V.0 Fuel Cells Sub-Program Overview

Introduction

The Fuel Cells sub-program supports research, development, and demonstration of polymer electrolyte membrane fuel cells (PEMFCs) including fuel cell stack components, fuel processors for stationary applications, and balance-of-plant (BOP) components. Transportation applications (direct hydrogen fuel cells for vehicles) are one focus of the sub-program since substituting hydrogen from diverse, domestic resources for petroleum-based fuel in light-duty vehicles will significantly reduce dependence on foreign oil and also reduce criteria pollutants and greenhouse gas emissions. PEMFCs are currently the technology of choice for light-duty vehicles because their low temperature operation allows them fast-start capability. The sub-program supports development of small-scale stationary power, portable power (direct methanol fuel cells) and auxiliary power unit (solid oxide fuel cells) technologies. Because the market will tolerate a higher cost of these applications, they are expected to enter the market first. These fuel cell applications should enable consumer awareness and education, and help establish a manufacturing and supplier base.

In Fiscal Year 2007, 25 new projects from a 2006 solicitation/lab call were initiated in the following areas: improved fuel cell membranes, water transport within the stack, advanced cathode catalysts and supports, cell hardware, innovative fuel cell concepts, effects of impurities on fuel cell performance and durability, and stationary fuel cell demonstrations involving international and intergovernmental partnerships. These new projects run two to four years with DOE funding of ~$100M. In FY 2006, 12 new projects aimed at extending the operating range of polymer electrolyte membrane materials to higher temperatures (120°C peak) and lower relative humidity (<50% inlet water vapor pressure) were initiated.

Goal

Develop and demonstrate fuel cell power system technologies for transportation, stationary and portable applications.

Objectives

- By 2010, develop a 60% peak-efficient, durable, direct hydrogen fuel cell power system for transportation at a cost of $45/kW; by 2015, a cost of $30/kW.
- By 2011, develop a distributed generation PEMFC system operating on natural gas or liquefied petroleum gas that achieves 40% electrical efficiency and 40,000 hours durability at $750/kW.[1]
- By 2010, develop a fuel cell system for consumer electronics (<50 W) with an energy density of 1,000 Wh/L.
- By 2010, develop a fuel cell system for auxiliary power units with a specific power of 100 W/kg and a power density of 100 W/L.

FY 2008 Technology Status

The sub-program continues to focus on materials, components, and enabling technologies that will contribute to the development of low-cost, reliable fuel cell systems. Cost and durability are the major challenges for fuel cell systems. Air, thermal, and water management for fuel cells are also key issues. Power density and specific power are approaching targets, but further increases are needed to meet packaging requirements of commercial systems. Efforts continue to evaluate, understand and mitigate degradation mechanisms by the national laboratories, universities, and fuel cell developers. These efforts are being enhanced by the use of advanced imaging techniques for in situ and post-mortem analysis of fuel cell stacks and membrane electrode assemblies. The Technology Validation

[1] Milestone delayed from 2010 to 2011 due to appropriations shortfall and Congressionally directed activities.

sub-program provides fuel cell vehicle data under real-world conditions and supplies valuable results to help refine and direct future activities in fuel cell research and development (R&D).

The Multi-Year Research, Development and Demonstration Plan was updated in April, 2007. The tasks are organized around components (membranes, electrodes, membrane electrode assemblies [MEAs], gas diffusion layers, bipolar plates, seals, and BOP components), supporting analysis, and benchmarking and characterization activities. Task areas are also included for stationary and other early market fuel cells (portable power and auxiliary power units) and for development of innovative concepts for fuel cell systems.

Targets, which vary by application, have been established for metrics such as fuel cell cost, efficiency, durability, power density, specific power, transient response time, and start-up time. Key performance indicators include cost for transportation fuel cells R&D and electrical efficiency for stationary fuel cells R&D. The 2007 cost of a hydrogen-fueled 80-kW_e fuel cell power system at high volume production is $94/kW, a 12% reduction from the 2006 cost of $108/kW on a path toward the 2010 target of $45/kW. For stationary systems, on-going projects show good progress toward higher electrical efficiency, lower cost and improved durability.

FY 2008 Accomplishments

3M has demonstrated a mechanically-stabilized membrane electrode assembly that has operated over 7,300 hours in the lab with voltage cycling, demonstrating the potential to meet the 2010 target of 5,000 hours in an automotive fuel cell system. This MEA incorporates 3M's nanostructured thin film electrode that together with a new alloy catalyst is approaching the 2010 target for total platinum content (g/kW).

The lower total platinum content of alloy catalysts such as that developed at 3M contributed to a reduction in the cost of 80-kW fuel cell systems projected to high-volume manufacturing (500,000 systems/year) from $94/kW in 2007 to $73/kW, as shown in Figure 1.

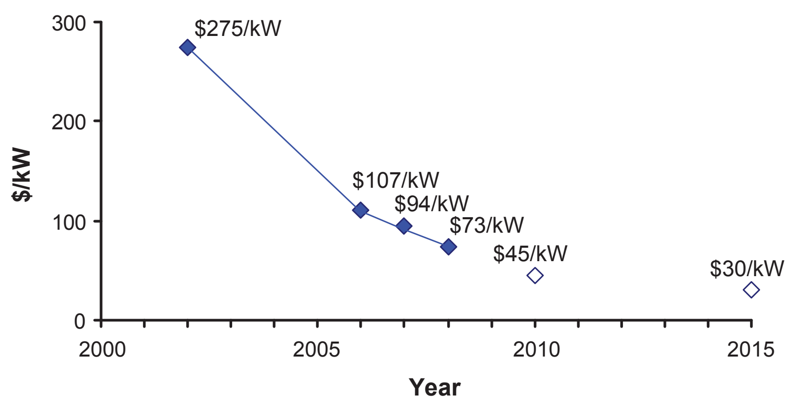


FIGURE 1. Modeled Cost of an 80-kW Fuel Cell System Projected to High-Volume Manufacturing (500,000 Systems/Year)

3M has been developing polymer membranes and MEAs for hot, dry operating conditions utilizing new side-chain structures that have potential to meet the sub-program's conductivity targets. Increased temperature operation and relaxed humidification requirements should lead to simpler, smaller power systems less susceptible to degradation by impurities in the fuel and air. By adding heteropolyacids and stabilizers, 3M has reduced membrane degradation without sacrificing performance. Case

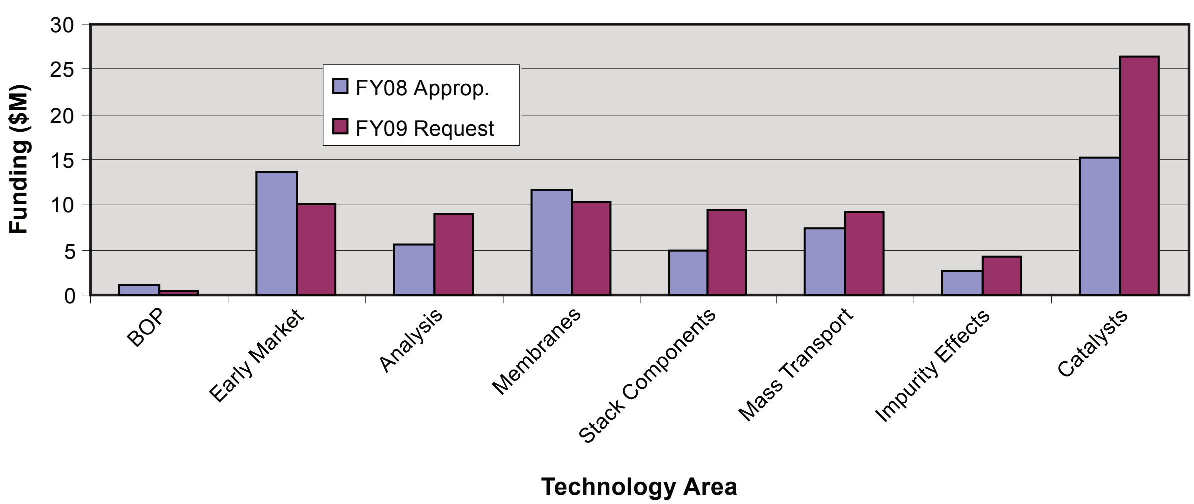
Western Reserve University has demonstrated materials that meet the target conductivity under hot, dry operating conditions, but they need to improve stability and durability of these materials for use in membranes. Fuel Cell Energy has demonstrated good fuel cell performance at these conditions.

Advances in materials and structures are aided by advances in characterization and imaging. Oak Ridge National Laboratory is developing the ability to provide time-resolved atomic resolution of catalysts, which should enable elucidation of catalyst degradation mechanisms. Their continuing work on microstructural characterization using transmission electron microscopy enables developers to visualize the effects of electrode degradation. The National Institute of Standards and Technology's continued development of neutron radiography for imaging water transport in operating fuel cells is utilized by both researchers and industrial developers. This year, a higher resolution capability was developed, promising unprecedented insight into water distribution and aiding in computational model validation.

As fuel cells approach a level of development that can support commercialization, real-world issues such as the development of fuel purity standards have received increased attention. Los Alamos National Laboratory, in collaboration with a number of other national laboratories and research universities, continues to quantify the effects of trace levels of impurities and to elucidate the degradation mechanisms, thereby facilitating development of acceptable operating conditions and of more tolerant materials and systems. This year, testing and modeling demonstrated the effects of cations and sulfur compounds, directly supporting efforts to develop an international hydrogen fuel quality standard.

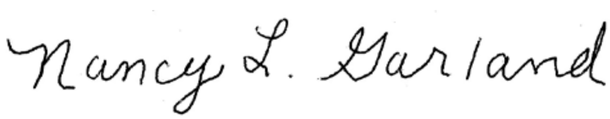
Budget

The President's 2009 budget request (subject to Congressional appropriation) emphasizes research and development on fuel cell stack components (membranes, catalysts, bipolar plates, and catalyst supports) while also supporting research, development, and demonstration for distributed power generation; portable, auxiliary, and off-road power applications; BOP components; and analysis. The following graph shows the budget breakdown by sub-program topic for the 2008 Congressional appropriation and the 2009 budget request.



2009 Plans

Cost and durability of stack components will continue to be a key focus of the Fuel Cells sub-program in FY 2009. Characterization, evaluation, and analysis that provide insight into fuel cell operation, especially characterization of behavior that leads to performance decay and failure, will be emphasized. The new projects started in FY 2007 will continue in FY 2009, subject to numerous go/no-go decision points. The Fuel Cells sub-program released a new solicitation in mid-FY 2008 for projects aimed at meeting the 2010 cost and technical targets.



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