

# Electrolysis

Alternative to Conventional fuels

**Hydrogen won by  
Electrolysis of water**

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Electrolysis of water is the decomposition of water (H<sub>2</sub>O) into oxygen (O<sub>2</sub>) and hydrogen gas (H<sub>2</sub>) due to an electric current being passed through the water.

### **Industrial electrolysis**

Many industrial electrolysis cells are very similar to Hofmann voltameters, with complex platinum plates or honeycombs as electrodes. Generally the only time hydrogen is intentionally produced from electrolysis is for specific point of use application such as is the case with oxyhydrogen torches or when extremely high hydrogen purity or oxygen is desired. The vast majority of hydrogen is produced from hydrocarbons and as a result contains trace amounts of carbon monoxide among other impurities. The carbon monoxide impurity can be detrimental to various systems including many fuel cells.

### **High pressure electrolysis**

High pressure electrolysis is the electrolysis of water with a compressed hydrogen output around 120-200 Bar (1740-2900 psi). By pressurising the hydrogen in the electrolyser the need for an external hydrogen compressor is eliminated, the average energy consumption for internal compression is around 3%.

### **High-temperature electrolysis**

High-temperature electrolysis (also HTE or steam electrolysis) is a method currently being investigated for water electrolysis with a heat engine. High temperature electrolysis is more efficient than traditional room-temperature electrolysis because some of the energy is supplied as heat, which is cheaper than electricity, and because the electrolysis reaction is more efficient at higher temperatures.

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### Efficiency

Water electrolysis does not convert 100% of the electrical energy into the chemical energy of hydrogen. The process requires more extreme potentials than what would be expected based on the cell's total reversible reduction potentials. This excess potential accounts for various forms of overpotential by which the extra energy is eventually lost as heat. For a well designed cell the largest overpotential is the reaction overpotential for the four electron oxidation of water to oxygen at the anode. An effective electrocatalyst to facilitate this reaction has not been developed. Platinum alloys are the default state of the art for this oxidation. The reverse reaction, the reduction of oxygen to water, is responsible for the greatest loss of efficiency in fuel cells. Developing a cheap effective electrocatalyst for this reaction would be a great advance. In 2008, a group led by Daniel Nocera announced a potentially more efficient catalyst composed of a cobalt metal, phosphate, and an electrode. Other researchers are pursuing carbon-based catalysts.

The simpler two-electron reaction to produce hydrogen at the cathode can be electrocatalyzed with almost no reaction overpotential by platinum or in theory a hydrogenase enzyme. If other, less effective, materials are used for the cathode then another large overpotential must be paid.

The energy efficiency of water electrolysis varies widely with the numbers cited below on the optimistic side. Some report 50–80%. These values refer only to the efficiency of converting electrical energy into hydrogen's chemical energy. The energy lost in generating the electricity is not included. For instance, when considering a power plant that converts the heat of nuclear reactions into hydrogen via electrolysis, the total efficiency may be closer to 30–45%

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### Water

**Water consumption:** 0,9 litre demin. water is needed for the production of 1 Nm<sup>3</sup> Hydrogen.

**100 MW system:** consumes approximately 21.000 litres water/hour.

**1 GW plant:** consumes appr. 2 000 Tons of water/d.  
Gasoline equivalent: 920 000 litres.  
Considering variations of weather conditions equivalence of 500 000 litres may be assumed as average days production of hydrogen.

Installation of the hydrogen production is suggested to be located in the proximities of great rivers, such as the Nile, due to a high demand of water.

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### **Hydrogen embrittlement**

Hydrogen embrittlement (or hydrogen grooving) is the process by which various metals, most importantly high-strength steel, become brittle and fracture following exposure to hydrogen.

At high temperatures, the elevated solubility of hydrogen allows hydrogen to diffuse into the metal (or the hydrogen can diffuse in at a low temperature).

When these hydrogen atoms re-combine in minuscule voids of the metal matrix to form hydrogen molecules, they create pressure from inside the cavity they are in. This pressure can increase to levels where the metal has reduced ductility and tensile strength up to the point where it cracks open. High-strength and low-alloy steels, nickel and titanium alloys are most susceptible. Steel with an ultimate tensile strength of less than 1000 MPa or hardness of less than 30 HRC are not generally considered susceptible to hydrogen embrittlement. Tests have shown that austenitic stainless steels, aluminum (including alloys), copper (including alloys, e.g beryllium copper) are not susceptible to hydrogen embrittlement along with few other metal.

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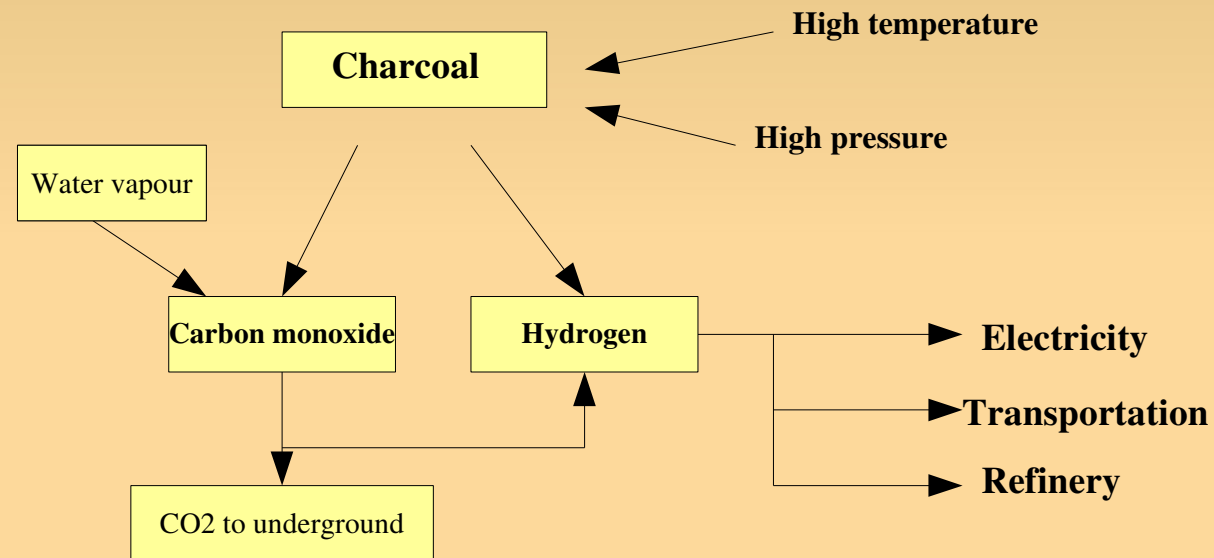
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### FutureGen

FutureGen is a US government project involving the construction of a near zero-emissions coal-fueled power plant to produce hydrogen and electricity while using carbon capture and storage. In March 2009 U.S. Secretary of Energy Steven Chu expressed support for continuing the project using stimulus funds.

It is a 2.4 billion USD project of a coal fired power plant.

The coal is not burned directly, but first transformed in carbon monoxide and hydrogen under high pressure and high temperature. Water vapour is added and carbon monoxide is transformed in carbon dioxide and hydrogen. The carbon dioxide is captured and pumped in the underground. The hydrogen is burned to generate electricity.



**The End**