

Comparison of Fuel Cell Technologies

Fuel Cell Type	Common Electrolyte	Operating Temperature	Typical Stack Size	Electrical Efficiency (LHV)	Applications	Advantages	Challenges
Polymer Electrolyte Membrane (PEM)	Perfluorosulfonic acid	<120°C	<1 kW - 100 kW	60% direct H ₂ ⁱ 40% reformed fuel ⁱⁱ	<ul style="list-style-type: none"> Backup power Portable power Distributed generation Transportation Specialty vehicles 	<ul style="list-style-type: none"> Solid electrolyte reduces corrosion & electrolyte management problems Low temperature Quick start-up and load following 	<ul style="list-style-type: none"> Expensive catalysts Sensitive to fuel impurities
Alkaline (AFC)	Aqueous potassium hydroxide soaked in a porous matrix, or alkaline polymer membrane	<100°C	1 - 100 kW	60% ⁱⁱⁱ	<ul style="list-style-type: none"> Military Space Backup power Transportation 	<ul style="list-style-type: none"> Wider range of stable materials allows lower cost components Low temperature Quick start-up 	<ul style="list-style-type: none"> Sensitive to CO₂ in fuel and air Electrolyte management (aqueous) Electrolyte conductivity (polymer)
Phosphoric Acid (PAFC)	Phosphoric acid soaked in a porous matrix or imbibed in a polymer membrane	150 - 200°C	5 - 400 kW, 100 kW module (liquid PAFC); <10 kW (polymer membrane)	40% ^{iv}	<ul style="list-style-type: none"> Distributed generation 	<ul style="list-style-type: none"> Suitable for CHP Increased tolerance to fuel impurities 	<ul style="list-style-type: none"> Expensive catalysts Long start-up time Sulfur sensitivity
Molten Carbonate (MCFC)	Molten lithium, sodium, and/or potassium carbonates, soaked in a porous matrix	600 - 700°C	300 kW - 3 MW, 300 kW module	50% ^v	<ul style="list-style-type: none"> Electric utility Distributed generation 	<ul style="list-style-type: none"> High efficiency Fuel flexibility Suitable for CHP Hybrid/gas turbine cycle 	<ul style="list-style-type: none"> High temperature corrosion and breakdown of cell components Long start-up time Low power density
Solid Oxide (SOFC)	Yttria stabilized zirconia	500 - 1000°C	1 kW - 2 MW	60% ^{vi}	<ul style="list-style-type: none"> Auxiliary power Electric utility Distributed generation 	<ul style="list-style-type: none"> High efficiency Fuel flexibility Solid electrolyte Suitable for CHP Hybrid/gas turbine cycle 	<ul style="list-style-type: none"> High temperature corrosion and breakdown of cell components Long start-up time Limited number of shutdowns

ⁱ NREL Composite Data Product 8, "Fuel Cell System Efficiency," http://www.nrel.gov/hydrogen/docs/cdp/cdp_8.jpg

ⁱⁱ Panasonic Headquarters News Release, "Launch of New 'Ene-Farm' Home Fuel Cell Product More Affordable and Easier to Install," <http://panasonic.co.jp/corp/news/official.data/data.dir/2013/01/en130117-5/en130117-5.html>

ⁱⁱⁱ G. Mulder et al., "Market-ready stationary 6 kW generator with alkaline fuel cells," ECS Transactions 12 (2008) 743-758

^{iv} Doosan PureCell Model 400 Datasheet, http://www.doosanfuelcell.com/attach_files/link/PureCell%20Model%20400%20Datasheet.pdf

^v FuelCell Energy DFC300 Product Specifications, <http://www.fuelcellenergy.com/assets/DFC300-product-specifications1.pdf>

^{vi} Ceramic Fuel Cells Gennex Product Specifications, <http://www.bloomenergy.com/fuel-cell/es5-data-sheet/>

For More Information

More information on the Fuel Cell Technologies Office is available at <http://www.hydrogenandfuelcells.energy.gov>.