Technology: Hydrogen

GENERAL DESCRIPTION

Mode of energy intake and output

Power-to-gas

Summary of the storage process

An electrolyser uses electricity from renewable energy sources to split water into hydrogen and oxygen. The hydrogen can then be stored, for example in pressurised containers, through the use of liquid organic hydrogen carriers, or in large scale salt caverns, and later used in a variety of applications. Depending on the electrolyser design and storage technologies used, a compressor may be required to bring the hydrogen to the required pressure for storage.

System Design

Depending on the scale, several technologies are available for storing the hydrogen. The options range from cylinder bundles and pressurised tanks to underground salt caverns with several 100,000 m³ of capacity. Another option is to liquefy hydrogen at cryogenic temperatures or store it in chemical (e.g. ammonia, methane, methanol) or physical bonds (e.g. metal hydrides, adsorption). As an alternative to stationary storage, small proportions of hydrogen may also be fed directly into existing gas grids to blend in with the natural- or biogas already present.

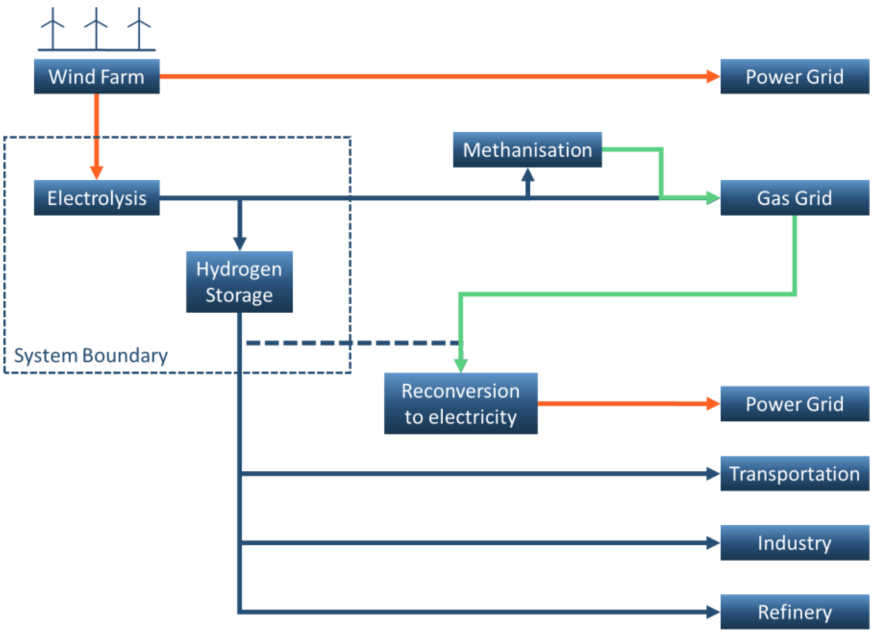

Figure 1: Possible power-to-gas routes for hydrogen

Focus on provision of power or energy

Energy

Suitable fields of application

Storage of surplus energy, mainly over periods ranging from weeks to months; provision of negative control energy; use in transport (fuel), industry (raw material), and the energy sector (fuel).

State of development/commercial availability

Demonstration stage (TRL 6-7)

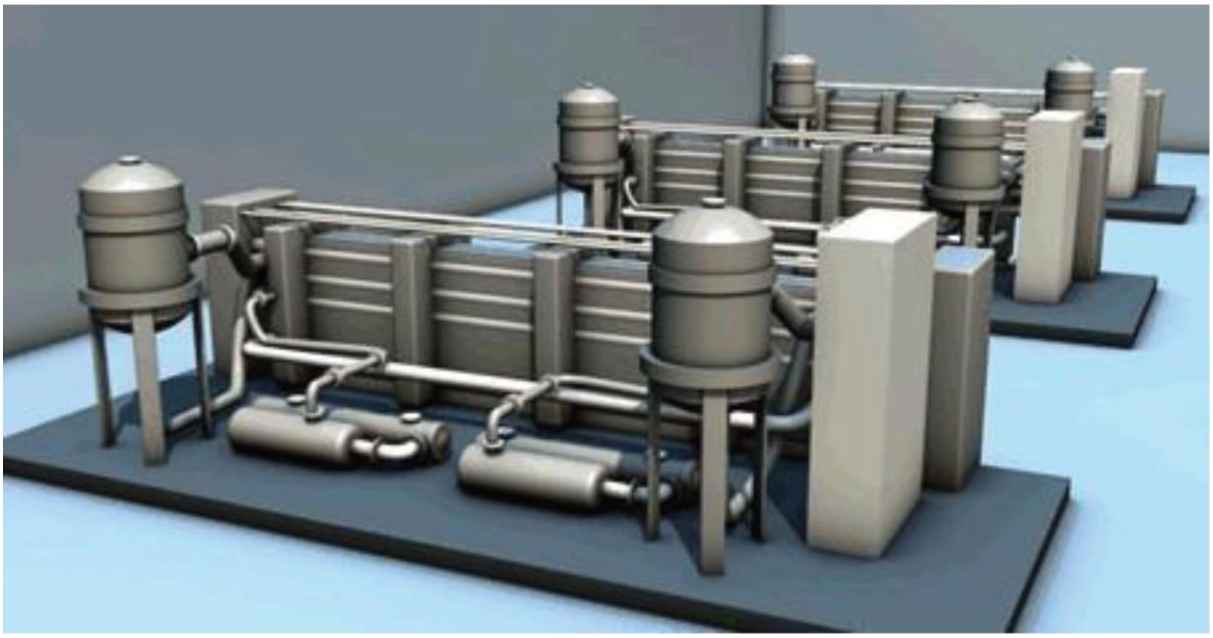

Figure 2: Planned 6 MW PEM Electrolyser (©Energiepark Mainz)

TECHNICAL SPECIFICATIONS

Specific energy storage density	kWh/m³ 100-1,200	kWh/t Not relevant
Specific power density	kW/m³ Not relevant	kW/t Not relevant
Typical/feasible storage size	MWh_{out} 0.005-200,000	MW_{out} 0.001-100
System efficiency	65 (kWh/kWh_{el})	
Storage efficiency	55 (kWh_{el}/kg)	
Storage duration	Weeks-months	
Response time	Seconds	
Service life (maximum)	Cycles 10,000	Years 15
Loss per time in %	-	

Notes

These figures refer to state-of-the-art alkaline and PEM electrolysis.

The system efficiency value refers to the path from electricity provision to generation and storage of hydrogen; any further utilisation of the hydrogen, e.g. for reconversion into electricity, is not taken into account. The calculation is based on hydrogen's lower calorific value.

ECONOMIC SPECIFICATIONS

Investment cost per kW: 2,000-3,000 € (2030: 1,500-2,000 €).

Investment cost per kWh: 8.33-385 € (2030: 3.75-200 €)

Notes on these specifications

The costs shown are specific to alkaline and PEM electrolysis. They each refer to the complete system consisting of electrolyser, compressor, and storage tank, including engineering, permits, and installation. The cost range is based on a not yet existing large-scale plant with a 500 MW_{el} electrolyser, a matching compressor, and a cavern with 120 GWh of storage capacity in 2030, and a small-scale plant with a 5 MW_{el} electrolyser, a matching compressor, and a pressure vessel with 32.5 MWh of storage capacity. The figures for a large-scale plant in 2030 are based on the findings of the study "Integration von Wind-Wasserstoff-Systemen in das Energiesystem" (Integration of wind-hydrogen systems into the energy system)[1], while the lower figure assumes a steeper cost degression for electrolysis to 500 €/kW in accordance with the FCH-JU Storage Commercialisation Study[2].

Operating and maintenance cost (based on investment/kW and kWh)

2-5 % of original investment per year

[1] https://www.planet-energie.de/de/media/Abschlussbericht_Integration_von_Wind_Wasserstoff_Systemen_in_das_Energiesystem.pdf

[2] https://www.sciencedirect.com/science/article/abs/pii/S1464285915301012