

# Hydrogen

Hydrogen is the simplest and lightest element known to exist, with only one proton and one electron per atom. It is an energy carrier, not an energy source—it must be produced from compounds that contain it. It is the most abundant element in the universe and is the source of the energy we receive from the sun, which is essentially a giant hydrogen gas ball. This radiant energy from the sun is important because it provides light and heat and makes plants grow.



## How Hydrogen is Formed

On Earth, hydrogen is only found in compound form such as with oxygen to form water and with carbon to form compounds such as methane, coal and petroleum. At room temperature, it is a transparent, highly flammable gas. It is stored in a "cell" or battery.

Hydrogen is usually produced through steam reforming or electrolysis. Steam reforming, which is the least expensive way to create hydrogen, involves separating hydrogen atoms from carbon atoms in methane. This method accounts for about 95% of the hydrogen produced in the United States, but the process creates greenhouse gas emissions.

In electrolysis, an electric current is used to split water into hydrogen and oxygen; then the hydrogen can be extracted and used. Nuclear high-temperature electrolysis uses the heat from a nuclear reactor to warm up water before applying an electric current; by warming the water up first, less electricity is needed to separate the hydrogen and oxygen, reducing the energy consumption.

Today, hydrogen is primarily transported short distances via pipeline. In some instances, hydrogen can be transported via tanker trucks or barges. It can also be transported using elements like ammonia or ethanol that contain hydrogen atoms. When hydrogen is transported long distances, it is best to liquefy it and move it in a tanker truck. But liquefaction is expensive and energy-consuming, so it is usually used in close proximity to where it is created to avoid long transports.

## Uses for Hydrogen

Hydrogen has a variety of important uses, including:

- Refining and treating metals
- Processing foods, such as hydrogenating oils or fats (like what you might find in the margarine in your fridge!)
- Refining crude oil in the petroleum industry
- Providing electricity through fuel cells

The main use for hydrogen, though, is as rocket fuel. Liquid hydrogen fuel is used by NASA to get space shuttles into orbit, and hydrogen batteries power the shuttles' electrical equipment. The hydrogen's only byproduct is pure water, which the shuttle crew can use as drinking water!

## Hydrogen for Transportation

Hydrogen has the potential to make a huge impact on the world's transportation energy needs. Hydrogen combustion engines and fuel cells could benefit the environment while reducing the world's consumption of fossil fuels. These engines work by converting hydrogen's chemical energy into mechanical energy or through a chemical reaction between oxygen and hydrogen.

The problem with using hydrogen in transportation is that it is expensive to produce, store and transport. Now, the US Department of Energy's Office of Nuclear Energy is working on the Nuclear Hydrogen Initiative in an effort to produce large amounts of hydrogen using nuclear energy in an economical and environmentally friendly way. This effort could give the US emissions-free, large-scale hydrogen production that would provide fuel for cars and trucks. The Nuclear Hydrogen Initiative aims to have an experimental, pilot-scale hydrogen production system in place by 2013.

Governments in other parts of the world, including Japan and Germany, are also devoting funds to building new hydrogen-powered vehicles and refueling stations. Japanese carmaker Toyota announced plans in 2009 to introduce an affordable fuel-cell car by 2015 (*Japan Leads the Race for a Hydrogen Fuel-Cell Car*, The Christian Science Monitor, Feb. 1, 2010).

## Demand for Hydrogen

Many experts believe hydrogen is an important energy resource for the future since it is clean, abundant and can be produced from a variety of resources. However, new systems—including hydrogen production plants and refueling stations for hydrogen fuel-cell vehicles—must be designed and built before significant contributions of hydrogen can be used. If the cost and logistical obstacles can be overcome, however, and hydrogen is proven to be a feasible solution to the world's energy needs, the demand will go up significantly.