

VIII.5 Hydrogen Vehicle and Infrastructure Demonstration and Validation

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Phase 1 Partners:

- Shell Hydrogen, LLC, Houston, TX
- U.S. Army, Ft. Belvoir, VA
- Quantum Technologies, Inc., Irvine, CA
- Viewpoint Systems Inc., Rochester, NY
- NextEnergy, Detroit, MI
- U.S. Environmental Protection Agency, Washington, D.C.
- District of Columbia Department of Transportation, Washington, D.C.
- Virginia Department of Environmental Quality, Richmond, VA
- U.S. Postal Service, Washington, D.C. and Irvine, CA

Phase 2 Partners:

- Project Driveway drivers composed of media, policy makers, general public, businesses, and government

Project Start Date: October 1, 2004

Project End Date: September 30, 2009

Objectives

General Motors (GM) and energy partner Shell Hydrogen, LLC, are deploying a system of hydrogen fuel cell electric vehicles (FCEVs) integrated with a hydrogen fueling infrastructure to operate under real world conditions:

- Demonstrate progressive generations of fuel cell system technology.
- Demonstrate multiple approaches to hydrogen generation and delivery for vehicle fueling.
- Collect and report operating data.

Technical Barriers

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

- (A) Lack of Fuel Cell Electric Vehicle Performance and Durability Data
- (C) Lack of Hydrogen Fueling Infrastructure Performance and Availability Data
- (D) Maintenance and Training Facilities
- (E) Codes and Standards

Contribution to Achievement of DOE Technology Validation Milestones

This project contributes to the achievement of the DOE Technology Validation milestones listed below from the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 2:** Demonstrate FCEVs that achieve 50% higher fuel economy than gasoline vehicles. (3Q, 2005)
- **Milestone 4:** Operate fuel cell vehicle fleets to determine if 1,000-hour fuel cell durability, using fuel cell degradation data, was achieved by industry. (4Q, 2006)
- **Milestone 22:** Five stations and two maintenance facilities constructed with advanced sensor systems and operating procedures. (4Q, 2006)

Accomplishments

GM has accomplished the following project milestones:

- Deployed 50 vehicles demonstrating two generations of GM's proprietary fuel cell technology in various terrains, driving conditions, and climates including cold weather:
 - FCEV fleet included eight Phase 1 HydroGen3 FCEVs and 42 Phase 2 Chevrolet Equinox FCEVs (see Figure 1) employing GM's proprietary 3rd and 4th generation fuel cell (FC) technology.
- Constructed and utilized first class maintenance and training facilities located in Ardsley, NY, Ft. Belvoir, VA and Burbank, CA with a satellite hub located in Lake Forest, CA:



FIGURE 1. Chevrolet Equinox Fuel Cell Electric Vehicles

- Over 1,500 first responders received safety training through these facilities.
- Drivers receive first class customer service through the use of driver relationship managers and the On-Star call center providing 24-hour, 365-day support.
- Established retail and retail-like hydrogen stations for public fueling:
 - Seven fueling stations in operation spreading across the eastern and western regions with two additional stations to open in the 3rd quarter of 2009.
 - Different types of hydrogen generation/delivery options are demonstrated such as delivered compressed gas and on-site electrolysis.
 - Two stations are infrared capable and able to fast-fill 3+ vehicles back-to-back.
 - H₂ quality testing has been completed in both eastern and western regions, among the first stations in the U.S. to be tested at 700 bar.
- Opened nation's first retail hydrogen fueling station located in Washington, D.C; station has been in use since November 2004 and was the first retail station in the U.S. equipped to fuel with hydrogen dispensed at 700 bar.
- Partnered in opening the first retail hydrogen fueling station in CA; located in Los Angeles it features on-site generation through a canopy-mounted electrolyzer.
- Commissioned two new hydrogen stations in the past year:
 - GM and Clean Energy station in Los Angeles, CA near the Los Angeles International Airport (LAX) opened in record time, in less than five months (see Figure 2).
 - GM, Shell Hydrogen and the Port Authority of New York-New Jersey collaborated to open a fueling station at the John F. Kennedy (JFK) airport in New York (see Figure 3).
- Gathered comprehensive feedback on all elements of customer experience and vehicle performance to guide future FCEV and infrastructure development.
- Collected vehicle and station data according to the National Renewable Energy Laboratory (NREL) data reporting templates using automated logbook



FIGURE 2. Clean Energy Station near LAX in Los Angeles, CA



FIGURE 3. Shell Hydrogen Station Located at JFK Airport

entry and automated wireless data transfer from vehicles to a data server:

- Transitioned seamlessly from Phase 1 to Phase 2 in data collection and vehicle testing overcoming the challenges of a new vehicle platform, new generation of FC technology and the increase from eight to 42 vehicles on the road.
- Conducted and verified extensive cold weather performance testing; additionally, vehicles were deployed in North East U.S. this winter and performed as customers expected (see Figure 4).



Introduction

As a part of this project, GM has deployed 50 FCEVs demonstrating two generations of proprietary FC technology over the past 5 years. Today, GM has retired the eight commercially developed FCEVs from Phase 1, according to plan. The 42 Phase 2 vehicles are deployed in the New York City metropolitan, Washington, D.C., and Los Angeles, CA areas. Four maintenance and training hubs are used to support these deployments.



FIGURE 4. Chevrolet Equinox FCEV Completing Cold Weather Testing

The vehicles are accumulating miles and generating data that is submitted according to the NREL data reporting templates.

Our partner, Shell Hydrogen, has opened hydrogen fueling stations which are available for all original equipment manufacturer FCEVs to use. Two additional stations are scheduled to open later this year, one in each region. Also, GM can fuel at GM maintenance and training sites and at the Clean Energy station in CA. The stations employ various forms of hydrogen generation and delivery options including delivered compressed gas and the world's first canopy-mounted electrolyzer. Data from retail station operation is recorded and submitted according to the NREL data reporting templates.

Approach

GM is currently demonstrating FCEVs through the deployment and testing of 42 FCEVs in various terrains, driving conditions, and climates including cold weather. The project approach is to establish and install retail hydrogen stations for public fueling on the East and West Coasts, as well as explore hydrogen generation/delivery options such as electrolysis. Service operations support these FCEVs with personnel trained in maintenance, fueling, technical support and safety. Project Driveway drivers can expect an exciting and confident driving experience through the utilization of locally-based GM Driver Relationship Managers and OnStar service.

Report data required under the project is generated through on-road and dynamometer test data captured from the vehicles, as well as from the hydrogen infrastructure production and fueling operation data. In addition to these efforts, NextEnergy will develop codes and standards permitting templates and a database of permitting experiences.

Results

Two generations of GM's proprietary FC technology have been demonstrated in diverse climates, driving conditions, and terrains with vehicle deployments on the east and west coasts. Data was collected from the

deployments during both phases and the transition from Phase 1 vehicles to Phase 2 vehicles was seamless in data collection and vehicle testing.

All Phase 2 vehicles are a part of the Chevrolet Project Driveway program which was designed to provide GM with comprehensive feedback on all elements of the customer experience and vehicle performance. All of our customers whether business-to-business, government, or general public have high praise for the first class customer-focused service provided in their vehicle experience.

Maintenance and training are ongoing at our four hydrogen-ready training and service facilities. Seven fueling sites in the New York City metropolitan and Southern California area have been constructed to support the fueling of the vehicles, with two additional sites to open later this year. The stations demonstrate different types of hydrogen generation/delivery options such as delivered compressed gas and on-site electrolysis, with all but one dispensing at 700 bar.

Key vehicle and infrastructure data generated and reported that support the milestones are stack durability, fuel economy and vehicle range, FC system efficiency, maintenance and safety, and fueling rate. Dynamometer testing, including end-of-life testing, of Phase 1 vehicles has been conducted at GM's Milford Proving Ground according to the DOE schedule. Phase 2 vehicles have gone through the beginning of life testing which included cold weather tests. On road data collection has been automated wherever possible.

The hydrogen orientation program for emergency first responders has now been delivered in cities where GM's DOE vehicles operate totaling over 1,500 people trained. NextEnergy Center is now chairing task groups made up of a consortium of industry experts on hydrogen to provide feedback on the National Fire Protection Agency hydrogen codes. NextEnergy Center has also successfully transferred its hydrogen permitting database tools to its new Web site.

Future Directions

- Provide ongoing support for the operation of 42 Phase 2 DOE Chevrolet Equinox FCEVs.
- Continue new driver training on FCEVs, hydrogen safety, and hydrogen fueling.
- Inaugurate usage of additional hydrogen fueling stations in the New York City metropolitan area and the West Los Angeles area, both capable of dispensing at 700 bar.
- Participate in the NextEnergy annual conference.
- Continue to collect, analyze, and report data from project vehicles and fueling locations and meet all project deliverables.

The commissioning of a facility that dispenses hydrogen is a unique experience and breaks new ground. Based on our experience and lessons learned to date, we are making the following infrastructure recommendations:

- Retail-Like Fueling Stations
 - Geographically targeted regions where automakers want to put vehicles.
 - 700 bar fast-fill fueling with infrared communication link.
 - Compelling station designs (customer and technology perspectives).
 - Robust hydrogen capacity and throughput – designed for growth.
 - Operational with (or before) vehicles – market enabler.
- Access to all Stations
 - All automotive companies and their customers have access.
 - Standard fueling protocol – safe/fast/effective fueling of all vehicles.
 - Address liability exposure – straight-forward access agreements with consistent principles, or eliminate access agreements all together.
- Expedient Station Approval and Permitting Process
 - State-wide consistency and local adherence.
 - Community support.
- Funding Support and Incentives
 - Stations, station technology, and capacity upgrades.
 - Liability coverage/solution (funded liability pool, liability cap).
 - Assurance stations will be there on time – supply base.