DOE Hydrogen and Fuel Cells Program Record	
Record #: 8019	**Date:** October 31, 2008
Title: Fuel Cell System Cost - 2008	
Update to: Record 8002	
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Items:

The cost of an 80 kW automotive polymer electrolyte membrane (PEM) fuel cell system operating on direct hydrogen and projected for a manufacturing volume of 500,000 units per year is $73/kW for 2008 technology in 2008 dollars ($60/kW in 2002 dollars for comparison with targets).

AND

Reducing the cost of fuel cells manufactured at high volumes (by a factor of more than two in transportation applications) and improving durability and reliability while maintaining performance are required to ensure the commercial viability of fuel cells in transportation, stationary and portable applications.

Rationale:

In fiscal year 2008, TIAX LLC (TIAX) and Directed Technologies, Inc. (DTI) each updated their 2007 cost analyses of direct hydrogen, 80 kW, PEM automotive fuel cell systems based on 2008 technology and projected to manufacturing volumes of 500,000 units per year [1,2].

The TIAX analysis was based on a fuel cell system model developed by Argonne National Laboratory using properties of a state-of-the-art nanostructured thin film (NSTF) ternary platinum-alloy catalyst layer at a platinum group metal (PGM) loading of 0.25 mg/cm^2 (developed by 3M, which recently demonstrated over 7,300 hour durability with load cycling in single-cell testing [3]) and stack power density of 715 mW/cm^2. The DTI 2008 baseline analysis assumed conventional dispersed platinum (Pt) nanoparticle catalyst on carbon supports, with a stack power density (525 mW/cm^2) and PGM loading (0.21 mg/cm^2) averaged from available data from three vendors, and assumed balance-of-plant components that are further developed compared to the TIAX 2008 analysis.

DTI conducted an alternate analysis assuming power density and catalyst loading consistent with the TIAX analysis. The FreedomCAR and Fuel Partnership's Fuel Cell Technology Team (Fuel Cell Tech Team) concurred that the PGM loading of 0.25 mg/cm^2 and corresponding stack power density of 715 mW/cm^2 are representative of 2008 state-of-the-art automotive technology.

This DTI alternate analysis was selected as the basis for determining the status of the projected fuel cell system cost for 2008 because it assumes balance-of-plant technologies that are currently viable in automotive applications and PGM loading and stack power density representative of 2008 state-of-the-art automotive technology.

The resulting DTI projected system cost of $73/kW is further supported by the TIAX Monte Carlo sensitivity and uncertainty analysis, in which $73/kW is the mean of the distribution. Both the DTI and TIAX 2008 cost analysis models use 2008 dollars and a Pt commodity cost of $1100 per troy ounce, consistent with the Program's 2007 analysis.

As shown in Table 1, technology advances from 2007 [4] to 2008 [2] have led to a reduction of Pt loading and an increase in stack power density that significantly contribute to the $16/kW cost reduction for the fuel cell stack.

Table 1: Key Assumptions of Cost Analyses and Resulting Cost

Characteristic	Units	2007	2008
Stack power	kW_{gross}	90	90
System power	kW_{net}	80	80
Cell power density	mW_{gross}/cm^2	583	715
PGM loading	mg/cm^2	0.35	0.25
PGM total content	g/kW_{gross}	0.60	0.35
PGM total content	g/kW_{net}	0.68	0.39
Pt cost	$/troz. [a]	1100	1100
Stack cost	$\$/kW_{net}$ [a]	50	34
Balance-of-plant cost	$\$/kW_{net}$ [a]	42	37
System Assembly and Testing	$\$/kW_{net}$ [a]	2	2
System cost	$\$/kW_{net}$ [a]	94	73

[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 2008 cost status was estimated in 2002 dollars, resulting in a 2008 fuel cell system cost of $60/kW[1] in 2002 dollars:

$$\frac{\text{(2008 dollars/kW)}}{\text{(1 + inflation rate) ^ years}} = \frac{\$73/\text{kW}}{(1.033\text{^}6)} = \$60/\text{kW}$$

The fuel cell system cost reduction factor is found by dividing the 2008 cost status, shown above, by the 2015 fuel cell system cost target (established in 2002 dollars).

$73/kW / $30/kW = approximately 2.5 using 2008 dollars (and $60/kW / $30/kW, or 2.0, in consistent 2002 dollar terms).

[1] Jayanti Sinha, et al., "Direct Hydrogen PEMFC Manufacturing Cost Estimation for Automotive Applications," Status Presentation to the Fuel Cell Tech Team, September 24, 2008, http://www1.eere.energy.gov/hydrogenandfuelcells/fc_publications.html

[1] Estimation in 2002 dollars uses a 3.3% per year inflation rate for six years.

[2] Brian James, et al., “Mass Production Cost Estimation for Direct H_2 PEM Fuel Cell Systems for Automotive Applications,” Status Presentation to the Fuel Cell Tech Team, September 24, 2008, http://www1.eere.energy.gov/hydrogenandfuelcells/fc_publications.html

[3] Mark Debe, “Advanced Cathode Catalysts and Supports for PEM Fuel Cells,” 2008 U.S. DOE Hydrogen Program Annual Merit Review Proceedings, http://hydrogen.energy.gov/pdfs/review08/fc_1_debe.pdf

[4] U.S. Department of Energy (Hydrogen Program), "Record 8002: Fuel Cell System Cost - 2007,” http://www.hydrogen.energy.gov/program_records.html