# Hydrogen - A Promising Renewable Fuel


Hydrogen as an everyday fuel is indeed a revolution in science. Useful as a compact energy source in fuel cells and batteries, it is renewable and causes no pollution. Though the discovery of its use is considered a breakthrough, its cost effectiveness is yet to be ascertained.

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Revolutions in science and industrialisation may have enhanced the use of machines. Indeed these machines help improve the quality of human life. However, it is well known that these require energy and consequently, the energy requirement of the world is increasing at an alarming rate. According to the recent World Energy Outlook 2008, we derive around 80 per cent of our energy from fossil fuels like crude oil (36 per cent) natural gas (21 per cent ) and coal (23 per cent) (Fig 1). It is also well known that these fossil fuels are exhaustible and will get depleted very soon. Hydrocarbon resources are in the mid depletion stage and are likely to last for about five decades whereas coal reserves may be adequate for only a couple of centuries.

Most developing nations have a huge difference between the demand and supply of electrical energy. To keep pace with advancement and progress it has become necessary to strengthen power generation capabilities thus taking a toll on the available fossil resources. The growing population has increased the pollution levels in the atmosphere and the resultant emissions in our environment have shown serious consequences. All over the globe, regulatory bodies have suggested reduction in emissions. In such a scenario wherein efforts are being made to minimise the damage caused, through improved technologies with cost implications, renewable energy sources seem to be the ultimate solution for the energy deficit.

Clearly, hydrogen is poised to be one of the potential energy sources of the future. It has three basic benefits:

- The use of hydrogen largely reduces pollution. When hydrogen is combined with oxygen in a fuel cell, energy in the form of electricity is produced.
- Hydrogen can be produced from numerous sources such as methane, gasoline, biomass, coal or water.
- If energy is produced from water, it becomes a sustainable production system.

Thus, the issues related to energy, pollution, environment and sustainability can be tackled effectively using hydrogen energy. Hydrogen is also the lightest of all elements and is available in abundance. If a matured technology is developed, hydrogen can become the cleanest, most efficient and cost effective fuel. The main advantage of hydrogen energy is that it is produced from water, used as an energy carrier and its byproduct is also water. Extensive research is taking place for the generation of pure hydrogen, its handling, storage, efficiency and safety aspects.

## Properties of Hydrogen

Hydrogen is a light, odourless and colourless gas with a density that is 14 times lesser than that of air at standard temperature and pressure and liquefies at temperatures below -253° C. Its energy per unit mass content is around 141.9 MJ/kg which is around thrice of that of gasoline. Hydrogen does not occur naturally as a gas on earth - it is always found in combination with other elements. It is present in large quantities in water as also in many organic compounds - in gasoline, natural gas, methane, etc.

## Production of Hydrogen

Hydrogen is produced using various technologies; depending on the methods by which hydrogen is liberated, they are classified as steam reforming, electrolysis of water, gasification and partial oxidation.

**Steam Reforming:** The method consists of reforming hydrocarbons into their compounds with steam, using endothermic reaction. Hydrocarbons, mixed with steam at a temperature of about 1100° C under pressure, using a catalyst such as nickel, react to release hydrogen.

**Electrolysis of water:** Water breaks apart into hydrogen and oxygen when an electric current is passed through the electrolyte. The positively charged ions are attracted by the cathode where $H_2$ molecules are released. Oxygen is released at the anode. This method needs electric current which can be provided through renewable sources like solar, wind, etc.

**Gasification:** It is one of the oldest methods in which biomass or coal when mixed with a limited amount of oxygen at around 900°C, produces a synthesis gas (syngas) which contains hydrogen. After cleaning, it can be reformed into hydrogen.

**Partial Oxidation:** The thermal degeneration of hydrocarbons produces hydrogen. Raw materials such as natural gas, oil, gasoline are used for the conversion.

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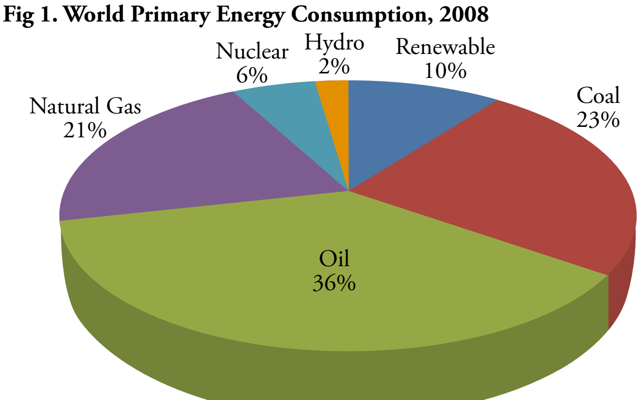
## Storage of Hydrogen

Hydrogen storage is one of the critical issues for successful implementation, commercialisation and sustainability of mobile applications like hydrogen fuelled automobiles. Various technologies used for storage of hydrogen are:

- Compressed hydrogen is essentially the gaseous state of hydrogen gas which is kept under pressure. Pressure in the order of 5000 psi - 10000 psi is used for hydrogen vehicles. However, the size of the tank is large which makes the storage system heavy.

**Fig 1. World Primary Energy Consumption, 2008**




Source : World Energy Outlook

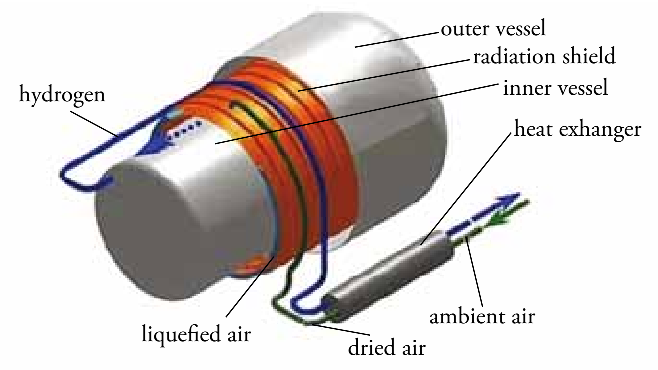



**Fig 2. Storage of liquid Hydrogen**

- Liquid hydrogen (Fig 2) or slush hydrogen requires cryogenic storage (20 K). Liquefaction imposes a large energy loss since energy is required to cool it down to that temperature. The tank must be well insulated and is the kind that can be used in space shuttles.
- Hydrogen can be stored in solid porous materials. Gas-on-solid absorption is inherently safe providing high density storage and increased safety.
- Carbon nanotubes can be a promising mechanism for hydrogen storage. One of the critical factors in the usefulness of carbon nanotubes, as a storage medium is the ratio of stored hydrogen to carbon. According to the US Department of Energy, a carbon material needs to store 6.5 per cent of its own weight in hydrogen to be considered as a fuel for automobiles.

## Storage of Liquid Hydrogen

**Safety:** Certain safety issues that concern the use of hydrogen as a fuel are that it is odourless, colourless and tasteless making it undetectable by human senses. Hence, a leakage will be very difficult to detect. Hydrogen burns very quickly and has a tendency to combine with other elements. Hence, before hydrogen is made available as a popular transport fuel, it is essential to make sure that the fuel is safe for mass storage. Issues related to control of combustion, explosion and detonation of hydrogen air mixtures are yet to be addressed.

**Application:** Hydrogen is high in energy, yet an engine that burns pure hydrogen produces no pollution. Hydrogen fuel cells have been used to power the electrical system of space shuttles. It is a promising technology for use as a source of heat and electricity for buildings and as an electrical power source for electric vehicles. Hydrogen has the potential to be an important energy carrier that can be delivered in a usable form to consumers.

> **Hydrogen has the potential to be an important energy carrier that can be stored, moved and delivered in a usable form to consumers.**

## Conclusion

Renewable hydrogen as a transport fuel is an attractive option, which can help the world in environment protection. However, it is important to make this source safe and commercially viable. The innovations happening at research laboratories are likely to provide necessary results to make the hydrogen economy a reality.

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## Cartoon