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## VIII.0 Technology Validation Sub-Program Overview

### Introduction

The Technology Validation sub-program has been focused on conducting learning demonstrations that emphasize co-development and integration of hydrogen infrastructure with hydrogen fuel cell-powered vehicles to permit industry to assess progress toward technology readiness. Technology Validation tests, demonstrates, and validates hydrogen fuel cell technologies and infrastructure and uses the results to provide feedback to the Program's research and development (R&D) activities.

### Goal

Validate—under real-world operating conditions—the status, relative to Program targets, of integrated hydrogen and fuel cell technologies that will be used in both the transition and early market periods for transportation, infrastructure, and electric power generation.

### Objectives

- **2014:** Validate a stationary fuel cell system that co-produces hydrogen and electricity at 40% efficiency, with 40,000-hour durability.
- **2015:** Validate fuel cell vehicles achieving 5,000-hour durability (service life of vehicle) and a 300-mile driving range between fueling.

### FY 2010 Technology Status

In 2010, the National Learning Demonstration—a government-industry cost shared project initiated in 2004 with four automobile and energy company teams—continued to provide data for evaluating the technology status with respect to fuel cell durability, driving range, and power park demonstrations. Data collected during the past five years has been analyzed. Thus far, more than 2.8 million miles have been traveled by the fuel cell vehicles in the project and 130,000 kg of hydrogen has been either produced or dispensed, with some of this hydrogen being used in vehicles not in the Learning Demonstration. Demonstrated fuel cell durability has exceeded 2,500 hours, and the vehicle driving range has exceeded the goal of 250 miles. Fuel cell system efficiency data at about 25% net power is 53–59% which is close to the DOE target of 60%.

In June 2009, the National Renewable Energy Laboratory (NREL) and Savannah River National Laboratory (SRNL) verified that Toyota's FCHV-adv fuel cell vehicle can achieve a driving range of 430 miles without refueling (Figure 1). The report and related video on range estimates for the Toyota FCHV-adv have been issued.<sup>1</sup>

### FY 2010 Accomplishments

#### National Learning Demonstration

- Learning Demonstration projects by Ford and Chevron were completed in Fiscal Year (FY) 2010, and DOE expects final reports soon.
- Generation-2 vehicles continued to be operated by customers, and data was provided to the Hydrogen Secure Data Center at NREL (Figure 2).
- Figure 3 shows all of the major key performance metrics that have been reported in the National Hydrogen Learning Demonstration.

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<sup>1</sup> K. Wipke, et al., "Evaluation of Range Estimates Report for Toyota FCHV-adv Under Open Road Driving Conditions," National Renewable Energy Laboratory and Savannah River National Laboratory, April 2009 (Report number SRNS-STI-2009-00446, prepared under SRNS CRADA number CR-04 003), [www.nrel.gov/hydrogen/pdfs/toyota\\_fchv-adv\\_range\\_verification.pdf](http://www.nrel.gov/hydrogen/pdfs/toyota_fchv-adv_range_verification.pdf); "Toyota Highlander FCHV," YouTube, [www.youtube.com/watch?v=iz0vD5E7glA](http://www.youtube.com/watch?v=iz0vD5E7glA).

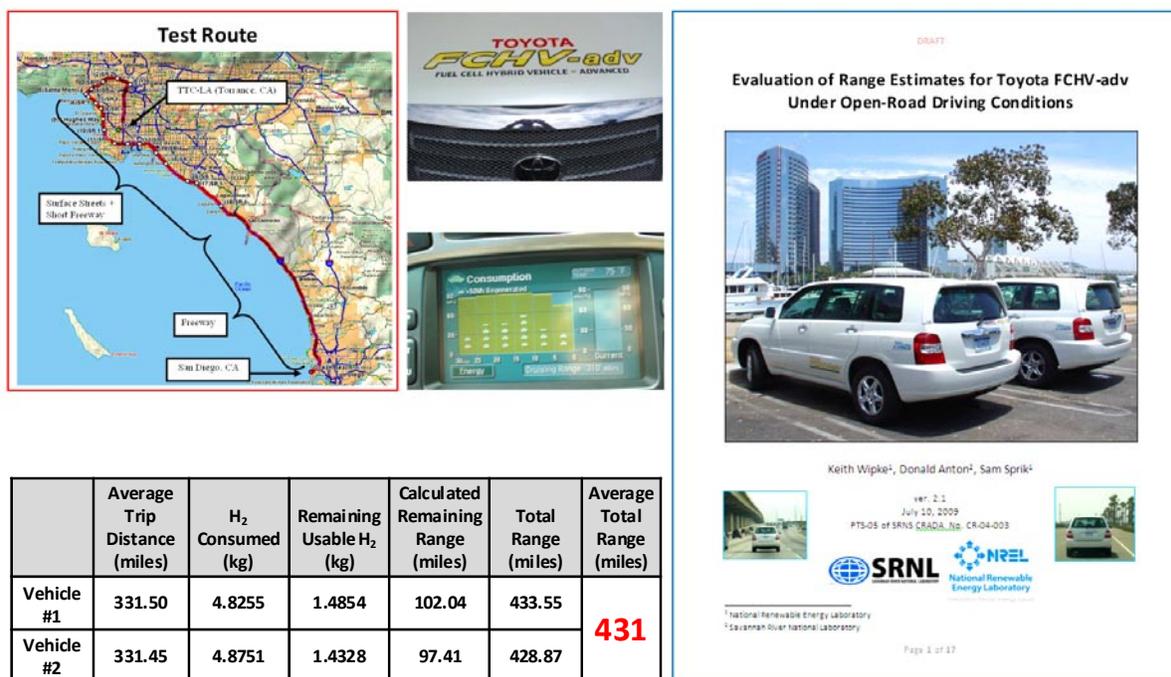


FIGURE 1. In June 2009, NREL and SRNL Verified Toyota FCVH-adv Driving Range of >400 Miles (without refueling)



FIGURE 2. Learning Demonstration Project Teams and their Two Generations of Vehicles

Vehicle Performance Metrics	Gen 1 Vehicle	Gen 2 Vehicle	2009 Target
<b>Fuel Cell Stack Durability</b>			<b>2,000 hours</b>
Max Team Projected Hours to 10% Voltage Degradation	<b>1,807 hours</b>	<b><u>2,521</u> hours</b>	
Average Fuel Cell Durability Projection	821 hours	1,062 hours	
Max Hours of Operation by a Single FC Stack to Date	2,375 hours	1,261 hours	
<b>Driving Range</b>	<b>103-190 miles</b>	<b>196-<u>254</u> miles</b>	<b>250 miles</b>
Fuel Economy (Window Sticker)	42 – 57 mi/kg	43 – 58 mi/kg	no target
Fuel Cell Efficiency at ¼ Power	51 - 58%	53 - <u>59</u> %	60%
Fuel Cell Efficiency at Full Power	30 - 54%	42 - <u>53</u> %	50%

Infrastructure Performance Metrics			2009 Target
<b>H<sub>2</sub> Cost at Station (early market)*</b>	On-site natural gas reformation <b>\$7.70 - \$10.30</b>	On-site Electrolysis <b>\$10.00 - \$12.90</b>	<b>\$3/gge</b>
Average H <sub>2</sub> Fueling Rate	0.77 kg/min		1.0 kg/min

\*Outside of this project, DOE independent panels concluded at 500 replicate stations/year:  
 Distributed natural gas reformation at 1500 kg/day: **\$2.75-\$3.50/kg** (2006)  
 Distributed electrolysis at 1500kg/day: **\$4.90-\$5.70** (2009)

FC – fuel cell; gge – gasoline gallon equivalent

**FIGURE 3.** Summary of Key Performance Metrics for the Learning Demonstration

### Fuel Cell Bus Evaluation

- Data has been collected on nine fuel cell buses at five sites. Overall, the buses have traveled more than 395,000 miles. Fuel economy results of the fuel cell buses were 39% to 141% better than diesel and compressed natural gas buses.

### Hawaii Hydrogen Power Parks

- Selection of a contractor has been made, all agreements have been executed, and the hydrogen station is due to be delivered to Hawaii in FY 2010.
- The selected system is from PowerTech which produces 12 kg of hydrogen per day and allows rapid-fill to 350 bar with flexibility to expand output.
- At the Volcanoes National Park site, hydrogen is to be produced through electrolysis powered by renewable electricity from Hawaii Electric Light Company.
- Specifications for the shuttle buses were developed by the Hawaii Volcanoes National Park and the Hawaii Center for Advanced Transportation Technologies.
- The PowerTech fueling station will be deployed at the Marine Corps base in Hawaii to support General Motors Equinox fuel cell vehicles until vehicles at Volcanoes National Park are ready for deployment.

### Energy Station at Fountain Valley<sup>2</sup>

- Air Products and FuelCell Energy shipped the fuel cell system to Fountain Valley, California, and completed the installation at the Orange County Sanitation District. Initial operation will use natural gas, in order to obtain baseline information to compare with the system's operation prior to shipment.

<sup>2</sup>This station is based on a technology that co-produces power, heat, and hydrogen. This type of system is referred to as CHHP (Combined Heat, Power, and Hydrogen or Tri-generation). As shown in Figure 4, the station uses a high-temperature fuel cell to co-generate electricity, heat, and hydrogen. The fuel cell can use a diversity of hydrogen-rich fuels, including digester gas, natural gas, landfill gas, and syngas. This technology is expected to provide a source of cost-competitive, renewable hydrogen.

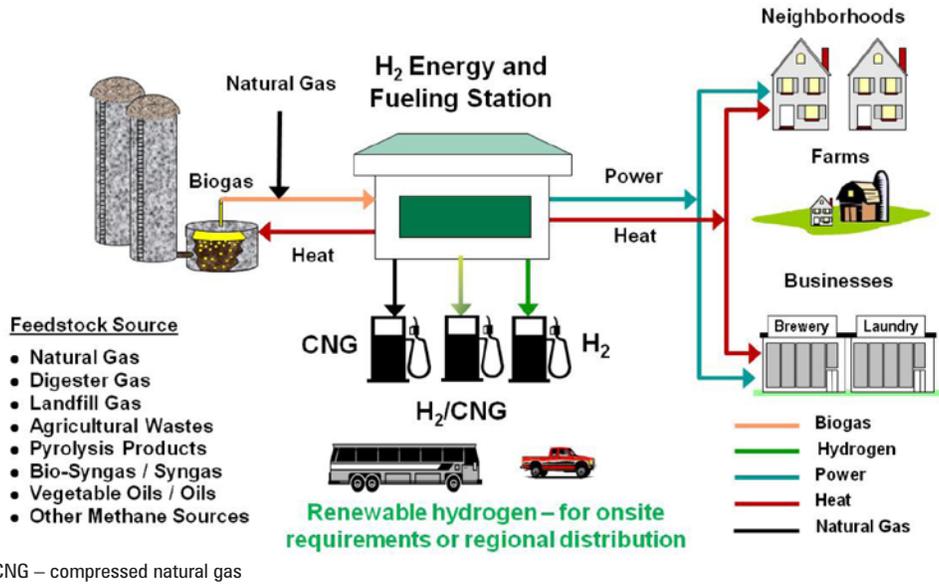
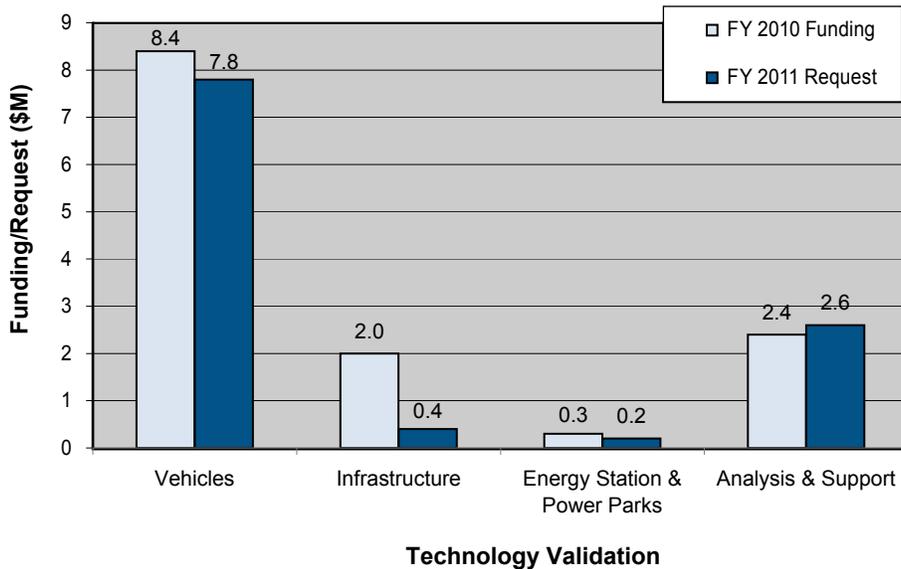


FIGURE 4. Concept for the Energy Station at Fountain Valley, California

### Budget

The funding portfolio for Technology Validation addresses the need to validate integrated hydrogen and fuel cell technologies for transportation, infrastructure, and electric power generation in a systems context, under real-world operating conditions. In FY 2010, \$13 million in funding was appropriated for the Technology Validation sub-program. The President’s FY 2011 request includes \$11 million for Technology Validation activities.



## FY 2011 Plans

In FY 2011 the final two National Learning Demonstration projects (General Motors and Mercedes-Benz North America) will conclude and final reports will be prepared.

The Program's validation activities also encompass fuel cell buses. The Technology Validation sub-program collaborates with the Department of Transportation to validate fuel cell and hydrogen technologies in transit bus demonstrations conducted by the Federal Transit Administration, and to harmonize data collection efforts with other fuel cell buses demonstrations worldwide.

In FY 2011, the power park at Volcanoes National Park will begin operation, supplying electricity to the visitors' center and hydrogen fuel to the plug-in hybrid fuel cell shuttle buses.

The Hydrogen Energy Station at Fountain Valley will be fully operational in FY 2011 and data will be collected on electric power and heat generation, hydrogen production, and vehicle refueling.

Within its Market Transformation activities, the Program has collaborated with the Department of Defense (DOD) Defense Logistics Agency (DLA) on the demonstration of fuel cell forklifts. As the main provider of fuel and supplies for the DOD as well as several civilian agencies, DLA supports a vast infrastructure of distribution centers across both the United States and abroad. By introducing fuel cell forklifts into their distribution centers, DLA capitalizes on an excellent opportunity for testing fuel cells under real world conditions and providing feedback to manufacturers. As part of this effort, NREL will collect and analyze the operation and performance data of the forklifts.

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