



Hydrogen Fuel: Alternative Energy

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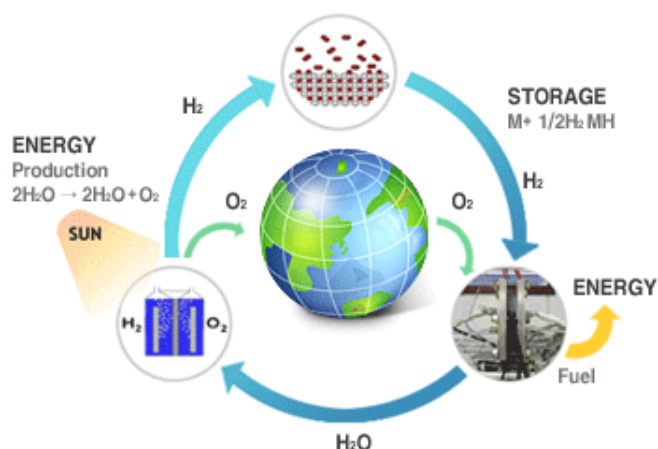
Hydrogen can be considered as the most abundant element, making up to $\frac{3}{4}$ of the mass of the universe. In today's world, every government and scientist is facing a nerve wrecking global crisis of shortage of fuel. What if we use the most abundant element in the universe as a fuel source, there wouldn't be no shortage of Hydrogen. It is an element that would survive billions of years in the future, in contrast to fossil fuels, natural gas, and nuclear power.

In 1992, Hydrogen was considered to be an alternative fuel under the Energy Policy Act of 1992. In addition, President George W. Bush issued a \$1.3 Billion funding to the project in 2003. Like any other renewable energy, it takes time and research to achieve an economic, zero-emission, and efficient fuel. Leading to a Hyundai Tucson Fuel Cell CUV, hydrogen powered, zero-emission car available in the Los Angeles/Orange County region in the state of California, USA.

Unlike current electric cars taking 8-12 hours to recharge, this automobile has a range of 265 miles with 10 minutes of refueling time. Unfortunately, hydrogen fuel is a relatively new alternative fuel, leading to very few hydrogen fuel gas stations. As hydrogen fuel becomes more common, the availability of hydrogen-powered automobiles expands throughout the globe.



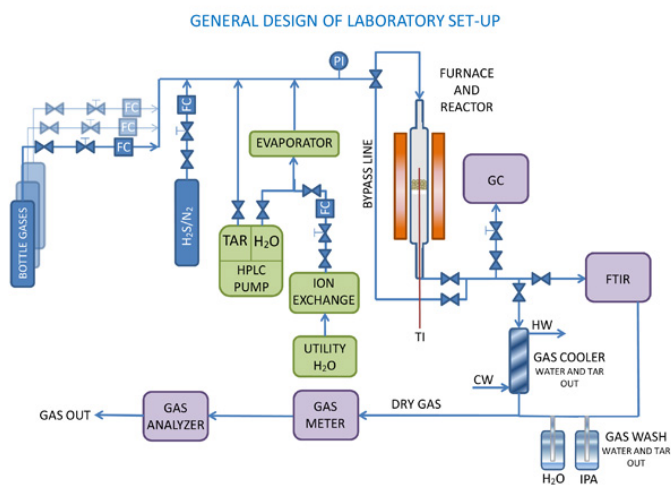
Even though it is the most abundant element, Hydrogen isn't easy to come by. It is contained in various different compounds such as: water (H_2O), hydrocarbons like methane (CH_4), and various other organic matters. Hydrogen can be around three times more efficient than gasoline/petrol, but more research has to be done in order for the extraction process of hydrogen to be economical, allowing majority of the population to have access to it. In addition Hydrogen is synthesized into a liquid allowing easy access and transfer capabilities. One kilogram of Hydrogen gas has the equivalent amount of energy as one gallon of petroleum. Liquid hydrogen then powers the fuel cells in electric automobiles; fuel cells can be viewed as an internal combustion engine in petroleum automobiles. The only emission would be warm water, H_2O .



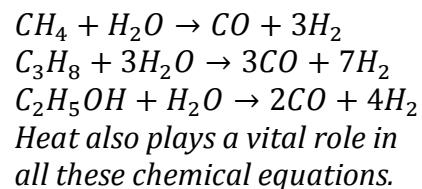
Hydrogen can be acquired through natural gas, coal, solar energy, wind, and biomass. The most efficient and emission-free procedure to acquire hydrogen is through solar energy and water, this technique was developed by researchers at CU Boulder. Essentially, the sun light/rays are amplified and concentrated by mirrors to a central tower. The concentrated heat is then directed towards a chemical chamber containing metal oxides, which when heated up,

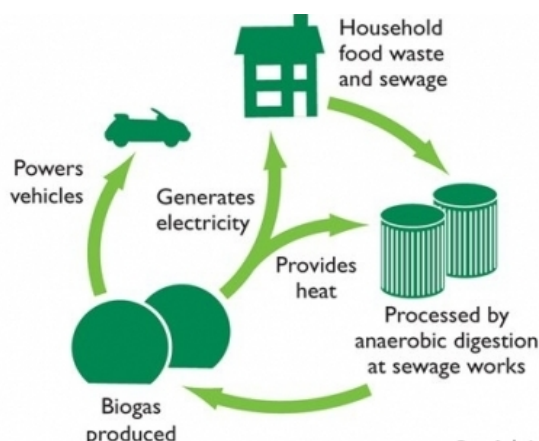
releases oxygen atoms. With the help of steam, acquired by boiling up water through the concentrated heat, the oxygen atoms start to stick to the surface of the metal oxides allowing the release of hydrogen atoms. Hence, hydrogen gas is acquired. However in terms of storage, hydrogen gas requires a lot of storage space, which is why then hydrogen gas is converted into liquid hydrogen. Liquid hydrogen can be achieved by cooling down hydrogen gas to 20.28°K (about -252.87°C). Liquid hydrogen can then be contained in pressurized and thermally insulated containers to maintain it in its liquid form and allowing ease in transportation.

Nevertheless, the technique is expensive as it relies on solar energy. The most common method used to harness hydrogen gas is steam reforming. About 95% of the hydrogen produced in the United States is by this method. This method involves the usage of natural gas, such as methane, ethanol, and propane (mostly hydrocarbons). The hydrocarbons are then exposed to steam and a catalyst allowing the



separation of hydrogen gas. However, natural gases are being used in the production of hydrogen gas, leading to pollutants such as Carbon Monoxide and Carbon Dioxide, destroying the idea of clean energy. Not only does this harm the environment and contribute to global warming, but it also increases the natural gas consumption (a non-renewable energy).



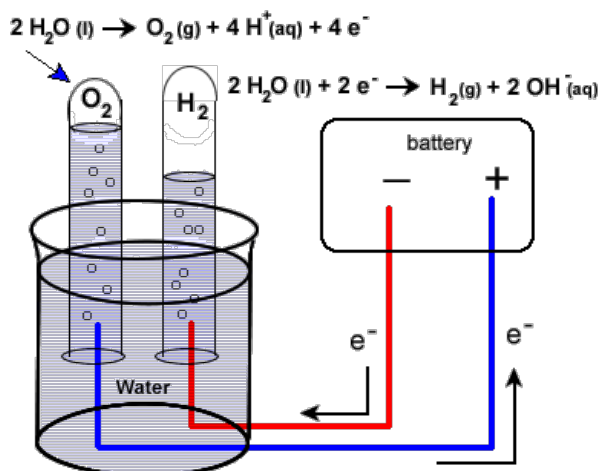


One of the numerous techniques that produce hydrogen involves household wastes, called conversion of biomass and wastes. At first glance at the idea, it seems to solve a lot of problems, however, it also emits greenhouse gasses contributing to global warming. Using this technique, hydrogen gas is produced through a process called pyrolysis (gasification of biomass resources).

Biomass resources include plastics, waste grease, and agricultural wastes. It also uses biomass that is mainly grown for energy extraction purposes. During the pyrolysis process, a liquid is formed as a product that contains various different elements and compounds in form of energy, such as hydrogen gas. This method has potential as it removes undesired wastes from the streets and places it for good use. In addition, biomass is produced daily all over the globe in the form of waste and it is quite cheap to convert into energy. However, this produces various greenhouse gasses, such as Carbon Monoxide and Carbon Dioxide. Furthermore, as soon as the gasses are emitted, such as the Hydrogen gas, it is extremely difficult to capture it, as it is a quick process. Converting biomass and wastes to hydrogen gas is effective but still requires our ozone layer to pay the price.

Small-scale experiment diagram

Another method of acquiring hydrogen from water is through electrolysis. This process involves electricity (in the diagram, electricity is displayed through a battery), and water in a system called the electrolyzer.

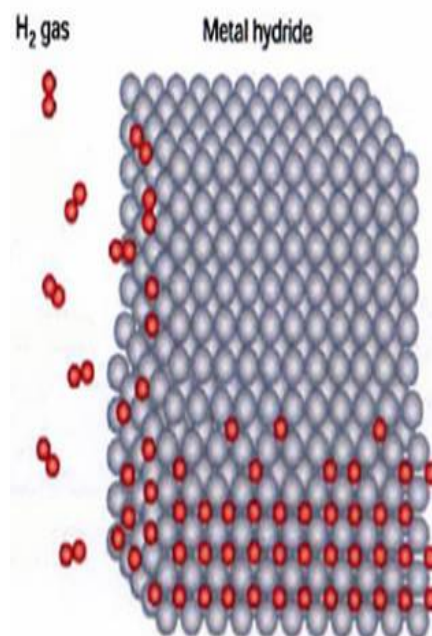


This process uses electricity to split up Hydrogen & Oxygen. It has zero greenhouse gas emission, depending on where the electricity comes from. It is a renewable energy and environmentally friendly.

Despite the process of electrolysis to have a said zero greenhouse gasses produced, it still depends on how the electricity was acquired. If electricity were acquired through a hydroelectric dam, then it would be considered a green zero-emission technique. However, this technique is expensive to acquire hydrogen gas on a large-scale electrolysis. If a large-scale electrolyzer were built for the production of hydrogen gas, then there would be an enormous amount of stress on the electricity grid, potentially leading to a large-scale explosion.

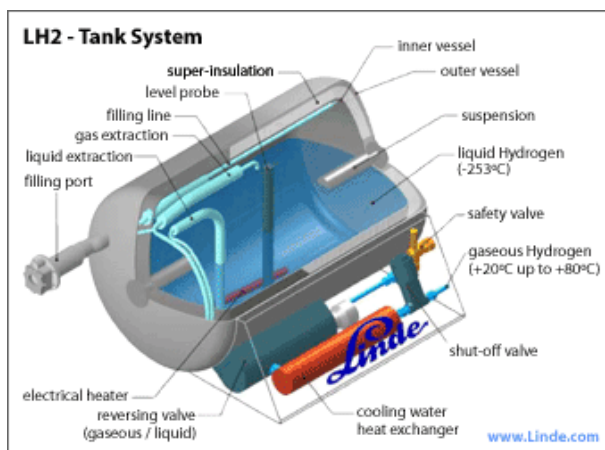
Often times acquiring a renewable energy is difficult compared to storing it. Biodiesel, for example, can be stored as easily as petroleum. However regarding hydrogen gas it is quite the opposite. Storing hydrogen gas and liquid is difficult. There are three known ways to store hydrogen fuel, cryogenic, solid, and compression.

Solid storage is achieved through combining hydrogen gas with metal hydride. This can be easily achieved since hydrogen as an element can react, and wants to react with group 1 and 2 metals from the periodic table to form hydrides. Then, in order for consumer use, water is used to react with the hydride to separate hydrogen gas from metal hydride. This allows extremely low explosion risks. However, the metals are expensive, costing around \$370 per pound, as well as very heavy. Hence, storing certain amounts of hydrogen consumes a lot of space.



Compression storage is achieved by compressing hydrogen, using a compressor, from the atmospheric pressure to a range between 5,000 and 10,000 PSI. Then it is stored in high pressure and thick tanks/containers, this increases a lot of weight to the tanks allowing little amount of hydrogen in each container. Hydrogen has the highest energy content by weight of any fuel; however, its energy content by volume is very low. Hence, looking at a price of \$280 per pound.

The most efficient way to store hydrogen fuel is in its liquid state. In order to acquire hydrogen in a liquid state it needs to be cooled down to approx. 20K (roughly -253 Celsius). This does require a lot of energy, but on the plus side it greatly reduces storage volume allowing maximum amount of hydrogen stored in little of spaces. In a fuel cell electric automobile, it is an ideal storage form. The cost for liquid storage is roughly \$8 per pound, cheap compared to other storage methods. In addition, it allows ease for transportation.



It's a known fact that our world is running out of petroleum and other natural non-renewable resources due to the high demand and high consumption in each country. In the United States alone, Transportation accounts for 71% of U.S petroleum consumption, 40% of it was imported petroleum from foreign nations. The United States might have a few decades left of oil consumption before the reserves are empty.



Hence, leading into alternative energy/fuel. In 1992, hydrogen fuel was considered to be a very effective and possibly an alternative fuel to petroleum, however this required a lot of funding and research, which paid off in the end in the form of the Hyundai Tucson Fuel Cell CUV. It is an automobile containing a fuel cell (electric car) that is powered by liquid hydrogen. It is true that liquid hydrogen is still expensive compared to petroleum,

but it is rich in terms of zero-emission, meaning 100% harm-free to the environment. It is still work in progress, as scientists need to explore new ways for a more economical production of hydrogen fuel without losing its efficiency, as it is three times more efficient than petroleum, in order to allow majority of the world's population to have access to it. Hydrogen fuel is the answer to our global crisis.

