VII.3 Hydrogen to the Highways – Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

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- Mercedes-Benz USA LLC (MBUSA), Montvale, NJ
- DTE Energy, Detroit, MI
- NextEnergy, Detroit, MI

Start Date: December 22, 2004
Projected End Date: September 30, 2011

Fiscal Year (FY) 2011 Objectives

- Record, collect and report data from fuel cell vehicles and the hydrogen fueling operations to validate DOE targets (Table 1).
- Demonstrate the safe installation of hydrogen fueling stations and fuel cell service facilities as well as the safe operation of all fuel cell vehicles (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.

TABLE 1. 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

gge – gasoline gallon equivalent

Technical Barriers

This project addresses the following technical barriers from the Technology Validation secion (3.6.4) of the Hydrogen, Fuel Cells and Infrastructure 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 Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

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

FY 2011 Accomplishments

- Submitted over 110 compact disks (CDs) of data to demonstrate that fuel cell vehicles are on track to be commercially viable by 2015.
- Successfully completed seven years of external operations of Gen I vehicles (five years past the original target date).
- Maintained smooth operations of the DTE hydrogen station.
- Transitioned FCV activities from research and development (R&D) to mainstream commercial efforts.

- Began customer operations of production-level Gen II vehicles.
- Participated in various working groups to ensure continuous progress with regards to codes and standards.
- Worked with California Energy Commission (CEC), Air Resources Board (ARB) and other original equipment manufacturers (OEMs) to prepare fueling infrastructure.

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/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 designed 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 various climatic regions of the United States. The Team is also providing data from Gen II vehicles under the similar operations as Gen I vehicles to compare technology maturity during project duration. All vehicles have been equipped with a data acquisition system that automatically collects statistically relevant data for submission to National Renewable Energy Laboratory (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 and Gen II FCVs

Although Gen I FCVs were designed for a 2-year operation, A-Class F-CELLs have outperformed engineering expectations as the vehicles have been in full operation for over seven consecutive years. Since the inception of this demonstration project, the Mercedes Team submitted over 110 CDs of Gen I Raw Data to NREL and demonstrated that A-Class F-CELLs exceed the 2,000-hour stack durability target. Through the course of 2010, the Mercedes Team gradually transitioned the vehicle activities from Gen I A-Class to Gen II B-Class FCVs.

The engineering team performed extensive vehicle durability and performance test prior to launching the Gen II B-Class FCVs. First, Gen II vehicles were tested in temperatures ranging from -30°C (Sweden) to 50°C (Death Valley). Furthermore, engineers validated the 250-mile range and cold-start capability down to -17°C while reaching 50% of maximum power within 30 seconds (see Figure 1). Initial test results show Gen II fuel cell stack will most likely meet the 2015 DOE target of 5,000 hours durability.

Prior to deploying Gen II vehicles into customer hands, the Mercedes Team transitioned FCV activities from R&D to mainstream commercial activities. B-Class F-CELL vehicles were incorporated into Mercedes' standard business processes within departments such as warranty, customer assistance, parts and distribution as well as roadside assistance and sales (see Figure 2). Unfortunately, due to limitation of fueling infrastructure, the Mercedes Team had to hand-select Gen II FCV customers to ensure that these individuals were in close proximity to the few hydrogen fueling stations functioning in Southern California. Once the customers were chosen, the customer acquisition process became the responsibility of the dealership. Customers were then required to undergo the same documentation review and qualification processes as typically expected.

FIGURE 1. Cold Weather Testing of Gen II Vehicles

FIGURE 2. Transitioning FCV Efforts from R&D to Commercial Activities

FIGURE 3. Deployment of Gen II Vehicles to External Customer (Vance van Petten)

The first Gen II FCVs were delivered to external customers in December of 2010 (see Figure 3). Customers have fuelled and driven B-Class F-CELL vehicles in a variety of regions providing a complete range of climate and traffic conditions from congested city driving to open road highways to rural roads. All Gen II vehicles have been equipped with data acquisition and reporting capability, allowing the Mercedes Team to generate substantial vehicle raw data for submission to NREL.

World Drive

Setting out from Stuttgart in Germany, three B-Class F-CELLs have undertaken a 125-day circumnavigation of the world (see Figure 4). Traveling across four continents and through 14 countries, the three vehicles have confirmed technical maturity of fuel cell technology, as well as the suitability for everyday use of the vehicles. On February 25th, the F-CELL World Drive embarked on the second leg of its tour when three B-Class F-CELL set out from Fort Lauderdale on the East Coast of the United States across eight cities including New Orleans, Miami, San Antonio, Phoenix, Los Angeles, Sacramento, Salem and Seattle. Vehicle raw data generated from the 19,000-mile World Drive has been collected and will be submitted to NREL for analysis.

FIGURE 4. World Drive Tour in San Francisco, California

Codes and Standards

Much progress was made with respect to codes and standards. First of all, a decision was reached with respects to the 70 MPa fueling connector geometry. This subject was reason for intense discussions in working group titled International Organization for Standardization (ISO) 17268, "Gaseous Hydrogen Land Vehicle Refuelling Connection Devices", which decided to keep the nozzle and receptacle design primarily used in Europe and United States. The same design was selected for Society of Automotive Engineers (SAE) J2600, "Compressed Hydrogen Surface Vehicle Fueling Connection Devices". Consequently, the ISO and SAE teams were able to finalize and harmonize these documents.

J2719, "Information Report on the Development of Hydrogen Quality Guideline for Fuel Cell Vehicles" was recently finalized and is currently up for ballot. After the first version of J2601, "Fueling Protocols for Gaseous Hydrogen Surface Vehicles", was published in 2010 and became the foundation for many hydrogen refueling protocol discussions, the SAE interface group began working on Version 2 of J2601, which has been expanded to include bus, home and fork lift refueling.

NextEnergy

Serving as voting member and Committee Chair of National Fire Protection Association (NFPA) 2, NextEnergy continued to work on the standard intended to streamline as well as clarify the infrastructure design

and permitting process. During the course of the year, the Team released the first public version of NFPA 2 and is in the process of expanding the document for a 2014 revision cycle. Furthermore, NextEnergy hosted an annual 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. NextEnergy continued to host DOE's Permitting Guide for Hydrogen Technologies and Specifications on its website at www.nextenergy.org.

Outreach and Media

Mercedes-Benz FCVs were on display at several car shows over the course of 2010. The year began with a presence at the Detroit Auto Show where the B-Class F-CELL was part of a green vehicle ride-n-drive. At the Washington Auto Show in Washington, D.C. in February, the F-CELL was incorporated into the MBUSA exhibit. The vehicle was then displayed at the show in New York after being introduced on a nationally broadcast morning talk show. Over the summer of 2010, the F-CELL was also displayed at the Aspen Ideas Festival in Colorado and the U.S. Tennis Open in New York, both of which MBUSA officially sponsors.

At the Detroit Auto Show in January of 2011, one FCV was wrapped with F-CELL World Drive decals and displayed during the press conference when the world tour was announced. The Fuel Cell and Hydrogen Energy Association Conference and Exposition took place in Washington, D.C. in February. Mercedes-Benz was present with a vehicle display which emphasized the lease program in California and the World Drive which had just commenced in Europe.

Fueling Stations and Co-Production Facilities

DTE Hydrogen Technology Park

Since the electrolyzer and dispenser were replaced, the site equipment has run its best for cold weather operations. The electrolyzer ran without any problems and system testing was conducted for all safety circuits. DTE Energy has had a number of tours of the DTE Energy Hydrogen Technology Park both from industry, educational institutions and the general public. Under the auspices of the Department of International Visitor Leadership Program, visitors from Romania, Kosovo and Estonia toured the Technology Park to understand how non-governmental sectors foster innovative and efficient public-private relationship as well as promote community development and corporate citizenship (see Figure 5).

FIGURE 5. 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 OEMs, government officials and energy partners to build a hydrogen fueling infrastructure:

- Supported ARB/CEC by recommending station specifications, site locations and supplier qualification guidelines.
- Worked with the California Fuel Cell Partnership to develop an action plan detailing strategy for deploying hydrogen fueling stations and FCVs.
- Collaborated with other OEMs to determine and coordinate locations of future fueling stations.

The number of stations is increasing. However, the number of present operational and public stations is the limiting factor for customer selection. The Mercedes Team strongly supports a joint approach of automotive OEMs, energy companies and government agencies such as DOE to overcome the fueling limitation by 2015, the year anticipated for the beginning of commercialization.

Conclusions and Future Directions

Conclusions

- Maintained smooth operations of the DTE station.
- Worked with CEC/ARB and other OEMs to prepare fueling infrastructure.
- Finalized Gen I operations and deployed Gen II F-CELLs to external customers.
- Transitioned FCV activities from R&D to mainstream commercial efforts.

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

Future Work

- Maintain and finalize smooth operation of Gen II FCVs.
- Submit final report.
- Continue the development and transition to commercialization of hydrogen FCVs.

FY 2011 Presentations

1. Becker, S. "Technology Demonstration with F-CELL Vehicles," Zero Emission Conference 2010, November 2010.

2. Becker, S. "Emission-Free Mobility with Fuel Cell Vehicles," HyNor Conference 2010, November 2010.

3. Froeschle, P. "Lessons Learned in German FC/Hydrogen Initiative," New York State Fuel Cell and Hydrogen Infrastructure Planning Summit NYSERDA, December 2010.

4. Froeschle, P. "Current FCV Program Plans for Commercialization," New York State Fuel Cell and Hydrogen Infrastructure Planning Summit NYSERDA, December 2010.

5. Froeschle, P. "H2 Mobility – An Initiative to Build a Hydrogen Infrastructure," Fuel Cell & Hydrogen Energy Conference and Expo, February 2011.

6. Froeschle, P., Wolfsteiner, M. "Daimler's Global Fuel Cell Vehicle Demonstration Program with the Mercedes-Benz B-Class F-CELL," Fuel Cell & Hydrogen Energy Conference and Expo, February 2011.

7. Grasman, R. "Emission-Free Mobility with Fuel Cell and Battery Electric Vehicles," North European Renewable Energy Convention, September 2010.

8. Grasman, R. "Our Roadmap to Emission-Free Mobility," North European Renewable Energy Convention, September 2010.

9. Grasman, R. "Daimler Fuel Cell & Electric Drive Strategy," H2Expo, June 2011.

10. Kaehler, B. "H2-Mobility – An Initiative to Build a Hydrogen Infrastructure," 8th Symposium Hybrid- And Electric-Vehicles, February 2011.

11. Mohrdieck, C. "Mobility with Hydrogen and Fuel Cells – One Step Closer to Commercialization" Fuel Cell & Hydrogen Energy Conference and Expo, February 2011.

12. Mohrdieck, C., Hinsenkamp, G. "Requirements for Components of an Advanced Fuel Cell Power train System for Mobile Applications," Fuel Cell & Hydrogen Energy Conference and Expo, February 2011.

13. Wind, J. "The Electrification of the Automobile – Fuel Cell Electric Vehicles and Battery Electric Vehicles", F-Cell Symposium, September 2010.

14. Wolfsteiner, M. "On the Road to Sustainable and Emission-Free Mobility," First Bavarian Electro mobility Days, November 2010.