DOE/EE Transportation Perspective

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Introduction

Fuel cells represent a developing technology which could potentially replace the internal combustion engine in all areas of the transportation sector. They operate with significantly higher fuel efficiency, greatly reduced emissions, and the capability of running on a variety of fuels (such as hydrogen, ethanol, methanol, and natural gas). The widespread introduction and use of fuel cell vehicles could have a major impact on reducing petroleum consumption and on improving air quality in urban areas. This paper provides an update on the status of the U.S. Department of Energy (DOE) program directed at the development of fuel cell propulsion systems for transportation applications.

Program Drivers

This program is responsive to requirements of the U.S. Energy Policy Act of 1992 (EPACT) which authorizes the development of fuel cell vehicles. It also represents the key fuel cell work being done under the Partnership for a New Generation of Vehicles (PNGV) -- a U.S. government/industry research and development initiative involving representatives from seven Federal agencies and the three major domestic automakers (Chrysler, Ford, General Motors) that began in 1993 to strengthen U.S. competitiveness in the automotive industry. DOE's program specifically addresses the PNGV goal of developing a vehicle to achieve up to three times the fuel efficiency of today's comparable vehicle.

Besides the legislative drivers for this program, there is keen international competition in the race to develop PEM power systems for automobiles -- extensive efforts are underway in North America, Europe and Japan. Toyota demonstrated a fuel cell powered vehicle in late 1996. Daimler-Benz has built a second-generation six-passenger van powered by a 50-kW PEM fuel cell and has announced plans to demonstrate a small A-class car powered by fuel cells at the October 1997 Tokyo Auto Show. Daimler-Benz and Ballard Power Systems of Canada have announced a joint venture in which they will invest over $200 million during the next three years in the development and commercialization of fuel cell engines.

Program Goal

The goal of the DOE Fuel Cells in Transportation Program is to develop highly efficient, low or zero emission automotive fuel cell propulsion systems. Specific objectives include: By the year 2000, validate fuel cell propulsion systems that are (a) 2-3 times more energy efficient than today's comparable vehicles; (b) more than 100 times cleaner than Federal EPA Tier II emissions standards; and (c) capable of operating on hydrogen, methanol, ethanol, natural gas, and gasoline. In addition, by the year 2004, our objective is to validate fuel cell propulsion systems that meet customer expectations in terms of cost (competitive with conventional vehicles) and performance (equivalent range, safety, and reliability as conventional vehicles).

Technical Accomplishments

Recent technical accomplishments of the program will be presented. Some highlights include:

• Platinum Catalyst Reduction -- Catalyst loadings on fuel cell electrodes were reduced to 0.25 mg/cm2 with performance validated in 10-kW size stacks.

• Advanced Bipolar Plates -- Low-cost, lightweight metallic plates were developed by Mechanical Technology Inc, Allied Signal, and Delphi Automotive Systems and validated in fuel cell stacks of up to 10-kW size. As a result, stack power densities of greater than 400 W/kg were attained.

• Automotive-Size Stacks -- A full-size 50-kW PEM fuel cell stack was built and tested.

• Fuel-Flexible Reformer -- A 50-kW partial oxidation reformer was developed and demonstrated by Arthur D. Little, with measured efficiencies of 78% and 84% for gasoline and ethanol, respectively.

• Carbon Monoxide Clean-Up System - Los Alamos National Laboratory developed a preferential oxidation (PrOx) system to convert low levels of carbon monoxide to carbon dioxide in reformed fuels. The PrOx system reduces the CO concentration from greater than 1% to less than 0.01%, a level that does not degrade fuel cell performance.

• Low-Temperature Reforming Catalyst for Gasoline -- Argonne National Laboratory developed a novel, fuel-flexible partial-oxidation (POX) catalyst for reforming gasoline and alternative fuels. The product gas contained 60% hydrogen for gasoline and ethanol, 65% for methanol, and 72% for natural gas.

• High-Efficiency Air Compressors and Expanders -- Scroll, variable-displacement, and turbo compressors were built and tested. Air compressor efficiencies of 86%, and expander efficiencies of 90%, were measured with minimal loss in efficiency over a broad range of flow conditions.

• Fuel Cell Vehicle Design -- Fully configured fuel cell vehicle designs were developed by Ford, General Motors, and Chrysler Pentastar.

• Membranes for Direct Methanol Fuel Cells -- Improved membranes were developed by a team from International Fuel Cells and the Universities of Connecticut, Iowa, and Southern Mississippi. A Nafion/poly (propylene) dendrimer membrane reduced methanol crossover by 67% while adding only 8 mV to the cell voltage loss compared with Nafion 117 at 0.1 A/cm2.

• Modeling and Simulation -- Detailed systems models were developed at Argonne National Laboratory to permit PNGV to conduct systems analysis and vehicle engineering studies for fuel cell vehicles.

• Manufacturing Assessments -- Studies by divisions of General Motors, Ford and Chrysler concluded fuel cells could be manufactured in quantity at a price comparable to today's internal combustion engine.

Future R&D Activities

DOE conducted a competitive procurement in 1997 for focused R&D on transportation fuel cells. DOE's future fuel cell R&D activities, to be completed during the next 2-3 years under $50 million of new cost-shared initiatives, will be disclosed and discussed.