2010
Technology Validation
Summary of Annual Merit Review of the Technology Validation Sub-program

Summary of Reviewer Comments on the Technology Validation Sub-program:

Reviewers consider the Learning Demonstration work to be very relevant to the DOE's objectives of conducting independent assessment and dissemination of fuel cell vehicle (FCV) information and providing real-world feedback to researchers and partners to improve technology. The information gathered will help improve technology readiness for FCVs and lead to successful market introduction. This project validated the performance of the technologies under real-world conditions.

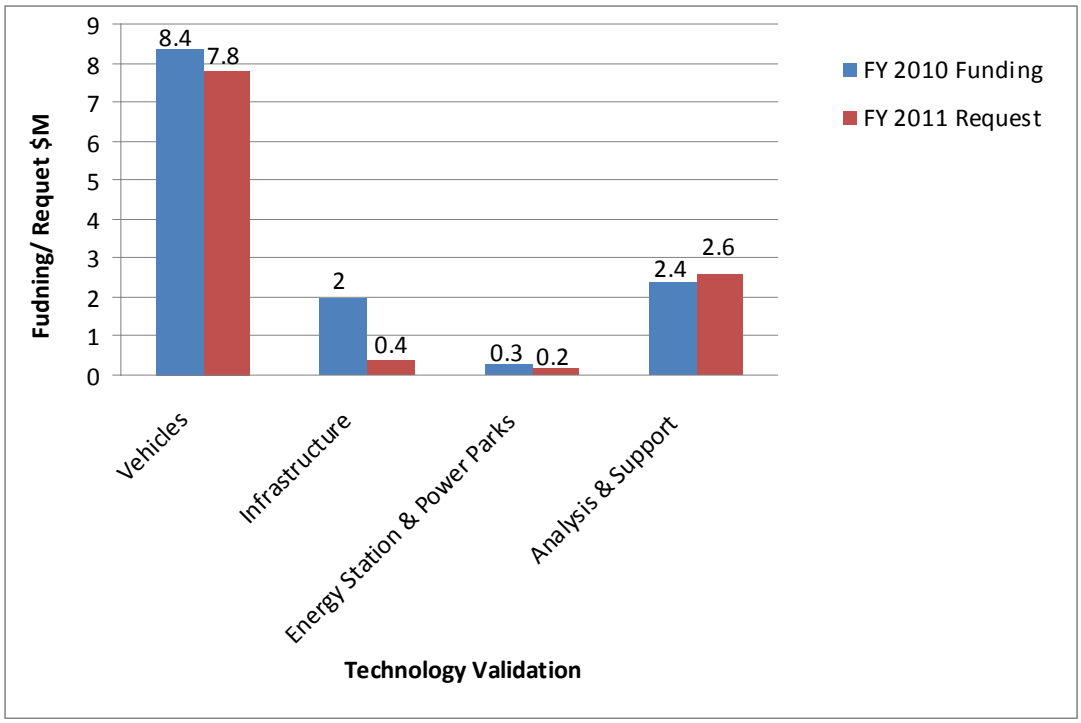
Reviewers believe it is critical that DOE work with the FCV automakers to validate their first, second, and other pre-commercial generations of fuel cell technologies. It is also critical that hydrogen infrastructure technologies be demonstrated in tandem with the FCV deployments. The Learning Demonstration project does both very well. The reviewers suggested that a plan be developed for continued operation and testing of the Generation II vehicles and refueling stations after completion of the present project.

The energy station project concept, which involves producing hydrogen as a co-product of power generation, is also considered very relevant to DOE objectives to improve the availability and reduce the cost of hydrogen for vehicle refueling.

Reviewers stated that the fuel cell bus evaluation project is well focused on the key technical targets. It plays an integral role in assimilating and analyzing data from various fuel cell bus projects across the country. Since the individual bus projects are essentially independent, this project is a necessary component of the overall effort to identify trends, improvements, problem areas, etc., in fuel cell bus developments and operation.

Technology Validation Funding by Technology:

The funding portfolio for the Technology Validation sub-program stresses the continuation of the Learning Demonstration project as it enters its final year. Second generation vehicles from two of the demonstration teams will continue to be operated, and data collection next year will provide information as to the state-of-the-art of these FCVs. Durability and range will continue to be the major data that will be collected and reported. A high-temperature fuel cell energy station will be operating, and data will be collected for at least a six month demonstration of the system. The FY 2011 funding profile is subject to Congressional appropriations.



Majority of Reviewer Comments and Recommendations:

The reviewer scores for the Technology Validation sub-program had a maximum of 3.7, a minimum of 2.2, and an average of 3.0. The major recommendations by reviewers are presented below.

Learning Demonstrations: A future technology validation program should not team a single automaker with an energy company, because this leads to insufficient use of private fueling infrastructure. A future program should instead adopt the German or California Fuel Cell Partnership model, of having every energy station decoupled from a specific automaker and having every party agree to provide hydrogen publicly to all consumers.

A final project report should be developed at the conclusion of the project. The plan should include a presentation of results at the International Partnership for Hydrogen and Fuel Cells in the Economy and the International Energy Agency venues.

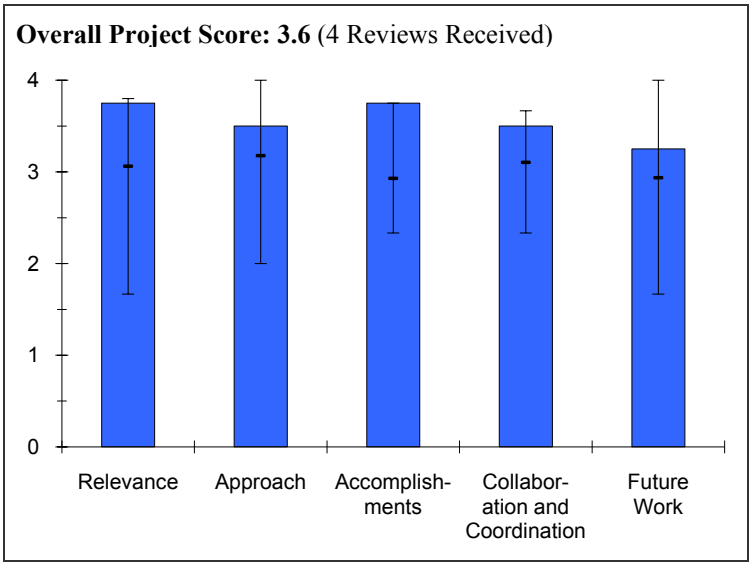
Energy Stations: The energy station project concept, which involves co-production of hydrogen and electric power, is very relevant to DOE objectives to improve the availability and reduce the cost of hydrogen for vehicle refueling. The renewable hydrogen concept also aligns with DOE goals and objectives.

Analysis: Careful analysis of key aspects of vehicle operation (hydrogen cost, stack efficiency, durability, and driving range) demonstrates improvements in all aspects except hydrogen cost projections. The analysis of transient operation improvements demonstrates the technical depth of the program and helps feed information back to manufacturers and researchers.

Project # TV-01: Controlled Hydrogen Fleet and Infrastructure Analysis
Keith Wipke; National Renewable Energy Laboratory

Brief Summary of Project

The objectives of this project are to: 1) provide facility and staff for securing and analyzing industry sensitive data at the National Renewable Energy Laboratory's (NREL) Hydrogen Secure Data Center (HSDC); 2) perform analysis using detailed data in HSDC to: a) evaluate current status and progress toward targets, b) provide feedback on current technical challenges and opportunities into the Department of Energy (DOE) hydrogen research and development program, c) provide analytical results to originating companies on their own data (detailed data products), and d) collaborate with industry partners on new and more detailed analyses; and 3) publish/present progress of the project to the public and stakeholders (composite data products).



Question 1: Relevance to overall DOE objectives

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

- This project is very relevant to the DOE Hydrogen and Fuel Cell Technologies Program (FCT). The data collected and reported in this project is vital to measuring the progress of the programs and to glean information that is critically important to guiding future directions of the technical work.
- This project is well defined and relates directly to DOE technical targets.
- This is project performs analysis and reporting of crucial testing of vehicles and fueling.
- This work is very relevant to DOE fuel cell objectives of conducting independent assessment and dissemination of fuel cell vehicle (FCV) information and providing real-world feedback to researchers and partners to improve technology. The information gathered will help improve technology readiness for FCVs and lead to successful market introduction. This project validated DOE targets in real-world conditions.

Question 2: Approach to performing the research and development

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

- The approach focuses on the collection of actual, in-the-field operating and performance data in a self-reporting format. Then, the information is disseminated in a comprehensive compilation that allows proprietary information provided by suppliers and users to be protected. The approach is a solid and sound type of data collection and reporting, and its value has been validated by the large number of references to the project, coupled with acceptance by the reporting organizations.
- Although there are only two of the original four original equipment manufacturers (OEM) left to validate the last few objectives. That is a sufficient amount for this project.
- The detailed products that NREL has published have been helpful to the OEMs and all parties involved in the analysis of the results.
- The approach for this project was right from the beginning, and it continues to be right.
- The project is well-designed to address technical barriers set by industry and DOE. The scope of testing covers all of the bases.

- The approach is very reasonable for providing real-world analysis, data collection, and information dissemination efforts, while protecting sensitive information. Composite data products are a good way to provide summaries without revealing any company-sensitive information. (This has been an area of concern for partners). This approach was focused on addressing the key areas of interest to the DOE FCT Program.

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

This project was rated **3.8** based on accomplishments.

- This project continues to make excellent progress. Reported progress includes more than 100,000 vehicles hours and 2,500,000 vehicles miles. The project has resulted in more than 80 public data publications with new results and updates published every six months, which is truly outstanding. The depth of technical analysis and interpretation of collected data is excellent.
- The vehicles tested in this project have been phenomenal. The project continues to relentlessly pursue the technical targets and to improve vehicle fuel cell performance and fueling infrastructure. This is an excellent use of public funds and the statistics speak for themselves (e.g., 2.5 million miles driven).
- The products developed by NREL in response to OEM data needs and public needs have been fantastic (e.g., 80 composite data products published, 20 of which are new this last year).
- There has been good progress in durability for the stack for Generation 2 over Generation 1.
- The project is meeting DOE goals.
- They greatly reduced transients, making durability goals easier to achieve.
- The refueling information is very important, especially in comparison to battery charging.
- Toyota's 431 mile driving range is extremely useful.
- There is a significant number of vehicles (almost 150 vehicles total, over 100,000 hours) and stations (23 total) in data collection effort. It is good to see vehicles with higher hours/miles included. The project continues to track key stations that serve as backbones for hydrogen efforts.
- There are a significant number of composite data products (20 new, 52 updated) in the last year. It is good to keep information up to date, and presented at key venues.
- Careful analysis of key aspects of vehicle operation (hydrogen cost, stack efficiency and durability, and driving range) demonstrates improvements in all aspects.(Hydrogen cost projections are not so optimistic.) The analysis of transient operation improvements of particular interest demonstrates the technical depth of the program and helps feed information back to manufacturers and researchers.

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

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

- The basic nature and approach of this project requires extensive collaborative interactions with suppliers and users. Numerous publications and presentations have been accomplished in this review period. There have been collaborative interactions with automotive and energy industry partners, FreedomCAR and Fuel Tech Team, industry and state government organizations, and federal government agencies including the Department of Defense (DoD).
- Everyone is engaged and loves these projects.
- They are collaborating with all the right partners – car companies, industry associations and state groups. They need better marketing and promotion of the program and results to the media, both public and government.
- They are collaborating with industry partners and major constituents of interest to discuss results and methodology. New collaboration with DoD Defense Logistics Agency should be beneficial to both parties.

Question 5: Approach to and relevance of proposed future research

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

- The future work plan includes continuing the work already underway to establish operational and performance trends and improvements. Added emphasis with OEMs and infrastructure developers on supporting early market introductions is vital to timely deployment of hydrogen and fuel cell technologies.

- This is an outstanding real-time, real-world learning project that should be fully supported by the DOE through the end of the budget and funding cycle.
- They are a very crucial partner to help facilitate the automaker goal of commercialization in the 2014-2015 timeframe. Data will help educate consumers and local officials where stations and vehicles will be deployed.
- The project is nearly complete, but closeout activities appear to be appropriate to finish up the work (i.e., final report and leveraging of past experience to assist future deployment and validation projects).

Strengths and weaknesses

Strengths
- They employed a proven and tested approach to data collection and information dissemination.
- They made extensive use of analytical multivariate techniques.
- The results are essential for the auto OEMs and the entire value chain, including hydrogen suppliers, refilling stations and carbon manufacturers.
- They have a very comprehensive data collection.
- They enacted a thorough and careful analysis of important aspects of vehicle and station operation.
- There was a wide variety of data products presented, which have been updated to reflect current information.
- There was good partnership with key constituents.

Weaknesses
- No weaknesses noted.
- None.
- They need to promote findings and activities more. If the public and/or government knew of the scope of this project and results and data found, it would greatly help industry fight critics and skeptics who write off FCVs. A website is not enough because most people would not know to look there.
- No significant weaknesses observed as the program is well defined and successful.

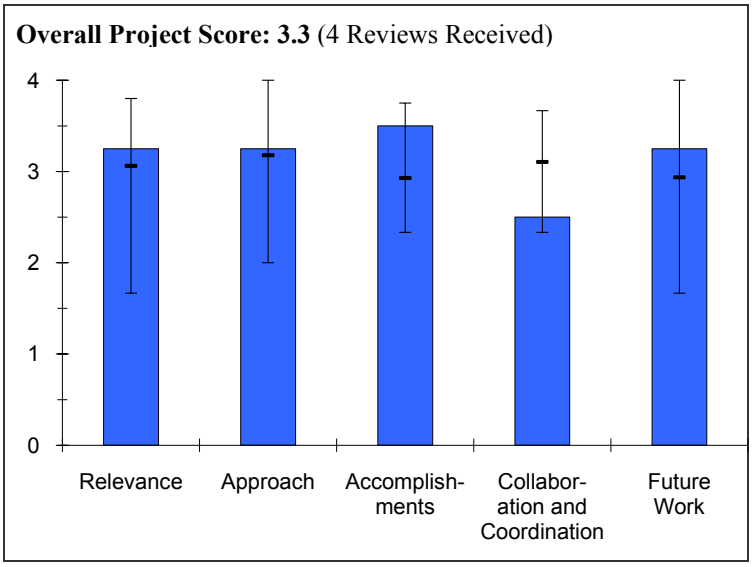
Specific recommendations and additions or deletions to the work scope

- Keep up the good work!
- A final project report dissemination plan should be developed. The plan should include a presentation at the International Partnership for the Hydrogen Economy (IPHE) and the International Energy Agency (IEA).
- The battery analysis could be improved. The life-cycle cost analysis should be looked at and analyzed.
- There should be an expanded presentation of results from primarily fuel cell events to broader auto events, government conferences, etc.
- No additions or deletions identified as the project is nearly complete.

Project # TV-04: Hydrogen to the Highways
Ron Grasman; Daimler

Brief Summary of Project

The objectives for this project are to: 1) record, collect, and report data from fuel cell vehicles and hydrogen fueling stations to validate DOE performance targets regarding fuel cell stack durability, vehicle range, and hydrogen cost at the station; 2) demonstrate the safe installation and operation of service facilities; 3) continuously update safety manuals and provide training; and 4) participate in various working groups to ensure continuous progress regarding hydrogen codes and standards.



Question 1: Relevance to overall DOE objectives

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

- This project develops two generations of FCVs and validates operation and performance in real-world use. The project to validate the practical operation of FCVs is very relevant to DOE FCT Program objectives. The program is ineffective if it does not have validation and introduction to potential consumers.
- The light-duty vehicle market is the largest potential market for proton exchange membrane (PEM) fuel cells. It is critical that the DOE work with the hydrogen fuel cell vehicle (HFCV) automakers to validate their first, second, and other pre-commercial generations of fuel cell technologies. It is also critical that hydrogen infrastructure technologies be demonstrated in tandem with the HFCV deployments. This project does both very well.
- The project addresses barriers in FCV performance and durability and development of a hydrogen refueling infrastructure, which are barriers A and C in the multi-year plan.
- The program addresses DOE goals for technology validation and aligns well with Daimler internal program goals. They are moving the technology toward greater commercial readiness. They are addressing not only vehicle technology goals, but also associated issues such as maintenance and codes and standards.

Question 2: Approach to performing the research and development

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

- The approach involves the development and introduction of two generations of FCVs, along with the necessary refueling and support infrastructure required for testing and validation of vehicle operation and performance, in comparison to conventional consumer automobiles. The approach is consistent with the goals and objectives of the project and with the DOE FCT Program.
- Daimler appears very committed to rolling out HFCVs to the public in the 2015 timeframe. Their approach seems to address many of the needed technical barriers that must be overcome for a successful transition to commercialization. Two key components of overcoming these barriers are validating cold start and 2,000 hours of stack durability, and Daimler considers those to be principle objectives.
- The approach is to advance vehicle technologies from Generation I to Generation II and prepare for commercialization. The data acquisition system on all vehicles is important for supplying data to NREL. Both the east and west coast operations are useful for obtaining data from differing weather conditions. Most of the operations moved to the west coast in the past year. It is highly desirable that they maintain operation of refueling stations.

- The technical approach is reasonable, with two generations of technology being developed for demonstration in real-world applications. Activities in the maintenance and service and codes and standards provide a well-rounded approach to addressing major issues from vehicle and infrastructure standpoints. They have developed an associated hydrogen fueling network. Was there any overlap in hydrogen fueling with other TV projects?.

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

This project was rated **3.5** based on accomplishments.

- During this period of the project, transition from Generation I to Generation II vehicles was completed. Testing has shown improved performance of the Generation II vehicles. Progress was also reported in the area of safety, codes and standards. The progress appears to be consistent with the project schedule. The project demonstrated successful operation of refueling activities.
- Daimler has shown outstanding progress over the course of this project. After their 30 Generation I vehicles were retired, with six years operational achieved versus the planned two years, they made tremendous improvements on their Generation II HFCVs. From Generation I to Generation II, size is down 40%, power consumption is down 30%, and range has increased 150% (although some of this is due to going from 350 bar to 700 bar compressed hydrogen). It should be very interesting to hear the results as they start Generation II HFCVs on the road.
- Quality vehicles were produced according to standard Mercedes-Benz processes. They commissioned and tested 70 MPa stations in Burbank, California, and maintained operation of a DTE Energy (DTE) station in Michigan, continued good involvement in the area of safety, codes and standards, and convinced station owners to eliminate the personal protective equipment requirement. Their participation in community outreach efforts is commendable. Progress in the development of the Generation II vehicles seems slow and no stack durability data was provided, though it was noted most failures were attributed to hoses, brake pads, etc.; It would have been good to have seen more data on stack durability (claim is for >2,000-hour durability). All testing to date is "internal." It is always questionable if they will be able to keep stations open until greater numbers of vehicles are on the road.
- There were significant accomplishments made on the vehicle side: Generation II vehicles show great improvement over Generation I vehicles in range, power, and fuel consumption. Generation II vehicles are being approached from a near-commercial viewpoint (versus one-off prototypes) with extensive testing and verification.
- Their participation in safety and codes and standards efforts is good and is very important from a safety and performance standpoint.
- Their participation in outreach efforts is also important. They must reach the public with the new advances in performance and technology through venues such as road shows and auto shows.
- They achieved durability and cold start targets, particularly on Generation II vehicles. First generation vehicles exceeded lifetime expectations and several are still in operation.
- They continue to work with DTE Energy on a hydrogen station in Michigan that is open to all users (not restricted to Daimler). They are improving technology of this station with new equipment.

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

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

- Interaction and collaboration with project partners was reported and documented; however, additional exposure of the FCVs to the general public for testing and evaluation in a less controlled environment could have been very beneficial, as well as a means of gaining additional input of real-world assessment of the viability of FCVs from a consumer perspective.
- DTE works in the ”green”, or renewable, hydrogen market space, and it is wise for Daimler to validate that type of hydrogen as policy makers will inevitably require hydrogen to be produced from renewable sources over time. NextEnergy is a not-for-profit organization in the Detroit, Michigan, area that is widely respected and works well with the auto companies. They are keeping a permitting database with easy and public access via their website. The DTE hydrogen station in Burbank had a good deal of outreach associated with it. They are

also working with the International Organization for Standardization (ISO), National Highway Traffic Safety Administration (NHTSA), and Society of Automotive Engineers (SAE) on codes and standards.
- They have three (really two) other partners.
- The collaborations are good and the specific collaborations with NextEnergy on permitting database are particularly noteworthy. They are collaborating with NREL on larger data collection efforts.
- The presentation does talk about the need for OEM collaboration on fueling station deployment, but was this actually done?

Question 5: Approach to and relevance of proposed future research

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

- Plans of future work to fully integrate Generation II vehicles into the test fleet are consistent with project goals and objectives.
- The project has a timely and effective approach to bring the Generation II vehicles into the program and will enable this program to have bridged two full generations of automotive fuel cell technology. This approach will provide great data for a DOE Technology Validation program and will help inform the public of the major improvements anticipated.
- The project should prepare for Generation II vehicle demonstrations and continue providing data to NREL/DOE and participating in community outreach activities. There were no timelines provided for beginning customer operations of production-level Generation II vehicles.
- Future plans are reasonable given that the project is near to close-down. Daimler is looking toward production-level vehicles as well as national-level outreach and education.

Strengths and weaknesses

Strengths
- The project is led by a major automobile OEM with support from infrastructure developers.
- The project is providing operational and performance data to NREL for third party, independent evaluation and analysis.
- The project is validating light-duty fuel cell vehicles in multiple markets.
- The project is providing hydrogen via renewable sources.
- The company (Daimler) is clearly bought into the future of HFCVs and is making the most of this technology validation program to further the effort along.
- Real-world vehicle operation has been shown for Generation I vehicles but not much yet for Generation II. There is a good supply of data to NREL/DOE. They kept stations opened and moved most of the operations to west coast where fleets will largely be located. They were an active participant in codes and standards development.
- The codes and standards work is beneficial and important.
- The project has good progress on vehicle technology improvements to build toward pre-commercial markets.

Weaknesses
- There is limited public exposure to the project.
- None.
- There is slow movement to Generation II vehicles and commercialization and an uncertain commitment to keeping refueling stations open.
- Collaborations are somewhat limited to Daimler-internal organizations (only NextEnergy and DTE are listed external partners), though this does not appear to have affected success.

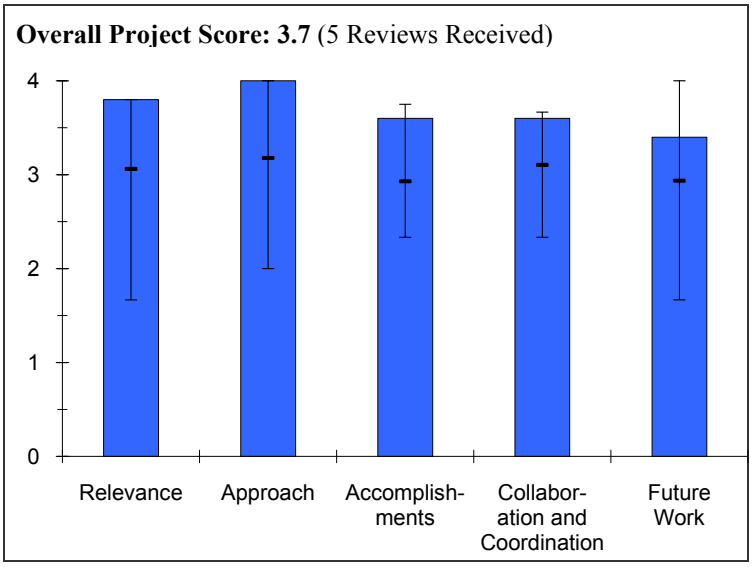
Specific recommendations and additions or deletions to the work scope

- A plan should be developed for continued operation and testing of the Generation II vehicles and refueling station after completion of the present project.
- They should explore methods to increase public awareness of the project and its results. Additional general public exposure will enhance the maximum benefit of the project.

- A future technology validation program should not team an automaker with an energy company, because this leads to too much private fueling infrastructure. A future program should instead adopt the German or California Fuel Cell Partnership (CaFCP) model, have every energy station decoupled from a specific automaker, and agree to provide hydrogen publicly to all comers.
- The project is ending in fiscal year 2010. It appears to have satisfied many, but not all, goals. The project should keep stations open with industry co-funding and get Generation II vehicles into the public sector.
- The project ends September 2010, and there are no recommendations for additions or deletions at this late juncture.

Project # TV-05: Hydrogen Vehicle and Infrastructure Demonstration and Validation
Gary Stottler; General Motors

Brief Summary of Project



The overall project objective is to deploy a system of hydrogen fuel cell electric vehicles integrated with a hydrogen fueling 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 fueling; and 3) collect and report operating data. The past year's objectives were to execute next generation of fuel cell technology by: 1) working with vehicle operators to obtain hours and data; 2) collecting, analyzing, and reporting data from program vehicles and fueling locations; 3) completing, operating and maintaining fueling stations, and providing data; and 4) producing and submitting an interim technical report. The current year's objectives are to: 1) complete technology insertion into vehicle fleet, and 2) collect, analyze, and report data from technology insertion and baseline vehicles.

Question 1: Relevance to overall DOE objectives

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

- This project involves real-life vehicle demonstration and performance validation making it quite relevant to the goals and objectives of the DOE FCT Program. In particular, Project Driveway, a meaningful test and evaluation by a sample representing consumers, is relevant in that self-serve refueling is also a part of the project.
- The project is relevant to the DOE technical targets. The relevance to General Motors (GM) is apparent as they want to develop HFCVs. Their cost share speaks for itself. All of the multi-year program targets are being addressed by this project.
- This type of project is extremely important to the future of cleaner transportation and a reduced dependence on petroleum. They introduced a transportation infrastructure that also significantly reduces GHG (greenhouse gas) emissions as well as other criteria pollutants. GM is a domestic automaker, and the ability to shift to the electrification of the vehicle is critical to its continued existence and the hundreds of thousands of domestic jobs associated with GM. It is also critically important to team with an energy company, in this case Shell. Low-cost, convenient hydrogen infrastructure is critical to the success of any GM rollout of HFCVs.
- This is definitely critical to DOE objectives and meeting and surpassing technical targets.

Question 2: Approach to performing the research and development

This project was rated **4.0** on its approach.

- The approach centering on real-life vehicle testing and refueling is very innovative. Testing under various climatic conditions, including cold weather driving and starting, is very important. It was beneficial to have an emphasis on gathering vehicle durability and refueling codes and standards, including local permitting officials.
- Again, the statistics provided since the onset of this project demonstrates GM's level of technical, financial, and company commitment to achieving results.

- Deployments in New York City, Washington D.C., Los Angeles, and Sacramento are all future early markets and serve to educate the public about the promise of HFCVs. The technical and human factors learning associated with this effort have been enormous according to GM. This technical approach is focused on demonstrating the HFCVs, and understanding both the customer experience and maintenance and servicing requirements. These are all important elements of a pre-commercial technology validation. The project had a broader validation effort across multiple regions and climates by partnering with Shell, and in some cases building their own, to have a total of eight hydrogen stations..
- They opened eight stations in key areas (Washington, D.C., New York City), which allows a real retail experience for users. It is also important to show potential customers that fueling with hydrogen is very similar to fueling with gasoline. There are more than 100 cars in the hands of the public, government representatives, and celebrities.

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

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

- Progress during the past period was good, especially the introduction of Generation II vehicles with notable technical improvements. The determination that hydrogen station performance was lagging vehicle performance is an important conclusion derived from this year's progress.
- They have excellent customer interface and feedback and five years of service station maintenance. They have introduced 100 phase-2 vehicles since 2007. It was a significant accomplishment to normalize customer refueling. They have good geographic variation, which helps to demonstrate the vehicles in various driving conditions. They have progressive engineering based on experience. There have been improvements to Generation II based on lessons learned from Generation I. They have demonstrated fuel cell stack durability and product functionality and have met customer expectations. They are using commercially available renewable hydrogen at various locations. Permitting has been a huge lesson learned and now the codes and standards are better defined as a result of these projects.
- The improvements made between Generation I, Generation II, and Generation II's tech insertion have been very promising. The NREL data will eventually reflect much of these improvements, but other areas can already be seen. Fuel cell durability has increased to the point that it can now meet customer expectations in terms of service life. The driving range has already increased, but it is expected to improve another 15%-20% in the Generation II tech insertion phase. Education and codes and standards can be helped by having the Environmental Protection Agency (EPA) use an HFCV GM Equinox to transport employees for two years.
- They have increased range and stack durability to help meet customers' expectations. They predict range improvements will progress even more in the future.
- The project exhibits good cold start capability.

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

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

- Collaborations, including those with federal, state, and local governments, were very good. The interactions with the general public were particularly important, and the project partners seem to work well together
- There was good collaboration with NREL on methodology.
- They are fully engaged at the state and local levels with the right players on codes and standards.
- Air Liquide has been very supportive on transportation and dispensing equipment.
- They are putting their vehicles into a wide variety of users' hands, which will gain a wide variety of feedback. GM is working with NextEnergy on codes and standards development. They are also helping inform the best hydrogen dispensing and distribution methodologies throughout these pilot efforts.
- They are partnering with key companies, namely Disney, and government agencies like the United States Postal Service (USPS), which could lead to potential purchases.
- It is key for all automakers to work together on codes and standards.

Question 5: Approach to and relevance of proposed future research

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

- Future plans to continue to operate and demonstrate Generation II vehicles while upgrading technical performance is very reasonable for the last year of this project. It is important to keep the emphasis on durability as well as performance improvement.
- Generation II durability on vehicles will be tracked and evaluated.
- GM appears committed to commercialization of HFCVs in the 2015 timeframe, clearly making the case that plug-in hybrid vehicles (PHEV) and battery electric vehicles have their limitation in terms of size and range. They plan to make as many as 1,000 HFCVs in their Generation III rollout, and a technology validation program built around this larger volume would help solidify the education and codes and standards. Additionally, hydrogen infrastructure needs should be addressed concurrently in a future phase. GM's initiative to improve the Generation II vehicles based on experience and feedback is welcomed.
- They have more vehicles with increased durability, while decreasing the size and weight of the fuel cell and its components. They are increasing range but need to get to 300-350 miles.
- GM has learned a great deal as the result of this program, in terms of both the vehicle-related elements and the fueling infrastructure elements. The degree of sophistication in the fueling has been evidenced by GM's ability to identify Hawaii as an important early market. Their ability to develop a strategy and identify a coalition of partners and stakeholders to develop this opportunity.

Strengths and weaknesses

Strengths
- This was a sound approach.
- There were good interactions among the project partners.
- There were extensive collaborations with many organizations including the general public.
- Real-world durability has increased. Many lessons have been learned on the fuel cell stacks and many improvements have been implemented. The ease of use and cost of infrastructure have been valuable to evaluate.
- Generation II crash tests were conducted on four vehicles without incident of hydrogen leaks.
- The project addresses the light-duty vehicle market, which has the potential for the largest environmental and petroleum reduction benefits. The project also addresses many locations that will be early markets for HFCVs and codes and standards through the work with NextEnergy. The project addresses hydrogen infrastructure with an energy company (Shell) that leans forward more than others in alternative energy pilots.
- The project exhibits real-world testing and key partnerships.
- The project exhibits tremendous progress of the fuel cell system in terms of performance, volume, weight, and cost.

Weaknesses
- There needs to be more on assessing and evaluating refueling operations in order to bring station development up to a par with vehicle performance.
- None.
- None.
- The range needs to increase, but it should occur in next stages of program
- They have not been able to identify a sellable approach to initial fueling infrastructure development.

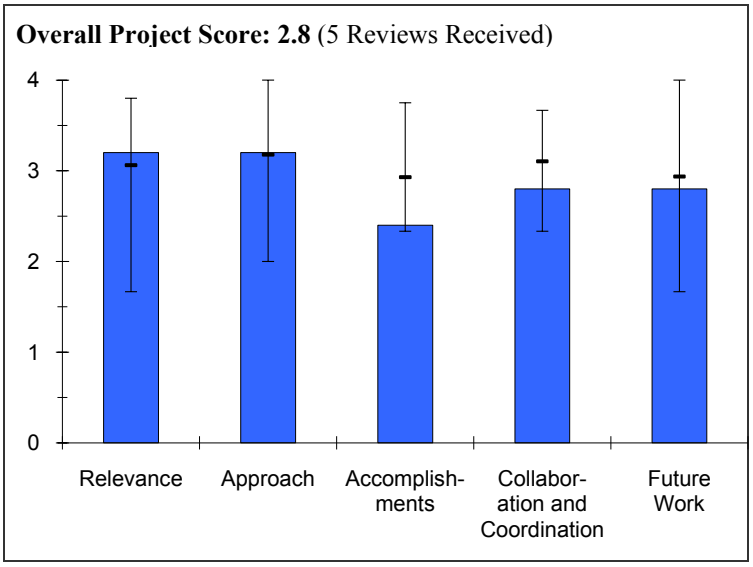
Specific recommendations and additions or deletions to the work scope

- The project should place more emphasis on refueling station operations, including performance enhancements and cost reduction for hydrogen production and delivery. A prime objective in the final year should be a focus on evaluating and recommending which directions should be taken to reach the cost target for hydrogen of $3 per-gasoline-gallon equivalent.
- None.

- Another technology validation phase is needed beyond September 2011. DOE should ask GM and others to propose a framework that would best meet their needs.
- The future work identified by GM is appropriate if it is possible to stay the course.

Project # TV-06: Validation of an Integrated Hydrogen Energy Station
Ed Heydorn; Air Products

Brief Summary of Project



The overall objective of this project is to determine the economic and technical viability of a hydrogen energy station designed to co-produce power and hydrogen. The project will utilize a technology development roadmap to provide deliverables and go/no-go decision points. The concept for this project was FuelCell Energy's (FCE) molten carbonate fuel cell (MCFC) plus Air Products' (AP) hydrogen purification system. Design, fabrication, and shop testing of the demonstration unit have been completed. The demonstration operation will be beginning in mid-2010 on renewable feedstock at the Orange County Sanitation District (OCSD). The project will validate process economics based on system performance.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.2** for its relevance to DOE objectives.

- This project is relevant because it demonstrates both hydrogen production and electrical power generation. In addition, it is important that a high-temperature fuel cell (molten carbonate) is demonstrated (a fuel cell technology that is fairly unique to this DOE program).
- The decentralized hydrogen energy stations might be an interesting alternative to central production and should be evaluated.
- The decentralized co-production opportunity offers a chance at high overall efficiency.
- The negative consequences of stranded hydrogen infrastructure are that it is not economically viable, and it puts too much pressure on federal, state, and local governments to subsidize these efforts. The problem is eliminated wherever the infrastructure can have a dual use. Combined heat hydrogen and power (CHHP) through high-temperature, stationary combined heat and power (CHP) fuel cells provide a partial solution to this stranded hydrogen infrastructure problem and should be pursued with vigor.
- The project evaluates the economic and technical viability of a hydrogen energy station co-producing electricity and hydrogen fuel. This is Barrier I of the multi-year plan.
- The project concept is very relevant to DOE objectives to improve availability and cost of hydrogen for vehicle refueling as co-product of economic power generation. The renewable hydrogen concept also feeds DOE goals and objectives.

Question 2: Approach to performing the research and development

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

- This project has employed a sound approach structured to assess the economic and technical feasibility of a co-generation mode of operation. The project is about 89% complete. The approach addresses significant DOE goals and objectives with a unique methodology.
- There is practical field testing in the works. The real-world fueling station and energy supply were sound approaches.

- This project combines both CHHP projects with renewable feedstocks (partially) through landfill gas at the OCSD in Fountain Valley, California. The involvement of both federal (DOE) and state (California Air Resources Board, or CARB, and South Coast Air Quality Management District) funding is the model for future projects where multiple stakeholders can participate. FuelCell Energy's MCFC is an excellent choice for the stationary fuel cell. The location of the CHHP project is ideally suited for early market hydrogen infrastructure by being in Southern California.
- There is a logical progression of the project from feasibility evaluation, to system design, to construction and deployment and operation. It is a very slow process occurring over 10 years. Energy stations would facilitate the introduction of renewable hydrogen as a transportation fuel. There is good system design with over 80% potential efficiency, and it is a good site selected for a demonstration at a municipal wastewater treatment plant. The project will need a low-cost clean up system for biogas, which could impact economics, and the solution for this was not addressed in the presentation.
- A four-phase approach is careful and logical. The proof of concept for hydrogen energy stations (e.g. whether it will it work and whether the power cost be reasonable) makes sense. They are approaching the deployment phase in 2010.

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

This project was rated **2.4** based on accomplishments.

- The project is in its fourth and final phase including operation, testing, and data collection. Validation testing has been completed, but it is unfortunate that on-site testing will be fairly short-term given that the project is scheduled to end in March 2011. The schedule should have been accelerated to allow more actual on-site operation and testing, including operation on actual digester gas.
- There has been evident progress on shop validation.
- While progress continues to be made, there have been significant delays. The original date for initial operating capability was November 2009. This slipped to May 2010 in time for the National Hydrogen Association conference, only to slip again to what is now July or August 2010. There appears to be solid reasons for this slippage, and AP and FCE want to make sure they have a good system-level product before operating it. However, a lot of confidence has been lost on this technology due to these delays.
- This has been a very long project! The most significant goals have not yet been accomplished, although an integrated hydrogen energy station is planned to open in California this summer. Ground has been broken for this station. The project will continue on with funding for the OCSD coming from CARB with project initiation in September 2011. So, it appears it may not be truly operational for some time yet. All testing up to this time has been done at FCE in Connecticut using an old molten carbonate fuel cell stack. Operation with simulated digester gas feed worked well. A new stack will be used in the OCSD demonstration. No economic analysis has been presented, although that was proposed to have been done by this point. DOE has been providing some assistance for the project. Good progress has been made in modifying the fuel cell to take out hydrogen from the anode gas and good purity data was presented.
- The system was successfully validated by shop testing, and safeguards against failure were verified. The project successfully produced a significant amount of hydrogen (and met design parameters for production and purity). The system was tested with simulated digester gas to verify operation.
- They have identified a location for an energy station near digesters to provide a renewable fuel source, but the location is not ideal. Will pipelines between the station and the production site be an issue?
- It appears that the schedule has slipped quite a bit. The 2009 presentation stated that operation would begin fiscal year 2009-2010 is now planned for deployment in summer 2010. There was no real discussion of the reasons behind schedule slip, nor was it really highlighted.

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

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

- There were good collaborations with industry, state, and local government agencies, plus a university, although the real collaboration begins with the on-site operation and testing.
- There was a low level of technical collaboration.

- Air Products has done a good job of keeping federal, state, and local authorities involved throughout this effort, mostly out of necessity as these are their funding sponsors and permitting authorities. But, they have collaborated to the general degree necessary. The only exception is the constantly slipping operational dates; this has hindered the ability of the various stakeholders to schedule an event to publicize the opening of this facility.
- The project had good industry, government, and university interactions and collaborations.
- There were significant and extensive collaborations with industry, government, and university, as well as good collaborations from the funding side.

Question 5: Approach to and relevance of proposed future research

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

- The plans for completing the project seem reasonable given the current status of the project.
- They have a clear perspective on application in Orange County.
- Air Products would like to see continued DOE involvement beyond March 2011, when the funding runs out, but they were not clear as to what that might be. They will operate the station for three years under a California Air Resources Board/California Energy Commission contract, so perhaps DOE does not need a follow on project. By then, CHHP technology will likely have evolved to a degree that would favor a new CHHP project somewhere else, rather than continuing with this effort.
- The project ends March 2011 and the energy station will not open until Sept. 2011. Future funding will be provided by CARB. They plan to scale up first to a 400-500 kg/day DFC®1500 system, then to an 800-1000 kg/day DFC®3000 system, though it is unclear if this will happen in the CARB funding cycle (three yrs, $2.7 million).
- Future work appears reasonable as they are addressing economics and scalability in this proposed work. The project will need to stay close to the new schedule in order to be successful.

Strengths and weaknesses

Strengths
- Good approach involving demonstration of a number of important issues – high-temperature fuel cell, hydrogen-electricity co-production, hydrogen pipeline to fueling station, and operation on digester gas fuel.
- They have strong partners.
- The approach is to demonstrate decentralized energy supply with high efficiency as an alternative to central production.
- They demonstrate high-efficiency via CCHP (47% steam methane reformer, >80% CHP).
- The project demonstrates an extension to a renewable source.
- The project demonstrates renewable hydrogen production during off-peak electricity demand hours using CHHP technology. The hydrogen station is in close proximity to a future build out of HFCVs. There is a strong team with leaders in hydrogen (AP) and FCE for MCFC stationary fuel cells.
- The project exhibits a reliable fuel cell technology and made a good choice of a demonstration site at OCSD. The system design appears solid, although the biogas clean-up system, and its efficiency is not clear.
- They are addressing both vehicle and distributed energy concepts (both current issues).
- The project exhibited a very high efficiency of the entire system.
- These proved to be innovative technologies for the hydrogen production step.
- The renewable hydrogen aspect is valuable.
- The project had significant leveraging of multiple funding sources to complete the project.

Weaknesses
- There was only a very limited time for on-site full operation and concept demonstration. It is unfortunate that time for only limited on-site operation is possible given the significant investment of time, effort and funding expended on this project to date.
- The project demonstrated uncertain scalability.
- The economic aspects (cost and maintenance) of decentralized purification are still unclear.

- The project is running out early, prior to the actual demonstration starting September 2011. (CARB support is required in addition to DOE.)
- A realistic estimate on the hydrogen co-production price was not given due to dependence on upcoming analysis, economies of scale, and optimal size.
- There were too many delays in reaching operational capability.
- The project had very slow progress in meeting objectives. It is unclear what problems can be anticipated in the fuel cell scale up. No system economics analysis has been presented for the OCSD, Fountain Valley station.
- The project has not done much economic analysis yet (mostly proof-of-concept testing). This is not really a serious problem yet, but it must be addressed now that the concept has been proven.
- Scheduling delays have pushed the project timeline back.

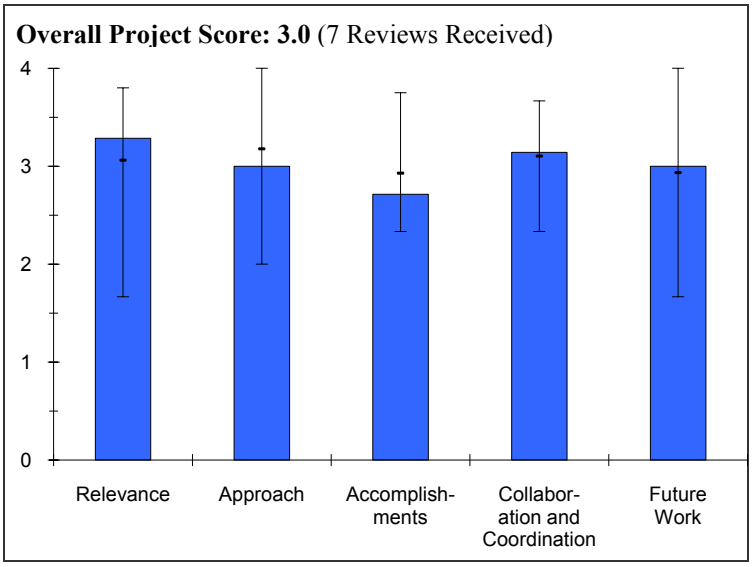
Specific recommendations and additions or deletions to the work scope

- It is strongly recommended that the DOE and California agencies take steps to ensure that this facility continues to demonstrate operation, including performance testing and data collection and analysis, and meaningful, realistic economic evaluation of operation in the co-production mode using digester gas fuel and producing hydrogen with sufficient purity for use in FCVs.
- They should concentrate on analysis of overall efficiencies, economics, and clear statements on cost per kilowatt hour and kilogram hydrogen.
- They should communicate technology and project barriers more clearly.
- They should communicate partner contributions more clearly.
- They should show progress from the past year in a clearer way.
- None.
- Encourage AP to speed up the OCSD demonstration. AP and the CARB can fund the effort going forward. Hopefully, data will be provided to the DOE.
- The project is near completion and it is recommended that they complete the future work as described. Economic analysis will be very important to build interest in the concept.

Project # TV-07: California Hydrogen Infrastructure Project
Ed Heydorn; Air Products.

Brief Summary of Project

The objectives of this project are to: 1) demonstrate a cost effective infrastructure model in California for possible nationwide implementation; 2) design, construct, and operate five hydrogen fueling stations; 3) collect and report infrastructure data; 4) document permitting requirements and experiences; 5) validate expected performance, cost, reliability, maintenance, and environmental impacts; and 6) implement a variety of new technologies with the objective of lowering the costs of delivered hydrogen.



Question 1: Relevance to overall DOE objectives

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

- This project is relevant in that it focuses on demonstration of hydrogen fuel station operation and addresses a number of DOE FCT Program goals and objectives.
- This was a congressionally directed project. Fortunately, AP has made it relevant to the DOE multi-year program plan.
- The continuous demonstration of different refueling pathways, mobile and stationary, extensive liquid hydrogen truck-in data, and the pipeline supply is still pending.
- There was no funding in 2009 and 2010. Did that reduce activities?
- It is critically important to investigate all types of hydrogen infrastructure, so that it can be economically scaled to the demand and associated requirements. This investigation will help inform infrastructure choices, as well as cost estimates during the pre-commercialization and early commercialization phases of HFCV rollout.
- This strongly supports DOE program. It is crucial to build and operate hydrogen stations around California, because that is the target location of automakers' vehicle rollouts.
- This project addresses the barrier of lack of hydrogen refueling infrastructure performance and availability data, and the cost of delivered hydrogen, which is barrier C of the multi-year plan. Five hydrogen refueling stations in California are to be operated to provide a model for nationwide implementation.

Question 2: Approach to performing the research and development

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

- The approach involves locating hydrogen fueling stations in various locations and operating environments to demonstrate viability and assess economic feasibility. The project has a good concept of emphasizing the introduction of new technology and employing several hydrogen production and distribution approaches.
- This project has some similarities to other AP projects funded by the DOE.
- There is no detailed insight into the impacts of different delivery and dispensing methods. It would be especially interesting to do an economic comparison of these impacts.
- There are different stations with multiple sources. Do you already see advantages of one of the demonstrated hydrogen delivery and station storage technologies based on demand?
- AP looked at all different practical configurations in hydrogen infrastructure, including pipeline-fed hydrogen stations, tube trailer delivery to low-demand locations, attractive retail-like stations, and renewable hydrogen

stations. They accurately described the barriers they were attempting to overcome and progress made or not made against those barriers.
- There are some stations still being built.
- The project should work with OEMs to establish station requirements. They should also select suitable sites, complete required agreements and permitting, and collect and report on-line performance data to the DOE. There is value in operating several stations using different refueling mechanisms. Some stations in this project are questionable (e.g., only one vehicle in operation at Placerville station), and it is questionable whether this is a good use of limited resources. Although we do get some cold weather, higher altitude data show that we can get hydrogen to outlining locations, but not at low cost. Most projects are co-funded by industry (Nissan and Shell) and California government (CARB and SCAQMD). The plan for the Orange County, Fountain Valley demonstration of energy station is useful for addressing renewable hydrogen and co-production barriers. The Torrance pipeline station demonstrates that we can get low-cost hydrogen to the user. The University of California, Irvine (UCI), evaluation of air quality impact is useful.
- They fall short in being able to meet the objective of documenting a cost-effective infrastructure model that could become a national model.

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

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

- The progress seems rather slow. This project has been underway for over four years, and only two stations are operating with only six months left in the project.
- The system has demonstrated 5-10 pounds per hour, or 100 kilograms per day and greater than 200 kilowatts of electricity.
- Fuel Cell Energy has determined how to get the main stream slip out of the anode.
- They decided to use waste water from OCSD in Fountain Valley.
- There was no evident progress in 2009, and there is no commissioning of a new station.
- AP generally accomplished what they set out to do. The pipeline station is important in evaluating the most economical delivery modes. The Long Beach tube trailer station was probably the least effective as it received very little demand considering the general location it was in. The station near Lake Tahoe was appropriate and useful for the small demand it was supporting. It was a smart approach to choose California for all of their station demonstrations as this state's zero-emission vehicle mandate and low-hydrogen costs in the Los Angeles basin will likely be the first site for HFCV commercialization.
- The demand for some stations' hydrogen has been increasing, and progress is being made on the construction of the Torrance station.
- It is difficult to completely separate out accomplishments for this project from the other AP project, TV-06. There has not been remarkable progress since the fiscal year 2009 review. The project is very behind schedule on the Torrance and Orange County Sanitation District/Fountain Valley demonstrations. These demonstrations are still not online, and it will be some time before they are, especially the OCSD demonstration. UCI's successful 350/700 bar station is exceeding expectations for use with plans for expansion. There have been no boil-off losses since demand is high enough. It was good to site this in Southern California. The new delivery concept trailer that deployed can dispense hydrogen at 10,000 psi.
- AP had good results for the Fountain Valley project, and it has potential to be a difference maker in terms of identifying a cost-effective model for delivering renewable hydrogen. The new delivery concept could also help boost sales of the smaller stationary fuel cell products.

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

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

- There were good collaborations among project partners.
- This project has good collaboration.
- Why are they not integrating and doing an independent analysis for cost evaluation of different station and delivery concepts?

- AP held a number of events relative to their various station openings. They also did a good job with the California regional authorities (e.g, CARB and AQMD). Where they fell short is in their reluctance to share information within the industry as a whole. This reluctance is partially understandable from the standpoint of protecting their intellectual property. They could, however, be a bit more forthcoming to the public at large as to what impact these stations would have to the ultimate cost of delivered hydrogen. This in turn would help the DOE and other government entities realistically evaluate and project hydrogen costs in the future.
- There were good collaborations and partners with OEMs and energy companies.
- There was a lot of collaboration with UCI.
- There was a good mix of industry, government, and academic partners.
- AP has developed a strong team of collaborators.

Question 5: Approach to and relevance of proposed future research

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

- With only a few months left in the project, the plans for future work are logical and reasonable. It is essential that all stations begin operation and collect operational data prior to completion of the project.
- They have an aggressive timetable to finish this project. They will be installing the pipeline, fueling station, and energy station.
- Commissioning of the Torrance pipeline fueling station is now ahead. The new progressive pipeline fueling is of high interest because the liquid-based stations are state of the art.
- AP provided lessons learned and suggestions on what infrastructure would work better in specific situations. They had sound ideas for furthering this effort in a way that would demonstrate lower cost and more readily available hydrogen in future phases.
- They have continued construction and operation of five stations.
- The project ends in December 2010. Future work includes continuing operation and commissioning the Torrance and Fountain Valley/OCSD stations capable of dispensing hydrogen at 350 and 700 bar. They continue to report operational data to the DOE.
- The future actions are appropriate. However, they need to be more aggressive in the delivery and in the public outreach and education aspects.

Strengths and weaknesses

Strengths
- There is strong support from the project partners, i.e. state and federal agencies.
- AP has the ability to leverage all the various collaborators to negotiate a successful project.
- AP did well in the practical test of setup and operation of different delivery methods and station concepts.
- AP demonstrated a variety of hydrogen storage and delivery technologies at a wide range of locations across California.
- AP had varied hydrogen production and delivery at each station.
- There is a good mix of industry, government, and academic partners. There are a variety of refueling options being explored with ranging cost to the user.
- The scope of the work is appropriate.

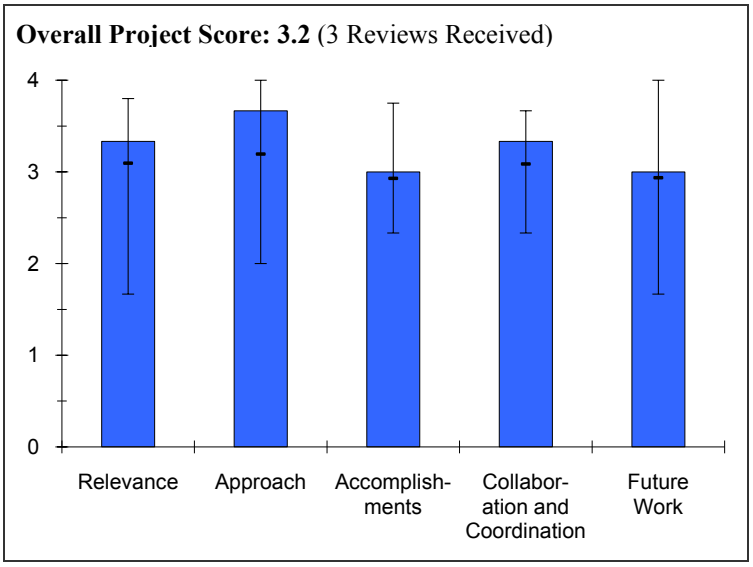
Weaknesses
- The project appears to be running out of time with major objectives left to be completed.
- An economic analysis should be part of this project at each stage. Economics should be expressed in terms of cost per kilogram for hydrogen delivered.
- There were few activities in 2009 and 2010 with little new recent findings.
- There is no comparison of different pathways and station concepts in terms of economics.
- The funding and the project might end before all stations are completed.
- Progress has been slow. It is also questionable whether they can keep all stations open.
- The delays in completing important projects, such as the Fountain Valley project, are a concern.

Specific recommendations and additions or deletions to the work scope

- Plans should be made to continue operation, data collection, and analysis (including economic evaluation) following completion on the project. Station operators should be identified, and a smooth transition to these new operators should be initiated as soon as possible.
- A safety plan should be developed before the project is finished. In the event this project is successful, it could be the blueprint for other similar projects. An analysis of the economics of the system needs to be conducted.
- AP should investigate and compare the economics of different station concepts (liquid hydrogen station versus pipeline station), evaluate challenges of different technologies, and give cost breakeven points dependent on demand.
- The project started in fiscal year 2005 but did not receive DOE funding in either 2009 or 2010. If necessary (it may not be), they could consider funding at low levels to maintain data collection efforts. The industry and California government should shoulder most of the costs going forward. The project has been behind and reached logical phase out.
- The scope is appropriate. The timeliness of the execution needs to improve.

Project # TV-08: Technology Validation: Fuel Cell Bus Evaluations
Leslie Eudy; National Renewable Energy Laboratory

Brief Summary of Project



The overall objective of this project is to validate fuel cell technologies in transit applications. The objectives are to: 1) analyze fuel cell (FC) bus performance and cost compared to conventional technologies to measure progress toward commercialization; 2) provide lessons learned on implementing fuel cell systems in transit operations to address barriers to market acceptance; and 3) harmonize data collection efforts with other fuel cell bus demonstrations worldwide in coordination with the Federal Transit Administration (FTA) and other U.S. and international partners. The objectives for 2010 are to: 1) complete analysis and report results on first generation FC buses; 2) begin data collection and analysis for next-generation fuel cell buses at Burbank, SunLine, and Public Transportation Authority for western Alameda and Contra Costa Counties (AC Transit); and 3) conduct crosscutting analysis of FC bus status at all sites.

Question 1: Relevance to overall DOE objectives

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

- The project is relevant to the data collection objectives of the technology validation program. It looks at a significant early fuel cell market and gathers important operational data.
- It's unsure that buses are a great fit for fuel cells relative to other advanced technologies. The program has so far been able to provide a lot of data that validates this. While the program has been valuable in terms of providing data to the bus OEMs to enhance and expedite their development efforts, it is missing targets for cost and performance that will support a product that is competitive with all technologies.
- The project is well focused on the key technical targets. It plays a key role in assimilating and analyzing data from various fuel cell bus projects across the country. Since the individual bus projects are essentially independent, this project is a necessary component of the overall program to identify trends, improvements, problem areas, etc. in fuel cell bus developments and operation.

Question 2: Approach to performing the research and development

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

- The data collection approach is sound and follows standard procedures for such collection in a cost-effective manner (i.e. analysis of largely existing data).
- The annual status report is a good summarization of results and progress.
- Collecting data on both first-generation and second-generation fuel cell buses marks a good opportunity for comparisons.
- The sharp focus on assimilating and analyzing data from the various fuel cell bus projects should yield valuable information on public transit applications of fuel cell busses. The approach is consistent with the stated objectives of the program and with the Technology Validation program. Good approach to compare fuel cell bus performance parameters with conventional technology and also to include some refueling data.

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

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

- They have completed analysis of four separate first-generation fuel cell bus fleets. Fleets were California-centric, but this would be expected).
- The project demonstrated a good summary of key information (miles traveled, fuel used, fuel economy, miles between repair calls). The cost analysis is also very helpful to show general trends in fuel, operational, and capital costs.
- Collecting and analyzing information on fueling stations illustrates very different fueling needs for buses versus light-duty vehicles.
- A good amount of data is shown for gen 1 busses. It is too early in timeline to show gen 2 data, but it appears that these evaluations have been started. Comparison of results with conventional CNG and diesel busses highlights both improvements (e.g., better fuel economy) and problem areas (e.g., reliability). Refueling data is also important, particularly refueling time which impacts transit system operations.

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

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

- Collaborations with transit agencies encompass a great many of the properties operating fuel cell buses. Also the project did well in working with major manufacturers of buses and some additional key organizations (CARB and CALSTART) both here and internationally.
- Good collaboration with the fuel cell bus projects across the country.

Question 5: Approach to and relevance of proposed future research

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

- The future work plans continue on a successful path.
- The future activities follow logically from the program's objectives; that is, analyze the latest data coming from the current and future fuel cell bus projects.

Strengths and weaknesses

Strengths
- Collaborations with many transit agencies, FTA, and others to collect and analyze information from most FC bus projects in U.S. is a strength.
- Their data analysis, publications, and presentations are strong.
- The project has a good ability to provide key performance data to OEMs.

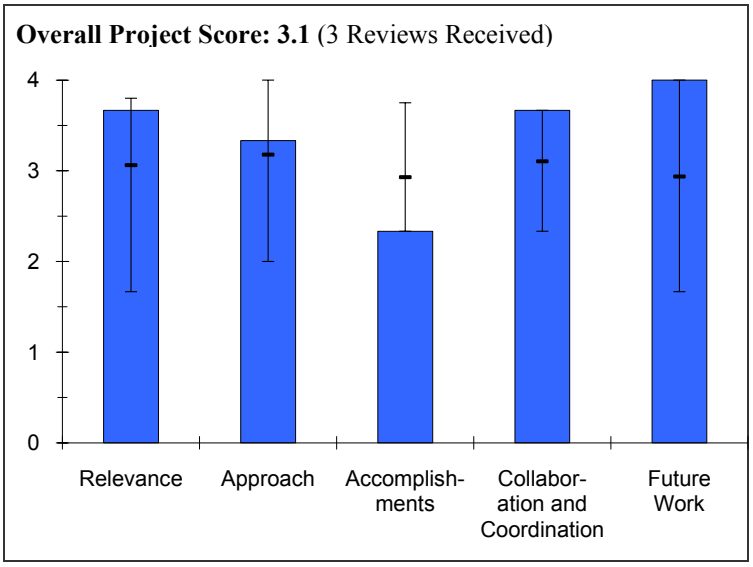
Weaknesses
- None identified.
- The targets for cost and performance, which will result in fuel cell buses that are competitive with other technologies, were not presented.

Specific recommendations and additions or deletions to the work scope

- None at this time.
- The project should include targets for cost and performance, as well as the development of road maps to achieve these targets.
- This project should continue for as long as the bus demonstration projects are providing meaningful data to be collected and analyzed. By assimilating results across a range of environmental conditions and from different manufacturers and operators, a much clearer picture of the status of fuel cell bus technology should emerge.

Project # TV-09: Hawaii Hydrogen Power Park
Richard Rocheleau; Hawaii Natural Energy Inst.

Brief Summary of Project



The objectives of this project are to: 1) install hydrogen fueling station infrastructure at the Hawaii Volcanoes National Park (HAVO) by August 2010; 2) support the operations of the National Park Service (NPS) hydrogen plug-in hybrid electric shuttle buses for 24 months through January 2013; 3) conduct engineering and economic analysis of the HAVO fueling station and bus operations on different routes, grades, elevations, and climatic conditions; 4) validate fuel cell system performance in harsh environments including high sulfur dioxide levels in the atmosphere; 5) position HAVO as an alternative-fueled vehicle test bed for the NPS; 6) provide a high-level of public outreach with hydrogen technologies; and 7) attract new partners and applications for the Big Island to support the development of hydrogen transportation infrastructure.

Question 1: Relevance to overall DOE objectives

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

- Hawaii is an excellent location to demonstrate renewable hydrogen technologies. They have the highest electricity and fuel rates and require fossil fuels to be delivered from afar. The multi-faceted approach chosen in this effort is also of critical value to the DOE FCT Program. A system-wide approach using multiple, available applications in a site with two million visitors will be very informative across a variety of areas.
- This is a truly pioneering project in terms of type of vehicle, renewable fueling infrastructure, and collaborators.
- The project addresses a number of different aspects of hydrogen infrastructure and hydrogen production from renewables, and supports FCV testing under a variety of conditions.
- This is a good, broad project that should generate useful, real-world information on systems performance versus key technical targets.

Question 2: Approach to performing the research and development

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

- The multi-agency approach was very good from the standpoint of raising the necessary funds for a large demonstration and getting buy-in from a variety of stakeholders. It did, however, introduce more complexities and led to significant delays to this project. Working with HAVO will allow maximum visibility for this project. Teaming with the Hawaii Electric Light Company (HELCO) for renewable electricity for the hydrogen production is also a sound approach. Using the plug-in hybrid electric and hydrogen hybrid vehicles is a novel approach. The poor fit for a fuel cell bus at HAVO should have been anticipated earlier by doing accelerated market research.
- Progress has been hindered by delays in processing the necessary approvals for various elements of the program.
  The project has a broad approach focused on gaining information for overcoming key technical barriers, including hydrogen production from renewables cost and durability, hydrogen refueling infrastructure

performance information, and FCV performance and durability including the validation of fuel cell system performance in harsh environments.
- There is a strong public outreach component to this project.

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

This project was rated **2.3** based on accomplishments.

- There have been lengthy delays in this effort, tying up significant DOE research and development funds for a long time. The acoustic information, acoustic data analysis, NEPA study, and the multi-agency agreements have all contributed to these delays. While some of these delays are to be expected in a project as technically aggressive as this, others appear to be caused by the lack of sufficient pre-planning and/or earlier resourcing of this effort.
- Progress has been hindered by delays in processing the necessary approvals for various elements of the program.
- The project demonstrated good progress but has experienced some slow down due to external constraints and lack of supplier information or data.

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

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

- Hawaii Natural Energy Institute (HNEI) has done a great job in bringing a number of different entities into this project. The NPS Climate Friendly Parks initiative is a good fit for what is being demonstrated. The state of Hawaii, Hawaii Electric Light Company, Office of Naval Research (ONR), U.S. Army, and DOE teaming will lead to a wide dissemination of results. Delays in this project may have been limited through detailed project and scope collaboration with many of these same entities early on. The acoustic issue, in particular, may have been remedied somehow, perhaps by locating the station further away from residences (if possible).
- This project has helped establish good relationships between the DOE and other federal agencies.
- There is an excellent diversity of relevant and significant partners embedded into the project.

Question 5: Approach to and relevance of proposed future research

This project was rated **4.0** for proposed future work.

- HNEI is constantly exploring ways to have these efforts provide an even bigger impact to its stakeholders. The latest is with respect to their discussions with Puna Geothermal Ventures about their geothermal power. This dialogue could result in affordable hydrogen over a wide ranging area. They also continue to facilitate productive discussions with DOE and ONR on technical projects of mutual interest.
- The project has identified opportunities for renewable energy storage of potentially great value to the program.
- Future activities are in line with the project's timeline and milestones.

Strengths and weaknesses

Strengths
- The project did well in renewable hydrogen production. The NPS and HAVO involvement helped maximize the education component. The multi-agency involvement across a wide variety of stakeholders was beneficial for this program.
- The project had a good scope and coalition of state and federal partners.
- This is a good, strong project that balances a broad approach with sufficient detail to gain valuable data toward technical targets and barriers.

Weaknesses
- The project encountered significant delays to its schedule.
- There were delays in processing agency approvals.

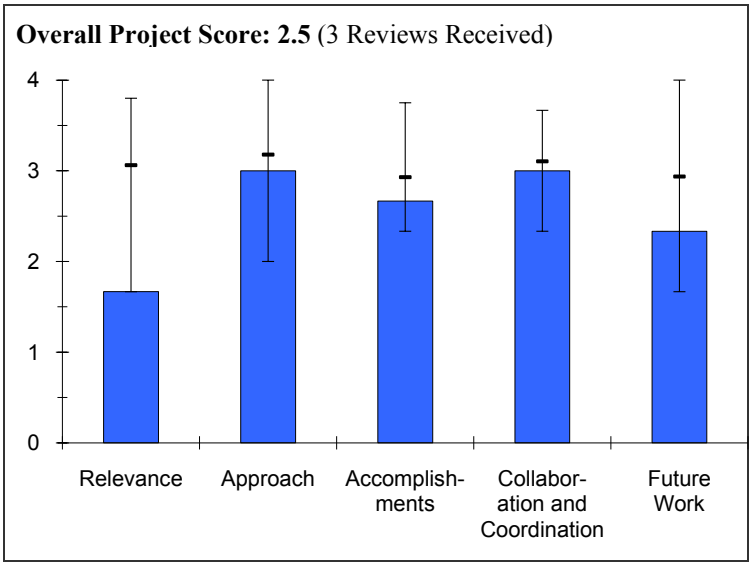
Specific recommendations and additions or deletions to the work scope

- The project should accelerate its activities.
- The project should integrate with renewable energy storage efforts on the Big Island.

Project # TV-10: Tanadgusix (TDX) Foundation Hydrogen Project/PEV Project
Connie Fredenberg; Tanadgusix Foundation

Brief Summary of Project

The main focus of this validation and demonstration project is to procure and evaluate the performance of commercially available and/or custom-made, alternative-fueled vehicle(s) on St. Paul Island, Alaska. Initially, the vehicles will be used for the eco-tourism operation owned by TDX Corporation, but the goal is to have village-wide use. In the winter of 2008, when fuel could not be delivered to the island due to sea ice, fuel was rationed to five gallons per vehicle each week at a cost of $12 per gallon. For this project, excess electricity from the existing high penetration wind-diesel system on St. Paul Island will produce the transportation fuel.



Question 1: Relevance to overall DOE objectives

This project earned a score of **1.7** for its relevance to DOE objectives.

- This project should be moved to the Plug-in Hybrid Electric Vehicle (PHEV) Vehicle Technologies Program as it is no longer considering the use of fuel cells. It is still relevant to DOE objectives, but not the DOE FCT Program objectives.
- This project has changed focus from hydrogen-powered vehicles to PHEVs.
- It appears from the presentation that this is a wind power and plug-in electric vehicle (PEV) project and not a hydrogen project. The only mention of hydrogen was the decision not to include an electrolyzer because of costs, storage, etc. Furthermore, the project is geared very specifically to the conditions present at the location of the study, and there is little relevance to other areas or applications.

Question 2: Approach to performing the research and development

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

- This approach has been changed to a PHEV project. The project did the right thing in making this change, as sticking with an HFCV (hydrogen fuel cell vehicle) project posed problems in terms of hydrogen infrastructure. Additionally, this island has some of the best wind you will ever see. An island in the Aleutians with this much renewable energy and so much trouble to import petroleum is a perfect site for leveraging the renewable energy into a transportation fuel (electricity).
- This small Aleutian island has a source of renewable wind energy, which can be employed for PHEVs. This is a critical need since vehicular fuel is very expensive and difficult to supply in the winter months. The application is perfect and the need is great.
- The approach is acceptable regarding the wind power, but the development of PEV ATVs has very limited application outside of this project.

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

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

- The principal investigator (PI) had to make a decision as hydrogen refueling of a HFCV was not practical. It makes a lot more sense to move to a PHEV Van ($90,000). Apparently, it has been so widely accepted that plans are in place to purchase another custom van for this terrain.
- One PEV has been placed in operation on the island.
- Other than completing some limited studies, the only experimental results were obtained on a single vehicle, and these results indicate some severe problems associated with the use of an electric drive vehicle under the harsh conditions encountered in the area. These problems include motor overheating and stoppage, difficulties with sealing the battery compartment, steering rod issues, potential corrosion, and a driving range significantly less (about 50%) than expected. The results would suggest not continuing with more vehicles until such problems are resolved.

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

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

- Collaborating with the Glenn Research Center is a positive. Also, other remote tribal villages in Alaska will learn about powering vehicles with excess renewable electricity and will likely follow suit. The vehicle maker is in Oregon, so this also helps the domestic manufacturing base.
- The necessary collaborations are in place.
- The project includes good collaborators.

Question 5: Approach to and relevance of proposed future research

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

- This will be moved to the Vehicle Technologies Program, and future activities will be explored with that management team.
- The future work is reasonable and focuses on additional vehicles and charging stations.
- The future plans include procuring a second PEV ATV and possibly a medium-sized pick-up truck. However, as stated above, major problems emerged in the first vehicle's operation, and no plans were presented to address these.
- There were no plans presented for incorporating a hydrogen element to the project.

Strengths and weaknesses

Strengths
- The project did well at exhibiting renewable transportation with excess wind-generated electricity. The project demonstrates to remote customers in our nation that they can reduce petroleum dependency and associated greenhouse gas emissions by switching to electrification of their vehicles with renewable power.
- This project showed an excellent renewable energy application driven by a major need.

Weaknesses
- Resources devoted to fuel cell technologies are (out of necessity) being diverted to PHEV demonstrations.
- None.

Specific recommendations and additions or deletions to the work scope

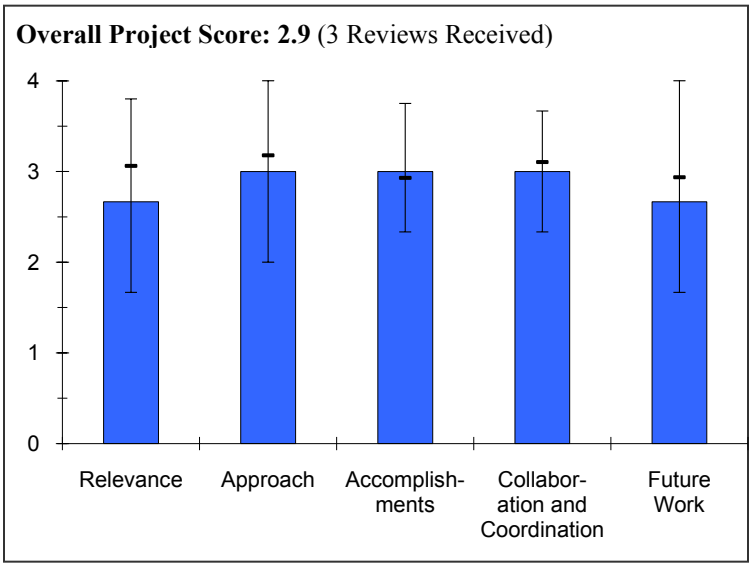
- None.
- Since the wind turbine produces the least amount of energy in the summer months, which is when the vehicle use is at a maximum, it may be beneficial for a small hydrogen electrolyzer or fuel cell system to be incorporated to store winter wind energy and then provide additional electricity in the summer.
- The project should be funded under a different DOE office or funding agency.

Project # TV-11: Texas Hydrogen Highway - Fuel Cell Hybrid Bus and Fueling Infrastructure Technology Showcase

David Hitchcock; Texas Hydrogen Highway

Brief Summary of Project

The objectives of this project are to: 1) provide public outreach and education by showcasing the operation of a 22-foot fuel cell hybrid shuttle bus and hydrogen fueling infrastructure; 2) showcase the operation of a zero-emissions vehicle for potential transit applications; and 3) to advance commercialization of hydrogen-powered transit buses and supporting infrastructure.



Question 1: Relevance to overall DOE objectives

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

- This project demonstrates fuel cell operation in conjunction with a fueling station. The project, while relevant to the goals and objectives of the DOE program, certainly is not unique since there are many fuel cell buses that have been operating for years. The value of this project appears to be increasing public awareness in a new area (Texas).
- Public showcasing of a hydrogen-fueled transit bus is relevant to the public knowledge and acceptance of hydrogen vehicles.

Question 2: Approach to performing the research and development

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

- The project has a reasonable approach based on providing public and government educational opportunities in an effort to promote understanding and acceptance of clean technologies. However, there appears to be few unique or innovative features of the project. There is very limited information given regarding the fueling station or refueling operations, and no mention was made of providing data and operational information to NREL (National Renewable Energy Laboratory) for the National Fuel Cell Database.
- The fuel cell bus and hydrogen refueling station were funded by non-DOE sources.

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

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

- The bus has been delivered and showcased in several locations within the region (Texas). The project appears to be on schedule.
- The public was given significant hands-on exposure to the hydrogen-fueled bus and fueling station.

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

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

- Collaborations are primarily with project partners (subcontractors). The project has significant interactions with sponsors where the bus has been showcased within the region, which is consistent with the project's goals and objectives.

- The project has significant interactions with other Texas institutions.

Question 5: Approach to and relevance of proposed future research

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

- Future plans include a final event with state officials before the project ends in September 2010 and appears to be adequate.
- This project ends in September 2010, and one final outreach event is planned prior to that date.

Strengths and weaknesses

Strengths
- The team was able to perform the key duties necessary to procure and operate a fuel cell bus and fueling infrastructure in a large state where fuel cells and hydrogen have little presence.
- The project provided public exposure to an operational hydrogen-powered bus and fueling station.
- The bus and fueling station were provided by non-DOE funding sources.

Weaknesses
- None.

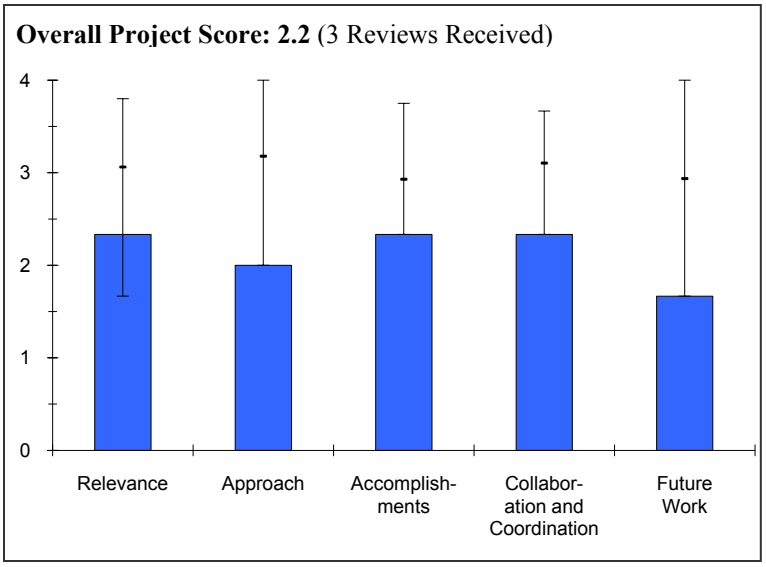
Specific recommendations and additions or deletions to the work scope

- The project should ensure that operational data is shared with NREL.
- The project should engage the partners in a coordinated public outreach that includes the American Recovery and Reinvestment Act programs being implemented at several Texas locations.
- None.

Project # TV-12: Florida Hydrogen Initiative
David Block; University of Central Florida

Brief Summary of Project

This project seeks to develop DOE and Florida's hydrogen and fuel cell infrastructure by: 1) creating partnerships for applied demonstration projects; 2) sponsoring research, development, and demonstrations in hydrogen and fuel cells technology; 3) facilitating technology transfers to create, build, and strengthen high-growth, high-technology companies; 4) developing industry support for applications; and 5) developing unique university-level education programs.



Question 1: Relevance to overall DOE objectives

This project earned a score of **2.3** for its relevance to DOE objectives.

- This project appears to act as a clearinghouse for fuel cell projects by soliciting and funding hydrogen and fuel cell projects. It is not clear why the selected projects could not be funded directly by the DOE through a competitive process.
- This proposal, as initially conceived, had some degree of relevance to DOE research, development, and demonstration objectives. The significant changes over time, however, make it less relevant. The fact that this was a Congressional addition, with limited influence by the DOE over its scope, did not help.
- This project appears to take a broadly based approach that includes a number of stand-alone projects.
- The individual projects cover a wide variety of hydrogen-related topics, with the only continuity showing is that all of the projects take place in Florida. That said, all of the projects are focused on hydrogen technologies and, in that sense, are relevant to the overall objectives of the program.

Question 2: Approach to performing the research and development

This project was rated **2.0** on its approach.

- The approach appears to be consistent with the goals and objectives of the project.
- The Florida Turnpike project never materialized due to the lack of orange waste (40% planned - 3% actual) that was originally envisioned. The next idea of a renewable fuel cell exhibit that would be rotated among the Florida museums also never materialized. Instead, they only put the exhibit in an Orlando museum. In summary, the technical approach failed that commitment test as key players dropped out across the board.
- As stated earlier, this work consists of a number of unrelated projects ranging from engineering demos and studies to fairly specific materials studies related to fuel cell membrane electrode assemblies (MEA) and electrocatalysts. Some of the projects would appear to be better suited for support under different parts of the overall hydrogen program so that their impact could be better integrated with other ongoing work in their respective topics.
- The present approach appears too broad and lacks sufficient focus in the individual topic areas to result in significant progress toward overcoming the technical barriers in the timeframe of the project.

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

This project was rated **2.3** based on accomplishments.

- Given the goals and objectives of the project, progress appears to be reasonable. Progress may have been hampered by a change in leadership of the project; however, new projects have been solicited and selected and are in the process of being initiated.
- This project was earmarked by Congressman Weldon, who has since been voted out of office, and it has had a number of setbacks. The original university is out of the picture and was replaced with Florida Atlantic University. The Florida Turnpike project never went through due to a lack of orange waste product from which to produce renewable power. The quote from the Netherlands for renewable methanol was too expensive to follow through on as a substitute. The prime contractor changed during this effort. To their credit, three project tasks are being envisioned to replace those cancelled, which include two-year efforts on leak detection, low-cost catalysts, and MEA durability. Nineteen proposals were received and five were selected.
- There appeared to be major differences in progress among the individual projects. Some of the engineering studies could be rated at 3 (good), while other projects showed progress at the 2 (fair) level. Overall, a project rating of 2 seems appropriate within the grading system of these forms, but an overall ranking of 2.5 would be preferred.

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

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

- Collaborations appear to be primarily with the organizations involved in the project's selection process.
- A lot of collaboration was done, but few lasting commitments were made with the various project stakeholders, which in turn resulted in an overall effort that has become somewhat piecemeal as opposed to strategic in nature.
- Collaboration among institutions is good, particularly with the engineering projects.

Question 5: Approach to and relevance of proposed future research

This project was rated **1.7** for proposed future work.

- Information on future activities was not presented.
- To their credit, they are working with Enerfuel and others in the new tasks to see it through to at least a conclusion, if not a successful one.
- Again, it is difficult to assess an overall ranking of future activities since the individual projects varied greatly in their approach. The overall ranking was based on the observation that only one of the projects specifically mentioned future work.

Strengths and weaknesses

Strengths
- The specific projects selected and funding appear to be relevant and should contribute to the hydrogen and fuel cell state-of-the-art technology.
- None.

Weaknesses
- This program had too many cancelled and redirected projects, which became less relevant as they were re-scoped. There was also a lack of commitment from a variety of stakeholders.

Specific recommendations and additions or deletions to the work scope

- The DOE should refund back to Congress any future Congressional aid of this nature.
- They should keep the engineering projects within the current scope and shift the materials studies to another sub-program within the hydrogen office.