V.G.9 Cost Analyses of Fuel Cell Stack/Systems

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Objectives

The objective for 2006-2008 cost assessment project is to provide technical support services to the DOE for cost estimation/analysis for direct hydrogen polymer electrolyte membrane fuel cell (PEMFC) systems for automotive applications. In the first year, our objectives will be to:

- Estimate the manufacturing cost of a "baseline" 80 kW (net) integrated transportation fuel cell system with today's technology at different production scales, i.e., 100 units/year for four consecutive years, 30,000 units/year, 80,000 units/year, 130,000 units/year, and 500,000 units/year.
- Update the 2005 PEMFC cost projection to reflect advances in technology.
- Estimate the cost of systems that meet DOE 2010 and 2015 technical targets.
- Assist the peer review team reviewing the methodology and results of the 2005 TIAX PEMFC System Cost Projection.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section (3.4.4.2) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(B) Cost

Accomplishments

Assist the One-Time Peer Review Panel with their assessment of the 2005 PEMFC cost project results and methodology. The panel's findings, which resulted from their discussions with developers and TIAX, were favorable with some recommendations for improvements.

Introduction

TIAX has developed PEMFC cost projections for transportation systems for DOE for many years, starting around 1998. Since this work started, technology focus has shifted from reformate-based systems to direct hydrogen and the baseline system power rating has increased from 50 kW to 80 kW, the latter assumed to be a hybrid system for a mid-size vehicle. The specification of the system has evolved, initially starting with evaluation of efficiency only at rated power, and now to consideration of efficiency at 25% of rated power to reflect operation at part load where a vehicle will spend a majority of its time. As a consequence, design voltages shifted from 0.8 volts to 0.65 volts leading to smaller less costly stacks for a given power rating. Other parameters considered included temperature of operation and the implications for water management and the cost of platinum (e.g., loading, price of platinum, and power density). All of these cost analyses have been at high volume. However, as fuel cell vehicle technology starts to go through field demonstrations, the question of fuel cell powertrain manufacturing cost during early stages of commercialization and low production volumes is asked more frequently. The cost of fuel cell powertrains during this period is of interest because government incentives may be needed to facilitate the transition to high volume production. Additionally, process costs at low volume will be a much higher percentage of the manufacturing cost, and understanding the major cost contributors could highlight processes that might benefit from R&D investment.

Approach

As a starting point, we will use the stack and system configuration from our 2005 project with NREL/DOE [1,2]. By definition, the fuel cell system includes: the stack, thermal/water/air management systems, and control, but excludes any component related to hydrogen storage. The high volume cost projected for this system provides a minimum point for the economies of scale analysis. We will check with the Fuel Cell Tech Team whether we should continue to use this system, or whether it is overly complex and should be simplified as some of the original equipment manufacturers (OEMs) indicated to the One-Time Peer Review Panel.

We will use three process scenarios to construct an integrated low-to-high volume cost curve as illustrated in Figure 1. The intersection of the curves is the location of the natural transition points from batch to semi-automated to fully-automated production.

Components within the system can be separated into two categories: low count and high count. In the latter, the stack components such as membrane electrode assemblies (MEAs), bipolar plates, gas-diffusion layers, and interconnects have part counts in the hundreds. While balance-of-plant (BOP) components, such as the heat exchanger(s), humidity controllers, compressor (/expander), and stack end-plates and manifold, may be present as single units. At least several of the stack components are amenable to reel-to-reel continuous processes and will benefit greatly from high volume production and will see economies of scale at much lower volumes than the BOP. For the more conventional BOP components, we will use Boothroyd Dewhurst Design for Manufacturing and Assembly (DFMA®) software to estimate costs.

Materials are a major cost contributor to fuel cell systems. For the materials that are available now, we will talk to suppliers to understand volume pricing of these materials. For materials presently not available, we will use our activities-based modeling approach to scale-up production and estimate cost. The current fuel cell cost model assumes a vertically integrated manufacturing process for the stack components. This raises the question of how stack manufacturers will set-up their processes. In all likelihood a stack manufacturer will assemble the stack from purchased components, produced to their specification, from suppliers. In this scenario, the component costs will include the margins and corporate overheads. We will use sensitivity analysis to assess the impact of these margins at different production scales.

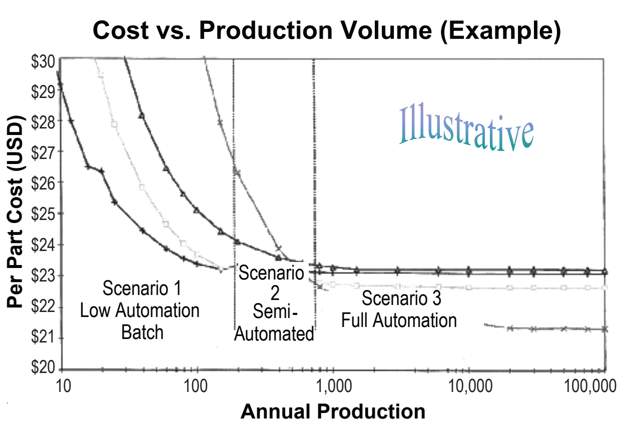

FIGURE 1. Example of cost versus production volume curve synthesized from three production scenarios.

Platinum is the largest material cost contributor to the stack and system and its contribution will depend on power density (mW/cm^2), platinum loading (mg/cm^2), and platinum commodity price ($/troy ounce). Consequently, a large percent of the stack and system cost will not scale with production volume, but will depend on world commodity prices.

The cost contribution of other supporting processes, such as quality control and stack burn-in, should decrease as production volume increases. At low volumes, one may use 100% inspection and extended burn-in tests to verify component and stack performances, while at high volume statistical inspection methods will reduce quality control (QC) costs.

The objective of this project in the first year is to assess the impact of production volume on manufacturing cost. However, it is useful to discuss what this project will not produce. We will not develop projections of fuel cell system price as a function of production volume. Price includes contributions such as R&D, sales and marketing, general and administrative, taxes, and profit. R&D costs are also complicated by how to amortize investments made up to the point of commercialization.

Results

This is a new project this year and results will be presented in the next annual report.

Future Directions

In the second and possibly subsequent years, technology pathways to lower cost will be assessed. Possible approaches to be considered may include ambient versus pressurized operation; high-temperature, low-humidity operation; lower temperature, low relative humidity hydrocarbon membranes; alternative air compression approaches; alternative cell/stack configurations and materials; and effects of fuel cell vehicle hybridization.

References

1. E.J. Carlson, P. Kopf, J. Sinha, S. Sriramulu, Y. Yang, "Cost Analysis of PEM Fuel Cell Systems for Transportation", September 30, 2005, NREL Report - NREL/SR-560-39104.

2. Eric J. Carlson, Peter Kopf, Jayanti Sinha, Suresh Sriramulu, Yong Yang, DOE 2005 Hydrogen Annual Report, VII.I.9 Cost Analyses of Fuel Cell Stack/Systems.

FY 2006 Publications/Presentations

1. Poster at the 2006 DOE Hydrogen Program – Annual Merit Review and Peer Evaluation (Washington, D.C., May 16-19, 2006).