POWER TO GAS
Biological Methanisation

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agriKomp

agriKomp GmbH
Energiepark 2
91732 Merkendorf
Germany

Phone +49 9826 65959-0
info@agrikomp.com
www.agrikomp.com

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Power-to-Gas
Storing and using surplus electricity

CHALLENGES POSED BY SURPLUS ELECTRICITY

The energy transition is progressing mainly through the expansion of electricity generation from renewable sources such as wind power and solar energy. With the growth of fluctuating sources, storage solutions are becoming even more important. To meet this challenge, targeted investments in grid modernisation, energy storage and smart load management are necessary.

The feed-in of renewable energy is highly dependent on the weather conditions and the time of day, whereas electricity consumption is not equally flexible. The result is a growing imbalance between generation (when the sun is shining or the wind is blowing) and consumption (which takes place regardless of these factors).

Surplus electricity refers to electrical energy that could theoretically be generated but cannot be fed into the grid due to grid capacity constraints – or is not generated at all because plants such as wind turbines or solar power stations have to be capped. This phenomenon occurs when the supply of renewable energy overwhelms the current electricity grid.

It is important to utilize valuable surplus electricity, either by storing it or by using technologies that convert the electricity into primary energy sources to make it storable for longer periods. Following this conversion, the energy can be used later. For example, by utilizing surplus electricity produced in the summer during the winter.

STORAGE ISSUES

Although there is intensive research into energy storage and suggestions for using electric vehicle batteries, what is needed above all is seasonal long-term storage. Existing physical long-term storage solutions, such as pumped-storage power stations, are cost-effective and geographically limited (current capacity at present: 0.04 TWh).

Batteries can only store energy for short periods (hours and days) and have insufficient storage capacity (currently around 0.03 TWh). To get an idea of the storage capacity currently available: in less than half an hour, all of Germany's pumped-storage and battery storage facilities would be emptied if they had to assume the power supply.

POWER-TO-GAS AS SOLUTION

Germany has a very large and nationwide energy storage facility: the natural gas grid, with a capacity of around 290 TWh.

When converted to methane or hydrogen, a huge amount of surplus electricity can be stored in the natural gas grid and distributed through it. The solution to the storage problem involves technologies for converting surplus electricity into chemical, gaseous energy carriers, a process known as Power-to-Gas.

The idea is simple: electricity from renewable sources is used to split water into hydrogen and oxygen via electrolysis. Surplus electricity can be stored as green hydrogen thanks to this process. However, the hydrogen infrastructure is still underdeveloped, and hydrogen has a significantly lower volumetric energy density.

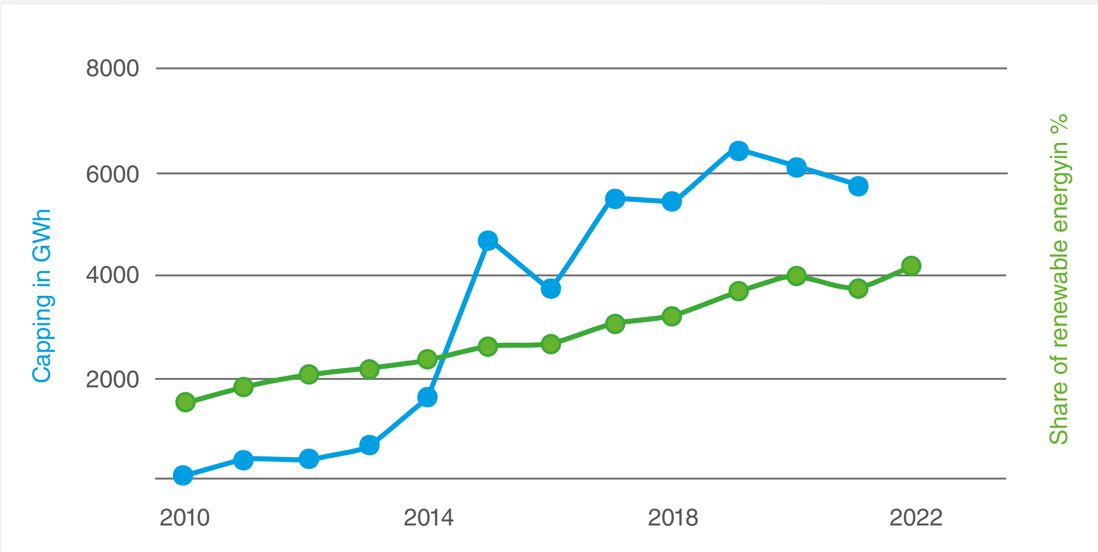
As a result, the storage capacity of the natural gas grid, when fully filled with hydrogen, would be reduced by a factor of three to four compared to filling it with methane.

BIOLOGICAL METHANATION

Far more efficient is the further conversion of renewable hydrogen into methane, which has an energy density per unit volume approximately three times higher than that of hydrogen. Methane, the main component of natural gas, can be stored and transported via the existing gas grid. The use of high-calorific natural gas is widespread and familiar – among end users such as households, and in industrial processes in the chemical, pharmaceutical, metal, cement and glass manufacturing sectors.

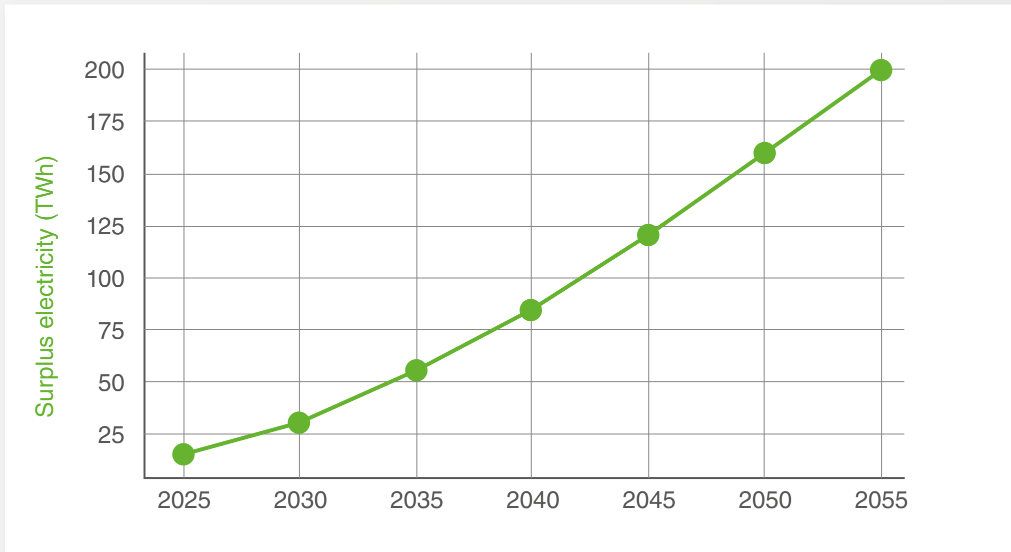
In biological methanation, microorganisms in a reactor convert hydrogen and carbon dioxide into methane and water. **($4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$)**

Capacity capping and renewable energy share (2010–2022)



Source: Statistka, Energycharts.info

Predicted surplus electricity in Germany (2025–2055)



Source: Own graphic

Biological Methanation

Hydrogen and CO_2 are converted into E-Methane.

THE MAIN IDEA

There are many biogas plants that do not utilize the CO_2 contained in the biogas yet. Raw biogas contains up to 50 % CO_2, which can be utilized for this purpose. When converted into CH_4 via biological methanation, the utilization rate of the carbon in the raw biogas is significantly increased. As a result, renewable (green) hydrogen from electrolysis and biogenic CO_2 from biogas production are converted into e-methane and water.

Wind turbines or solar panels are often installed nearby or on the farms themselves, which would generate surplus electricity if they were not capped. The surplus electricity produced is used to generate green hydrogen. Combined with biological methanation, biogenic CO_2 and green hydrogen are converted into e-methane, which can be fed into the natural gas grid. This is how sector coupling between the electricity and gas grids is achieved: surplus electricity (which would otherwise never have been generated) is stored in the gas grid using power-to-gas technology.

ADVANTAGES OF POWER-TO-GAS

- Reduction in the use of fossil-based energy sources
- The existing gas grid can be utilised
- Power-to-Gas technology enables electricity from renewable energy sources to be stored for the long term
- Surplus electricity is converted into methane, which can be transported via the gas grid, stored and reused locally
- Utilisation of renewable electricity that would not have been generated at all due to capping ('surplus electricity')
- Increase in methane production from biogas plants without requiring additional land

BIOLOGICAL METHANATION USING THE GICON®-TRICKLE-BED PROCESS

For biological methanation, we rely on the GICON® trickle-bed process. Since 2015, engineers have been working on the production of e-methane from hydrogen and carbon dioxide. The trickle-bed process developed focuses on storing renewable energy during peak loads through the electrolysis of hydrogen and subsequent methanation. The process also generates heat, which can also be utilized.

When integrated into a biogas plant or biogas processing facility, the CO_2 produced during biogas generation is utilized. This helps to reduce reliance on fossil fuels in gas consumption, as the carbon comes from biogenic sources. Furthermore, the conversion of CO_2 unlocks additional material flows that generate extra revenue for the operation. This significantly improves the plant's profitability.

Long story short: surplus renewable electricity is converted into green hydrogen via electrolysis, which, together with biogenic carbon dioxide from the biogas plant, is turned into e-methane.

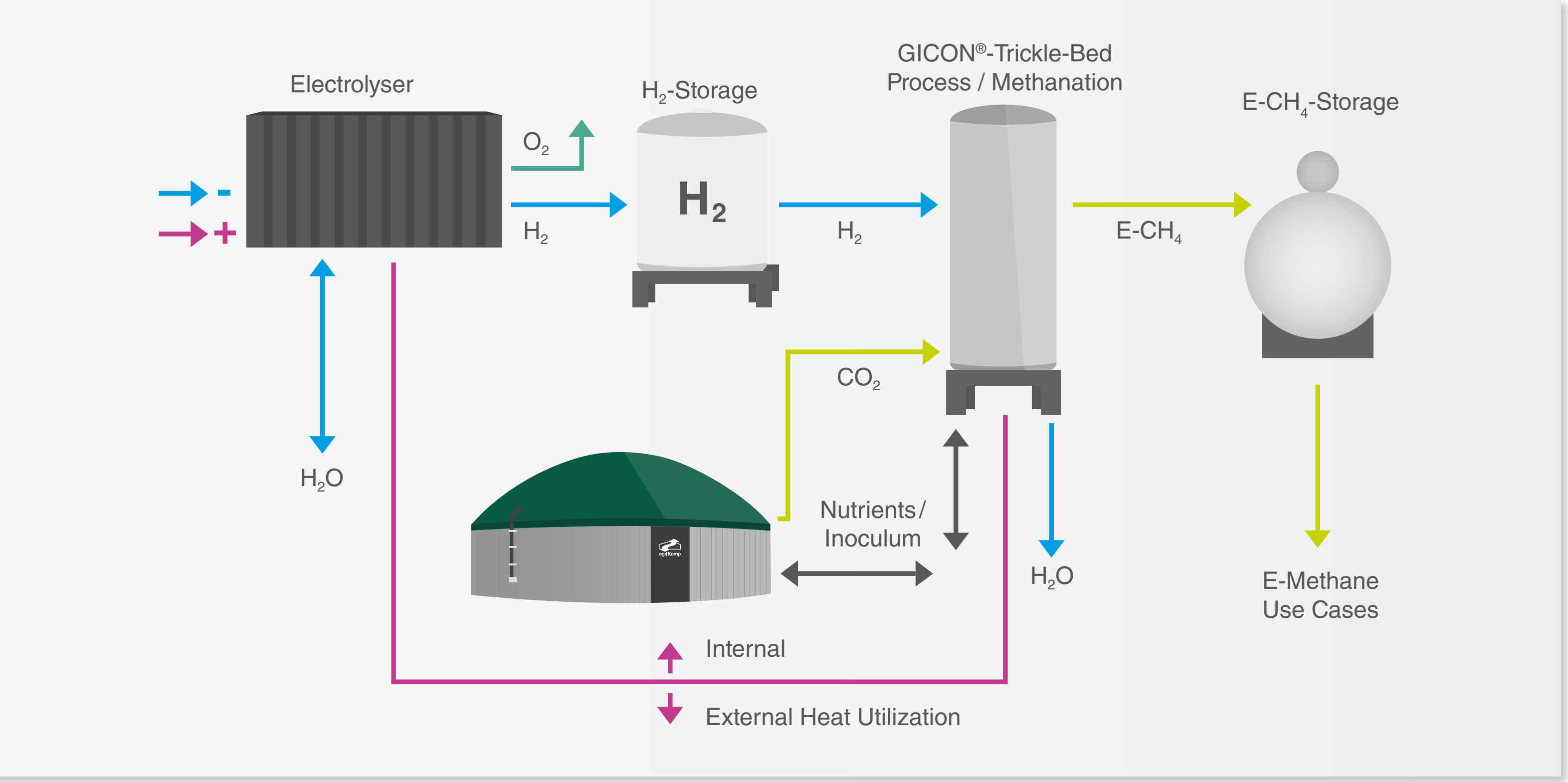
THE PROCEDURE

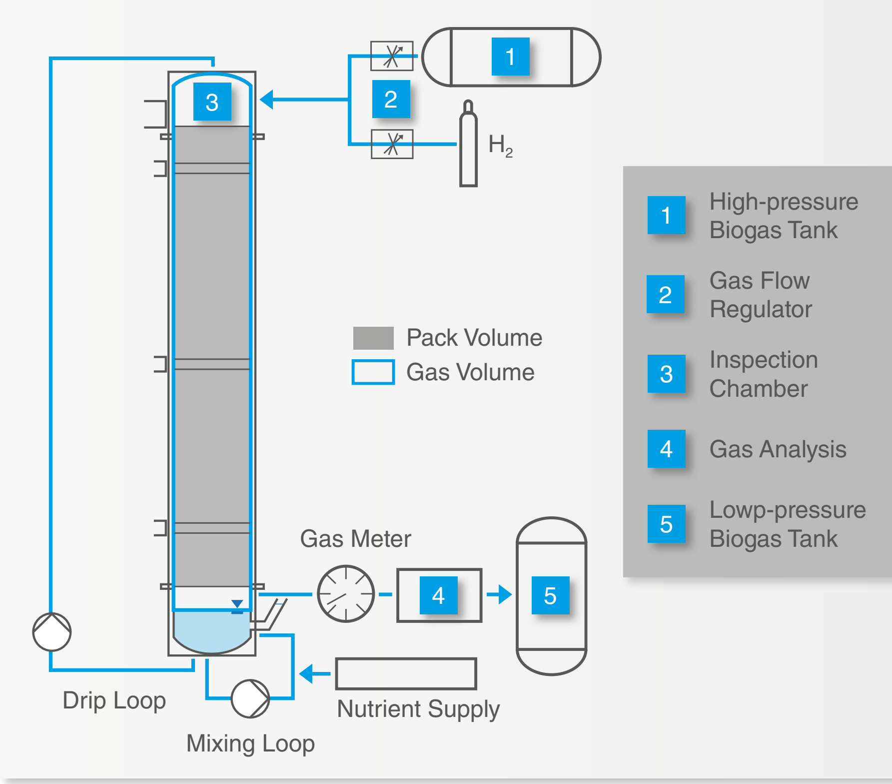
Biological methanation using the GICON® trickle-bed process is a conversion process to produce methane with the use of microorganisms.

It is based on a process known as methanogenesis: Microorganisms known as archaea use biocatalysis to convert hydrogen (H_2) and carbon dioxide (CO_2) into methane (CH_4). The relevant microbial metabolic processes proceed under strictly anaerobic conditions and in an aqueous environment.

The process takes place in a separate reactor (ex situ process). Any carbon source can be used for this purpose, e.g. from a biogas plant, from permeate from biogas upgrading, or even from industrial processes.

The trickle-bed process takes its name from the controlled supply and distribution of a process water flow, which is held in the reactor sump and recirculated by means of a pump. It serves primarily to supply micro- and macronutrients, which are added to the recirculate in the form of liquid digestate from a biogas plant.





Biological Methanation
Strong Partnership

IN DETAIL

In the GICON® trickle-bed process, the microorganisms responsible for methanisation mainly colonise carrier media within the reactor. These carrier media have a large specific surface area.

The space between the support structures serves as a gas chamber, through which the supplied gases – H_2 and CO_2 or biogas – flow from top to bottom. As the gases pass through the reactor, the microorganisms convert them into methane and water. The process is configured in such a way that a methane concentration of over 95% by volume is achieved at the bottom of the reactor. This allows the methane to be discharged directly from the reactor for further treatment without the need for the gas to be recirculated within the trickle-bed reactor.

The process is characterised by a simple design, as it requires neither mixing of the process fluid nor recirculation of the gas, nor any increase in pressure.

Initially, the reactor is inoculated with digestion medium from a biogas plant to establish the anaerobic biofilm.

STRONG PARTNERSHIP

The patented GICON® trickle-bed process is implemented in a plant designed and manufactured by us as an experienced plant engineer. We can supply all components of the system, from the complete biogas plant through biogas upgrading to e-methane and biological methanation. We are also happy to handle the repowering of an existing plant.

ADVANTAGES OF THE PROCESS

- Safe, efficient and easy-to-operate process
- Flexible operation possible, depending on the availability of H_2 or CH_4 requirements.
- Based on established technology and many years of development work
- Very low energy consumption
- Demand-driven process control
- Process stability through biofilm technology
- High product quality: CH_4 > 95 vol%
- Tolerance to impurities (H_2S, NH_4)