
Fuel Cell Types

Fuel cells are a family of technologies containing five primary types, based on the type of “electrolyte” used. Each has specific characteristics that may make it better for some applications than others.

Polymer Electrolyte Fuel Cell (PEFC) or Proton Exchange Membrane Fuel Cell (PEMFC) — The electrolyte in this type of fuel cell is an ion exchange membrane made of some type of polymer that is a good conductor of protons. This type of fuel cell runs at low temperatures (usually around 80°C), with electrical efficiencies of about 45%, and is the primary candidate for automotive, small stationary, and portable power applications. PEM fuel cells require very pure hydrogen as the fuel.

Phosphoric Acid Fuel Cell (PAFC) — The electrolyte in this type of fuel cell is phosphoric acid, concentrated to 100%. PAFCs have an operating temperature of about 100–220°C, and achieve an electrical efficiency of about 37–42%. Buses and stationary applications currently use PAFCs.

Molten Carbonate Fuel Cells (MCFC) — The electrolyte in this type of fuel cell is usually a combination of alkali carbonates, retained in a ceramic matrix. The fuel cell operates at 600–700°C. The high temperature enables the end user to use the both the electricity and the thermal energy generated by the fuel cell, resulting in electrical efficiencies of more than 70 percent. MCFCs are well-suited to large-scale stationary applications, and are currently being demonstrated for powering buildings. High-temperature fuel cells can more easily use a wide range of fuels without using a “fuel reformer.”

Solid Oxide Fuel Cells (SOFC) — The electrolyte in the SOFC is a solid, nonporous metal oxide.

At temperatures over 650°C, the SOFC can utilize a hydrocarbon fuel directly, without reforming, similar to the MCFC. Also similar to the MCFC, the SOFC generates both electricity and usable thermal energy. High-temperature SOFCs are being demonstrated for stationary power applications, while low-temperature SOFCs are also being looked at for automotive applications.

Alkaline Fuel Cells (AFC) — This was one of the first modern fuel cells to be developed, and was used to provide on-board electric power for the Apollo space vehicle. The electrolyte in this fuel cell is Alkaline (KOH). AFCs require pure hydrogen and pure oxygen as the reactants. The operating temperature for this type of fuel cell is around 200°C.

Other types of fuel cells — There are other types of fuel cells that are newer to the family of fuel cells. The Direct Methanol Fuel Cell (DMFC) is very similar to the PEMFC, but it is able to directly utilize liquid methanol at the anode. There is also a Regenerative Fuel Cell, which contains a membrane that can both electrolyze water into hydrogen and oxygen and, with the flick of a switch, recombine the two elements, producing electricity and water.

Fuel Cell Type	Operating Temperature	Efficiency
PEFC/PEMFC	~80°C	~45%
PAFC	~100–220°C	~37-42%
MCFC	~600–700°C	>70%
SOFC	~600–1000°C	>70%
AFC	~200°	~60%