Fuel Cells

Fuel cells use a chemical reaction to produce electricity and heat from any hydrogen-rich fuel. Originally invented in 1839 (sic), they have been used on spacecraft starting with the Mercury and Apollo programs, and long have been a subject of research and development for applications on earth.

With costs of power inversion coming down quickly, and significant advances in the actual fuel cells and fuel reforming, fuel cells may at last be on the verge of commercial viability.

Fuel cells run quietly, without moving parts. They maintain their efficiency over a wide range of loads and can be used for load following. They have no combustion cycle, and do not need cooling water. But the driver in fuel cell development is its potential use in hybrid cars to reduce air pollution.

Fuel cells can run on any hydrogen-rich fuel, such as natural gas or methanol. The ultimate fuel of choice for fuel cells is pure hydrogen. If hydrogen is produced from fossil fuels, the fuel processing produces waste heat. When the process and fuel cell heat are used to produce hot water for domestic or commercial use, the combined electric and thermal fuel use efficiency can exceed 90 percent.

BPA Activities to Date

BPA has a 5-kilowatt demonstration fuel cell with a fuel reformer that converts methanol and water into hydrogen and carbon dioxide. It will be used in remote locations where emergency propane or diesel powered backup generation and battery storage would otherwise be used.

Implications for BPA's Future

BPA could use fuel cells directly in the power system to replace other forms of back-up power in remote locations. This could help avoid building costly transmission that might result in stranded costs.

How a Fuel Cell Works

Fuel cells separate hydrogen ions and electrons at an anode through a chemical reaction. The ions flow through an electrolyte to a cathode without leaving the fuel cell. The electrons flow through a circuit to the cathode. This is the electricity. At the cathode, the hydrogen ions and electrons join with oxygen from the air to form hot water.

When a fuel such as natural gas is used to power a fuel cell, the hydrogen first must be separated from other components of the fuel. This "fuel reforming" can produce waste products. For example, reforming natural gas produces waste carbon dioxide. When a fuel cell is fueled by hydrogen, the only waste product is pure hot water.

Parts of a Fuel Cell Power Plant

1) Reformer. Converts the incoming fuel, such as natural gas, into hydrogen.

2) Cell stacks. The fuel cells are typically stacked (rather like capacitors) to achieve the desired voltage.

3) Power inverter and conditioner. Inverts the direct current produced by the fuel cells to alternating current synchronized at 60 hertz.

Types of Fuel Cells

Proton Exchange Membrane (PEM): Current favorite, used in hybrid vehicles. Runs at lower temperatures than some other options. Fast start-up.

Solid Oxide Fuel Cell (SOFC): May prove more efficient at lower cost for stationary power production.

Molten Carbonate: Runs at high temperatures.

Phosphoric acid: Used in 1970s demonstration projects. Cost per kWh high compared to other choices now.

Alkaline Fuel Cell: Low temperature, older technology, requires careful pressure balance between air and fuel electrode.

DOE/BP-3116
October 1998
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