«HyperP2G» Project

More Power for P2G Plants

Development of reliable long-term storage solutions for cushioning the pronounced fluctuations in power generation by wind turbines and solar installations is a key challenge of the German energy turnaround. Power2Gas (P2G) technology, i.e. utilisation of excess current generated by renewable energy installations to produce hydrogen, methanation, and feed-in into the natural gas grid, is the most promising technological approach to solution of the power storage problem. PFI is conducting intense research in this area and also operates Germany's largest plant for biological methanation at Pirmasens-Winzeln Energy Park. A new two-year research project which started in September 2017 aims to significantly improve the performance of this plant.

Background – Power2Gas

Germany is pursuing the goal of generating 60 % of its energy requirements from renewable resources by the year 2035. However, progressive expansion of "green" energy generation is increasingly leading to network stability problems. According to Schleswig-Holstein's Energy Ministry and the network operator Tennet, in Schleswig-Holstein alone in 2015 some 3000 gigawatt hours of electricity from renewable energy sources could not be fed into the network for fear of power grid overload.

As soon as 2025, further expansion of renewable energy sources will necessitate not only upgrading of grid capacities but also large-scale introduction of effective long-term power storage units. As the sole available national long-term power storage solution, Power-to-Gas Technology (P2G) will play a key future role. Biological methanation in combination with the natural gas grid as storage system represents a highly promising P2G technology. In the first step hydrogen is produced by electrolysis of water, with excess electricity from wind power and solar installations serving as energy source. The hydrogen together with carbon dioxide from various possible sources (biogas plants, industry) are then used to produce methane in bioreactors. Coupling to existing biogas plants offers ideal conditions for cost-effective operation. The CO_2 produced by the biogas plants can then be used directly for the process, i.e. without further purification. No additional costs for the supply of CO_2 are then incurred. This also represents a significant advantage over competing processes for industrial methane synthesis (*Sabatier process*).

The process has been successfully implemented by PFI at Pirmasens-Winzeln Energy Park. The trickle-bed reactors developed by PFI convert the CO_2 present in the biogas produced by the PFI biogas plant and the electrolytically generated hydrogen into natural gas containing 99 % methane. This gas has been fed into the local natural gas grid of the Pirmasens Municipal Utility Company since the end of 2016 (see Fig. 1).

Fig. 1: Biogas plant (foreground) and trickle-bed reactors for biological methanation at Pirmasens-Winzeln Energy Park

Use of Hyperthermophilic Production Strains to Enhance Productivity

On the basis of our research into the growth and productivity of methanogenic bacteria, we have been able to demonstrate that certain thermophilic strains (optimum growth between 55 and 65 °C) are significantly more effective than organisms which grow at moderate temperatures (35 to 45 °C). A special thermophilic production strain is therefore being used in the plant at Winzeln Energy Park.

More recent laboratory-scale studies have shown the way to attain further significant increases in efficiency through use of so-called hyperthermophilic bacterial strains. These particular organisms only feel really comfortable at temperatures above 80 °C. Very high methane production rates under these extreme conditions could be demonstrated in laboratory experiments. The goal of this project is to significantly increase the space-time yield of biological methanation relative to the current state of the art by utilisation of these particularly effective hyperthermophilic methanogenic bacteria.

Upscaling from a laboratory via a technical to a pilot scale is planned in order to ensure the practical utility of the developed process. Further studies concern optimisation of growth media, energetic and thermal management in plant operation under hyperthermophilic conditions (over 80 °C) as well as effects of differing reactor operating conditions on process stability. Through selection of the most effective production strains in combination with further process optimisation measures the project should make a key contribution to an improved cost effectiveness of P2G plants.

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