ENERGY STORAGE

Factsheet 2 – Hydrogen

The International Energy Agency expects world energy demand to grow by 60% between 2000 and 2030. Economic growth and a desire to reduce carbon emissions is placing increased emphasis on the need to find new energy sources for transport, heat and power. The ability to store energy and convert it to electricity to meet a particular need is becoming increasingly important in this context.

Recent foresighting activity by ITI Energy identified that the current energy storage market, although established for many decades, has potential for rapid growth and significant technological change. The study found that the total global market is currently well in excess of $40Bn per annum and is expected to grow at more than 10% p.a. The current market excludes any potential market growth created as a result of new energy vectors such as hydrogen.

As a result of this and parallel work we are interested in a range of technical innovations concerning storage systems which can contribute to significant improvements in performance as well substantial reductions in cost. In addition storage technologies, with applications in wider industrial process markets, are of interest to us.

Hydrogen in context

The hydrogen economy is a vision of where the world uses hydrogen as an energy carrier in place of oil and other fossil fuels. Hydrogen would be used to heat homes and power vehicles, with fuel cells or internal combustion engines. Hydrogen can be generated from a range of sources, however when produced via renewable sources it can help to reduce carbon emissions.

Until the early 1970s, liquid hydrogen's main use was as a rocket fuel by NASA. Today, the commercial market is many times larger than the government market. Many industrial applications use hydrogen, such as metals processing, plate glass production, fats and oils hardening, semiconductor manufacturing, and pharmaceuticals and chemicals manufacturing. The petroleum refining industry is the single largest growth area for hydrogen today.

In the future if hydrogen is to be used as a replacement or hybrid fuel solution, and energy carrier, it will require an infrastructure for safe and cost-effective hydrogen transport, storage and distribution.

Today the challenges for hydrogen are many - technical, economic and social.

Hydrogen properties

- Hydrogen readily combines with oxygen to form water.
- It has a high energy content per weight (nearly 3 times as much as petrol), but the energy density per volume is quite low at standard temperature and pressure. Hydrogen's volumetric energy density can be increased by storing the hydrogen under increased pressure or storing it at extremely low temperatures as a liquid. Hydrogen can also be adsorbed into metal hydrides.
- Because it is much lighter than air, it disperses very quickly.
- Hydrogen burns with a pale-blue, almost-invisible flame, making hydrogen fires difficult to see.

- The combustion of hydrogen does not produce carbon dioxide (CO_2), particulate, or sulfur emissions. It can produce nitrous oxide (NO_X) emissions under some conditions.

- Hydrogen can be produced from renewable resources, such as by reforming ethanol (this process emits some carbon dioxide) and by the electrolysis of water (electrolysis is very expensive).

Hydrogen production

- The U.S. hydrogen industry currently produces 9 million tons of hydrogen per year for use in chemicals production, petroleum refining, metals treating, and electrical applications. If used as an energy carrier, 9 million tons of hydrogen could power 20-30 million cars or 5-8 million homes.

- Steam methane reforming, a process that converts hydrocarbon fuels such as natural gas into hydrogen and carbon monoxide, accounts for 95% of the hydrogen produced.

- Other hydrogen production methods include the following:

    - Electrolysis, which uses an electrical current to split water into hydrogen and oxygen; the electricity can be generated from renewable sources

    - Gasification, which uses heat to break down into a gas from which hydrogen can be generated

    - Photobiological techniques, which use algae to produce hydrogen in the presence of sunlight

    - Photoelectrochemical processes, which split water into hydrogen and oxygen using only sunlight

    - Thermochemical processes, which involve using nuclear or solar heat to split water into hydrogen and oxygen

Hydrogen storage and delivery

- Hydrogen can be stored as a compressed gas or liquid, a chemical compound or nano-material.

- Hydrogen can be transported by pipeline or over the road in cylinders, tube trailers, and cryogenic tankers; a small amount can be shipped by rail or barge.

- Pipelines, which are owned by merchant hydrogen producers, are limited to a few areas where large hydrogen refineries and chemical plants are concentrated.

- Hydrogen distribution via high-pressure cylinders and trailers has a range of 100-200 miles from the production facility. For longer distances of up to 1,000 miles, hydrogen is usually transported as a liquid in super-insulated, cryogenic, over-the-road tankers, by rail, or barges, and then vaporised for use on the customers premises.

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