Fuel Cell as a Distributed Generation Technology

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Fuel cells can convert a remarkably high proportion of the chemical energy in a fuel to electricity. With the efficiencies approaching 60%, even without cogeneration, fuel cell power plants are nearly twice as efficient as conventional power plants. Fuel cells contribute significantly to the cleaner environment; they produce dramatically fewer emissions, and their byproducts are primarily hot water and carbon dioxide in small amounts. And because of their modular nature, fuel cells can be placed at or near load centers resulting in savings of transmission network expansion. Industry has slowly begun to appreciate the commercial value of fuel cells. In addition to stationary power generation applications, there is now a strong push to develop fuel cells for automotive use. Even though fuel cells provide high performance characteristics, reliability, durability and environmental benefits, a very high investment cost still is the major barrier against large-scale deployment

Basic Principles

The fuel cell works by processing a hydrogen-rich fuel - usually natural gas or methanol - into hydrogen, which, when combined with oxygen, produces electricity and water. This is the reverse electrolysis process. Rather than burning the fuel, however, the fuel cell converts the fuel to electricity using a highly efficient electrochemical process. A fuel cell has few moving parts, and produces very little waste heat or gas.

A fuel cell power plant is basically made up of three subsystems, or sections. In the fuel-processing section, the natural gas or other hydrocarbon fuel is converted to a hydrogen-rich fuel. This is normally accomplished through what is called a steam catalytic reforming process. The fuel is then fed to the power section, where it reacts with oxygen from the air in a large number of individual fuel cells to produce direct current (dc) electricity, and by-product heat in the form of usable steam or hot water. For a power plant, the number of fuel cells can vary from several hundred (for a 40 kW plant) to several thousand (for a multi-megawatt plant). In the final, or third stage, the dc electricity is converted in the power conditioning subsystem to electric utility grade alternating current (ac).

Types of Fuel Cells

The electrolyte defines the key properties, particularly the operating temperature, of the fuel cell. Consequently, fuel cells are classified based on the types of electrolyte used as described below.

1. Polymer Electrolyte Membrane (PEM)
2. Alkaline Fuel Cell (AFC)
3. Phosphoric Acid Fuel Cell (PAFC)

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4. Molten Carbonate Fuel Cell (MCFC)

5. Solid Oxide Fuel Cell (SOFC)

Table 1. Comparison of Five Fuel Cell Technologies

Type	**Electrolyte**	**Operating Temperature (deg. C)**	**Applications**	**Advantages**
Polymer Electrolyte Membrane (PEM)	Solid organic polymer poly-perflouro-sulfonic acid	60-100	Electric utility, Transportation, Portable power	Solid electrolyte reduces corrosion, Low Temperature, Quick start-up
Alkaline (AFC)	Aqueous soln of potassium hydroxide soaked in a matrix	90-100	Military, Space	Cathode reaction faster in alkaline electrolyte; high performance
Phosphoric Acid (PAFC)	Liquid phosphoric acid soaked in a matrix	175-200	Electric utility, Transportation and heat	Up to 85% efficiency in co-generation of electricity
Molten Carbonate (MCFC)	Liquid soln of lithium, sodium and/or potassium carbonates soaked in a matrix	600-1000	Electric utility	Higher efficiency, Fuel flexibility, inexpensive catalysts
Solid Oxide (SOFC)	Solid zirconium oxide to which small amount of ytrria is added	600-1000	Electric utility	Higher efficiency, Fuel flexibility, inexpensive catalysts. Solid electrolyte advantages like PEM

Properties of these five types of fuel cells and their applications as a distributed generation technology will be discussed at the panel session.

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