MORE GAS THANKS TO BIOLOGICAL METHANATION

Switzerland's gas supply is currently still heavily based on natural gas. To achieve Switzerland's climate targets, this fossil fuel must be replaced by renewable gas. A technological advance is a step in this direction: Through the methanization of CO_2 and hydrogen, the production capacity of biogas plants can be increased significantly. A feasibility study by the Aargau energy supplier Eniwa AG explains the ecological advantages of this process for small and medium-sized plants as well as the economic considerations for the approach to be sucessful.

The biogas treatment plant at WWTP Reinach. To date, 175 t of CO_2 are removed from the raw biogas and is released into the environment per year. The CO_2 could be converted into renewable gas using a biological methanation process. The renewable hydrogen needed for methanation could one day be produced on site by electrolysis. Eniwa is building a large photovoltaic plant (2.3 MW output) near the WWTP scheduled for completion by 2022. Photo: WWTP Reinach

A technical report about the results of a research project in the field ofbioenergy, which was financially supported by the Swiss Federal Office of Energy. The report has been published in the technical magazine Aqua-&Gas (issue November 2021).

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Eniwa AG, headquartered in Buchs, Aargau, supplies energy, water and fiber-optic connections to more than 100,000 customers in about 30 communities around Aarau. Eniwa supplies around half of the energy in the form of gas. The majority is still of fossil origin ('natural gas'), while eight percent comes from renewable substrates ('biomethane'). An important supplier of the renewable gas is the biogas plant 'Swiss Farmer Power' in Inwil (LU), in which Eniwa holds a stake. Part of the demand is covered by imports.

The Federal Council's net-zero strategy poses huge challenges for Eniwa and other Swiss gas utilities. "In 2050, we will only supply climate-neutral gas. We will have to massively expand domestic production. In addition, it will also require imports of renewable gas," said Samuel Pfaffen, head of corporate development at Eniwa. While gas sales will decrease overall because of the substitution of heat generation from district heating and heat pumps, the renewable share will increase. Eniwa therefore faces the task of procuring significantly more renewable gas in the coming years.

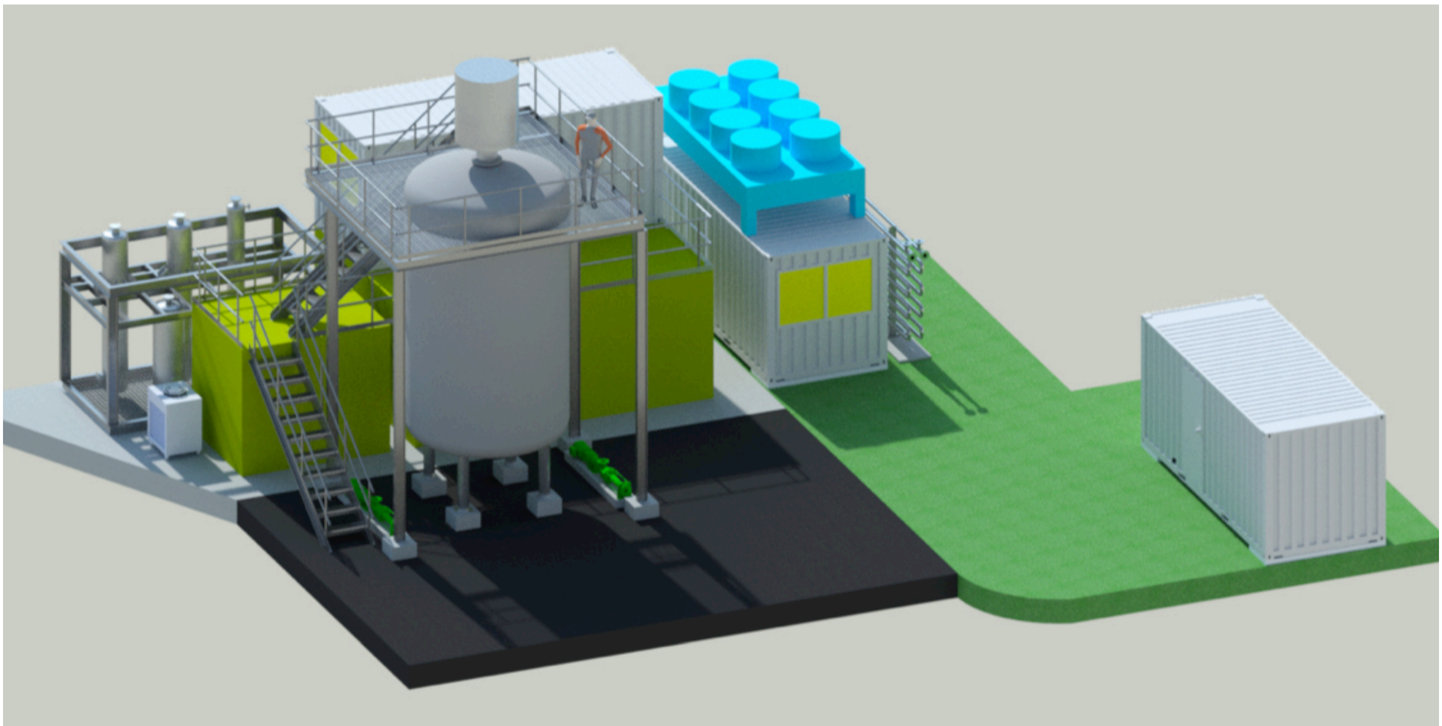
Reuse CO_2, Close Loops

Renewable gas is produced today in agricultural and industrial biogas plants (including wastewater treatment plants) by fermenting organic matter. In many cases, the resulting raw biogas is converted into electricity and heat in a block heating plant. If a grid connection is available, the gas can also be fed into the grid. For this purpose, the carbon dioxide contained in the raw biogas must first be separated. What remains is the energy carrier methane (CH_4), which is identical to natural gas but is referred to as 'biomethane' because it is based on organic substrates.

Eniwa Project in Reinach

Separating CO_2 from the raw biogas and releasing it into the atmosphere does not make sense from a climate policy perspective. An alternative is to 'refine' the CO_2 into renewable gas by adding (renewable) hydrogen (H_2). Pilot plants at the hybrid plant in Solothurn and at the Werdhölzli wastewater treatment plant in Zurich have basically confirmed the suitability of this process (see SFOE technical article 'Alles nutzen, was im Klärgas steckt', available in German language at https://pubdb.bfe.admin.ch/de/publication/download/8736). In winter 2021/22, the technology will be used for the first time on an industrial scale at the Limmataler Regiowerk Limeco in Dietikon (ZH).

Eniwa is involved in the Limeco project - and would now like



Visualization of the plant for biological methanation as designed in the feasibility study for the Reinach WWTP: The bioreactor (gray) is flanked on the left by the activated carbon filter, on the right by the heat exchanger with compressors. The container on the far right is used to store additives. Illustration: microbEnergy

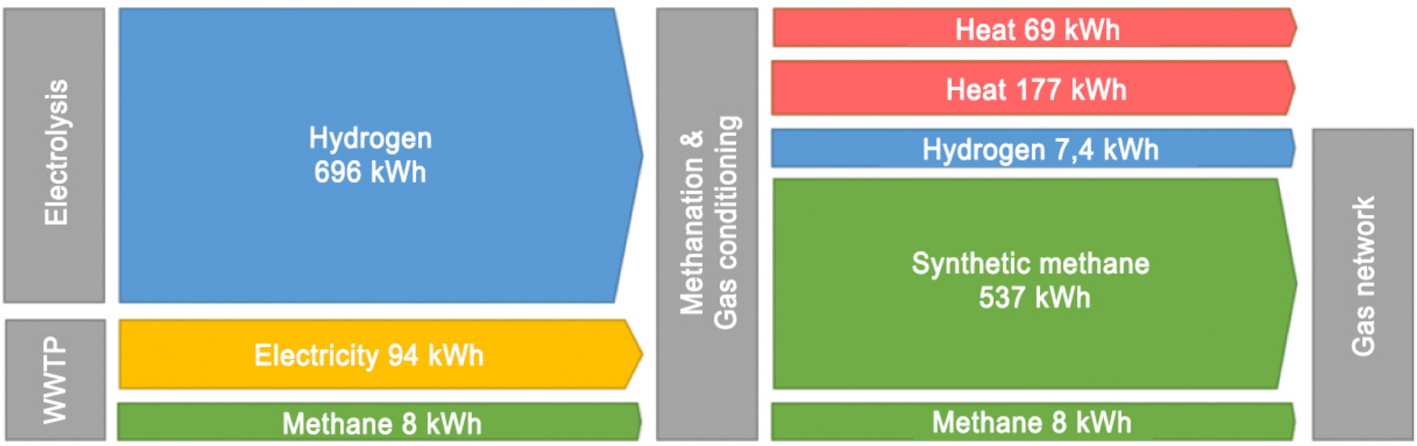
BIOLOGICAL METHANATION

Since 2015, biomethane has been fed into the gas network (approx. 25 Nm³/h) from the wastewater treatment plant (WWTP) in Reinach, Aargau. The feedstock is raw biogas produced in the digestion tower of the WWTP. This raw gas consists mainly of methane (approx. 60%) and CO_2 (approx. 40%). In order for the biomethane to be fed into the grid, the raw biogas is passed through a membrane filter (physical filter) made by the Swiss company Apex (see SFOE technical article 'Biogas-Veredelung im kleinen Massstab', available in German language at https://pubdb.bfe.admin.ch/de/publication/download/9813). Alternative processes to remove CO_2 are chemical absorption (amine scrubbing), pressure swing adsorption, pressurized water washing, physical absorption and cryogenic processes.

To date, the captured CO_2 has been released into the atmosphere. Thanks to biological methanation, the carbon dioxide can also be converted into renewable gas (and water) together with renewable hydrogen. This occurs via a metabolic process in microorganisms (archaea), which takes place at a pressure of 9 bar and a temperature of 65 °C. The methane produced has a high methane content. The methane produced in this process has a purity of over 96% and thus meets the requirements for injection into the natural gas grid. There are alternative methanation processes, but according to Pfaffen, they are less technologically advanced. BV

to possibly use the technology for methanizing CO_2 from raw biogas to convert its existing biogas plant at the WWTP in Reinach (AG). To this end, a feasibility study was recently completed under the name 'BioBooster', which was financially supported by the Swiss Federal Office of Energy. The biogas plant in Reinach currently produces 2.6 GWh of biomethane per year. If the CO_2 contained in the raw biogas is methanized, this would increase to 4.3 GWh in the future. The increase would be roughly enough to supply 85 four-person households in a single-family home and would correspond to around 5% of the volume of biomethane that Eniwa currently supplies. If the process proves successful, it will also be used on a larger scale in a future biogas plant in Telli in Aarau.

The study, with participation from the University of Applied Sciences of Eastern Switzerland (OST) and the company microbEnergy Gmbh (Schwandorf/D), has confirmed the feasibility of methanation. In the present case, biological methanation by means of microorganisms (archaea) is used (see text box). A laboratory test with sewage sludge from the Reinach WWTP was successful. The amazing thing is that methanation by microorganisms can be ramped up from zero to full capacity within minutes, even after long downtimes.



Energy balance of biological methanation as reported in the feasibility study for the production of renewable gas (also referred to as 'synthetic methane') at WWTP Reinach. According to the BioBooster final report, biological methanation in itself has a calculated efficiency of 69%. If in addition, the heat generated during methanation is used, the efficiency is even higher. Graphic: BioBooster final report.

The German company microbEnergy carried out laboratory tests with sewage sludge from the Reinach WWTP. The tests showed that this substrate is suitable for biological methanation. Photo: microbEnergy.

"The plant thus operates very flexibly," emphasizes Samuel Pfaffen. This flexibility makes it possible to produce the hydrogen needed for methanation when 'surplus' wind or solar power is available. This creates renewable gas that can be fed into the gas grid, where it substitutes for fossil gas. "Power-to-gas is a hopeful technology for closing the winter gap," says Pfaffen.

High Costs

Because of high costs, however, whether the Eniwa project in Reinach will come to fruition remains uncertain. Eniwa currently sells biomethane at a premium of 7 cents per kWh. According to Pfaffen, biomethane from domestic production may cost somewhat more than imported biomethane, but it must remain affordable. Due to the high purchase price of renewable hydrogen (currently about 20 Rp./kWh), the cost of biomethane from the Reinach small-scale plant is 25 Rp./kWh in the most favorable of the scenarios examined, i.e. about twice as high as Eniwa's target price, which is about 12 Rp./kWh.

The price calculation in the 'BioBooster' project is a snapshot and refers to methanation plants of small and medium size (below 300 Nm³ raw biogas per hour). Lower prices are possible for larger plants. The decisive factor for the economic viability of methanation - according to another finding of the project - is the market price for renewable hydrogen. In the future, this could drop to the level of non-renewable hydrogen (today in the range of 5 to 9 Rp./kWh) thanks to larger electrolysis plants and cheaper wind and solar power. "This cheap hydrogen will then largely be imported, as there are too few operating hours with 'surplus electricity' available in Switzerland for the foreseeable future to operate electrolysers economically," says Pfaffen.

- The **final report** on the research project 'Bioboost - Flexible Biogas Booster' is available at: https://www.aramis.admin.ch/Texte/?ProjectID=45241

- For **information** on the project, please contact Dr. Sandra Hermle (sandra.hermle[at]bfe.admin.ch), Head of the SFOE Bioenergy Research Program.

- For more **technical papers** on bioenergy research, pilot, demonstration, and flagship projects, visit www.bfe.admin.ch/ec-bioenergie.

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