

2007

**Safety and Codes & Standards****Summary of Annual Merit Review Safety and Codes & Standards Subprogram****Summary of Reviewer Comments on Safety and Codes & Standards Subprogram:**

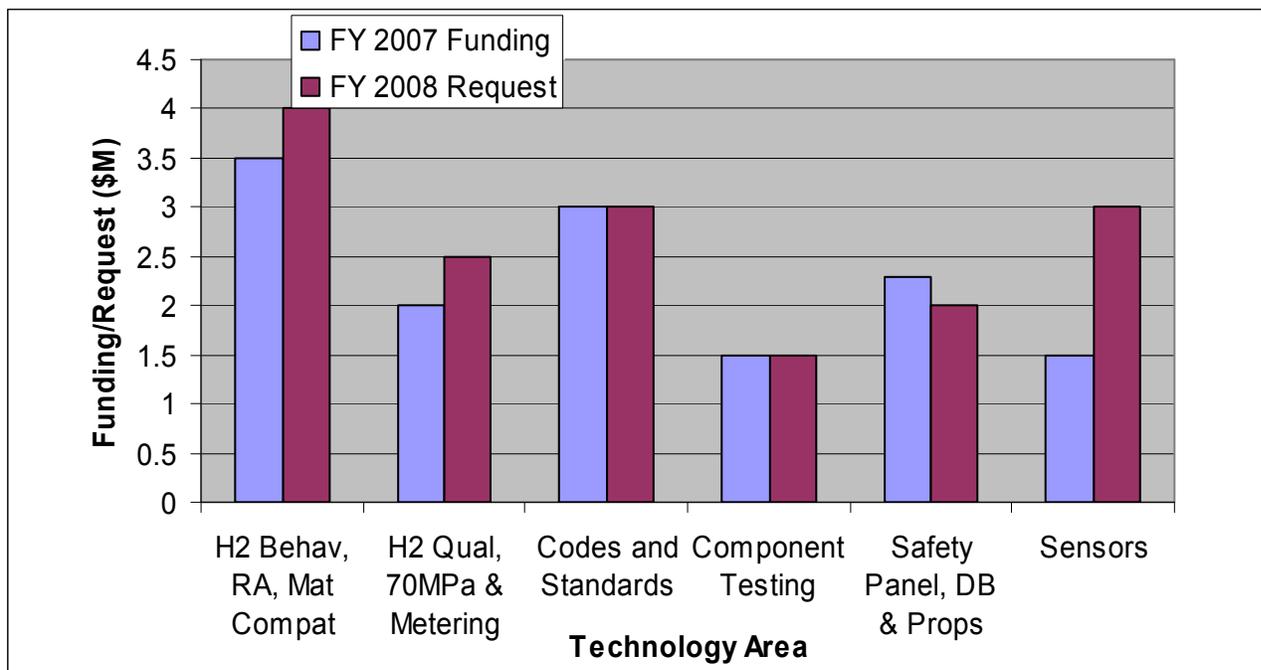
In general, Safety and Codes and Standards Subprogram reviewers stated that projects were productive and successful. The Reviewers were impressed by the breadth of activities and the ongoing commitment to safety, codes, standards and information-sharing activities. They stressed that successes in this subprogram touch every other DOE hydrogen-related activity by fostering acceptance, collaboration and communication with critical stakeholders.

Reviewers stressed the importance of continuing efforts in critical areas such as hydrogen materials research, hydrogen codes, standards and permitting materials coordination efforts, hydrogen quality, and safety incident reporting and best practices. Suggestions for maximizing progress included leveraging the efforts of universities, standards organizations, national labs, complementary government agencies, and industry.

Six safety projects were reviewed. The Hydrogen Materials Research and Development project is focused on materials research to support the development of technically sound codes and standards to ensure the safe design of infrastructure for the storage and transport of high-pressure hydrogen gas. The project was praised for excellent collaboration with industry and SDOs and CDOs. Reviewers noted that the public availability of the data obtained from this project was especially invaluable. It was suggested that new materials should be tested and system-level as well as component level tests should be explored. The Hydrogen Incident Reporting Database and Hydrogen Safety Best Practices Website were considered to be valuable tools for the future implementation of hydrogen infrastructure. More interaction with other safety organizations and a careful examination of the scope of the best practices website were encouraged. The Hydrogen Codes, Standards, and Permitting Materials work was praised for its varied engagement with industry, government, and researchers, particularly national laboratories. It was noted that hydrogen codes and standards work could benefit from greater focus in the future. However, hydrogen fueling station permitting activities were seen as progressing well. Hydrogen quality work was praised for its strong collaboration with a broad spectrum of stakeholders worldwide. Some reviewers pointed out the need to generate data in a timely manner and to work more with SAE and with state hydrogen programs. The Hydrogen Safety Panel was regarded as a strong concept with qualified membership. Fostering the collaboration and communication of safety experts has helped to promote and ensure safety across hydrogen-related projects. The number of safety plans reviewed was considered impressive. It was recommended, however, that Panel membership be rotated to disseminate knowledge and broaden the experience represented on the Panel. The final Safety, Codes and Standards project on intelligent optical sensors, however, received lower than average reviews. Although the project was deemed relevant to DOE program goals, the project may have difficulty overcoming technical barriers and could benefit from outside collaboration and a commercialization plan.

**Safety and Codes & Standards Funding:**

Safety and Codes and Standards funding includes international activities as well as national development and coordination among several agencies. While funding had been a major concern in previous years, this fiscal year, the subprogram received full funding. In particular, progress in the area of hydrogen quality was considered a consequence of increased funding over last year.



### **Majority of Reviewer Comments and Recommendations:**

Subprogram scores were average to high, with an overall average of 3.3. Reviewers also indicated that the Safety Panel has a range of high quality representatives but the Panel should rotate its membership to stay fresh. The overall progress on Materials R&D was seen as impressive.

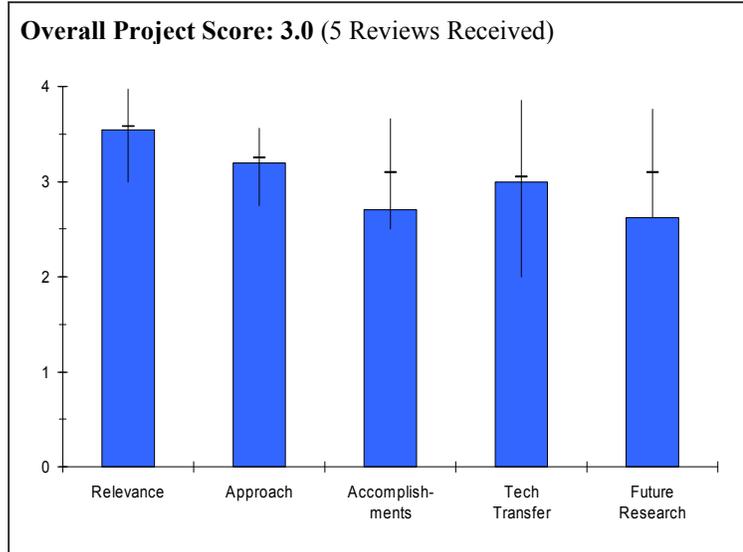
Because the Program received full funding this year, the distress over budget cuts that was seen in previous years was pleasantly absent.

Recommendations included:

- Expansion of the set of materials tested under the Materials R&D activity.
- Expansion of data generation for hydrogen quality work; ensure coordination with ANL's hydrogen quality working group.
- Increase collaboration with regulatory agencies, CDOs and SDOs, professional groups, and other federal agencies for the Hydrogen Best Practices Manual and Incident Reporting Database.

**Project # SA-01: Codes, Standards and Permitting Materials***Jim Ohi; NREL***Brief Summary of Project**

In this project, the National Renewable Energy Laboratory is working to implement a consensus national agenda on domestic and international codes and standards for hydrogen systems in commercial, residential, and transportation applications; facilitate permitting of retail hydrogen fueling stations in the U.S. through education and outreach to state/local code officials; establish requirements for hydrogen codes and standards based on scientific data, modeling and analysis; and enhance DOE's role in the development of International Standards Organization (ISO) and other international standards; and strengthen consistent and sustained representation by U.S. government and industry at international standards forums. This will be accomplished by bringing together experts to address key issues, coordinating collaborative national and international efforts between government and industry, and by serving as the central point of contact for up-to-date information on codes and standards activities.

**Question 1: Relevance to overall DOE objectives**

This project earned a score of **3.5** for its relevance to DOE objectives.

- The project is critical to safety and safe deployment of the hydrogen economy.
- Safety is critical to commercialization.
- There is some overlap between some of the groups sponsored under the codes and standards activities.
- There is some overlap with DOT activities in vehicle safety.
- The C&S effort is always looked at as being a building block for the hydrogen economy.
- Safety, codes and standards will be necessary for a smooth transition to a hydrogen economy.
- National Template is a good initiative to coordinate OEMs.
- This project is highly relevant, if not critical, to the success of the Hydrogen Fuel Initiative.

**Question 2: Approach to performing the research and development**

This project was rated **3.2** on its approach.

- The project identifies research gaps.
- The project facilitates research programs and partnerships between national laboratories, industry, and government.
- The project in some ways focuses not so much on technical barriers as on policy or harmonization barriers.
- The project has an overall plan that it is following. This is a difficult and multifaceted topic which needs a plan that spans years.
- Wide-ranging approach requires strong management
- Good approach to R&D.
- A R&D timeline needs to be presented.
- The approach on hydrogen fueling stations appears sound and was presented in sufficient detail.

**Question 3: Technical accomplishments and progress toward project and DOE goals**

This project was rated **2.7** based on accomplishments.

- Facilitates coordination between Codes and Standards Development Organizations through FreedomCAR, Hydrogen and Fuel Cell National Coordinating Committee, Hydrogen Safety Panel.
- Progress has been good in this area and has come a long way over the last few years. Good progress this past year as well.
- Progress on using composite vessels in DOT and ASME applications is continuing to lag, but it looks like there is a lot of effort on tanks this next year.
- Accomplishments and progress lack depth.
- Good progress relating to hydrogen compatibility.
- Need to work also with state agencies relating to familiarity.
- Very good progress on HFS work.

**Question 4: Technology transfer/collaborations with industry, universities and other laboratories**

This project was rated **3.0** for technology transfer and collaboration.

- Close coordination particularly among national laboratories.
- The project interfaces with multiple organizations.
- Drop testing needs to be validated.

**Question 5: Approach to and relevance of proposed future research**

This project was rated **2.6** for proposed future work.

- This effort is more of a forum for sharing information and collaborating on research planning, but not on research supporting all codes and standards activities.
- Future component work seems very focused on tanks, hopefully not to the detriment of other important pieces.
- Future direction is lacking in focus.
- Not very descriptive related to proposed future research.
- Are these the critical items that need to be addressed in the next year?

**Strengths and weaknesses**

Strengths

- Large number of participants, cross-cutting industry, government, researchers
- Project is providing overall path for C&S activity to monitor and identify areas that need assistance. The PI is knowledgeable about the effort.
- Important topic, engaging industry.
- An experienced team.

Weaknesses

- Some overlap between subgroups, and Standard Development Organizations working independently anyway.
- The project can only influence rather than drive standards process.
- Program is lacking in focus.
- Substantial goals or milestones are lacking.
- Need to engage the right stakeholders.
- Choice of words for describing.
- Very ISO focused.

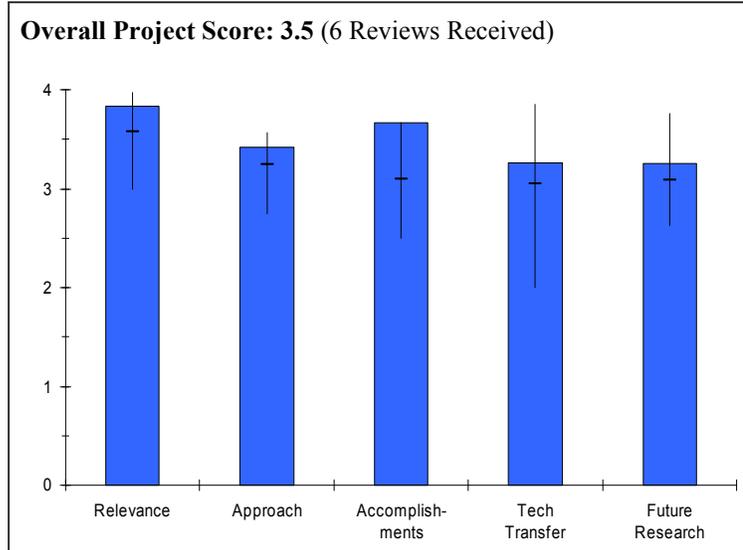
- Slide 3, Approach: Program Structure, should be updated to more appropriately reflect safety portion of the overall program.
- This project covers a lot of ground with many facets and interactions with other parties, but I did not get a sense of what the critical areas that require attention/action over the next year are, for example. Consider approaching the presentation in 2008 in this manner.
- Provide all slides to reviewers prior to the meeting. I was surprised to be reviewing a second part to the presentation.

**Specific recommendations and additions or deletions to the work scope**

- None. The scope may be too broad at this time, but better to have some overlap and a broad scope if resources permit during this developmental stage.
- Provide funding to industry partners to accelerate standards development, improve quality, and increase efficiency of process. These standards processes are on a volunteer basis and it takes years due to infrequent/inconsistent activity.
- The project could help resolve internal differences within different divisions of DOT (e.g., NHTSA/PHMSA) with respect to the use of composite vessels.
- Focus on a study for hydrogen release while engaging industry expenses.
- Help direct NCMS projects related.
- Review future work plans with Tech Team before implementation.
- I suggest developing a pictorial representation(s) of the material shown on the slide entitled Technical Progress: Information Repository Concept. I found the slide difficult to follow.

**Project # SA-02: Hydrogen Materials R&D***Brian Somerday; SNL***Brief Summary of Project**

To ensure safe design of structures for storage and transport of high-pressure hydrogen gas, this project is focused on acquiring material property data that reflects service conditions. Sandia National Laboratories will identify and document existing data on hydrogen compatibility of materials from technical journals and reports, and then generate new data through materials testing, emphasizing testing in high-pressure hydrogen gas. The project provides advocacy and technical support for the codes and standards change process.

**Question 1: Relevance to overall DOE objectives**

This project earned a score of **3.8** for its relevance to DOE objectives.

- Materials compatibility data are needed for deployment of infrastructure.
- This is the basic information that is required to roll out the technology to support the hydrogen economy. This work will not be funded privately, and if it were, would be proprietary.
- Materials compatibility is key to safety and the implementation of codes and standards.
- Very relevant program for Codes and Standards.
- Very important project for accomplishing the Hydrogen vision.
- This project is highly relevant to the success of the Hydrogen Fuel Initiative.

**Question 2: Approach to performing the research and development**

This project was rated **3.4** on its approach.

- Sharply focused on testing.
- Sharply focused on providing comprehensive technical reference.
- The approach is excellent and the Tech Reference guide is an excellent resource and repository of information.
- Good involvement of SDOs and industry for testing.
- Good approach relating to initial work.
- Approach is good, but should also consider composites, low carbon steels, and other materials beyond stainless, copper, and aluminum.
- The overall approach is very sound, combining experimental work, collaboration with "external" groups such as ASME and collaboration with "internal" groups such as the DOE Pipeline Working Group.
- An excellent approach for making information available more broadly through the web-based technical reference.

**Question 3: Technical accomplishments and progress toward project and DOE goals**

This project was rated **3.7** based on accomplishments.

- Completed volume 1 of Technical Reference.
- Completed a lot of testing.

- Generated benchmark cracking thresholds.
- Developed test robust procedures.
- Progress could be faster, but the project speed is understandable. The progress is still excellent.
- Good initial set of materials.
- Excellent progress including new glove-box testing.

#### **Question 4: Technology transfer/collaborations with industry, universities and other laboratories**

This project was rated **3.3** for technology transfer and collaboration.

- The Technical Reference consolidates materials compatibility data for all industry stakeholders.
- It appears that Sandia is very responsive to partners and actively seeks input on approach and priorities.
- Good collaboration across industry and with codes and standards organizations
- SNL has taken their results and published, given to standards organizations
- Good coordination of materials testing with Pipeline Working Group, but that data should also be included in materials database.
- Several aspects to the collaboration which appear to be well thought out.
- I assume that collaboration with industrial gas companies and others experienced with handling hydrogen is through the ASME collaboration.

#### **Question 5: Approach to and relevance of proposed future research**

This project was rated **3.3** for proposed future work.

- Plan's continuation of testing materials builds on past efforts.
- Plan's augmenting publication of technical references.
- There is a plan laid out for FY08 and it shows good progress on issues that are important to the hydrogen economy.
- Future work clearly builds on past accomplishments.
- Very clear plan related to present and previous R&D activity. However, future plan needs to be better defined.
- Comments made by others regarding component testing, weld-related work should be considered.
- I would ask myself the question whether the community that will benefit from access to and knowledge of this work is fully aware of the work; consider other communication mechanisms as appropriate.

#### **Strengths and weaknesses**

##### Strengths

- Generating valuable data set for deployment of infrastructure.
- Performing basic work that no one else is doing, and will help the entire industry equally. If done independently, the work would be private and not as readily available.
- Answering questions that have been out there for years, but no one had the resources to test.
- Very impressive progress.
- A systematic, analytical approach to materials compatibility.
- Technical expertise of staff involved and results achieved as noted in the S,C&S award.
- An excellent presentation.

##### Weaknesses

- None.
- The tests are time consuming, so limited data can be generated in one year. This also makes it difficult to fully evaluate all the variables which could affect results.
- Fatigue testing can't effectively evaluate or speed up time-based issues that might occur over years.
- Need to coordinate closer with pipeline materials working group.
- Component-level testing / understanding of system effects not known.

**Specific recommendations and additions or deletions to the work scope**

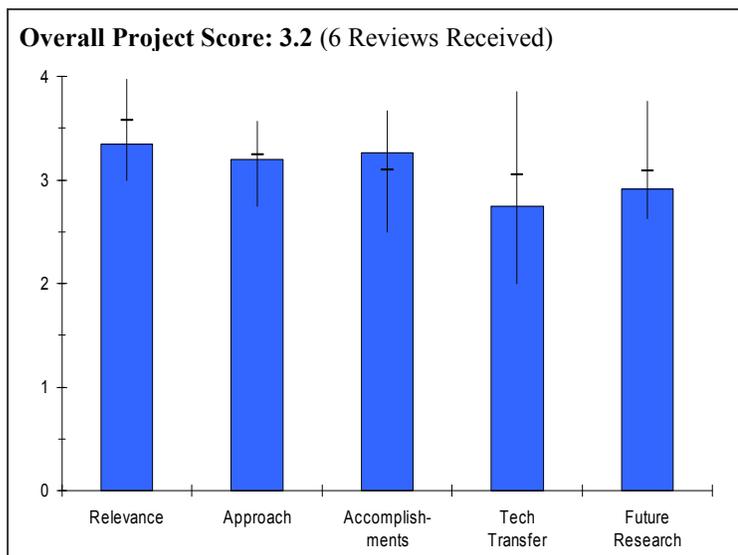
- None.
- Additional materials should be added beyond stainless steel.
- Increase support for this effort in order to meet standards timeline.
- Survey industry regarding new materials.
- Explain who they mean by "materials work."
- Consider adding other materials beyond stainless, aluminum, and copper.

**Project # SA-03: H<sub>2</sub> Incident Reporting Database and H<sub>2</sub> Safety Best Practices Website***Linda Fassbender; PNNL***Brief Summary of Project**

The objectives of this project are to 1) establish a web-based system for open sharing of lessons learned from hydrogen incidents and near misses through use of a confidential reporting tool for such safety events; and 2) provide a Hydrogen Safety Best Practices resource to enable widespread benefit from the wealth of knowledge and experience already attained in industry, aerospace and elsewhere.

**Question 1: Relevance to overall DOE objectives**

This project earned a score of **3.4** for its relevance to DOE objectives.



- The incident database is a good support system for encouraging cross-learning among various DOE funded programs.
- The best practices website could be useful to certain organizations new to working with hydrogen and not familiar with existing literature. Caution should be exercised in characterizing the purposes of both websites, the intended audiences and uses, and the context of the information available.
- Real-world safety performance data collection is critical to deployment of the hydrogen economy.
- Providing single-point resources for sharing lessons learned and best practices will be beneficial in the safe implementation of the hydrogen economy.
- An important contribution to hydrogen safety.
- Although hydrogen is used widely, and hydrogen safety is well-established in the hydrogen industry, the ability to move safe practices to a larger user group will enhance safety when hydrogen usage increases across many sectors. This argues strongly for this project's importance.
- There is relevance for this project to support the Hydrogen Fuel Initiative. I have reservations as to the utility of this project as presently configured. However, small changes in scope and direction may relax my reservations. They will be discussed below.

**Question 2: Approach to performing the research and development**

This project was rated **3.2** on its approach.

- Development of the Best Practices website should advance in cautious and close coordination with entities within the codes and standards and regulatory communities. These organizations historically house best practices within standards, codes, regulations, and other published documents.
- The DOE Best Practices website should limit its scope to cover a summary of high points of available practices from published, standards, codes and regulations (and other relevant published documents), by subject area, to act as a guide to official literature and a link to relevant captured incidents.
- Straightforward approach. Collect incident and best practices data and disseminate through publicly available website.
- A good process has been set up to capture hydrogen incidents and develop lessons learned.
- Good plan for best practices.
- The research methods used appear to be thorough and reliable.
- The data sources appear to be appropriate.

## **SAFETY, CODES & STANDARDS**

- It is recommended that all potential data sources be used including NFPA, NASFM, DOT, UL, Factory Mutual, Insurance Companies, and other industry data bases. Inclusion of these data sources may contribute additional data.
- The approach adopted for this project appears sound.
- Expanding the search and report function to leverage synergistic industries by incorporating fuel gas (natural gas) and industrial compressed gas incidents and best practices will help address best practices and generate a list of common escapes that then can be addressed by training.

### **Question 3: Technical accomplishments and progress toward project and DOE goals**

This project was rated **3.3** based on accomplishments.

- The structure of both websites is clean, easy to read, and well structured.
- Capturing even 10 incidents from last year's programs is an excellent accomplishment.
- Search features will be very useful to program participants and site users.
- 130 incidents to date.
- The website receives several thousand hits.
- Technical accomplishments seem modest.
- H2 incidents website is up and running.
- Best Practices is under development.
- There was a recent change of leadership. The new leadership has grabbed the ball.
- Good progress shown by implementing incident reporting website.
- Process for handling incidents appears to be well thought out.
- Review of Best Practices by Hydrogen Safety Panel is a good way to ensure technical accuracy and relevance – this is a strength.
- Long length of project might be inconsistent with moving to commercialization. Who will do this when DOE stops?
- The progress appears to be appropriate for the time and budget.

### **Question 4: Technology transfer/collaborations with industry, universities and other laboratories**

This project was rated **2.8** for technology transfer and collaboration.

- In future reports, the project should report how it is linked with the Safety Panel, the Tech Val teams, and other program groups (interfaces, meeting frequency, feedback loops). The DOE program participants are both the primary audience/users, and (should be) the primary reporting parties into the incidents database – without proper and proactive coordination, the usefulness of the database will decrease.
- Data sharing through website.
- Appears that incidents are reported.
- Lessons learned/best practices/incidents linked.
- Linked to Hydrogen Safety Panel so that information here is transferred into safety assessments of DOE projects.
- Limited to date.
- In future, there could be more active collaboration with other safety organizations (OSHA, NFPA, NTSB, Fire Marshall's Association, etc.).
- Additional linkages to other DOE Hydrogen Safety efforts would be helpful.
- It would seem that this need will persist beyond the length of the project. Some technology transfer or collaboration with an organization who will take over this task for industry would be a valuable addition.
- The information transfer and collaboration activities are a good start.

### **Question 5: Approach to and relevance of proposed future research**

This project was rated **2.9** for proposed future work.

- As identified by another reviewer during the question and answer period, a timeline for the databases and websites should be developed including possible handoff/interface scenarios out in 2012 (e.g., handing off/working with the insurance, codes & standards, and regulatory communities who typically maintain this type of information for other industries/technologies).
- It was unclear about how “trends” information would be identified through the incident database, how that information will be reported and reviewed, and who will receive that information.
- User interaction will be a key future feature that is well worth pursuing. This capitalizes on the community learning strengths of both online tools.
- Ongoing data collection.
- Leads to identifying trends.
- Review, feedback from safety panel, and integrating incidents and best practices.
- Need to develop other useful initiatives after Best Practices is up and running.
- Continued improvement in data and reporting is included in the plans. This is a strength.
- The proposed future work is consistent with the present scope of the project.

### **Strengths and weaknesses**

#### Strengths

- Making appropriate, non-proprietary, safety-relevant information available to DOE program participants.
- Encouraging interaction, continuous review and development, and communal learning among program participants.
- Real-world data collection is necessary.
- Project provides single-point resources for best practices and incident tracking.
- Web based – living documents.
- Right topics.
- Website dissemination.
- Comprehensive effort.
- Review by Hydrogen Safety Panel.
- The project heavily leverages the existing hydrogen infrastructure which is based on industrial practices and OEM procedures, which are much less cavalier than the practices used in synergistic industries, which follow commercial practices and/or public usage.

#### Weaknesses

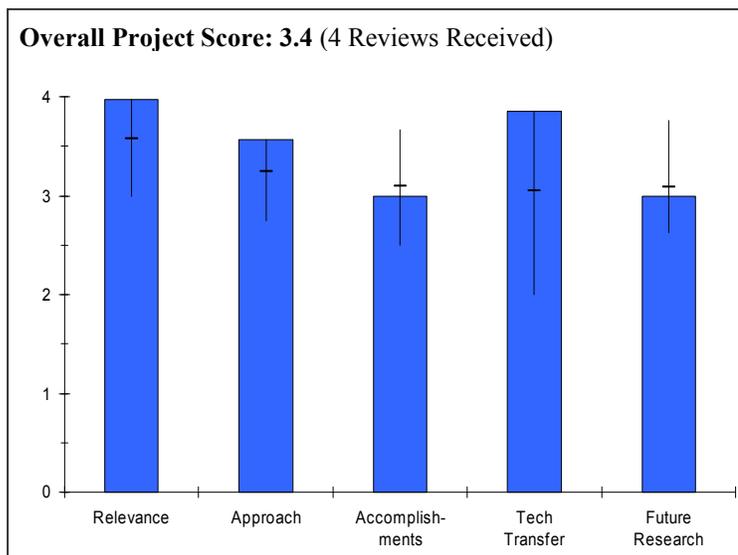
- If the incident website is identified by high-profile first responder and other outside-of-industry stakeholder groups, the information available could be taken out of context (lab/research incidents vs. real-world incidents). Appropriate language should be clear and upfront on both websites to characterize the primary audience, context of the information, and scope of available information.
- Adding some type of time-related signature to each incident report would be useful to identify learning trends and track the frequency of related incidents over time. If specific timing/date information is considered sensitive, perhaps more general time stamps can be pursued.
- There may be some overlap with best practices developed by CDOs and SDOs.
- Change of management.
- Probably has been underfunded in past.
- There could be better collaboration with other hydrogen safety programs.
- Need some sort of transition to a commercial entity to handle this for the industry beyond the DOE funding timeline.
- The project does not explore the synergistic industries such as the natural gas and the compressed gas industries. Many of the more common occurrences that probably occur with usage by the general public would not be expected to be reflected in the data from safety sensitive industrial practices. The safety guidelines used by people trained for handling bulk quantities is more restrictive than the practices of the general public working with much smaller quantities.
- I am concerned that this activity will be perceived and marketed as hydrogen is a more dangerous fuel as compared to natural gas and petroleum.
- The collaboration for data does not appear to leverage all the existing incident reporting structures.

**Specific recommendations and additions or deletions to the work scope**

- The scope of the Best Practices website should be carefully considered in consultation with relevant government regulator agencies (e.g., OSHA), Codes & Standards Development Organizations (e.g., CGA), and professional groups (e.g., NASFM) who have traditionally published guidance information. The most useful outcome is that the Best Practices website helps summarize, at a high level, basic practices, links users to existing established information, and links each subject area to relevant captured incidents.
- Interfacing with the Tech Val program to understand if the 10 captured incidents are representative of all incidents or if they represent only a subset (indicating that some percentage of incidents are not being reported); in the case of the latter, barriers to reporting should be identified and addressed.
- None.
- DOE should nurture it and keep it well funded.
- Develop longer term plan with new initiatives.
- Consider a separate CNG incident database (rationale: hydrogen tanks and components are very similar to those of CNG. There is a much larger population available, which can provide quantitative failure rates).
- Implement an RFP, RFQ, or other methodology for partnering with industry to move this function into mainstream industry. Similar work is done by many, many industries, and should be done with hydrogen also.
- Expand the scope to include the natural gas and compressed gas usage. Specifically, including the natural gas vehicle activities, compressed gas cylinder usage and LPG usage.
- Expand the data mining to other sources – for example, federal (DOD, DOL OSHA, DOT PHMSA, US EPA), state (Environmental Protection, State OSHA) and private industry (Commercial and Residential insurance).

**Project # SA-04: Hydrogen Quality***Jim Ohi; NREL/LANL***Brief Summary of Project**

The National Renewable Energy Laboratory (NREL) is conducting research and development (R&D) and testing in support of national and international codes and standards efforts in the area of hydrogen fuel quality. Overall objectives are to collect, evaluate, and report assemblage of data and information, and to recommend hydrogen fuel quality specifications. In addition, NREL is developing consensus on critical analytical methods and procedures needed to verify recommended maximum levels of contaminants; forming two sub-teams to focus separately but iteratively on single-cell testing (performance-durability) and fuel cell system and fuel infrastructure engineering requirements and costs; and forming a modeling sub-team to develop and apply an empirical model to focus testing and enable projection of test results.

**Question 1: Relevance to overall DOE objectives**

This project earned a score of **4.0** for its relevance to DOE objectives.

- Very relevant, as evidenced by funding increase and good use of critical partners.
- Hydrogen purity is a very important parameter to rolling out hydrogen as a fuel. It is currently a very controversial topic that needs to be resolved and is potentially a roadblock unless all stakeholders agree on an approach.
- Hydrogen fuel quality is critical to success of hydrogen economy.
- This task is highly relevant to the Hydrogen Fuel Initiative.

**Question 2: Approach to performing the research and development**

This project was rated **3.6** on its approach.

- Looks comprehensive; with international partners; good baseline chart.
- A purity standard is very important, but it's more important to get it right than to get it fast. The approach seems more geared toward getting a specification in place rather than a practical specification in place.
- The approach needs to consider cost, effectiveness, and frequency of testing methods as part of the process.
- The international approach is appropriate.
- Plan for testing impact of impurities is well thought out. Just need to bring a sense of urgency to the process.
- The approach is appropriate for generating an International Standard.

**Question 3: Technical accomplishments and progress toward project and DOE goals**

This project was rated **3.0** based on accomplishments.

- Chart and graphs used in presentation showed great progress.
- The specification is moving forward, but barriers still exist on cost/verifiability.

- Not clear that He impurity targets are difficult to achieve if use LH<sub>2</sub> distribution to stations (or LH<sub>2</sub> step in forecourt as clean up; impact of He on fuel cell is being evaluated now – efficiency hit to be quantified).
- To certify or validate station performance, also need to measure fuel temperature and flow rate in addition to catching a canister sample for analysis.
- Composite test matrix plans should have target dates for completion (and those dates should reflect a sense of urgency).
- Please bring a sense of urgency to this work.
- The progress to date appears limited. It is assumed that this is paced on funding.

### **Question 4: Technology transfer/collaborations with industry, universities and other laboratories**

This project was rated **3.9** for technology transfer and collaboration.

- Great collaboration with worldwide partners.
- The project has representation from a wide variety of stakeholders.
- Extensive collaboration network.
- Work with USFCC ensures broad-based applicability and guidance.
- Very nice plan for ISO support work laid out in presentation. Need a similar work plan for coordination with SAE.
- Create comparable slide for SAE (just like ISO slide) – showing earlier establishment by SAE of interim standard and continuing reconsideration of inert levels by the SAE group. ISO and SAE are really working together.
- The stated and imbedded collaboration is reflective of the current, active industry representatives.
- The lack of acknowledgment of the testing completed by JARI and funded by NEDO in support of this activity is disappointing.

### **Question 5: Approach to and relevance of proposed future research**

This project was rated **3.0** for proposed future work.

- Future work is “data-driven.” Good approach. Good integration with other labs and agencies.
- The project needs to put more emphasis on the ability to accurately and cost-effectively validate fuel quality at stations. A specification that is unverifiable at reasonable cost is not a help.
- Very nice plan for ISO support work laid out in presentation. Need a similar work plan for coordination with SAE.
- Create comparable slide for SAE (just like ISO slide) – showing earlier establishment by SAE of interim standard and continuing reconsideration of inert levels by the SAE group. ISO and SAE are really working together.
- The objective of the future research is limited and does not reflect the short-term needs of the industry but rather the longer-term, international viewpoint, especially that of Europe.
- The specific needs are to generate a domestic standard and verification test methods to support the Hydrogen Initiatives in states like California, Michigan, Ohio, New York, Florida, etc. These states adopt domestic consensus standards by law.

### **Strengths and weaknesses**

#### Strengths

- Increased funding should help this program go a long way – much better than last year.
- The project is taking a scientific approach.
- Extensive coordination and input from the broad spectrum of stakeholders.
- The strength of this project is the international collaboration focused on a longer term event horizon.

Weaknesses

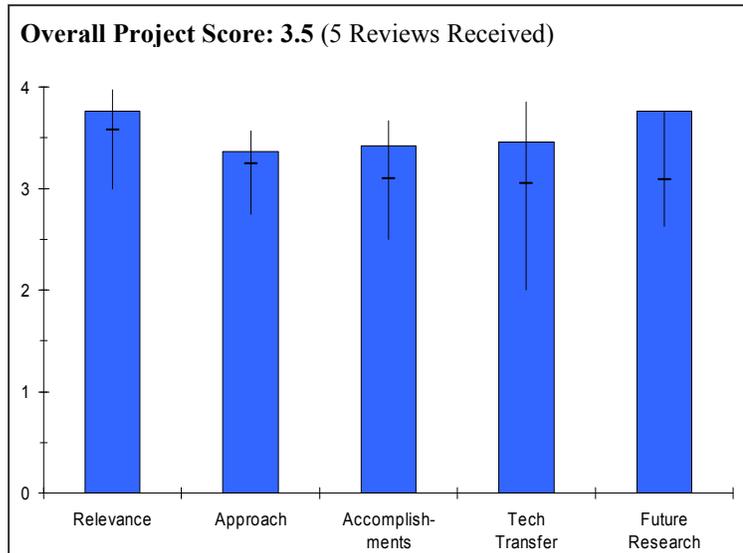
- The tendency might be to take purity to a “lowest common denominator,” which could result in a more stringent specification than necessary. Gaining consensus will be difficult given the variety of interests involved.
- The final purity specification must be verifiable using practical processes and at reasonable cost.
- Particulates cannot be excluded from the process stream with existing connection technology. Including particulates in the specification is problematic.
- Seems to be a focus on ISO to the detriment of SAE. SAE 2719 has been approved. Furthermore, SAE is an international organization.
- Lack of timelines and a commitment to them.
- Lack of public data on hydrogen impurities in current hydrogen sources; for example, if CO is present at 1 ppm, NH<sub>3</sub> and H<sub>2</sub>S might not even be issues, since their concentrations are essentially zero, but we need public data to show this.
- The weakness of this project is the lack of progress to comply with the state hydrogen programs, many of which are still following the original DOE schedule. This is specifically evident when observing activity in California, which by law requires a fuel standard by January 2008.
- This weakness is magnified when it is understood that other states copy or adopt the activities of California, often with out the caveats and variances.

Specific recommendations and additions or deletions to the work scope

- Make sure that this work is consistent with, and complementary to, the AN-06 project being done by Romesh Kumar at Argonne.
- Expand research into making fuel cells more tolerant of fuel impurities as an alternate approach, or alternatively adding filtration equipment (e.g., fuel filter) to protect against damage.
- Dave Masten (GM) should be added to the North American Team membership.
- Continue to make data on hydrogen quality publicly available, or at least get a mechanism in place so that the Hydrogen Quality Task Force can get access to the data to guide the hydrogen impurity work.
- Accelerate these activities by eliminating the delays being encountered.
- Refocus the near term efforts to support the domestic agenda.
- Impart a sense of urgency to the parties involved in the data generation.

**Project # SA-06: Hydrogen Safety Panel***Steven Weiner; PNNL***Brief Summary of Project**

The Hydrogen Safety Panel supports the DOE Hydrogen Safety Program, focusing on the development and implementation of practices and procedures that will help ensure safety in the operation, handling and use of hydrogen and hydrogen systems for all DOE projects. Bringing together a broad cross-section of industrial, government and academic expertise, the panel provides expertise and guidance to DOE and assists with identifying safety-related technical data gaps, best practices, and lessons learned. Safety reviews focus on engagement, learning and discussion and are not treated as audits or regulatory exercises.

**Question 1: Relevance to overall DOE objectives**

This project earned a score of **3.8** for its relevance to DOE objectives.

- Safety review of DOE funded projects is critical to the continuation of the Program.
- Safety is critical in research and demonstration programs.
- This project is critical to the continuation of the initiative and achieving the goals of the Hydrogen Initiative. One major incident could bring the Initiative to a sudden end.
- Anything that is done to accelerate the distribution of hydrogen safety knowledge will be beneficial to the Initiative.
- Safety is an important aspect of the Program.
- Outstanding project that is very important to Hydrogen vision.
- The near term effect of this activity is relevant to generating and disseminating safety guidance on projects support the Hydrogen Fuel Initiative.

**Question 2: Approach to performing the research and development**

This project was rated **3.4** on its approach.

- Providing safety review is a learning process.
- The expertise of the Panel membership is important to developing the approach for safety assessments and identifying gaps.
- The approach of focusing on priorities established by the Panel is very good.
- Not all of the barriers are being addressed to the extent that they could if funding were unlimited. Considering funding constraints, this approach represents a good balance.
- Safety reviews are performed in a way that brings considerably more knowledge to the process than would be achievable with out this activity.
- Focusing on safety plan content rather than format is very appropriate.
- Concept is good. I can only hope that the telephone interviews are effective.
- Realistically, the approach being taken is the only viable option.

**Question 3: Technical accomplishments and progress toward project and DOE goals**

This project was rated **3.4** based on accomplishments.

- Safety panel reviews of DOE projects.
- Review of NREL data templates.
- Providing guidance and input to safety plans, practices.
- Conducting 23 safety reviews and reviewing 50 safety plans is pretty impressive.
- Responses from 147 projects on this year's two new questions is phenomenal and represents a wealth of information that will soon be available to the community.
- I guess the real measure of progress is the lack of serious hydrogen incidents. So, the panel is succeeding.
- Process appears to be working very well with several project plans have been reviewed.
- 2007 Safety questionnaire question "...the potential to result in the worst consequence" can be leading and there is no metric identified. Question should probably be eliminated.
- Accomplishments appear to be consistent with funding.

**Question 4: Technology transfer/collaborations with industry, universities and other laboratories**

This project was rated **3.5** for technology transfer and collaboration.

- Transfer/collaborations through diverse membership.
- Transfer between panel members and principal investigators.
- Transfer between Panel and H2 Incident Reporting and Best Practices, which ultimately provides a broader audience.
- When looking at the spectrum of representatives on the Panel, one would certainly agree that the collaborations are good; however, there are some prominent hydrogen organizations that are not represented. NASA Stennis and SRNL for example.
- Voluntary participation by DOE-funded organizations appears to be very good, based on the number of safety reviews and safety plans completed.
- It appears that volunteer efforts may be equal to the DOE-funded activity.
- Energy companies, OEMs, and National Labs covered and participating.
- Need to periodically reevaluate the membership of the committee.
- Difficult to assess. Collaboration is actually the organizations that have utilized the service. Over 50 projects have utilized this service.

**Question 5: Approach to and relevance of proposed future research**

This project was rated **3.8** for proposed future work.

- Continuation and enhancement of existing program.
- Continuation of successful work is going in the right direction.
- The work proposed is consistent with the goals.

**Strengths and weaknesses**Strengths

- It is necessary to provide a uniform, multi-disciplined, safety assessment to the DOE research and demonstration efforts.
- Rapid dissemination of safety information.
- Availability of Panel, representing broad expertise.
- Broad spectrum of membership on the Panel across sectors working on hydrogen.
- Experts in the field.
- Strong leadership and approach.

### Weaknesses

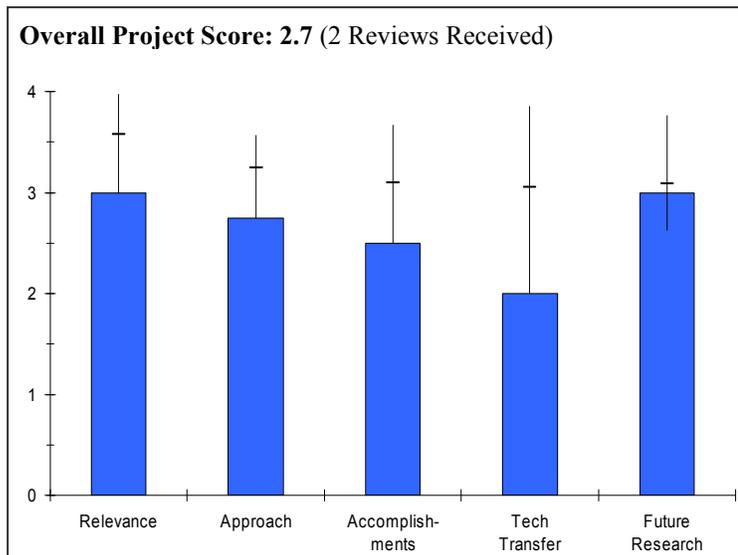
- There is overlap with other projects. This is not a negative thing, but it exists.
- Maybe missing additional/valuable expertise on the safety of hydrogen.
- Lacking a member on the Panel from one of the energy companies participating in the technology validation program.
- Potential underreporting of real H<sub>2</sub> safety events (who wants to look bad). Need to be aware of this.
- Should rotate membership on the committee for freshness and new/different perspectives.
- Safety questionnaire question is not likely to provide desired results.

### Specific recommendations and additions or deletions to the work scope

- None.
- Stennis Space Center in Mississippi claims to handle more hydrogen than any other organization in the country.
- Savannah River National Laboratory also makes large claims about working with hydrogen.
- Suggest that both of these organizations be considered for inclusion on the panel.
- Add a member to the Panel from one of the energy companies actually participating in the technology validation program. Actually, this seems to be a glaring hole in the Panel makeup.
- In case it comes up again, I don't recommend adding CNG or LG data to the safety database. The materials are quite different in behavior from hydrogen.
- Consider turning over membership of panel to spread knowledge and broaden experience on the panel.
- Continue the activity as described.

**Project # SAP-02: Hydrogen Safety Sensors***Bob Lieberman; Intelligent Optical Systems***Brief Summary of Project**

The overall objectives of this project are to reduce or eliminate interferences from humidity and oxygen exhibited by virtually all current optically-based hydrogen detectors and to establish and fully characterize a compact hydrogen detector. Specific objectives in 2006 and 2007 included 1) transfer existing indicator chemistry from commercial to in-house porous glass substrate and improve indicator performance; 2) transfer indicator chemistry from porous glass substrate to polymeric substrate; 3) establish ppm-level response to hydrogen in one or more candidate substrates; 4) establish good hydrogen sensitivity, response time, and sensor performance with little or no response to moisture and oxygen; and 5) develop compact multi-channel detector/test system.

**Question 1: Relevance to overall DOE objectives**

This project earned a score of **3.0** for its relevance to DOE objectives.

- Development of hydrogen sensors for a variety of applications supports safety goals of DOE program.
- Low-cost hydrogen sensors are definitely needed for market penetration of hydrogen technologies.

**Question 2: Approach to performing the research and development**

This project was rated **2.8** on its approach.

- Focused on technical barriers regarding sensitivity, durability.
- Compensation for drift and for moisture might be handled by adding sensors to the same chip, which may be workable, but certainly is not a major breakthrough.
- IOS anticipates that their sensor will be competitive with others, but probably will not sell for significantly less.
- Consideration is being given to add a “scrubber” to eliminate the sensitivity to CO.

**Question 3: Technical accomplishments and progress toward project and DOE goals**

This project was rated **2.5** based on accomplishments.

- Significant progress toward goals, but several barriers remain in order to reach targets.
- Polymeric substrate longevity is now up to 5 or 6 months, but needs to be 10 to 15 years.
- Dynamic range is only 0 to 10%, but it is possible to duplicate sensor systems and have one operate in the range of 0 to 10% and another in the range of 10 to 100%.

**Question 4: Technology transfer/collaborations with industry, universities and other laboratories**

This project was rated **2.0** for technology transfer and collaboration.

## SAFETY, CODES & STANDARDS

- Reviewer is not aware of outside collaboration in this effort.
- IOS has had some discussions with potential customers, such as the auto manufacturers.
- IOS is planning to manufacture the sensors themselves or to establish a wholly owned subsidiary; therefore, technology transfer is less critical.

### **Question 5: Approach to and relevance of proposed future research**

This project was rated **3.0** for proposed future work.

- Plans and target goals are clearly stated.
- Sensors appear to have good commercial possibilities if targets are met.
- There will be need for follow-on funding to complete the development of this sensor; however, I would recommend that it be tied to a solid commercialization plan.
- ISO mentions in one slide the concept of a continuous fiber sensor. This is an excellent idea and should be pursued as a second priority.

### **Strengths and weaknesses**

#### Strengths

- Project addressing problems in current sensor sensitivity to CO and humidity.
- Working on accurate, low-cost H<sub>2</sub> sensors is definitely a priority.

#### Weaknesses

- ISO is proposing to correct many of the shortcomings of the sensor by adding a specialty sensor(s) to counteract the response. Although this will work, it increases the potential for sensor failure.

### **Specific recommendations and additions or deletions to the work scope**

- None.
- Add a commercialization plan.
- Initiate the development of the fiber version of the sensor.