Hydrogen

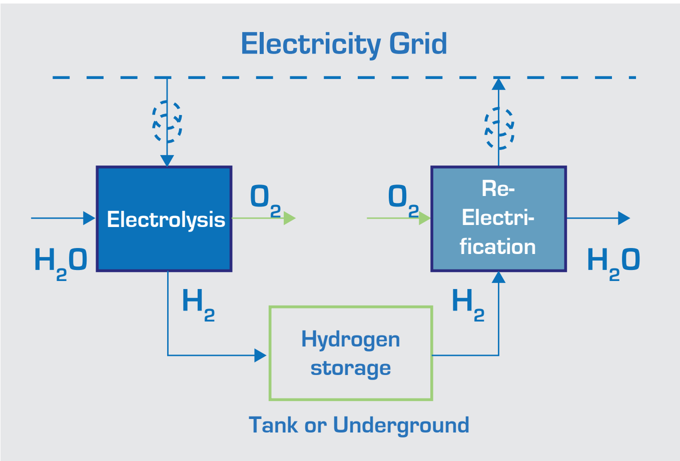
European Association for Storage of Energy

Chemical Energy Storage

1. Technical description

A. Physical principles

Electrical energy is stored by electrolysing water to produce hydrogen and oxygen. The oxygen is released and the hydrogen is then stored. For grid electrical energy storage applications, the hydrogen is then re-electrified (e.g. via fuel cells) thus recombining hydrogen with oxygen to produce electricity. Heat and water are released as a by-product. Alternatively gas turbines or engines can reconvert hydrogen into electricity as well.



B. Important components

The three main components are the following:

Electrolyser: 3 types of electrolysers are known:

- Alkaline Electrolyser (most mature and already commercialised)
- PEM Electrolyser (today MW-scale at demonstration phase)
- High Temperature electrolysis (R&D phase)

Hydrogen Storage:

- As a liquid at temperatures below -253°C
- As a compressed gas in storage tanks or salt caverns
- Physically stored as a metal hydride compound
- Chemically converted into ammonia or methanol and stored as a liquid
- Chemically converted into Synthetic Natural Gas (SNG) and stored in the Natural Gas-grid
- Dissolved in liquids

Re-Electrification through:

- Gas Turbines
- Engines
- Fuel Cells

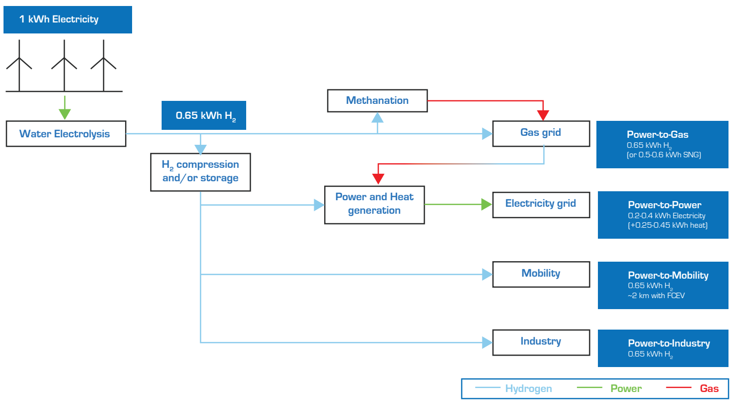
C. Key performance data

Power range	1 kW - 1 GW
Energy range	Some 10 kWh – several GWh
Discharge time	Some h – some weeks
Cycle life	n.a.
Life duration	5-30 years
Reaction time	<sec - <min
Efficiency	20-40 %*
Energy (power) density	30 - 2,550 kWh/m³ (H_2 tank storage)
CAPEX: energy	1-10 €/kWh
CAPEX: power	2,000 - 5,000 €/kW

* with repowering via a fuel cell

D. Design variants (non exhaustive)

Different design variants are defined according to the utilisation. Here below the example of an alkaline (or PEM) electrolyser.



Some technologies can achieve efficiencies above 80% with heat valorisation.

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2. State of the art

Currently, there are many power-to-gas projects emerging in Germany and other European countries.

Most of these projects employ alkaline or PEM electrolysers, with technologies developed by various manufacturers. These components are available in a size range from a few kW to several hundreds of MW and are able to operate with short ramp-up time associated with intermittent renewable generation.

It has been demonstrated that the different electrolyser types can follow the load changes produced by the output of a wind farm very quickly. This means that electrolysers could be used as negative, or – in continuous operation - also as positive operating reserve for the grid system.

Most of these demo projects envisage the use of hydrogen for mobility purposes or wholesale via the gas grid (with direct hydrogen injection or with methanation step). Only a few of them have large scale storage and re-electrification in its scope.

Large scale hydrogen storage itself has already operated for several years at two locations in the UK and the USA, but a wider use in the context of fluctuating wind generation is still not realised.

At the same time, a lot of demonstration projects related to the mobility application are running all over the world.

3. Future developments

- Electrolyser: up-scaling and cost reduction in order to be able to compete in the energy supply and storage landscape with alternative pathways.
- Hydrogen storage: large demonstration projects employing salt caverns are on the way. Further experience needs to be gathered on how this particular storage system could interact with wind generation and the gas and electricity networks.
- Increase of the hydrogen admixture into natural gas infrastructure (grid and caverns) and for all connected consumers.
- Increase of the hydrogen content in conventional gas turbines.
- Methanation step: technological advancements (Sabatier reaction or biological process), up-scaling and cost reductions in order to become a viable chemical storage alternative.

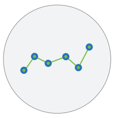
4. Relevance in Europe

The hydrogen storage technology is well suited to facilitate the integration of the large amounts of renewables that will be installed in Europe in the future.

There are numerous applications to make use of the hydrogen, which are not only limited to the power sector (with re-electrification):

- It can be injected into the gas grid: direct injection (blending) or converted into SNG after a methanation process. In this case, the energy is stored in the existing gas infrastructure.
- It can be used for mobility purposes in Fuel Cell Electric Vehicles. Here, the energy is usually stored in hydrogen tanks.
- It can be converted into methanol and thus stored as a liquid to be used as blend for fuels or as a chemical platform in the industry.
- It can be used as a commodity by the chemical industry.
- It can be stored on a very large scale in salt caverns, which would be very well suited for large off-shore wind parks or in places where is there is high discrepancy (time/space) between energy production and consumption.

5. Applications



Balancing demand & supply: seasonal & weekly fluctuations, ancillary services

Grid management: grid extension alternative, grid reinforcements...

Hydrogen refuelling stations
Hydrogen production as raw material

6. Sources of information

- EASE Members
- The Fuel cells and Hydrogen Joint Undertaking
- The North Sea Power to Gas Platform
- The HyUnder project
- DENA Strategieplattform Power-to-Gas
- Siemens
- Hydrogenics

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