- 24 to 25 lb/kW;
- 0.80 to 0.92 ft^3/kW, using a packing factor of 0.5; and
- \$95 to \$100/kW, assuming a mass production of 100 000 units/yr.

The LANL guidelines for weight (less than 700 lbs) and volume (less than 12 ft^3) of the 20-kW passenger car power plant were satisfied by both of the power plants.

Both conventional reforming and partial oxidation/reforming fuel processing options were considered. Both approaches were found to be feasible although system efficiency was lower for the partial oxidation option.

The peak power of the PAFC power plant was 61 kW. The peak power of the TFMSA fuel cell power plant was 10 kW higher than that of the PAFC. The pressurized reformer had a sufficient inventory of reformed gas to support this peak power of 71 kW for 0.7 s.

Because of the similarity of the results for the two power plants and the immaturity of the TFMSA technology, no effort is planned for TFMSA fuel cells in 1983. Plans for the PAFC are described in the "Assessment of Phosphoric Acid Fuel Cells for Vehicular Power Systems" summary.

Recent publications

1 Assessment of trifluoromethane sulfonic acid and phosphoric acid fuel cells for vehicular power plants, Energy Research Corporation, *Final Report, Contract No. 4-L61-3861 V-1*, Los Alamos National Laboratory, December 1981.

ASSESSMENT OF SOLID POLYMER ELECTROLYTE (SPE) FUEL CELLS FOR VEHICULAR POWER PLANTS

General Electric Company, Wilmington, MA 01887 (U.S.A.)

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 an SPE fuel cell stack.

The power plant system was required to use methanol as the fuel and air as the oxidant. Physical and electrical power plant requirements for providing suitable performance in a compact passenger car were established by LANL.

A baseline SPE power plant system was designed. This system is perhaps not the optimum configuration, but it does serve to indicate the possible capabilities of the SPE power plant. As shown in Table 1, the baseline power plant system design easily meets the volume and weight requirements. The power and voltage characteristics match those specified.

The following are major features of the baseline SPE power plant system.

TABLE 1

Comparison of SPE power plant requirements and baseline system

Item	Requirement	Baseline system
Volume (ft^3)	12	4.1*
Weight (lb)	700	337
Net peak power (kW)	60	66
Net continuous power (kW)	20	20
Nominal system (V d.c.)	96	96
System efficiency at net continuous power (% HHV)	—	50

*Volume of components or 34 percent packing density in 12 ft^3.

- The system operates on dry methanol rather than a methanol–water mixture, thus leading to a significant reduction in weight and volume of fuel carried onboard for any given vehicle range. The SPE cell is designed to produce liquid water at the cathode electrode. The water is then used in the fuel processing section for shift conversion to reduce the carbon monoxide level to an acceptable percentage (0.17 percent) of the fuel feed stream entering the fuel cell.
- Rapid on-stream response and peak power are provided by electrolysis-produced hydrogen and oxygen stored onboard. The electrolyzer uses a fraction of output power during low-power intervals, providing pure hydrogen and oxygen for high performance on demand. This also allows rapid system startup from ambient temperature because full-rated continuous power can be drawn from the SPE fuel cell at room temperature on hydrogen/oxygen while the fuel processor comes to operational temperature.
- The reaction air is mechanically compressed at the cathode inlet in a free piston compressor. The work for this compression comes from a combination of expansion of the cathode exhaust and a portion of the steam generated in removing the waste heat of the fuel cell by boiling water within the cell coolant chambers.
- Projected cost for systems at a production rate of 100 000 systems/yr is approximately \$164/kW (1981 dollars). To achieve this cost it was assumed that

  –Catalyst loading could be reduced from the present 8 g/ft^2 of active area to 0.75 g/ft^2 and

  –An SPE costing less than \$10/ft^2 could be used rather than the present Nafion membrane, which costs \$35/ft^2.

Based on this study, it appears that given adequate research and development, it is feasible to consider SPE fuel cell power plants for transportation applications. Electrochemical research in 1983 will address reducing the catalyst loading and obtaining a low-cost SPE.

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

United Technologies Corporation (UTC), South Windsor, CT 06074 (U.S.A.)

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: