

Fuel Cells – Power Where It’s Needed

Fact Sheet: Fuel Cells

Fuel cells use an electrochemical process to convert hydrogen into electricity without combustion. Fuel cells produce power without generating pollution and can convert up to 80 percent of their fuel into electricity. By contrast, fossil fuel power plants are, at most, 40 percent efficient. The only by-products from fuel cells powered by hydrogen are breathable oxygen, drinkable water, and some heat. Fuel cells operate quietly and are efficient generators of electricity.

The first fuel cell prototype was made in 1838 by Sir William Grove in England. Equipment manufacturer Allis-Chalmers built a fuel-cell-powered tractor in Minnesota in 1955. Although it functioned well, post-war petroleum fuel prices made gasoline and diesel powered internal combustion engines more cost effective. The first commercialized fuel cells were used by NASA to power spacecraft in the 1960s and continue to supply electricity to the spacecraft of today.

Back on Earth, fuel cells are beginning to be used as pollution-free replacements for internal combustion engines as well as batteries in portable devices, and are providing electricity for homes and buildings. Fueled by domestically produced hydrogen, they have the potential to make the United States an energy-independent nation.

- Fuel cells can be made in any size to power everything from cell phones to power plants. More efficient than batteries, which contain toxic materials, fuel cells provide power as long as hydrogen and oxygen are present.
- The global fuel cell industry will generate more than \$18.6 billion a year by 2013.
- All major automakers are working to commercialize fuel cell vehicles. Honda and Toyota began leasing fuel cell cars in 2003.
- Fuel cells are expected to become cost-competitive with

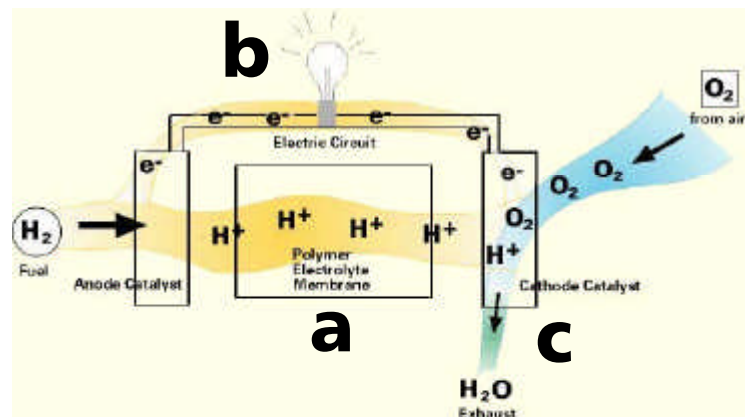
traditional technologies this decade; first in portable devices, then as stationary power supplies for homes and buildings, and then in vehicles.

How do fuel cells work?

A fuel cell uses hydrogen to create electricity through a simple electrochemical process. Every fuel cell has one positive and one negative plate, or electrode. As with a battery, the positive and negative plates allow for a flow of electrons. A conducting material, or electrolyte, carries the hydrogen’s protons from one electrode to the other.

- Through a simple chemical reaction, an electrolyte, such as a polymer electrolyte membrane, separates an electron from the proton of a hydrogen atom.
- The freed electron travels through a wire to power any electrical device.
- A proton and electron reunite to form hydrogen and the hydrogen combines with oxygen to form water.

Depending upon performance needs, different types of conductive material, or electrolyte, are used inside a fuel cell. Due to their low operating temperatures, polymer electrolyte membrane, also called proton exchange membrane or PEM fuel cells are most commonly used in small devices and vehicles. Other types or electrolytes are alkali, molten carbonate, phosphoric acid, solid oxide, and ceramic.



Graphic: Fuel Cells 2000 and U.S. Department of Energy.



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All fuel cells use hydrogen as fuel. There are many sources of hydrogen. It can be obtained from water or plant material (carbohydrates). It can also be obtained from fossil fuels (hydrocarbons). A “reformer” can be used to obtain hydrogen from hydrocarbons such as methanol, gasoline, or natural gas. Hennepin County is partnering with the OEA, Minnegasco, and 3M to place a fuel cell powered by natural gas in a county library, where the public will be able to see what can soon be providing electricity to our homes.

The University of Minnesota is partnering with the OEA and Xcel Energy to use the electricity provided by photovoltaic (PV or solar) panels to make hydrogen from water that will be used to power a fuel cell. Since water is both the fuel and by-product of this process, it is possible to reuse the water in a closed loop system. University students will learn technologies and principles of an energy system that can provide pollution-free electricity any time, night or day.

Fuel cells in motion

Pre-commercial fuel cell buses began road testing in 1997. The first fuel-cell-powered cars appeared on roads in 1998. Although still too expensive for widespread use, Honda and Toyota are leasing small numbers of fuel cell cars today. Since both use electric generation and conservation technologies, information these companies gained through development of hybrid gasoline/electric vehicles is being transferred to fuel cell vehicles. The hybrid fuel cell/electric system allows for use of smaller fuel cells, extending vehicle range.

Worldwide, major auto manufacturers are developing fuel cell vehicles. Honda and Toyota are leasing limited numbers of these vehicles in the U.S., powered by fuel cells.



SunLine Transit of Thousand Palms, California, is operating “emission-free” buses that are fueled by hydrogen generated by solar electrolysis of water. Using hydrogen produced from water through use of renewable energy (in contrast to hydrogen produced from fossil fuels) to power fuel cells produces pollution-free power.



By using hydrogen produced from solar electrolysis of water, this “zero emission” fuel cell bus provides pollution-free transportation.

Resources

- Smithsonian Museum has an overview of the history and types of fuel cells at <http://fuelcells.si.edu>.
- Fuel Cells 2000, a nonprofit organization, provides extensive information on fuel cell technologies at www.fuelcells.org.
- Ballard Power Systems, a manufacturer of proton exchange membrane fuel cells, focuses on developing fuel cell technology for a variety of applications: www.ballard.com.
- Plug Power, a manufacturer of residential fuel cells, www.plugpower.com.
- “Hydrogen – The New Fuel of Choice,” an OEA fact sheet on commonly asked questions about hydrogen, www.moea.state.mn.us/p2/energy.cfm.
- “Types of fuel cells,” an OEA fact sheet on different types of fuel cells, www.moea.state.mn.us/p2/energy.cfm.

For more information

For more information on pollution prevention energy technologies and fuels, visit the OEA web site: www.moea.state.mn.us/p2/energy.cfm