DOE Hydrogen and Fuel Cells Program Record	
Record #: 9012	**Date:** October 7, 2009
Title: Fuel Cell System Cost - 2009	
Update to: Record 8019	
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Item:

The cost of an 80-kW automotive polymer electrolyte membrane (PEM) fuel cell system operating on direct hydrogen and projected to a manufacturing volume of 500,000 units per year is $61/kW for 2009 technology in 2009 dollars ($51/kW in 2002 dollars for comparison with targets).

Rationale:

In fiscal year 2009, TIAX LLC (TIAX) and Directed Technologies, Inc. (DTI) each updated their 2008 cost analyses of 80-kW direct hydrogen PEM automotive fuel cell systems based on 2009 technology and projected to manufacturing volumes of 500,000 units per year [1,2]. DTI and TIAX use Design for Manufacturing and Assembly (DFMA®) and similar bottom-up costing methodology to estimate the cost of the majority of the system components.

The TIAX analysis was based on a fuel cell system model developed by Argonne National Laboratory [8] using properties of a state-of-the-art 3M nanostructured thin film (NSTF) ternary platinum-alloy catalyst layer. The platinum group metal (PGM) loading was 0.15 mg/cm^2, and the stack power density was 700 mW/cm^2. Based on this analysis, the TIAX 2009 projected system cost was $55/kW for an 80-$kW_{net}$ system. The DTI 2009 analysis also assumed NSTF ternary platinum-alloy catalysts at a PGM loading of 0.15 mg/cm^2, with a stack power density of 833 mW/cm^2 [7]. The projected cost for the DTI system was $61/kW for an 80-$kW_{net}$ system. DTI and TIAX 2009 cost analysis models used 2009 dollars. The Pt commodity cost of $1100 per troy ounce was consistent with the Program's 2006, 2007, and 2008 analyses.

The DOE, in collaboration with the FreedomCAR and Fuel Partnership's Fuel Cell Technical Team (the Tech Team), reviewed both cost analyses, and determined that the DTI analysis presented a fuel cell system that better represented status technology. The stack components chosen by DTI, which included metal bipolar plates, non-woven gas diffusion layers (GDLs), and reinforced membranes, were determined to be more appropriate than the carbon-based bipolar plates, cloth GDLs, and non-reinforced membranes used in the TIAX analysis. Stack conditioning, included only in the DTI analysis, was considered necessary for status technology, whereas the anode humidifier included in the TIAX analysis was not considered necessary. Based on review of the cost analyses and discussion with the Tech Team, DOE selected the DTI projection of $61/kW as the 2009 high-volume system cost status.

Although the 2009 cost status was based on the DTI analysis, the agreement between the TIAX cost estimate and the DTI estimate supports the validity of the DTI analysis. Additional support for the validity of the cost analysis methodology was provided by an independent review of the 2008 cost analyses, which determined that the bottom-up methodology used by both DTI and TIAX was appropriate, and the projected costs were credible [4].

As shown in Table 1, technology advances from 2008 [5] to 2009 [2] have led to a reduction of Pt loading and an increase in stack power density, contributing to the $12/kW cost reduction for the fuel cell stack.

Table 1: Key Assumptions of Cost Analyses and Resulting Cost

Characteristic	Units	2008	2009
Stack power	kW_{gross}	90	90
System power	kW_{net}	80	80
Cell power density	mW_{gross}/cm^2	715	833
PGM loading	mg/cm^2	0.25	0.15
PGM total content	g/kW_{gross}	0.35	0.18
PGM total content	g/kW_{net}	0.39	0.20
Pt cost	$/troz. [a]	1100	1100
Stack cost	$\$/kW_{net}$ [a]	34	27
Balance-of-plant cost	$\$/kW_{net}$ [a]	37	33
System Assembly and Testing	$\$/kW_{net}$ [a]	2	1
System cost	$\$/kW_{net}$ [a]	73	61

[a] Dollars are in year of analysis.

For comparison to the DOE targets developed in 2002 and quoted in 2002 dollars ($45/kW by 2010 and $30/kW by 2015), the 2009 cost status of $61/kW in 2009 dollars equates to $51/kW in 2002 dollars [6].

[1] Jayanti Sinha, et al., "Direct Hydrogen PEMFC Manufacturing Cost Estimation for Automotive Applications," Presentation to the Fuel Cell Tech Team, August 12, 2009, http://www1.eere.energy.gov/hydrogenandfuelcells/fc_publications.html

[2] Brian James, et al., "Mass Production Cost Estimation for Direct H_2 PEM Fuel Cell Systems for Automotive Applications," Presentation to the Fuel Cell Tech Team, August 12, 2009, http://www1.eere.energy.gov/hydrogenandfuelcells/fc_publications.html

[3] Brian James, et al., "Changes Since 8/12 Tech. Team Presentation," Slides provided to the Fuel Cell Tech Team, September 14, 2009.

[4] "Fuel Cell System Cost for Transportation-2008 Cost Estimate," National Renewable Energy Laboratory, Golden, CO, May, 2009, http://www.hydrogen.energy.gov/pdfs/45457.pdf

[5] U.S. Department of Energy (Hydrogen Program), "Record 8019: Fuel Cell System Cost - 2008," http://www.hydrogen.energy.gov/program_records.html

[6] United States Department of Labor, Bureau of Labor Statistics, CPI Inflation Calculator. http://www.bls.gov/data/inflation_calculator.htm.

[7] Mark K. Debe, 3M Company, "Advanced Cathode Catalysts and Supports for PEM Fuel Cells." 2009 DOE Hydrogen Program Review. May, 2009. http://www.hydrogen.energy.gov/pdfs/review09/fc_17_debe.pdf

[8] Ahluwalia, Wang, Tajiri, Kumar, "Fuel Cell Systems Analysis." 2009 DOE Hydrogen Program Review. May, 2009. http://www.hydrogen.energy.gov/pdfs/review09/fc_29_ahluwalia.pdf