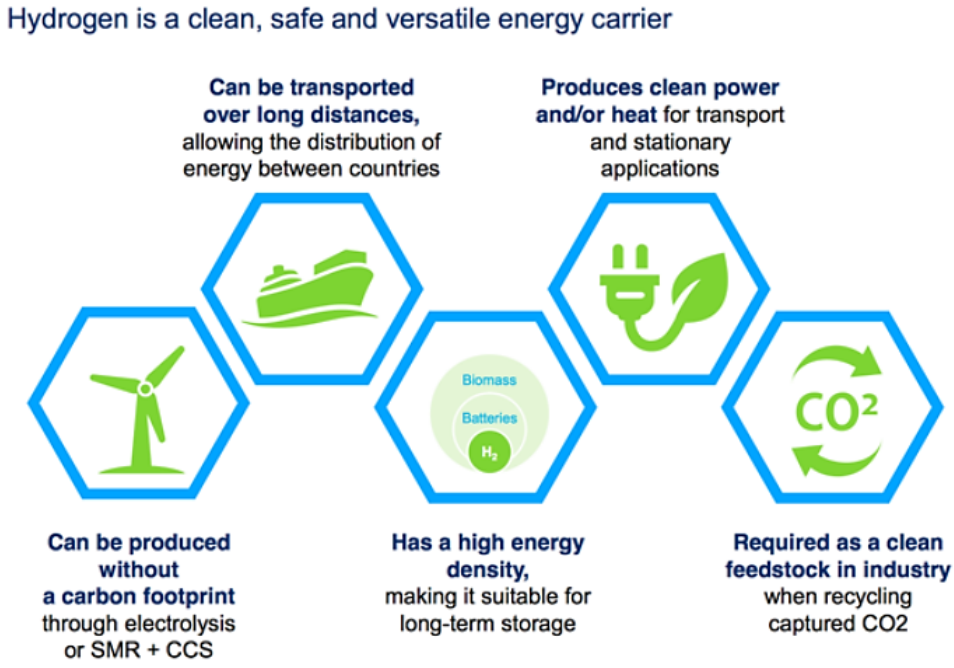
HYDROGEN EUROPE – TECHS [Overview]

Hydrogen Basics



- Hydrogen (H2) is the most abundant element on earth but it rarely exists alone, therefore it is produced by extracting it from its compound.
- Hydrogen can be produced in numerous ways. Some methods produce CO2 while others are carbon free.
- H2 can be renewable or decarbonized if produced using renewable or carbon free electricity.
- Hydrogen has the highest energy content of any common fuel by weight.
- Hydrogen is a high efficiency, low polluting fuel that can be used for transportation, heating, and power generation in places where it is difficult to use electricity or as a CO2 neutral feedstock for chemical processes (ammonia-fertilizers).

> "I believe that water will one day be employed as fuel,
> that hydrogen and oxygen which constitute it, used singly or together, will
> furnish an inexhaustible source of heat and light, of an intensity of which
> coal is not capable".
> - Jules Verne, "The mysterious island"

Jules Verne referred to hydrogen already in 1874 and although he is known for his exceptional "science fiction" writing, he expressed something that 112 years after his death would become reality.

But what is hydrogen exactly?

Robert Boyle produced hydrogen gas in 1671 while he was experimenting with iron and acids, but it was not until 1766 that Henry Cavendish recognized it as a distinct element. The element was named hydrogen by the French chemist Antoine Lavoisier.

In daily life, when we refer to hydrogen, we refer to H2 or dihydrogen, the molecule made of two atoms of hydrogen usually in a gaseous form.

The atom of hydrogen is the first element in the periodic table, with chemical symbol H and the first element created after the Big Bang. It is the most common substance in the universe and the richest energy source for stars like the sun. It consists of one proton (a core unit of positive charge) and one electron (negative charge). It has atomic number 1 and its standard atomic weight is 1,008. The World Hydrogen Day has been derived from this fact and is on the 8th of October of each year.

Hydrogen does not exist naturally on Earth. Since it forms covalent compounds with most non-metallic elements, most of the hydrogen on Earth exists in molecular forms such as water or organic compounds. Combined with oxygen, it is water (H2O). Combined with carbon, it forms methane (CH4), coal, and petroleum. It is found in all growing things (biomass).

Hydrogen has the highest energy content of any common fuel by weight, but the lowest energy content by volume.

It is a high efficiency, low polluting fuel that can be used for transportation, heating, and power generation in places where it is difficult to use electricity. Once hydrogen is produced as molecular hydrogen, the energy present within the molecule can be released, by reacting with oxygen to produce water. This can be achieved by either traditional internal combustion engines, or by devices called fuel cells.

The most important primary energy source for hydrogen production currently is natural gas, at 70%, followed by oil, coal, and electricity (as a secondary energy resource). Steam reforming (from natural gas) is the most used method for hydrogen production. To date, only small amounts of hydrogen have been generated from renewable energies, although that amount is set to increase in future. Electrolysis currently accounts for around 5 % of global hydrogen production If hydrogen is extracted from water using a machine called an electrolyser, which uses an electric current to split H2O into its constituent parts and renewable or carbon free electricity is used, the gas has a zero-carbon footprint, and is known as green hydrogen.

Also, hydrogen-based chemistry could serve as a carbon sink and complement or decarbonize parts of the petrochemical value chain. Today, crude oil (derivatives) is used as feedstock in the production of industrial chemicals, fuels, plastics, and pharmaceutical goods. Almost all these products contain both carbon and hydrogen (hence their name hydrocarbons). If the application of carbon capture and utilization (CCU) technology takes off (as part of a circular economy or an alternative to carbon storage), the technology will need (green) hydrogen to convert the captured carbon into usable chemicals like methanol, methane, formic acid, or urea. This use of hydrogen would make CCU a viable alternative for other hard-to-decarbonize sectors like cement and steel production and would contribute to the decarbonization of part of the petrochemical value chain.

Since hydrogen's production translates into extracting it from its compound by using energy from other primary sources, it is an energy carrier, which is used to move, store, and deliver energy produced from these sources.

For more information on the physical and chemical properties of hydrogen please refer to the **Shell Study on Hydrogen**