

## VI.A.4 Hydrogen Vehicle and Infrastructure Demonstration and Validation

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### 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.
- Commonwealth of Virginia Department of Environmental Quality, Richmond, VA
- U.S. Postal Service, Washington, D.C. and Irvine, CA

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 vehicles (FCVs) integrated with a hydrogen refueling 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 refueling.
- Collect and report operating data.

### Technical Barriers

This project addresses the following technical barriers from the Technology Validation section (3.5.4) 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
- (C) Lack of Hydrogen Refueling Infrastructure Performance and Availability Data
- (D) Maintenance and Training Facilities
- (E) Codes and Standards

### 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 2:** Demonstrate FCVs 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

General Motors has accomplished the following project milestones:

- Eight Phase 1 HydroGen3 FCVs have been deployed: six in the Washington, D.C. area, two in Southern California:
  - Maintenance sites continue to be operational.
  - Support personnel continue to receive technical and safety training as required.
- Full operation for over two years at the nation's first retail liquid and compressed hydrogen refueling station at Benning Road, Washington, D.C. with functional Visitor Center (see Figure 1).
- All compressed hydrogen FCVs of the current fleet are equipped with 700 bar compressed hydrogen storage systems and are the first fuel cell vehicles to receive certification for using 700 bar.
- Several hundred first responders have received safety training.
- Partnering with the U.S. Environmental Protection Agency, District of Columbia Department of



**FIGURE 1.** Shell Hydrogen Benning Road Hydrogen Refueling Station

Transportation, Commonwealth of Virginia Department of Environmental Quality, and U.S. Postal Service for fleet operation of vehicles:

- U.S. Postal Service displayed GM’s HydroGen3 FCV for a White House event in March this year showcasing the U.S. Postal Service’s commitment to alternative fuel technologies (see Figure 2).
- Site selection underway for New York City (NYC) metropolitan area and Southern California retail refueling stations.
- Site selection, permitting, and construction modifications underway for NYC metropolitan area and Southern California maintenance and training facilities.
- Vehicles collect data according to the National Renewable Energy Laboratory (NREL) Data Reporting Templates by operating in driving demonstrations and refueling at Shell Benning Road and Ft. Belvoir facilities.
- On-road data collection:
  - Logbook data entry automated where possible.
  - Implemented automated wireless data transfer from vehicles to a data server via the world wide web.
- Chassis dynamometer testing:
  - Data accuracy and efficiency enhanced by installation of precision hydrogen massflow measurement equipment and a continuous supply of hydrogen.
- NextEnergy codes and standards:
  - Training presentation materials.
  - Completed final design changes to permitting experience and permitting authority databases based on stakeholder feedback.



**FIGURE 2.** Visit by President Bush with U.S. Postal Service Alternative Fuel Fleet

- Databases moved from build phase to data population phase.
- Held first codes and standards annual conference.



## Introduction

This project has been underway for approximately two and one half years and has made progress in support of the long term goals of the DOE’s Technology Validation Program. GM has deployed eight of its commercially developed FCVs according to plan and is maintaining them with two maintenance and training centers. The vehicles are accumulating miles and generating data that are submitted according to the NREL Data Reporting Templates.

Our partner Shell Hydrogen is operating a retail hydrogen refueling station that GM FCVs and other companies’ FCVs are using. In addition, GM FCVs can refuel at GM maintenance sites. Data from retail station operation, including refuelings, are recorded and submitted according to the NREL Data Reporting Templates. Hydrogen is trucked in from a central location and stored at the refueling station for dispensing.

## Approach

GM will demonstrate FCVs through deployment and testing a total of 40 FCVs in various terrains, driving conditions, and climates including cold weather. The project approach is to establish and install retail hydrogen stations for public refueling on the East and West Coasts, as well as explore hydrogen generation/delivery options such as electrolysis. Service operations will support these FCVs with personnel trained in maintenance, refueling, technical support and safety.

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

## Results

Six Opel Zafira hydrogen fuel cell minivans were deployed in the Washington, D.C. area along with two Opel Zafira compressed hydrogen fuel cell minivans in the Southern California area. GM has successfully partnered with the U.S. Environmental Protection Agency, District of Columbia Department of Transportation, Commonwealth of Virginia Department of Environmental Quality, and the U.S. Postal Service for fleet operation of these vehicles. Maintenance and training are ongoing at the U.S. Army Ft. Belvoir, VA and Quantum, Lake Forest facilities. Additional sites in the NYC metropolitan and Southern California area have been selected and construction modifications are underway.

Key vehicle and infrastructure data generated and reported that support the milestones are stack durability, fuel economy and vehicle range, fuel cell system efficiency, maintenance and safety, and refueling rate.

Dynamometer testing of the Phase 1 FCVs has been conducted at GM's Milford Proving Ground according to the DOE schedule. On-road data collection has been automated wherever possible. We have increased our accuracy and efficiency with the installation of new equipment and the continuous supply of hydrogen, respectively. Automated wireless data transfer from the FCVs to a data server via the world wide web has been implemented.

The hydrogen orientation program for emergency first responders in the State of Michigan has now been delivered over nine times since its development in January, 2006. The Emergency First Responder-Authorities Having Jurisdiction (EFR-AHJ) training will be expanded to City Building Department Officials. NextEnergy will continue the delivery of the EFR-AHJ training in 2007.

## Conclusions and Future Directions

### Future Work

- Launch Phase 2 deployment vehicles (see Figure 3).
- Continue to pursue new vehicle operators.
- Inaugurate usage of hydrogen refueling stations in NYC metropolitan area and Southern California.



FIGURE 3. Chevrolet Equinox<sup>®</sup> Fuel Cell Vehicle

- Commission maintenance and training facilities in the NYC and Los Angeles metropolitan areas.
- Codes and standards permitting experience and permitting authority databases data population to continue.
- Data collection enhancements for collecting and reporting.

The commissioning of a facility that contains hydrogen, no matter the quantity, 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 refueling stations
  - Geographically targeted regions where automakers want to put vehicles.
  - 700 bar fast-fill refueling.
  - Operational with (or before) vehicles.
- Access to key existing stations
  - Access agreements with consistent principles or gasoline-like liability terms or eliminate access agreements altogether.
- Expedient station approval and permitting process
  - State-wide consistency and local adherence.
  - Community acceptance.
- Funding support and incentives
  - Stations and upgrades.
  - Liability coverage (funded liability pool, liability cap) or full-service attendants to mitigate liability issues.
  - Station operating costs/refueling costs.
- Replicated infrastructure template

**FY 2007 Publications/Presentations**

1. U.S. Navy Naval Facilities Engineering Command, Washington, D.C. – October 2006.
2. Danish Secretary of Transport and Energy, Washington, D.C. – November 2006.
3. District of Columbia Public Schools Science Department Chairs, Washington, D.C. – November 2006.
4. Engineering Advancement Association of Japan, Washington, D.C. – December 2006.
5. NHA Annual Hydrogen Conference 2007, San Antonio, TX – March 2007.
6. National Defense University, Washington, D.C. – March 2007.
7. Alt Fuels Conference, Anaheim, CA – April 2007.
8. State of Virginia Department of Environmental Quality, Woodbridge, VA – April 2007.
9. National Science Bowl, Bethesda, MD – April 2007.
10. U.S. EPA Office of Administration and Resources Management, Washington, D.C. – May 2007.
11. DOE Hydrogen Education Initiative at Shell Hydrogen Benning Road Station for Paul Public Charter School, Washington, D.C. – May 2007.