STATUS OF SOFC DEVELOPMENT IN U.S.A.

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ABSTRACT

Solid oxide oxide fuel cells represent a highly efficient power generation/cogeneration source in the United States and worldwide. Currently, the U.S. is a leader in this technology in the tubular, monolithic and planar solid oxide fuel cell areas. In addition, research is being conducted in intermediate temperature solid oxide fuel cells. An overview of the status of these technologies, research, and critical issues is presented.

INTRODUCTION

Solid oxide fuel cells represent a highly efficient power generation/cogeneration source in the United States and worldwide. These systems provide an opportunity to generate electrical energy at electrical efficiencies up to 60 percent (HHV) with a high temperature thermal by-product that can be used for space heating, industrial processing, or additional electrical generation. They are projected to have low particulate and gaseous emissions and should be readily siteable. As a result, they are of particular interest to the U.S. Department of Energy.

DEVELOPMENT ACTIVITIES

Fuel cell research and development by the private sector in the U.S. began in the 1950s. In the 1960s, the National Aeronautics and Space Administration (NASA) used fuel cells successfully in the Apollo and Gemini spacecrafts, and private sector groups began developing fuel cell power plants directed toward residential and commercial applications. In the 1970s, this effort was broadened to include electric utility power plant applications. The U.S. Energy Research and Development Administration (ERDA) became actively involved in fuel cell research and development in 1976, and this activity was transferred to DOE in 1978.

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technologies, research, and critical issues is discussed below.

The primary objective of DOE’s Fossil Energy Fuel Cell program is to fund the
development of key fuel cell technologies in a manner that maximizes private sector
participation and in a way that will give contractors the opportunity for a competitive
posture, early market entry, and long-term market growth.

The SOFC technology is currently characterized by tubular and monolithic/planar
cell concepts. The tubular concept is the most developed technology. Standard cell
length has been increased from 36 to 100 cm (14.2 to 39.4 in.). Cell technology and
scale-up activities continue. The tubular SOFC program is continuing subscale
bundle/generator tests and is now positioned to commence with the design and tests of
commercial-scale technology (i.e., 100 kW). A 20-kW tubular SOFC generator was
successfully tested for approximately 3000 hours on a variety of fuels including
hydrogen, natural gas, and naphtha. One 25-kW DC generator and one 25-kW AC
cogeneration unit have been customer tested for more than 1400 hours each. In addition,
single and multi-cell tests have been conducted for over 32,000 hours. It is planned to
begin testing a 100-kW AC generator by early 1994.

The monolithic SOFC (MSOFC) technology is in the bench-scale developmental
phase. Testing of single laboratory scale (1 in. x 1 in.) cells has shown increased
performance. A 100-watt nonfunctional stack was successfully built to verify process
development advances.

The SOFC AR&TD (Advanced Research and Technology Development
Program) is continuing with research at Argonne National Laboratories (ANL)
(alternative SOFC electrolytes and SOFC seals), Pacific Northwest Laboratories (PNL)
(alternative SOFC materials research), and Westinghouse Science and Technology
Center (effects of contaminants on the SOFC).

Program goals for the SOFC have been identified. The mature market installed
cost goal ranges from $1000 to $1200/kW (for natural gas or coal fueled, respectively)
with an endurance goal of 40,000 hrs. In the tubular SOFC program, single-cell testing
is demonstrating that the technology can maintain state-of-the-art performance for
extremely long test periods (i.e., 25,000+ hours). Commercial performance goals for the
program range from 134-430 mW/cm² (124-400 W/ft²) operating at 0.5 to 0.7 volts per
cell and 250-700 mA/cm² (230-645 A/ft²). Selecting specific performance design points
will vary according to system application. Cell lengths between 1 and 2 meters are
projected.
In the MSOFC program, the initial development goal is to demonstrate the capability to fabricate 100-Watt stacks. The single cell performance goal is 0.5 volts per cell and 150-250 mA/cm$^2$ (140-235 A/ft$^2$). A cell size of 6.5 $\times$ 6.5 cm (2.6 $\times$ 2.6 in.) is projected for these laboratory stacks. Commercial cells are expected to have a cell size of 15.2 $\times$ 15.2 cm (6 $\times$ 6 in.) and a performance of 0.5 volts per cell at 500 mA/cm$^2$ (465 A/ft$^2$).

The following contractors have been funded by the DOE to develop fuel cell stacks with a goal of selling on-site, industrial, and electric utility units:

- Allied Signal, Torrance, California.
- SOFC monolithic
- Westinghouse, Pittsburgh, Pennsylvania.
- SOFC tubular.

Several alternative concepts are being funded through the Small Business Innovative Research (SBIR) Program. In addition, DOE has been funding Argonne National Laboratories, Pacific Northwest Laboratories, and the University of Missouri-Rolla, to address some of the baseline issues.

FUTURE PROGRAM

DOE is planning on releasing a Request for Proposals (RFP) in the planar SOFC area in the first quarter of 1993. It is planned that this will include all variations of planar SOFC configurations including state-of-the-art planar and monolithic configurations for both intermediate and high temperature SOFC’s. Awards are expected by August of 1993.

In addition, both Electric Power Research Institute (EPRI) and Gas Research Institute (GRI) are planning on continuing their baseline programs.