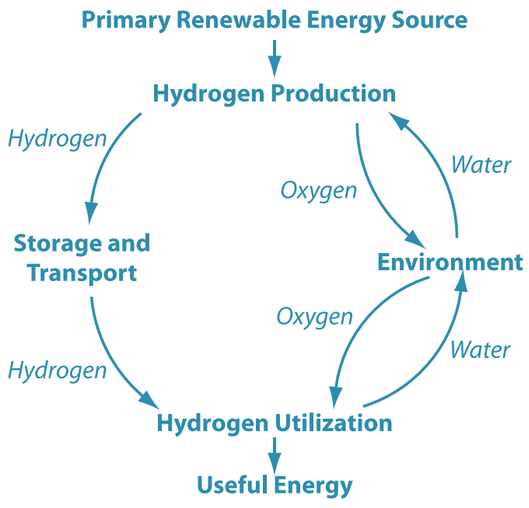
HYDROGEN AT A GLANCE

WHAT IS HYDROGEN?

Hydrogen is the simplest element. One atom of hydrogen-1, its most common isotope, has only one proton and one electron. In elemental form, hydrogen is the least dense element and is a gas at standard temperature and pressure. It has the highest energy content of any common fuel by weight, but the lowest energy content by volume. Even though hydrogen is the most abundant element in the universe, it is only found on Earth combined with other elements in compounds like water, methane, and fossil fuels, and organic matter (biomass). Hydrogen is one of the most promising energy carriers for the future. Hydrogen does not produce air pollution when used and it can provide energy in places where the electric grid does not reach.

HYDROGEN LIFE CYCLE



HYDROGEN USES

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Liquid hydrogen is the fuel that once propelled the space shuttle and other rockets. Hydrogen fuel cells powered the shuttle's electrical systems, producing pure water, which was used by the crew as drinking water.

In the future, however, hydrogen will join electricity as an important energy carrier, since it can be made safely from renewable energy sources and is virtually non-polluting. It can also be used as a fuel for zero-emissions vehicles, to heat homes and offices, to produce electricity, and to fuel aircraft. Cost is the major obstacle.

The first widespread use of hydrogen could be as an additive to transportation fuels. Hydrogen can be combined with compressed natural gas (CNG) to increase performance and reduce pollution. Adding 20 percent hydrogen to CNG can reduce nitrogen oxide (NO_x) emissions by 50 percent in today's engines. An engine converted to burn pure hydrogen produces only water and minor amounts of NO_x as exhaust.

A few hydrogen-powered vehicles are on the road today, but it will be some time before you can walk into your local car dealer and drive away in one. Today 74 hydrogen fuel stations are operating in the U.S., but not all are open to the public.

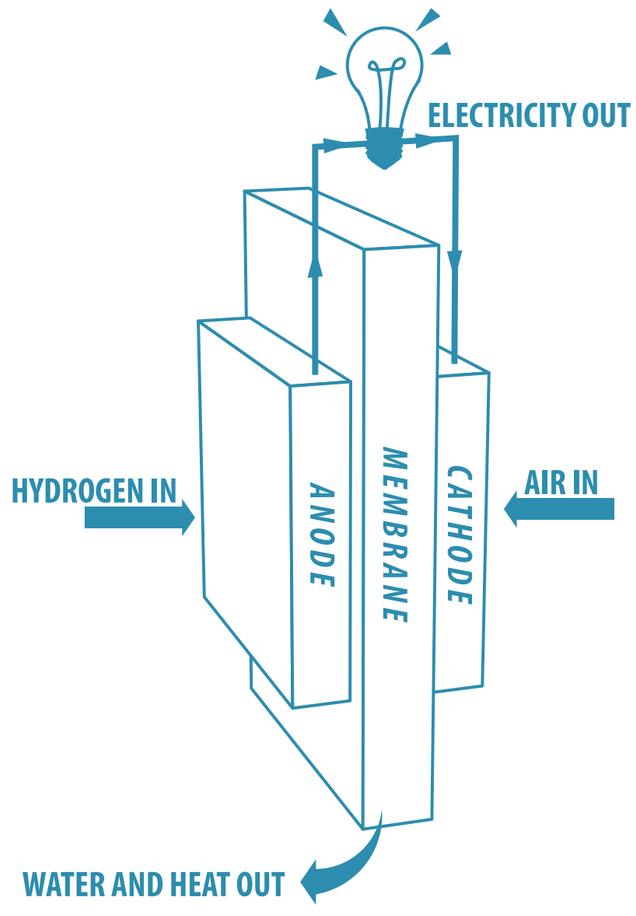
Can you imagine how huge the task would be to quickly change the gasoline-powered transportation system we have today? Just think of the thousands of filling stations across the country and the production and distribution systems that serve them. Change will come slowly to this industry, but hydrogen is a versatile fuel; it can be used in many ways.

Fuel cells (batteries) provide another use option, just as they were utilized by NASA. Fuel cells basically reverse electrolysis—hydrogen and oxygen are combined to produce electricity. Hydrogen fuel cells are very efficient and produce only water as a by-product, but they are expensive to build.

With technological advances, small fuel cells could someday power electric vehicles and larger fuel cells could provide electricity in remote areas. Because of the cost and lack of infrastructure, hydrogen will not produce electricity on a wide scale in the near future. It may, though, be added to natural gas to reduce emissions from existing power plants.

As the production of electricity from renewables increases, so will the need for energy storage and transportation. Many of these sources—especially solar and wind—are located far from population centers and produce electricity only part of the time. Hydrogen may be the perfect carrier for this energy. It can store the energy and distribute it to wherever it is needed.

HYDROGEN FUEL CELL



HOW HYDROGEN IS MADE

Since hydrogen gas is not found on Earth, it must be manufactured. There are several ways to do this. Industry produces the hydrogen it needs by a process called steam reforming. High-temperature steam separates hydrogen from the carbon atoms in methane (CH_4). The hydrogen produced by this method isn't used as a fuel, but for industrial processes. This is the most cost-effective way to produce hydrogen today, but it uses fossil fuels both in the manufacturing process and as the heat source.

Another way to make hydrogen is by electrolysis—splitting water into its basic elements—hydrogen and oxygen. Electrolysis involves passing an electric current through water to separate the atoms ($2H_2O$ + electricity = $2H_2 + O_2$). Hydrogen collects at the cathode and oxygen at the anode.

Hydrogen produced by electrolysis is extremely pure, and electricity from renewable sources can power the process, but it is very expensive at this time. Today, hydrogen from electrolysis is several times more costly than natural gas and 1.5 times more costly than gasoline per Btu.

On the other hand, water is abundant and renewable, and advances in renewable electricity could make electrolysis a more attractive way to produce hydrogen in the future.

There are also several experimental methods of producing hydrogen. Photoelectrolysis uses sunlight to split water molecules into its components. A semiconductor absorbs the energy from the sun and acts as an electrode to separate the water molecules.

In biomass gasification, wood chips and agricultural wastes are super-heated until they turn into hydrogen and other gases. Biomass can also be used to provide the heat.

Scientists have also discovered that some algae and bacteria produce hydrogen under certain conditions, using sunlight as their energy source. Experiments are underway to find ways to induce these microbes to produce hydrogen efficiently.

Nearly every region of the country (and the world) has one or more resources that can be used to produce hydrogen. It can be produced at large facilities or at small distributed facilities for local use. One of its main advantages is its flexibility.