APPENDIX B: SUBPROGRAM COMMENTS PROVIDED BY REVIEWERS

Production and Delivery Subprogram Comments

Hydrogen Production Element

1. **Was the Subprogram 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 Subprogram if appropriate.)**

- Yes, the broad goals of the program, as well as quantitative targets, were discussed. Critical issues and challenges were specifically identified for each of the key production approaches being pursued in this program. Progress for each of the production approaches relative to last year was clearly addressed.
- The program was adequately covered. All programs were mentioned, but there was only intermittent mention of primary contributors. Consistency in attribution of programs should be adhered to.
- The progress was adequately covered; however, the challenges—specifically with regard to cost targets and market barriers, equipment reliability, and the tie-in with the infrastructure validation program were not discussed.
- The subprogram was covered well.
- Some progress was highlighted, but it is difficult to tell how close the future technologies are to cost targets.
- Hydrogen production was covered OK. There was too little emphasis on coal, natural gas, and wood; there was too much emphasis on ethanol and other high-cost, low-value offerings (nuclear heat, in particular). It was nice to see some compressor work. It is very important, and there could be more. There was little emphasis on competitive costs, life cycle (durability), and purity needs. These points would have helped us see progress from the standpoint of where we want to go, not only from the point of what was done.
- Would have liked to have a good talk on the zeroing out of the mobile hydrogen program. It's awfully relevant to all those here.
- Good summary presentation. Key issues were identified and progress was delineated. Some targets were more qualitative than quantitative.
- The Hydrogen Production Subprogram was adequately presented considering the limited time available. The scope of the subprogram (i.e., various aspects from budgetary to technical) and relevant information were nicely illustrated and were very informative.
- The subprogram area was adequately covered and progress was clearly presented given the time frame of the presentation. I particularly appreciated the fact that the subprogram's manager referred to DOE's zero request for FY 2010 (which not all managers did in their presentations).
- The subprogram area was thoroughly covered, and all important issues and challenges were identified. Progress against the previous year was discussed.
- The subprogram was adequately covered during the review. Gaps were clearly identified and progress was highlighted.
- The subprogram needs to present a specific/numeric [progress towards multi-year program plan (MYPP) targets] chart showing year-by-year progress.
- The Hydrogen Production kick-off session provided a clear and concise overview of its challenges, direction, and accomplishments.
- Yes to all. The team leader covered highlights of the 2009 program accomplishments and covered 2009 budget in the context of 2008 and 2010 proposals.
- Yes. The rationale of 2010 was explained well.

- Yes, the subprogram area was adequately covered and challenges and barriers of respective areas were identified. The presentation also addressed progress highlights of selective projects compared to the previous year.
- The subprogram was well presented in the overview presentation, giving an update on the status of research in each area of hydrogen production. Progress compared with last year was strong considering the 80% budget cut.
- The subprogram area was broken down into past accomplishes, budget, and successes. The subprogram area was adequately covered with important issues and challenges identified. Progress was clearly presented in comparison to past years.
- Important issue: The FY 2010 budget is set at zero for production and delivery of hydrogen. This is based on a balanced budget and the fact that DOE sees the plug-in hybrids as a near-term solution.
- Challenges: Capital cost for hydrogen production is a critical barrier, and the next cost targets are set at $2-3/kg.
- A very good overview was given of the Hydrogen Production Subprogram.
- Goals were clear and highlights were clearly presented:
- The presentation was a good overall review of the Hydrogen Production Subprogram.
- The important issues and challenges for the various options for hydrogen production were clearly and concisely presented.
- The presentation included a very good overview of the progress of the subprogram in terms of technical achievements and advancements. However, it was not apparent how these technical achievements were moving these production technologies towards the overall cost goal of $2-3/kg for delivered hydrogen.
- Several important processes were not discussed; however, presentation time was insufficient to permit comprehensive presentation of all the important work in the subprogram. Progress in thermochemical production did not address well-reviewed cost estimates, some of which seem competitive with other production processes. Comparison of progress with previous year's work was limited to only a few of the many processes. For example, no mention of the Integrated Lab Scale testing of the nuclear-driven sulfur-iodine cycle was mentioned. Furthermore, no mention of cross-agency collaboration between nuclear and solar thermochemical work was evident, missing an important element of this work in contrast to many DOE stove-piped activities.
- The subprogram on hydrogen production was presented and outlined. The presentation focused on past research accomplishments and on the budgetary plans of DOE's Offices of Energy Efficiency & Renewable Energy (EERE), Fossil Energy (FE), and Nuclear Energy (NE) for the near future. The goal of $2-3/gge was mentioned, but it was not clear from the presentation what production means have the most promise to achieve it. It was mentioned that DOE recommended zero participation from NE and EERE programs for FY 2010, but there was no justification given on why such a decision was reached. In other words, there were no underlying technical reasons listed for the non-participation of these specific components of DOE over the next year. It was mentioned that biofuels were to continue to be explored, but it was not clear why. This reviewer believes that biofuels is an approach that has no traction within the citizenry as a long-term solution. In addition, it is an approach not given very high marks by the National Research Council review of the Hydrogen Program.
- "Yes" to all questions.
- Yes, within the allotted time, the subprogram area was adequately covered. Not enough information was presented with regard to the important issues and challenges that still remain and need resolution. This may be due to the fact that each component of the subprogram area was covered extensively at regular meetings that take place in the course of the year. However, it would be nice to provide a detailed matrix showing progress made in each project, from year to year, and DOE's programmatic targets. It would be nice to have all hydrogen production and

delivery technologies rated using the same yardstick. For example, slides 8 and 9, give a very wide range of hydrogen production costs for photoelectrochemical (PEC)- and polyborazylene (PB)-based technologies?! While at the same time, no estimated cost figures are given for other technologies.

- Given the short amount of time for the presenter, the subprogram was covered succinctly and in sufficient detail.
- This presentation also should have been 30 minutes long. The subprogram could not be adequately covered in 15 minutes. Hence, important issues were only briefly covered, which left more questions than answers. For example, I would have liked to have seen more side-by-side comparisons among the various hydrogen production technologies. Also, no time was left to ask questions.
- The subprogram area was adequately covered. Important issues and challenges were identified, and progress was clearly presented and highlighted.

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

- The current portfolio addresses the major issues and challenges.
- No technology gaps were mentioned and no plans defined to meet these challenges.
- The state of the art and the contrast with the actual field data need to be improved.
- In view of program termination or lack of 2010 budget, what are the plans to capture and consolidate the lessons learned, if any?
- The program has both near-term technologies and longer-term technologies covered. Emphasis for longer-term production should be on renewable hydrogen production.
- Electrolysis is focused on low-temperature technologies; however both low-temperature and high-temperature electrolysis technologies should be covered.
- There were some gaps, I thought, in particular when considering the customer for hydrogen. There was no sense that cost or convenience was an issue. Rather, there was an emphasis on meeting various targets despite that some approaches probably would not find real-world customers, even if they worked.
- Plans were identified. No large gaps were identified.
- It appears that several major issues and challenges regarding the Hydrogen Production Subprogram have been identified, and the DOE-funded projects presented here, reflect the diversity of the approaches.
- Technical barriers and plans for addressing the barriers were correctly identified.
- Issues and challenges were fully identified, and there were no gaps in the project portfolio.
- A gap resolution plan was identified through various technology pathways. There are gaps in the project portfolio but it is possible that funding limitations would not allow adequate coverage. Portfolio gaps include more focus on delivery of feedstock to the forecourt and focus on hydrogen quality/purity.
- The largest gap moving forward is our inability to produce near-zero, carbon-emitting hydrogen.
- Are plans identified for addressing issues and challenges? Plans are not mentioned in the subprogram presentation.
- Are there gaps in the project portfolio?
- By-product hydrogen is not mentioned in the subprogram presentation. Is it only covered as a "delivery item"?
- Coal without carbon capture and sequestration (CCS) is not explicitly mentioned in the longer-term goals.

- The presenter did not discuss plans, but >90% of projects did. The plans broadly address issues, but frequently lack focus on the key information needs for the present state of the technology.
- In terms of portfolio, two gaps among the areas I reviewed are as follows:
    - The delivered hydrogen cost target is $3/kg (which is already high), but many solar nuclear programs are allowed to target much higher cost by using the same value without adding in delivery.
    - Making hydrogen fuel from an already useable liquid fuel (e.g., ethanol) has limited incentive.
- Good summary was provided of various technologies being developed under the DOE umbrella.
- Yes, plans were identified for addressing issues, challenges, and technical barriers, which at present, constitute advances needed for the success of the project. There are no gaps in the project portfolio.
- Given the current budget, there are no plans to address the challenge of hydrogen production in a hydrogen economy. The only gap in the project portfolio is funding to address the gaps already identified.
- The biggest issue is that the funds for delivery are being reduced. However, Congress appears set to re-establish the budget at the requested rate. This year, they plan to down-select a single nuclear technology to scale up. The program designed to produce hydrogen from the hydrogen generation module (HGM) is focused on E-85. However, the availability of E-85 is not sustainable in today's market. E-20 to E-30 maybe more realistic to obtain.
- Very good and clear description of production issues and challenges, both for near-term and long-term technologies.
- With a zero budget, plans are obviously not there.
- The plan is focused solely on distributed production for the transition. There are people in the hydrogen community, including Energy and Industrial Gas companies who believe that semi-central production, or taking some hydrogen off existing and expanding production units at or near a city gate combined with tube trailer (or liquid) hydrogen delivery, presents an “as good” or better approach for the transition to hydrogen fuel cell vehicles. This line of thinking and appropriate associated research should be added to the DOE Hydrogen Production Subprogram.
- There was very little discussion about the future of the Hydrogen Production Subprogram relative to the very small FY 2009 budget and $0 request for FY 2010. The remaining un-obligated and un-costed funding could have been discussed. It was stated that DOE’s Office of Basic Energy Sciences (BES) had $50M that would be used toward research that could benefit hydrogen production. There were no slides on what research was being done by BES to support this statement.
- Plans were not presented in light of the DOE decision to terminate this activity.
- Yes, the Delivery Subprogram team leader cited the key items for work on delivery. Pipelines, compression, and storage are several of these key areas.
- The program seems to have identified natural gas reformation, renewable liquid reformation, and electrolysis as the most attainable production means for the near future and a number of other means such as biomass gasification, solar, nuclear, etc. as long-term plans. It was identified that the hydrogen-from-coal approach is capable of achieving the 2010 target and that electrolysis is also approaching the relevant target. However, no specifics were given with regard to the specific challenges and directions that need to be followed. The results of the various approaches were not compared, and a message to take home with regard to what can be achieved in the near future was not given.
- Yes.
- This is a difficult question. No doubt, DOE has spent considerable time and effort to identify challenges and issues that need to be addressed in each project activity of the subprogram areas. However, it is not obvious how one compares hydrogen production and delivery costs in one

technology area that is renewable to another that utilizes non-renewable resources (e.g., coal). Likewise, how can you really compare hydrogen production by solar to hydrogen production based on nuclear energy use. The choice of the resource affects the choice of technology for generating hydrogen. One major gap in the project portfolio is complete lack of accounting of greenhouse gas production in each technology area. Another gap is the apparent DOE decoupling of technologies' hydrogen production costs from their efficiency.

- Reformation should still be included in the program for the future (if funded again). While there are a couple of commercial, small-scale reformers on the market, there is still research to be conducted in controls systems, catalyst development, and multiple fuels capabilities.
- Again, due to the time limitation, it was unclear if plans are in place to address issues and challenges. One potential gap is the apparent rush to downselect technologies. It's one thing to cancel funding for technologies that are not meeting milestones, but it is shortsighted to downselect among technologies that are meeting milestones.
- Yes, plans are well identified. There are no gaps in the project portfolio.

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

- Yes. There is no clear near- or long-term technical solution to hydrogen production, and this program provides a well-balanced portfolio to aggressively pursue the most promising avenues for each of the production approaches to enable meeting the DOE targets.
- The subprogram spans three DOE offices: EERE, NE and FE. This is a wide-ranging effort, requiring extensive coordination across DOE and its contractors. Good coordination of efforts was presented, and objectives and results were clearly defined.
- The subprogram could improve by changing focus, sharpening the need for the termination phase, capturing the lessons learned, and developing a path forward.
- The subprogram is focused on hydrogen production. It covers a span of technologies for hydrogen production, both in the near term and long term. It is premature to focus the subprogram further, especially as concerned with hydrogen production from renewables.
- Focus on hydrogen is less broad than for most meetings. This was a good-sized meeting with a good variety and appropriate length.
- The subprogram is highly focused, yet it presents several viable options. The current pivot in DOE's Hydrogen Program direction could impact progress and meeting needs.
- The subprogram on Hydrogen Production is well managed with a number of very good projects on relevant key areas and for addressing the R&D needs of hydrogen production. The progress reported for these projects is substantial.
- The subprogram area is well focused and managed, given the constraints of the Hydrogen Program.
- The subprogram area is well focused, well managed, and apparently effective in addressing DOE Hydrogen Program R&D needs.
- It is quite well focused, covering most of the important pathways, and it is indeed well managed. Focused execution of the subprogram plans should lead to good results and address the R&D goals.
- The hydrogen production team has a strong work ethic and management style. The challenges to reduce the cost of sustainable hydrogen production are significant. The production team effectively manages a wide spectrum of production technologies and implementation timeframes.
- Yes, it does.
- The subprogram itself is divided into several sub-subprograms (e.g., biological hydrogen or solar thermochemical). As a whole, these sub-subprograms are fairly well focused on their appropriate critical issues, which may differ from one to the next. Some have defined flow sheets, and are

doing proof-of-concept experiments and economic analysis; some are much longer term and are engaging in knowledge-build activities. By and large, it is a reasonably well-managed portfolio.

- The team leader is doing a good job managing the subprogram. However, in 2009, hydrogen production was zeroed out. Some work continued with carry-over funds, and DOE supported further effort. However, this question is no longer relevant. In 2010, there is no Hydrogen Program. The go-stop pattern associated with government-sponsored research is not productive. The subprogram area is focused and well-managed. Provided all the research subjects were adequately funded, it will overcome the technical barriers and meet the technical targets according to the DOE MYPP and the DOE Hydrogen Program R&D goals.
- The subprogram is extremely well focused and managed. This last year, they did quite a bit with next to nothing.
- It appears that the subprogram is on target to meet its goals and objectives.
- The subprogram appears to be very well focused and well managed, with a strong portfolio of diverse near- and long-term pathways.
- The subprogram has done well with minimal resources.
- The program does appear to be well managed in terms of using the available funding for projects that address the critical issues to reduce the cost of hydrogen production from a wide variety of clean, domestically resourced production pathways.
- It is not clear why so much funding is going into coal gasification in FY 2009 ($25M) while little went to the EERE Hydrogen Production efforts ($10M). Coal gasification hydrogen production is fairly well understood. The key to this approach is being able to sequester the carbon. Carbon sequestration is funded independently. There is a great deal of research needed for the production options being researched by EERE, as clearly stated in the presentation.
- The Production and Delivery Subprogram has engaged most of the management and decision tools essential to effective progress to meet established goals. Inherent in the subprogram, however, are necessary R&D investments to permit decisions that would better focus resources to "winning" concepts. Funding has been consistently inadequate to allow program management to move quickly toward decision milestones. This should be seen as critical of DOE and its consistent reluctance to request a budget adequate to the stated task and schedule.
- The subprogram is focused and well managed but underfunded for two years now.
- The subprogram appears to have a balanced portfolio. But since there was no comparison between the various production approaches, I cannot state whether the subprogram is focused as far as technical approaches and corresponding advantages are concerned. It was not clear as to what the objectives of the subprogram are: Is the objective toward massive hydrogen production that meets the needs of the country for vehicular transport in the long term, or does the subprogram aim at exploring distributed hydrogen production capabilities using whatever means are available? The subprogram is lacking such a focus.
- The subprogram area is all-inclusive, but not focused. It can be made more focused by, among others, incorporating the propensity to release GHG and other environmental emissions (air and water) as a factor for consideration in all hydrogen production and delivery technologies funded by DOE.
- The DOE team is doing a great job.
- The portfolio of projects seems good. Again though, I question the management decision to prematurely downselect among good, competing technologies.
- The subprogram area is focused, well managed, and effective in addressing the DOE Hydrogen Program R&D needs in the out years.

4. Other Comments:

- Economical hydrogen production is clearly one the most important areas in the entire Hydrogen Program. The customer will ultimately demand the most economic means of transportable energy, and this will ultimately be hydrogen. Even in the event that all other EERE and NE hydrogen programs are eliminated, this program element (Hydrogen Production) should be continued. No plans were offered to move this effort along, and this will lamely be seen as short sighted.
- The subprogram needs to quickly develop and plan for the next phase and capture its findings and lessons.
- This subprogram does not appear to have funding in the administration request. This subprogram is critical to the long-term success for fuel cell technology. It does not make sense how hydrogen will be available without funding for Hydrogen Production and Delivery. This area needs to be funded.
- I would not mind seeing high-temperature nuclear hydrogen dropped (there are sufficient safety concerns without having to run at 1000°C). Ethanol to hydrogen seems equally mysterious—why? I would have liked to hear a good talk on the zeroing out of the mobile hydrogen program. It's extremely relevant to all those here.
- The Hydrogen Delivery Scenario Analysis Model (HDSAM) work was especially valuable in understanding/anticipating how various hydrogen delivery scenarios impact the cost/capacity/delivery method.
- For peer review and progress evaluations, it would be helpful if reviewers have access to the original proposal.
- The Peer Review Meeting had a number of parallel sessions (oral presentations) on important and closely related subjects. It will be helpful to most attendees and reviewers if oral presentations for closely related subjects can be scheduled so they do not overlap.
- The overview was complete and thorough. The presentation was the right amount of detail and the presentation itself was excellent.
- In light of constrained funding, should the program portfolio be narrowed? (i.e., maybe focus more on near-term technologies to bring them to market and leave out the long-term ones till there is a sustainable budget for those.)
- This presentation was not available before the review.
- My biggest concern is that portfolio is comprised mostly of technologies that have the potential to provide hydrogen at costs that are significantly more costly than petroleum-based fuels or hydrogen. The cost differential infers a cost of carbon, and the inferred carbon cost represented by these technologies is well above anything that rational people are talking about. So I don't see how a consumer or commercial interestor would ever be able to make the decision to choose to use or commercialize any of these technologies. There may not be a solution to this problem that includes hydrogen as an energy distribution means. It may just be too expensive to be worth the trip.
- The team leader is a great manager.
- None.
- Membrane technology efficiency is approaching targets.
- This was a nice presentation giving a good overview of the status of hydrogen production, both technologically and economically.
- It is interesting to note that both Europe and Japan spend more on production and delivery than they spend on storage, whereas this trend is reversed in the United States.
- Need to address questions of how the subprogram might proceed with minimal funding.
- The overall production cost goal of $2-3/kg for delivered hydrogen was established in 2005. This important goal should be reassessed considering how much the cost of oil has changed/fluctuated

since then and relative to how the U.S. now perceives the importance of global warming and potential carbon policy.
- There was no time for questions.
- The notion that production and delivery work is "deferred" while other more near-term technologies are brought to maturation is essentially unrealistic, and it is overly optimistic to think that the work could be picked up in the future and moved forward. The teams of experts who do know what has been done will dissipate and much of what has been accomplished will have to be re-done before further progress can be achieved.
- The program needs to be focused given the recent remarks by the Secretary of Energy that hydrogen does not provide a near-term solution to our energy needs. The program seems to be more balanced than spearheading the most effective solution. In a 2004 report titled "The Hydrogen Economy," the National Research Council (NRC) identified coal and nuclear energy as the most promising means for hydrogen production. I did not see the NRC's view weighing in the subprogram elements and objectives. For instance, biomass-related approaches do not provide the solution to hydrogen production, do not serve the technical demand for massive production, and most importantly, using farmland for fuel production does not resonate well with the public. The subprogram needs to become more relevant toward the strategic needs for getting the hydrogen economy up and running with regard to the most urgent problem, that is, the need for a green transportation vehicle fleet.
- With the impression on the requested DOE FY 2010 budget allocation, it is unclear what the DOE long-term goal/strategy of Hydrogen Production Subprogram is.
- The team leader and associates have done an outstanding job given the budgetary realities their subprogram has had to deal with. I found the folks managing this subprogram area, in general, and the team leader, in particular, very knowledgeable, friendly, extremely approachable, and easy to work with. I give the team leader "4 out of 4" for managing the subprogram.
- None.
- It was really nice that budget information for FY 2010 was provided to the audience during the presentation.

Hydrogen Delivery Element

1. Was the Subprogram 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 Subprogram if appropriate.)

- Good job summarizing the different areas.
- The subprogram was very thoroughly covered, with the primary objectives reviewed along with the programs being pursued to meet these objectives.
- The dollars/kg (<1.00 gge) number has not been revised, given today's economics. What is the basis of this threshold? Any thought to revising the number annually?
- Yes, the subprogram was covered adequately. It would have been interesting to include a critical analysis of the subprogram progress (or lack thereof).
- The subprogram was well covered, and progress was identified.
- Not bad. I wish costs were covered more explicitly. I wish customer benefits were covered better. Does a cheaper, high-pressure tank help make hydrogen a good transportation fuel, or is the energy density way too low? I would have like to have a good talk on the zeroing out of the mobile hydrogen program. It is awfully relevant to all those here.
- The subprogram was described with good examples of progress. However, the recent change in focus and funding places large burden on program managers to achieve goals.
- Progress was given, but for some programs it is hard to discern any chronological progress.

- Excellent discussion of the Production and Delivery Subprogram. Critical issues associated with delivery were identified—namely, reducing the cost of compression, increasing capacity of trailers for truck delivery, and lowering liquefaction costs. Good examples were presented of progress being made for truck delivery (i.e., increasing capacity to 600 kg). Issues for pipeline delivery were identified: cost of pipelines, application of polymer composites, and development of advanced pipeline compressor technologies.
- The subprogram was covered. Challenges and their relative importance were not clearly identified; the presentation was more of a status report. Year-to-year progress was not clearly identified.
- The Delivery area was properly covered with challenges identified and major highlights presented.
- The subprogram area was adequately covered and all important issues and challenges were identified and discussed. Progress against the previous year was presented and discussed.
- I could not attend the presentation due to a conflict.
- Yes to all.
- Yes, the subprogram areas were adequately covered with important issues, barriers, and challenges clearly identified. The significant progress was clearly presented and highlighted in comparison to previous years.
- Good discussion of tradeoffs and "big picture" issues that need to be considered in the delivery system. Good overview of near-term vs. long-term challenges and priorities. Good description of how the R&D accomplishments address key barriers and what benefits the R&D will provide.
- I would have liked to have heard discussion on how the decrease in budget from FY 2008 to FY 2009 to the FY 2010 request has/will impact program priorities, plans, and ability to meet targets.
- The subprogram was very well described with excellent background of the DOE Hydrogen Delivery Subprogram. The relationship between delivery storage and use of hydrogen (well-to-wheel) cost and trade-offs were described. The progress was presented as well as the successes to date.
- Good overview of the relevant DOE program elements in hydrogen delivery.
- Challenges and approaches were clearly stated. Complexity of tradeoffs was described. Developments in trucking were described.
- This was an overview. The clarity in progress relative to previous work suffered from the scope of activity being covered. At the same time, it seemed that the presenter was not that well-informed on quantitative information regarding benefits and deficiencies of the various delivery options. In fairness, the presentation time available to each presenter was clearly inadequate for overview presentations. The presenter had to make choices regarding what would be emphasized and what would not. That generates team disconnects and political problems that frequently cause more damage than a less informative presentation.
- The team leader gave a masterful summary of the programs under his wing. Very clear and concise articulation of long-term and near-term objectives. Very systematic presentation of progress achieved and where the current emphasis lies.
- Excellent summary presentation!
- The technology issues and challenges were clearly identified, and progress was presented. Due to reduced funding, changes in priority were not clearly identified.
- Yes, the subprogram was well covered in adequate detail.
- Very good overview of the subprogram.
- “Yes” to all questions.
- The subprogram areas were adequately covered. Important issues and challenges were not identified uniformly and certainly not with respect to the previous year. Please consider including

a bird's eye view matrix that summarizes, for each delivery project, progress made since last year to achieve and/or approach DOE hydrogen delivery program targets (that should also appear on the matrix/table).
- All items were covered succinctly in the time allowed.
- This presentation also should have been 30 minutes long. The subprogram could not be adequately covered in 15 minutes. Hence, important issues were only briefly covered and left more questions than answers. Also, there was no time to ask questions. I realize more details are provided in the individual talks, but a longer overview is still needed. I didn't get a good sense of the progress that has been made in delivery from the previous year.
- Yes, the subprogram area was adequately covered. Important issues, barriers, and challenges were clearly identified. Progress since last year was clearly presented.
- The team leader covered the Hydrogen Delivery Subprogram well, citing key accomplishments and challenges.

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

- Plans are good given the very low budget available.
- A very concise review of planned efforts was given.
- One possible gap in delivery is the possibility of distributed generation through local electrolysis. This would eliminate the long distance physical transport of hydrogen and replace it with transport of energy through electric potential. (This may have been considered and down-selected unbeknownst to the reviewer.)
- Compression technology should be looked at in detail, including costs and breakthroughs in technologies.
- Yes. The forecourt challenges are numerous. As the intersection of multiple technologies, delivery is a critical part of the supply chain. What is not clear is the plan for transition.
- Other specialized carriers should be considered. These should include the materials developed from the hydrogen storage materials centers of excellence. It also does not consider liquid fuel transport as a hydrogen carrier. It also should include fuels which can be transported through pipelines and fuels which can be efficiently produced and reformed at low temperatures, such as dimethyl ether (DME) and methanol.
- No obvious gaps beyond the elephants in the room, as mentioned above: cost, value to the customer, and the zeroing out of the subprogram.
- The project portfolio covers a good balance between clever near-term solutions for delivery of hydrogen to longer-term, cost-effective approaches.
- Plans and descriptions of projects to address major challenges were presented, as evidenced by near-term projects to design advanced compression technologies and explore polymer composite pipelines. Long-term progress on demonstration of pipeline compressors is critical and will depend on continued support at an enhanced level. A critical issue appears to be the “chicken-or-egg” issue found with hydrogen: industry will not get serious about hydrogen delivery until they see a market, and the market will not be developed until they see an infrastructure to provide hydrogen.
- Could have been made clearer.
- Plans for addressing issues were properly identified.
- Plans for addressing issues and challenges were presented. There appear to be no gaps in the project portfolio.
- Existing challenges are receiving priority while new opportunities are folded into the work.
- Plans were not explicitly shown in the subprogram presentation. There are no gaps in the portfolio.

- Yes, plans are identified to address issues and challenges relevant to each project according to the DOE MYPP. There are no gaps in the project portfolio.
- Funding trends would seem to indicate that truck/carrier and compression are being de-emphasized. It was unclear whether the funding decrease was based on funding limitations or whether the challenges have been resolved.
- Portfolio gaps include: onsite "polishing" step for hydrogen quality, hydrogen quality sensors or controls, and geologic storage purity/feasibility.
- The goals and objectives of the delivery team were clearly explained, along with the trade-off issues and how the subprogram fits within the total DOE hydrogen roadmap. There are gaps in funding due to the decreased budget in FY 2010, and beyond that, there is a need to address codes and standards to ensure the safety and integrity of the different approaches.
- Good job in presenting overview of the DOE approach and in developing hydrogen delivery systems.
- Gaps are due to lack of funding, not due to failure to recognize or plan. Due to lack of funding, only a few projects are funded.
- The intimate relationships between transport, delivery, and fueling options were not clear to this reviewer. That could be related to ignorance on the part of this reviewer or to lack of presentation clarity.
- Most issues were well laid out, but some needed more clarification. (E.g., what are the key decisions regarding the active magnetic regenerative liquefier (AMRL) and the Praxair ortho-para approach? Have they convinced DOE that such approaches confer useful advantages? Is the rail option adequately defended?
- Due to the significantly lower amount of funding in FY 2009, not all the technologies or analysis can be accomplished, but these were not addressed in the presentation in an adequate manner.
- Plans are nicely addressed over short- and long-term time frames. The challenges are certainly there and are focused on the many technical imperatives necessary to create a hydrogen infrastructure.
- Yes.
- It was not clear to me where each activity in terms of achieving its goals. I expected a much better presentation of the analysis findings and where each technology stood with respect to the hydrogen delivery costs.
- Consideration should be given to re-inserting onsite reforming for hydrogen (if program funding permits). While there are a couple of commercial, small-scale reformers, developmental work remains for multi-fuel capabilities, new catalysts development, and continued work on controls systems.
- Again, due to the time limitation, it was unclear if plans are in place to address the major issues and challenges. How is this subprogram coordinated with the Hydrogen Production Subprogram? For example, Production and Storage each have their costs and energy loss goals. However, that may eliminate some production technologies that minimize the cost and energy loss of distribution, as well as have improved safety, minimal greenhouse gas emissions, and easier coordination of supply and demand. For example, onsite electrolysis is relatively expensive and energy intensive, but it eliminates these distribution issues. How are these types of cross-cutting issues addressed?
- Yes, plans are identified to address issues and challenges relevant to each project. There are no gaps in the project portfolio.

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

- Good projects and valuable activities. This is a well-managed subprogram.

- The subprogram is very well organized. The technology development manager has a good grasp of the required technologies and the direction for technical development.
- Yes, given the comments above.
- Generally, yes, but because of previous budget re-allocation, the progress has been slow to come.
- The subprogram is appropriately focused and managed. It should be prematurely focused.
- Fine, except for the elephants in the room, as mentioned above: cost, value to the customer, and the zeroing out of the subprogram.
- The subprogram appears well focused. The subprogram manager correctly cautioned his contractors that the absence of metrics will be weighted heavily against them in the excruciatingly difficult selection process.
- While I applaud the manager's approach to turn the dramatic decrease in funding into a mechanism for increased focus in the programs, my concern is that the decrease is cutting into the bone and will result in loss of important programs.
- The subprogram appears to be very well managed with a good balance between fundamental R&D and engineering of advanced systems. The severe cutback in funding is limiting progress.
- Yes.
- The subprogram area is well focused, and I could not identify any major gaps in the portfolio.
- The subprogram area is focused, well managed, and effective.
- Yes, the Hydrogen Delivery Subprogram appears focused on the significant challenges that come with transporting this energy carrier. Continued success of this subprogram will bring commercially available hydrogen-fueled cars towards reality.
- Yes, it does.
- The subprogram area is well focused and well managed. Provided adequate funding, progress of the projects will address the DOE Hydrogen Program R&D needs in the out years.
- The subprogram needs consistent funding, at least at the FY 2009 level, in order to continue important R&D progress on cost-effective delivery of hydrogen. Given the erratic and relatively low-level of funding that the program has experienced, the subprogram has been very well managed, focusing on top priorities and making good progress on addressing the challenges.
- The involvement of industry in defining priorities has been good, and collaboration on pipeline R&D through the Pipeline Working Group has been very beneficial and should be continued.
- The subprogram areas appear to be focused and well managed. However, due to the reduced budget in FY2010 and beyond, the timeline to commercial use will need to be adjusted.
- Accomplishments in the DOE subprogram for Hydrogen Delivery were clearly summarized.
- Yes. Good blend of short- and long-term projects. At this stage, many delivery options are still on the table. With limited funding, the subprogram has not been able to adequately fund critical research.
- It was not clear from the presentation that all the issues relating to interfaces between production, storage, delivery, and fueling are engaged in the subprogram. It could be that some of these problems were addressed elsewhere in the program. Nevertheless, it seems important to have all this rolled up into a single program element.
- Definitely well managed, but final resolutions not spelled out as strongly as I had hoped. (E.g., mechanical versus electrochemical compression: which stands out, or will both continue to be further developed as options?)
- The subprogram is well managed and has identified key challenges to the large scale delivery of hydrogen. However, it is not clear what technology has the greatest potential during a transition strategy as the market advances for hydrogen. If the funding is reduced further, based on the analysis model, which technologies must be stretched out to allow the original equipment manufacturers (OEM) to make the commercialization decision?
- Yes.

- Well focused and well managed.
- Yes.
- The subprogram appears to include a large collection of potentially viable hydrogen delivery techniques. However, only one technology was downselected (e.g., N-ethylcarbazole-"like" liquid carrier). I expected more downselects!
- The DOE team does a great job.
- From the limited information given in the introduction, this subprogram seems focused, well managed, and effective. My main concern is how cross-cutting issues among the various subprograms are treated.
- The subprogram area is focused, well managed, and effective in addressing the DOE Hydrogen Program R&D needs.

4. Other Comments:

- Analysis work needs to consider the car side of the work and include the effect of the car on infrastructure performance and cost.
- This subprogram is a necessity in order to bring together the ancillary technologies for hydrogen to become a commercial reality. Funding should be increased to demonstrate the required technologies.
- Listening to the Delivery team progress, it is natural to question if funding was allocated correctly to all aspect of the program. Would it have been more effective to support some of the more achievable technologies in delivery and forecourts at the expense of storage, for example? Delivery could have been a low-risk, high-reward play in the entire portfolio. Some of the technologies being considered here have far-reaching applications beyond hydrogen.
- This subprogram does not appear to have funding in the administration request. This subprogram is critical to the long-term success for fuel cell technology. It does not make sense how hydrogen will be available without funding for hydrogen delivery. This area needs to be funded.
- I would have liked to hear a good talk on the zeroing out of the mobile hydrogen program. It is extremely relevant to all those here.
- Only regrets are the cuts to an important program.
- The subprogram manager should be commended for this program that involves basic/fundamental research coupled with applied/engineering design studies. A delivery test loop facility should be established at a national lab to address pipeline and compressor issues.
- The presentation was clear and conducted in an excellent manner.
- None.
- Excellent program goals and objectives. Well-thought-out modeling and analysis ensure that delivery infrastructure options are in step with the fuel cell development and commercialization.
- A good presentation. Some additional attention to the role of collaborations and to future work would have been helpful.
- It is interesting to note that both Japan and the European Union spend more on production and delivery R&D than storage. The U.S. R&D budget is dominated by storage.
- Need to address questions of how this subprogram might proceed with minimal funding.
- The missing ingredient in all this is a commercial business plan that assures that different roles and responsibilities are adequately identified and accommodated in a dynamic enterprise that would be responsive to unexpected events. The issue is more important because system obstacles could bring down regional transportation that relies on daily, and possible several daily, distribution events.
- Keep up the comparisons, but clearly spell out the priorities if a decision needs to be made today.
- Solid subprogram and well managed.

- Some of the technologies, such as the higher capacity tube trailers, seem to be viable to replace current high strength steels. Is this technology being accelerated for commercial applications? If not, should that not be a higher priority when the funding is cut by more than 50%?
- Why was there such a large decrease in funding from FY 2008 to FY 2009? This, coupled with reputed further decreases for FY 2010, does not bode well for serious infrastructure R&D required if we are really serious about hydrogen.
- With the impression on the requested DOE FY 2010 budget allocation, it is unclear what the DOE long-term goal/strategy of Hydrogen Production and Delivery Subprogram is.
- The DOE Hydrogen Analysis Model (H2A) cost analysis summary for each technology should be included in one summary slide.
- None.
- It appears that the distribution of hydrogen from large-scale production facilities has many insurmountable challenges such as cost, energy loss, hydrogen loss, materials, safety, public acceptance, etc. If this is not true, a better case could have been made in this introduction. It would be desirable to increase the presentation time to 30 minutes, so that more details can be learned.

Hydrogen Storage Subprogram Comments

1. **Was the Subprogram 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 Subprogram if appropriate.)**

- Yes – the technology gaps were adequately identified; the targets and explanations of new directions were adequately addressed. Progress was demonstrated via the gap chart and new materials discovery.
- The subprogram area was adequately covered, important issues and challenges were identified and the technical progress and accomplishments over the past year were summarized.
- Yes, the subprogram area was covered quite well. The challenges were identified and progress highlighted.
- The subprogram was covered adequately. However, the challenges were not defined adequately. Considering that we are in the fourth or fifth year of this program, a more detailed analysis was warranted.
- The presentation was, in general, thorough; it would have been interesting to discuss the status of other storage systems target besides gravimetric (i.e., volumetric targets and filling/kinetics comes to mind). Modeling hypotheses as to the determination of systems hydrogen storage density from materials hydrogen storage density should have been stated more clearly in the presentation. (I didn't have time to ask this question during the session.)
- Yes to all questions.
- The subprogram area adequately covered most of the important issues and challenges identified. The most important progress compared to last year is the target update and the new Engineering Center of Excellence (CoE), which is the leading effort in DOE Hydrogen Program.
- Good overview of the subprogram area and its strategy, technical goals, main achievements, and developments during the reporting period.
- One of the goals and objectives were stated for off-board storage (stationery, portable); however, these targets were not shown, discussed, or established.
- The team leader was very knowledgeable about the ongoing activities in hydrogen storage. She presented a comprehensive overview of all the areas of storage including the expanded engineering effort. The highlights of accomplishments made in some selected areas were useful.

- Important issues and roadblocks in hydrogen storage were appropriately identified. A nice summary of progress made in the past year was presented. The subprogram area was more than adequately covered. Overall, the presentation gave a clear and concise picture of the status and challenges in hydrogen storage.
- The subprogram area was adequately covered. The important issues and challenges were identified; however, the reasons for revised targets were not clear.
- The goals of the program were succinctly stated relative to the major issues of cost mass volume fill time. Others were included by reference. New targets were explained. Progress was shown by the CoE giving the highlights like mild alane regen, improved spillover kinetics, improved range and durability from the demo, and allied life estimate in many dimensions. It is clear what progress remains to be accomplished.
- "Yes" to all the questions based on the subprogram presentation. I did not hear the Plenary presentation.
- Yes, the presentation gave a very thorough description of the subprogram including goals and objectives, issues, challenges, and progress.
- The subprogram was clearly described both in terms of the revised targets for system storage and the current state of progress for materials discovery. However, current status for materials and systems was not accurately represented in the presentation. In particular, blanket statements such as "currently no technology is able to meet the revised 2015 targets" are not wholly accurate. Achievement of the DOE targets is a complicated matter that deserves a fair quantitative assessment of which milestones or targets have been met to date and which ones are far from being met. There will be compromises to be made for certain targets but, in aggregate, the storage system may exhibit a surprisingly favorable performance. This can be qualified by noting that the recent system-level modeling carried out by Argonne National Laboratory on cryosorption in metal-organic framework (MOF)-177 yields better performance results than originally thought possible based on gravimetric capacities alone.
- Overall challenges were communicated, and the progress was captured. The progress for the "new concepts/other materials" category was not presented and not visible; information on these would be helpful especially given that the 2009 budget appropriation will increase for this category.
- Very good overview of progress in the subprogram area. Excellent description of overall progression of material capacity/temperature is given in slides 12-15. That information provides a useful snapshot of the current status and emerging trends.
- A greater emphasis on critical issues, obstacles, and challenges faced by each of the specific technology areas (i.e., chemical hydride, metal hydride, sorption) would have been helpful. Without that information, it is difficult to put the progress into proper context.
- Although they remain challenging objectives, the revised performance and cost targets are generally much better aligned with expectations and projections based upon current data and future projections.
- Unable to review due to conflict.
- Yes.
- Excellent presentation.
- The subprogram was covered pretty well.
- The year's progress in areas of hydrides, chemical, adsorbents, testing, gas storage, etc. were covered well.
- The subprogram area has been covered in an adequate manner. Progress in respect to previous years has been clearly presented and discussed. Although no major breakthroughs have been achieved (storage is a really challenging problem), all important aspects have been addressed.
- The subprogram presentation covered all relevant topics including challenges, progress, changes, etc., with the exception of the 2010 budget. The breakdown for progress in each area of storage

(i.e., CoEs, analysis, etc.) was informative and 2008 progress was apparent. The rationale for changes to the targets was clear.
- Two graphs on volumetric and weight density progress were good, but the two added points to the gravimetric/volumetric density plot mixed material properties with system properties and real data with estimated values for systems.
- Good review of recent progress by PIs covered all major areas.
- A comprehensive overview was given of the subprogram. The new targets for this subprogram were presented, and the rationale for the new targets was explained (i.e., based on real world experience of current fuel cell vehicles). The challenges were then presented in relationship to meeting the 2015 targets. Highlights of progress from the different centers were given, providing a flavor of the exciting new work coming out of the subprogram.

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

- The Engineering CoE will play a key role in providing feedback to the material research PIs regarding what other material characteristics will be critical for an effective system design. To many of the PIs who previously concentrated on only two high-level targets (i.e., weight, volume), this center should provide valuable feedback regarding the importance of other characteristics such as heat capacity, thermal diffusivity/conductivity, packing geometries, agglomeration effects, etc.
- The presentation identified the issues and challenges and discussed the revised performance and cost targets. Not enough information was presented to pick out gaps in the project portfolio.
- Plans are identified. Storage systems and performance targets for real market applications are being developed, which shows confidence in meeting DOE goals in the near future.
- Partially. It is important to have a "look back" and gap analysis in the near future.
- The overdue Engineering CoE would have addressed most of the outstanding issues in the field. The Storage Subprogram should have addressed the nearer-term application for hydrogen energy technologies, and set application-specific storage targets (e.g., public transportation in buses, materials for hydrogen storage in portable applications, etc.).
- Yes, plans were adequately identified. There are no apparent gaps.
- The plans sufficiently address the issues and challenges.
- Critical areas and challenges were adequately discussed along with the revised performance and cost targets. There are no apparent gaps in the project portfolio. What was missing was a reference to the future work plans (possibly as a result of the current discussions and uncertainty on future funding). This issue was only addressed when asked by the reviewers during the presentation.
- Everyone knows that funding for the Hydrogen Storage Subprogram has been zeroed out in next year's budget proposal, yet DOE does not seem to have any plan to address this challenge. The only plan mentioned was to "bring the Hydrogen Storage Subprogram to an orderly close." I sincerely hope that we can do better than this!
- Storage needs and performance targets need to be defined based on progress in the project portfolio.
- The plans identified issues and challenges. Close collaboration with basic science seems lacking.
- The gaps were made clear in the presentation. In Q&A, the plan was to bring the Center to an orderly close in compliance with the budget request. A database to make all learnings accessible will be developed. If funded by Congress, they will manage that to the degree possible with the funds allowed.
- Plans for addressing issues and challenges were adequately addressed.
- I am sure there are a few gaps, but no major ones come to mind right now.

- Yes, the subprogram is very comprehensive and covers the area of hydrogen storage for vehicular applications very well.
- Few or no details were given on addressing current and future issues or challenges. This gap in the presentation is, however, understandable given the uncertainty of future funding of the vehicle hydrogen and fuel cell program.
- The plans to tackle the existing challenges could have been elaborated upon more (i.e., presentation of a timeline). Also, the plan and next steps for the added early market application could have been included.
- The issues and challenges did not receive sufficient emphasis in the presentation. At this stage of the overall program, there are critical barriers that remain (some may be "showstoppers"). Although the presentation described progress in each of the technology areas, very little information was provided concerning the status of the project with respect to the most serious obstacles. Likewise, virtually no information was provided about plans to address those challenges. One or two additional slides (after slide 20) describing problems and mitigation strategies would have been helpful.
- Looks very good.
- DOE has very recently decided to eliminate the need for vehicular hydrogen storage, so this program element may be reconfigured to support the areas of stationary fuel cells and portable power.
- Explanations of new targets were useful.
- The Engineering CoE seems like a good addition at this stage.
- Stationary storage seems like a worthy technical area for this subprogram, but it was hardly addressed at all.
- Hybrid high pressure gas/hydride tanks seem to be an important part of the Japanese on-board storage effort. Is there a role for this approach (including established, lower-capacity hydrides) within the DOE program?
- Nothing was said about the future (if any) of the materials CoE concept.
- The subprogram has reached a level of maturity that contributes substantially towards timely identification of plans to address the main challenges. The portfolio has grown to a level that seems to cover almost all essential issues without leaving major gaps. The only topic I would like to see more extensively covered relates to hybrid (high pressure, solid) storage systems investigation and development.
- The most pressing issue and challenge is the proposed discontinuation of funding in storage, which would make progress impossible.
- From a technical standpoint, given the addition of the Engineering CoE, it is unclear how the other Systems Analysis projects (e.g., ANL or TIAX) will be effectively integrated. The models and information they have provided are invaluable and should be leveraged going forward. The added goal of looking at early market storage applications was presented here, but has not been disseminated to PIs in a timely way for them to be included in their work plans this year.
- There was no clear discussion on why an increase in analysis work is needed.
- There was no discussion of future plans.
- Alternative applications have been identified (which are likely to be earlier-to-market opportunities) and are being incorporated into the subprogram (e.g., stationary, portable electronics, niche vehicle), but targets are needed for these new applications. This new direction should be commended because the vehicle-only applications were overly restrictive for the subprogram.
- Given the uncertainty of funding for the next 12 months, the orderly wrap-up of the subprogram was indicated as a priority. However, if this subprogram ceases to exist, this will be a major hole in the DOE program. It is inconceivable that DOE will not continue to support work into one of the key technological barriers for hydrogen systems. The United States is currently leading the

hydrogen field, but risks playing catch-up with other major economies (e.g., Japan). This will be a detriment to U.S. industry because early-to-market industries will have a crucial competitive edge over the rest. Hence, the continuation of the work in some shape or form must be a priority for DOE.

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

- There is a subprogram manager for each of the four areas, which allows good communication between the different areas. It is clear that the cross-fertilization of ideas is occurring between the different CoEs and that redundancies are being eliminated through the effective project management of the team and the CoE leads.
- The subprogram area appears to be focused, well managed, and effective.
- The subprogram is well managed.
- It may be useful to include some additional basic studies to identify a few additional storage systems/approaches. Hydrogen storage in organic materials may be worth a closer look.
- Generally "yes," but there needs to be further improvement. With some work on "look backs," lessons learned, and gap analysis, some of the bottleneck issues can be addressed. This is a reflection of the technical difficulty of the subject matter.
- New storage targets are much more realistic. Dumping the "old vehicle architecture assumption" is refreshing. The subprogram does appear to be well focused.
- Yes.
- The subprogram areas are all well managed.
- The Storage Subprogram is well managed and has a diverse R&D portfolio with clear ties to technical targets.
- Large efforts within relatively small domains of materials for each project resulted in difficulties in downselecting. It became very time consuming to discover new domains of storage materials.
- The subprogram is well focused and the CoEs are functioning well. The performance and cost targets for hydrogen storage are clear.
- The subprogram area appears to be very well focused and well managed to achieve DOE Hydrogen Program needs.
- The subprogram area is important to addressing the DOE Hydrogen Program. It seems focused and well managed.
- The program has an appropriate broad spectrum of projects for a materials discovery mission. Within that broad approach is a disciplined go/no-go structure to ensure focus on programs with potential to improve hydrogen transportation.
- The short answer here is "yes."
- Yes.
- The subprogram is not focused enough toward addressing the DOE Hydrogen Program R&D needs in a reasonable timeframe. DOE program managers have not engaged themselves enough with the Materials Centers of Excellence to impose no-go decisions on material classes that show little or no chance of ever meeting gravimetric or volumetric targets early on. The statistics presented for downselecting various materials at each of the MCoEs represent, in many cases, materials of very similar class or composition, and any permutation or combination of them is not likely to meet the stated targets. Nevertheless, work has been allowed to persist for these classes of materials year after year, sacrificing valuable resources that could have been used on more promising materials.
- The subprogram appears to be well managed and focused.
- The subprogram area is very well managed and has been shown to effectively address the DOE needs for hydrogen storage. The CoE "model" is working well and is providing opportunities for

interaction and collaboration that would be unlikely if projects were funded independently. There appears to be more inter-Center collaboration as well. As some project areas between CoEs begin to merge, this collaboration is healthy and greatly benefits the overall program.

- Yes.
- Yes.
- Yes.
- Yes, generally.
- I think that the management of the subprogram has been one of its main positive assets over the years, and this seems to continue now too. It has been quite effective in addressing the various R&D needs of the DOE Hydrogen Program, and nowadays it appears to be sufficiently focused on the challenges. The launching and first activities of the Engineering CoE and the synergy with Basic Research projects are very positive aspects that I noticed this year.
- The subprogram is extremely well managed. Coordination and monitoring of projects and resources is done effectively to maximize technical progress. Project scopes appear to be efficiently directed to keep priority on high-impact, high-value research. Coordination with CoE managers also appears to be effective for cascading information and suggested directions.
- The subprogram has been well managed in past years and has shown important progress in the area of hydrogen storage.
- This seems to be a very well managed subprogram. The different types of solid state materials are the focus of the individual CoEs, ensuring the program has breadth but retaining a necessary level of focus.
- Very significant advances have been made for the various material systems, bringing materials closer to the system targets of the DOE Hydrogen Program. This work needs to continue.

4. Other Comments:

- The audience would have preferred a slide on the impact of the President's proposed budget on the subprogram. Even a timeline outlining programmatic decisions would have been appreciated.
- The work on advanced hydrogen storage materials and systems should continue.
- A sudden termination of this project may significantly hamper our quest for alternative energy sources and reduce our chance to resolve energy deficit before it turns into a global energy crisis.
- One of the ways to satisfy growing energy requirements is the conversion of solar energy. This energy can be immediately used in the form of electricity to power a broad variety of tools and devices. It can also be stored in a chemical form in hydrogen-rich chemical substances: hydrides. It is worth noting that conversion of solar energy into materials with high hydrogen content, such as oil and natural gas (carbon hydrides), is the way in which fossil fuels formed in nature. Biomass production and its conversion into hydrogen gas/biofuels is another example of when solar energy is stored in the form of carbon-based hydrides.
- In view of the 2010 budget issues and the challenges still facing the storage, it is warranted to engage in a systemic cradle-to-grave evaluation and look backs.
- Some questions to consider: How could we have done this differently? Were the goals even achievable? What are the lessons for the next material-discovery project? How can we recover the most out of this work?
- There are still many questions about the target setting and relevancy of the targets. The revised targets do not reflect the technical and economic challenges and new realties facing the subprogram. It is imperative to revise the entire set of targets and change the basis on what has been learned and established.
- I am surprised that this subprogram is being cut, despite the spectacular progress that has been achieved over the last five years—the steady progress and all the potential applications that will arise from this work in the fields of storage, gas purification, and even battery materials science.

It is the opinion of this reviewer that this decision is unsound. Restarting this subprogram in a few years, when it is realized that this issue is unavoidable even for the new fuel cell focus of the program (i.e., forklift trucks, portable applications), is likely to result in a permanent loss of leadership in the field. This subprogram could have been saved in line with the new shorter-term priorities by adding application-specific storage density targets for shorter-term applications (e.g., forklift and intensive mobile indoor applications, portable applications, public transportation applications), while keeping longer-term targets.

- More information regarding alternate plans and directions to be taken in regard to recent DOE FY 2010 budget announcements would have been helpful.
- The downselection process has obviously greatly benefited the project, focusing the resources on the most promising material systems.
- The CoEs are proving to be an excellent tool for mobilizing resources and expertise.
- Interactions of Materials CoEs among themselves and with the Engineering CoE should be strongly encouraged. Also, all data generated so far should be properly recorded and stored. This is to ensure conservation of the results and full exploration of the materials data gathered over all these years, even if the funding of the program is finally substantially reduced, pending current discussions.
- It is a great disappointment that work in hydrogen storage will be reduced at a time when so much progress has been made over the past several years.
- There seems a potential for MOF material in the area hydrogen storage, but not much was discussed. Overall, the presentation was good.
- Other aspects were also covered, such as the H Prize. Also, the presentation covered the desire for feedback and noted the process for reviews again.
- Re-evaluating and re-adjusting of the hydrogen storage system targets (for whatever rational reason DOE chooses to offer) was essential to both the real and perceived success of the subprogram. The prior target values were unrealistic from day one and unnecessary. Solving our energy problems cannot be done by technology alone. There needs to be major transformations in cultural habits and in the way people think.
- I believe that the area of metal-particle-decorated materials, as predicted by simulations and other theoretical calculations, should not be funded anymore. I believe that this work originated largely as an attempt to somehow legitimize the very early and completely erroneous work on hydrogen uptake by carbon nanotubes and fibers [that turned out to be only metal impurity particles that do the absorbing of hydrogen (or just plain wrong)]. The idea that somehow those metal particles or atoms can decorate carbon structures, remain stable, and absorb lots of hydrogen has not ever really been convincingly demonstrated experimentally, and consequently, seems to be wishful thinking and not based in reality. It seems that the "spillover" effect is another manifestation of this mind-set. It is long past time to move on to materials that have a real chance of being real and practical hydrogen storage materials. I also believe that part of the difficulty of moving on to real, valid experimental results is the fact that hydrogen sorption measurements are very complex and quite difficult to do correctly. We have seen many, many times over the past 15 years, results that are first sensational, then unbelievable, and finally dismissed as spurious or due to an experimental issue. We need more focus on good-quality, robust, accurate, and believable experiments. That is where more funding should go.
- There appears to be good two-way communication between DOE program management and CoE managers and project PIs. This is essential for facilitating progress, focusing technical efforts, and resolving conflicts in a program of this scope and depth.
- None.
- It will be interesting to see how the Hydrogen Storage Subprogram element reconfigures itself in light of recent DOE decisions. Hopefully, some aspects of hydrogen storage will remain. Attention should be given to characterizing hydride storage materials if their thermodynamics are

such that the operating temperature is near room temperature. If high temperature is required kinetically for thermal activation, then rehydrogenation will be kinetically inhibited. PIs should keep in mind the question of what synthesis and/or characterization methods would be required to detect a good, reversible hydrogen storage material that operates near room temperature. How can the kinetics be made adequate to allow rehydrogenation at laboratory pressures?

- Comments on longer term funding would have been helpful. Although mentioned only briefly in response to a question, the zeroing of the FY 2010 storage budget seems to be highly problematic. Implications of this event should have been discussed.
- In my opinion, this is a successful subprogram that deserves to be supported to fulfill its aims over the coming years.
- Given the progress made by the CoEs, it would be a calamity for all the work to stop over the next few months. Some contingency plans need to be developed to ensure this essential work continues in some form.

Fuel Cells Subprogram Comments

1. **Was the Subprogram 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 Subprogram if appropriate.)**

- The subprogram overview was sufficient. The major players in this program have stayed the same for quite some time now, so in-depth review beforehand is not necessary. The most important/relevant aspects of this presentation, budget/appropriation by year and the 2010 proposed budget, was not discussed at all, which was very disappointing.
- In both the Fuel Cells Subprogram overview and the Plenary presentation, the Fuel Cells Subprogram was clearly covered in a direct and concise manner. The progress based on a comparison with the previous year was clearly described and the challenges identified.
- The presenter focused heavily on the fuel cell stack components such as catalysts and membrane work. This is where the focus of the subprogram really should be. In that sense, the concentration on those elements is appreciated. However, since this is supposed to be an overview of all the activities, other elements perhaps should have been presented, such as the balance of plant components (almost as large a percentage of cost as catalysts) or stationary work on solid oxide fuel cells (SOFC). Understandably with time constraints on the presentation, these portions may have had to have been put aside.
- Yes. The presentation adequately covered the goals for the stationary power and other early markets. The presentation also discussed the goals and challenges and for the transportation applications.
- "Yes" to all questions.
- The subprogram was well covered; the challenges and progress were identified.
- The subprogram seems to be making excellent progress on the cost targets.
- As of Wednesday at noon, my sense is that the research that is done is adequately covered, but there are at least two glaring holes: (1) The customer—no talk has addressed what he/she would get, who the target customer for each project is, or what it would cost him/her to use the hydrogen/fuel cell technology relative to other options like making the car lighter or going to high-efficiency diesel. (2) With funding zeroed out for mobile fuel cell/hydrogen, one would expect someone from DOE to explain to us what they would like us to do now.
- Good overview of the subprogram. Main issues of technical targets were identified. Progress was both in the form of cost projections and highlights from specific programs. If there was a highlight in water management, that would have been nice to include. Progress was represented

as a function of being relative to the target from DOE. A similar comparison of the contractor's progress relative to last year would have been informative too.

- The subprogram area was well covered.
- In several cases, progress was not clearly presented compared to the previous year.
- An adequate subprogram overview was presented. Goals were discussed including 2011 distributed generation—fuel cells operating on natural gas or liquefied petroleum gas (LPG), with 40% electrical efficiency, 40,000–hour durability, and a cost of $750/kW. Other goals for consumer electronics, auxiliary power, and transportation were identified. Transportation was de-emphasized this year. Early market entry is a major goal and challenge; also, job creation, increased public awareness, and establishment of a domestic supplier base are goals. Challenges in durability, reliability, and the cost of materials and subsystems were identified. Major accomplishments were presented, including $73/kW modeled cost for transportation fuel cell systems projected to 500,000 units/year, high-conductivity membrane milestone met, and catalyst loading decrease exceeding the milestone.
- Subprogram areas were adequately discussed as goals have changed little from previous years.
- Discussion on the reduction of the Hydrogen Fuel Cell budget for 2010 was notably absent. How can the program representatives just ignore this “900-pound gorilla” in the room?
- It was inconsiderate that the subprogram representatives took no questions.
- The presenter covered the subprogram area completely and thoroughly identified important issues.
- Clear progress was made towards the DOE targets. Progress on catalyst, membrane, and cost targets were shown. Membrane electrode assembly (MEA) durability progress and improvements in fundamental understanding of electrocatalysts are impressive. Targets are being met on time.
- Yes, the subprogram was adequately covered and important issues were identified; good progress was demonstrated.
- The Fuel Cell Technologies segment of the program was adequately covered with the reiteration of overall goals and timelines. Increased attention to stationary and portable applications was also highlighted.
- Important issues and challenges were identified at the component level (i.e., catalysts, membranes, MEAs), and new progress from FY 2009 was clearly stated (i.e., Brookhaven, Giner, 3M).
- The stationary combined heat and power (CHP) approach needs to provide more details, with more systems consideration. To achieve 40% electrical efficiency with the target cost the system will require better integration of the stack and fuel processor. With DOE's current emphasis on high temperature proton-exchange membranes (HT PEM), achieving this target will be difficult. The stack needs to operate at around 160-200°C for CO sensitivity and ability to use stack waste heat for integration with the fuel processor.
- The subprogram area was adequately covered with good rationales for why particular areas are targeted. Progress was presented, but it was not clear where the stationary applications are and what the progress is here. Fuel processing for stationary is a “mystery.”
- The overview of the Fuel Cell Technologies Subprogram provided a good summary of the subprogram's most remarkable achievements.
- Yes, the subprogram was adequately covered.
- Progress on fuel cell cost reduction was well documented.
- The subprogram area was covered in full. Issues and challenges were clearly identified. Progress was adequately identified.
- Excellent summary.
- The team leader adequately covered the subprogram and summarized the important issues and challenges. Progress on proton conducting membranes was not adequately presented. Half of the membrane projects met the DOE go/no-go conductivity target. This should have been emphasized

in the presentation, especially because the target was very challenging. Also, about half of the membrane projects were terminated because they did not meet the go/no-go target. This too should have been mentioned in the talk because it clearly indicates DOE's seriousness when it comes to material performance.

- Cost estimates and breakdown of projected costs by component were useful in providing guidance on research needs. A number of specific challenges were identified with specific approaches that addressed them. In the past, I have seen breakdowns of subprogram funding based on fiscal year (including estimates of out year) that allowed one to see the changing priorities of the subprogram and better understand how research priority changes were being addressed.
- Coverage was adequate; clear focus on remaining technical barriers was maintained, and progress from last year was demonstrated.
- Yes, it was fully covered.
- Yes. The presenter had the difficult task in explaining the future redirection of the subprogram, but did it well. Importantly, the presentation focused on the fact that this meeting was not a conference, but a review of work performed in the last year and project plans for the remainder of the awarded effort.
- The presentation was well done. Accomplishments were featured. Challenges were mentioned.
- I would like to see a breakdown of areas where cost reductions have been achieved, and where they are expected, i.e., percent improvement in membrane, air management, etc. with respect to time. This would show trends in specific areas. It would also be relevant to show what are seen as the largest impediments to meeting goals, in addition to showing the accomplishments. Perhaps a slide showing the relationship between individual tasks and specific, or most important, goals or objectives would illustrate how the balance between activities and relative importance is planned.
- Understandably, the plans for transportation were limited.
- The subprogram area was adequately covered, and important issues were indentified. However, for several of the presentations I attended, progress relative to one year ago was not clearly presented.
- The subprogram was presented with an emphasis on membranes and catalysts, which is somewhat appropriate. It is unfortunate that wide ranges of projects (i.e., plates, water transport, impurities, analytical techniques) were not covered. It should be emphasized that the government's ability to provide fundamental knowledge is also part of helping non-public entities further develop the technology.
- Some of the progress shown for catalysts and membranes was a bit “overhyped” compared to what the results truly are.
- The subprogram was redirected with increased emphasis on stationary fuel cell systems, consumer products, and auxiliary power units (APU). These are important and new challenges. The transportation cost challenge was identified at $45/kW, which is a difficult target. It was not clear what approach would be used to achieve the $45/kW target. Is lower platinum content the key, or a reduction in balance of plant? For balance-of-plant (BOP), the compressor/expander module (CEM) still appears to be a major cost challenge when thermal management, fuel management, water management, and air management are included.
- The review appeared complete. Progress was clearly met with many projects.

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

- The key challenges are reducing cost and improving durability primarily of fuel cell MEA components. The team is heavily centered on these topics. Balance-of-plant (BOP) components are somewhat weak, however. Much of the cost reduction with balance-of-plant can be attributed

to engineering from industry (i.e., not suitable for high-risk DOE funding). Currently, most of the components of BOP are made from expensive stainless steels and pressure fittings. These materials are not suitable for high volume manufacturing. Work is needed to develop cheaper tubing and fittings. Work should be dropped on enthalpy wheels. (They just don't provide enough benefit for the cost.)

- Cost and durability are key for fuel cell commercialization. DTI cost analysis shows steady progress to achieving the cost targets; however, a road map should be discussed showing how that will be achieved to guide research.
- Initial investment on manufacturing equipment needs to be discussed because no company will make heavy capital investment in this field without a future, particularly based on recent comments made by the Secretary of Energy.
- The plans for addressing the existing challenges were presented. It appears that the portfolio is well structured, without gaps.
- The major milestones and future solicitation were identified. Not enough information was presented to judge the future plans or identify gaps in the project portfolio.
- Yes, plans were identified, and there are no gaps.
- Gaps appear to be present if the DOE program shifts emphasis to near-term applications.
- The missing areas were like an “elephant in the room.” We would have asked about them, but the microphones were removed at the relevant sections, and there was no Q&A there either. The collapse of the auto industry also hangs in the air over this. Will anyone build the fuel cell vehicles we are working on? Does anyone want to? Will anyone buy one?
- Plans were presented in a general, high-level roadmap for next several years. Specifics on targets underneath those goals were not noted (i.e., "bipolar plates" is listed, but no cost or technical targets mentioned on slide 7).
- There are significant gaps in DOE's fuel cell portfolio, particularly in the area of durability, which I hoped would be addressed with last year’s solicitation. It is an embarrassment that, over a year after the Funding Opportunity Announcement, the awards have not been announced.
- Several go/no-go decision points are planned designed to move fuel cells into the marketplace. A gap would be inadequate funding for the transportation-specific application, which is a more distant goal. This could cause this objective to move even further out.
- A major gap exists in how the low-cost targets are ultimately to be met. How will projects be taken through the “valley of death,” from lab experiment to commercial production?
- The presenter completely addressed all pertinent areas expected in an overview.
- More information could have been presented on plans for the Hydrogen Program for 2010 and beyond. The next four to five years are critical.
- Additional work on evaluating catalyst performance at low relative humidity is needed.
- Yes.
- Plans were identified at a level of detail appropriate for an overview presentation. Since the main challenges for fuel cells are in materials development, the fuel cell team is pursuing the proper areas of R&D.
- The biggest gap in my mind was absence of medium-temperature fuel cells (160-200°C). This is the sweet spot (from a performance, durability, and cost point of view) for stack operation and integration with a fuel processor to achieve high electrical efficiency.
- Fuel processing for stationary is not clearly defined. Plans for addressing membranes, catalysts, and MEAs are identified but need better rationales for priorities.
- Component-level projects (e.g., MEA, bipolar plates) need to share more information about cost and manufacturability.
- No known gaps in the portfolio.

- Actions for addressing issues and challenges were adequately identified. I was not aware of any gaps in the project portfolio.
- Issues and challenges are being addressed, especially with the re-direction of the program activities.
- The presenter could have spent more time on identifying future issues and challenges for hydrogen fuel cells and how EERE plans to address future such issues and challenges.
- I feel quite comfortable with the Fuel Cell Subprogram, although from only the presentation, it would be difficult to make this assessment. This is the difficulty of trying to represent such a broad subprogram in such a limited setting, and I do not believe it could be significantly improved.
- Yes.
- Plans for addressing challenges are clear. The extent to which these will be relevant, given the possibility of significant shift in mission/goals associated with new administration and new budget, is not clear. Stationary CHP is probably not represented to the extent that it should be to adhere to administration priorities.
- The fuel cell development for vehicles is sound as it is. Considering a weakened automotive industry in the United States, national laboratories like ANL might be granted a more important role in systems development. The strong focus on the fuel cell stack rendered good results. Systems development becomes increasingly important as stack research materializes.
- This is hard to answer at this point; a program redirection and refocus is not yet defined. Rationale for change was laid out. Targets and progress toward them were discussed.
- Yes, plans are OK. However, it was mentioned that a new "roadmap" is being addressed.
- It would be beneficial to show a correlation between the operating constraints and the limitations in applicable fuel cell operations. For example, what are the limitations if a fuel cell operates at a constant condition versus at large load cyclic conditions?
- Analyses of the gains in each of the most critical areas would be very useful. For example, while the performance of the catalysts at BNL show an improvement over platinum (Pt) only, what are the limitations and barriers that have been identified (if they have been identified)? Besides the positive, which is important, what new or different challenges have the results or analyses presented? Not every improvement or advancement is final. This could serve as a yardstick over time.
- The portfolio is appropriate for the current goals relating to hydrogen-fueled fuel cells for transportation.
- There are gaps in the project portfolio (i.e., BOP), but it is difficult for the DOE to find the right parties who can conduct a project in that area without the project being about producing a commercial device.
- In terms of research dollars, plans were shown for addressing issues and challenges, but it is hard to say if DOE has a technical strategy on fuel cell development, which is good to a greater extent. At the moment, both metal- and carbon-based plates are funded, both perfluorinated sulfonic acid (PFSA) and hydrocarbon membranes are funded, both nanoparticle and thin film catalyst designs are funded, and so forth. The plan has been to not eliminate anything before it needs to be eliminated.
- The plans for addressing the challenges for the stack appear to focus on high temperature membranes, but the examples given suggest that sulfonic acid membrane will be used. This would indicate high pressure operation that was shown in the ANL presentation to increase the cost of the CEM. It is not clear how this will be achieved. The durability of the membrane systems (Giner and Case Western Reserve University) was not addressed. Have extended stack evaluations been done with the new membranes? If alternative membranes with phosphoric acid are used, they will demand higher platinum contents on the cathode to compensate for anion adsorption; this topic was not discussed.

- The new program portfolio will need much pruning unless funding is restored. Many current projects (e.g., APUs) clearly fit into the technology-neutral program described by the plenary speaker (Acting Program Manager) on May 18, 2009.

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

- The team is generally well focused. However, as a FreedomCAR program, the team is conducting research on too many stationary or heavy-duty applications. I understand that this team is likely the only "home" for these applications; however, DOE can extract more value from funding light vehicle duty research. Much of what is learned in this field will likely spill over into all the other markets since vehicle-level fuel cells are the most challenging in terms of cost, power density requirements, cycling, etc. Knowledge learned from stationary applications (e.g., SOFCs) will likely find little use in light duty vehicle applications (i.e. FreedomCAR).
- The subprogram is effectively run. A go/no-go decision was made recently on the membranes under the high-temperature program, but the results have not been made public at this time.
- The managing of this portfolio is exemplary. It is a key component of the Hydrogen Program. The subprogram area is pretty focused, well managed, and effective.
- Yes. This subprogram is well managed and covers the required development areas, with the possible exception of changing priorities.
- The subprogram is in complete disarray after telling the researchers they were being zeroed out for the main application they were building towards. Current researchers are trying to redirect. Fuel cell manufacturers no longer have obvious customers. Several previously defunded researchers presented. They were doing what they think is best, but seem to lack direction.
- Yes, addresses all the critical subcomponents.
- The DOE Hydrogen Program R&D needs are not well defined at this time. It is impossible to answer this question without clear understanding of DOE's priority on automotive fuel cell system development.
- The program addresses current needs and is focused on most recent changes in direction in the program (i.e., early market penetration and transportation de-emphasized). The program manager is new, but has many years experience and program appears to be well managed. New direction in program office will require adjustments. Next year, review will be more telling in regard to effectiveness.
- The presentation appeared completely effective.
- Yes. Much progress is being made due to the focused effort.
- No, the current administration is backing off hydrogen. This is a mistake considering how close DOE is to solving many of the critical issues. The program should refocus on hydrogen fuel cells.
- The subprogram was focused, well managed, and effective for FY 2009. Notable materials breakthroughs occurred under their management.
- It appeared very well managed.
- The program is switching targets, so this area seems a little confused at the moment. This area should work with analysis group to sharply define goals and stick with them.
- The subprogram appears to be well managed.
- When there are parallel efforts across several projects, it would be helpful to have some means of side-by-side comparison and/or exchange of information so that each project's relative success can be evaluated on the same metric.
- The Fuel Cell Subprogram is well focused on addressing the key barriers, particularly the durability and cost issues. The subprogram is very well managed.
- The subprogram appears to be adequately managed and effective in addressing the identified needs of DOE Hydrogen Program R&D.

- Yes. The program is very well focused and managed. It is effectively addressing DOE needs. Clear evidence of this can be found in the membrane projects which met DOE's extraordinarily high proton conductivity target of 0.1 S/cm at 120°C and 50% relative humidity. The DOE managers are to be commended for selecting the correct projects and pushing the researchers to achieve a high conductivity.
- Yes, but again this has more to do with this reviewer's knowledge of the Fuel Cell Subprogram and the impact that it has had rather than from information passed along during the plenary session or subprogram overview talk.
- Yes. A number of the projects I reviewed did not appear to fit into the Fuel Cell Subprogram goals well, or it simply was not explained. Also, a number of projects are quite immature given the dates associated with the Subprogram goals.
- Yes. The DOE subprogram is very well managed, focused, and addresses the R&D needs as defined in the program. A major factor is the technologically very knowledgeable staff DOE assigns to this research area.
- Yes, the subprogram continues its history of defining, supporting, and managing relevant work and making demonstrable progress toward challenging goals.
- This R&D plan has been on the roadmap "road" for some years. There have been a few detours, and missed turns, if the "truth were told." However, there has also been considerable success, and the challenge now is to build on that strong result. The DOE team is working on this, and that task will be far easier because things have gone well up to now.
- The coverage seems to address all areas. However, the benefits of the modeling of catalysts and fluid dynamics in water transport and the correlation between advances made in the experiments and preparations and modeling projections is absent. This is an area that needs to be expanded in order to take advantage of the analyses of problems and how we can justify taking risks in areas that may have larger payoff within the current work.
- I think this area is appropriately focused and managed. Effectiveness is varied; several projects in the membrane area seem to be very poor, and those efforts did not improve over the past year. Despite the focus on conductivity-based milestones, it appears that a lot of effort went into characterizing and making fuel cells with polymers that were not sufficiently conductive to be of further interest. Projects in the catalysis area were more effective, I think, in making advances and avoiding wasted effort.
- The subprogram may not appear focused from the perspective of people who believe the DOE research should be delivering a product, but it is focused from the perspective that DOE research should merely be supporting the development of new materials, the acquisition of fundamental knowledge, and the adaptation of new analytical tools.
- At a minimum, DOE is funding topics that are highly relevant. DOE could better manage the approach of each individual project, but the relevance is extremely high.
- It is up to private consumers of DOE research data to develop fuel cell products, not DOE. DOE should not be held accountable for the development of fuel cell products or for the validation of those products and systems.
- The subprogram needs to have a clearer focus on the cost reductions associated with BOP. The catalyst efforts are making progress, but it is still unclear if high temperatures will result in catalyst recrystallization.
- The subprogram area is well managed and addresses DOE R&D needs.

4. Other Comments:

- It is difficult for the industry to plan future activities based on a very unclear 2010 DOE budget/scenario for hydrogen/fuel cells.
- This subprogram has a chance to catalyze the ultimate success of the DOE Hydrogen Program.

- The audience wanted clarity and elaboration of the impact of President's budget on the fuel cell portfolio. Perhaps, this was not possible because of the timing.
- If DOE intends to concentrate on near-term applications, additional technologies require funding (e.g., reformate anode tolerant catalysts, portable power systems, methanol oxidation catalysts). Operating conditions likely shift for stationary applications, making durability measurements difficult due to the length of time.
- If someone in DOE wants continuation of this work, it would be nice to know who, or what for.
- The rapid shift away from hydrogen for transportation applications was well presented.
- I hope we can have more fuel cell sessions at future meetings. The current situation is a "huge mess."
- None—the overview was everything one could expect.
- As indicated by the mention of multiple focus areas in the slides (i.e., stationary, portable, and transportation), FY 2010 will be challenging for everyone. The fuel cell team should communicate effectively with researchers to clarify the current focus for each project and be realistic in what any single project can do simultaneously towards different applications. Trying to do everything at once will likely create poorly focused and useless results. For example, durability projects will need to select one set of Accelerated Stress Tests tailored to either transportation, stationary, or portable demands.
- Thanks for all the hard work. Congratulations.
- The program is in flux at the moment. The best plan is to identify the need, define technical goals, and set programs to attain the goals regardless of changing priorities.
- Availability of funding appears to be the main barrier to accelerating the R&D efforts. The good momentum in the Fuel Cell Subprogram needs to be sustained to achieve targets.
- Skillfully done!
- The projects that are earmarks should continue to be reviewed. Being reviewed helps the PI focus and improves the likelihood of getting something useful out of the project. And, the reviewers' comments can also help steer the projects to get the most "bang for the buck."
- It will be interesting to see how the Fuel Cell Subprogram reconfigures itself, given the redirection from DOE.
- More funding and extended time of funding should be provided to those DOE-EERE fuel cell projects that have been highly successful in meeting/exceeding the DOE performance targets.
- Presentation did what it needed to do, in that it provided a clear introduction to the session and a general overview of the subprogram. More information on the future plans/budget based on component/approach would have been useful to the extent that it is understood.
- Given the tremendous progress made toward viable, light-duty transportation under this subprogram, and the long-term promise of sustainable transportation for which we have precious few alternatives, I would hope that the transportation focus is not entirely lost as the program is redirected and refocused.
- Of course, it is hard to project what is in store with the new administration.
- The DOE program on fuel cells is a long-term effort that has produced a lot of progress towards creating systems that avoid the use of foreign oil, that do not emit greenhouse gases, and that use energy more efficiently than thermally-limited conversion processes. A lot of great work has been done over the past 20 to 25 years in PEM fuel cells, and future generations will profit from it greatly. Not all the benefits (in fact, hardly any) of this program have yet been realized in commercial products, but given commercial delivery timelines, that is to be expected. The benefits, however, will be realized in the fullness of time.
- Overall, the recognition of the early, pre-automotive applications should be beneficial. The key issue appears to be the increase in temperature and its effect on the BOP.

Systems Analysis Subprogram Comments

1. **Was the Subprogram 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 Subprogram if appropriate.)**

- Year-to-year progress and direction, issues, and challenges were all very clearly explained. The subprogram was well covered and issues identified. The presentation was well laid out to convey the needed information.
- Good discussion of program objectives with highlights of 2013, 2014, and 2015 programmatic goals and objectives. Early emphasis on stationary electrical generation in using the Macro-System Model was followed by environmental studies and resource requirements. The manager provided a breakdown of subprogram tasks on studies and analysis, development of models, support functions, and systems integration. A good balance of support was found within these areas with a major emphasis on evaluating synergies of integrating transportation and stationary fuel cell systems and barriers to implementing these strategies. Primary issues and challenges identified included inconsistency of existing data, market complexities, and assumptions. A good presentation was given on past analysis priorities and transition to current focus on incorporating stationary fuel cell systems with transportation needs and the potential to implement distributed hydrogen generation at stationery fuel cell sites.
- A clear flowchart was presented showing various domains of work and the interplay between them. Crisp targets and milestones.
- Various issues related to the transition to a hydrogen economy were identified and approaches were evaluated; useful new insights were gained.
- The subprogram was very well represented, as were important issues and challenges. Progress was clearly shown in comparison to the previous year.
- The area was covered, but perhaps needed to be prioritized better. Lots of different factors were discussed for both stationary and vehicle uses, but each application has different technical requirements. This made identification of the important issues and challenges difficult. Simplify the message to get everyone on board. Progress was shown, but it was not clear from where and to where.
- The Analysis Subprogram covers a very broad range of activities, and these were adequately covered in the review. Significant progress was presented in developing new models and methods and providing a consistent set of analysis tools. Significant new results were adequately presented.
- Model/tool development needs were addressed, as well as progress in developing tools to analyze various impacts (environmental, economic, cost, etc.).
- The coverage was excellent. There was a lot of material, but it was covered in a timely and clear manner. The speaker did an excellent job.

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

- The Systems Analysis Subprogram seems to assume a pervasive hydrogen infrastructure based on dominance of the hydrogen car. While the subprogram and the associated projects address this scenario very well, they do not seem to consider the case of a more limited deployment of hydrogen cars sharing the road with electric vehicles.
- The project portfolio should include assessments of distribution and use profiles consistent with what this reviewer believes to be the most likely future: a large numbers of electric cars, a grid

that supports them, and hydrogen competing with fossil fuels in certain markets less suited to electric cars.
- Setting cars aside, there is a huge existing market for hydrogen in industrial processes. Central hydrogen generation scenarios should focus on refinery and agricultural uses of hydrogen.
- It is not clear how the overall analysis can be validated and verified to be accurate. This was briefly mentioned (e.g., data inconsistency), but how it was to be overcome was not clearly addressed.
- Good presentation of future plans to address issues associated with co-production of hydrogen at stationary fuel cell sites. New tasks were brought on board to address the impact that a transition to a hydrogen economy would have on job creation. Also, an analysis was conducted to show the impact future government funding would have to accelerate the deployment of fuel cells. A shortfall still appears to exist on bringing the cost of stationary fuel systems down in spite of accelerated government expenditures—$40-55B in government expenditures to introduce two million FCVs. This is a rather expensive subsidy of FCVs; at $20,000 per vehicle, this is a large gap. (DOE note: Reviewers assumptions were incorrect. Government expenditures of $55B were for ~5.5M vehicles by 2023.)
- The project portfolio is quite diverse and covers most of the related aspects of hydrogen infrastructure development and its implications. There are a lot of useful tools for use by industry and academia to assess intended and unintended impacts.
- Plans where identified for future improvements, although some projects seemed to be anticipating little or no funding in FY 2010.
- Plans are given but, again, it is difficult to see where the priorities lie. The Analysis Subprogram should provide the information with which to formulate policy, but this is all over the map. I am not aware of any significant gaps in the portfolio of projects.
- It is not clear that overall energy models such as the National Energy Modeling System (NEMS) and the MARKet ALlocation) Model (MARKAL) adequately include the potential impact of hydrogen technologies. Efforts to (more appropriately) incorporate hydrogen technologies into these models should be considered.
- The plans were well identified with no obvious gaps.

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

- It is well focused and managed with respect to the DOE Hydrogen Program R&D needs; I suggest in my answer to Question #2 that the program might consider the possibility of hydrogen not being the dominant transportation fuel.
- Yes. Connecting all the analytical tools will be important to make them all useful.
- The subprogram appears to be well managed although, from a perspective of a novice in hydrogen analysis, it is difficult to understand the relationship between the 17 different models under development.
- The program is instrumental in assessing the overall progress in the DOE Hydrogen Program. It is very well managed with focus on delivery and cross-interaction with various technology areas. The subprogram seems to be well focused.
- No. It seems to be addressing everything and needs to be divided into clearer subsections so that the analysis presents clear options for policy decisions.
- The Analysis Subprogram is very well managed, considering the broad spectrum of tools being developed and analyses being conducted.
- The development of a suite of tools has progressed logically, and current focus on the potential impact of various government policies is appropriate.
- It appears to be focused and effective. There is no basis for a judgment of management.

4. Other Comments:

- There may be duplication of effort between AN-13 and AN-14.
- Keeping the information up-to-date might be a challenge.
- The Systems Analysis Subprogram, in general, plays a critical role of putting hydrogen and fuel cell R&D programs into perspective and shows a path to how it can be deployed successfully in the marketplace. DOE should continue funding this program.
- This is a critical activity for DOE. Whether or not there should be a hydrogen economy is still being debated and is not a settled issue. Many projects would benefit by directly asking the questions, "Is hydrogen the fastest way to bring renewable energy into the market?" and "Is hydrogen the ultimate solution for a renewable energy future?"
- The switch to stationary and early market applications is clearly causing problems. The stationary aspects need to be assessed against competing technologies such as redox flow batteries, which are much more efficient.
- The results of the environmental modeling of a transition to a hydrogen economy suggest that there are no major problems with even the most successful hydrogen penetration scenarios. If so, future work on the fine details may be of lesser importance and could be wrapped up, if necessary, under tight budget constraints.
- It would have seemed appropriate to have at least mentioned the possible effects of the budget request.

Manufacturing R&D Subprogram Comments

1. Was the Subprogram 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 Subprogram if appropriate.)

- This subprogram area was adequately covered. Important issues and challenges have been identified, and good progress is evident.
- Yes to all of the above questions.
- Great to see the challenge of growing a domestic supplier base addressed.
- The subprogram was adequately covered, and issues and challenges were identified. A more thorough comparison with the previous year could have been presented.
- Good overview of the subprogram.
- This presentation failed to highlight two key requirements of managing a manufacturing portfolio:
    - What are the key gaps that must be closed to make fuel cell manufacturing viable? Where are the bottlenecks that drive cost, quality, and/ or flexibility of a process? What benchmarks are you aiming for?
    - What is the long-term viability of a process?
- Once the gaps have been identified, what processes are specific to a particular material or technology? Can that translate to future or similar processes? Fuel cell technology is fast moving and changing. The subprogram must exercise judgment to identify processes that will carry through all the iterations of a technology.
- The overview presentation was poorly prepared and delivered. Only a very brief description of the program was given. Little attention was paid to the critical technologies required and challenges needing to be addressed and overcome.

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

- Plans for addressing issues and challenges were appropriately covered, and there were no significant gaps in the project portfolio.
- Most focus seems to be on fuel cell components. Some additional focus on manufacturing of infrastructure manufacturing might be helpful including high pressure components for gas compression, dispensing systems, and metering.
- See above (question 1).
- Critical challenges were not clearly elucidated, and no plans for addressing challenges were offered.
- There appears to be no element related to the stack assembly process. Are there other projects looking at robotics, assembly line design, or other critical cost elements for stack (and system) assembly that would lead up to the 2013 goal?

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

- The subprogram is well focused, well managed, and effective in supporting the R&D challenges and goals.
- The subprogram has elements that address the stated goals for reducing the barriers to commercialization in cost reduction, quality control, and production improvements.
- The subprogram area appears to be focused, well managed, and effective in addressing the DOE Hydrogen Program R&D needs, with one exception—in general, the assessment of potential cost reductions needs to occur earlier in many of the individual projects.
- The DOE team appears to be doing a great job.
- The subprogram does not appear to be focused. (See reasons above.) They seem to be working on projects that were submitted to them without first having taken a holistic view of the entire value chain.
- This is a relatively small subprogram with a tremendous array of challenges that need to be addressed. Yet, it can only address a small number of the challenges in reducing manufacturing cost and increasing quality. These results, in a segmented program with little focus, are not the fault of subprogram management.

4. Other Comments:

- Development of the technologies required to reduce manufacturing costs will minimally impact the commercial application of these technologies in an environment where competing energy technologies are cost competitive.
- Assessment of manufacturing readiness levels for low rate initial production is an important tool in aiding industry stakeholders in marketing strategies.