

## Pollution-free Electricity

**R**enewable energy sources such as wind and solar produce pollution-free power, but the flow of electricity from wind turbines or photovoltaic panels is intermittent. Energy is only provided when the wind blows or the sun shines. But how can you store energy from intermittent sources so it can be available at any time?

### Renewable hydrogen power

Hydrogen can store energy efficiently. When electricity is applied to water molecules ( $H_2O$ ), you can separate the hydrogen (H) from the oxygen (O) atoms so that the hydrogen can be stored for later use.

A **fuel cell** uses hydrogen as a power source to create electricity through a simple electrochemical process. The only by-products from the fuel cell are breathable oxygen, drinkable water and some heat.

- a. Through a simple chemical reaction, a “proton exchange membrane” removes an electron from a hydrogen atom.

- b. The freed electron travels through a wire to power any electrical device.
- c. The hydrogen atom, minus one electron, is released to the air, where it combines with an oxygen atom to form pure water.

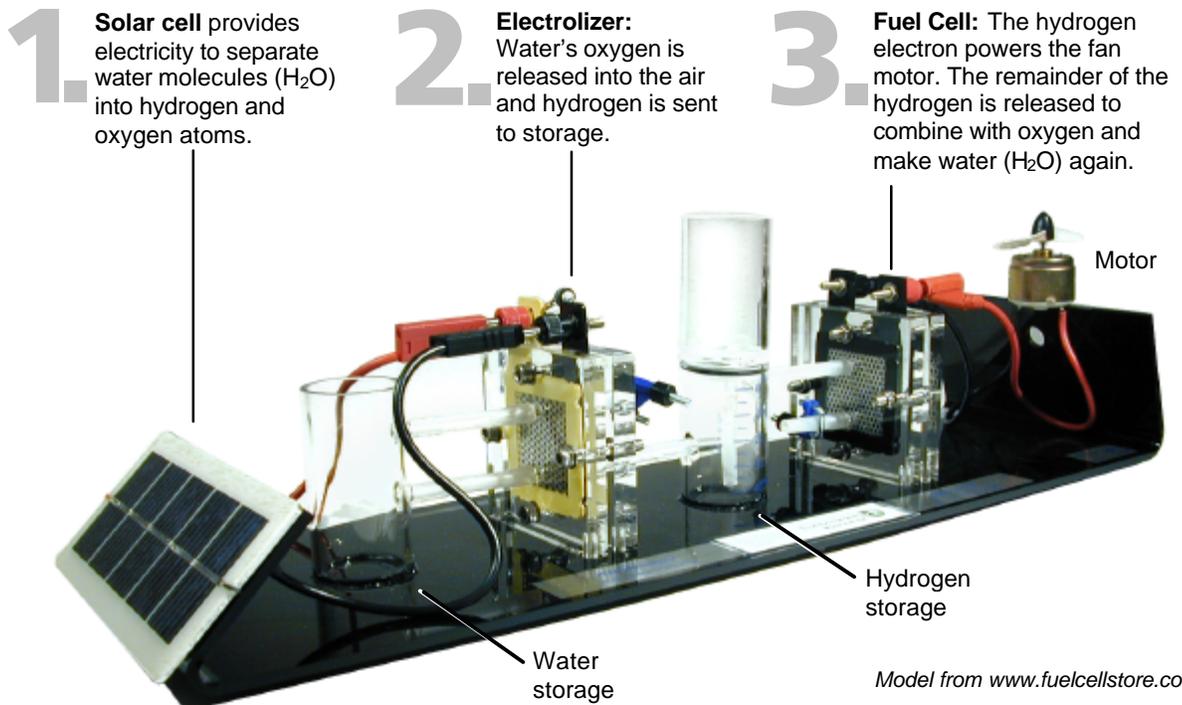
### Other hydrogen sources

Fuel cells can run on any source of hydrogen, including hydrocarbons: natural gas, methanol or gasoline. These non-renewable fuels must first be run through a converter to separate the hydrogen.

This conversion process does create some air pollution. However, a hydrocarbon-powered fuel cell generates only half of the greenhouse gases compared to when hydrocarbons are burned in internal combustion engines.

Natural-gas-powered fuel cells that are not dependent upon power plants to generate electricity are in use today. Although economic factors have kept this technology from being widely applied, its use is increasing in powering homes and buildings.

## How does a renewable, hydrogen-powered fuel cell system work?



Model from [www.fuelcellstore.com](http://www.fuelcellstore.com).



Minnesota  
Office of  
Environmental  
Assistance

[www.moea.state.mn.us](http://www.moea.state.mn.us)

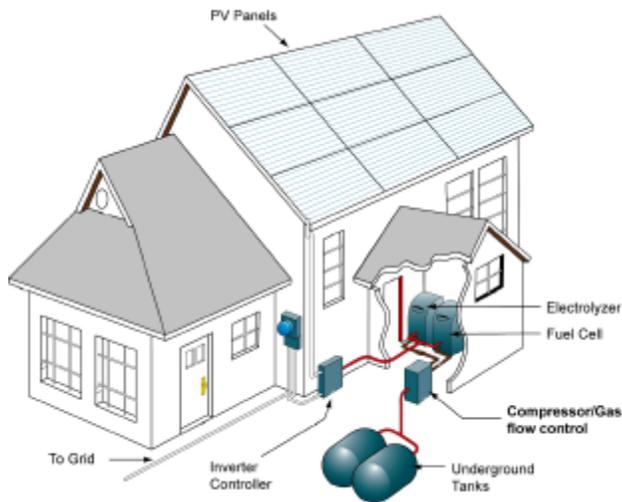
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## Hydrogen-based home energy system

Although several years away from mass market, buildings similar to this one are moving from the drawing board to reality.

In this design, rooftop solar cells provide the electricity to separate water into oxygen and hydrogen. The hydrogen is stored in underground tanks for use in the fuel cell, which would provide uninterrupted electricity for the home.



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Is hydrogen a safe fuel? Experience has shown that risks are similar to using other flammable gases such as propane or natural gas. Today, more than 3.2 trillion cubic feet of hydrogen are used safely in the U.S.

### Other uses for fuel cells

In addition to power generation for homes and offices, fuel cells are being adapted for other uses.

Motorola, for instance, has a cell phone prototype that is powered by a methanol fuel cell. The methanol cartridges will last up to ten times longer than a rechargeable battery.

Electrolux Corporation is experimenting with fuel cells in common appliances such as vacuum cleaners. Other manufacturers are experimenting with putting them in electric bicycles.

In early 2002, the Bush administration announced that it was replacing a program to develop high-mileage gasoline/electric hybrid vehicles with one to develop hydrogen-powered fuel cell vehicles. Cost-competitive fuel cell vehicles are expected within ten years.

## A hydrogen economy

In the United States, interest in making a transition to a hydrogen-based energy system is growing because it would free the U.S. from the costs of dependence on foreign sources of fuel. In addition to environmental benefits, the improved economic and national security offered through use of hydrogen versus fossil fuels are increasingly recognized as in the best national interest.

On the international front, Iceland declared it will be the first nation in the world to convert to a hydrogen-based economy. With no fossil fuel reserves and abundant geothermal and hydro energy, Iceland will use electricity produced from these renewable sources to separate hydrogen and oxygen from water.

Buses will use the hydrogen directly; and fuel cells in cars, trucks and ships will use liquid methanol made by combining hydrogen with existing carbon dioxide. Existing fueling stations can be used.

The government plans to make Iceland a net exporter of hydrogen with a goal of becoming a “Kuwait of the new energy economy.”

### For more information

Fuel Cells 2000 provides extensive information on fuel cells, from the basics to monthly technology updates: [www.fuelcells.org](http://www.fuelcells.org)

Plugpower is a supplier of pre-commercial, natural-gas-powered fuel cells for residential use. [www.plugpower.com](http://www.plugpower.com)

Educational desktop models of solar-powered fuel cells, manufactured in Germany, are available through their U.S. distributor, The Fuel Cell Store: [www.fuelcellstore.com](http://www.fuelcellstore.com).

Environmental benefits of fuel cells are discussed in the greenhouse gases section of the OEA’s 2002 *Pollution Prevention Evaluation Report*: [www.moea.state.mn.us/p2/p2evaluation2002.cfm](http://www.moea.state.mn.us/p2/p2evaluation2002.cfm)