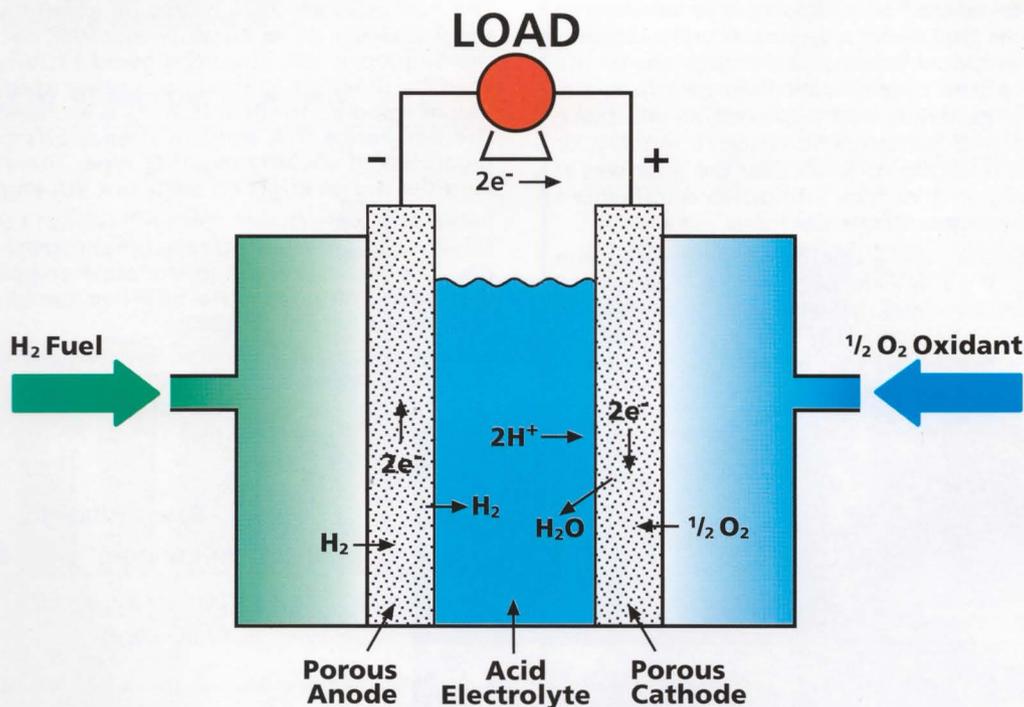


## The Hydrogen Fuel Cell

Definition: "An electrical cell that converts the intrinsic chemical free energy of a fuel directly into direct-current electrical energy in a continuous catalytic process."

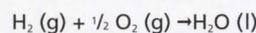
### DIAGRAM SHOWING THE PRINCIPLE OF OPERATION OF A FUEL CELL



A.J. Appleby and F.R. Foulkes, *Fuel Cell Handbook*, Van Nostrand Reinhold, 1989.

The technical process of the modern automotive fuel cell is as follows, the gases hydrogen (from fuel or as a pressurised gas) and oxygen (usually from air) are fed to a stacked array of fuel cells. Each cell is comprised of a polymer electrolyte membrane combined with a catalyst - usually platinum. The stacked array, which needs to be kept humidified, has various other connections for services etc. The electrolyte only allows one of these two gases to pass through it as electrically charged ions; hydrogen negatively charged electrons remain on one side of the cell with a positive charge being generated on the oxygen supply side. The cell is provided with a porous anode and cathode which allow the reaction between the gases and the electrolyte which generates a stream of electrons (as an electric current) which pass between them. This is used to externally power the electric load. In the case of motor cars, the vehicles motive power source is an electric motor(s) plus in some cases a separate capacitor - used like a battery for rapid electric storage and discharge during acceleration. Electrical energy can also be stored in the capacitor from that produced from braking or deceleration.

In a typical thermal power conversion process, the heat of combustion of the fuel is turned into electrical work via a Carnot heat-engine cycle, coupled with a rotating electrical generator.



Under standard conditions of temperature and pressure, 25°C (77°F) and 1 atm (100 kilopascals) the reaction takes place with a free-energy change ( $G = -56.69$  Kcal (237 kilojoules) per mol of water. Since the formation of water involves two electrons, this value corresponds to -1.23 electronvolts (1eV = 23.06 Kcal/equivalent). Thus at thermodynamic equilibrium (zero current) the cell voltage should be 1.23V, yielding a theoretical efficiency based on the heat of combustion [(H for H<sub>2</sub>O = -1.48 eV) of 83.1%.

One advanced example of this process was recently unveiled by Mazda of Japan, its the Demio FCEV (Fuel Cell Electric Vehicle) and a picture of it is shown below. This experimental prototype car is

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