Website address:

https://www.biooekonomie-bw.de/en/articles/news/environmentally-friendly-alternative-to-fossil-natural-gas-methane-from-biomass

Environmentally friendly alternative to fossil natural gas: methane from biomass

In cooperation with the research unit of the German Technical and Scientific Association for Gas and Water (DVGW), KIT researchers have successfully built a pilot plant in which biogas produced by fermenting residual organic materials can be upgraded to synthetic methane (synthetic SNG). Biobased methane is not only a sustainable energy source for the heating and transport sectors, but also opens up new opportunities for temporary storage of renewable energies.

Honeycomb-shaped nickel catalysts

© Andreas Spiegel, KIT

So-called methanation, i.e. a chemical reaction by which carbon monoxide (CO) or carbon dioxide (CO_2) and hydrogen (H_2) are converted to methane (CH_4), is not new. The reaction was discovered by the chemist Paul Sabatier in 1902[1]. However, what is really innovative is found inside the pilot plant and consists of metallic nickel: a honeycombed catalyst that facilitates methanation in a one-step process, thus ensuring high efficiency.

Highly efficient methanation process opens up new opportunities for the bioeconomy

Dr.-Ing. Siegfried Bajohr, head of EBI's Chemicals Fuel Technology (EBI ceb) Division, which developed the metallic nickel catalyst, sees great potential in the new process, especially for the bioeconomy. This is because the biomass gasification of organic residual materials such as waste wood or the fermentation of biomass enables large quantities of biogas to be produced and turned into high-quality methane in a subsequent step.

The higher the methane content, the higher the calorific value of the gas. From a methane content of just under 80 percent by volume, the gas produced can be fed into the natural gas grid and thus replace its fossil equivalent[2]. From there, the biobased energy source can then not only be used for heating purposes, but also as fuel in the transport sector. At present, the heating and transport sectors are still predominantly based on fossil fuels: with only 13.9% in the heating sector and 5.6% in the transport sector, the proportion of renewable energies (wind, photovoltaic and biomass) in Germany's energy mix in 2018 was still relatively low[3].

From waste wood to high-quality natural gas substitute

Methanation using carbon dioxide as an example.

© Viola Hoffmann

Nevertheless, up to 7 million tonnes of waste wood accumulate in Germany every year. About 30% (2.2 million tonnes) of the waste wood is turned into materials and the remainder into energy (combustion plants)[4]. The new methanation process represents a far more efficient and environmentally friendly recycling route than conventional methanation processes. Converting the chemical energy contained in the wood into the natural gas substitute methane offers several advantages. The hydrogen needed for methanation can be obtained from water by electrolysis using electrical energy. As power generation from wind power and photovoltaic systems fluctuates and temporary storage is a problem, the new process would be able to use the excess energy to produce hydrogen. The hydrogen generated could then used to synthesize methane and feed it into the natural gas grid[5].

Modular design allows flexibility and scalability

Depending on the desired size, small biogas plants and large power plants can both be used as carbon suppliers. The intelligent coupling of methanation with the respective carbon source can even save energy: for example, the process can use waste heat from methanation to heat the biogas fermenter. A look at current consumption of natural gas and the sources from which it is produced clearly highlights the importance of process developments such as those of Bajohr and his colleagues which are aimed at fully exploiting substitution potentials by 2020 (4 billion m^3) and reducing dependence on natural gas imports. The researchers are confident because they have already successfully tested the process on a pilot scale. The methanation plant is the size of a normal freight container and was tested by the DVWG's cooperation partner Cortus Energy AB under the name DemoSNG in Köping, Sweden. The partners were able to produce biomethane from waste wood and use it as fuel for the company's own natural gas vehicles[6].

Process scheme showing the conversion of waste wood into high-quality synthesis gas/methane for use in the heating and mobility sectors.
© Bajohr et al. 2011[5]

Energy Lab 2.0: working towards the industrial scale

Biomethane substitution potentials vs. actual natural gas consumption and sources.
© FNR 2014[7]

The pilot plant has since returned to KIT Campus North, where it will be further tested for industrial use as part of Energy Lab 2.0. Using the plant in combination with smaller biogas plants is no problem; it fits into a standard shipping container. According to Bajohr, the greatest challenge now lies in upscaling the process to the industrial scale. The honeycomb structure of the methanation reactor through which the gas flows as it is turned into methane, has the distinct advantage that the structure allows high radial heat transfer. This means that the process heat can be removed from the system very quickly, which simplifies the reactor design in contrast to other methanation reactors. Whether this also works on an industrial scale remains to be seen. In Energy Lab 2.0, the methanation process is initially integrated into a large-scale, intelligent energy network that links various new technologies together and serves as a simulation platform for the sustainable and efficient energy supply.

As the goal is to increase the proportion of renewable energy in gross electricity consumption to 60% by 2050, while at the same time drastically reducing CO_2 emissions, the implementation of the technologies tested in the Energy Lab 2.0 cannot happen quickly enough[8,9].

References:

[1] HELMETH (2019): Integrated High-Temperature ELectrolysis and METHanation for Effective Power to Gas Conversion.
www.helmeth.eu/index.php/technologies/methanation-process

[2] Paschotta, R. (2019): Erdgas. www.energie-lexikon.info/erdgas.html

[3] Federal Environment Agency (2019): Erneuerbare Energien in Zahlen.
www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/erneuerbare-energien-in-zahlen

[4] Federal Environment Agency (2014): Holzindustrie.
www.umweltbundesamt.de/themen/wirtschaft-konsum/industriebranchen/holz-zellstoff-papierindustrie/holzindustrie

[5] Bajohr, S.; Götz, M.; Graf, F.; Ortloff, F. (2011): Speicherung von regenerativ erzeugter elektrischer Energie in der Erdgasinfrastruktur. Fachberichte, Rohrnetz.

[6] KIT (2018): Press release: Production of Renewable Gas from Waste Wood
https://www.kit.edu/kit/english/pi_2018_107_production-of-renewable-gas-from-waste-wood.php

[7] FNR (2014): Biomethane.
biogas.fnr.de/fileadmin/biogas/Bioerdgas-Potenziale.jpg

[8] KIT (2017): Energy Lab 2.0: The future energy systems in the focus.
Broschüre zum Download: www.elab2.kit.edu/113.php

[9] IWR (2014): Forschungsanlage erzeugt Methan aus Ökostrom und Biomasse.
www.iwr.de/news.php?id=27829

Article

08-May-2019
Viola Hoffmann

Further information

Engler-Bunte-Institut, Teilinstitut Chemische Energieträger - Brennstofftechnologie
Karlsruher Institut für Technologie (KIT)
Dr.-Ing. Siegfried Bajohr
Engler-Bunte-Ring 1

76131 Karlsruhe
Phone: +49 (0)721 608-48928
E-mail: siegfried.bajohr(at)kit.edu

- Energy Lab 2.0 project
- KIT Energy Center
- Cortus Energy AB

The article is part of the following dossiers

Biogas – a promising source of renewable energy?

Bioanalysis – techniques for the characterization of biological material

Sustainable bioenergy

bioenergy | biomass | biogas | renewable energy | sustainability | bioeconomy