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Entering a New Stage of Learning from the U.S. Fuel Cell Electric Vehicle Demonstration Project

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Abstract—The National Fuel Cell Electric Vehicle Learning Demonstration is a U.S. Department of Energy (DOE) project that started in 2004. The purpose of this project is to conduct an integrated field validation that simultaneously examines the performance of fuel cell vehicles and the supporting hydrogen infrastructure. The DOE's National Renewable Energy Laboratory (NREL) has now analyzed data from over five years of the seven-year project. During this time, over 144 fuel cell electric vehicles have been deployed, and 23 project refueling stations were placed in use. We have analyzed data from over 430,000 individual vehicle trips covering 2,500,000 miles traveled and over 130,000 kg hydrogen produced or dispensed. During 2010, two of the four project teams will be concluding their involvement in the project, and the other two are continuing. Thus we will be able to focus our analysis efforts on a smaller number of vehicles and stations, and enter into a new stage of learning for this project. This will allow us to dig deeper into the data to provide additional technical value to the two remaining teams as they improve their systems' technical performance in preparation for pre-commercial launch of larger fleets of vehicles in California and New York. It will also give us an opportunity to gather data and analyze performance of improved vehicles compared to those that have been previously demonstrated, since these vehicles are one step closer to commercially available customer vehicles.

Keywords— fuel cell electric vehicle, demonstration, fuel cell degradation, hydrogen fueling infrastructure

1. Key Project Results Compared to Objectives

Key objectives of the project are to evaluate fuel cell durability, vehicle driving range, and on-site hydrogen production cost. Progress towards these objectives will be briefly highlighted in the following subsections.

1.1 Fuel Cell Stack Durability

The maximum number of hours a first-generation stack accumulated without repair is 2,375, which is the longest stack durability from a light-duty FCEV in normal use published to date that we are aware of. With significant drops in power observed at 1,900–2,000 hours, it appears as though this is a solid upper bound on first-generation stack durability (characterizing 2003–2005 technology).

For second-generation fuel cell stacks (2005–2007 technology), the range of maximum hours accumulated from the teams is now approximately 800 to over 1,200 hours, with the range of team average hours accumulated of approximately 300 to 1,100 hours. Relative to projected durability, the Spring 2010 results indicate that the highest average projected team time to 10% voltage degradation for second-generation systems was 2,521 hours, with a multi-team average projection of 1,062 hours. Therefore, the 2,000-hour target for durability has been validated.

1.2 Vehicle Driving Range

Second-generation vehicle driving range was between 196 and 254 miles from the four teams, and met the 250-mile range objective in FY 2008. In June 2009, an on-road driving range evaluation was performed in collaboration with Toyota and Savannah River National Laboratory. The results indicated a 431-mile on-road range was possible in southern California using Toyota's FCHV-adv fuel cell vehicle. More recently, the significant on-road data that have been obtained from second- and first-generation vehicles allowed a comparison of the real-world driving ranges of all the vehicles in the project. The data show that there has been a 45% improvement in the median real-world driving range of second-generation vehicles (81 miles) as compared to first-generation (56 miles), based on actual distances driven between over 25,000 refueling events.

1.3 Onsite Hydrogen Production Cost

Cost estimates from the Learning Demonstration energy company partners were used as input to an H2A analysis to project the hydrogen cost for 1,500 kg/day early market fueling stations. Results indicate that on-site natural gas reformation could lead to a price range of $8–$10/kg, and on-site electrolysis could lead to a range of $10–$13/kg hydrogen cost. While these results do not achieve the $3/gge cost target, two external independent review panels commissioned by DOE concluded that distributed natural gas reformation could lead to a price range of $2.75–$3.50/kg and distributed electrolysis could lead to a price range of $4.95–$5.70/kg. Therefore, this objective was met outside of the Learning Demonstration project.

1.4 Overall Performance Summary

This project has exceeded the expectations established in 2003 by DOE, with all of the key targets being achieved except for on-site hydrogen production cost, which would have been difficult to demonstrate through this project.