installations of fuel cell backup power systems, will not be initiated at the expense of continual support for "core" program activities.
- One Technology Validation program goal is to demonstrate 50,000 hour life of 100 kW–3 MW stationary fuel cell systems, but that would take 5.7 years of continuous testing, and it is unclear if there is any evidence that such a test has even been planned for such large fuel cell systems, let alone started. Fuel cell auxiliary power unit durability is 15,000 hours or 1.7 years; again, there was no indication that such a test has been planned. In some circumstances, one can propose accelerated life testing, such as increasing the repetition rate of equipment that must be cycled on and off or increasing the radiation striking a photovoltaic panel, for example. No means of conducting accelerated life testing of fuel cell systems was presented.

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

- The Technology Validation program area appears to be well focused, well managed, and effective.
- Overall, the program area is important and well managed. Its partnership with, and dependence on, the National Renewable Energy Laboratory's (NREL's) outstanding data collection/analysis team is key to the success of its efforts and to achieving its goals and objectives. The line of demarcation between the Technology Validation and Market Transformation programs is not completely clear. A case could be made that the H2Pump project, with eight demonstration systems, is within the purview of the Market Transformation program area. The planned funding opportunity announcement (FOA) topics include demonstrations. (Given that, both demonstrations and data validation of the demonstration project(s) results are important and need to be closely linked.)
- For the most part, yes. However, two other fueling station components need attention. Certainly, compressors should be a top priority, given their high failure rate. The Technology Validation program should consider the development of gas pre-cooling refrigeration systems for 700 bar dispensing; current refrigeration systems are too costly, which could impede early market introduction. Similarly, hydrogen

dispensers are too expensive, and the program should consider the development of low-cost 700 bar dispensers, including the development of durable and accurate flow meters.

4. Other Comments:

- Future Technology Validation program overview presentations should include a brief statement on how decisions are made regarding projects to be funded by the program. For example, it would be helpful to have some insight into the merits of the H2Pump project and rooftop installations of fuel cell backup power systems, relative to other opportunities. One guess is that the total amount of hydrogen that can potentially be produced by H2Pump's technology is small compared to current hydrogen demand—and very small relative to demand in a "hydrogen economy." If the analysis of its potential has not been done, it should be considered for inclusion in the Systems Analysis program and accomplished before more funds are committed to hydrogen recycling projects. DOE's funding decisions should reflect analysis that identifies technologies capable of providing a significant portion of the demand for hydrogen and that address a robust market for fuel cells.
- The electrochemical pump program should be redirected. The current focus on recovering hydrogen from metal annealing furnaces is a niche market that will not advance the Hydrogen and Fuel Cell Program's mission of expediting the commercialization of fuel cell electric vehicles (FCEVs) and stationary fuel cells. The recovered hydrogen is needed in the annealing furnace and cannot be used as a fuel for FCEVs, for example. Instead of capturing hydrogen from furnace exhausts, the program should be redirected to developing an inexpensive electrochemical hydrogen compressor to replace mechanical compressors, with twin goals of lower capital cost and vastly improved durability and low maintenance.

Safety, Codes and Standards Program Comments

1. Was the 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 program if appropriate.)

- Yes, the Safety, Codes and Standards (SCS) program area was adequately covered, important issues and challenges were identified, and progress was clearly presented.
- Coverage of the SCS program area was very good. The range of projects discussed was consistent with the program and the projects to be discussed later. The presenter discussed the issues and challenges and described how these were being addressed in the research and other ongoing projects. Progress was described well, including standards approved, training materials and coverage, and lessons learned. Also described well were the research results and how they were being fed into the regulations, codes, and standards activities and disseminated to the public and other users. The new "app" for Apple products is very exciting, as are plans to expand the app to other applications.
- While some issues and challenges were identified and progress was clearly presented in comparison to the previous year (e.g., progress related to safety [jets and flames, emergency response training, information products, etc.]), there are key issues that do not appear to be a priority with DOE.
- No. There were statements made by some of the presenters that were challenged by the audience. There is still so much that needs to be completed before one can truly state that risk can be identified and quantified. The first round of standards has been published and some realistic preliminary economic targets have been established. Product and system innovation will now follow to meet the commercial requirements that are being set forth by industry. Funding and support is now critical to ensure that industry takes on the risk and starts investing in this market space. The plan to manage this transition (hand off) was not clearly articulated.

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

- The program plans seem very well thought out, with much work this year focused on developing data and tools that will address known issues and challenges. Meetings and webinars that targeted specific issues, such as hydrogen fueling protocols and materials issues, were also developed and conducted. The program is always seeking feedback to identify gaps as they are discovered and to begin to address them. It may be worthwhile to consider revisiting the national template and international template to update and validate future plans that meet the anticipated priorities of industry and other stakeholders.
- While the overview presentation stated that the execution of high-priority R&D is a necessary and integral part of the SCS activity, the topics for future R&D work and the approach that will be taken for implementing this R&D are not identified.
- There are limited plans. There seems to be a disconnect in what DOE is doing to support the hydrogen industry in the transition period. Hydrogen as a transportation solution is very much still driven by DOE funding. If funding were to be stopped, hydrogen would not go forward in the United States. The hydrogen champions that were critical in driving the industry are now passing the batons to the next group. This group is not driven by the same passion and search for technological solutions, but rather by finding commercial solutions that can leverage the benefits of hydrogen as a fuel. The current commercial environment is not supportive of hydrogen when compared to other fuels, such as compressed natural gas and electricity. DOE needs to better realize and develop plans to support a hydrogen transition. Outreach and support to teach and help quantify and mitigate the commercial risk is most important. The signal of reduced DOE funding for the Hydrogen and Fuel Cells Program (the Program) has had a large, negative impact in the private sector. As a result, it seems that the hydrogen economy is always looming on the horizon, but only after another technical hurdle is overcome. There are still many technical showstoppers that this industry must tackle before it will be ready for the mass public: achieving accurate fuel metering, achieving component reliability, managing thermal issues, developing low-cost materials that are compatible with long-term hydrogen exposure at in-service conditions, and developing new and novel fueling station designs that are cost effective and allow infrastructure to be profitable. These are examples of issues that still need to be resolved and need to be tackled by a joint public-private enterprise. A reduction in funding for the Program drives the private sector to question the viability of this fuel as an alternative when placed beside the others, such as natural gas vehicles, electric vehicles, biofuels, etc.

- The planning on the slides for the SCS program area ended in 2012; this is very shortsighted. Yes, there were some big issues not covered in the presentation:
  - Through California Senate Bill (SB) 76, SAE J2719 has become law in California. The detection limits can be measured by expensive laboratories; however, since the standards for detection are not complete there are inadequate appropriate testing means. Though the priorities regarding the testing of single cells to appropriate loadings, CO detection, are important, they are not even close to the importance of finishing the detection methods.
  - Field Testing: (continuation of laboratory tests) Fueling standards should be further validated at a designated development station to show the positives and negatives (for instance SAE J2601 versus the MC Method, etc.). This station could also be a basis for metering and hydrogen quality testing.
  - Regarding CSA standards on dispenser components, the hose, breakaway, and connectors standards have not *been tested before becoming ANSI approved*; this should be investigated with data.
  - SAE J2578 /J2579 need data to be validated. Topics like stress rupture are inadequately covered in those documents.
  - Setback distances need to be aligned between the ISO and SAE world. This should be a coordinated data effort with the Japanese and European Union (EU) counterparts.
  - The hydrogen sensor work is obsolete because the industry has solutions in its production vehicles and stations. This project should be halted.
  - Hydrogen metering: Hydrogen metering is being evaluated through the National Renewable Energy Laboratory (NREL), and there is already an additional funding opportunity announcement (FOA) to investigate this. However, there needs to be a follow-on project that incorporates testing flow meters not only in the laboratory, but also in the field until a commercially acceptable flow meter is found to get within 2% accuracy.

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

- Yes, the SCS program area appears to be well considered, with regular feedback mechanisms to remain effective. Despite personnel changes, the program remains well managed.
- Yes. In particular, there are two major strong points in the SCS program area: (1) the direct interaction of researchers in the program with standards development organizations is very useful and highly contributes to the effectiveness of the program and (2) the active dissemination and outreach to ensure access to safety-relevant information for other stakeholders (authorities having jurisdiction) and the wider public.
- The program area has been able to achieve very strong results with limited funding. The management team should be commended for its courage in prioritizing research and cutting the projects that are less essential. The only challenge is that the program funding continues to drop and, as a result, its ability to benefit society is threatened. More focus on outreach is needed or all of the good that is being achieved with the Program's funding will never be realized.
- The program area is well focused and well managed, but not effective in meeting their previous goals for the DOE Hydrogen and Fuel Cells Program. However, lack of input from industry on the latest needs illustrates a large gap (as outlined in the response to Question 2) and should be addressed to facilitate the commercialization of fuel cell electric vehicles and hydrogen infrastructure.

4. Other Comments:

- The importance of the international efforts is clear in the SCS program presentation, but this is less clear in presentations of the overall Hydrogen and Fuel Cells Program or in many of the project activities funded by the SCS program area. It is unclear if internal communications could be improved on this point.
- Suggestions: create a "Near-Term R&D Needs" list for codes and standards by canvassing industry members at ASTM/CSA/SAE needs, etc. to develop a roadmap; be a part of "accelerating key" industry codes and standards; and delete all hydrogen sensor work—this is not valuable to the industry at all.
- Parts of the underpinning research for the SCS work are carried out in a number of national laboratories. It may be worthwhile to try to better exploit synergies with non-U.S. activities (e.g., EU, Japan) when performing this R&D. It may be useful to identify a number of performance indicators (metrics of success) with associated targets and propose evaluators to assess the degree of achievement of these targets during the review.

Market Transformation Program Comments

1. Was the 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 program if appropriate.)

   - Yes, the Market Transformation program area was adequately covered, important issues and challenges were identified, and progress was clearly presented.
   - The program manager did a great job in his presentation.
   - Given the time allowed and the purpose, the presentation and material delivered were just about right. It might be worthwhile to explore some ways to better show how targets have trended over time. For instance, one could plot the increasing deployment of material handling equipment (MHE) funded by DOE, and then because that is virtually complete, reflect how that has spurred and helped catalyze the market and show how commercial deployment has progressed during and after those DOE-funded deployments. It would be helpful to capture how the activity in the program has supported the broader and more robust introduction in the marketplace. It is unclear whether that type of metric clearly comes through.

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

   - It looks like there is a "road map" for leveraging program resources for the next 4–6 years. One would think one of the major challenges that fuel cells must address over the next few years is keeping pace with battery improvements, so being agile in study and demonstration may be essential over that time frame.
   - It would be good to see significantly more resources allocated for the Market Transformation program area. It is time to get serious about this.
   - No, plans for addressing issues and challenges were not adequately addressed.

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

   - Yes, the Market Transformation program area appears to be focused, well managed, and effective.

4. Other Comments:

   - There is a good variety of projects with strong, important markets.
   - In addition to providing trending charts, as suggested in Question 1, it is recommended that some "market" metrics be introduced or discussed in the program overview or for each project. For instance, for micro-CHP, if the potential market is small commercial buildings, it should be defined what the characteristics of the buildings are, how many are located around the country, how much energy they use, etc. One would think that these types of metrics would help define priorities for the R&D and investment.

Systems Analysis Program Comments

1. Was the 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 program if appropriate.)

   - Yes, the Systems Analysis program area was adequately covered, important issues and challenges were identified, and progress was clearly presented.
   - Yes, however some interesting projects from last year were not reviewed. Evaluation of the Systems Analysis program area is best done across multiple years, given the broad portfolio of topics.
   - There was a good summary of overall objectives and plans to implement the Assistant Secretary's new initiative, H2USA.

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

   - Yes, plans for addressing issues and challenges were identified.
   - Yes, plans and gaps were identified and addressed. The issue of funding continues to be a concern.
   - A good adjustment in parameters was made within models to address fast-changing resource availability and costs, as well as consumer demand.
   - A greater emphasis on near-term market barriers is warranted, given the status of fuel cell vehicles and the challenges with infrastructure deployment. A major gap is the lack of analysis of policy options to incentivize actors and finance infrastructure, but it appears that future work on H2USA may address this need.

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

   - Yes, the Systems Analysis program area appears to be focused, well managed, and effective.
   - Yes, the program area appears to be focused, well managed, and effective. The manager is articulate and clear in his presentation of the program.
   - Interactions between types of analysis and applications were illustrated with examples. There were good flowcharts to describe the process. The main focus is on analysis rather than model development.
   - Yes, except for the gap of near-term market focus.

4. Other Comments:

   - The Systems Analysis program area has moved logically from model development to model use to producing analysis for prime clients (other Fuel Cells Technologies Office programs and upper DOE management, as well as other stakeholders).
   - The program should continually be assessed for direction and effectiveness if supply chain, manufacturing, and export of product become priority areas.