VI.A.2 Ford & BP Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

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Projected End Date: June 2009

Objectives

- Ford:
  - Gain vehicle operational data in differing climate conditions, to direct and augment future design efforts.
  - Provide input to the industry-government efforts to define a future hydrogen economy.
- BP:
  - Develop retail compatible hydrogen refuelling systems.
  - Evaluate emerging hydrogen technologies that have the ability to meet DOE cost and performance targets.
  - Explore cost and commercial feasibility of renewable-based hydrogen generation.

Technical Barriers

This project addresses the following technical barriers identified in the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan (April 27, 2007):

(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

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).** Dynamometer testing has been completed on the Phase I Ford Focus fuel cell vehicle (FCV), and field test vehicles both have demonstrated performance that indicates that this milestone has been met, confirming 50% higher fuel economy.
- **Milestone 4: Operate fuel cell vehicle fleets to determine if 1,000 hours fuel cell durability, using fuel cell degradation data, was achieved by industry (4Q, 2006).** Durability for 1,000 hours has been demonstrated on the first engineering test vehicles in accelerated on-road durability testing. The 18-car demonstration fleet continues to accumulate hours for further confirmation of this milestone.
- **Milestone 5: Validate vehicle refueling time of 5 minutes or less for a 5 kg tank (1kg/min) (4Q, 2006).** On the Focus models, 4 kg of hydrogen are carried at 5,000 psi. Data indicates an average fill rate using the communication system meets this milestone. Non-communication 'full' fills may take more than 5 minutes.
- **Milestone 7: Validate vehicle refueling time of 5 minutes or less for a 5 kg tank (1kg/min) at 5,000 psi through the use of advanced communications technology (4Q, 2007).** Fill times of 5 minutes or less have been demonstrated for 'full' fills using vehicle-to-station communication. This milestone has been met.
- **Milestone 8: Fuel cell vehicles demonstrate the ability to achieve 250-mile range without**

impacting passenger cargo compartment (4Q, 2008). Ford has a Technology Demonstrator Vehicle (TDV) plan that provides progressive design levels demonstrating improved range in functional configurations (Table 1). This plan has demonstrated the 250 mile range in an SUV configuration with slightly reduced passenger volume, and a plug-in hybrid FCV cross-over vehicle with little passenger compartment compromise.

- **Milestone 10: Validate FCVs 2,000-hour fuel cell durability, using fuel cell degradation data (4Q, 2009).** Ford is submitting ongoing field vehicle data in support of this milestone.
- **Milestone 11: Validate cost of producing hydrogen in quantity of $3.00/gge untaxed (2Q 2008).** BP has assessed through meetings with suppliers several technologies to understand their current status and potential of meeting the $3.00 gge target untaxed by 2008. The following is a list of a few of the technologies reviewed to date; H2Gen 2000, Air Products Harvester, and Proton Energy High Pressure proton exchange membrane (PEM) system with Electrochemical Compression and GE Autothermal Reformer. Of these systems, the H2Gen 2000 and the Air Products Harvester unit can meet the $3.00/gge untaxed hydrogen production cost target using the H2A model assumptions.
- **Milestone 22: Five fueling stations and two vehicle maintenance facilities constructed using advanced sensor systems and operating procedures (YE 2008).** Service Facilities: Ford has completed two service facilities (including unique fuel cell vehicle diagnosis and tracking software/hardware) for project vehicles in Dearborn, MI and Sacramento, CA. In Florida, repair work is being performed in a nearby, cooperating Ford dealership. The existing facilities utilize state-of-the-art hydrogen sensors, and have service procedures established for hydrogen fueled vehicles, and operating procedures for personnel working in a hydrogen vehicle service facility.

  Fueling Stations: In Michigan, BP began operation of the City of Taylor (CoT) hydrogen liquid delivery station in October 2006. In Florida, construction and installation of the electrolysis hydrogen station was completed in April 2007 and all that remains for operational approval is completion of the BP internal safety audit. In California, the Sacramento Airport station permits were withdrawn due to protracted negotiations. Therefore resources were reallocated and greater emphasis was placed on permit preparation for the renewable energy station at Sacramento Municipal Utility District (SMUD). Thus far the California Environmental Quality Act (CEQA) approval process has been completed for this station (Table 2).
- **Milestone 23: Total of 10 stations constructed with advanced sensor systems and operating procedures (1Q, 2008).** BP informed both Ford and DOE that the number of stations will reduce down from 10 permanent stations to three mobile refuelers and four permanent stations.
- **Milestone 24: Validate a hydrogen cost of $3.00/gge (based on volume production) (4Q, 2009).** H2GEN and Air Products have provided data that demonstrates the ability to meet the $3.00/gge cost target using the H2A model for their perspective reformation technology. BP will not provide independent verification.

Accomplishments

Since the last annual report, the principle accomplishments in this technology demonstration are:

- Fleet mileage accumulation is approaching DOE target accumulation rates.
- Fleet hour accumulation is approaching DOE target accumulation rates.

TABLE 1. Technology Demonstration Vehicle (TDV) Plan

Vehicle Attributes	H_2 Storage Upgrade	Robustness Demonstrator	Designed Around Hydrogen Demonstrator	Flexible Series H_2 Hybrid
Fuel Cell Generation	Gen 1	Gen 2 (Stage 1)	Gen 2 (Stage 2)	APU
Number of Vehicles	1	1	5	2
Timing	2Q '07	1Q '06	4Q '06	4Q '06
Range (miles)	240	200	>300	300
Hydrogen Storage (bar)	700	350	350	350
Unassisted Cold Start	2°C	2°C	<0°C	-15°C
Assisted Cold Start	2°C	2°C	-15°C	-25°C
Fuel Efficiency (mpg)	50	50	50	40-70

TABLE 2. Infrastructure Demonstration Summary

Location	Open	Planned	Decommission
California			
Sacramento Mobile Refueler	Oct 2005		Dec 2007
SMUD		Sep 2007	Sept 2009
Florida			
Jamestown Mobile Refueler	Sept 2005		July 2007
Jamestown Stationary Site w/electrolyzer	Apr 2007		Sept 2009
Michigan			
City of Taylor Temporary Station	Oct 2005		Jan 2007
City of Taylor Stationary Site (liquid delivery)	Oct 2006		Sept 2009
Dearborn (700 bar) (liquid delivery)		1'Q 2008	Sept 2009

- Data submission of six complete data sets to the National Renewable Energy Laboratory (NREL).
- Demonstrated fueling fill times that meet project milestone target of five minutes or less.
- Fueling station deployment includes the City of Taylor and the Florida Progress Energy stations. The permitting process has begun for the SMUD station.
- New concept vehicle architecture has demonstrated the ability to improve vehicle operating characteristics and consumer focused attributes in designs developed for hydrogen-powered drivetrains.

Introduction

In order to meet the objectives and deliverables of this technology demonstration project, Ford and BP have developed an approach that permits demonstration of the current state of technology while continuing to develop and prepare demonstrations for newly emerging technologies and techniques. In this approach, Ford has deployed 18 vehicles with state-of-the-art fuel cell system designs in customer fleet applications. Detail data of the operating parameters is being collected using computerized, automated data collection and analysis techniques. At the same time, new concepts of vehicle and component design are being developed using emerging technologies to demonstrate progress against the DOE's longer term milestones and targets.

At the beginning of the vehicle demonstration, BP first deployed delivered hydrogen to permit fleet operations. With initial fleet deployment complete, BP will work with local authorities where the cars are operating, to locate, plan and certify permanent hydrogen fueling stations in each of the fleet operating areas.

Approach

The Ford vehicle demonstration approach utilizes two phases: 1) deployment of 18 customer operated vehicles in three different geographic and climatic areas (California, Florida and Michigan); and 2) Development of TDVs that incorporate advanced technology and design concepts directed at meeting future DOE targets for improved hydrogen storage and interface, durability, fuel economy, and reduced weight and cost.

BP's infrastructure approach follows in two phases: 1) test infrastructure deployment by installing H_2 delivered stations, including electronic data collection for select sites; and 2) assessing the ability to meet cost targets by installing onsite renewable H_2 electrolysis production and/or 700 bar fueling at select sites. Completed station installations include the City of Taylor and Florida Progress Energy. Future stations include renewable electrolysis at SMUD and 700 bar at Ford Dearborn.

Results

The vehicles are operating efficiently (meeting fuel consumption targets) and effectively (charted vehicle "up-time" in excess of 94%). The fleet and involved personnel have also continued to demonstrate a 100% safety performance with no incidents or near misses. Three second phase demonstrators are built and have demonstrated new concepts for packaging of the various system components for improved performance, range and noise reductions.

On the infrastructure side, results have been more difficult to attain. The City of Taylor station has presented challenges with dispenser and compressor reliability. Hence, during the first six months of operation, the station has only performed 203 fuelings for a total of 450 kgs. As the Jamestown station will be fully operational soon, this station along with CoT presents an opportunity to better understand the differences in support service for a variety of gas and equipment suppliers and a greater opportunity for further data gathering.

Conclusions and Future Directions

The project is providing important data on both vehicle performance and infrastructure development.

Three configurations of FCV vehicles, a passenger car, an SUV and a cross-over have already demonstrated useable customer designs with some compromise for passengers. Data collection will continue for the 18 customer vehicles, providing the required data to support the project milestones. Advanced vehicle designs will continue to be prepared in accordance with the TDV project approved by the DOE.

Infrastructure development has taken longer than planned, but is moving forward. Alternative production techniques and associated cost analysis will continue to be pursued with the completion of the permanent fueling stations.

FY 2007 Publications/Presentations

1. TDV2 was presented at the L.A. Auto Show in January.

2. TDV7 was presented at the Washington Auto Show and in high level automotive discussions in Washington, D.C. and a press overview including President Bush.