

### **A Welsh invention!**

### **What Makes Hydrogen so Useful for Energy Production?**

Hydrogen is the simplest element and most plentiful gas in the universe. Yet hydrogen never occurs by itself in nature?it always combines with other elements such as oxygen and carbon. Once it has been separated, hydrogen is the ultimate clean energy carrier. How clean? Clean enough that the U.S. Space Shuttle program relies on hydrogen-powered fuel cells to operate shuttle electrical systems, and the crews drink one of the byproducts: pure water! Hydrogen is an obvious alternative to hydrocarbon fuels, such as gasoline. It has many potential uses, is safe to manufacture, and is environmentally friendly. Today many technologies exist that can use hydrogen to power cars, trucks, electrical plants, and buildings?yet the absence of an infrastructure for producing, transporting, and storing large quantities of hydrogen prevents its practical use.

### **How is Hydrogen Produced?**

Most methods of producing hydrogen involve splitting water (H<sub>2</sub>O) into its component parts of hydrogen (H<sub>2</sub>) and oxygen (O). The most common method involves steam reforming of methane (from natural gas), although there are several other methods.

- Steam reforming converts methane (and other hydrocarbons in natural gas) into hydrogen and carbon monoxide by reaction with steam over a nickel catalyst
- Electrolysis uses electrical current to split water into hydrogen at the cathode (+) and oxygen at the anode (-)
- Steam electrolysis (a variation on conventional electrolysis) uses heat, instead of electricity, to provide some of the energy needed to split water, making the process more energy efficient
- Thermochemical water splitting uses chemicals and heat in multiple steps to split water into its component parts
- Photoelectrochemical systems use semi-conducting materials (like photovoltaics) to split water using only sunlight
- Photobiological systems use microorganisms to split water using sunlight
- Biological systems use microbes to break down a variety of biomass feedstocks into hydrogen

- Thermal water splitting uses a very high temperature (approximately 1000°C) to split water
- Gasification uses heat to break down biomass or coal into a gas from which pure hydrogen can be generated

### **What's Preventing Wide-Scale Hydrogen Production Today?**

Cost is the biggest impediment to using hydrogen more widely as a fuel. Many expensive changes must be made in our nation's energy infrastructure to accommodate hydrogen. For example, electricity is required by many hydrogen production methods, which makes hydrogen more expensive than the fuels it would replace.

### **Hydrogen Quick Facts**

Hydrogen has the highest energy content per unit of weight of any known fuel?52,000 British Thermal Units (Btu) per pound (LHV).

The U.S. hydrogen industry currently produces 9 million tons of hydrogen per year (enough to power 20-30 million cars or 5-8 million homes) for use in:  
Chemicals production; Petroleum refining; Metals treating; Electrical applications. Hydrogen is primarily used as a feedstock, intermediate chemical, or specialty chemical.

Steam methane reforming accounts for 95% of the hydrogen produced in the U.S.

Other methods of hydrogen production are

- Gasification of fossil fuels (e.g. coal)
- Splitting water using electricity, heat or light
- Thermal or biological conversion of biomass

Hydrogen is currently transported by pipeline or by road via cylinders, tube trailers, and cryogenic tankers, with a small amount shipped by rail or barge.

Hydrogen distribution via high-pressure cylinders and tube trailers has a range of 100-200 miles from the production facility. For longer distances of up to 1,000 miles, hydrogen is usually transported as a liquid in super-insulated, cryogenic, over-the-road tankers, railcars, or barges, and then vaporized for use at the customer site.

Hydrogen can be stored as a compressed gas or liquid, or in a chemical compound.