

Transforming  
volatile power from  
renewable resources to CH<sub>4</sub>  
by catalytic three-phase methanation.



## The Three-Phase Methanation (Power-to-Gas)

Methanation is a promising process for storing volatile renewable energies in form of chemical energy carriers. The three-phase methanation (3PM) is a unique catalytic process with highly dynamic operability.

In the bubble column reactor of the 3PM a mix of hydrogen and carbon dioxide or carbon monoxide disperses into a suspension of solid catalyst particles and inert liquid – the three phases. At the surface of the catalyst, the educt gases react to methane.

Excellent selectivity and educt conversion rate guarantee high yields, a methane synthesis with hardly any byproducts and a methane output of about 10 m<sup>3</sup>/h in the shown pilot plant.

The efficient heat absorption of the liquid phase allows dynamic load changes from 0 to 100 % within a few minutes, grants an optimal control of the reaction and allows heat extraction for further purposes.

By feeding the methane into the omnipresent gas grid, storage capacities and all established applications for natural gas can be used.

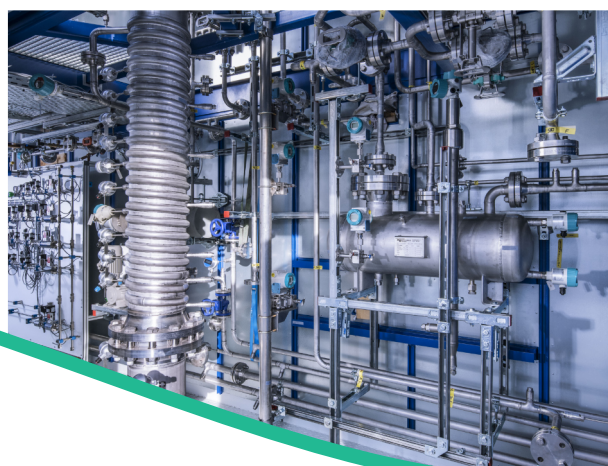
### Key data:

- Feed gas: Syngas with H<sub>2</sub> and CO<sub>2</sub> (and/or CO)
- Product: CH<sub>4</sub>
- Nominal power: 100 kW (CH<sub>4</sub> output)
- Pressure: 1 - 20 bar
- Temperature: 250 - 330 °C
- Bubble column reactor: Ø<sub>i</sub> = 250 mm, l = 2.500 mm
- Modified 40' shipping container

### Facts:

- **Scale:**  
Pilot plant at KIT can supply around 50 households with CH<sub>4</sub>
- **Methane-Yield:**  
CH<sub>4</sub> yield > 95 % possible
- **Dynamic Operation:**  
Load changes from 0 to 100 % within one minute
- **Efficiency:**  
Methanation efficiency of 80 %. Can be increased further by utilization of reaction heat (T > 250 °C).

The picture of the process room shows several main components:  
gas mixing rack, reactor, condensate vessel (f.l.t.r)  
Photo: A. Bramsiepe, KIT

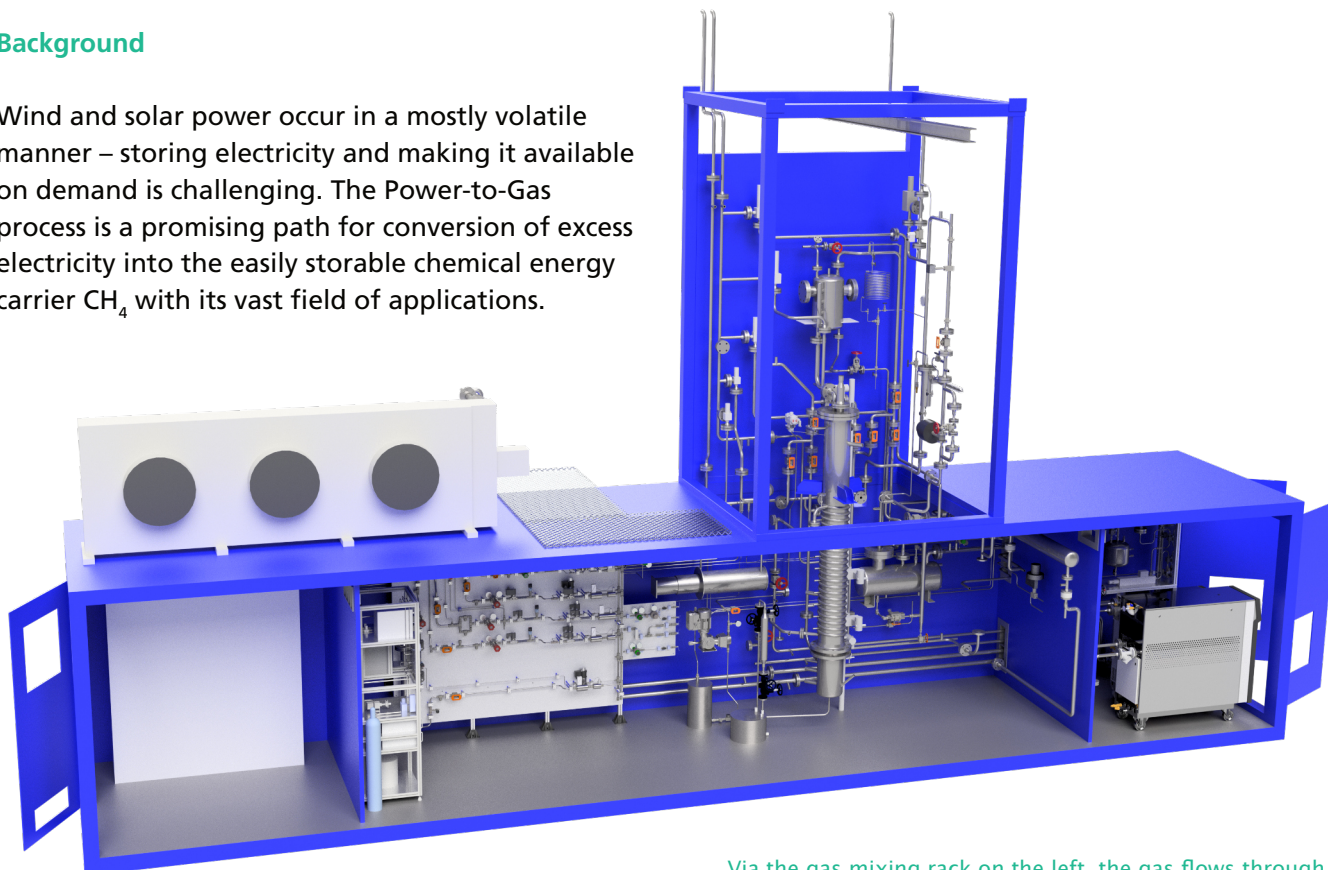




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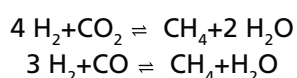
## Background

Wind and solar power occur in a mostly volatile manner – storing electricity and making it available on demand is challenging. The Power-to-Gas process is a promising path for conversion of excess electricity into the easily storable chemical energy carrier  $\text{CH}_4$  with its vast field of applications.



## The 3PM plant

KIT operates a pilot scale 3PM plant to create research results and process knowledge. The focus lies on a more profound understanding of reaction kinetics, hydrodynamics and mass transfer in dynamically operated bubble column reactors for catalytic reactions like methanation. The larger scale eliminates wall effects, a decisive advantage compared to laboratory scale. The 3PM enables the conversion of hydrogen and carbon dioxide and/or monoxide to methane according to following equations:



Via the gas mixing rack on the left, the gas flows through a heat exchanger and is introduced into the reactor from below. Afterwards, the product gas is cooled and dried and available for utilization. Two thermostats on the right of the drawing control the temperature of the reactor and the heat exchangers and can be coupled with heat utilization processes.  
Picture: Raphael Küchlin

## Vision

Feeding sustainably produced methane into the well-established gas infrastructure with its vast storage capacity fuels multitudes of applications throughout the country and mobility applications in form of renewable LNG or CNG.

The utilization of carbon dioxide from renewable sources and its subsequent reuse in the form of methane is  $\text{CO}_2$ -neutral and therefore does not increase greenhouse gas emissions. Apart from the high load flexibility, the excellent heat extraction capabilities of the 3PM process offers opportunities for further increases in process chain efficiency due to intensive heat integration.

Dr. Siegfried Bajohr  
Engler-Bunte-Institut (KIT)

Engler-Bunte-Ring 1  
Gebäude 40.51

[siegfried.bajohr@kit.edu](mailto:siegfried.bajohr@kit.edu)