DOE Hydrogen and Fuel Cell Technologies Program Record		
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Title: On-Road Fuel Cell Stack Durability – 2016		
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Item

The research and development (R&D) work funded by DOE and others over the last decade has enabled substantial improvements in fuel cell durability. DOE independent validation of on-road fuel cell electric vehicles (FCEVs) showed a more than four-fold increase in the maximum projected durability of fuel cell systems, increasing from 950 hours in 2006 to over 4,100 hours in 2016 to 10% voltage degradation. The maximum operating hours recorded for a single FCEV has remained at 5,600 hours. Also in 2016, based on industry feedback, DOE increased the DOE ultimate durability target to 8,000 hours to allow for at least 150,000 miles of driving on a lower average speed drive-cycle. The durability of fuel cell electric buses has also been evaluated since 2000 in transit agency demonstrations, and has continued to increase after having surpassed the 2016 interim 18,000 hour target in 2015. The current bus maximum lifetime is over 23,000 hours, and this record-setting bus continues to operate.

Supporting Information

On Road Durability

In 2016, the DOE Fuel Cell Technologies Office made the decision, based on industry feedback, to increase the ultimate target for fuel cell durability from 5,000 hours to 8,000 hours. The 5,000 hour target was initially set to correspond with an expected lifetime of 150,000 miles driven within a particular range of speeds. Increasing the target to 8,000 hours effectively expands the metric so that vehicles can achieve 150,000 miles in slower-speed driving conditions (e.g. city driving).

Through the work of the DOE Technology Validation sub-program's Learning Demonstration, as evaluated by NREL's National Fuel Cell Technology Evaluation Center (NFCTEC), fuel cell electric vehicles have been driven in real-world operation over the course of the last 8 years. Data have been collected on hours of operation for both generation 1 and 2 vehicles. Analysis of the data provided by NREL has shown that the maximum projected durability, which is the projected time to 10% voltage degradation for the fleet that displays the best average durability, has more than quadrupled over the last ten years, increasing from 950 hours in 2006 [1] to 2,500 hours in 2009 [2] and reaching 4,100 hours in 2016 [3]. In 2016, the maximum operating hours recorded for a single FCEV are 5,600 hours, the same value as reported in 2015 [4]. The current Technology Validation fuel cell vehicle evaluation project has incorporated additional vehicle manufacturers and is utilizing new fuel cell vehicle technology. Average projected durability values that summarize the durabilities of all fleets in operation for a given year show a consistent

improvement in durability over the last ten years. Figure 1 shows the increase in on-road durability achieved between the 2006–2007 period and the present.

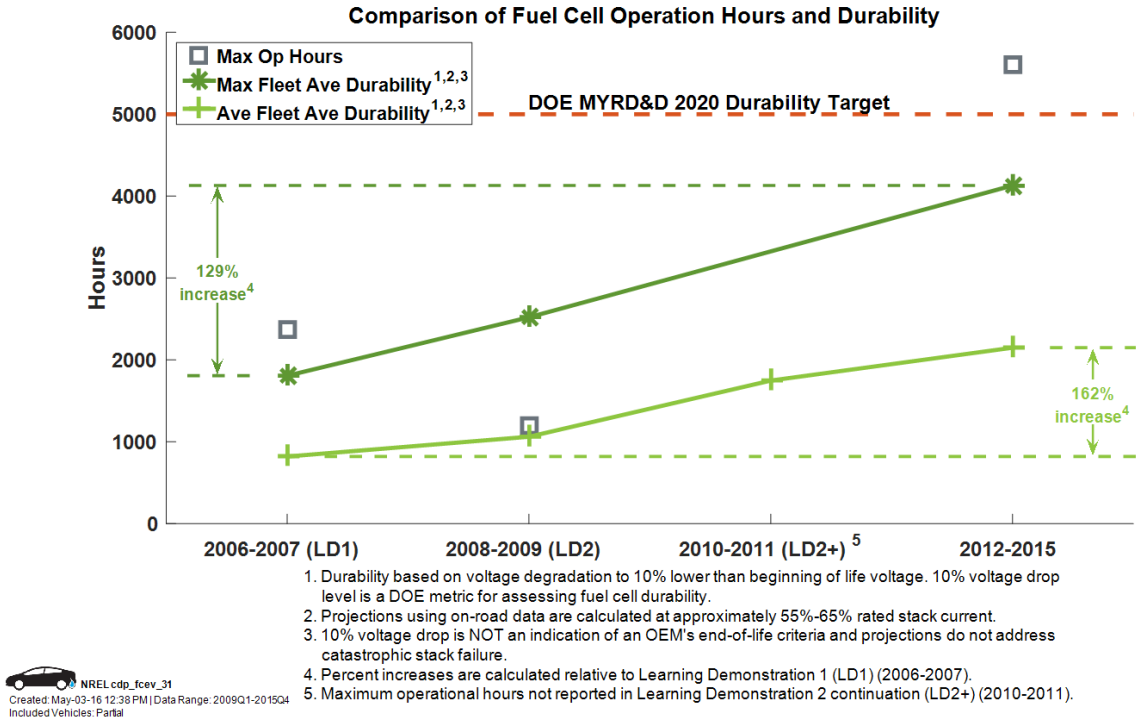

Figure 1. Comparison of fuel cell operation hours and durability. [5]

Through demonstrations taking place at transit agencies, the National Fuel Cell Technology Evaluation Center (NFCTEC) evaluates the durability of fuel cell electric buses (FCEBs) and fuel cell power plants (FCPPs). FCEB performance was analyzed on the basis of the particular buses, infrastructure, and implementation experience present at each transit agency. NREL's analysis of the data has shown that manufacturers have made progress in real-world FCEB durability. The ultimate durability performance target set by the DOE and the Department of Transportation's Federal Transit Administration (DOT FTA) is 4–6 years (or 25,000 hours) for the fuel cell propulsion system, with an interim target of 18,000 hours to be achieved by 2016. As of July 2016, a single fuel cell power plant (FCPP) had reached 23,000 hours and counting, significantly higher than the 18,000 hour 2016 interim durability target, and three additional systems have surpassed 16,000 hours. Out of the 18 FCPPs analyzed in 2016, 11 or 61% have surpassed 14,000 hours of operation. [6] The average of hours accumulated for all buses analyzed is 12,700 hours. [6]

The FCPP that was found to have surpassed the 2016 interim fuel cell bus operation target was evaluated by NFCTEC. This FCPP was originally part of an early generation design and demo of three buses at AC Transit in Oakland, CA. The FCPP went into service in March 2006 and was removed from service in August 2010 at 7,727 hours of operation. It was subsequently installed in a next generation bus (Van Hool, Siemens hybrid system integrated by Van Hool with an EnerDel battery) in August 2010. In the next generation bus, the FCPP reached 20,000 operating hours in July 2015 and 23,000 hours in July 2016.

Table 1 shows the 2016 interim and ultimate targets set for bus and power plant lifetime as well as the statuses for each as of July 2016.

Table 1. Status and targets to date for FCEB and FCPP lifetimes. [6]

	Units	Fleet Minimum	Fleet Maximum	Fleet Average	2016 Target	Ultimate Target
Bus lifetime	years	0.8	6.0	4.4	12	12
	miles	27,740	155,987	105,258	500,000	500,000
Power plant lifetime	hours	2,379	23,002	12,703	18,000	25,000

Overall, FCEB technology continues to approach the technical targets set by DOE and DOT FTA that need to be achieved in order for FCEBs to become competitive with current commercial-technology buses.

References

[1] Keith Wipke, "Completed Learning Demonstration Composite Data Products as of December 1, 2006," CDP#1B: Projected Hours to 10% Stack Voltage Degradation, http://www.nrel.gov/hydrogen/pdfs/41090.pdf

[2] Keith Wipke et al., "All Composite Data Products: National FCEV Learning Demonstration with Updates Through January 18, 2012," CDP#1: Hours Accumulated and Projected Hours to 10% Stack Voltage Degradation, http://www.nrel.gov/hydrogen/pdfs/54021.pdf

[3] Jennifer Kurtz et al., "Fuel Cell Electric Vehicle Evaluation," Annual Progress Report, 2016, https://www.hydrogen.energy.gov/annual_progress.html

[4] Jennifer Kurtz et al., "Spring 2016 Fuel Cell Vehicle Evaluation Results," CDP#21: "Operation Hours and Projected Hours to 10% Voltage Drop," http://www.nrel.gov/hydrogen/images/cdp_fcev_21.jpg

[5] Jennifer Kurtz et al., "Spring 2016 Fuel Cell Vehicle Evaluation Results," CDP#31: "Comparison of Fuel Cell Operation Hours and Durability," http://www.nrel.gov/hydrogen/images/cdp_fcev_31.jpg

[6] Leslie Eudy et al., "Fuel Cell Buses in U.S. Transit Fleets: Current Status 2016," http://energy.gov/sites/prod/files/2016/12/f34/fcto_2016_fuel_cell_bus_report.pdf