Power to Methane - Methane Synthesis from H_2 and CO_2 by Using Water Electrolysis and Post-Combustion Capture

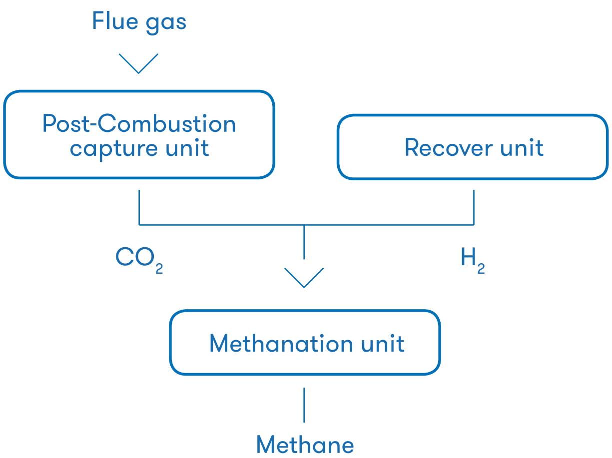
European Association for Storage of Energy

Chemical Energy Storage

1. Technical description

A. Physical principles

Hydrogen is produced by water electrolysis while carbon dioxide is captured from a flue gas via post-combustion capture. Both gases are converted to methane by using a catalytic or bio-catalytic reactor. With the utilisation of waste heat from the electrolyser unit and addition of a high temperature heat pump, the overall efficiency can be increased. Moreover, the utilisation of reaction heat could also increase the overall efficiency.



B. Important components

The main components are the following:

- Electrolyser unit:
  - Pressurised alkaline electrolyser, or
  - High-temperature solid oxide electrolyser, or
  - Proton exchange membrane (PEM) electrolyser
- Post-combustion capture unit:
  - Amine based absorption/desorption process as known from chemical processes
- Methanation unit:
  - Catalytic conversion of hydrogen and carbon dioxide to methane

C. Key performance data

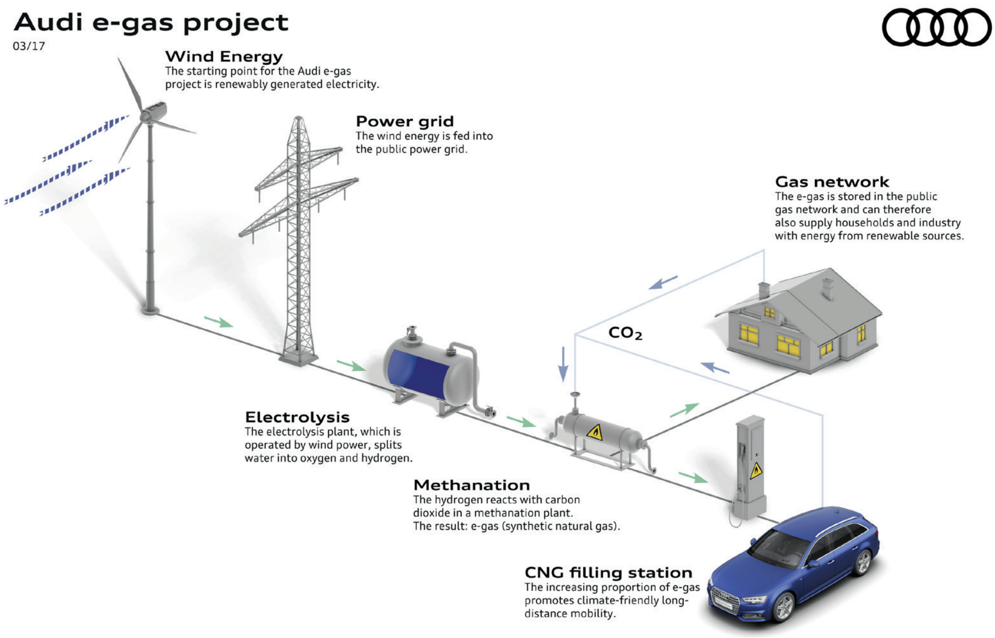
Power range	1MW-1GW
Energy range	1MWh-several GWh
Discharge time	Some weeks
Operating Hours	8500 h/year
Life Cycle	30 years
Reaction time	Sec
Efficiency	48-53%
Energy density	13,9MWh/t
CAPEX: energy	n.a.
CAPEX: power	1,9 – 2,9 m€/MW

D. Design variants

Different design variants of power to methane process are mainly defined according to the on-site availabilities of the feed stocks hydrogen and carbon dioxide, respectively. The methanation reactor is the core component and therefore always needed.

2. State of the art

The power to methane concept is already implemented. It increases the e-gas contributions, enhances environmentally friendly long-distance mobility, fills CNG-Stations and offers a supply for the public electricity grid.



3. Future developments

- Methane reactor unit: up-scaling and further development in order to achieve higher product capacities.
- Plant: build of first-of-its-kind plant in order to achieve experience for future plants and improvement of the total process.
- Similar technology for gasification plants using biomass: Increasing the carbon conversion to nearly 100% by adding hydrogen to raw syngas (Power to fuel as a sustainable business model for cross-sectoral energy storage in industry and power plants).
- Development of new reactor designs for process intensification, leading to improvements in reaction kinetics, energy efficiency, and decrease in capital costs.
- Development of new catalysts for more durable and cost-effective processes.

4. Relevance in Europe

The methanation technology is well suited to facilitate the integration of large amount of renewables that will be installed in Europe. There are numerous applications to make use of the methane, which are not only limited to the power sector. For instance, the methane can be injected into the gas grid. In this case, households and industry use the renewable methane for example for heating. The methane can also be used for mobility purposes. Methane offers the unique possibility to connect the power sector to the gas, mobility, and industrial sectors.

5. Applications

Balance excess capacity and RES from power plants, waste incineration or industry with existing technology.

Provide flexibility services to the grid through a smart management of process energy consumption.

Build power to methane plants next to an existing industrial operation.

Achieve the targets of the Renewable Energy Directive (RED) and Fuel Quality Directive (FQD).

Find the right fit between available power, utilisation factors, CO_2 sources, infrastructure and, offtake distribution.

6. Sources of information

- Power-to-Methane: A state-of-the-art review, Karim Ghaib, Fatima-Zahrae Ben-Fares
- Renewable Energy Storage and Power-To-Methane, Roger Andrews
- Power to Methane – An Integral Part of Biomethane Industry, Jan Stambasky
- Enea consulting: The potential of power-to-gas, Jacques de Bucy, Olivier Lacroix, Laurent Jammes
- Potenziale von Power-to-Gas Energiespeichern - Modellbasierte Analyse des markt- und netzseitigen Einsatzes im zukünftigen Stromversorgungssystem, Mareike Jentsch

i Council Directive (EU) 2015/652 of 20 April 2015 laying down calculation methods and reporting requirements pursuant to Directive 98/70/EC of the European Parliament and of the Council relating to the quality of petrol and diesel fuels

ii Directive (EU) 2015/1513 of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources

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