VII.7 Fuel Cell Electric Vehicle Evaluation

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Project Start Date: October 2012
Project End Date: Project continuation and direction determined annually by DOE

Overall Objectives

- Validate hydrogen fuel cell electric vehicles (FCEVs) in real-world setting
- Identify current status and evolution of the technology

Fiscal Year (FY) 2013 Objectives

- Complete the update of data templates
- Complete a priority rating for existing FCEV analyses and Composite Data Products (CDPs)
- Complete the first round of processing and analyses of data from multiple FCEV original equipment manufacturers (OEMs)

Technical Barriers

This project addresses the following technical barriers from the Technology Validation section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

(A) Lack of Fuel Cell Electric Vehicle and Fuel Cell Bus Performance and Durability Data

Contribution to Achievement of DOE Technology Validation Analysis Milestones

This project contributes to the achievement of the following DOE milestones from the Technology Validation section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

- Milestone 2.3: Validate fuel cell electric vehicles achieving 5,000-hour durability (service life of vehicle) and a driving range of 300 miles between fuelings. (4Q, 2019)

FY 2013 Accomplishments

- Completed a prioritized list of FCEV data analyses and CDPs for current project
- Completed the update of data templates (vehicle operation, maintenance, safety, and specification templates were updated based on previous templates, discussions with stakeholders, and validation-topic priorities)
- Received and processed vehicle data from multiple FCEV OEMs
- Supported kick-off meetings with individual project partners and detailed conversations on the provided data
- Completed the update of security procedures for the Hydrogen Secure Data Center (HSDC)

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INTRODUCTION

The DOE has funded projects for the collection and delivery of FCEV data submitted to the National Renewable Energy Laboratory (NREL) for analysis, aggregation, and reporting. Multiple real-world sites and customers are included in this FCEV demonstration project. This activity addresses the lack of on-road FCEV data and seeks to validate improved performance and longer durability from comprehensive sets of early FCEVs, including first-production vehicles. NREL's objective in this project is to support DOE in the technical validation of hydrogen FCEVs under real-world conditions. This is accomplished through evaluating and analyzing data from the FCEVs to identify the current status of the technology, compare it to DOE program targets, and assist in evaluating progress between multiple generations of technology, some of which will include commercial FCEVs for the first time.

APPROACH

The project's data collection plan builds on other technology validation activities. Data (operation, maintenance, and safety) are collected onsite by project partners for the fuel cell system(s) and infrastructure. NREL receives the data quarterly and stores, processes, and analyzes the data in NREL's HSDC. The HSDC is an off-network room with access provided to a small set of approved users. An internal analysis of all available data is completed quarterly and a set of technical CDPs is published every six

months. The CDPs present aggregated data across multiple systems, sites, and teams in order to protect proprietary data and summarize the performance of hundreds of fuel cell systems and thousands of data records. A review cycle is completed before the CDPs are published. This review cycle includes providing Detailed Data Products (DDPs) of individual system- and site-performance results to the specific data provider. DDPs also identify the individual contribution to the CDPs. The NREL Fleet Analysis Toolkit is an internally developed tool for data processing and analysis structured for flexibility, growth, and simple addition of new applications. Analyses are created for general performance studies as well as application- or technology-specific studies.

RESULTS

Much of the activity in FY 2013 focused on the steps necessary to get the projects started. NREL supported these steps through data templates (see Figure 1), the HSDC security procedures, project partner interactions, and analyses prioritization. The following priorities were the result of targets, feedback, and discussions between NREL, DOE, and project partners.

The priorities identified as critical were:

- Fuel cell durability
- Vehicle operation (hours and miles)
- Specifications (power density and specific power)
- Range, fuel economy, and efficiency
- Fill performance
- Reliability

The priorities identified as important were:

- Drive behaviors
- Fill behaviors
- Power management
- Energy
- Transients
- Comparisons to conventional vehicles

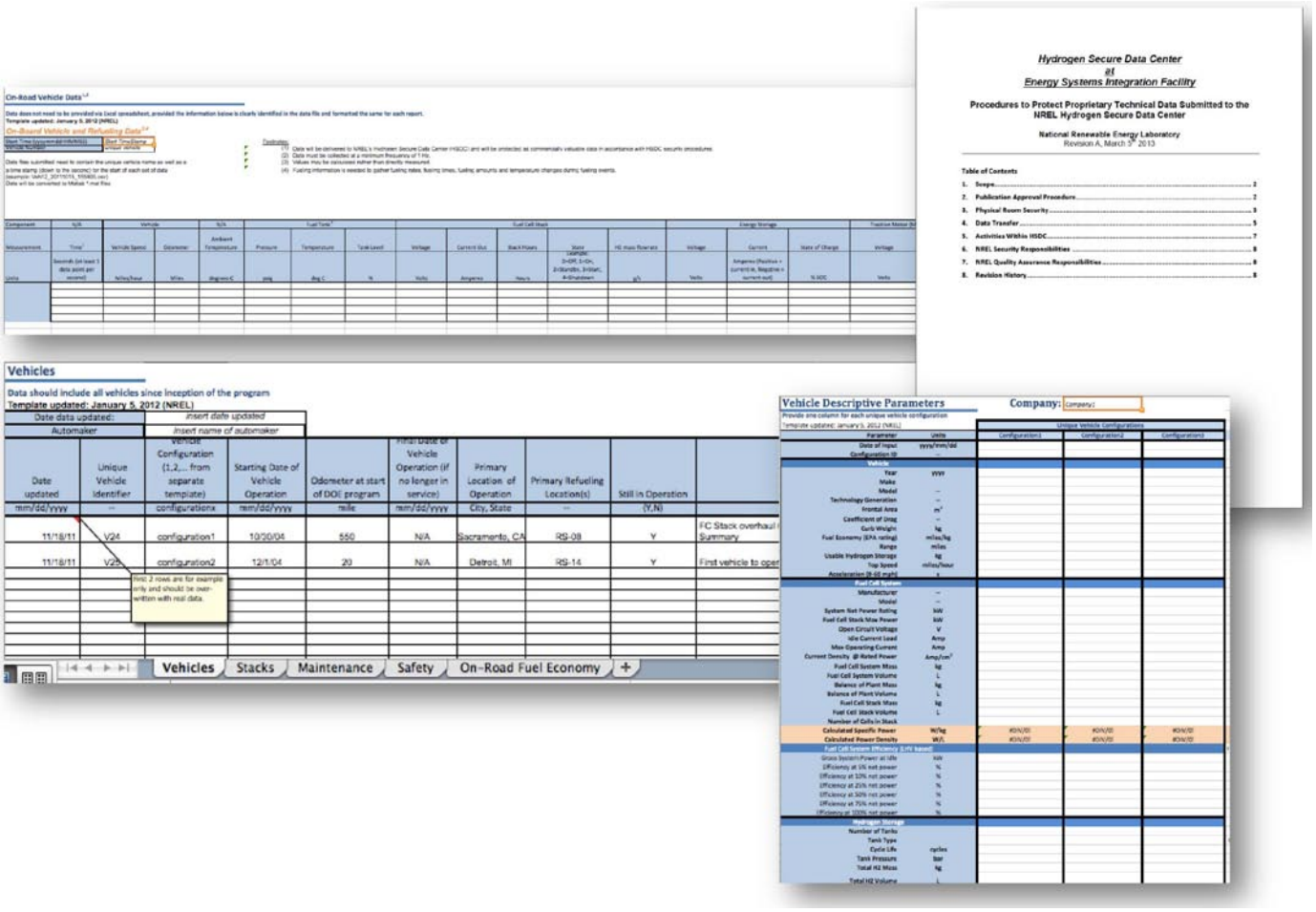

FIGURE 1. Updated FCEV Data Templates and HSDC Security Procedures Document

NREL supported project kick-offs and one-on-one meetings to gain consensus on the methods for data transfer and the steps for building and maintaining trust, such as sending fake CDPs to demonstrate the review process.

Data has been received and processed from multiple OEMs, and data from the remaining project partners is expected by the end of FY 2013.

CONCLUSIONS AND FUTURE DIRECTIONS

This project is still in the early stage. By the end of FY 2013, we expect to complete the first quarterly processing of data from enough OEMs to produce and publish the first, limited set of CDPs in early FY 2014. This first analysis round will rely heavily on the analysis work completed in the FCEV Learning Demonstration project (see Figure 2). Analysis results will focus on the critical and important topics and will validate the performance of current FCEVs against DOE targets and Learning Demonstration benchmarked performance (see Figure 3).

FY 2013 PUBLICATIONS/PRESENTATIONS

1. Kurtz, J.; Wipke, K.; Sprik, S.; Ainscough, C.; Saur, G. (May 2013). "Fuel Cell Electric Vehicle Evaluation." NREL poster prepared for the 2013 DOE Hydrogen and Fuel Cells Program and Vehicle Technologies Office Annual Merit Review and Peer Evaluation.

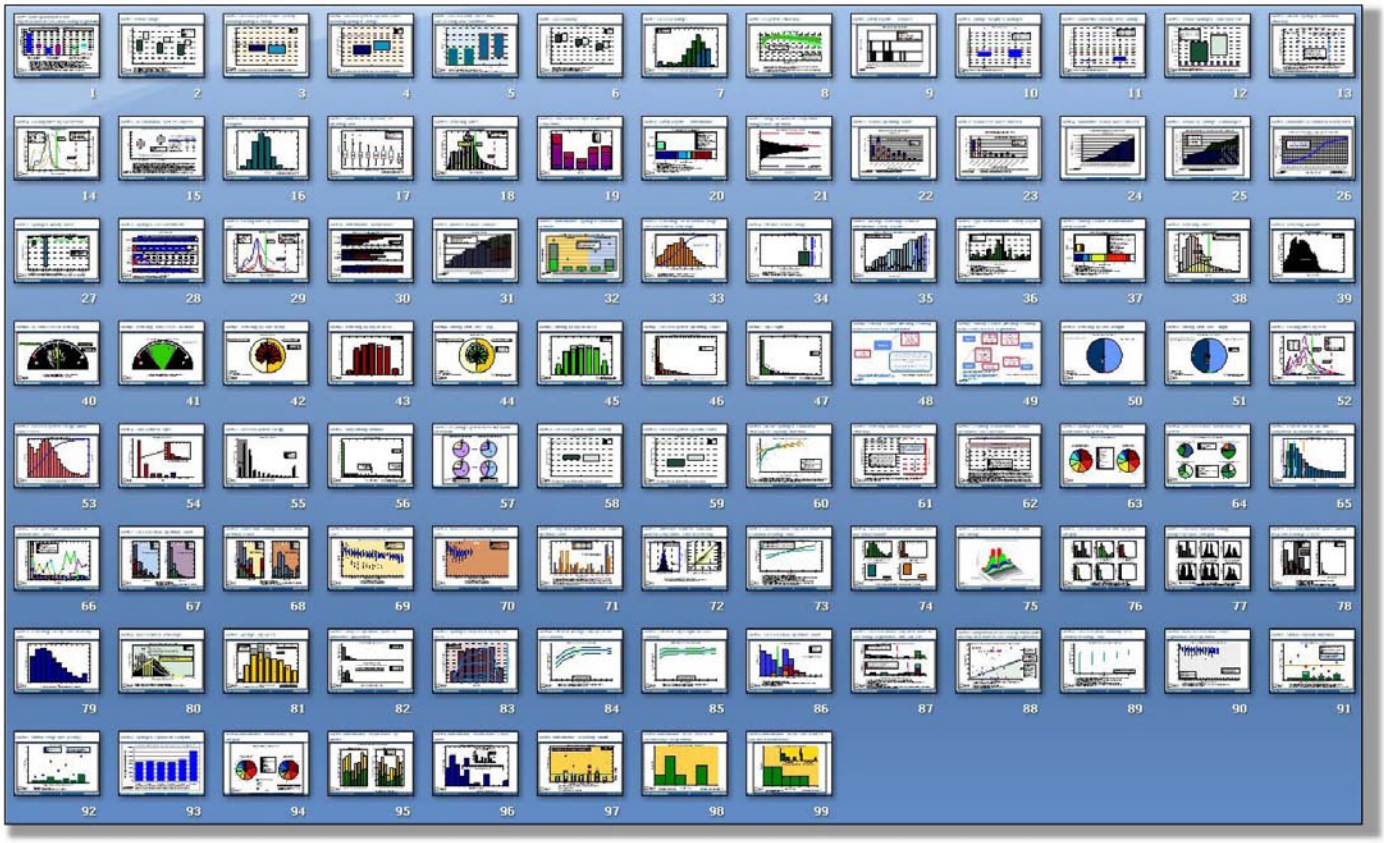

FIGURE 2. Snapshot of 99 FCEV CDPs from Learning Demonstration Project

Vehicle Performance Metrics	Gen 1 Vehicle	Gen 2 Vehicle	2009 Target	After 2009Q4
Fuel Cell Stack Durability			**2,000 hours**	
Max Team Projected Hours to 10% Voltage Degradation	**1,807 hours**	**2,521 hours**		--
Average Fuel Cell Durability Projection	821 hours	1,062 hours		1,748 hours
Max Hours of Operation by a Single Fuel Cell Stack to Date	2,375 hours	1,261 hours		1,582 hours
Driving Range			**250 miles**	
Adjusted Dyno (Window Sticker) Range	**103 - 190 miles**	**196 - 254 miles**		--
Median On-Road Distance Between Fuelings	56 miles	81 miles		98 miles
Fuel Economy (Window Sticker)	42 – 57 mi/kg	43 – 58 mi/kg	no target	--
Fuel Cell Efficiency at ¼ Power	51% – 58%	53% – 59%	60%	--
Fuel Cell Efficiency at Full Power	30% – 54%	42% – 53%	50%	--

Infrastructure Performance Metrics			2009 Target	After 2009Q4
H_2 Cost at Station (early market)	On-Site Natural Gas Reformation **$7.70 – $10.30/kg**	On-Site Electrolysis **$10.00 – $12.90/kg**	**$3/gge**	--
Average H_2 Fueling Rate	0.77 kg/min		1.0 kg/min	0.65 kg/min

Outside of this project, DOE independent panels concluded at 500 replicate stations/year:
Distributed natural gas reformation at 1,500 kg/day: **$2.75-$3.50/kg** (2006)
Distributed electrolysis at 1,500kg/day: **$4.90-$5.70** (2009)

Outside review panel

FIGURE 3. Learning Demonstration Key Performance Metrics and Targets