VII.0 Technology Validation Sub-Program Overview

INTRODUCTION

The Technology Validation sub-program demonstrates, tests, and validates hydrogen and fuel cell technologies and uses the results to provide feedback to the Fuel Cell Technologies Office's research and development (R&D) activities.

Continuing efforts include the real-world evaluation of fuel cell bus technologies at various transit authorities and monitoring performance of fuel cells in stationary power, backup power, and material handling equipment (MHE) applications. New data collection projects awarded include light-duty fuel cell electric vehicles (FCEVs), hydrogen stations, hybrid electric medium-duty trucks, rooftop backup power, and advanced hydrogen refueling components.

GOAL

The goal of the Technology Validation sub-program is to validate the state of the art of fuel cell systems in transportation and stationary applications as well as hydrogen production, delivery, and storage systems and assess technology status and progress to determine when technologies should be moved to the market transformation phase.

OBJECTIVES

The objectives of the Technology Validation sub-program are to:

- Validate hydrogen FCEVs with greater than 300-mile range and 5,000 hours fuel cell durability by 2019.
- Validate a hydrogen fueling station capable of producing and dispensing 200 kg H_2/day (at 5 kg/3 min; 700 bar) to cars and/or buses by 2019.
- Validate commercial stationary fuel cells against 2015 system targets (50,000 h, 45% electrical efficiency) by 2017.
- Validate durability of auxiliary power units against 2015 fuel cell system target (15,000 h, 35% electrical efficiency) by 2017.
- Validate large-scale systems for grid energy storage that integrate renewable hydrogen generation and storage with fuel cell power generation—operating for more than 10,000 hours, with a round-trip efficiency of 40% by 2020.

FISCAL YEAR (FY) 2014 TECHNOLOGY STATUS AND ACCOMPLISHMENTS

Fuel Cell Bus Evaluation

During FY 2014, data from four fuel cell electric bus (FCEB) demonstrations at three transit agencies were collected and analyzed; AC Transit (Oakland, California), SunLine (Thousand Palms, California), and BC Transit (Whistler, Canada). The objective of this effort is to determine the status of fuel cell systems for buses and to aid other fleets with the implementation of next generation FCEBs. Fuel cell buses continue to show improved fuel economy (ranging from 1.8 to 2.4 times higher) compared to baseline (diesel and compressed natural gas) buses in similar service. Fuel economy for the FCEBs ranged from 5.8 miles/diesel gallon equivalent (DGE), up to 7.3 miles/DGE (for an average of 6.8 miles/DGE), approaching the Federal Transit Administration's performance target for FCEB fuel economy of 8 miles/DGE. The top three fuel cell powerplants accumulated operating hours reported by the National Renewable Energy Laboratory (NREL) for these buses were 16,419, 11,908, and 9,903. A measure of reliability—the miles between road calls—was found to be 48% higher than first generation buses. FCEB availability demonstrated a 20% improvement, increasing from 57% to 69%. The highest percentage of road calls realized was not associated with the fuel cell system itself. The majority of the road calls were due to bus-related general maintenance, batteries, and hybrid propulsion systems, while fuel cell-related issues made up approximately 2% to 17% of the road calls. (NREL)

Hydrogen Component Validation

The main objectives of this project include the independent validation and systems integration of commercial and advanced prototype hydrogen production, compression, dispensing, and fuel cell technologies. In FY 2014, the project focused on performing highly accelerated life testing of diaphragm hydrogen compressors, which aims to

reproduce component failures and correlates these failures to real-world usage. The project team has partnered with compressor manufacturers to instrument, monitor, and analyze compressor performance in a relevant accelerated-testing environment. The team will also be identifying failure modes and working with manufacturers to improve reliability of future designs while collaborating with national laboratories to improve diaphragm compressor modeling. Compressor performance (power and pressure data) has been analyzed and mapped. (NREL and Pacific Northwest National Laboratory)

Hydrogen Station Analysis

The objective of this project is to collect data from state-of-the-art hydrogen fueling facilities, such as those operated by the California Air Resources Board, Proton OnSite, and the Gas Technology Institute, providing valuable feedback on data related to hydrogen infrastructure. (NREL)

- California Air Resources Board's Newport Beach, California station features onsite generation of 100 kg H_2/day through a small-scale natural gas steam methane reformer, demonstrating the footprint and equipment arrangement of such a retail facility. Evaluation results will be used to make recommendations on how to optimize discrete station components. The station is operational and additional data collection hardware is installed and calibrated. A full data set is expected by January 2015.
- Proton OnSite's fully containerized station deployments (SunHydro #1 located in Wallingford, Connecticut and SunHydro #2 located in Braintree, Massachusetts) demonstrate advanced technologies, including (1) higher-pressure (57 bar) hydrogen generation with electrochemical compression, (2) higher-efficiency generation with lower resistance electrolyte and advanced catalyst, (3) higher capacity composite storage, and (4) advanced packaging concepts for reduced footprint. This project goes beyond data collection; it aims to validate the first full-scale demonstration of a high-pressure water electrolyzer. The new high-pressure electrolyzer has been built and data monitoring is underway at the SunHydro #1 station. Design is complete and construction is underway at the SunHydro #2 station.
- Gas Technology Institute has partnered with Linde to demonstrate 100 kg H_2/day refueling stations in four Northern California locations (Foster City, Cupertino, Mountain View, West Sacramento) and a Southern California location (San Juan Capistrano), where new 900-bar ionic compression technology is utilized. The West Sacramento and San Juan Capistrano stations are expected to be installed and commissioned by the third and fourth quarters of 2014, respectively.
- California State University, Los Angeles is operating a 30-60 kg H_2/day, electrolyzer-based hydrogen station powered by renewable electricity on its campus to test, collect data on, and validate hydrogen refueling architecture and individual components in a real-world operating environment. The station was commissioned in May 2014. Performance evaluation data are being provided. The project also serves educational purposes, as it provides a "living lab" environment for engineering and technology students.

Stationary Fuel Cell Evaluation

This project informs the sub-program, the public, fuel cell manufacturers, and other stakeholders about the performance of stationary fuel cell systems operating under real-world conditions while reporting on the baseline, progress, and technical challenges. Operation, maintenance, and safety data are collected and analyzed quarterly for stationary fuel cell systems. In FY 2014, installation data from California's Self Generation Incentive Program were collected for 317 fuel cell-based units (totaling 131 MW, cumulative). Natural gas was seen as the most popular fuel choice, but there was a small resurgence of biomass projects in late 2013. The mean availability of the fuel cell systems was 93%, with about 35% of systems having availability over 95%. The mean electrical efficiency of the fuel cells was 27%, with less than 3% of the systems analyzed with over 35% electrical efficiency (based on higher heating value). Average installed cost was found to be $10,200/kW and $6,700/kW with incentives. (NREL)

Early Markets Analysis

Early market application of fuel cell technologies includes validating MHE and backup power fuel cell performance through analysis and reporting of real-world operation and value proposition metrics.

By the fourth quarter of 2013, 852 backup power units were operating as part of the Technology Validation sub-program. These units were found to be operating with average availability of about 99.5% in 23 states. Reasons for unsuccessful starts include an e-stop signal, no fuel, and other system failures. A backup power cost of ownership

analysis was also conducted. When the fuel cell backup power units were operated for 72 hours, the cost of ownership of the fuel cell system, without incentives, was found to be approximately 1.2 times higher than that of a diesel generator and more than five times lower than that of a battery system. In the same runtime scenario, but when incentives were considered, the cost of ownership of the fuel cell system was found to be approximately equal to that of the diesel generator and more than six times lower than that of a battery system.

By the fourth quarter of FY 2013, 490 MHE fuel cell units were operating as part of the Technology Validation sub-program, filling up on average in 2.3 minutes, and operating an average of 4.4 hours between fills. Among components related to the infrastructure, hydrogen compressors were consistently found to be a leading category for monthly maintenance hours. Control electronics is not as consistent but was also found to be a leading maintenance category. (NREL)

Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST)

This project is a new effort with a goal of ensuring FCEV customers have a positive fueling experience relative to conventional gasoline/diesel stations as vehicles are rolled out in the near term and transition to advanced fueling technology beyond 2017. The focus of this project is on station components and systems using core laboratory capabilities and leveraging resources to maximize impact. H2FIRST coordinates with industry, academic, and government partners, and also with H2USA. Five project teams have been organized: Station Performance Testing, Dispenser/Components, Reference Station Design, Hydrogen Contamination Detector, and Technical Assistance. A reference station matrix is also being developed for targets and metrics. This project is coordinated between the Technology Validation; Safety, Codes and Standards; and Hydrogen Delivery sub-programs. (NREL and Sandia National Laboratories, SNL)

Fuel Cell Electric Vehicle Analysis

Six major auto manufacturers (General Motors, Honda, Hyundai, Mercedes-Benz, Nissan, and Toyota) were awarded $5.5M to demonstrate advanced light-duty FCEVs, and data will be collected from up to 90 vehicles. The first composite data product will be published to NREL's website in December 2014.

Fuel Cell Hybrid Electric Medium-Duty Trucks

Two new projects were selected to demonstrate fuel cell hybrid electric medium-duty trucks.

FedEx Express partnered with Smith Electric Vehicles for the deployment and demonstration of an 80-kWh eTruck outfitted with a 10-kW fuel cell, extending the truck's range from 56 miles to 150 miles. The vehicles will be deployed at the FedEx Memphis, Tennessee headquarters and locations throughout the Los Angeles, California metro area. FedEx will make use of already existing hydrogen refueling infrastructure; a station currently installed at the Memphis site as well as several retail hydrogen refueling stations around the Los Angeles area. FedEx Express uses approximately 40,000 vehicles in its fleet, which could potentially be replaced with fuel cell hybrid vehicles. With fuel cells, the vehicles could save 196 million gallons diesel fuel and associated emissions per year. (FedEx Express and Smith Electric Vehicles)

The Center for Transportation and the Environment partnered with the University of Texas Center for Electromechanics, Electric Vehicles International, Hydrogenics USA, Valence Technology, and the United Parcel Service of America, Inc. (UPS) to develop, validate, and deploy 17 fuel cell hybrid battery electric walk-in delivery vans for parcel delivery service, which will be able to achieve an extended range of 150 miles. In the initial phase, one demonstration vehicle will be deployed for six months at a UPS facility in California for real-world validation. In the second phase, UPS will operate the additional 16 vehicles for over three years at two or more distribution centers throughout the state of California, making use of the already existing hydrogen fueling station infrastructure. Fuel cell hybrid vehicles could potentially take the place of ~46,000 diesel walk-in vans in UPS' fleet alone. With fuel cells the vehicles could save 120 million gallons of diesel fuel and associated emissions per year. (Center for Transportation and the Environment, University of Texas, Electric Vehicles International, Hydrogenics USA, Valence Technology, and UPS)

Cryogenic Pressurized Hydrogen Storage and Delivery

The use of a 100-kg H_2/hr, 875-bar high-pressure liquid hydrogen pump is being investigated and validated. Factors like fill density, electricity consumption, and refuel time will be evaluated during long-term testing. Liquid hydrogen pumps have the potential to increase hydrogen storage density (and vehicle driving range) by up to 30%,

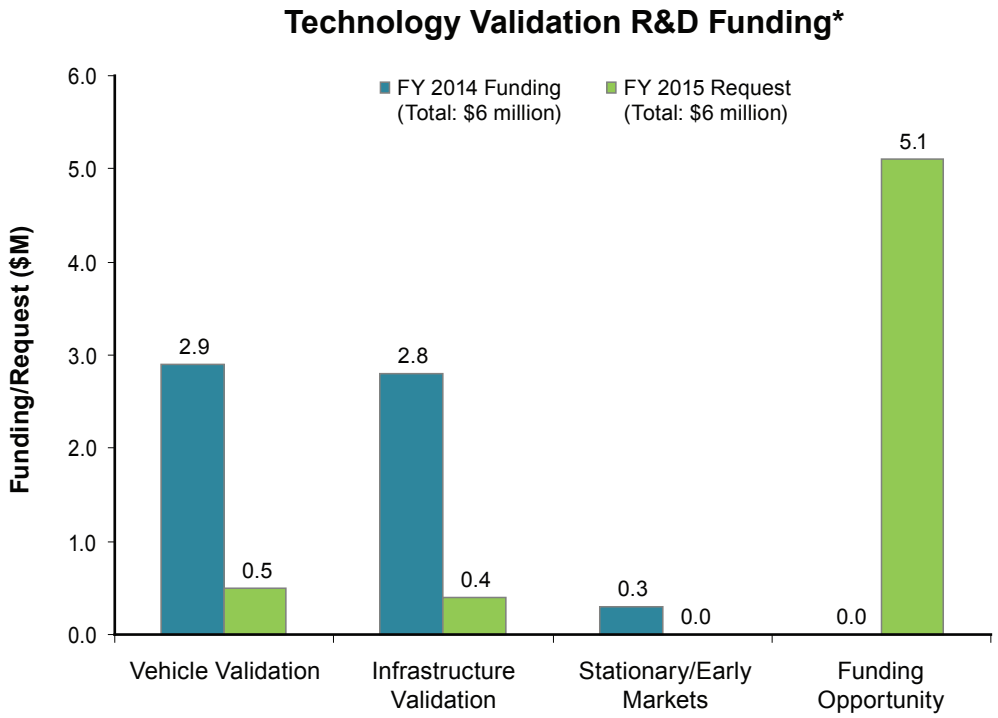
while enabling five-minute refueling and minimizing delivery costs. The high-pressure pump is installed and operational, and validation testing is underway. (Lawrence Livermore National Laboratory)

High-Pressure Hydrogen Bulk Delivery

An advanced tube trailer based on high-pressure (8,500 psi or 590 bar) composite over-wrapped pressure vessel technology is being developed and tested to validate its performance under real-world conditions. Up to 920 kg of hydrogen can be stored in a single trailer, providing up to three times the capacity increase of conventional steel tank trailers. High-pressure composite hydrogen storage can lower existing hydrogen fueling costs by 30% to 60%, and can ultimately eliminate the need for some of the onsite compression. The new composite hydrogen trailer supply also provides the advantage of significantly lowering hydrogen fueling station site preparation costs, equipment costs, operating costs, and hydrogen product costs. (Air Products and Chemicals, Inc. and Structural Composite Industries)

BUDGET

The funding portfolio for Technology Validation enables the sub-program to continue to collect and analyze data from fuel cells operating in transportation and stationary applications, as well as hydrogen production and delivery technologies. In FY 2014, $6 million in funding was appropriated for the Technology Validation sub-program, and $6 million was requested for FY 2015 (subject to congressional appropriations).



* Subject to appropriations, project go/no-go decisions and competitive selections. Exact amounts will be determined based on R&D progress in each area and the relative merit and applicability of projects competitively selected through planned funding opportunity announcements.

FY 2015 PLANS

In FY 2015, the Technology Validation sub-program will continue its detailed evaluations of fuel cell buses, FCEVs, hydrogen fueling stations, hybrid electric medium-duty trucks, rooftop back-up power, advanced hydrogen refueling components, stationary power deployments, and early market applications. Potential future funding opportunities (expected in the Fall of 2014) may emphasize hydrogen refueling station and components validation, and may also include validation of stationary and early market fuel cells, subject to appropriations.

In coordination with the Hydrogen Delivery and Safety, Codes and Standards sub-programs, a key focus in FY 2015 will be the H2FIRST project, a collaborative project between SNL and NREL coordinated with the H2USA Stations Working Group. H2FIRST includes research, development and validation tasks to support critical needs for hydrogen fueling stations, to help ensure a positive user experience relative to conventional vehicle fuels as commercialization of light-duty vehicles begins. H2FIRST project tasks include Reference Station Design, Hydrogen Contamination Detectors, and the Hydrogen Station Equipment Performance testing device development. The Hydrogen Station Equipment Performance device will be capable of testing hydrogen station fueling performance against the SAE International Standard SAE J2601 fueling protocol. Additionally, the Technology Validation sub-program will coordinate with the Office of Energy Efficiency and Renewable Energy's crosscutting grid integration activities to identify areas of synergy and potential applications for hydrogen and fuel cells.

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