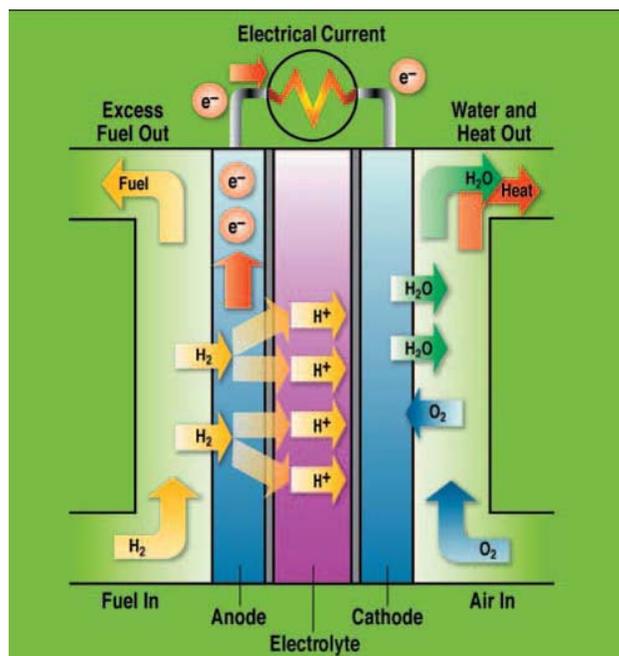


## VII Fuel Cells

### VII.1 Fuel Cells Sub-Program Overview

#### Introduction

The Fuel Cells Sub-Program supports research and development of polymer electrolyte membrane fuel cells (PEMFC) including fuel cell stack components, fuel processors for stationary applications, and balance-of-plant components. Transportation applications (direct hydrogen fuel cells for vehicles) are the primary focus of the sub-program since substituting domestically produced hydrogen for petroleum-based fuel in light-duty vehicles will significantly reduce our dependence on foreign oil, diversify our energy resources, and reduce pollution and greenhouse gas emissions. PEMFCs are currently the technology of choice for light-duty vehicles because they have fast start capability and operate at low temperatures. The sub-program also supports stationary power, portable power (direct methanol fuel cells) and auxiliary power unit applications (solid oxide fuel cells) to a limited degree.



In FY 2005, significant advances were made in the following areas: catalyst development, membranes and bipolar plates. A solicitation (\$17.5 million available over 5 years) was issued for development of high-temperature ( $\leq 120^{\circ}\text{C}$ ), low relative humidity (25-50% RH) polymer electrolyte-type membrane materials suitable for use in a PEMFC. A second solicitation with a broader scope is also planned for release in FY 2006, which could provide up to \$100 million over four years for fuel cell R&D in the following topic 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. The sub-program held the “Workshop on Operation of Fuel Cells at Sub-Freezing Temperatures” in February 2005 to identify technical challenges and R&D needs related to start-up and operation of fuel cells at sub-freezing temperatures. Research over the past year at Los Alamos National Laboratory has also helped to define problems and issues associated with cold-starts and the freeze-thaw cycle, which, combined with the workshop results, will help inform a focused R&D effort to address these issues.

#### 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 2010, develop a distributed generation PEM fuel cell system operating on natural gas or liquefied petroleum gas that achieves 40% electrical efficiency and 40,000 hours durability at \$400-\$750/kW.
- 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 (3-30 kW) with a specific power of 100 W/kg and a power density of 100 W/L.

### **FY 2005 Technology Status**

Cost and durability are the major challenges to fuel cell commercialization. Size, weight, and thermal and water management are also key barriers. 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. Validation of fuel cell technology targets related to real-world performance, reliability, durability and environmental benefits is conducted in the Hydrogen Infrastructure and Fuel Cell Vehicle Learning Demonstration Project (see Section VIII.A). The Multi-Year Research, Development and Demonstration Plan was updated in February 2005. The major changes in the fuel cell section of the plan were the removal of the target tables for on-board fuel processors resulting from the decision to discontinue those activities in August 2004; the addition of target tables at the component level (membranes, electrocatalysts, membrane electrode assemblies, bipolar plates) to support the shift from systems development to R&D at the component level; and the addition of a hydrogen quality table.

Targets, which vary by application, have been established for fuel cell cost, efficiency, durability, power density, specific power, transient response time, start-up time, and emissions, among others. 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. The 2005 cost of a hydrogen-fueled 80-kW fuel cell power system is \$110/kW, compared to the 2005 target set at \$125/kW. For stationary systems, the 2005 target of 32% electrical efficiency at full power was met for a natural gas or propane fueled 50-250 kW stationary fuel cell system.

### **FY 2005 Accomplishments**

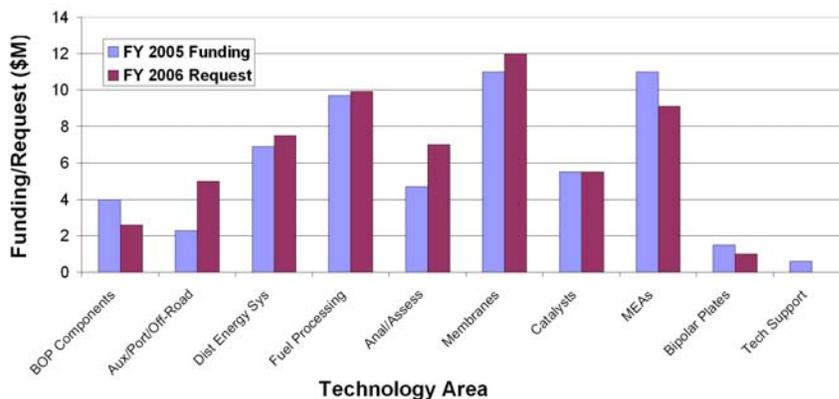
- Carried out durability testing at steady-state conditions and simulating a vehicle drive cycle, and characterized membrane electrode assemblies (MEAs) *in situ* by polarization curves and electrocatalyst surface area measurements (Los Alamos National Laboratory).
- Developed a membrane that can be mass-produced, with conductivity comparable to Nafion<sup>®</sup>, durability of >4000 hours, and when incorporated into an MEA, platinum loading that is lower than DOE's 2010 target (3M).
- Organized and conducted a workshop on fuel cell operation at sub-freezing temperatures; demonstrated survivability for 40 sub-freezing cycles down to -40°C using cloth gas diffusion layers (Los Alamos National Laboratory).
- Completed the first phase of round robin fuel cell testing as part of the U.S. Fuel Cell Council's efforts to develop single-cell testing protocols (Los Alamos National Laboratory).
- Demonstrated 20x improvement in Pt mass-specific activity of PtRe/Pd/C and Pt/Au/Ni/C catalysts over commercial Pt/C catalysts (Brookhaven National Laboratory).
- Developed and validated an automotive fuel cell system model, specifically targeting humidification systems and operation at subfreezing conditions to guide the development of technical targets (Argonne National Laboratory).

- Identified the significant changes to the catalyst size and structure within a membrane electrode assembly after cycling and long-term fuel cell operation using advanced microstructural characterization techniques (Oak Ridge National Laboratory).

## Budget

The President's 2006 Budget Request (subject to Congressional appropriation) emphasizes R&D on fuel cell stack components (membranes, MEAs, bipolar plates, and advanced catalysts) while also supporting R&D for stationary fuel processors, balance-of-plant (BOP) components, and technical analysis. As recommended by the 2004 National Research Council report, the Fuel Cell Sub-Program continues to increase

government funding for high-risk R&D that can lead to breakthroughs in fuel cell materials and component designs that lower costs, improve durability and increase reliability. The graph above shows the budget breakdown by major sub-program areas for the 2005 Congressional appropriation and the 2006 budget request.



## 2006 Plans

Cost and durability of stack components, i.e., membranes, catalysts, bipolar plates, membrane electrode assemblies, etc., will continue to be a key focus of the Fuel Cell Sub-Program in FY 2006. Focus on characterization, evaluation and analysis to provide insights into fuel cell operation, especially characterization of behavior that leads to performance decay and failure, will be emphasized. Awards from the high-temperature, low-humidity membrane solicitations will be made. Selections from the broader fuel cell solicitation will be made with plans to initiate the projects in FY 2007, depending on appropriations.

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