



Battelle

The Business of Innovation

Market Opportunity Assessment for Direct Hydrogen PEM Fuel Cells in Transition Markets

Harry J. Stone
Battelle Memorial Institute
May 18, 2006

Overview

Timeline

- Project start date: November 2003
- Project end date: September 2007
- Percent complete: 42% (Mar 2005)

Barriers

- All distributed generation systems barriers
- All fuel-flexible fuel processor barriers
- All fuel cell component barriers

Budget

- Total Project Funding: DOE Share \$3,163,800 and No Contractor Cost-Share
- Funding received in FY04: \$515,851
- Funding received in FY05: \$700,000
- Funding expected in FY06: \$650,000

Partners

- H2A, NREL
- More than 30 companies and agencies have participated in expert focus groups and facilitated discussions
- More than 80 current or candidate users have participated in interviews

Sample Focus Group Participants/User Interviewees

Industry

- Plug Power
- Chevron Texaco Technology Ventures
- Caterpillar
- Ion Power
- Ballard
- UTC Fuel Cells
- Nuvera Fuel Cells
- Methanex
- Proton Energy Systems
- W.L. Gore
- DuPont
- 3M
- Porvair
- Hydrogenics
- Engelhard
- ReliOn
- GrafTech
- Johnson Matthey Fuel Cells

Users

- Telecom Market Sector
 - Verizon Wireless
 - Verizon Communications
 - Nextel
 - Cingular
 - BellSouth
 - Qwest
 - Lucent
- Finance and Banking Market Sector
 - PEMCO Financial Services
 - Washington Trust Bank
 - Merrill Lynch
 - LaSalle Bank Corporation
 - Fifth Third Bank
- Hotel Market Sector
 - The Wynn
 - Starwood
 - Fairmont
 - Bally's
 - Marriott
 - Choice Hotels
- Electric Utilities
 - NYPA
 - American Electric Power,
 - Chugach Electric,
 - WE Energies,
 - Energy Northwest,
 - Green Mountain Energy,
 - Arizona Public Power

Government, Universities, and Non-Profits

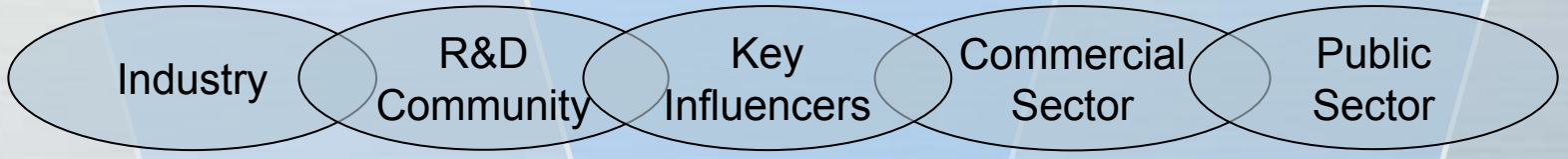
- Department of Energy
- U.S. Army Fuel Cell Program
- The Ohio State University
- Electric Power Research Institute
- Ohio Fuel Cell Coalition
- NASA Glenn Research Center
- Edison Welding Institute
- Ohio Department of Development
- Case Western Reserve University
- NextEnergy
- Rensselaer Polytechnic Institute
- Mississippi State University
- Edison Materials Technology Center
- NIST
- Battelle

Objectives

- To assist DOE in the development of fuel cell systems by providing an analysis of the technical, economic and market drivers of PEM fuel cell adoption
- 2005: Complete interim report on economic analysis of PEM fuel cells for stationary applications
- 2006: Develop market opportunity assessments for direct hydrogen PEM fuel cells (H-PEMFC) in near-term transition markets (2008)

Approach

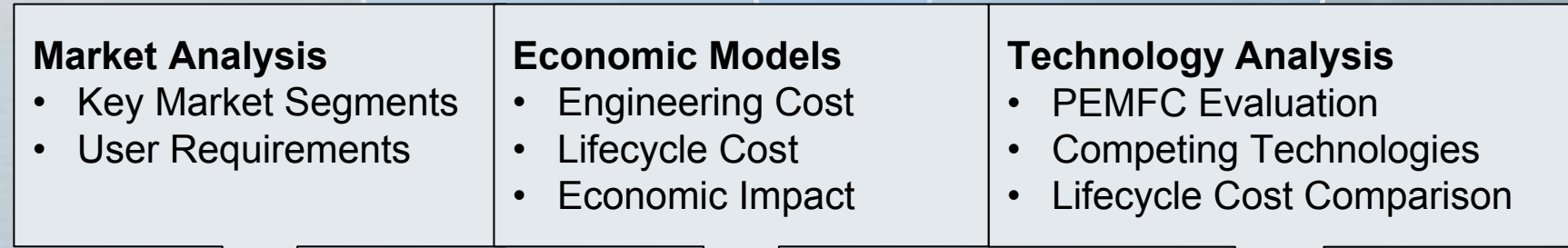
Participating Stakeholder Groups



Data Collection



Battelle Analysis



Opportunities for Commercialization of PEM Fuel Cells

Technical Accomplishments and Progress: PEM Fuel Cell Cost and Technology Analysis

Completed interim report on PEM fuel cells including:

- Analysis of early adopter markets for backup power
- Engineering cost models (2 systems, 3 production volumes)
- Sensitivity analysis of cost drivers (2 systems)
- Potential cost impacts of developing component technologies
- Lifecycle cost analysis for direct hydrogen system and comparison with batteries/diesel generator in backup application



2006 Revised Workplan

▶ Identify and prioritize transition markets (TM) for H-PEMFC

- TM are “pre-automotive” markets that utilize components and underlying technologies similar to automotive H-PEMFC.
- Segment and develop understanding of public and private sector TM
- Identify 3 TM for H-PEMFC potential demonstration and adoption by 2008

▶ Analysis three high priority TM

- Determine user requirements for adoption of H-PEMFC
- Perform competitive analysis (cost and quality) of existing H-PEMFC (considering improvements highly likely by 2008) and alternative technologies
- Develop value propositions, estimate market penetration rates and provide a market opportunity assessment for H-PEMFC
- Support communication of the findings

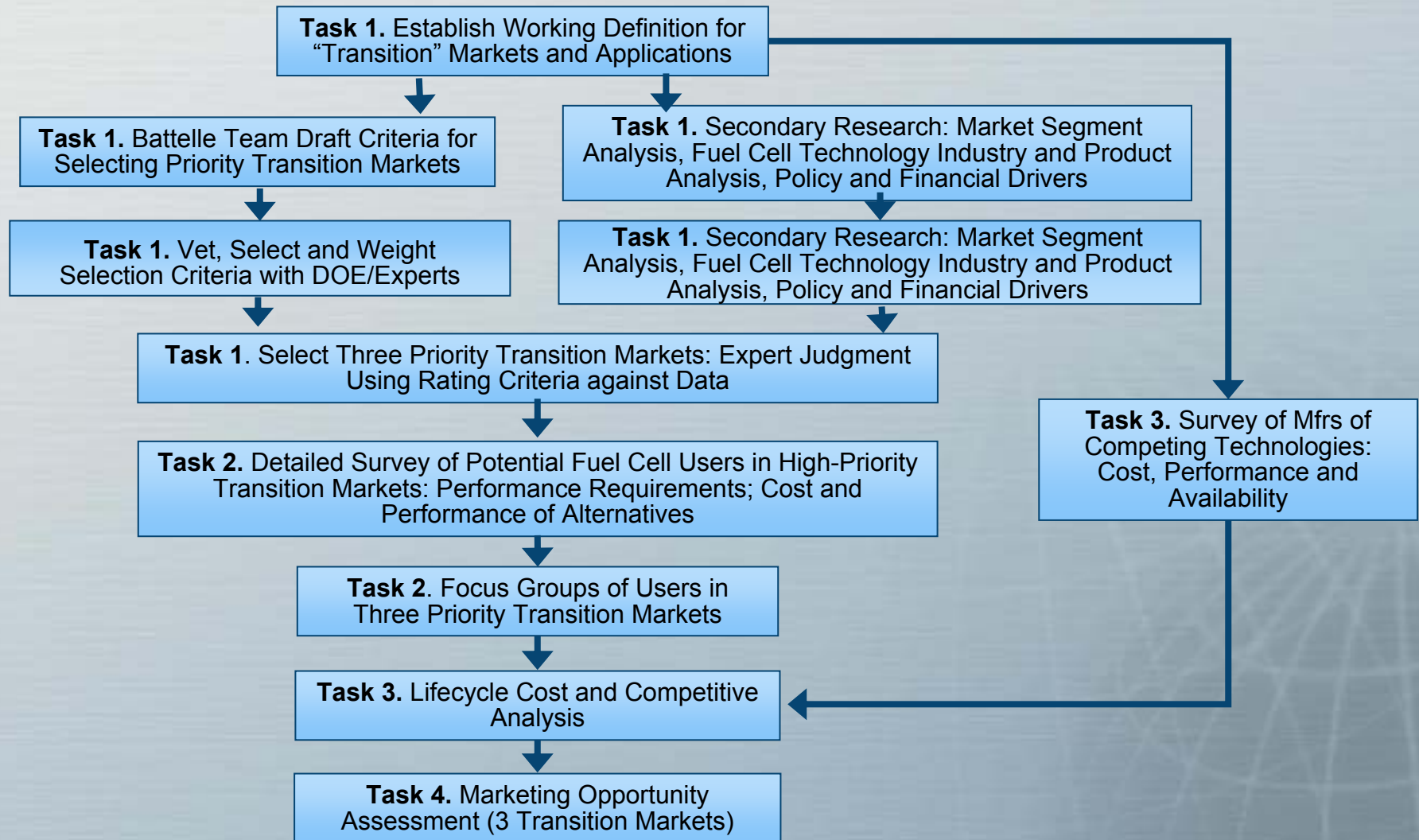
2006 Revised Workplan Schedule

ID	Task Name		
		February	September
1	Task 1.1: Definition of TransMkts		
6	Task 1.2, 3.2: Identification of TransMkts and Mkt Segments		
15	Task 1.3: Validate Rating Criteria		
18	Task 1.4: Characterization of TransMkts Using Rating Criteria		
19	Task 1.5: ID Most-promising TransMkt Opportunities		
20	Task 2.1, 3.2: Target User Requirement Surveys		
28	Task 2.2: Follow-up Interviews with Users		
29	Task 2.3: User Focus Groups		
34	Task 2.4: Analysis of Marketing Data		
35	Task 3.1: ID Competing Solutions		
38	Task 3.3: Lifecycle Cost Analysis of One PEMFC & Segment		
48	Task 3.4: Lifecycle Cost Analysis of One Alternative & Segment		
58	Task 3.5: Prepare Report on Competitive Positioning		
59	Task 4.1: Development of Value Propositions		
60	Task 4.2: Estimate Market Penetration Rates		
61	Task 4.3: Market Opportunity Assessment		

Technical Accomplishments and Progress: PEM Fuel Transition Market Analysis (2006)

- Completed marketing research plan
- Defined transition markets and completed market segmentation
- Developed criteria for selecting priority transition markets
- Interviewed and surveyed potential users in each H-PEMFC transition markets
- Identified potential high priority transition market segments
- Developed preliminary electricity generation modules for H2A Model enabling cost comparisons between fuel cells and alternative electricity generation

Marketing Research Plan



Definition of Transition Applications and Markets

Transition applications and markets for PEM fuel cells are defined as those applications and market opportunities that support the development of technology and the industry necessary to ensure the commercialization of automotive H-PEMFC by 2015.

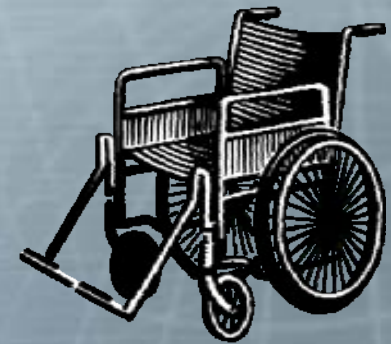
Transition markets for direct hydrogen PEM fuel cells can be “pre-automotive” markets that utilize components and underlying technologies similar to automotive H-PEMFC. Transition markets are composed of applications that have some operational characteristics similar to automotive H-PEMFC.

Transition markets for PEM fuel cells for direct hydrogen PEM fuel cells can also be those markets with early adopters for backup power and grid independent power applications. It is anticipated that increased demand from these markets could decrease cost of components, maintain investor interest, and facilitate the development of a supplier base of H-PEMFC technology.

Transition Applications and Markets – Specialty Vehicles

Specialty Vehicles

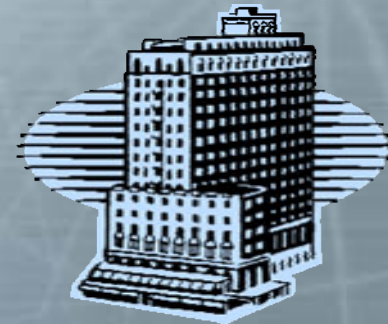
- Lift Trucks/Forklifts
- Automated Guide Vehicles
- Mining Vehicles
- Personnel Carriers
- Burden Carriers
- Industrial Utility Vehicles
- Golf Carts
- Turf Maintenance Vehicles
- Commercial Sweepers
- Ice Resurfacers
- Wheelchairs
- Lawn Mowers
- Unmanned Undersea Vehicles
- Unmanned Aerial Vehicles
- Motorized Bicycles/Scooters



Transition Applications and Markets – Stationary Power *(continued)*

Back-up Power Applications

- Telecom
- Finance
- Professional Scientific, and Technical Services (Information Technology)
- Pharmaceuticals
- Grocery Stores and Large Department Stores
- Casinos
- Hotels
- National Parks
- Ski-Parks (Ski-Lifts/Gondola Operation)
- Amusement Parks
- Healthcare
- State and Local Departments of Emergency Response
 - First Responder Stations and Call Centers
 - Emergency Centers (Emergency Shelters)
 - Emergency Communications Centers
 - Police Stations
 - Fire-houses



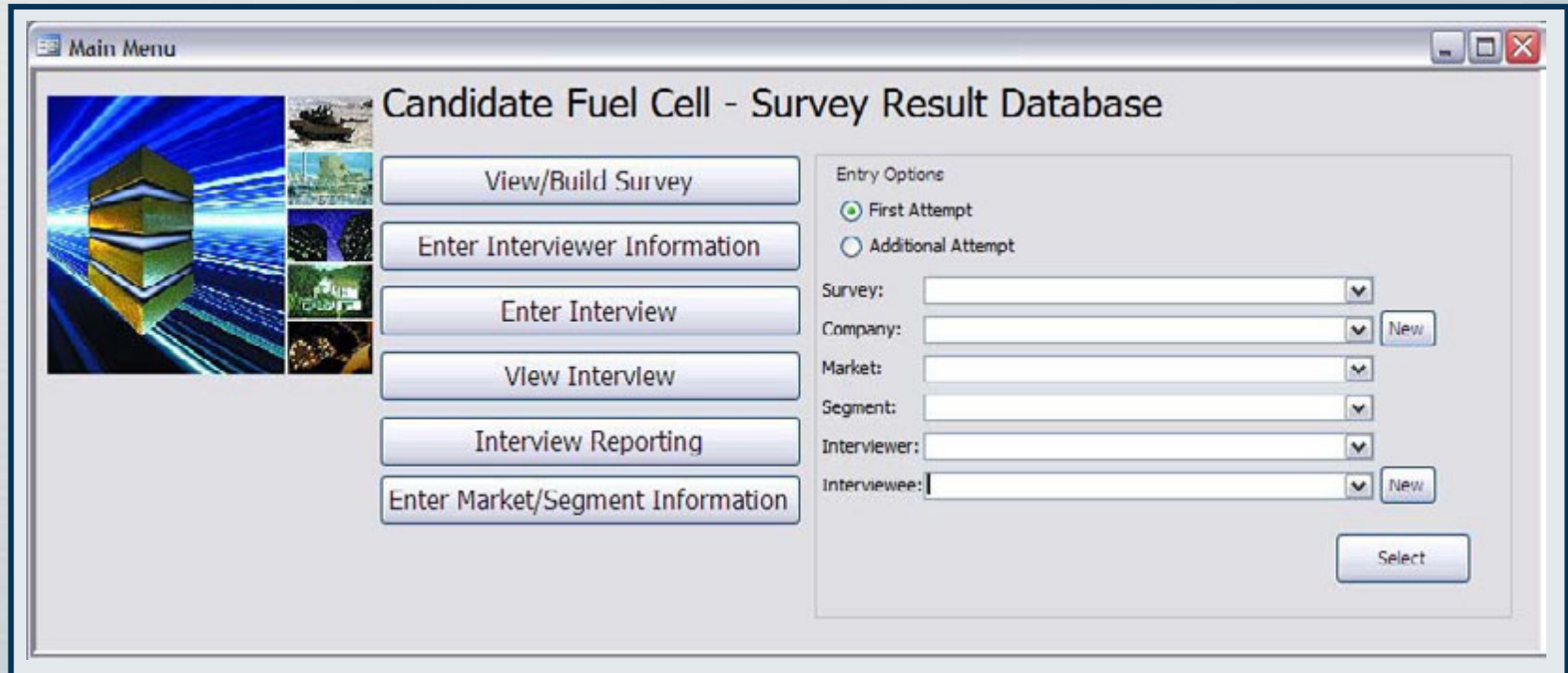
Transition Applications and Markets – Stationary Power *(continued)*

Back-up Power Applications (continued)

- Federal Agencies (Primarily for back-up power of communication facilities)
 - NASA
 - NRC
 - Federal Highway Administration
 - Federal Aviation Administration
 - Department of Defense
 - Department of Homeland Security
 - NOAA
 - DOE
 - EPA
- Railways
- Airports
- Water Distribution
- Food
- Petroleum and Coal Products
- Chemical Manufacturing
- Metals Processing and Refining
- Computer and Electronic Products
- Oil and Gas Manufacturing
- Transportation Equipment
- Utility substations



Marketing Data: Accessible for Analysis



The screenshot shows a software application window titled "Candidate Fuel Cell - Survey Result Database". The window has a "Main Menu" title bar and standard window controls (minimize, maximize, close). On the left side, there is a vertical stack of six buttons: "View/Build Survey", "Enter Interviewer Information", "Enter Interview", "View Interview", "Interview Reporting", and "Enter Market/Segment Information". To the left of these buttons is a vertical strip of six small images. On the right side, there is a form area with the following elements:

- Entry Options:** Two radio buttons, "First Attempt" (selected) and "Additional Attempt".
- Survey:** A dropdown menu.
- Company:** A dropdown menu with a "New" button to its right.
- Market:** A dropdown menu.
- Segment:** A dropdown menu.
- Interviewer:** A dropdown menu.
- Interviewee:** A dropdown menu with a "New" button to its right.
- Select:** A button located at the bottom right of the form area.

Draft Rating Criteria for High Priority Transition Market Selection

Market Criteria

- H-PEMFC product characteristics and their potential benefits must fit user requirements (high priority needs)
- H-PEMFC products are available for immediate application, or can be developed over the short-term
- H-PEMFC offer unique value to market segment not met by competing technologies
- Sufficient market size and growth potential of the market segment to ensure current and continued fuel cell adoption
- Cost of reaching the market, including product development and marketing, is reasonable

Draft Rating Criteria for Priority Transition Market Selection *(continued)*

▶ Government Market Criteria

- Demonstration of H-PEMFC in stationary applications in this market segment will contribute to increased learning of H-PEMFC technology operation, its reliability and cost-effectiveness by end-users, potentially leading to increased adoption of H-PEMFC in the marketplace and impacting costs of H-PEMFC through increased demand
- Demonstration of H-PEMFC in this market segment will translate to improvements in automotive H-PEMFC design and development, from learning and demonstration of technology operation
- Availability of financial support for demonstration of H-PEMFC technology
- Codes and standards are in place or near complete to facilitate adoption of hydrogen technologies

H2A Module Showing Electrical Outputs

Assumed Start-up Year	2005
After-Tax Real IRR (%)	10%
Depreciation Type (MACRS, Straight Line)	MACRS
Depreciation Schedule Length (No. of Years)	3
Analysis Period (years)	20
Plant Life (years)	1
Assumed Inflation Rate (%)	1.90%
State Income Taxes (%)	6.0%
Federal Income Taxes (%)	35.0%
Effective Tax Rate (%)	38.9%
Design Capacity at 100% Capacity (kW)	50.00
Operating Capacity Factor (%)	100%
Plant Output (kWh/day)	1,200.00
Plant Output (kWh/year)	438,000.00

Future Work

FY 2006

- Complete competitive analysis including lifecycle cost and performance of H-PEMFC and alternatives in priority markets
- Complete market opportunity assessments in 3 TM
- Develop value proposition for H-PEMFC in 3 TM
- Use innovation diffusion models to analyze market penetration rates

Future Work

- Future work will be based on EERE requirements and 2006 findings

Project Summary

Relevance

Perform market opportunity analysis to identify early and critical transition markets to automotive fuel cells where H-PEMFC are likely to successfully compete.

Approach

Integrate marketing research methods (surveys, focus groups, scenario analysis, innovation diffusion modeling), technology evaluation (surveys, expert focus groups) and economic analysis (engineering cost models, lifecycle cost models) to understand market opportunities and adoption rates.

Technical Accomplishments and Progress

Completed market analysis and lifecycle cost analysis for selected backup power applications; completed first phase of transition market analysis.

Acknowledgements

DOE

- Kathi Epping, EERE, HFCIT Fuel Cell Team
- Steve Chalk, EERE, HFCIT Program Manager
- Valri Lightner, EERE, HFCIT Fuel Cell Program Team Leader
- Sigmond Gronich, EERE, HFCIT Technology Validation Team Leader
- Margaret Mann, NREL

Battelle Project Staff

- Darrell Paul – Program Manager
- Kathya Mahadevan – Technology and Market Analyst
- Kathleen Judd – Market Analyst

Responses to Previous Year Reviewers' Comments

Focus more applications relevant to transportation fuel cells

- Shifted focus to transition markets of value to vehicles

Work more closely with OEMs who have fuel cell products; increases market data and customer involvement

- Increased involvement with OEMs in market selection and technology evaluation
- Shifted focus to emphasize marketing research in support of transition market penetration

Publications and Presentations

- Stone, Harry J. Economic Analysis of Stationary PEM Fuel Cell Systems. 2005 Annual Program Review Proceedings, Meeting May 23-26 in Crystal City, VA, 2005.
- Stone, Harry J. Economic Analysis of Stationary PEM Fuel Cell Systems. 2004 Annual Program Review Proceedings, Meeting May 24-27 in Philadelphia, Pennsylvania, 2004.
- Millett, Steve, and Kathya Mahadevan. Scenario analysis of the commercialization of proton exchange membrane (PEM) fuel cells for stationary applications in the U.S. by the year 2015. 2004 Fuel Cell Seminar, San Antonio, TX, 2004.
- Millett, Steve, and Kathya Mahadevan. Commercialization scenarios of PEMFC applications for stationary power generation in the United States by the year 2015. *Journal of Power Sources*. April, 2005.

Critical Assumptions and Issues

- Users know and understand enough about their energy technologies and fuel cells to provide credible information
- Manufacturers and integrators of fuel cells are willing to provide enough market and product performance information
- Launch success assumes technologies in the field perform to expectations and sufficient incentives are provided to overcome inertia of the status quo and possible cost barriers

