IV.G.4 Economic Analysis of Stationary PEM Fuel Cell Systems

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Objectives

- Perform an economic analysis of fuel cells and their associated markets in order to understand the cost targets that will drive the research and development (R&D) necessary for the commercialization of stationary polymer electrolyte membrane fuel cell (PEMFC) systems.
- Develop a technical targets table for each applications, e.g., cost, reliability, size, and emissions.
- Identify PEM fuel cell applications with large potential markets and/or high commercialization potential.
- Identify critical success factors required for commercialization.
- Educate stakeholders and raise awareness of national programs.

Technical Barriers

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

- Distributed Generation Barriers
  - E. Durability
  - F. Heat Utilization
  - G. Power Electronics
  - H. Startup Time
- Fuel-Flexible Fuel Processors Barriers
  - I. Fuel Processor Startup/Transient Operation
  - J. Durability
  - K. Emissions and Environmental Issues
  - L. Hydrogen Purification / Carbon Monoxide Cleanup
  - M. Fuel Processor System Integration and Efficiency
  - N. Cost
- Component Barriers
  - O. Stack Material and Manufacturing Cost
  - P. Durability
  - Q. Electrode Performance
  - R. Thermal and Water Management

Approach

- Analyze fuel cell technology and cost reduction enablers and trends for stationary applications of PEMFCs of different sizes (1 to 250 kW).
- Forecast alternative scenarios for the commercialization success of PEMFCs based on alternative states of factors impacting technologies, markets, and economics.
- Facilitate feedback from a Stakeholder Partnership Team to improve the analysis and forecast development and to enrich communication tools for educating the broader stakeholder community; ensure balanced representation of views from industry, academia, government, non-profit organizations, consumers and target markets.
- Disseminate knowledge to facilitate commercialization by increasing understanding of PEMFCs in target markets; increase awareness of the attributes that provide competitive advantage for PEMFCs; and accelerate awareness of innovations that may reduce cost and increase performance of PEMFCs.

Accomplishments

- Developed integrated evaluative approach and preliminary economic (cost) model.
- Completed two expert focus groups to provide input on descriptors for the Interactive Future Simulations™ model.
- Completed first draft of macro-scenarios.
- Surveyed over 60 fuel cell developers, users, and competitors.
- Collected data on non-technical factors, e.g., industry factors and policy issues, affecting PEMFC commercialization.
- Initiated detailed analysis of the economics of PEMFCs for backup power applications, especially in the telecommunications industry.

Future Directions

- Complete macro-scenario analysis and prepare cascading scenarios for each individual marketplace.
- Select/evaluate specific, high-potential market segments.
- Populate the cost model.
- Prepare case studies on high-potential market segments.
- Use enhanced economic analysis (e.g., contingent valuation) to improve understanding of benefits and costs that may not be captured by simple payback or return on investment calculations.
- Establish and hold meetings of the stakeholder group to guide and inform the analysis of factors impacting commercialization scenarios.
- Continually update technology and market data.
- Develop and implement communications to broader stakeholder interests.

Introduction

The overarching objective of this project is to refine and expand our understanding of the economic, technology, and market factors that drive the R&D needed for the commercialization of stationary PEMFC systems. Outcomes of this study will include a technical targets table showing cost, reliability, size, response, and emissions, for each application, i.e., distributed, back-up, peak-shaving, and residential markets. In addition, large potential markets for PEM fuel cell applications will be identified and evaluated to determine critical success factors required for commercialization.

Approach

Battelle's approach involves three analytic tasks and a communication task. First, a detailed analysis of the markets and economics of PEMFCs is performed. Technology status and trends, including performance and cost, are analyzed. The data is secured from secondary research and from surveys and interviews with stakeholders: customers, potential customers, manufacturers, suppliers and competitors related to potential fuel cell markets. The second task uses facilitated expert focus groups to identify important trends, issues and factors. Battelle's Interactive Future Simulations™ software is used to describe scenarios and outcomes based on the critical factors (descriptors) described by the experts. Expert feedback is used to refine the scenarios and identify the most likely scenarios. Likely scenarios provide insight into critical success factors.

The third task involves integrating stakeholders into development of commercialization strategies likely to yield success. Facilitated Stakeholder Partnership Team discussions will generate ideas and vet findings. The final task is to develop and execute communications to stakeholders. Communications include presentations, publications, and internet accessibility to knowledge.

Results

Battelle's overall conceptual model is shown in Figure 1. A literature search was performed to find economic and market models related to fuel cell applications. A preliminary first cost model has been developed incorporating insights from published studies and is currently being reviewed and revised by Battelle cost analysts and fuel cell engineers.

The data required by the economic models was identified, and surveys and interviews have begun to gather the data. Survey recipients have included fuel cell manufacturers, manufacturers of competing technologies, customers and potential customers. To date, 60 comprehensive interviews of stakeholders have been completed. Some key themes are: cost is the most significant barrier *in most cases;* reliability is a must; durability is critical *in most cases*; and

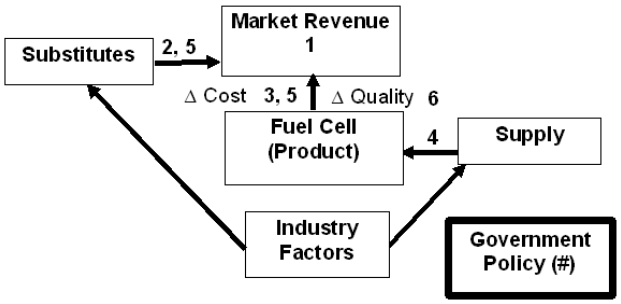

Figure 1. Conceptual Model of Fuel Cell Revenues (Numbers indicate impact points for potential governmental policy interventions.)

hydrogen storage/reformation are critical issues *in most cases*.

The research is providing insight into non-price competitive advantages as well as opportunities to improve public awareness and comfort with fuel cells. Understanding the advantages that will increase the rate at which potential markets and customers adopt fuel cell technologies is critically important to realistic expectations of sales in 2015.

Independent of, but coordinated with, the model development and data-gathering efforts, two Scenario Analysis expert focus groups have been held. The first focus group included 16 participants representing the Ohio Fuel Cell Coalition, NASA Glenn Research Center, FirstEnergy, GrafTech, Johnson Matthey Fuel Cells, The Ohio State University, EWI, Cinergy, Ohio Department of Development, American Electric Power, Case Western Reserve University, and Battelle. This group identified and rank-ordered 65 potential drivers impacting the market for stationary PEMFCs in the U.S. to the year 2015, from which the top 20 descriptors were identified (Table 1).

The top twenty descriptors were then vetted, with the second expert focus group addressing the question, "what are the most important additions, deletions, and further modifications to the current descriptors and other inputs to the Interactive Future Simulations Model™?" The second focus group included representatives from DuPont, Hydrogenics, NextEnergy, Verizon Telecom, Plug Power, Ballard, Nuvera, U.S. Department of Energy, Methanex, Engelhard, Ion Power, Porvair, Chevron Texaco,

Table 1. Top Twenty Descriptors Influencing Fuel Cell Commercialization in Stationary Applications

Value of PEMFC to Customers
Cost of PEMFC
PEMFC Investments
PEMFC Manufacturing
PEMFC Stack Technical Advances
Hydrogen Availability
Fossil Fuel Technological Improvements
Energy Storage Technologies
Environmental Regulations and Standards
Public Policy Support for PEMFC
National Energy Policy and Security
Electrical Grid Sufficiency and Reliability
Cogeneration, Backup Power, and Distributed Generation Options
Grid Electricity Prices
Prices of Fuels for PEMFC
Fuel Cell Commercialization Leadership
PEMFC Stationary Power Units in Japan and Europe
PEMFC in Automotive Applications
PEMFC Applications and Markets
Economic Impact of PEMFC

Gore Fuel Cell Technologies, Proton Energy Systems, 3M, Verizon Wireless, Catepillar, U.S. Army Corps of Engineers, and Battelle.

The experts reviewed, discussed, and offered suggestions for improvements to the inputs to the scenarios. The inputs included the initial 20 descriptors, their alternative outcomes (states) by 2015, the a priori probabilities of the states occurring by 2015, and the cross-impact guides to the cross-impact matrix. Based upon the numerous experts' suggestions, the set of descriptors was expanded to 22 descriptors with a total of 73 states. In addition to adding two more descriptors, 15 descriptors were redefined or respecified according to experts' feedback from the May 12 meeting of the second expert focus group. A new set of scenarios has been generated and is being analyzed.

Conclusions

- The combination of analytic approaches is proving useful for validating and expanding the current understanding of the current status of PEMFCs in stationary applications and the interplay of factors that can lead to different future states for the industry.
- Cost, durability, reliability, and hydrogen (cost/availability) are critical barriers to PEM fuel cell adoption identified by potential customers; however, experts recognize a wide range of additional factors and exceptions that may impact commercialization of fuel cells and must be considered in projections.

FY 2004 Publications/Presentations

1. Paul, Darrell, Harry Stone, Gretchen Hund, Kathya Mahadevan, Steve Millett, "Economic Analysis of PEM Fuel Cell Systems," 2004 DOE Stationary & Transportation Fuel Cell Project Kick-off & Coordination Meeting, Washington, D.C. (2004).

2. Stone, Harry J., "Economic Analysis of Stationary PEM Fuel Cell Systems," DOE Hydrogen Program, 2004 Program Review, Philadelphia, PA (2004).