Solid State Energy Conversion Alliance (SECA) Solid Oxide Fuel Cell Program

Nguyen Q. Minh
GE Hybrid Power Generation Systems (HPGS)
19310 Pacific Gateway Drive
Torrance, CA 90502-1031
(310) 538-7250
nguyen.minh@ps.ge.com

Donald Collins
(304) 285-4156
donald.collins@netl.doe.gov

Objectives

- Develop a low-cost, high-performance 3-to-10-kW solid oxide fuel cell (SOFC) system suitable for a broad spectrum of power-generation applications.
- Demonstrate a fuel-flexible, modular SOFC system that can be configured to create highly efficient, cost-competitive, and environmentally benign power plants tailored to specific markets.

Key Milestones

- Complete preliminary system cost estimates and identify cost areas.
- Complete SOFC stack design.
- Complete pre-reforming design and demonstrate operation for various fuels.
- Define a prototype system.
- Complete system cost estimation.
- Demonstrate a prototype system of the baseline design.
- Develop a detailed design for the application specified in Phase I (Phase II).
- Demonstrate a packaged system in field-test to meet operational characteristics (Phase III).

Approach

The SOFC system is a power module (3- to 10-kW) capable of operating on a variety of fuels. The system consists of all the required components for a self-contained unit, including fuel cell stack, fuel processing subsystems, fuel and oxidant delivery subsystem, thermal management subsystem, and various control and regulating devices. The system is also designed to be modular and can be integrated to form a larger system. Figure 1 shows an example of the system concept.

The key components include a low-cost, lightweight SOFC and a compact, fuel-flexible fuel processor, along with thermal management and advanced control subsystems:

- The SOFC is a compact stack of thin-electrolyte cells (fabricated by the GE HPGS tape-calendering process) and thin-foil metallic interconnects. The stack design is based on an advanced concept that maximizes active cell area and minimizes sealing. The fuel cell can operate directly on light hydrocarbon fuels (such as natural gas) and incorporates materials for high performance at reduced temperatures (<800°C). These characteristics provide a low-cost, fuel-flexible fuel cell suitable for operating under various conditions, without significant redesign or modification of the system. The tape-calendering process for manufacturing thin-electrolyte cells is a potentially low-cost, mass-customization technique suitable for high-volume production and automation using available commercial equipment.
- The fuel processor is a catalytic reactor that functions as a pre-reformer. Depending on the type of fuel and operating conditions, the pre-reformer can be operated as catalytic partial oxidation (CPOX) or autothermal reforming (ATR) for processing different fuels. These characteristics permit a lightweight, compact, fuel-flexible fuel processor design, resulting in smaller system size and lower cost.
- The system employs an integrated thermal management approach to utilize by-product heat and reduce heat losses, and, consequently, increase the overall

system efficiency. The system also has a flexible control structure that can be modified or optimized for different applications.

GE HPGS uses its system engineering approach and manufacturing and product development experience along with its Six Sigma and other design methodologies in the development of the systems. There is an advisory team to support the program by providing guidance on application requirements market assessment, and the direction of development areas. Phase I will culminate in a demonstration of a modular, fuel flexible system operating under conditions required for different applications. A specified application will be selected at the beginning of Phase II. Phase II will result in a demonstration of a package system for the specified application. Phase III will result in field testing of a packaged system for the specified application for extended periods to demonstrate operating characteristics required for commercial power plants.

Results

Progress in this program can be summarized in several areas:

- The detailed program schedule has been completed. Requirements of program and its subtasks have been defined. All the technical tasks have been initiated.
- The various fuel processing options (heterogeneous CPOX, electrochemical CPOX, ATR, steam reforming, all with additional internal reforming within the fuel cell stack, and internal reforming only) have been evaluated and assessed.
- System design tools have been established. A baseline system has been defined. A preliminary conceptual design has been detailed and system performance has been projected. A preliminary system cost model has been nearly completed.
- Progress in stack design, material evaluation, lifetime, control and power electronics, and thermal management has been made. Conceptual stack designs have been under investigation. Cell components have been fabricated and their performance is under evaluation.

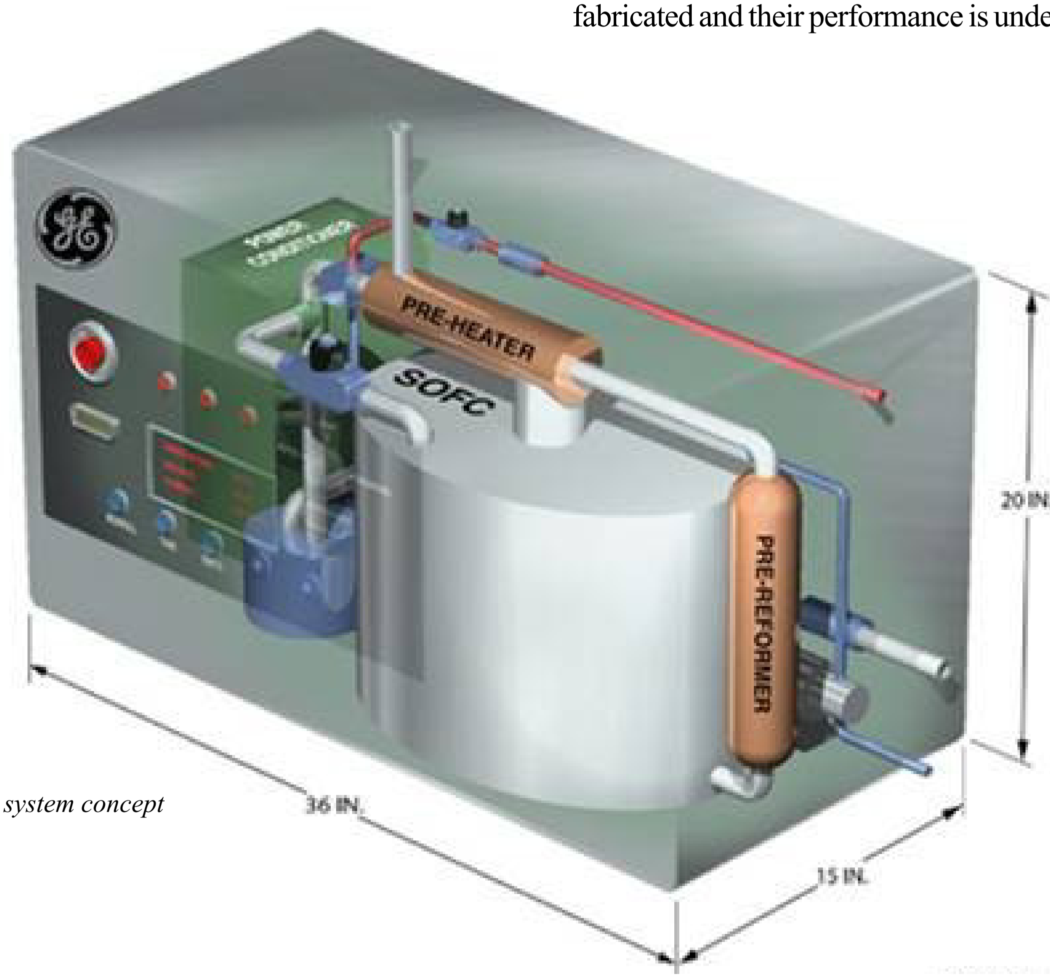

Figure 1: *SOFC system concept*

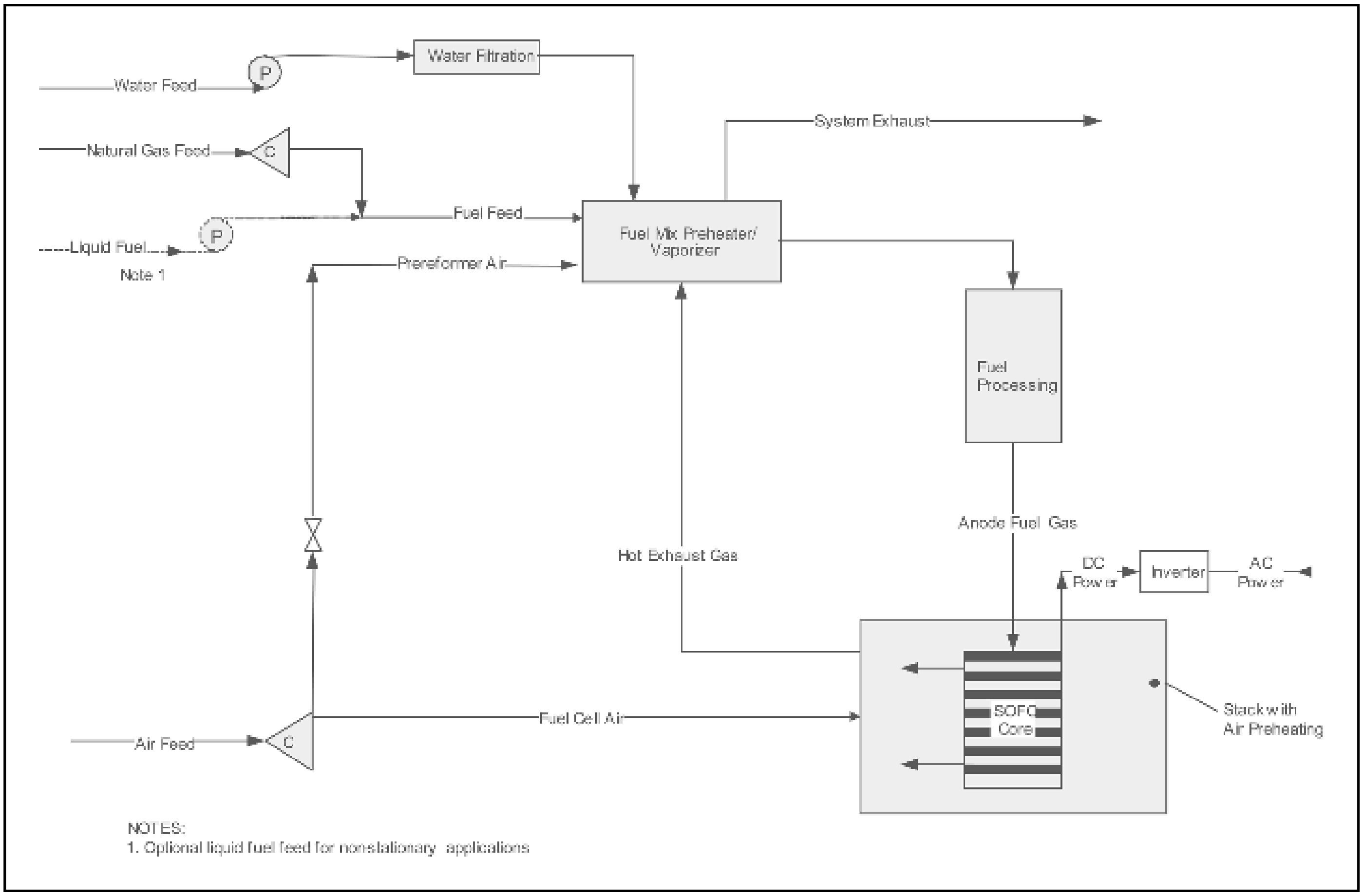

Figure 2: *Preliminary conceptual system design*

	Stationary	Mobile	Military
Fuel	Natural Gas	Gasoline	Diesel
Stack			
Voltage, V	0.75	0.75	0.75
Utilization	0.80	0.80	0.80
Power			
Fuel cell, kW	5.7	5.9	6.1
Net, kW	5.0	5.0	5.0
Efficiency			
Net, %	40	33	30

Figure 3: *System performance estimates*

Conclusions

The Solid State Energy Conversion Alliance (SECA) Solid Oxide Fuel Cell Program was awarded in FY 2001. Significant progress has been achieved across the areas planned. Successful integration of all the required components will demonstrate a fuel-flexible, modular SOFC system that can be configured to create highly efficient, cost-competitive, and environmentally benign power plants tailored to specific markets.