HYDROGEN
MINI GRID SYSTEM

FACTSHEET

Hydogen Generation

What is Hydrogen?

Hydrogen is the lightest element and, at room temperature and pressure, is a colorless, odorless, tasteless, highly flammable diatomic gas with the molecular formula H_2. Hydrogen is the most abundant of the chemical elements and makes up roughly 75% of the universe's elemental mass

However, hydrogen, unlike conventional hydrocarbon fuels (such as oil, gas and coal), does not exist in large quantities in nature in a useful, pure, form. Consequently, hydrogen, like electricity, is not a 'fuel' but an 'energy carrier' and must be produced using energy from another source. However, hydrogen has a significant advantage over electricity; it can be easily stored for later use. This storage capability allows it to be used as a fuel for vehicles, for electricity and heat generation and as a storage medium for electricity generated from intermittent renewable sources e.g. wind energy.

Hydrogen can be produced by many different techniques using primary energy sources ranging from raw fossil fuels to renewable energy.

Hydrogen Production Technologies

The main obstacle preventing the wholescale adoption of the 'Hydrogen Economy', and in particular the use of hydrogen for transportation, is that hydrogen must be cost-competitive with conventional fuels and technologies on a per-mile basis. Only then will the use of hydrogen succeed in the commercial marketplace.

Steam Reforming – This is currently the most common method of generating large quantities of Hydrogen. During reformation a hydrocarbon gas, often methane, is mixed with steam at high temperature and pressure, in the presence of a catalyst, to produce a syngas made up of hydrogen (H_2) and carbon dioxide (CO_2). Around 95% of hydrogen produced in the USA comes from hydrocarbon reforming.

Gasification or Partial Oxidation – This is an effective way of obtaining energy from coal, biomass or any other carbon containing material which contains traces of contaminants. These heavier hydrocarbons are reacted with oxygen and steam, cracking the hydrocarbon to produce H_2 and CO_2, a syngas similar to that produced during Steam Reforming. Gasification is a commercially viable process and is typically used in countries with large coal resources.

Electrolysis – During electrolysis an electric current is passed through water causing it to split into its constituent atoms H_2 and O_2. However, the rise in electricity costs has made this process less economically viable. Electrolysis typically consumes approximately 4.5kWh/l of hydrogen production and can be totally carbon-free if the electricity used is produced from a renewable source such as wind, solar or hydropower.

An electrolyser is essentially a fuel cell working in reverse (See HMGS Fuel Cell Factsheet).

Biological Methods – Under the right conditions algae and bacteria can be encourage to produce hydrogen by photosynthesis or fermentation. At present these technologies are largely in the Research and Development, R&D, stage although some large scale, semi-commercial, plants are planned.

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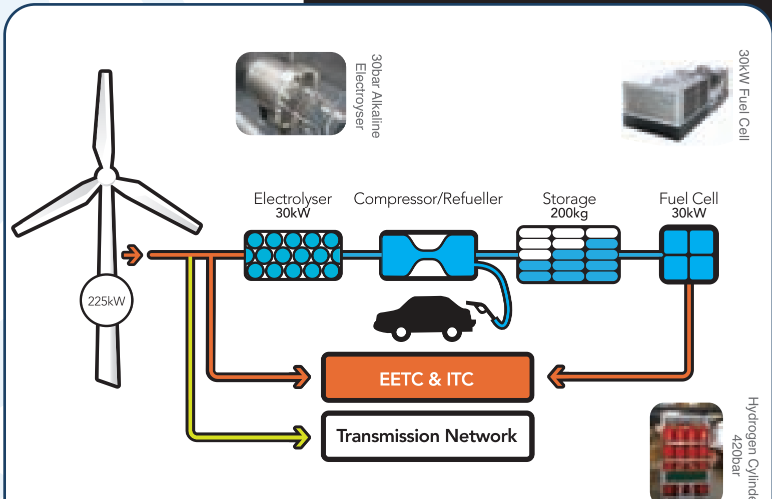
Thermo-chemical water splitting – This process uses high temperatures (850 – 950°C) and chemicals to split water. The most popular is the sulphur-iodine cycle. During the cycle, oxygen and hydrogen are produced from water and all the chemicals used are recycled.

Future Research – R&D activity is typically focussed on increasing the efficiency of these production methods. Any increase in production efficiency would improve the economic viability of the Hydrogen Economy.

However, other prospective technologies, such as photoelectrolysis (the use of a solar cell that splits water directly without using electricity) are also receiving a significant amount of R&D attention.



Schematic of HMGS

Hydrogen Production from Renewable Energy Sources

One of the most promising technologies for the large scale sustainable production of hydrogen is electrolysis using electricity from renewable resources – allowing hydrogen to be produced with zero greenhouse gas emissions.

All electrolysers consist of an anode and a cathode separated by an electrolyte. However, different electrolysers function in slightly different ways.

- **Proton Exchange Membrane (PEM) Electrolyser**
  In a PEM electrolyser the electrolyte is a solid plastic material. The water reacts at the anode to form oxygen and positively charged hydrogen ions (protons). These hydrogen ions migrate across the PEM to the cathode where they combine with electrons from the external circuit to form hydrogen gas

  Anode Reaction: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$
  Cathode Reaction: $4H^+ + 4e^- \rightarrow 2H_2$

- **Alkaline Electrolysers**
  In Alkaline electrolysers the PEM is replaced with an alkaline solution (typically sodium or potassium hydroxide) that acts as the electrolyte.

- **Solid Oxide Electrolysers**
  Solid oxide electrolysers use a solid ceramic material as the electrolyte. This selectively transmits negatively charged oxygen ions at elevated temperatures and therefore generates hydrogen in a slightly different way:

  - Water at the cathode combines with electrons from the external circuit to form hydrogen gas and negatively charged oxygen ions;
  - The oxygen ions pass through the membrane and react at the anode to form oxygen gas and give up the electrons to the external circuit

	Electrolyte	Temperature	Technology Status
PEM	Solid plastic	80 - 100°C	Pre-commercial – at a similar stage as hybrid vehicles.
Alkaline	KOH, NaOH	100 - 150°C	Has been commercial for decades. A well mature technology that can be installed tomorrow - similar to the familiar ICE engine.
Solid Oxides	Solid ceramic	500 - 800°C	Still under research

The Hydrogen Mini Grid System (HMGS)
The HMGS uses an alkaline electrolyser that has been specifically designed and configured by the Pure Energy Centre, Hydrogen specialists, for use with renewable energy generated electricity. This avoids the electrode degradation common with other electrolysers due to the fluctuating electrical supply (voltage and current) typical of intermittent renewable energy sources.

In addition, the HMGS electrolyser generates hydrogen at a pressure of 30bar, significantly higher than many other electrolysers which operate at atmospheric pressure. This pressure can be increased to up to 200bar and researchers are developing electrolysers that can withstand 350bar. This reduces the onward compression costs, maximises the potential amount of hydrogen that can be generated and allows the hydrogen to be used for a wide diversity of applications from electricity generation to refuelling hydrogen powered cars.

http://www1.eere.energy.gov/hydrogenandfuelcells/production/natural_gas.html
http://www.ne.doe.gov/hydrogen/thermochemical.pdf

The construction, commissioning and subsequent operation of the HMGS is being carried out by TNEI Services Ltd. and their partners the Pure Energy Centre. For more information please contact the team:

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