DOE Hydrogen and Fuel Cells Program Record	
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Title: On-Road Fuel Cell Stack Durability – 2015	
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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 nearly four-fold increase in the maximum projected durability of fuel cell systems, increasing from 950 hours in 2006 to 3,900 hours in 2015. Additionally, the maximum operating hours recorded for a single FCEV has reached 5,600 hours. The durability of fuel cell electric buses has also been evaluated since 2000 in transit agency demonstrations, and has already surpassed the 2016 interim 18,000 hour target with a bus maximum lifetime of over 20,000 hours having been achieved.

Supporting Information

On-Road Durability

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), vehicles have been driven in real-world operation over the course of the last 7 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 nearly quadrupled since 2006, increasing from 950 hours that year [1] to 2,500 hours in 2009 [2] and reaching 3,900 hours in 2015 [3]. In 2015, the maximum operating hours recorded for a single FCEV has reached 5,605 hours [4]. The current Technology Validation fuel cell vehicle evaluation project has incorporated new vehicle manufacturers and is utilizing new fuel cell vehicle technology that have helped to drive this increase. Though limited data sets and the need to protect proprietary data have prevented publication of maximum projected durability in the years between 2009 and 2014, the average projected durability values, which summarize the durabilities of all fleets in operation for a given year, are available and show a consistent improvement in durability over this period. Figure 1 shows the increase in on-road durability achieved between the 2006–2007 period and the present.

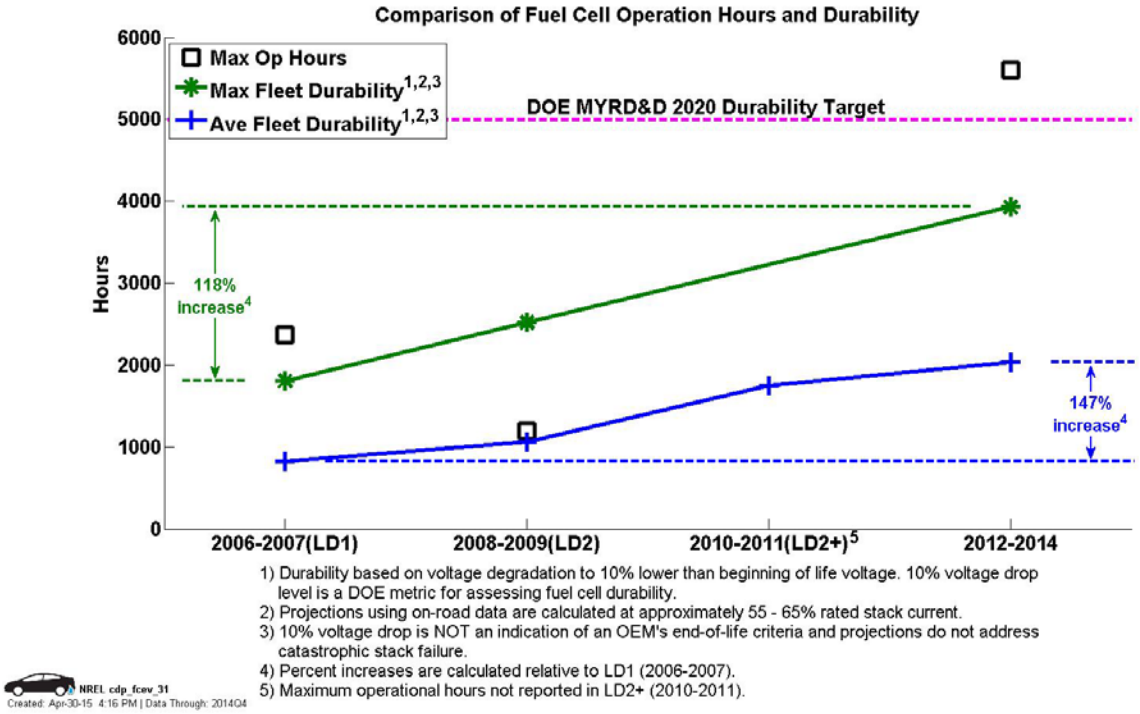

Figure 1. Comparison of fuel cell operation hours and durability [5]

Since 2000, fuel cell electric buses (FCEB) have also been evaluated through demonstrations taking place at transit agencies. The 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 the end of July 2015, a single fuel cell power plant (FCPP) had reached 20,000 hours, significantly higher than the 18,000 hour interim durability target. Moreover, 12 out of the 19 FCPPs analyzed in 2015 have surpassed 10,000 hours of operation [6]. The average of hours accumulated for all buses is 10,102 hours [6].

Table 1 shows the 2016 interim targets and ultimate targets set for bus and power plant lifetime.

Table 1. Status and Targets for FCEB and FCPP Lifetimes [6]

Target	Units	Fleet Minimum	Fleet Maximum	Fleet Average	2016 Target	Ultimate Target
Bus lifetime	years	0.25	4.9	3.6	12	12
	miles	7,978	117,217	81,108	500,000	500,000
Power plant lifetime	hours	667	20,024	10,102	18,000	25,000

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 buses were manufactured by Van Hool with a Siemens hybrid system integrated with ZEBRA batteries by ISE and a fuel cell system by US Hybrid (originally provided by UTC Power). 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 with an EnerDel battery by Van Hool) in August 2010. In the next generation bus, the FCPP reached 20,000 operating hours in July 2015. According to US Hybrid, the FCPP is still operating with no major repairs or cell replacements.

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/docs/fy07osti/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/docs/fy12osti/54021.pdf.

[3] Jennifer Kurtz et al., "Fuel Cell Electric Vehicle Evaluation," 2015 Annual Merit Review, Slide 8, http://www.hydrogen.energy.gov/pdfs/review15/tv001_kurtz_2015_o.pdf.

[4] Jennifer Kurtz et al., *Spring 2015 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 2015 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 US Transit Fleets: Current Status 2015*, http://www.nrel.gov/docs/fy16osti/64974.pdf.