

Project # AN: Systems Analysis*Fred Joseck; AN***Degree to which the Sub-Program area was adequately covered and/or summarized**

- Well. Goals of Sub-Program were clearly explained, as were projects that were funded to address each goal. History of the sub-program was also clearly explained.
- Sub-program was well addressed, but it would be good to include a chart showing the relationship of all analysis projects.
- Overall, Mr. Joseck provided an excellent summary of his sub-program, which encompasses a diverse set of projects that supports the entire hydrogen program.
- An easy-to-grasp overview was provided for the FY 2008/2009 budget.
- The "Analysis Portfolio" slide assisted significantly in understanding of the major program elements. The "Systems Analysis Progress" slide and discussion were most helpful in briefly conveying the history and evolution of the sub-program.

Were important problem/issue areas and challenges identified/discussed, including plans for addressing these items in the future?

- Yes, challenges identified included analyzing transition scenarios and modeling potential impacts on existing infrastructures (e.g. water, electricity, NG, petroleum).
- Issues have been identified and as funding is available, they are being addressed.
- The description/discussion of issues and challenges was too brief and general.
- There was insufficient attention devoted to how the work being done in the sub-program is addressing the complex challenges and resolving the issues associated with model integration, policy impacts, etc.

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

- Yes, there is a clear focus on the problems of analyzing benefits of hydrogen technology vs. costs, as well as analyzing transition issues, including impacts on existing infrastructures (fuel, water, electricity).
- Subprogram has well thought out progression from identifying issues to policies.
- Accomplishments cited and the discussion of future plans conveyed a sense that good progress is being made in achieving analysis that is better integrated, focused, and relevant for making program decisions.
- During the past year, there seems to be progress in getting more benefit from the Systems Analysis budget. Results of activities such as the transition scenario analyses are being communicated and disseminated so as to assist organizations and decision-makers outside DOE as well.

Other comments:

- Mr. Joseck's sub-program is funding a number of outstanding analysts and modeling initiatives. Significant attention must be devoted to assuring that communication among the various project performers is sufficient and productive. The challenge in accomplishing this is particularly acute in the management of analytical projects other than those being conducted by DOE's national laboratory teams.
- It is recommended that more attention be paid to analyzing viability of potential competing technologies, including plug-in hybrids, advanced ICE (e.g. HCCI running on CNG, DME, Methanol, etc.). Also, it is recommended potential ways in which hydrogen-based transportation fueling infrastructure might be preferable to alternatives like electric battery vehicles or plug-in hybrids, or widespread use of biofuels be evaluated. Hydrogen might have advantages in terms of efficiency of turning feedstock energy into useable transportation energy, for example.

Project # FC: Fuel Cells

Nancy Garland; FC

Degree to which the Sub-Program area was adequately covered and/or summarized

- Fuel Cell subprogram area was covered adequately.
- The program was very well-covered this year. There were about 60% more oral presentations than in the past. I was impressed.
- Comprehensive presentation of the goals, the work, the achievements and the plans was given as well as allocation of money to the various fields

Were important problem/issue areas and challenges identified/discussed, including plans for addressing these items in the future?

- Programmatic problems, challenges, and solutions were discussed in wrap-up sessions.
- Problem areas were discussed. Reviewers were not shy about asking questions.
- Issues and challenges were well-addressed.
- Plans for future listed areas of work in sufficient detail.

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

- With the exception of the earmark projects, the program focusses effectively to meet DOE H₂ program needs.
- Yes, it does. The sub-program does need to shift greater emphasis to catalysts (over membranes), but the recent solicitation indicates that this is understood.
- Simply and clearly: YES!

Other comments:

- Significant efforts on some projects are focussing on meeting interim targets, sometimes with the Pis employing approaches that are not likely to meet long term targets. I would recommend downplaying the interim targets if not part of primary path to meet final targets.
- The general goals are addressing consumer electronics as well.
- There was no presentation concerning that; if this is true and the program is focusing on automotive and stationary this would be good.
- Maybe DOE can think about Fuel Cells for aeronautic applications (reducing CO₂ and other emissions from air transport is a big issue in Europe).
- In general: another well-prepared and well-run Review Meeting - Congratulations!

Project # MF: Manufacturing*Pete Devlin; MF***Degree to which the Sub-Program area was adequately covered and/or summarized**

- Manufacturing R&D sub-program addresses the manufacturing issues to achieve the cost targets of mobile and stationary fuel cells and storage systems. It was very well summarized. Critical focus areas were described clearly. Ties between manufacturing and market transformation were also covered adequately. It was also very clearly stated that one of the important objectives of the sub-program is to enable the growth of the domestic supplier network. This issue should always be in the forefront of the discussions related to priorities associated with the U.S. hydrogen programs.

Were important problem/issue areas and challenges identified/discussed, including plans for addressing these items in the future?

- Critical problems areas are clearly and well identified. The timelines for accomplishing critical milestones toward achieving cost targets were presented.

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

- The sub-program area is very focused and well-managed. It is the critical component of the DOE Hydrogen Program R&D needs. It was disappointing to hear that there was no allocation for this area in the FY 2009 budget request. Using Manufacturing Readiness Levels to assess current and future technologies is a very effective tool in managing this area.

Project # PD: Production and Delivery

Monterey Gardiner; PD

Degree to which the Sub-Program area was adequately covered and/or summarized

- Excellent overview! This briefing was at the right level for the AMR.
- The program was summarized satisfactorily via barriers and funding proportions but it could have highlighted the specific projects that were funded.

Were important problem/issue areas and challenges identified/discussed, including plans for addressing these items in the future?

- Issues, priorities and plans were well covered and put the subprogram into perspective.
- Issues were addressed but future plans were not addressed.

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

- Distribution of funds appears to be well aligned with barriers and priorities.
- The sub-program seems to be reasonably focused but there seems to be too much emphasis on hydrogen liquefaction.

Other comments:

- Great to have an enthusiastic manager presenting the subprogram.

Project # SA: Safety, Codes, & Standards*Antonio Ruiz; SA***Degree to which the Sub-Program area was adequately covered and/or summarized**

- The description is well-balanced and clear with well-justified actions.
- A list of projects and their focus would be helpful in clarifying the effective Sub-program actions.

Were important problem/issue areas and challenges identified/discussed, including plans for addressing these items in the future?

- The key issues are identified well and presented with synthetic but clear actions to address them.
- Plans present acceptable actions for future Sub-program implementation.
- The Global Technical Regulation (GTR) effort is not clearly stressed.
- In the past, with limited or standing funding, the emphasis and efforts on the Global Technical Regulation were better motivated and described.

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

- The Sub-program is well managed with clear vision of the necessary actions to meet DOE needs and address DOE barriers.
- The collaborations with other sub-programs must be improved due to the cross-cutting nature of the Safety, Codes and Standards activities.
- The international activities require better specification.

Other comments:

- The use of prenormative research occurring in other sub-programs (FC, TV, ST) should be used more to levelize funding and synergistically integrate resources and expertise.

Project # ST: Hydrogen Storage

Sunita Satyapal

Degree to which the Sub-Program area was adequately covered and/or summarized

- The overall Storage Program effort was covered well given the short time allowed. The presenter assumed everyone in the audience was totally familiar with the program and that may not be true. More time could have been spent to explain and review the slide that shows the program organization relative to the CoEs, independent projects, etc. It was not clear if the program had any prioritization among the three areas of sorption, chemical hydrogen storage, and metal hydride materials. That left one to assume the program believes all three have an equal chance of success and should be funded at about the same level.
- Program was very well summarized. The shown graphs and plots will once again be used as a "master plot" for other world-wide research activities, as previous slides from earlier reviews have been already widely cited and copied.
- Excellent, concise summary by DOE. All the key sub-program elements and issues were adequately addressed.
- Good placement of emphasis on what the storage targets really mean and on the fact that the storage capacity targets are not the only ones that matter.
- The progress chart showing where systems are with respect to the temperature and gravimetric targets has great value. Perhaps we need one like that for volumetric storage versus temperature and another for kinetics versus temperature.
- Sub-Program was covered in the program plenary session and the storage technical session review. However, a copy of hydrogen storage session review was not available.
- Clear and complete, challenges noted but congratulations on progress both technical and administrative [are] offered.
- The Team leader delivered a comprehensive snapshot of the current state of the storage subprogram while also discussing its strategy, technical goals, and highlighting main achievements and future directions. Quite an achievement given the timeframe of the presentation. An excellent overview putting this subprogram in perspective.
- The coverage was appropriate in terms of annual progress and the future work.
- Great overview of project organization, challenges, key accomplishments, and targets. Charts were easy to understand from the back of the large room.
- DOE targets were highlighted, with the important challenge that all targets need to be met simultaneously.

Were important problem/issue areas and challenges identified/discussed, including plans for addressing these items in the future?

- The presentation did a good job of reviewing the storage program targets and key challenges. The emphasis was on the gravimetric and volumetric capacity targets and some of the other important targets only got a quick mention. In particular the cost target should also have been emphasized since it is perhaps the toughest target and should not be neglected.
- All important issue areas have been discussed and future plans to address them have been mentioned.
- It was once again important to remind the scientific community to the fact, that DOE targets are SYSTEM targets. As there are so many examples out there, where the target are misinterpreted or incorrectly cited. Additionally, it was important to mention that DOE targets not only consist of gravimetric and volumetric densities. Hydrogen capacity versus operating temperature is also one of the most important key graphs for the whole storage project.
- Another very comprehensive is the slide of the progress of the storage densities over the last years.
- This was done in sufficient detail to highlight the major issues.
- If the truth be told, none of the CoEs, independent projects, etc. that comprise the Hydrogen Storage Sub-Program is comfortably close to meeting all the "system" targets by December of 2010 which is only 30 months away.

- Yes. Problem of DOE targets referring to systems rather than materials has been addressed and emphasized.
- Yes, plus the downselect process.
- Important issues, persisting problem areas, and challenges facing the storage activities were clearly identified and discussed within the time constraints of the presentation. Main accomplishments were also highlighted and attention was drawn to research gaps and future R&D directions.
- There was adequate identification.
- Material Capacity versus temperature plot was very informative. It highlights the importance of systems integration, and not just material capacity.
- Progress towards DOE targets was shown. Progress towards meeting the volumetric requirement seems to be lagging, and was acknowledged.

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

- The Storage program is outstanding and very well managed. There are two aspects of the program that could be looked at: (1) It appears that the DOE is providing about equal funding to each of the three routes being researched, Sorption, Chemical Carriers, and Metal Hydrides. Based on the information that has been generated by this program and other researchers, it might be appropriate to de-emphasize metal hydrides and carbon based sorption options at this point in time. This would enable greater funding of the other sorption systems and the best chemical carrier systems and/or other parts of the DOE Hydrogen and Fuel Cell Program. (2) If a material solution is not found, it appears that high-pressure cold hydrogen gas or perhaps supercritical hydrogen is the best alternative. There is very little funding within the Storage Program that would lower the cost and improve the performance of these approaches. It may be appropriate to significantly increase the funding for these approaches. This may need to include research to reduce the cost of the carbon fiber needed for high-pressure tanks.
- The Sub-Program is focused very well. Especially, this has been impressively shown by the down-selection process of different storage technologies, which will not fit the DOE targets.
- The sub-program is very well managed. The team in that office always looks very tired. They really are working hard.
- The CoEs are equally well organized and managed. The CoE overviews were very well orchestrated and got positive messages across. The down selecting done by two of the CoEs was much needed and was done reasonably well. I would have set the bar a bit higher, e.g., >9 wt.% H instead of >6 wt.% H. The Hydrogen Sorption CoE didn't do much down selecting-- if they had, just about all of the systems they are studying would have fallen by the wayside.
- Yes. Making the hard choices needed to make good progress. Offering help to all researchers as well.
- The storage sub-program is efficiently managed and sharply focused on technical targets. It has a robust portfolio, responsive to R&D needs, getting more refined, and constantly evolving in the right direction.
- This is a very difficult technical field. In short there is room for improvement in this area. So the sub-program could use a strategic revision as well as tactical improvements. Of course considering the remaining length of the program, the options are limited.
- The project seems clearly focused on finding storage technologies that meet DOE targets both on-board and off-board vehicles. It was evident from the presentation that there is a well managed down selection process for storage technologies.

Other comments:

- What I call back-of-the-envelope calculations can show that many of the single materials and composite embodiments under study in the sub-program right now have no chance of meeting one of or in many cases either of the 2010 capacity targets. In a system context, it will almost always be the case that the system will add amounts of weight and volume roughly equal to the fully charged storage material by itself. The word "system" as used in the description of the targets has put the matter of agreeing on an acceptable material capacity in a broad gray area. Proposers recognize that the targets are system based up front in their proposals then claim success when they achieve material capacities equivalent

APPENDIX E: SUBPROGRAM EVALUATIONS

to the system targets. More simply said, a material or composite structure better achieve 9 wt.% H to be put on the table for system development. Then of course there's all the other targets.

- Reviewed what was wanted of reviewers as well, and why it was important, plus allied work audience might care about.
- It appears that hydrogen storage will be part of a long-term national research portfolio. This program is/was a first step. As part of the lesson-learned efforts, technically and strategically, it is imperative to start a self-critical analysis of the effectiveness, progress, and the methodology for future research program portfolio design.
- (i) It is important to further encourage strong cross-CoE interactions and closer collaborations to address commonalities, avoid duplication of efforts, particularly in cross-cutting issues, and optimise use of resources. An example - the aerogel work: need to share experiences between the MH and the Sorbents CoEs. (ii) Ensure that there is a continuous interaction of the materials CoEs with the soon to be established Engineering CoE - this very point could also be considered as one of the performance indicators for the materials CoE.

Project # TV: Technology Validation*John Garbak; TV***Degree to which the Sub-Program area was adequately covered and/or summarized**

- Good overview; however, there was not a good picture of all the projects funded and how they related to each other.
- Mr. Garbak provided an excellent overview of the Technology Validation sub-program during the opening plenary session on June 9.
- The overview was repeated in opening the Technology Validation session on June 10. It would have been preferable to use this opportunity to convey more details of sub-program history, evolution, highlights, accomplishments, results and plans.
- An easy-to-grasp overview was provided for the FY 2008/2009 budget and budget request.

Were important problem/issue areas and challenges identified/discussed, including plans for addressing these items in the future?

- The most important issue of fuel cell life was discussed.
- On June 10, the description/discussion of issues and challenges was too brief and general.
- There was insufficient discussion devoted to how the sub-program's activities, plans and initiatives are addressing the challenges and resolving the issues, both those within the sub-program and those related to the overall hydrogen program.

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

- Sub-program is certainly well focussed on validation of the technologies that have been developed.
- It would be beneficial to show/discuss what is being learned from the infrastructure and vehicle demonstrations and how this is being fed back into the HFCIT R&D Program.
- This important and well-funded sub-program is getting good results for the expenditures being made. However, this conclusion is not the result of the brief overview provided by Mr. Garbak at the opening of the session, but more by the project presentations delivered throughout the day.
- During the coming year, the projects other than the four major automotive/energy company projects should be objectively scrutinized to better understand their potential for contributing to achieving hydrogen program goals and targets.