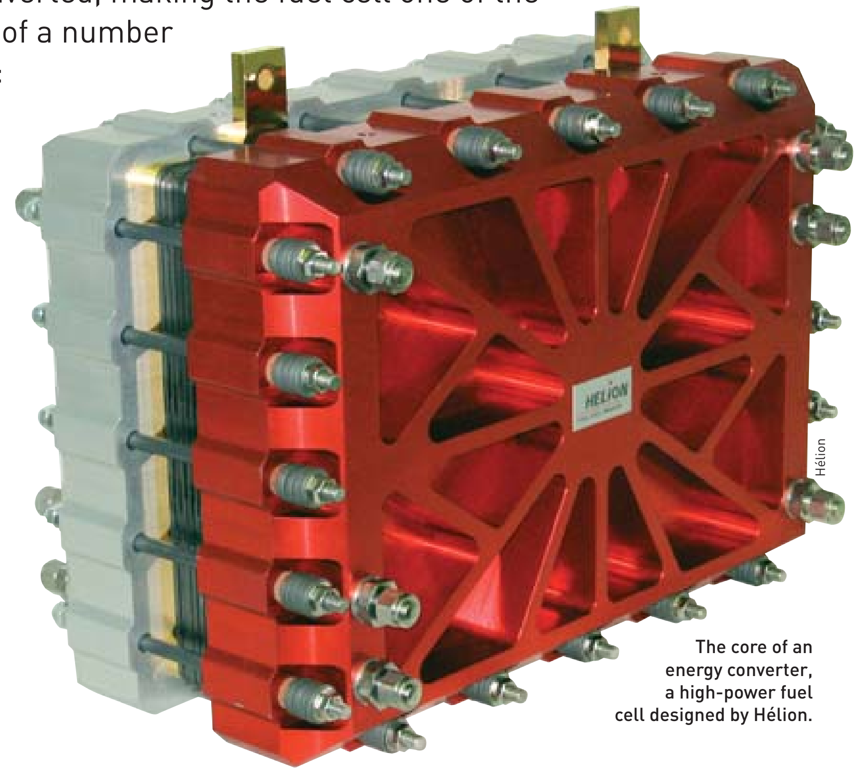
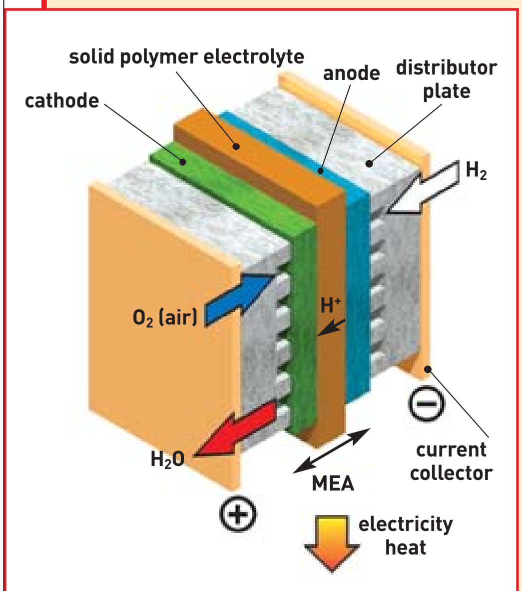
Energy converters

As outstanding devices to effect the conversion into electricity of the crucial energy carrier hydrogen is fast becoming, fuel cells may be numbered among the more promising technologies, in terms of sustainable development. Indeed, nearly half of the chemical energy held in hydrogen is thus converted, making the fuel cell one of the most efficient energy systems. Out of a number of technologies, two are prioritized: the low-temperature PEMFC polymer pathway, and the high-temperature SOFC ceramic pathway. These afford broad prospects for utilization, in three areas: portable applications, transportation, and stationary applications. CEA, together with its partners, is working on development of commercially viable fuel cells, constructed from the original "building blocks" already in their possession, or that have reached an advanced stage of definition.



The core of an energy converter, a high-power fuel cell designed by Hélion.

C How does a fuel cell work?



Operating principle of the fuel cell: the example of the proton-exchange membrane fuel cell. MEA stands for membrane-electrode assembly.

The fuel cell is based on a principle discovered quite some time ago, since it was in 1839 that Sir William Grove constructed the first electrochemical cell working with hydrogen as its fuel, thus demonstrating the ability to generate electric current through direct conversion of the fuel's chemical energy. Since the fuel cell has the special characteristic of using two gases - hydrogen H_2 and oxygen O_2 - as its electrochemical couple, the oxidation-reduction reactions occurring inside the fuel cell are particularly simple. The reaction takes place inside a structure (the basic electrochemical cell), consisting essentially in two electrodes (the anode and cathode), separated by an electrolyte, i.e. a material that lets ions through. The electrodes employ catalysts, to activate, on the one side, the hydrogen oxidation reaction, and, on the other, the oxygen reduction reaction.

In the case of an acid-electrolyte cell (or proton exchange membrane fuel cell), the hydrogen at the anode is dissociated into protons (or hydrogen ions H^+) and electrons, in accordance with the oxidation reaction: $H_2 \rightarrow 2\ H^+ + 2\ e^-$. At the cathode, the oxygen, the electrons and the protons recombine to yield water: $2\ H^+ + 1/2\ O_2 + 2\ e^- \rightarrow H_2O$. The principle of the fuel cell is thus the converse of that of water electrolysis. The thermodynamic potential for such an electrochemical cell, consequently, stands at around 1.23 volt (V). However, in practice, the cell exhibits a voltage of about 0.6 V for current densities of 0.6-0.8 A/cm^2. The efficiency of such a fuel cell is thus equal to about 50%, the energy dissipated naturally being so dissipated in the form of heat.