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 the primary 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 (APU, solid oxide fuel cells) technologies. The market will tolerate a higher cost of these applications so portable, stationary and APU fuel cells are expected to enter the market first. These fuel cells should enable consumer awareness and education, and help establish a manufacturing base.

In FY 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 will 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

The primary focus is on fuel cells for transportation applications, with the following 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.

The secondary focus is on stationary power and other early market fuel cell applications to establish the manufacturing base, with the following objectives:

- 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 2007 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

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

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 sub-program provides fuel cell vehicle data under real-world conditions and, in turn, supplies valuable results to help refine and direct future activities in fuel cell 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. For transportation applications, the 2005 cost target has been met assuming high volume production. The 2006 cost of a hydrogen-fueled 80-kW_e fuel cell power system at high volume production is $107/kW, compared to the 2005 target of $125/kW. For stationary systems, the 2005 target of 32% electrical efficiency at full power was met.

FY 2007 Accomplishments

DuPont developed a membrane that operates almost 5,000 hours with both humidity and voltage cycling. Reinforcement provides mechanical stability; chemical stability is increased by replacing the reactive end groups of the polymer with stable moieties. Advanced stabilization strategies are used for peroxide mitigation.

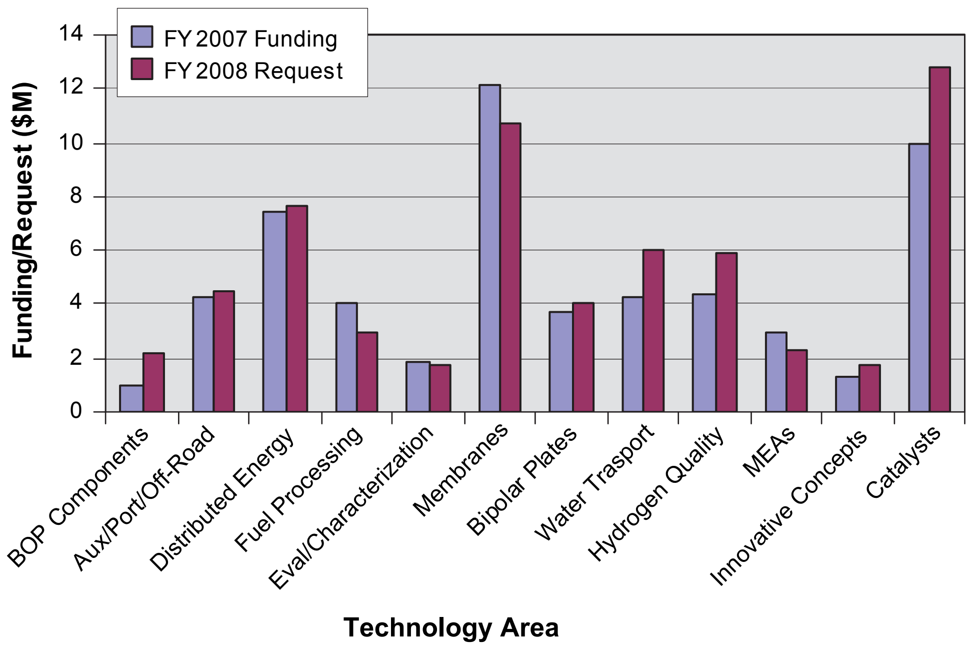
Arkema has been developing blends of Kynar®, i.e. PVDF (polyvinyledene fluoride), a very stable chemical that provides mechanical stability with a proton conducting polymer electrolyte. Their initial membranes had issues with loss of sulfonic acid groups. Arkema addressed this issue by eliminating the vulnerable linkage to the sulfonic group while maintaining conductivity. Their latest generation membrane shows very little increase in degradation products up to 2,500 hours. 3M correlated the initial fluoride release rate from a membrane with the lifetime to generate a method to estimate MEA lifetime relative to DOE's 2010 stationary system goals.

3M had increased the durability of their non-precious metal catalysts achieving 1,000 hours of operation with practically no irreversible degradation losses.

Los Alamos National Laboratory is correlating changes in material compositions and fuel cell operation with changes in water transport in the fuel cell. Changes in mass transport properties during fuel cell operation lead to decreased performance and are correlated to hydrophocity loss of the gas diffusion layer. Fluorine redistributes in the gas diffusion layer during start/stop operation which could be a problem because the Teflon® loading in the gas diffusion layer affects water transport.

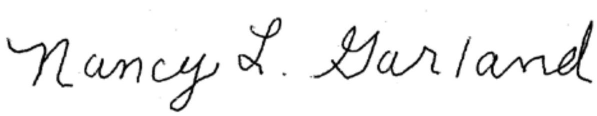
Budget

The President's 2008 budget request (subject to Congressional appropriation) emphasizes R&D on fuel cell stack components (membranes, catalysts, bipolar plates, and catalyst supports) while also supporting RD&D for distributed power generation and fuel processing for stationary power; portable, auxiliary, and off-road power applications; BOP components; and analysis. The graph below shows the budget breakdown by sub-program topic for the 2007 Congressional appropriation and the 2008 budget request.



2008 Plans

Cost and durability of stack components will continue to be a key focus of the Fuel Cells sub-program in FY 2008. 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 ramp-up activities in FY 2008. The Fuel Cells sub-program plans to release a new solicitation in late FY 2008 for projects aimed at meeting the 2010 cost and technical targets.



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