



Fuel Cells - Facts Sheet

Basics

The first demonstration of a fuel cell was by William Grove in 1839. Real developments in fuel cells first happened for space applications in the 1960's. Since the 80's and until now much development in fuel cells has been focused on use for transportation, combined heat and power production and power supply in portable products.

Fuel cells convert the chemical energy in a fuel, mostly hydrogen, into electricity and heat without any noise and mechanical movement. The only emission of the reaction in the fuel cell is pure water. A fuel cell is like a battery with the only difference that it will continue to provide power as long a fuel is provided.

Fuel cells are very scaleable and flexible in design thus giving a wide range of possibilities of usage. A fuel cell can power a small mobile cell phone, or a car, or even be used for large central power plant.

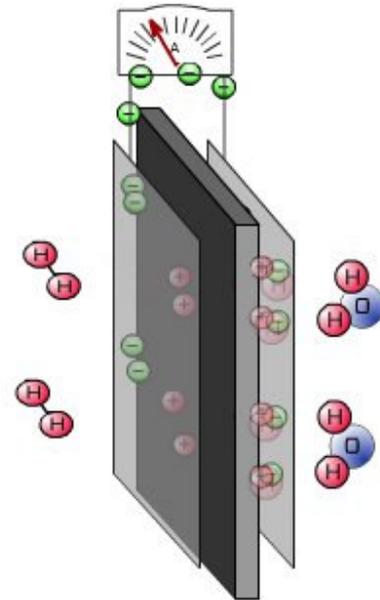
Fuel Cell principles

Basic principle

The basic principle of a fuel cell is a chemical reaction between hydrogen and oxygen that produces power and heat.

The picture, next to, shows the principle.

Hydrogen and oxygen (air) is supplied on each side of a cell. The cell consists of an electrolyte membrane (PEM) with a catalyst layer on each side. When hydrogen is lead to the first catalyst layer, the anode, the hydrogen molecules are split into their basic elements, a proton and an electron. The protons migrate through the electrolyte membrane to the second catalyst layer, the cathode. Here they react with oxygen to form water. At the same time the electrons are forced to travel around the membrane to the cathode side, because they can not pass the membrane. This movement of electrons thus creates an electrical current.



PEM Fuel Cell

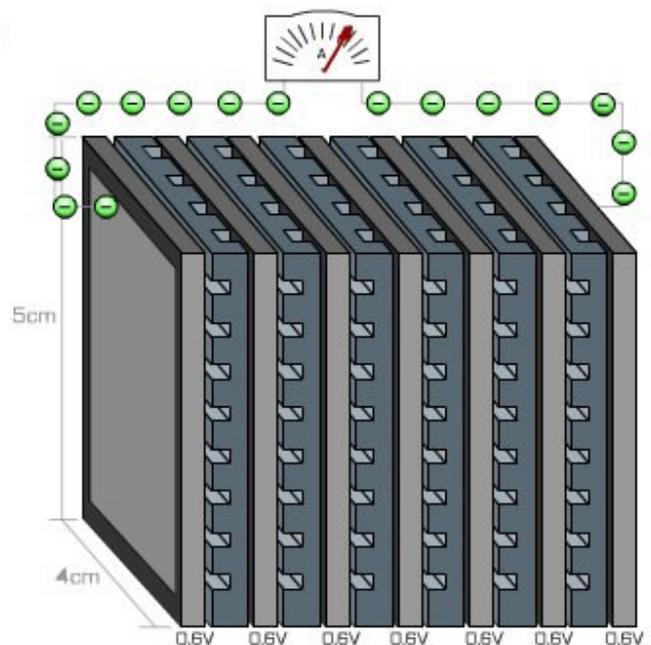
Stack principle

Each cell in the fuel cell typically supplies 0,6 voltage when a load is applied to the fuel cell. The area of the cell creates a typically current on 0,5 ampere/cm². To create the effect needed for the application of the fuel cell, cells are stacked together.

The picture, next to, shows the stack principle.

It is the stack principle that makes fuel cells scaleable and flexible in design thus giving a wide range of possibilities of usage.

Please note that the principles vary for each type of fuel cell. The above is the principles of the most common fuel cell, the PEM.



PEM Fuel Cell Stack



Fuel Cell types

A wide range of fuel cell types exists, each operating on different fuels and at different temperatures. The table below outlines the most common types and their characteristics.

Fuel cell types and characteristics

Fuel cell type	PEM	AFC	PAFC	DMFC	MCFC	SOFC
Name	Proton Exchange membrane	Alkaline	Phosphoric Acid	Direct Methanol	Molten Carbonate	Solid Oxide
Applications	Vehicles, mobile applications and combined heat and power production	Space applications	Large scale combined heat and power production	Mobile applications from micro to small scale	Medium to large scale combined heat and power production, up to MW	All sizes of combined heat and power production, up to multi MW
Operating temp. degrees Celsius	50-100	50-200	about 220	About 70	About 650	500-1000
Reactant Ion	H ⁺	OH ⁻	H ⁺	H ⁺	CO ₃ ²⁻	O ²⁻
Fuel	Hydrogen	Hydrogen	Hydrogen	Methanol	H ₂ , CO and/or CH ₄	H ₂ , CO and/or CH ₄
Cell component	Carbon-based	Carbon-based	Graphite-based	Carbon-based	Stainless-based	Ceramic
Catalyst	Platinum	Platinum	Platinum	Platinum/ruthenium	Nickel	Perovskites
Electrical efficiency	40-50%	60%	37-42%	30-40%	> 50%	> 50%
Cell life time	< 3000 hours	< 5000 hours	> 5000 hours	< 3000 hours	> 10000 hours	> 10000 hours
Anode reaction	H ₂ → 2H ⁺ + 2e ⁻	H ₂ + 2(OH) ⁻ → 2H ₂ O + 2e ⁻	H ₂ → 2H ⁺ + 2e ⁻	CH ₃ OH + H ₂ O → CO ₂ + 6H ⁺ + 6e ⁻	H ₂ + CO ₃ ²⁻ → H ₂ O + CO ₂ + 2e ⁻	H ₂ + O ²⁻ → H ₂ O + 2e ⁻
Cathode reaction	½O ₂ + 2H ⁺ + 2e ⁻ → H ₂ O	½ O ₂ + H ₂ O + 2e ⁻ → 2(OH) ⁻	½O ₂ + 2H ⁺ + 2e ⁻ → H ₂ O	3/2 O ₂ + 6H ⁺ + 6e ⁻ → 3H ₂ O	½O ₂ + CO ₂ + 2e ⁻ → CO ₃ ²⁻	½O ₂ + 2e ⁻ → O ²⁻

Data with great inaccuracy due to different data sources, calculations methods, technology, system configurations and level of commercialisation.

Fuel Cell advantages and disadvantages

Fuel cells hold some advantages with great potentials. However great research challenges lay ahead to make the technology commercial.

Fuel Cell advantages and disadvantages

Advantages	Disadvantages
High electrical and total efficiency potential (much higher than the combustion engine)	Low efficiency (today)
Variable loads	Large research and development challenges
Low emissions (Zero emission)	Short lifetime
Low maintenance due to no moving parts	High stack and system price
Low noise	Few fuel cell suppliers
Scalable technology	Missing fueling infrastructure
Combined Heat and Power production	Low life time and not enough operation experiences

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