Recent publications

1 Feasibility study of SPE fuel cell power plants for automotive applications, General Electric Company, *Final Report No. LANL-2*, Los Alamos National Laboratory, December 1981.

ASSESSMENT OF PHOSPHORIC ACID FUEL CELLS (PAFC) FOR VEHICULAR POWER SYSTEMS

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The purpose of this program was to provide the information necessary to critically assess the technical and economic viability of a vehicular power plant based on a PAFC stack.

The power plant was required to use methanol as the fuel and air as the oxidant. A 58 wt.% methanol–water mixture was selected as the fuel. UTC's approach to assessing the potential of the PAFC consisted of six steps:

- There was preliminary screening to select the best near-term power plant approach for vehicle application.
- A near-term power plant based on application of the designs and technology status demonstrated in power plants delivered for utility application was defined at a level of detail permitting physical description of each of nine major components.
- The deficiencies of this power plant relative to the vehicle goals were identified.
- Specific improvements to overcome these deficiencies were identified, and an approach with tangible evidence of potential feasibility was selected to overcome each deficiency.
- An advanced power plant, based on these improvements, was defined, and its characteristics were estimated and compared to the goals.
- A program to develop an advanced vehicle power plant that meets the goals was defined.

In the near-term power plant based on demonstrated cell stack and fuel processor technology and designs, fuel flows through the cell stacks where reject heat is used to vaporize the fuel and is circulated to a vapor separator. The methanol–water vapor is passed over a reform catalyst and converted to a hydrogen-rich gas. This gas passes through the fuel cell where 85 percent of the hydrogen is consumed. The remaining hydrogen is burned to provide reformer heat.

The characteristics of this power plant were estimated based on several key features:

TABLE 1

Comparison of near-term power plant and advanced power plant characteristics to vehicle goals

	Vehicle goals	Fuel cell power plant characteristics near-term	advanced
Rated power (kW)	20	20	20
Peak power (kW)	60	30	60
Efficiency (%)	maximum	44	50 - 60
Weight (lb)	680	780	500 - 600
Volume (ft^3)	24	26	12 - 15
Startup time (min)	minimum*	7 - 10	5 - 7
Production cost ($/kW)	minimum*	250 - 300	150 - 250
Overhaul period (h)	5000*	5000	5000

*Goals established by UTC; all others specified by LANL.

- Demonstrated cell performance,
- Demonstrated cell design and cell weight per unit area,
- Reform catalyst performance equal to the initial level demonstrated for the catalyst used in UTC's 1.5-kW Army power plant, and
- Short-term stack over-temperature permissibility.

The power plant characteristics are compared to the vehicle goals in Table 1. High volume and low overload capability are the major deficiencies.

A determination of the contribution of individual system components of the intermediate power plant to weight, volume, and cost indicated that weight and volume are controlled by ancillary system components and cost is controlled by the cell stack.

The approach selected to reduce ancillary component size is to integrate the cell stack and reformer as much as possible both thermally and physically. This will reduce the demand on ancillary components, improve packaging, and improve power plant efficiency.

Two approaches are available for increasing overload capability to the required level. The first approach increases stack area so that the required overload power can be delivered. This would increase efficiency but would double stack size and aggravate weight, volume, and cost problems. The other approach is to improve cell performance. Two improved performance levels are envisioned. The lower improved performance level utilizes improved electrode and electrolyte matrix materials and structures to reduce diffusion and resistance losses. A higher level of improved performance requires a change in the cathode reaction.

Two approaches to changing the cathode reaction are considered. One involves changing the electrolyte. Unfortunately, the electrolytes that have been shown to accomplish this improvement appear to require lower cell temperatures. Operating at reduced cell temperature would eliminate the efficiency advantages associated with cell stack and reformer integration and increase performance losses associated with carbon monoxide in the fuel gas. Another approach involves substituting an intermediate reactant for oxygen. The reactant is reduced in an electrochemical reaction at the cathode and then oxidized chemically to its initial state (a redox couple).

Table 1 shows that the advanced power plant defined in the study can meet the goals. Further improvements, particularly in startup time and cost, may be achievable, and alternative approaches may also meet the same goals.

The following are key features of the advanced power plant:

- Atmospheric pressure operation,
- Cell stack and reformer physically and thermally integrated in an approach known as internal reforming,
- Improved cell performance compared to existing power plants,
- Ancillary components designed for the specific power plant to reduce weight and volume, and
- Stack can be operated at elevated temperatures for short periods.

The following program to develop an advanced vehicle power plant was outlined as part of the study:

- Further conceptual design studies that consider integration of the power plant and the vehicle to explore the best selection of system configuration and system design point in the context of vehicle performance and economic trade-offs for a passenger car, delivery van, and city bus;
- Investigation of cell stack technology improvements in the areas of higher performance and reduced cost;
- Investigation of more tolerant and more effective reform catalysts and improved reformer configurations and cell stack/reformer integration; and
- Development of an advanced power plant for vehicle applications and testing of this power plant in a vehicle environment to evaluate vehicle design requirements and power plant potential.

In 1983, electrochemical research will address investigations of redox and alloy electrocatalysts with the goals of higher performance and reduced cost.

Recent publications

1 Assessment of phosphoric acid fuel cells for vehicular power systems, United Technologies Corporation, *Final Report No. FCR-4059*, Los Alamos National Laboratory, March 1982.