Technology Validation

Summary of Annual Merit Review Technology Validation Subprogram

Summary of Reviewer Comments on Technology Validation Subprogram:

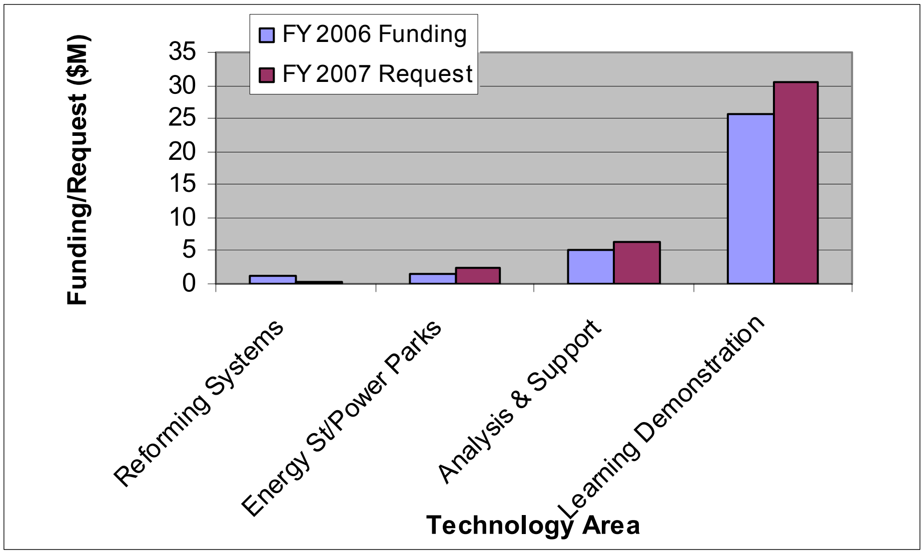
Reviewers considered the Technology Validation effort critical to the President's Hydrogen Fuel Initiative. Reviewers thought highly of the Learning Demonstrations, Natural Gas to Hydrogen and Energy Station projects. The Learning Demonstration project must interface with a wide variety of organizations by design to co-develop hydrogen infrastructure in parallel with hydrogen fuel cell-powered vehicles. Reviewers felt real time data monitoring of vehicle operations is impressive. Vehicle operations in diverse operating environments were considered a real plus. DaimlerChrysler's progress in the development of a maintenance facility in Long Beach, CA. and their use of a potential leaking model to design the facility was a significant contribution. Reviewers indicated that there was an impressive list of technical issues identified and addressed by the project teams. Lessons learned pointed to future areas of research including technical, insurance, user concerns and fueling issues. The reviewers felt larger vehicles would be required in the future to meet DOE targets for range.

The reviewers would like to see more public disclosure. However, they indicated that database development is necessary for technology transfer objectives to be furthered. The NREL Agreement is an outstanding method of facilitating interaction between principal hydrogen economy investigators. This Agreement is critical to validating whether the U.S. light duty fleet and fueling infrastructure are successfully meeting targets. This data allows DOE and OEM's to discuss program progress on an even basis. The public need to understand the progress being made using public money is an important aspect of these programs. Confidence in DOE oversight can be helped very much by this program. DOE's ability to communicate the essence of the data trends publicly will be very important. The program is clearly well thought out and appears to be managed in an organized fashion. Very well planned and executed.

The reviewers indicated that good technical progress was made in the Natural Gas to Hydrogen reformation systems. A new PSA system appeared to be of high value. Power Parks were considered limited by the size of the equipment used and therefore were difficult to apply to actual systems. Scale up factors that had to be applied lacked credibility. The high-temperature Energy Station was recommended for further development. However, the reviewers did not recommend future funding for the Solid Oxide Fuel Cell project. Congressionally directed projects were the four lowest-rated projects in this Subprogram.

Technology Validation Funding by Technology:

The funding portfolio for Technology Validation stresses the continuance for the 5 year Learning Demonstration project as it enters the third year of that effort. Second generation vehicles will be introduced in FY 2007 that will be instrumented to provide information on meeting 2009 fuel cell durability, vehicle range and cold start targets. Natural gas to hydrogen projects will be concluded and an assessment will be made on the status of the technology to meet $3.00 per gge target for hydrogen production. A high-temperature fuel cell Energy Station will be funded to complete detailed design and enter into fabrication if a Go decision is made. Power Park activities will be continued as part of the Learning Demonstration or completed in FY 2007. A 2^{nd} generation cryo-compressed storage tank will be designed and parts ordered for installation on a vehicle in FY 2008. The 2007 funding profile is subject to Congressional Appropriations.



Majority of Reviewer Comments and Recommendations:

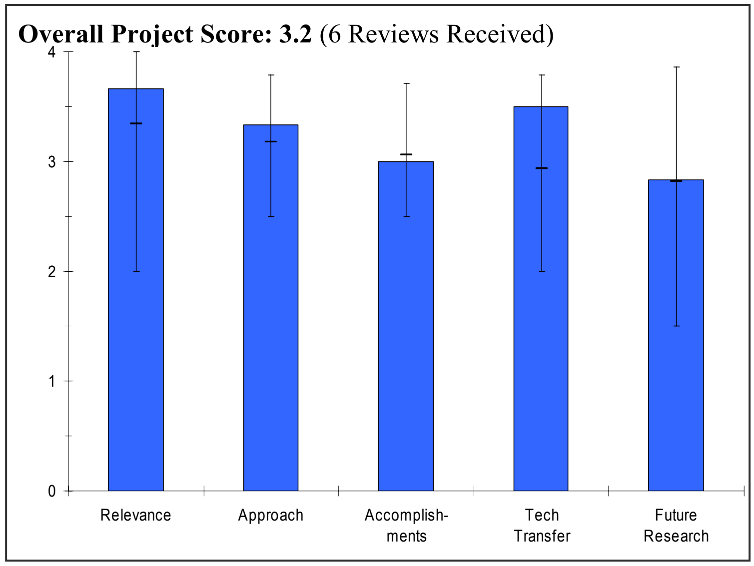
The Reviewer scores for the Technology Validation Subprogram were on average slightly higher or similar with those of other subprograms (the maximum, minimum, and average scores for Technology Validation projects were 3.7, 2.5, and 3.1 respectively). These compare to the overall maximum, minimum, and average project scores of 3.7, 1.4 and 3.0, respectively. The Technology Validation project portfolio includes a mix of projects with several projects nearing their completion date and others like the Learning Demonstration in the second year of a five year program. The major recommendations by the reviewers are presented below for each of the task areas. DOE will act on reviewer recommendations as appropriate for the overall Hydrogen Technology Validation effort.

- **Learning Demonstrations –** These were well-directed projects critical to the support of the President's Hydrogen Fuel Initiative. The NREL Agreement for analysis of the four teams' efforts is critical to validating whether the U.S. light duty fleet and fueling infrastructure are meeting program targets.
- **Natural Gas to Hydrogen Stations –** Useful data on all aspects of refueling station operation. Good technical progress in fuel reforming efficiency, fast-fill testing and fuel dispensing. Little progress made in hydrogen compression technology. New PSA appears to be of high value. Insufficient station operation for complete demonstration.
- **Power Parks –** Good projects to assess utility interest in the program. Limited size of equipment that impacts scale-up factors' credibility.
- **Energy Stations –** Molten Carbonate Fuel Cell project relies on mature technologies. Engineering design should be able to be implemented. Phase 3, detailed design and fabrication, of the project should be done.
- **Storage –** Reasonable plan to install cryo-gas tank on a hydrogen hybrid vehicle. 2^{nd} generation cryo-gas tank hardware suitable for vehicle use. Need to provide design for manufacturing, production and investment.
- **Analyses –** The NREL Agreement is critical to be able to convey information to the public. On the Power Park analyses there was a good understanding of energy peak performance parameters. Strong effort to validate tools using real world systems for both efforts.

Project # TV-01: DTE Energy Hydrogen Technology Park

Rob Bacyinski; DTE Energy

Brief Summary of Project



In this project, DTE Energy will develop and test a working prototype of a hydrogen-based energy station concept that utilizes a combination of renewable and non-renewable power (including on-site solar) with electrolysis and stationary PEM fuel cell technology to take advantage of low-cost power during off-peak hours to generate hydrogen for on-peak power generation and vehicle fueling. Using state-of-the-art hydrogen generation, storage, regeneration and control technologies, the project will evaluate opportunities to reduce overall system cost and maximize performance. The project will also contribute to the development of relevant safety standards and codes required for commercialization of hydrogen-based energy systems.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.7** for its relevance to DOE objectives.

- Has all elements required for a power park.
- This program has broad education and demonstration capability and is providing essential H_2 delivery infrastructure facility and education in a key vehicle test area.
- The project objectives are right on the mark with key program goals.
- Excellent focus on co-production of electricity, H_2, use of renewable energy and stakeholders.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- The basic approach is too small for meaningful scale up analysis. It is good as far as it goes.
- Use of PV in Detroit is not a good initial choice of renewables.
- Use of multiple demonstrations is a good choice for this initial learning and re-fueling center.
- The project uses multiple energy sources, including renewable.
- Selection of technology options (PV, wind, biomass) are very useful.

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

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

- Many of the accomplishments were last years.
- The results are limited by the size of the equipment. The scale up factors lack credibility. The basic goals are being compromised by looking into such things as pyrolysis of peanuts.
- Installation is complete, that required full safety analysis and permitting; good accomplishment
- Data collection and preparation for reporting, has apparently been ongoing with good quality.
- 1500 Hr PEM life provides interesting comparison to manufacturer data for real world use of this generation of 5 KW PEM units.

- Good progress has been made on all tasks. Pitfalls have been identified and overcome.
- Good understanding of energy peak performance parameters, particularly Hydrogen and energy costs, availability, etc.

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

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

- Good public outreach.
- There is excellent collaboration with other teams such as the fleet demo's as well as the analysis groups.
- The one open house held for public view of project was a huge success. This indicates big pent-up demand for more education and outreach.
- The unacceptable operation of the Hydrogenics (Stuart) electrolyzer has been reasonably well publicized. This is an example of public demos identifying issues, and fixing them.
- Good information for industry stakeholders – needs to be transferred – as lessons learned report.
- The project relies on several different partners, but the coordination and collaboration appear to be very good.
- Use of academia and the national lab are very productive.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.8** for proposed future work.

- The activities appear to be a kitchen sink of normal project management and there is nothing proposed that seems to be very productive.
- The reevaluation of a very small electrolyzer is of questionable value. Peanut pyrolysis is an area all its own.
- There is a clear need for this refueler in the area.
- Future work should also address the utility business model(s) and/or analysis of policy options incentives or means to reward the use of utility off-peak power for this application. What would be the impacts to cost and benefits with each policy option?
- The remaining work will lead the project to a good conclusion.
- Identification of a "high value proposition" scenario will be very useful.

Strengths and weaknesses

Strengths

- Frank and open presentation regarding analysis on costs.
- Well organized and executed. Strong technical abilities. Good experience with contemporary industry.
- Well positioned to demonstrate H_2 infrastructure in area that is key to H_2 vehicle options.
- Good electrolyzer refueling station demonstration. With lots of good data and real world information. This facility should be continued to operate to obtain more long term data on performance and degradation.
- The project includes H_2 production from renewable resources.
- The goals are very well aligned with HFCIT program goals for distributed production, vehicle fueling, and power park demonstration.
- The team includes all major stakeholders for an energy park.
- The analytical approach to evaluate "total cost" is very effective.
- The outreach and collaborative activities are excellent.
- Use of "off peak" and "peak" rates to improve the economics.

Weaknesses

- Few publications or broad dissemination of data planned.
- Scale is too small. Getting diverted with peripheral issues.
- Will be difficult to maintain "advanced tech Demos" in a rapidly evolving field. It's possible that this site will become stale in the near future.
- The mix of energy park elements includes a fuel cell, electrolyzer, PV wind, and biomass. How would you use the data collected so far to recommend a preferred use of these elements to promote the energy park concept?

Specific recommendations and additions or deletions to the work scope

- This project should revert to the utility's responsibility since it is deriving self serving information mostly.
- Get bigger equipment all around. Go to at least 1 Megawatt size. Let someone else look at pyrolysis of peanuts.
- Separate refueling from advanced technology demonstration function.
- Suggest deleting any future work on Analyses and recommended course of action for improving PEM fuel cell stack durability- this is better done by key vendors and OEMs – not at university. It is not clear how the pyrolysis part of this project fits into the power park demonstration. Determining the cost of 'cleaning' syngas product to 99.995% purity could be done in other DOE projects dealing with bio-gasification and proceses. This part of the project doesn't seem to fit here.
- May want to consider 10,000 psi fueling in future work.
- I fully agree with the scope as described.

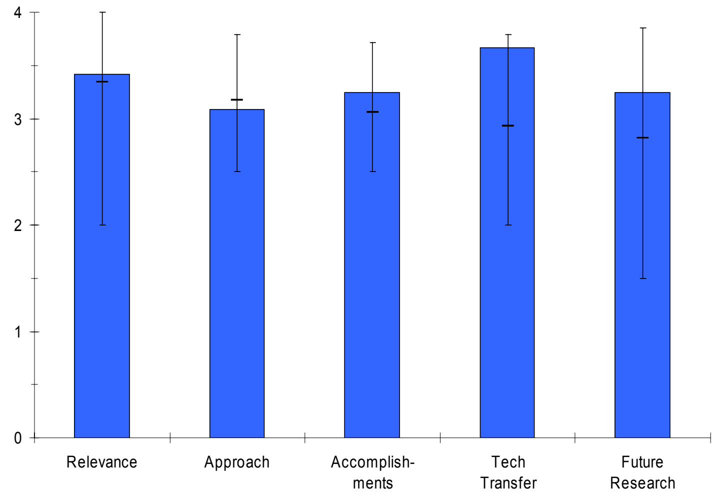
Project # TV-02: Power Parks System Simulation

Andy Lutz; SNL

Brief Summary of Project

Power parks combine power generation co-located with a business, an industrial energy user, or a domestic village. In this project, Sandia National Laboratory is developing a flexible power park system model to simulate distributed power generation in energy systems that use hydrogen as an energy carrier. The project analyzes the performance of demonstration systems for the Technology Validation program. Deliverables include a flexible computational tool to provide simulations of a variety of energy systems that produce hydrogen and independent analysis of system performance, thermodynamic efficiency and cost of hydrogen/electricity.

Overall Project Score: 3.3 (6 Reviews Received)



Question 1: Relevance to overall DOE objectives

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

- Develops a potentially valuable analytic tool, validated with field work.
- Still uncertain if modules can be validated.
- Simulation of real systems with validation is necessary for developing essential tools to aid developers and potential technology adopters. Availability of assessment tools is somewhat enabling for President's vision.
- Is a must to have a good analytical model. This can also be used to evaluate progress and results of other efforts.
- Design and optimization of integrated hydrogen systems will be important to facilitating the successful validation and deployment of hydrogen energy systems.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- Based on currently available modeling tools widely used in industry.
- Premise that present set of equipment demonstrations can be scaled to DOE target sizes is questionable; is a difficulty that needs attention.
- Modular Simulink code with Graphic User Interface. Assess against available data. Limitations of use of scaling laws and simplified models acknowledged – can be refined over time as more data become available.
- Good approach but scale factors are a weak point.
- Good effort to improve the user interface to target a wider range of users.
- Good expertise in system development.
- Strong effort to validate tool using real-world systems.

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

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

- State of model is quite good relative to stage of development of components it simulates.
- Seemingly robust conclusion that electricity costs are 1/2 of cost for electrolytic H_2 is interesting.

- Development of Graphic User Interface is significant new capability.
- Flexible, functional model available. Can be run by knowledgeable user, but user must make appropriate input choices (no "sensible" default).
- Good model but still needs to be validated at the large sizes.
- Progress on validating tool has been good, but the team needs to be more consistent with H2A/Programmatic efforts when doing potential cost and impact assessments. Need to benchmark component modules against H2A future case studies. For example, the PI presented conclusions relevant to the ability to meet DOE targets, yet there appears to be little basis behind the scaling assumptions used in the analysis.

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

This project was rated **3.7** for technology transfer and collaboration.

- One of the (possibly) unintended results of this program is that it has promoted communication and comparison of results among projects and reviewers at APS, DTE, HNEI, and theoretical/ academic centers.
- Availability of the tool will promote more communication and comparison in future.
- Broad, appropriate collaborations.
- How will the model be delivered to the industry? Who are the anticipated end-users? Are you working with them on this project to insure their needs are being addressed?
- There is excellent collaboration with other teams such as the fleet demo's as well as the analysis groups.
- The team has done an excellent job of partnering with real-world hydrogen system users.

Question 5: Approach to and relevance of proposed future research

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

- Continue to develop this basic analytical tool.
- The collaboration with Standards project is a smart move.
- Project is nearly complete. Remaining activities appropriate to project closeout.
- Future work regarding collaboration with Stanford's Global Climate & Energy Project to "Implement 2nd-law exergy analysis to measure efficiency in terms of availably energy for a process" – it is not clear how this fits into the current research approach or the relevance?
- The expansion to include peanut pyrolysis and an exergy study is questionable.
- Good plans to further validate the tool, including the addition of technologies.
- Need to better address consistency of cost projections compared to other programmatic efforts.

Strengths and weaknesses

Strengths

- Developing a common, predictive analytic tool(s).
- By using DOE project programs as a source of validating information, this project provides another review opportunity for those other programs, and allows a common comparison platform as well.
- Honest and thoughtful analysis. Good value for the budget. Analysis not propagandized – refreshing.
- PI well qualified and appropriate collaborations in place.
- Well organized and executed. Strong technical abilities.

Weaknesses

- Difficulty of scale-up of presently available components to physical sizes needed to meet DOE future targets.
- Still requires too much specific technical information to be generally useful to technical persons not familiar with all aspects of H_2 and FC's.
- Limited data and immature technology inherently limit validity of early models.
- Who is the model simulation for? Who are the end-users? Technology Transfer plan needs to engage end-uses of the product simulation tool. Is this going to be an industry tool or is it intended for research and universities?
- The reliance of scaling factors with questionable validity is a weakness.

Specific recommendations and additions or deletions to the work scope

- Add sizing and other appropriate screens for input parameters to catch obviously out-of-range input requests.
- Add time of use energy costs; hourly, weekdays/weekends, seasonal.
- Proceed with plan.
- Project nearly complete. Continued refinement of models as technology matures and testing against real projects would be useful.
- The proposed future work: Modeling of fuel cells for electrical power systems and distributed generation power electronics modeling for electrical grid network integration; Testing methods for analyzing electrical performance in relation to the electrochemical reactions; Electro-Impedance Spectroscopy Load and Transient analysis, etc. – does not seem relevant to the H_2 program.
- Add some default cost numbers as baselines for more widespread use.
- The project should be more integrated with the Program's H2A efforts. Need to incorporate recommendations/links so that potential users can be directed to use assumptions that are consistent with other programmatic modeling/cost analysis efforts, when actual costs are not available.

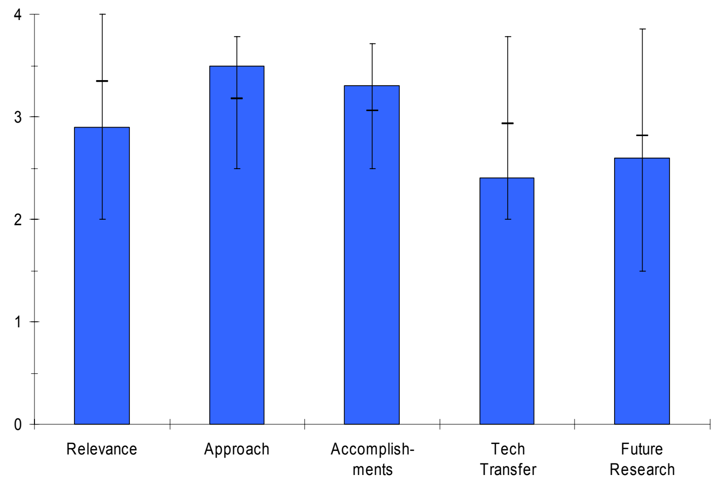
Project # TV-03: Insulated Pressure Vessels for Vehicular Hydrogen Storage

Salvador Aceves; LLNL

Brief Summary of Project

The objective of this Lawrence Livermore National Laboratory project is to demonstrate long range (200 to 500 mile) hydrogen hybrid vehicle with an insulated pressure vessel. Insulated hydrogen pressure vessels have lower cost and safety advantages relative to compressed storage. The second generation insulated pressure vessels built by LLNL filled with LH_2 can meet the 2007 volume and 2010 weight DOE targets (neglecting accessories). Future work will include development of improved insulated pressure vessels that can meet the DOE 2010 volume goal using LH_2.

Overall Project Score: 3.1 (5 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **2.9** for its relevance to DOE objectives.

- Strong relevance to DOE targets for storage volume/weight and vehicle driving range.
- The project goals line up well with program targets for H_2 storage and vehicle driving range. The Gen2 tank meets the 2010 systems weight target.
- Unsure if this technology will meet program objectives even if optimized.
- Also need to look at realistic use scenarios.
- Onboard storage is major challenge. This concept is a science based design option aimed at maximizing H_2 storage. This is insurance against possible public perception of range shortfall for Hydrogen Vehicles.
- Appears costly. Need production estimates to see if costs can be low enough to make this idea viable.

Question 2: Approach to performing the research and development

This project was rated **3.5** on its approach.

- Approach is good, unsure if technology should be pursued. Should evaluate against novel carriers as well as Gaseous Hydrogen.
- Established good theoretical basis for operational and design envelope.
- Followed with 1st generation proof of concept.
- Followed by 2nd generation hardware suitable for vehicle use.
- Design is directed at specific physical envelope.
- The approach is well thought out and makes sense as a path to meet the project objectives.
- Strong technical concept and rationale.
- Clear and logical rationale for the investigation of insulated pressure vessels.

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

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

- Good progress, just don't think targets will be met and intent of use once targets are met.
- Meets DOE Volume and Weight % goals.
- 2nd generation actually fits in backseat (not a foregone conclusion at outset!).

- The work is progressing well. Each of the tasks appears to be on track.
- Outstanding.
- Second generation insulated pressure vessel has significant improvements in orientation, weight, and volume, with further improvements possible.
- Hydrogen boil-off may be significantly reduced or eliminated.
- Insufficient information provided regarding tank cost and impact on cryogenic hydrogen cost compared to other storage alternatives; combination of potential operational benefits and costs makes it uncertain if the proposed cryotanks have economic viability.

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

This project was rated **2.4** for technology transfer and collaboration.

- Need to coordinate w/ others to determine technology feasibility in relation to others.
- Primarily a component development project.
- The extent of collaboration wasn't clear from the slides.
- High volume production study needed.
- Several presentations and papers during last year.
- Collaborations with several project partners.

Question 5: Approach to and relevance of proposed future research

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

- Opens new option available for specialized situations.
- High risk to possibility that new practical on-board storage option will emerge.
- Discussion of future work is very generic.
- The slides should have included the specific steps remaining to bring the project to a successful conclusion.
- Design for manufacturing, production plan and investment with resulting high volume unit cost is the big missing factor that needs to be addressed.
- Reasonable plan to install cryotank in a long range hydrogen hybrid vehicle to demonstrate thermal endurance and range.

Strengths and weaknesses

Strengths
- Technology development may show increase in liquid H_2 storage capability.
- Builds margin into quantity of H_2 onboard to mitigate holdover image difficulties with electric vehicle range. AND may develop option for range addition to typical gaseous storage for special cases.
- The tank designs are innovative and have been successful in terms of 2007 and 2010 volume and weight targets, respectively.
- Technically strong.
- Strong team with relevant expertise.

Weaknesses
- Liquid H_2 storage has problem with off gassing through lack of continuous use that is not feasible in a vehicular application.
- These tanks are expensive to manufacture.
- Unsure how leaks would be detected.
- No data on use in vehicular application.
- High risk in sense that it is not obvious that this is practical.
- Higher risk and complexity than Compressed H_2.
- The project seems to be open-ended. No mention was made about DOE's go/no go decision on cryo/compressed tanks or what the end result of the project will be. 2015 targets will be difficult to meet.

- Business case needs study – at least a conceptual forecast should be made.
- Insufficient attention to quantifying potential economic viability, including cryotank cost and cryogenic H_2 cost.

Specific recommendations and additions or deletions to the work scope

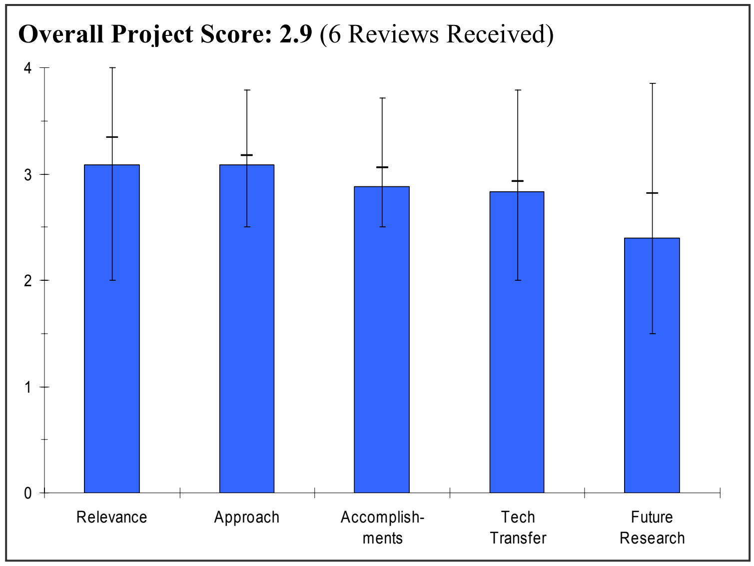
- Add go/no go with respect to technical validation against novel carriers both technical & economic. If both are not satisfied recommend finishing project w/o further work.
- This is worth pursuing and appropriate to DOE science based programs.
- Cost studies need to be added.
- Perform detailed analysis of system to determine potential economic viability.

Project # TV-04: Development of a Natural Gas-to-Hydrogen Fueling System

Bill Liss; GTI

Brief Summary of Project

GTI is designing a competitive, fast-fill natural gas-to-hydrogen fueling system with 40-60 kg/day delivery capacity with nominal 350 bar (5075 psig) dispensing. GTI is developing and validating onsite, integrated natural gas-to-hydrogen fueling stations, developing or testing state-of-the-art subsystems that address integration, operation, maintenance, reliability, and safety. Pre-packaged system designs with simple installation requirements are favored. Compact and efficient hydrogen generation technology is an important component of the system.



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.1** for its relevance to DOE objectives.

- Relevant to DOE objectives for hydrogen production efficiency.
- Important to a primary pathway.
- The project goals are in line with program goals for natural gas to hydrogen reforming.
- This type of project is very useful for "tech validation", but is not enabling for the President's vision when true breakthroughs are required elsewhere in the program.
- Distributed hydrogen reforming and dispensing is a very important part of getting early-on acceptance of hydrogen. This covers the development of such a system in detail.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- Logical plan, good scale.
- The approach appears to have been successful. Components were selected only after thorough consideration of possible options.
- Five generations of fuel processor built and tested. Multiple vendor PSA units assessed, along with some more advanced membrane approaches. Reformer efficiency is a design goal. Simple, robust fill algorithm sought.
- A well thought-out and thorough approach. It covers all aspects of making and dispensing hydrogen and describes both the theoretical and experimental components of the project in detail.
- Well thought out.
- Unclear if the H_2 cost target can be met; insufficient infomation provided.

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

This project was rated **2.9** based on accomplishments.

- Good technical progress in fuel reforming efficiency, fast-fill testing, and fuel dispensing.
- Areas such as hydrogen compression appear to have little progress, and insufficient detail provided on areas such as hydrogen purity.
- Some limited cost data provided for cascade storage, but insufficient cost information provided for other tasks.

- Issued a patent relevant to the project which is good validation.
- The project is nearly complete. The reformer design is on track to meet program targets for reforming, efficiency over all the progress was slow and several barriers were encountered.
- Fairly refined system developed. Reformer efficiency target achieved. Fill algorithm developed and will be made available through non-exclusive licensing at "a relatively nominal cost." Successful project.
- Definite progress, it seems that they have gotten some good results for all their components.
- I would have liked to see a little more detail in some areas such as comparison of data of various purification configurations.
- The answer to my safety question was only partially satisfactory. However, while experience in working with similar experience is certainly valid and welcomed, statements such as that often indicate that there is too much reliance on past experience and not enough focusing on the present task and determining what the safety risks are and how they are mitigated.
- Need to show more detailed results – comparison between tank types, fuel processing, etc. PSA / Fuel purification testing with various systems is extremely beneficial. Would be better to list findings between tested systems.

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

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

- Insufficient information provided regarding tech transfer and collaborations; however, several partners were involved in the project.
- Good commercialization intent, good connection to the natural gas industry to help build bridges to the infrastructure.
- Co-ordination with Greenfield is good. Co-ordination with others and dissemination of results were not adequately addresses.
- Broad, appropriate collaborations.
- The ability to partner with so many component manufacturers and get comparative data on these components is most desirable.
- Partners seem to be used to supply equipment. Little new work or R&D completed.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.4** for proposed future work.

- It appears that most the future work is outside the period of the current project; some important work will not be completed, such as long-term operation of the fuel processing system and demonstration of the mobile hydrogen system.
- Close to complete.
- The final steps make sense to bring the project to a logical conclusion.
- Project is essentially complete. Remaining activities appropriate to project closeout.
- They are just about finished with this project. Their plan to use their storage system for demonstrations and working with others toward commercialization appears to be the correct focus.
- No future work given, even finishing of reports with detail data would've been good.

Strengths and weaknesses

Strengths

- Accomplishments made in hydrogen production/fuel processing and fuel dispensing (CHARGEH_2, fill control algorithm, commercial dispenser, and cylinder filling).
- GTI is well placed to pursue these efforts and seems to make valid efforts to get the technology into marketplace.
- The project was successful in developing a complete natural gas to hydrogen fueling system, which is a key goal of the program.

- PI and company well qualified and appropriate collaborations in place.
- Great amount accomplished with existing funding , made good decision to keep project and achieve greatest amount of relevant results. Data can be used by others.
- Very nice well thought-out system. A thorough job.

Weaknesses
- Project is too diverse, and it appears that few accomplishments were completed in some areas.
- Insufficient information was presented in key areas, such as hydrogen purity and system/hydrogen cost.
- None evident.
- Need to show efficiency from an overall system perspective not individual components, using NG w/o CO_2 gas clean-up.
- Not much in the way of weaknesses here. I would like to be assured of the adherence to safety that I mentioned above.

Specific recommendations and additions or deletions to the work scope

- Would like to see additional efforts to get operational data into the knowledge base.
- Project nearly complete. Continued operation, data collection and subsequent system refinement by company will benefit product development.
- Scale should include a data report with pros/cons of various vendor's technologies both technically and economically. Should request recommendations for components improvements, not system improvements; systems seem to have enough evaluation completed.
- Get the system into commercial use!

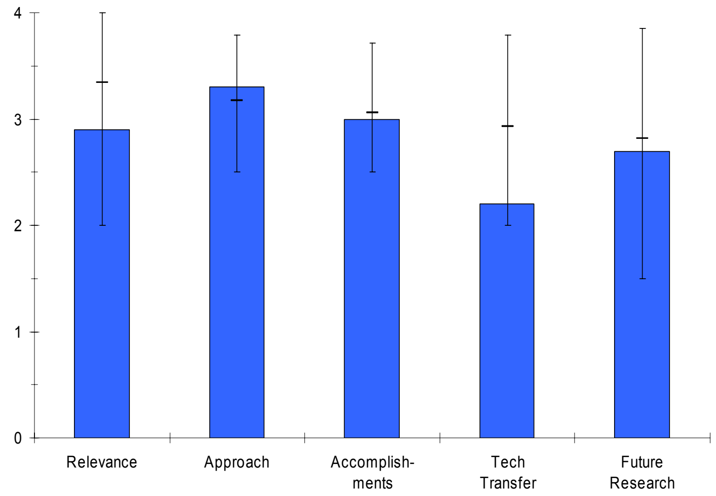
Project # TV-05: Development of a Turnkey H_2 Refueling Station

David Guro; Air Products

Brief Summary of Project

Air Products and Chemicals, Inc. is working on a project to demonstrate the economic and technical viability of a stand-alone, fully integrated hydrogen fueling station based on the reforming of natural gas. Building on the lessons learned from the Las Vegas H_2 Fueling Energy Station project, this project seeks to optimize the system, advance the technology, and lower the cost of hydrogen. The demonstration will be done through the operation of a fueling station at Penn State University with the purpose of obtaining adequate operational data to provide the basis for future commercial fueling stations. The top priority of the fueling station is maintaining safety standards in its design and operation.

Overall Project Score: 2.9 (5 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **2.9** for its relevance to DOE objectives.

- The intellectual property approach of APCI is designed to prioritize the distributed reformer to H_2 pathway. This undermines deployment necessary for the success of DOE's H_2 program.
- Distributed generation makes sense in next (early) infrastructure development.
- The customer's interface experience is vital. Not sure converting natural gas has long term relevance. (i.e. shortage of supply and need to import, and CO_2 production.)
- Relevant to several technical objectives related to storage, refueling infrastructure, O&M, and codes/standards.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- Engineering work first rate; however engineering selection very conventional.
- Wonderful.
- Appears to be a well-designed project that should provide useful data on all aspects of refueling station operation.
- Clearly focused on technical barriers.
- What will be the approach to scale-up to the 1500 kg /day system?
- Project seems primarily designed to position Air Products to market its fueling station.

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

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

- New PSA system appears of high value.
- Progress seems excellent but need to report issues or any incidents of interest.
- Appears to be a large project budget for the work accomplished.
- Six months of demonstration for the H_2 generator is insufficient, particularly when efficiency optimization will still be underway.
- H2A results indicate potential for meeting H_2 cost target.
- Significant progress has been made in all aspects of the station.

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

This project was rated **2.2** for technology transfer and collaboration.

- APCI tightly controls this project.
- Only apparent interaction was with Penn State.
- Stronger interface with current fuel distributors and sellers is needed.
- Collaboration with Penn State, although specific contributions from Penn State were not clearly described other than providing site.
- Few publications or presentations during last year.
- 1) Great collaboration with a state-run academic institution – Penn State University (slide 4). 2) Please explain Penn's activities relative to project in addition to involvement in fabricating and installing the unit (slide 4) – Any additional shared learning and technology transfer? 3) Please report related filed patents. 4) Please name the catalyst supplier (slide 12) – they seem to be a key collaborator. 5) Excellent technology transfer of a DOE tool to your research when you ran the H2A model for a cost comparison (slide 33) – results reproducible for others. 6) You made H_2 refilling station compatible with existing CNG filling site – very useful.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.7** for proposed future work.

- Vital to continue.
- Insufficient station operation time for complete demonstration.
- Continue to demonstrate performance, durability and reliability. Have the critical cost factors been identified which are required to achieve the $3 per kg goal? Does any of the future work address these critical factors?

Strengths and weaknesses

Strengths
- Competent and safe implementation of proprietary design.
- Excellent chemical engineering by a credible team.
- Looks at real world customer interface.
- A well-designed project that addresses all key areas of a hydrogen fueling station.
- Has potential to meet DOE H_2 cost target.

Weaknesses
- Task seemed very similar to earlier Air Products funded (DOE) efforts continual selection process to select components seems unnecessary.
- Natural gas hasn't a long term future as H_2 source.
- Insufficient time allowed for complete demonstration of system operation, reliability, maintenance, H_2 purity, etc.
- I would have like to seen more information on the Economics. What does H2A estimate for this scale of a system? It would have been helpful to see the base case economics and Air Products estimate for the 1500 kg/day system vs. H2A Model; Also it would have been helpful to see where the key cost reductions are going to come from in going from $ 13 per kg to $ 3 per kg. It would also have been useful to show the sensivities to power and natural gas costs to the overall economics. For example power costs of 8 cents per kWh were used – future electric rates may be 12-18 cents. Natural gas costs at the LDC may be on the order of $10-12 per MMBtu.

Specific recommendations and additions or deletions to the work scope

- Nothing at this late point in program.
- Extend demonstration time to at least one year to obtain maximum benefit from this project.
- Are there any issues with siting and installing such refueling systems within cities and communities? What lessons learned are being documented to enable future H_2 refueling stations to be permitted within communities?

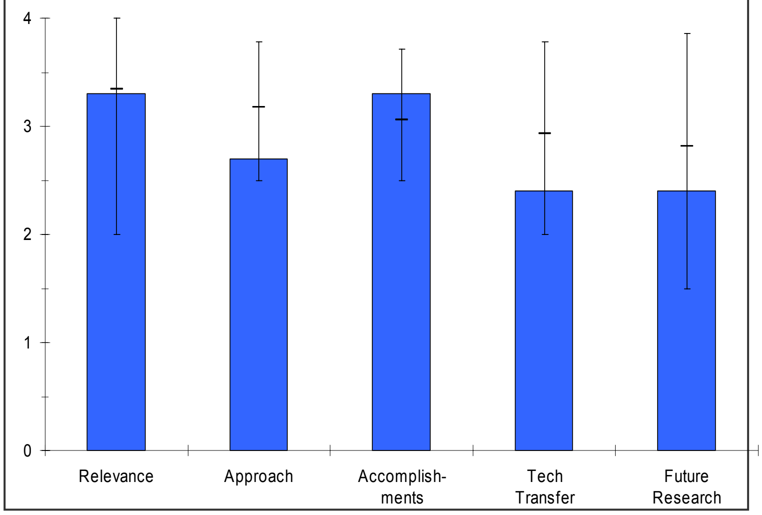
Project # TV-06: Validation of an Integrated Hydrogen Energy Station

Greg Keenan; Air Products

Brief Summary of Project

Air Products and Chemicals, Inc. is conducting a project to demonstrate the technical and economic viability of a hydrogen energy station using a high-temperature fuel cell to produce hydrogen and electricity. A total system design and engineering development effort will be completed with the goal to economically recover hydrogen from the anode of a high temperature fuel cell. The project will conclude in a year long demonstratioin of the system at a suitable site. Safety is the top priority in the system design and operation.

Overall Project Score: 3.0 (5 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- Interesting and some what novel for US energy development.
- Captures development opportunities for several key technologies needed for stationary H_2 infrastructure, while enabling H_2 refueling for transportation.
- Identifying near-term opportunities to drive hydrogen infrastructure will be important to enabling the transition to a hydrogen economy.
- We are running out of natural gas already – this makes no sense.

Question 2: Approach to performing the research and development

This project was rated **2.7** on its approach.

- Sound engineering.
- The 4 phase approach is a good, conservative design progression appropriate to this complex integration.
- It would have been helpful to see more detail on system performance. For example anticipated power (kWe or MW) size of the MCFC unit. The net AC power export; the net H_2 export. The overall efficiency of 49% seems high given that a MCFC unit on natural gas alone (with out H_2 export) is about 44-45%. It is also difficult to review the economics. Does the cost of H_2 reflect the capital cost of the MCFC unit.
- Good phased approach, including go/no-go decisions.
- Using a commercially-available MCFC was a good choice for validating the concept. This will serve as a good benchmark for when SOFC has matured.
- I'm sure it will work but it's not worth the trip.

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

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

- Only an engineering design, but not a high risk design. Looks well done.
- Work in progress is on schedule
- Analysis led to selection of PSA as separation technology to use.

- PSA turns out to give much better H_2 recovery than thought at much lower pressure differential; This is the type of new discovery that can occur when we push into new operational regimes, in this case recovery of H_2 from dilute stream.
- Significant improvement in hydrogen recovery and system throughput compared to phase 1 projections.

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

This project was rated **2.4** for technology transfer and collaboration.

- While this has led to good communication between FCE and APCI, there is no apparent additional collaboration or information available.
- Partnership development will be critical during the next two phases (site selection and implementation).
- Seems mostly self serving.
- A closed shop.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.4** for proposed future work.

- Obviously phase 3 needs to be done.
- What is "unexpected" effect discovered in design of Pressure Adsorption Swing in this case?
- Is additional cooling from excess Hydrogen production in FC potentially useful in SOFC's as well?
- Need to clearly identify criteria for the 12 month operating period. Similarly, site selection will be important for determining the potential to replicate this type of system elsewhere (i.e. Lessons learned for permitting, community outreach, system configuration, demand profiles, etc.).

Strengths and weaknesses

Strengths
- Technically sound.
- Integrated FC/H_2 recovery provides opportunity to utilize internal reformation step to provide product for electricity production as well as H_2 Production.
- Synergistic effects may prove more valuable than initial latchup would have indicated; e.g., supplements FC cooling, work with dilute H_2 stream has apparently led to new discovery in PSA design.
- This project relies on essentially mature technologies which increases the likelihood that it will be a validation of an integrated hydrogen and electricity co-generation system that could be replicated to drive hydrogen infrastructure development during the transition.
- This is a very strong team with a good understanding of integration issues, hydrogen safety, and infrastructure needs.

Weaknesses
- Needs alternative to use of natural gas.
- Risk involved in this sort of combining of flowsheet. The FCE unit is not being re-designed to accommodate this new capability, so possibility that it will perform as good or better than without the H_2 scavenging is a risk.
- I would have like to seen more information on the economics. The total capital cost of the entire package installed; the value or cost of electricity; the cost of hydrogen production in a life cycle analysis. For this to be a viable co-production solution; the MCFC unit has to be a compelling and competitive distributed generator production electrical power at better than grid prices – which are in the 8-12 cents per kwh range.
- As the project progresses to the next phases, emphasis will need to be placed on understanding demand profiles and how this may impact the system optimization.

Specific recommendations and additions or deletions to the work scope

- Need to show more economic analysis to support this approach. To be able to compare with distributed SMR or distributed electrolysis.
- Need to revise economic parameters to match up with H2A standards.
- Need to be clear (on charts) that cost projections are for a plant-gate hydrogen cost, not for a delivered hydrogen cost.
- Eliminate natural gas use.

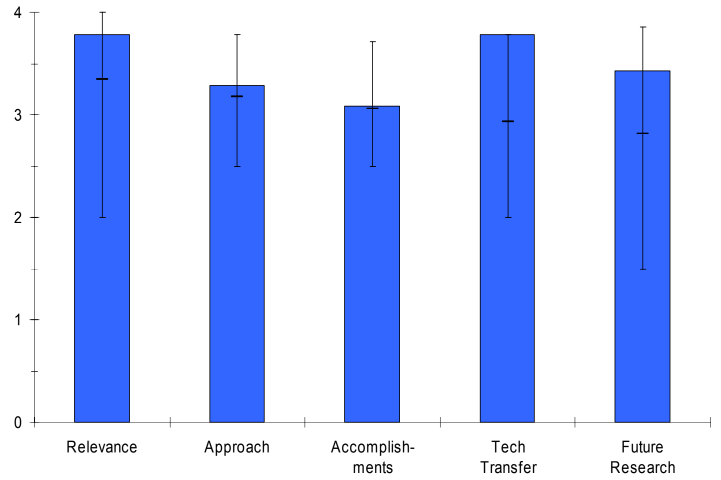
Project # TV-07: Hydrogen Vehicle and Infrastructure Demonstration and Validation

Roz Sell; General Motors

Brief Summary of Project

General Motors and energy partner Shell Hydrogen are deploying a system of hydrogen fuel cell vehicles integrated with a hydrogen refueling infrastructure to operate under real world conditions to: 1) Demonstrate progressive generations of fuel cell system technology; 2) Demonstrate multiple approaches to hydrogen generation and delivery for vehicle refueling; and collect and report operating data. This project will demonstrate two generations of fuel cell technology deploying forty fuel cell vehicles fueled with hydrogen from stations in five locations.

Overall Project Score: 3.4 (7 Reviews Received)



Question 1: Relevance to overall DOE objectives

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

- Program targets DOE technology validation objectives including education and outreach.
- Totally relevant.
- The presence of all of the Vehicle Demonstrations projects is critical to the path to the hydrogen economy.
- Outstanding core goals.
- The project objectives are right in line with program goals. The project should remain a high funding priority.
- Significant advances in vehicle technologies will be imperative for realizing the potential of hydrogen to meet the transportation needs. A critical element to achieving this will be experience and insights gained through operation of these vehicles in variable climates and under variable operating conditions.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- Need to present more information in this area. For example, what are the lessons learned in fueling and has the nozzle and associated filling apparatus performed adequately? Have hydrogen sensors operated properly? Has hydrogen flaring created any issues? Are you using a database to report lessons learned?
- More on actions to resolve issues would be desirable.
- It incorporates all that is needed to demonstrate hydrogen fuel cell vehicles and the infrastructure to support them. The presence of the fueling facility in DC lends an extra appeal for this project in its visibility. I don't know if 40 vehicles are necessary.
- Appears to be well thought out but as it is early in the implementation, it is difficult to determine focus.
- The approach is solid and will likely lead to a successful project. Hydrogen generation technologies were not discussed.
- It was impressive that they have 40 fuel cell vehicles in the program but only 8 have the data collection equipment on the road today.
- Testing of multiple on-board storage options is good.
- More emphasis needs to be placed on ensuring that operating conditions and cycles will have sufficient variability to ensure that data gathering and lessons learned are sufficiently robust.

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

This project was rated **3.1** based on accomplishments.

- Development of automated systems such as that employed to track fueling time is progress toward validating technical targets.
- Good start.
- Seems to be doing well; we don't have the individual technical data, of course, but GM seemed less forthcoming than the other projects. The data collection methodology and progress in C&S and training seems fine.
- Good "lessons learned" but it is still very early in the program.
- Vehicle deployment seems to be on track. Site selection is ongoing, but seems to be lagging behind the vehicle deployment. Maintenance and training is progressing well.
- It's very impressive to see how the Benning Road station is used as a learning facility. Their local outreach is outstanding. They have gone beyond what is required.
- Only one fueling station is currently operational and site selection for other fueling and maintenance facilities remains underway. The goal for this project is to have 5 fueling stations. Can this goal be met within the timeframe of the project?
- Good emphasis on community outreach and first responder training at the Benning Road station.
- Although it was accepted that data reporting would be handled under the NREL presentation, it would have been appropriate to have some discussion on vehicle and infrastructure performance. Have there been any issues? Is there any general reading?

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

This project was rated **3.8** for technology transfer and collaboration.

- Collaboration with maintenance and training personnel is critical. This concept carried forward could set the stage for the creation of high skilled labor in the U.S. Collaboration with urban planners is excellent. Zoning officials and local planning commissions and boards of county supervisors would also be worthwhile groups to target for collaboration and outreach.
- Seems very well coordinated.
- Excellent set of partners representing vehicle, energy, government, maintenance, data and regulations industries.
- Good communications with other team members. Good use of visitor center at refueling center. Good coordination regarding C&Ss.
- Collaboration with station operators and other stakeholders appears to be well coordinated.
- She identified the data validation requirements but provided little results. She explained the complexity of data collection, including the engineering effort on the vehicles.
- Good emphasis on partnership development and on gathering lessons learned from experiences to date.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.4** for proposed future work.

- Although there was insufficient information provided to determine the strategy for future work, the scope seems adequate.
- Good coverage.
- Looks good. NYC will be another high visibility locale.
- Very broad program which limits focus. Slow expansion of user base. Limited supplies of hydrogen to refuelers.
- The plan for future work is comprehensive and aimed at meeting the project goals.
- They will establish 2 more refueling stations by 2006. She clearly explained the lessons learned of establishing the infrastructure.

- Presentation would benefit from showing a multi-year timeline with key milestones. In particular, firm deadlines should be established for fueling station site selections, designs, construction, and operability, as well as delivery of second generation vehicles.
- More emphasis should be placed on validating hydrogen infrastructure. Targets need to be set for numbers of vehicles fueled, hydrogen deliveries made to the station (or hydrogen produced if on-site hydrogen production is to be included), storage and dispensing cycles, etc.

Strengths and weaknesses

Strengths
- Very good set of lessons learned. Especially like the non-self serving cadre of hydrogen experts to talk safety issues to localities.
- I really like the lessons learned, especially the call for third party safety experts.
- Good team cooperation. Good vehicle support. Good refueling station experiences.
- The project includes strong elements of safety and community outreach.
- They provide good explanation of infrastructure lessons learned. They are working on data enhancement. They provide good explanation on the learning part of the project.
- This is a good partnership with a strong emphasis on safety and on codes and standards development.
- Multiple vehicles in multiple locations should lead to valuable insights into technology status and RD&D needs.

Weaknesses
- Need more detailed plans on failure response and resolution.
- None really, just that GM appeared less forthcoming than the others.
- Very broad based approach. Slow start and few vehicles so far.
- Production and delivery options were not adequately addressed. Site selection seems to be behind schedule. The only operating stations are outside the project scope.
- They need to explain how the data enhancements will be made and when the results will be provided and systematized?
- Infrastructure development appears to be lagging. Decisions need to be made on site-selection and on hydrogen delivery options that will be employed if the benefits of the infrastructure validation are to be realized.
- PI should be able to report more on the general performance and operability of the vehicles and the infrastructure without having to go into the detailed data.

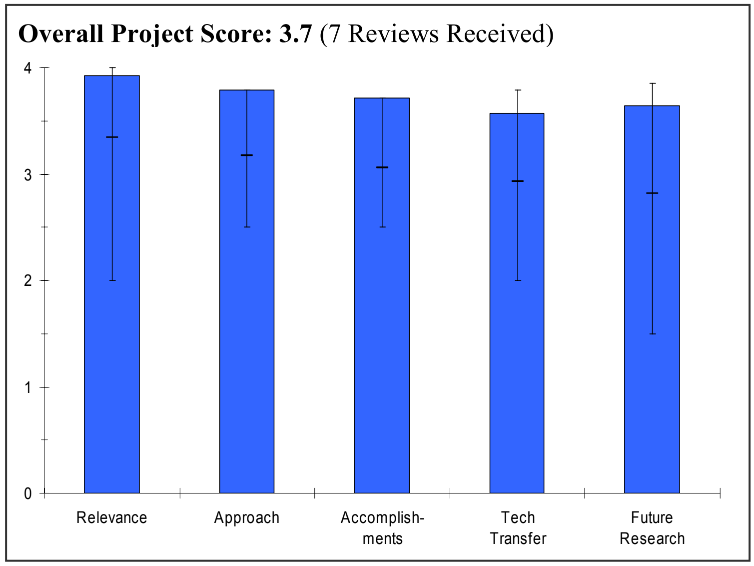
Specific recommendations and additions or deletions to the work scope

- More about customer self fueling experience is needed.
- The good work being presented by this and the other vehicle demonstration projects are huge boosts for the acceptance of hydrogen.

Project # TV-08: Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

Klaus BonHoff; DaimlerChrysler

Brief Summary of Project



In this project, DaimlerChrysler deployed 30 Gen I fuel cell vehicles in three ecosystems to validate current status of: 1) Durability of fuel cell stack and system; 2) Range of operation with compressed H_2; 3) Cost of H_2 from various production methods; and 4) Performance degradation over life via dynamometer and on-road testing. All 30 vehicles were equipped with a customer friendly Fleet Data Acquisition (FDA) system that will automatically collect statistically relevant data for submission to NREL as well as engineer analysis for technology improvement. As the energy partner of the project, DTE Energy opened the first public hydrogen refueling station in Southfield, Michigan with BP. DaimlerChrysler, BP and DTE Energy will also test emerging technology with the potential to meet DOE hydrogen cost target while evaluating emerging and renewable technologies to produce hydrogen and co-generation technologies to produce hydrogen and electricity. Data will be provided from Gen II vehicles under the same operating conditions as Gen I vehicles to compare technology maturity over the project duration.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.9** for its relevance to DOE objectives.

- Highly appropriate to get real world experiences.
- The focus on collecting data to validate critical performance measures was obvious in the presentation. For example, describing the range of ecosystems in which the vehicle is operated was good, however in the future briefly list those environments.
- He clearly outlined the goals and objectives for the project and they are the same as DOE's
- The presence of all of the Vehicle Demonstrations projects are critical to the path to the hydrogen economy.
- Have elements critical to success.
- Project goals are aligned with HFCIT programs goals for the learning demonstration.
- The project should remain a high funding priority.
- Significant advances in vehicle and infrastructure technologies will be essential for realizing the potential of hydrogen to meet the transportation needs. A critical element to achieving this will be experience and insights gained through operation of these vehicles in variable climates and under variable operating conditions.

Question 2: Approach to performing the research and development

This project was rated **3.8** on its approach.

- Good, but needs some feedback on current status compared to objective.
- The approach taken to accumulate vehicle mileage is good as is the strategy to ensure the approach is optimized (getting them to drive as much as possible). The Work on nozzle/receptacle communication is critical.
- They have a well thought out plan to address the barrier.
- The Michigan/California combination covers the weather extremities. I also like the customer perception and project crisis management plans.

- Seems to be self-focused but it is still early in the program.
- The infrastructure approach includes multiple hydrogen technologies. Safety, codes and standards, and maintenance are all included in the scope.
- Breadth of regional and drive cycle variability should yield valuable insight into fuel cell vehicle performance.
- CFD modeling a good approach for facility design.
- Good emphasis on deploying second generation vehicles into comparable operating conditions so that performance improvements can be verified.

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

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

- Diverse operating environments are a strong plus for program. Details on things gone wrong and lessons learned should be reported.
- The addition of the Long Beach facility vehicle bays, Computational Fluid Dynamics to model potential leaking contribute to important accomplishments. Good presentation of software developments to improve vehicle reliability.
- All 30 vehicles in customer's hands are equipped with data collection.
- 35000 miles driven.
- They have done some work on safety for buildings in case of an H_2 leak.
- I was happy to see some data – even if it was just cumulative and daily driving miles. It opened up a very interesting anomaly on weekly driving miles differences.
- I would like to learn more about the software to improve reliability.
- Very rapid deployment of 30 vehicles. Good maintenance facilities. Good feedback from operational experiences to improve reliability i.e. software modifications.
- Vehicle deployment is outstanding (30 vehicles and 35000 plus miles).
- A comprehensive service facility has been completed.
- Infrastructure development seems to be lagging behind vehicle deployment.
- Project has made significant progress in the deployment of vehicles, including the vehicle miles traveled.
- Showed clear design improvements that have resulted from the experiences gained through the project.
- Even though some of the fueling stations have been delayed, clear progress has been made on site selection and hydrogen delivery/generation choice.

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

This project was rated **3.6** for technology transfer and collaboration.

- Internal collaboration with employees is critical. Also, coordination with DOE education and outreach good. Collaboration with DTE and NextEnergy is a good match and leverages existing research efforts.
- Customer profiling work is valuable
- Status, technical data provided for each station
- This was very comprehensive
- A strong team that covers all the key areas.
- No public educational accomplishments or plans stated. Good collaboration with team and DOE.
- Collaboration with fleet partners has been good.
- Strong partnership development efforts on both the vehicle and infrastructure side.
- Ability to meet timelines for permitting of stations demonstrates good attention to stakeholder development at individual locations.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.6** for proposed future work.

- Suggest large cars and SUV's in future.
- Unclear what the strategy is behind future work and how future work will further DOE targets. In the area of customer perception however, the need is clear and the proposed work critical.
- The customer acceptance and perception study could be valuable
- Good set of future work. It seems that they are moving right along.
- I really like the customer perception and acceptance study that will be done.
- Future work stated as expansion of existing implementation.
- The plan for future work is good and will lead to meeting project goals successfully.
- Would benefit from a multi-year timeline identifying critical milestones for vehicles and infrastructure.

Strengths and weaknesses

Strengths
- Well planned and executed.
- Over 35,000 miles driven.
- Good explanation of data collection systems
- Key findings on safety were clearly explained
- Very good set of training programs.
- Good vehicle technical team. Good operational experience.
- Vehicle deployment is outstanding.
- Good balanced emphasis on both vehicle and infrastructure validation.
- Breadth of hydrogen delivery options and site locations should yield valuable insights into technology status and future needs.
- Demonstrated that the experience gained through this project is directly feeding back into vehicle and infrastructure performance improvements.

Weaknesses
- More details on status of range, cost, and durability needed.
- None.
- Lacks educational components.
- H_2 production and delivery options were not adequately addressed.
- Critical performance milestones should be set for the hydrogen infrastructure, such as target number of fills, volumes of hydrogen delivered/produced, storage/dispensing cycles, etc.

Specific recommendations and additions or deletions to the work scope

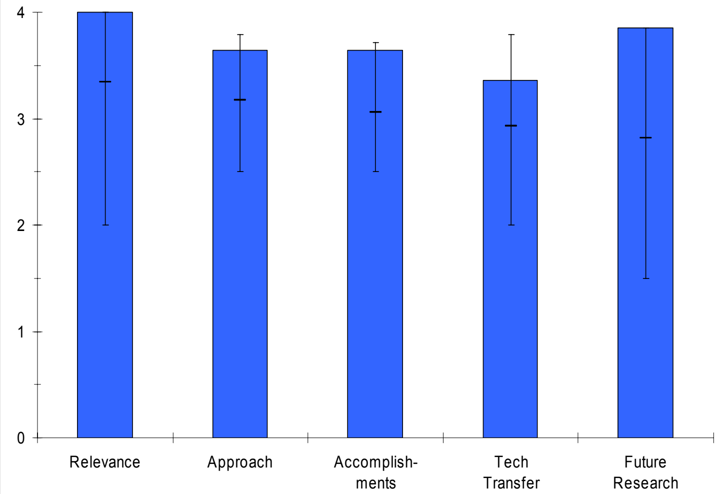
- Larger vehicles in future – to be more main stream for typical U.S. user.
- Instead of simply stating that "hydrogen fueling stations were designed, constructed and operated add in parenthesis the type of hydrogen station…i.e. (SMR, Mobile Refueler, Liquid).
- Excellent work!
- The good work being presented by this and the other vehicle demonstration projects are huge boosts for the acceptance of hydrogen.
- Add visitor centers and some public PR.

Project # TV-09: Hydrogen Fuel Cell Vehicle & Infrastructure Demonstration Program Review

Greg Frenette; Ford

Brief Summary of Project

Overall Project Score: 3.7 (7 Reviews Received)



To date in this project, Ford has placed 18 Gen I hydrogen fueled vehicles in fleet user service in three varied climatic regions to demonstrate the efficiency, reliability and durability of the fuel cell power concept, and to validate the concepts through the collection of real world data. In parallel, hydrogen fueling stations have been sited (City of Taylor, MI, Jamestown, FL and Sacramento, CA Airport) to establish an initial hydrogen infrastructure, demonstrate alternative hydrogen production concepts, and evaluate production technologies for cost effectiveness. Emerging technologies in vehicle and hydrogen infrastructure will be validated in separate, advanced engineering vehicles (Gen II) and fuel cell system designs that demonstrate improved functionality, range, durability, economy, weight and cost.

Question 1: Relevance to overall DOE objectives

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

- Outstanding match between DOE and collaborative objectives (especially when compared to other DOE research areas).
- The technical data and user perception information is critical to understand the consumer acceptance of hydrogen as a fuel.
- The presence of all of the Vehicle Demonstrations projects are critical to the path to the hydrogen economy.
- This is the core of the effort.
- The project goals are aligned with the HFCIT program goals for the learning demonstration. The project should remain a high funding priority.
- Just about perfect.
- Significant advances in vehicle and infrastructure technologies will be essential for realizing the potential of hydrogen to meet the transportation needs. A critical element to achieving this will be experience and insights gained through operation of these vehicles in variable climates and under variable operating conditions.

Question 2: Approach to performing the research and development

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

- Outstanding approach to vehicle deployment including the completion of the maintenance and training program. Quick assessment of vehicle technology shortfalls and rapid corrective measures taken – i.e. investigation of systems module valve.
- An impressive list of technical issues are being identified and addressed by the project team.
- Like the others, a good vehicle/infrastructure approach. Adding an Orlando station provides a more tropical region as well. Perhaps a more economical use of vehicles.
- Emphasis seems to be on vehicle data and analysis and infrastructure operation at the expense of Codes & Standards and public awareness education.
- Community outreach was not adequately addressed in the approach.
- Terrific plan and execution to date.

- Good phased approach for implementing infrastructure; good that the opportunity for validating more advanced delivery options (namely on-site generation) is not sacrificed because of the need for fueling infrastructure now.
- Interesting approach to both validate vehicles in the field under real-world conditions, while also conducting controlled durability/performance dyno-testing. Being able to tie the lessons from the two studies together will be important.

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

This project was rated **3.6** based on accomplishments.

- Description of the production method helps the reviewer determine the actual extent of progress. Excellent description about the lessons learned in miles accumulated. While 125,000 were targeted, 78,000 achieved. The rationale behind falling short was adequately described.
- The project has a good data gathering system and appears to use this data well. The project manager appears to have a well thought out plan of what they are doing.
- Very good assessment of difficulty of achieving their mileage goal. Nevertheless they accumulated more mileage than others. Very good discussion of lessons learned.
- Good number of vehicle miles (78,000 miles) experienced. Good feedback to vehicle design. Have restricted users in their use which may inhibit experience. It was stated that maintenance and training activities were "complete" for the project. This is a continuing thing and should not be considered finished.
- Vehicle deployment has been very good (18 vehicles) Significant training and maintenance effort has been completed.
- Two 2nd generation vehicles have already been built.
- Results and lessons learned are well reported here.
- Would like to see presentations at 6 to 10 opportunities over past 2 years (i.e.: SAE, H_2 Conference, other DOE).
- Performance improvements as a result of testing and lessons learned are evident.
- Good progress on infrastructure development and planning.

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

This project was rated **3.4** for technology transfer and collaboration.

- The transfer of fuel cell vehicles from the laboratory to the field is progressing rapidly.
- Collaboration with others was not apparent in the presentation.
- Seems to be more of a collaborative effort with data coming form DOE and non-DOE resources.
- Good team cooperation. Should expand to have more public disclosure/education.
- Good coordination with fleet operations and other stakeholders.
- Good collaboration among partners and suppliers.
- Good focus on emergency response training and community engagement events.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.9** for proposed future work.

- Description of the next phase was helpful and the specific description of work proposed in phases outstanding. The lessons learned also pointed toward future areas of research.
- It was clear from the presentation that the project team is responding to issues as they arise. There appears to be good effort to continuously improve.
- Appears to be right on track, following this year's work.
- Should consider more vehicles. The "lessons learned" were limited to vehicle experiences.
- The plan for future work is solid and will lead to a successful demonstration.
- Well planned.
- Good focus on specific targets. Would have liked to see these presented for future years, as well.

Strengths and weaknesses

Strengths
- Intellectually honest in assessment of progress.
- The gathering of real world data on almost 20 vehicles is a great strength. A good number of lessons learned in a wide variety of areas – including technical issues, insurance issues, user concerns, and fueling issues.
- They seemed to be a little more forthcoming with issues than some of the other vehicle projects.
- Good vehicle useage. Good feedback into vehicle design (i.e. software improvements).
- Vehicle deployment has been very good. Safety considerations have been given importance on the project.
- Outstanding in general.
- The PI did a very good job of reporting a breadth of lessons learned from the project. The presentation was well-balanced on both the vehicle and infrastructure sides.
- Clearly a well-qualified and well-integrated team.

Weaknesses
- Community engagement events are listed as technical accomplishments and perhaps should fall under collaboration
- Slow ramp-up of vehicles and operational experience on them. The support infrastructure (fueling) has contributed to this and is an issue as well.
- Focused too much on vehicles at the expense of other objectives such as public awareness.
- H_2 production and delivery options were not adequately addressed.
- Need to share results with the world!
- Need to better explain how correlations will be drawn between the vehicles in on-road service compared to the advanced vehicles undergoing controlled dyno-testing.

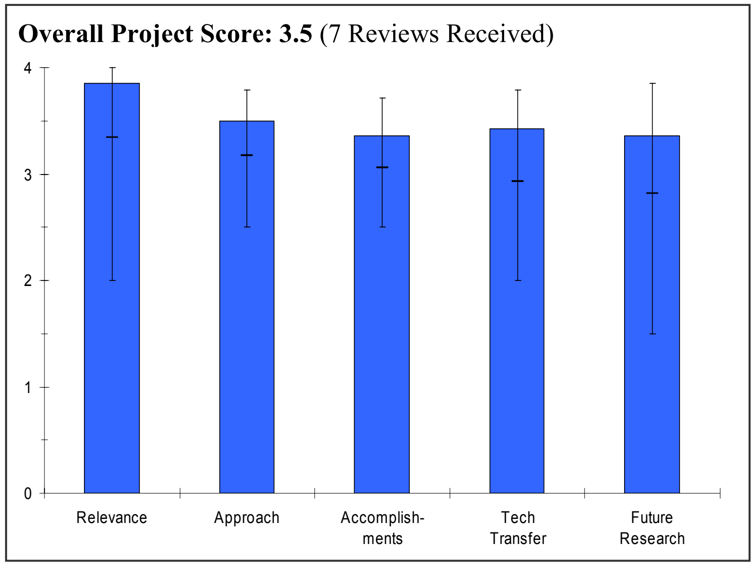
Specific recommendations and additions or deletions to the work scope

- Leave a few more minutes for questions from reviewers, however perhaps the additional information provided contributed to the outstanding score this reviewer provided.
- The good work being presented by this and the other vehicle demonstration projects are huge boosts for the acceptance of hydrogen.
- Suggest that visitor areas be established with refueling sites. Suggest that maintenance and training scope be continuing.

Project # TV-10: Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

Dan Casey; Chevron

Brief Summary of Project



Chevron Corp., Hyundai-Kia Motor Co. and UTC Power are conducting a five-year demonstration and validation project designed to showcase how fuel cell vehicles (FCVs) and hydrogen infrastructure can be designed to work together to fuel vehicles of the future. The primary goal of this project is to demonstrate up to six hydrogen energy stations (primarily in Southern California, with one site elsewhere to test cold climate conditions) and up to 32 FCVs as well as inform key audiences about hydrogen as a potential vehicle fuel. In addition, important safety and legal codes and standards for hydrogen refueling technologies will be developed in conjunction with the federal government and other authorities. Hyundai will provide a fleet of up to 32 vehicles, powered by UTC power plants. Hydrogen at the refueling stations will be generated using different types of natural gas reformer technologies and electrolysis. Other collaborators include Southern California Edison, Hyundai KIA America Technical Center, Inc., Alameda Contra Costa Transit and Tank Automotive Research, Development and Engineering Center, who will serve as vehicle fleet operators and site hosts for hydrogen fueling and power generation stations.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.9** for its relevance to DOE objectives.

- The relevance of work could be explained better to relate to the DOE multi-year plan.
- Very relevant.
- The demonstration of different methods of on-site hydrogen production was not lost on this team. Description of production details outstanding and allows reviewers to assess relevance beyond vehicle data collection.
- The information gathered on this and other similar projects is critical to understand the consumer acceptance and viability of hydrogen as a fuel.
- The presence of all of the Vehicle Demonstrations projects are critical to the path to the hydrogen economy.
- This is core to the effort.
- Significant advances in vehicle and infrastructure technologies will be essential for realizing the potential of hydrogen to meet the transportation needs. A critical element to achieving this will be experience and insights gained through operation of these vehicles in variable climates and under variable operating conditions.

Question 2: Approach to performing the research and development

This project was rated **3.5** on its approach.

- Good explanations of 32 vehicles deployed and infrastructure but relevance to barriers need more explanation.
- Very practical.
- Very clearly laid out in each area. Clearly stated rationale for geographic site selections.
- The presentation concentrated on operations and not as much of development. This is the nature of the project. The project appears to have a well thought out master plan.
- Their approach seems slightly more infrastructure based as they are emphasizing different kinds of stations.

- Too much emphasis on infrastructure and not enough detail about vehicles presented.
- Good activities related to climatic impacts on vehicle performance. Would like to see multiple data points, under extreme conditions, as the vehicles age.
- Good focus on complex infrastructure.

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

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

- Good explanation of safety record & stations.
- Good explanation of vehicle testing and monitoring systems.
- Seems a bit slow.
- Need report on things-gone-wrong and lessons learned.
- Should share story with other groups (i.e. SAE, etc.)
- Somewhat vague description of actual accomplishments. For example "worked on safety plan" doesn't mean a great deal. However, specific data was provided on bus refueling although teams had agreed to allow NREL to present detailed data. Good summary of percent of target reached.
- The project has shown significant progress. The presentation did not elaborate on details concerning technical hurdles.
- I like the fact that their first set of results feature safety plans. Some good testing under extreme conditions shown. Making some good progress in addressing vehicle range.
- Slow start on the number of vehicles deployed. Good variety of infrastructure examples.
- Accumulating good experience from vehicle fueling infrastructure.
- Would like to have seen more reported on lessons learned and improvements made as a result of conducting the learning demonstration.

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

This project was rated **3.4** for technology transfer and collaboration.

- Great use of transit companies (i.e. AC transit).
- Somewhat limited.
- Unclear what major collaborations are on this effort, although Chevron's efforts to collaborate across the country in the emerging hydrogen economy are increasing at an impressive rate! For example, sponsoring the NHA Power Park Student Design competition, funding the NREL renewable liquids feedstock study, chairing DOE's hydrogen production technical team
- There appears to be substantial collaboration with the direct participants. The presentation did not elaborate on technology transfer or collaboration beyond there.
- Another good team.
- Good coordination with other team members. Also has involved other projects such as bus demonstration projects.
- Good collaboration among partners.
- Appears to be limited community interactions beyond first responder training.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.4** for proposed future work.

- They presented clear vision for the project which builds on past progress.
- Not as broad as it could be.
- Somewhat confusing where future work was not sponsored by DOE and the strategy to be employed for conducting future work.
- The main goal of the project is to gather data and experience. A system to use this information for continuous improvement could be better described in future presentations.

- Seem that they will be adding more stations of different configurations and more vehicles. Looks good.
- Good on-site demonstrations. Should expand vehicle participation.
- Would benefit from multi-year milestones and targets.

Strengths and weaknesses

Strengths
- Real time monitoring of vehicle operations is impressive.
- Thorough, well staffed, and well planned – it appears.
- Listed the types of hydrogen production employed rather than making a generic statement about the provision of hydrogen. Excellent response to prior year reviewer comments.
- The program is demonstrating multiple fuel production methods to show capability and performance. A good project roadmap is in place and progress appears to be good. The program has a high number of vehicles with which to gather data.
- Good description of safety at stations.
- Good extreme condition testing – high altitude and high temperature conditions.
- Collaboration with other projects, i.e. AC Transit. Good infrastructure experiences.
- Good experience being gained with advanced on-site hydrogen generators.
- Good breadth of testing of vehicles.

Weaknesses
- Need to show the relevance of DOE targets to the project better.
- More sharing of results (expected and unexpected) needed.
- The presentation appears to have a strong focus on fuel infrastructure, to the detriment vehicle information.
- Slow start.
- Unclear how results are feeding back into advanced system development.
- Multi-point, multi-vehicle test at high altitude and cold/hot temperature would be required to identify statistically significant trends in vehicle performance/lifetime as a result of climatic variability.

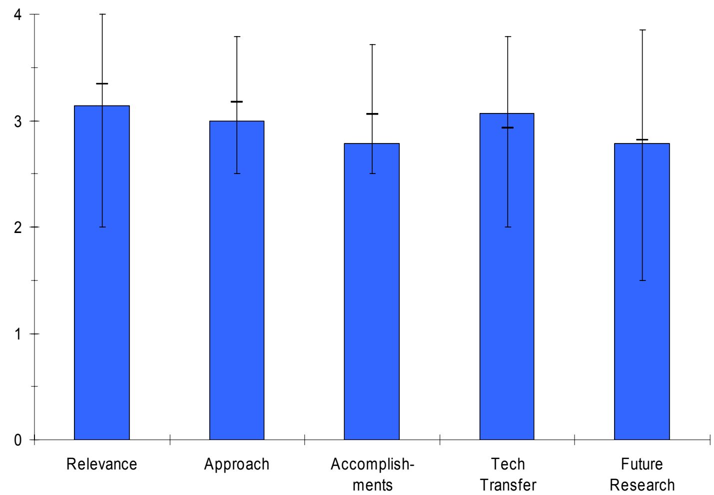
Specific recommendations and additions or deletions to the work scope

- Future plans should reflect results publicly reported and corrective actions.
- The good work being presented by this and the other vehicle demonstration projects are huge boosts for the acceptance of hydrogen.
- Expand use of vehicles.

Project # TV-11: California Hydrogen Infrastructure Project

Mark Pedersen; Air Products

Overall Project Score: 2.9 (7 Reviews Received)



Brief Summary of Project

This project is focused on demonstrating a cost effective hydrogen infrastructure model in California for possible nationwide implementation. It includes the design, construction and operation of seven hydrogen fueling stations; collection and reporting of operational data; documentation of permitting requirements and experiences; and validation of expected performance, cost, reliability, maintenance, and environmental impacts. This project will also implement a variety of new technologies with the objective of lowering the cost of delivered hydrogen.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.1** for its relevance to DOE objectives.

- Lower cost of delivered hydrogen by using existing infrastructure during the transition will help the Program achieve its goals. Focus on installation of infrastructure in a particular region, however may be premature as critical research needs have yet to be met that may determine transitional infrastructure.
- Not clear what is novel, what is to be learned, and why it's important.
- Limited to transitional cost factors using existing delivery infrastructures.
- They use current infrastructure and economics of scale to lower the delivered cost of H_2.
- The technical delivery cost target was not described.
- We've been talking about the need to get pipeline data for a long time; it's good that we're about to get some. You can't argue distributed vs. centralized hydrogen until you get data; this is a necessary project.
- Hydrogen delivery cost is a major barrier to cost-competitive hydrogen fuel. Understanding the opportunities and trade-offs of various infrastructure options will be importing for the ultimate design of the national hydrogen infrastructure.
- This project includes the first pipeline-supplied fueling station.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- Work with OEM's station operators, and other objectives similar to the learning demonstrations, is good. The descriptions of phase I and phase II were adequate. Although it is a most interesting concept, demonstration of the "world's first" pipeline fueling station is not included in the HFCIT delivery RD&D plan.
- Objective is vague.
- Very focused on delivery factors using "current hydrogen infrastructure." May be too transitional.
- The novel concepts for reduced costs, Hydrogen Based Unit (HBU) – lower capital and LH_2 – New Delivery Concept (NDC) are worthy ideas but need to have more clear milestones to determine what success will be.
- Do not understand the value of developing a hydrogen fueler, as this is not a long-term concept for H_2 supply.
- Energy requirements for liquid hydrogen supply should be evaluated ... Is this a long-term path from an energy efficient standpoint?
- Working with OEMs to decide station locations and vehicle needs is good. Interesting that they don't list the availability of hydrogen as being as important.

- The NDC approach is interesting, but I am not quite sure as to what is being addressed here as far as a permanent hydrogen infrastructure is concerned.
- I do like the additional purification of high purity H_2.
- Will gain good insight on multiple delivery options.
- Will be important to determine how the results of this project will feed into a California-wide and Nation-wide infrastructure model.

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

This project was rated **2.8** based on accomplishments.

- Relatively recent project, however some work seems to have occurred apart from the DOE contracted tasks. The Hydrogen Based Fuelers for example was developed independent from the project and will be worked into the effort and is being counted toward the Agreement's technical progress. Also, interim design is almost complete yet the project is relatively new.
- Too soon to really tell.
- Only 15% of project completed. Too early to show specific accomplishments.
- They have not had enough time to achieve many accomplishments.
- They do however have a good plan of action.
- Mainly design progress so far – this is what would be expected for a project of this magnitude that has only been operating for less than a year.
- Would like to see specific performance/cost targets being set of each station/technology option.
- Good progress on station site selection and on the suite of technology options that will be included.

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

This project was rated **3.1** for technology transfer and collaboration.

- Collaboration with State and Local officials is adequate.
- Focus seem to be California only.
- Good collaboration with vehicle people was indicated.
- They have identified who their collaborators are but the real work is yet to be seen!
- Good representation of partners from OEMs academia, etc.
- Although the project covers a large group of site-hosts and collaborators, it would be useful to better define the roles and responsibilities of the major players.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.8** for proposed future work.

- The project is a State deployment effort and the plan for future R&D is unclear.
- Not a clear plan.
- Expansion and continuation of project appears to be appropriate.
- This work needs to better explain how the technical barriers will be addressed.
- Only addresses the "coming months" Some layout of the rest of the project would have been helpful in the future plans section. The next steps, however, look good.
- Need to establish multi-year, target-driven milestones.

Strengths and weaknesses

Strengths
- The pipeline concept provides a low cost hydrogen production option while securing delivery capacity.
- Excellent background with similar industrial experiences. High technical capabilities.
- This project takes into account the current work being done in California.
- Being involved with the hydrogen safety program, I am very pleased to read the contractors response to a reviewer of last years peer review who stated that cost reduction is the first priority by stating that safety is the first priority. Keep up that mode of thinking!
- The project is designed to gain knowledge and establish the viability of multiple hydrogen delivery options.
- There is a good likelihood that the project will identify options for achieving hydrogen delivery targets.

Weaknesses
- The provision of hydrogen via "mobile refueling" could pose safety risks that if realized may impact public perception during the most critical stage of hydrogen economy development.
- Needs a clear definition of why, what exactly, when and how.
- Too focused on transitional factors. Only uses current infrastructure.
- They need more progress. Perhaps a timeline with milestones would be helpful to explain where the project is going.
- Project needs to emphasize a more target-driven approach, including baselining against current standards (cost, efficiency, etc) for hydrogen delivery.

Specific recommendations and additions or deletions to the work scope

- Clarify.
- Go to higher capacity site capabilities. (Lighthouse refueling concept)
- The report that is written on the stations should incorporate and compliment the work being done under the California H_2 Highway.

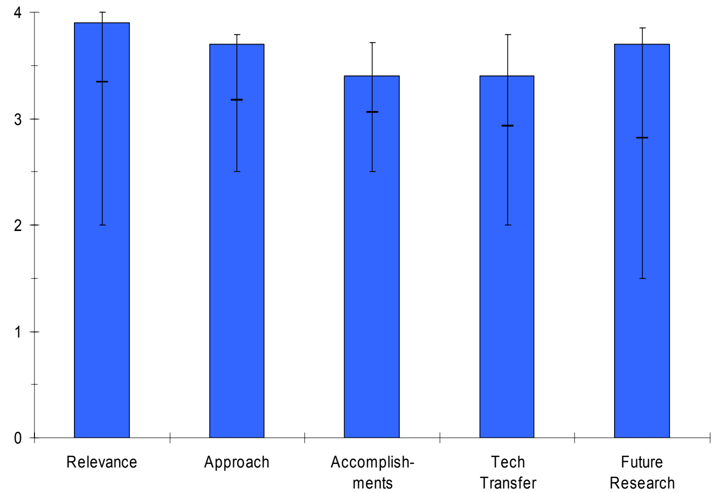
Project # TV-12: Controlled Hydrogen Fleet & Infrastructure Analysis

Keith Wipke; NREL

Brief Summary of Project

Under this multi-year validation project the National Renewable Energy Laboratory will assist DOE in demonstrating use of fuel cell vehicles and H_2 infrastructure under real-world conditions, using multiple sites, varying climates, and a variety of sources for hydrogen, including renewables. The objectives of this project include: 1) Validation of hydrogen fuel cell vehicles and infrastructure in parallel; 2) Identification of current status of technology and its evolution; and 3) Re-Focusing hydrogen research and development.

Overall Project Score: 3.6 (5 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.9** for its relevance to DOE objectives.

- Compiling and analyzing this operating data in a third party location will be helpful to understand the viability of fuel cell vehicles.
- Validation of both FCV and infrastructure in parallel is in line with reducing U.S. dependency on foreign oil since the majority of foreign oil use is in the U.S. light duty fleet.
- Government statistics on this information that has high public confidence is essential to development of public education on fuel cells and hydrogen.
- The method of data collection in a way that assures transparency and an accurate depiction of real performance and progress is an essential yardstick for society as we weigh alternate fuel options.
- Critical to know what progress is being made.
- Very thorough and well focused for this audience.
- This project will help validate the results from the Controlled Fleet and Infrastructure projects and will enable a broader look across the projects.

Question 2: Approach to performing the research and development

This project was rated **3.7** on its approach.

- The data gathering appears to be robust and comprehensive. An impressive amount of thought has gone into its design.
- The use of tax payer dollars to support an impartial team of national scientists and engineers is ideal for the purpose of third party data collection, processing and evaluation.
- Data collection technique appears adequate, and has sufficient markers to assure that data sets are complete and not altered by participants.
- With real data now starting to populate the database, it is an important time to think critically about the kinds of data being received. Based on data being received is there additional (different) data that's needed or data not needed.
- Suggest that fleet operators be consulted as well as OEM's on data being taken and how it is used. Local conditions may give additional meaning to data adequacy not apparent to data gatherers or OEM's.
- Outstanding!
- Very appropriate.
- Providing lessons learned from the data collection and analysis back to the projects is important.

- Disappointing that the team is not employing more robust, multi-variate data analysis approaches.
- Team would benefit from analytical chemistry expertise to better understand the capabilities and limits of some of the monitoring that is being employed (e.g. hydrogen purity measurements).

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

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

- The project has a clear set of analytical data to compile and clear goals against which progress can be measured.
- Aggregate conclusions presented to date are impressive. The Fleet Analysis Toolkit, if developed in a cost effective manner shows good progress. Actual results are demo accomplishments rather than NREL accomplishments.
- Things are in place, and real data is coming in. That's real accomplishment.
- Geared up to rapid increase in data.
- Status is thought provoking but mostly anecdotal so far.
- Project is doing a good job of benchmarking the current status across the different projects.
- Good effort has been made in establishing the systems for collecting and reporting the data.
- Conclusions presented on some of the slides are not nearly as robust as some of the conclusions presented by the individual projects. For example, what does "alarms could be improved" mean? Is there a root cause that has been identified?

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

This project was rated **3.4** for technology transfer and collaboration.

- The project must interface with a wide variety of organizations by design. The project appears to have done an excellent job collaborating with partners.
- Collaboration is required by participating OEMs. Other than database development, it is unclear how technology transfer objectives are furthered.
- This data allows DOE and OEM's to discuss program progress on an even basis.
- The public need to understand the progress being made using public money is an important aspect of these programs. Confidence in DOE oversight can be helped very much by this program.
- DOE's ability to communicate the essence of the data trends PUBLICLY will be very important.
- Top notch collaboration with all teams.
- Don't see much evidence of a 2-way communication.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.7** for proposed future work.

- Comments from the past have been addressed and there seems to be a plan forward.
- This criteria does not apply as directly, however the future of the data center is obviously to continue collecting data and validating the station and vehicle performance. The next stages of data collection and analysis were communicated adequately.
- Clearly this program must continue, and the public data will be closely watched.
- Validity and relevance of this database is currently high. Maintaining both of those characteristics with large data sets in a rapidly evolving field will be a challenge.
- Future work is more of the same. It may be too early to identify more specific focus areas.
- No change.
- Project needs to focus on identifying underlying data trends that might not be evident to the individual projects.
- The plans are important for benchmarking progress and for enabling public dissemination of the results. However, this is a significant effort and it will be important to demonstrate the value-added compared to what is being provided individually by the project themselves.

Strengths and weaknesses

Strengths
- The program is clearly well thought out and appears to be managed in an organized fashion. Very complete presentation that summarized objectives and status very clearly. Presentation material matches very well with review goals.
- This NREL Agreement is an outstanding method of facilitating interaction between principal hydrogen economy investigators. In addition, this Agreement is critical to validating whether the U.S. light duty fleet and fueling infrastructure will successfully be changed out.
- Objective perspective. Non-affiliation with data generators. High technical competence.
- Very well planned and executed so far.

Weaknesses
- The data is only as good as its incoming quality from the source. Despite an attempt to standardize, different organizations will report at different thresholds and at different quality levels.
- Detection of only 10 micrograms per liter with existing test equipment is not sufficient to provide a complete analysis of hydrogen purity data.
- Lack of transparency to public.
- Everybody has a car, so everybody considers themselves an expert on mileage, performance, range requirements, etc and maybe they are. In any case, DOE needs to learn how to give good reports of this accumulating data; reports that have public meaning and trust. With the apparent reticence of OEM's to make this stuff public, that may be difficult.
- Has proprietary restrictions on data disclosure.
- Can't really think of any.

Specific recommendations and additions or deletions to the work scope

- Tech Val assessment reports should be distributed more broadly with appropriate web-site links.

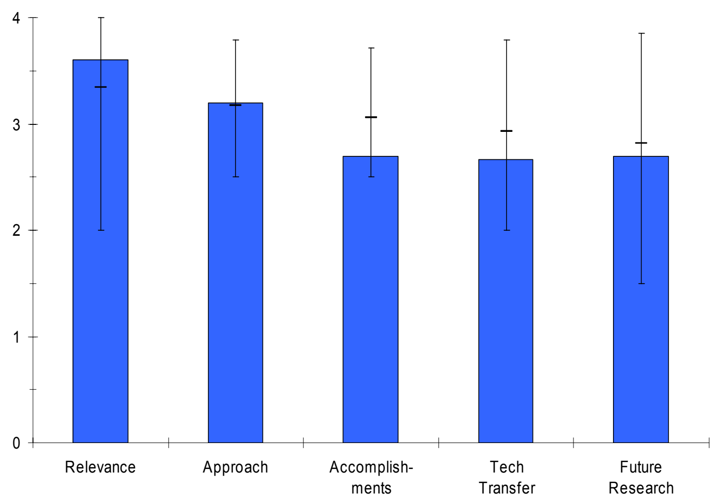
Project # TVP-01: Hawaii Hydrogen Center for Development and Deployment of Distributed Energy Systems

Richard Rocheleau; Hawaii Natural Energy Inst.

Brief Summary of Project

The objectives of this Hawaii Natural Energy Institute (HNEI) project include developing and operating a test bed to validate and characterize hydrogen technologies in a real world setting; characterizing the effect of trace level contaminants on the performance and durability of PEM fuel cells; and investigating critical steps for hydrogen production from biomass, including biomass gasification, tar reforming, hydrogen purification, and feedstock preparation. One component of this project is to integrate a renewable energy source with an electrolyzer, hydrogen storage, and a fuel cell to power a building.

Overall Project Score: 3.0 (5 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.6** for its relevance to DOE objectives.

- Hawaii is a good laboratory for demonstrating energy independence.
- The project includes three unrelated tasks, but each is fairly well aligned with HFCIT program goals. Each task addresses a need specified in the hydrogen program MYPP.
- This energy program has developed a broad technical base both of physical infrastructure and people knowledgeable of Hydrogen, its characteristics, and uses. This is a good example of a hydrogen technology center with a good track record capable of reliable hydrogen and renewable energy technology project deployment, evaluation, and education.
- All three tasks are highly relevant to Hydrogen Fuel Initiative objectives.

Question 2: Approach to performing the research and development

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

- Safety is noted as a barrier but is not addressed in the approach. The approach lacks details on the specific work to be one for the fuel quality assessment task 2.
- If Biomass is the most effective source of H_2 on the Islands – increase focus on biomass effort.
- The approach has been further sharpened and focused by inclusion of economic and engineering analysis for the Power Park task.

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

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

- Task 1 appears to be on track except no progress on economic analysis is reported. The construction and operation of the test stands is on track, but is not clear what types of fuel cells have been or will be tested and what will be done with the results. Not clear what work has been done to meet the objective of characterizing and preparing feedstocks.
- The program has progressed well on all three of its diverse tasks in this program.
- Good progress on all 3 tasks.

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

This project was rated **2.7** for technology transfer and collaboration.

- The amount of communication products seems modest.
- Not clear if or how the task 2 results will be shared with fuel cell makers.
- Clear evidence of published work by Graduate and Post Doctoral researchers in collaboration with HNEI on the several topics in this current program are presented.
- Work with a private wind farm owner, and developers of biomass gasification technology are evidence of the breadth of hydrogen related fields regularly in contact with the Center.
- The only holdback is whether, beyond providing tours for the curious, there is community outreach to non-energy related industry and academia. This is a minor knock on a quality tech center.
- Good complement of university, city, state and industrial collaborators. To the extent that this is successful it should serve as a good example for other programs.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.7** for proposed future work.

- The presenter says the power park portion is appropriately phasing out. It would seem the biomass gasification effort is timely.
- The future work will bring the project to a conclusion but it's not clear how results and findings will be shared with others.
- Good plan for future work. These efforts should be completed.

Strengths and weaknesses

Strengths
- Project has capable teammates.
- The individual tasks are well aligned with program goals.
- Broadly developed hydrogen knowledge base and hydrogen energy capable facility.
- And the same is true for renewable energy resources of interest to Hawaii except maybe geothermal.
- This appears to be a good demonstration, however there is very little data shown to enable one to understand just how well this system actually performed, and to economics of such a co-production system.
- Good integration of skills between academic and national labs.
- Good collaborations.

Weaknesses
- The dissemination of data, learning and results seems marginal.
- The project involves three unrelated tasks and the expertise at HNEI is not clear in all three areas.
- Very limited data or results on how well this system performed including: net ac power (did the unit ever achieve 5 kWe net AC?); Electrical efficiency at start of test and at end of test. The unit only operated for 2255 hours and only 1400 hours was in the field. This is not very much demonstration time- given the funding. The power generation availability (98%) seems high. Please provide the supporting data for this figure. It is difficult to evaluate the viability of this concept from the Key Metrics: What is the net ac efficiency from the SOFC Power Module? The economics of this approach is unclear based on the information presented: What are the near-term prospects for competitive distributed co-production systems? What will be the optimal scale for such systems – seems like 5 kWe is too small? Difficult to compare this transitional co-production option with others such as pure distributed SMR and distributed electrolysis.

Specific recommendations and additions or deletions to the work scope

- Suggest more communication output.
- Keep unit running and report on more performance data. Expand story on economics.
- It may be more appropriate from a technical management perspective to separately manage (and review) these 3 distinct projects.

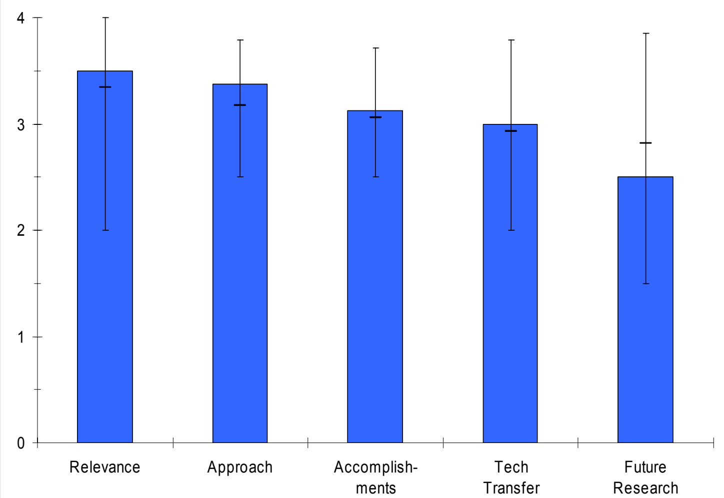
Project # TVP-03: Novel Compression and Fueling Apparatus to Meet Hydrogen Vehicle Range Requirements

Todd Carlson; Air Products

Brief Summary of Project

The objective of this project by Air Products and Chemicals, Inc. (APCI) is to develop a novel compression and fueling apparatus to meet hydrogen vehicle range requirements, as well as dramatically lower the cost, maintenance, and power requirements for fueling. A 700 barg dispensing system has been developed, and a 700 barg compressor has been built and is undergoing testing. Other components to support 700 barg hydrogen refueling are also being investigated.

Overall Project Score: 3.1 (4 Reviews Received)



Question 1: Relevance to overall DOE objectives

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

- A high pressure 14,000 psi compressor will enable a lot of transportation applications.
- Successful development could help President's Hydrogen Fuel Initiative
- Delivery costs are a major barrier to cost-competitive hydrogen fueling, with compression being a major cost contributor.
- The potential of the technology to compress hydrogen up to 15,000 psi at a low cost is significant.
- Critical to user acceptance.

Question 2: Approach to performing the research and development

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

- Logical.
- Approach is well thought out. Good engineering that appears to address most of problems. Need to emphasize issue of fluid mixing with hydrogen gas and low cost means to separate hydraulic fluid from hydrogen.
- Importance of safety has been well-recognized in the consideration of materials for the system.
- As identified by the PI, the issue of oil contamination must still be addressed, in particular how this will impact the O&M costs.
- Work should continue on determining the equipment configuration and cost for alternative fueling applications, namely 6500 psi storage and higher inlet pressures.
- Impressive pumping system.

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

This project was rated **3.1** based on accomplishments.

- The project seemed some what slow but the presenter made a good case for the extent of challenges faced.
- Program appears to moving forward at proper speed and solving technical issues as they develop. Program should move fast because it is based on previous design for non-hydrogen system that has similar characteristics.

- Good progress in assembling and testing the unit. Through this, additional opportunities for improved throughput were identified.
- Still some technical issues to be addressed, including cooling and oil contamination.
- More attention to fueling time is needed. Greater than 20 minutes for 10 kg is unacceptable.

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

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

- It would be helpful if an effort could be made to encourage production of the product in U.S.
- Limited technology transfer reported. This activity should increase since supported by federal funds.
- Good partnerships with material suppliers. This remains important for evaluating the best component options and the current and future costs.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.5** for proposed future work.

- This project is close to completion.
- Critical issue of hydraulic liquids in hydrogen, as identified in discussion with researcher, does not appear on plans for future work.
- Once the major technical issues are addressed, the system cost and operability needs to be validated in an integrated fueling application. PI has identified some opportunities for this; these plans and the cost of completing the validation need to be better defined with key milestones.
- The identified plans to evaluate configuration requirements for alternative fueling scenarios are important and should continue.
- Need effort on cooling to reduce fueling time – but at minimal energy use.

Strengths and weaknesses

Strengths
- Air products can validate this compressor in context to several different H_2 operations. This is an important element to giving the innovation legs.
- Good technical approach that should lead to lower O&M requirements.
- This is a very focused project with strong emphasis on cost reductions for compression while maintaining and even improving compression safety.
- PI has done a good job of identifying technical hurdles and approaches to addressing them. In the next year, it will be important to demonstrate that reasonable solutions to these hurdles can be implemented and to identify the costs associated with this.
- Great direct simplistic approach.

Weaknesses
- It is unclear how the scientific learning and core technology will be shared.
- Technology is nearing readiness for validation in a fueling application. Need to firm up plans on where the unit will be integrated and on defining a performance/durability test plan to validate the cost targets and better understand the full implications of the technology on cost-competitive hydrogen delivery.
- Need to reduce fueling time at minimum cost increase.

Specific recommendations and additions or deletions to the work scope

- It would be worthwhile to have the eventual license; do a poster on their adoptation (non recurring effort) at this innovation so as to faster commercialization lessons learned back into the knowledge base.
- Add low cost fuel time reduction.

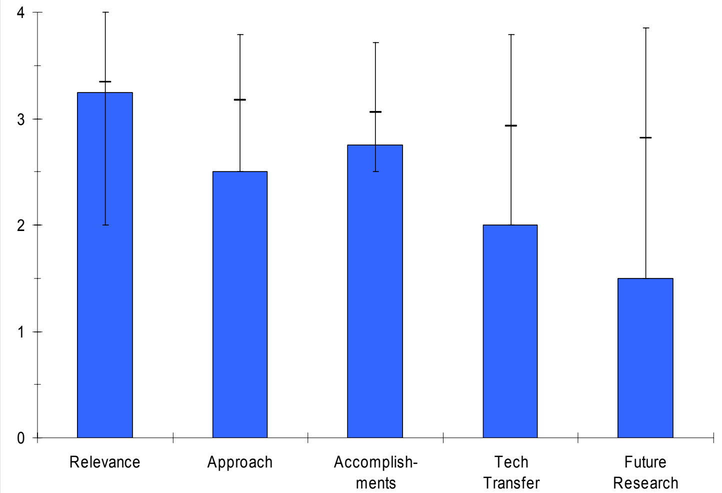
Project # TVP-05: Chattanooga Fuel Cell Demonstration Project

Joe Ferguson; City of Chattanooga

Brief Summary of Project

Through The Enterprise Center and its Connect the Valley Initiative, the City of Chattanooga is facilitating cooperative efforts between Ion America of Moffett Field, California, the City of Chattanooga, and the University of Tennessee at Chattanooga (UTC) to develop and demonstrate a prototype 5 kW class, grid parallel, solid oxide fuel cell system that co-produces hydrogen. This project provides technology validation of a near-term economical pathway to help build out the hydrogen infrastructure. The system being validated operates with high capacity factor even when the demand for hydrogen is relatively low.

Overall Project Score: 2.5 (4 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- Promotes high temperature stack deployment.
- Provides local first responder education and training.
- Provides safety education through safety evaluation at a new site.
- Co-production of hydrogen and electricity (hydrogen energy station) concept using high temperature fuel cells is very important to ultimate success in developing economical hydrogen infrastructure.
- This is an earmark according to the presenter.

Question 2: Approach to performing the research and development

This project was rated **2.5** on its approach.

- Project could have been more valuable if H_2 end-uses were integrated with original design.
- Next years operation will provide good opportunities for design of follow-on projects to utilize H_2.
- This project does not appear to be well integrated with DOE SECA program – the leading US SOFC program effort.
- This program was a demonstration of technology and not technology development per se so comments on approach not meaningful
- The University was paid to house the fuel cell with the 20% of the budget but never attempted to apply H_2 community knowledge.

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

This project was rated **2.8** based on accomplishments.

- The SOFC is a whole system and it's delivered, installed and operated in a grid connected mode. Not bad!
- The site from the picture looks adequate without flourish, and a local site safety analysis was done.
- The project accomplished the goals set out at the start.
- No attempt was made to rationalize this project in terms of accomplishments.

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

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

- The project seems well situated for broad local collaboration.
- The apparent lack of end uses for the Hydrogen is an opportunity to expand into new collaborative areas.
- How will the lessons learned from this project get transferred to DOE SECA vertical team players?
- No information presented that would enable the reviewer to comment on this aspect of the program.
- One might assume that a University would try to disseminate information from its projects, therefore the universities inaction undermines confidence in the commitment to a core mission.

Question 5: Approach to and relevance of proposed future research

This project was rated **1.5** for proposed future work.

- Evidence is still largely ambiguous. Successful deployment bodes well and is the reason for the "good" rating. Active attention to operational data and it's relevance to future SOFC and Hydrogen production efforts will be the minimum next requirement. Actively communicating the collected information to the community and Hydrogen program stakeholders, as well as soliciting H_2 uses will round out the project nicely. Failure to do so would leave the work half done.
- Unclear what future work is – there were no clear recommendations presented for key areas which still need to be worked on to make this concept ultimately viable in the market place.
- No future work or next steps described.
- Never another cent should be provided to this team.

Strengths and weaknesses

Strengths
- It's operational with apparent good characteristics in the early going. The project principals have proved competency in getting the hardware and permits in place.
- This appears to be a good demonstration, however there is very little data shown to enable one to understand just how well this system actually performed, and the economics of such a co-production system.
- Achieving the objectives within the time frame laid out.
- A useful demonstration of technology.
- The presenter agreed to publish the lessons learned in regulatory compliance.

Weaknesses
- Data and other presentation information appears largely supplied by ION America, the FC supplier, and is not yet complete enough to be of real value to the engineering and project evaluation community. This is understandable given the short operational period prior to this review, but operational data that covers the full range of operational characteristics including specifically the electrical and H_2 production capability is needed. This data should transparently depict parasitics, cost and quantity of fuel as a function of product output, and any operational and control issues that were of note.
- Very limited data or results on how well this system performed including: net ac power (did the unit ever achieve 5 kWe net ac?); Electrical efficiency at start of test and at end of test (i.e. was there any noticeable degradation of SOFC performance); The unit only operated for 2255 hours and only 1400 hours was in the field. This is not very much demonstration time- given the funding. The power generation availability (98%) seems high. Please provide the supporting data for this figure. It is difficult to evaluate the viability of this concept from the Key Metrics: What is the net ac efficiency from the SOFC Power Module? The economics of this approach is unclear based on the information presented: What are the near-term prospects for competitive distributed co-production systems? What will be the optimal scale for such systems – seems like 5 kWe is too small? Difficult to compare this transitional co-production option with others such as pure distributed SMR and distributed electrolysis.
- No description of the learnings from the program.

- No description of performance of the system components and areas for improvement.
- The presenter admitted he was propagating data provided by the hardware vendor without ANY analysis or sanity checks.

Specific recommendations and additions or deletions to the work scope

- Add some Hydrogen uses for the product hydrogen.
- Keep unit running and report on more performance data. Expand story on economics.
- While this was an apparently successful demonstration program within the DOE program, the reviewer questions what learning's are being disseminated.
- Why was the cost share less than 10% for a demonstration program?
- The university should be directed to at least attempt to contribute to the intellectual baseline.

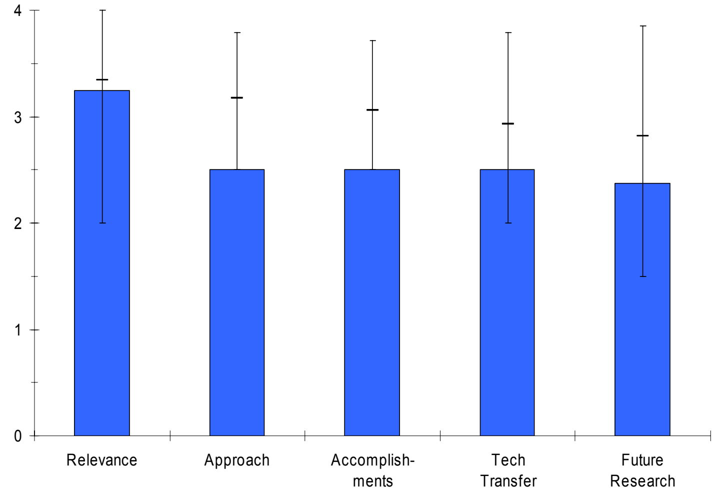
Project # TVP-06: NextEnergy Microgrid and Hydrogen Fueling Facility

Dave McLean; NextEnergy

Brief Summary of Project

This NextEnergy project is developing a hydrogen station in 5 phases: (1) supply hydrogen to the NextEnergy Center Microgrid via tube trailers to fuel hydrogen-based fuel cells and engine-generator sets; (2) supply hydrogen to a packaged vehicle fueling system via tube trailers; (3) install permanent storage and the associated equipment such as the Gas Control Panel, the hydrogen compressor, the electrical switch gear, and control and communication equipment; (4) install five hydrogen generator "test bays" and fill one test bay with equipment that will allow NextEnergy to produce ultra-high purity hydrogen on-site for use in OEM "fuel cell" vehicles; (5) install one additional high purity on-site hydrogen generator.

Overall Project Score: 2.6 (4 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- May be valuable for public education.
- Relevance is that it supports the overall goals of the Technology Validation program.
- This places hydrogen knowledgeable people and re-fueling facilities in a key transportation geographic node.
- This is a "shotgun" project trying to be all things to all people but when probed it is an attempt to gain goodwill.

Question 2: Approach to performing the research and development

This project was rated **2.5** on its approach.

- The plan is not innovative.
- As an engineering design and construction project in support of the Technology Validation Program, this project is well defined and being implemented.
- There are no particular goals or efforts to overcome any key technical barriers.
- Project vision is articulated well and the need to maintain flexibility of configuration is a likely good decision in this case, but a tighter definition of what would fill out the equipment and function of the facility would guard against the possibility, (NOT a problem in this case) of poor project management. Things are going well, but this is a high profile project and clearer more specific descriptions of planned capability would help a little.

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

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

- Apparently coordinated with the DOE TVP schedule.
- Despite the many competing needs at a facility of this type, good progress has been made. I understand that the facility permitting went very smoothly and was completed in less than four weeks.
- The difficulty of bringing competitors in the transportation sector together to accept hydrogen from a single facility is quite hard, and the progress in that direction is commendable if not yet finished.
- The ability to build a building with tax payer money is not an accomplishment.

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

This project was rated **2.5** for technology transfer and collaboration.

- The group proudly declares it is in service to the big 3. It is important that the big 3 allow the dissemination of meaningful information.
- No description about this aspect of the project to make relevant comments.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.4** for proposed future work.

- Nothing innovative. No commitment to sharing information. No commitment to training or education.
- Adequate target dates provided for remaining phases.
- The basic need to have a good hydrogen refueling center with capability to evolve with the rapidly emerging hydrogen vehicle technologies in the area is really the key feature of the facility. The fact that they are planning for a diverse set of hydrogen test and demos on site is a good feature.

Strengths and weaknesses

Strengths

- Might help bring the public along with learning and confidence.
- When completed, this site could serve as a useful resource as a test bed for various DOE supported distributed hydrogen production technologies.
- Apparently good interaction with the DOE Hydrogen Safety Review Panel
- Stakeholders in the success of this facility includes a large electric utility, a large (are there any other kind?) petroleum based energy company, three vehicle manufacturers, merchant hydrogen companies, and component suppliers and a University.

Weaknesses

- There is nothing available in the form of objective information and no commitment to fix that problem. The presenter was ignorant of the projects.
- No apparent goals to advance the state of the technologies.
- The goals of this project are limited to providing the test facilities for other technology development efforts, and that certainly serves a useful purpose.
- Many competing interests and the need to manage the project in a publicly transparent process. It could be a success.

Specific recommendations and additions or deletions to the work scope

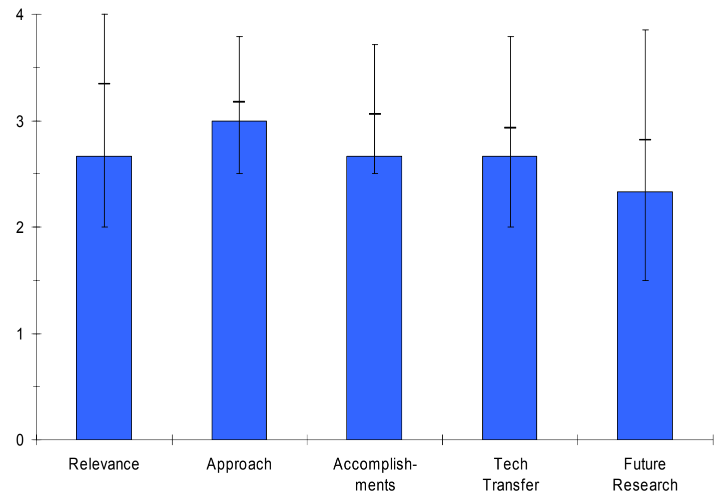
- Require a clear set of reporting and communication products. Cancel any sponsorship with taxpayer funds.
- What will the test protocol be for dispatch of the hydrogen generators? To what extent will the operational benefits of this micro-grid be documented and related to the local utility?

Project # TVP-08: Hydrogen Filling Station

Robert Boehm; UNLV

Brief Summary of Project

Overall Project Score: 2.7 (3 Reviews Received)



As a first step in the development of a hydrogen utilization network, the University of Nevada-Las Vegas Research Foundation is installing and analyzing the performance of a hydrogen generating and fueling system powered by solar energy. Objectives included development of the requirements for the generating and fueling system, survey of potential sites for the filling station and determining favorable /unfavorable characteristics of each, selection of the site with site plan and support to the site permitting process, design of the system layout, construction of the filling station in Las Vegas, monitoring operation of the system, and characterizing its performance. In the second step of the process, the filling station is being supplemented with a high-pressure electrolyzer that was developed for this project. Two utility vehicles are being converted to use hydrogen as fuel. One of these is an electric vehicle that will function as a hybrid full cell vehicle; the second is a hydrogen-fueled internal combustion engine system converted from a gasoline-fueled ICE system. Finally, engineering and performance demonstration of tandem solar cell systems is taking place as well as some basic science studies.

Question 1: Relevance to overall DOE objectives

This project earned a score of **2.7** for its relevance to DOE objectives.

- The project appears to include multiple unrelated tasks, though each has some applicability to program goals.
- No plans to evaluate economics of chosen technologies / systems against others; No plan to provide capital and operating cots of systems.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- The approach doesn't say anything about what work will be done on the project or what technologies will be investigated.
- A plan for data collection, analysis, and dissemination is not discussed.
- Barriers are not adequately discussed.
- Although not the most cost effective option, some information can be gained from pieces of the project. Cost of PV / H_2 generation option; Safety / permitting / construction lessons learned if included in results.

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

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

- The project timeline shows 78% complete, but the funding is only 55% expended.
- For being three years old, the project doesn't seem to be that far along.
- With amount of funding and numerous focus areas encompassed, more results should have been realized most accomplishments to date don't add to existing done knowledge .
- It would have been useful to present some results which relate to the 2009 Targets.

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

This project was rated **2.7** for technology transfer and collaboration.

- Collaborations aren't adequately addressed in the approach on the future work discussion.
- Industry partners providing hardware; Proton Energy seems to be the only subcontractor involved with overall project; project had no definite collaboration outside the project and limited with NREL.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.3** for proposed future work.

- Not clear how fundamental studies with proton adds values to this particular project.
- Project is working on areas that don't fit together and would be better if focused on particular process improvements such as: pressurized electrolyzes, solar / H_2 development economics, lessons learned on permitting.

Strengths and weaknesses

Strengths
- Vehicle conversions include both H_2 /ICE and FC/ICE hybrid vehicles.
- Project works with leading fueling station partners. Project has lessons learned in siting fueling stations. Project looking at novel low cost vehicle such as ICE / FC.

Weaknesses
- The scope includes multiple disjointed tasks. Funds would probably be better spent focused on vehicle conversions, the filling station, and data collection and analysis.
- Project spends funding on traditional hybrid / Fuel Cell vehicle development that is better accomplished with Freedom Car program. Project focused on creating Nevada road map that primary benefits a State. Project hasn't partnered with service business to use Fuel Cell vehicles only with the water district which has a limited need.

Specific recommendations and additions or deletions to the work scope

- A task should be added for data collection, analysis, and dissemination.
- Add economic analysis of proposed system against others. Delete Roadmap effort. Delete hybrid / Fuel Cell development effort as little to no new information is being generated. Add Go / No-Go on proposed system and if technically / economically infeasible look at completing more feasible options.

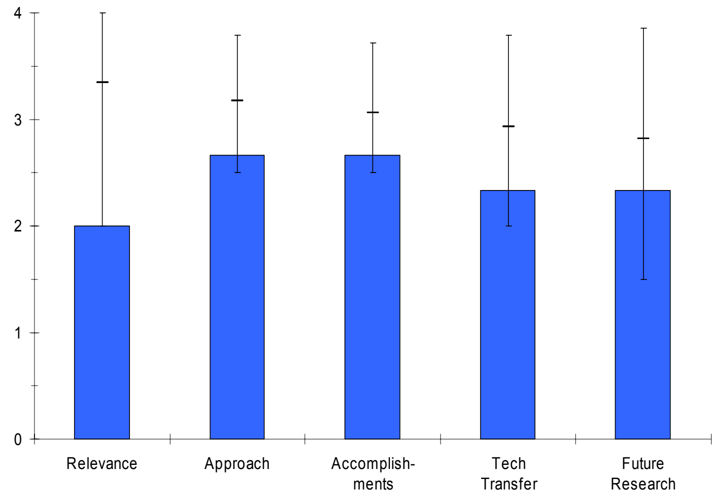
Project # TVP-10: Fuel Cell Powered Underground Mine Loader Vehicle

Arnold Miller; Vehicle Projects LLC

Brief Summary of Project

Vehicle Projects LLC is developing a zero-emissions, 23 metric ton, 160 kW, fuel cell-battery hybrid mine loader. Three fuel cell stacks will provide 90 kW of continuous power. Nickel metal-hydride batteries will provide peak power as well as the ability to recover energy through regenerative braking. Hydrogen will be stored onboard as a metal hydride. Vehicle Projects is evaluating the loader's safety and performance, primarily in surface tests, and evaluating its productivity in underground mines in Nevada and Ontario.

Overall Project Score: 2.5 (3 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **2.0** for its relevance to DOE objectives.

- Niche application for developing near-term demand for H_2.
- The concept of saving lives in a mine by preventing asphyxiation from diesel combustion would be useful – but is NOT articulated.
- Project was an early and significant program requiring difficult vehicle integration tasks. Program has shown that hydrogen and fuel cells can be deployed successfully in specialized applications.
- The breadth and target of DOE's H_2 & FC programs has changed since conception of this project. The need to develop consumer transportation alternatives has overtaken the need to develop niche specialized demonstrations, thus rendering this project a successful, but somewhat less important project for fulfilling the President's H_2 Initiative.

Question 2: Approach to performing the research and development

This project was rated **2.7** on its approach.

- Seems like a serialized, slow deliberate approach that is focused in satisfying the industry. Does not make a contribution to H_2 community.

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

This project was rated **2.7** based on accomplishments.
- The project is unimpressive in its simplicity. The progress is poorly documented.
- Technical accomplishment is quite high for this project; a large, heavy, underground ore loader/hauler travels with a PEM prime mover. However, follow-on developments have not apparently emerged.

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

This project was rated **2.3** for technology transfer and collaboration.

- There is a big list of participants but they appear to be superficial relationships.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.3** for proposed future work.

- This is supposed to be the last year and much of the work is done.
- Not clear what follow-on development has revealed itself, or is being pursued.

Strengths and weaknesses

Strengths
- The possible commercial result would be timely and on excellent illustration of H_2 power at work.
- Good technical follow-through on a well defined and difficult project.

Weaknesses
- This project doesn't appear to have committed industry participation.
- Project not leading to broader deployments or new FC capabilities.

Specific recommendations and additions or deletions to the work scope

- I suggest requiring this project conduct information exchange, public lessons learned, regulatory compliance, safety, and environmental impacts. There seems to be little inclination to share information by the project manager.