VIII.3 Hydrogen to the Highways

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- Daimler, Stuttgart, Germany
- Mercedes-Benz USA LLC, Montvale, NJ
- DTE Energy, Detroit, MI
- NextEnergy, Detroit, MI

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End Date: September 30, 2010

Objectives

- Record, collect and report data from fuel cell vehicles (FCVs) and the hydrogen fueling operations to validate DOE targets:

Performance Measure	2009	2015
Fuel Cell Stack Durability	2000 hours	5000 hours
Vehicle Range	250+ miles	300+ miles
Hydrogen Cost at Station	$3/gge	$2-3/gge

- Demonstrate the safe installation of hydrogen fueling stations and fuel cell service facilities as well as the safe operation of all FCVs.
- Continuously update safety manuals and provide training.
- Participate in various working groups to ensure continuous progress towards establishing codes and standards essential for FCV commercialization.
- Raise public awareness of hydrogen technology and demonstration projects.

Technical Barriers

This project addresses the following technical barriers from the Technology Validation section of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Lack of Fuel Cell Vehicle Performance and Durability Data

(B) Hydrogen Storage

(C) Lack of Hydrogen Refueling Infrastructure Performance and Availability Data

(D) Maintenance and Training Facilities

(E) Codes and Standards

(H) Hydrogen from Renewable Resources

Contribution to Achievement of DOE Technology Validation Milestones

This project will contribute to achievement of the following DOE technology validation milestones from the Technology Validation section of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 7**: Validate vehicle refueling time of 5 minutes or less for a 5 kg of hydrogen (1 kg/min) at 5,000 psi through the use of advanced communication technology. (4Q2007)
- **Milestone 8**: Fuel cell vehicles demonstrate the ability to achieve 250 mile range without impacting passenger cargo compartment. (4Q2008)
- **Milestone 10**: Validate FCVs 2,000 hour fuel cell durability using fuel cell degradation data. (4Q2009)
- **Milestone 12**: Validate cold start capability at -20°C. (2Q2011)

Accomplishments

- Externally operated Gen II vehicles for the sixth consecutive year although the vehicles were designed for a 2-year operation.
- Submitted over 100 DVDs of raw data to the National Renewable Energy Laboratory (NREL).
- Finalized internal operation and testing of Gen II pre-production vehicles.
- Preparing for Gen II deployment with external customers and dealership.
- Improved equipment reliability and maintained operation of the DTE refueling station.

- Participated in various working groups to ensure continuous progress with regards to codes and standards.

Introduction

The primary goal of this project is to validate fuel cell technologies for infrastructure, transportation as well as assess technology/commercial readiness for the market. The Mercedes Team, together with its partners, have been testing the technology by operating and fueling hydrogen FCVs under real world conditions in varying climate, terrain and driving conditions. Vehicle infrastructure data has been collected to monitor the progress toward the hydrogen vehicle and infrastructure performance targets of $2.00–3.00/gasoline gallon equivalent (gge) hydrogen production cost and 2,000-hour fuel cell durability. Furthermore, progress has been made to validate cold-start capability at -20°C. Finally, to prepare the public for a hydrogen economy, outreach activities have been designated to promote awareness and acceptance of hydrogen technology.

Approach

To achieve the project goals, the Mercedes Team deployed 30 Gen I vehicles into customer hands for real-world operations in three climatic regions of the United States. The Team is also providing data from Gen II vehicles under similar operations as Gen I vehicles to compare technology maturity during the project duration. All vehicles have been equipped with a data acquisition system that automatically collects statistically relevant data for submission to NREL, which monitors the progress of the FCVs against the DOE technology validation milestones. The energy partners have installed an infrastructure to provide hydrogen to the Mercedes Team's FCVs and to evaluate the technologies which have the potential to achieve the DOE hydrogen cost targets.

To raise public awareness of hydrogen technology and demonstration projects, the Mercedes Team aligned its communication activities with the goals of the DOE. In addition, project safety was maintained through continued inter-team communication, vehicle and infrastructure training, employee and customer education, and emergency responders training.

Results

Gen I FCVs

Although the Gen I FCV fleet was designed for a 2-year operation, A-Class FCVs have outperformed engineering expectations as the vehicles have been in full operation for over six consecutive years. Since the inception of this demonstration project, customers have fuelled and driven the vehicles in a variety regions providing a complete range of climate and traffic conditions from congested city driving to open road highways (see Figure 1) to rural roads. All Gen I vehicles have been equipped with extensive data acquisition and reporting capability, allowing the Mercedes Team to generate over 100 DVDs of vehicle raw data for submission to NREL.

Gen II Technical Accomplishments

As the Gen I FCVs have been driven for over six years, the Mercedes Team is gradually transitioning the operation from Gen I A-Class FCVs to Gen II B-Class FCVs. Gen II FCVs have been tested and internally operated in a wide range of terrains, driving conditions and climates including diverse temperature, humidity and ambient air pressure. For example, the B-Class FCVs were operated under real-life winter conditions at double-digit, below-zero temperatures where cold-start capability was subjected to thorough scrutiny and FCVs repeatedly started with frozen fuel cell systems (see Figure 2). B-Class FCVs were also

FIGURE 1. Gen I Vehicles in Operations for Over Six Years

FIGURE 2. Cold Weather Operation of Gen II F-Cells

driven in deserts during the harsh summer months when temperatures may reach up to 122°F (Figure 3). To expedite mileage accumulation and expeditiously provide DOE with on-road data, Gen II vehicles were operated by test operators on routes specifically selected to simulate real-world conditions. These durability tests demonstrated the reliable vehicle configuration and uncompromising performance of the Mercedes Gen II FCV. To complement on-road testing, the Mercedes Team performed dynamometer tests showing that Gen II vehicles exceed the 2009 DOE range targets and attain best-in-class fuel economy.

Not only has the Mercedes Team finalized the assembly and manufacturing of all B-Class FCVs designated for external operations through an assembly process similar to traditional vehicles, but authorized Mercedes-Benz dealership are being selected for Gen II fuel cell market in southern California. These dealers will act as the handover point, and make the transaction to customers. These dealers will also provide all customer interfaces for service and maintenance activities, as well as the turn-in point at lease end. The Mercedes Team is in the process of selecting initial customers from a compiled list of inquiries received via normal channels, previous partners in the A-Class FCV project and specific fuel cell related inquiries.

Codes and Standards

The Mercedes Team participated in various working groups to support and assist in the development of codes and standards necessary to commercialize FCVs. Of particular note is Society of Automotive Engineers (SAE) J2601, "Fueling Protocols for Gaseous Hydrogen Surface Vehicles," the first worldwide published guideline that established a fueling baseline for hydrogen FCVs. It is anticipated that future stations funded by the California Air Resources Board (CARB) and the California Energy Commission (CEC) will adhere to J2601. The SAE Fueling Interface Group has also made strides with J2600, "Compressed Hydrogen Surface Vehicle Fueling Connection Devices" and is currently determining whether the guideline should follow the proposed H70 geometry from the corresponding International Organization for Standardization (ISO) document. A revised draft of J2719, "Information Report on the Development of Hydrogen Quality Guideline for Fuel Cell Vehicles" is expected by June of 2010 in which the report will incorporate the proposed changes from corresponding ISO documents. The SAE Safety Working Group has made continued efforts to update J2578, "Recommended Practice for General Fuel Cell Vehicle Safety" and J2579, "Technical Information Report for Fuel Systems in fuel Cell and Other H2 Vehicles."

FIGURE 3. Hot Weather Testing of Gen II Vehicles

The Mercedes Team began its initial involvement with Canadian Standards Association (CSA) America 4.3 ("Temperature Compensation systems") and ISO Working Group 5 in which the members are actively involved in Draft International Standard 17268, "Gaseous Hydrogen Land Vehicle Refueling Connection Devices."

NextEnergy

NextEnergy continued to work on the National Fire Protection Association 2 Standard, intended to provide clarity to the infrastructure design process and to streamline permitting. NextEnergy is a voting member of the technical committee which has been instrumental in developing this extraction code for the industry. Being a voting member continues indefinitely but NextEnergy believes that it is vital to continue participation through the initial release and the first modification cycle of the document.

NextEnergy Center also held a Hydrogen Codes and Standards Conference which attracted first responders, local officials, hydrogen industry experts, and national code development organizations that provided updates on the latest developments of national and international hydrogen codes and standards. This conference featured updates from such organizations as SAE, American Society of Mechanical Engineers, CSA America, Compressed Gas Association, International Code Council, and the ISO.

Safety and Health

The process of fully commissioning the Burbank Station was completed. As a part of this process, a number of test fills were performed by the Mercedes Team to ensure that all of the safety and communication systems were fully operational. Additionally, fueling training was provided to employees of Mercedes, California Fuel Cell Partnership and City of Burbank.

Despite the novelty of 70 MPa fueling, the Mercedes Team determined that the technology was mature

enough to remove the personal protective equipment requirements at the City of Burbank Station for both 35 MPa and 70 MPa fueling.

The Incident Management Plan is receiving a major overhaul, as it is revised to fit the 2010 customer model. While the Plan is still in development, select dealers will play an active role in some safety relevant communications. In addition, the Safety Plan was updated to reflect the new company structure.

Outreach and Media

Mercedes-Benz FCVs were on display at several national shows over the course of 2009 and 2010. The year began with a presence at the Detroit Auto Show where the Concept BlueZero with its battery and fuel cell electric drive models was presented along with video material about the next generation B-Class F-Cell. The F-Cell was incorporated into the Mercedes-Benz exhibit at the Washington Auto Show in Washington, D.C. in February. The following month in Columbia, South Carolina, the Mercedes Team organized a presence at the National Hydrogen Association meeting where the 700 bar A-Class F-Cell was part of a ride-n-drive and the F600 cutaway model attracted participants in the exhibition hall. Finally, at the Los Angeles Auto Show in December, the B-Class F-Cell was presented for the first time in North America as part of a sustainability platform at the Mercedes-Benz exhibit booth.

The largest FCV-specific outreach event was the Hydrogen Road Tour in which seven auto manufacturers including Daimler participated. The convoy drove over 1,400 miles in nine days starting near the Mexican border in Chula Vista, CA and ending in Vancouver, Canada with a ride-n-drive finale at the Hydrogen and Fuel Cells 2009 Conference. The Team participated with two 700 bar A-Class FCVs. The A-Class F-Cells performed well and capably held their own vis-à-vis the newer FCV models of the other manufacturers.

Fueling Stations and Co-Production Facilities

DTE Hydrogen Technology Park

DTE Energy completed the installation of the replacement electrolyzer/dispenser, and as a result, the site equipment has run the best of any year thus far. DTE Energy has had a number of tours of the DTE Energy Hydrogen Technology Park both from industry, educational institutions and the general public (Figure 4). On Thanksgiving Day, the Park was shown on local television featuring solar, hydrogen and green economy. Not only was remote data collection added to collect dispenser data at the site, but modifications were also made to the dispenser to support fast-fill communications with 700 bar vehicles. Final technical report for the Technology Validation portion of the project has been finished with Lawrence Technological University graduate students and has been sent to the State of Michigan.

FIGURE 4. Tour of the DTE Energy Hydrogen Technology Park

Preparing for Fueling Infrastructure

As FCVs transition from a demonstration phase to commercialization, the development of well-established hydrogen fueling station network is critical and, as a result, the Mercedes Team has been actively collaborating with other auto manufacterers, government officials and energy partners to build a hydrogen fueling infrastructure:

- Supported CARB/CEC by recommending station specifications, site locations and supplier qualification guidelines.
- Provided commitment letters to appropriate suppliers requesting government funding and meeting Mercedes-Benz Research & Development North America requirements.
- Worked with the California Fuel Cell Partnership to develop an action plan detailing strategy for deploying hydrogen fuelling stations and FCVs.
- Collaborated with other auto manufacturers to determine and coordinate locations of future fueling stations.

Summary and Future Directions

Summary

- Improved equipment reliability and maintained operation of the DTE hydrogen fueling station.
- Continued mileage accumulation of Gen I vehicles.
- Finalized internal operation and testing of Gen II pre-production vehicles.
- Preparing for Gen II deployment with external customers and dealerships.

- Participated in various working groups to ensure continuous progress with regards to codes and standards.
- Continued data collection, analysis and reporting.

Future Work

- Prepare for Gen II demonstrations.
- Maintain and finalize smooth operation of Gen I FCVs with on-going service, maintenance and customer support.
- Begin customer operations of production-level Gen II vehicles.
- Maintain the high quality of technical vehicle and infrastructure data reporting to NREL.
- Enlist support of corporate communications for a more expansive national outreach in addition to ongoing community and industry related events.

Lessons Learned

Deploying FCVs and placing a hydrogen fueling station is a unique experience that breaks new ground. Based on the experiences and lessons learned, the following conclusions and recommendations are made:

- Extensive real world experience provided by DOE's Demonstration and Validation Project has shown that vehicles are ready for the commercialization phase.
- Customers need public, customer-friendly fueling stations with no access agreements.
- Older, strategically located hydrogen fueling stations need to be updated with 700 bar fast-fill fueling standards, such as "SAE J2601 (A70), to enable safe, fast and effective fueling for all vehicles.
- Auto manufacturer, energy company and government agency coordination is important for optimal selection of sites.
- Continued DOE funding and political support is essential.