Methanation of CO_2 from biogas for Power-to-Gas application

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Power-to-Gas technology is a storage option for renewable energies, allowing the storage of surplus electrical energy by linking the power grid with the gas grid [1][2].
In the frame work of the two research projects “EE-Methan aus CO_2” and “OptFuel” an experimental methanation plant was constructed, where the “OptFuel” project contents were examined.
The overall process concept was later proved in a pilot plant with other project partners (*Energieinstitut an der JKU Linz, Institut für Verfahrenstechnik, Umwelttechnik und Technische Biowissenschaften (TU Wien)* and *Christof Industries GmbH)* .

Methanation of CO_2

Methanation is a strong exothermic reaction, where hydrogenation of CO_2 and CO occurs, utilising group VIII metal based catalysts.
For the series of experiments a commercial nickel bulk catalyst in one fixed bed reactor was used. A gas mixture of H_2, CO_2 and CH_4 has been converted at different GHSVs (Gas Hourly Space Velocity), pressures and H_2/CO_2 ratios. Temperature in the reactor was kept constant, between 350-400 °C. With overall reaction for CO_2 :

$$CO_2\ (g) + 4H_2\ (g) \leftrightarrow CH_4\ (g) + 2H_2O\ (g) \quad \Delta H_R^0 = -165\ kJ/mol \quad [3]$$

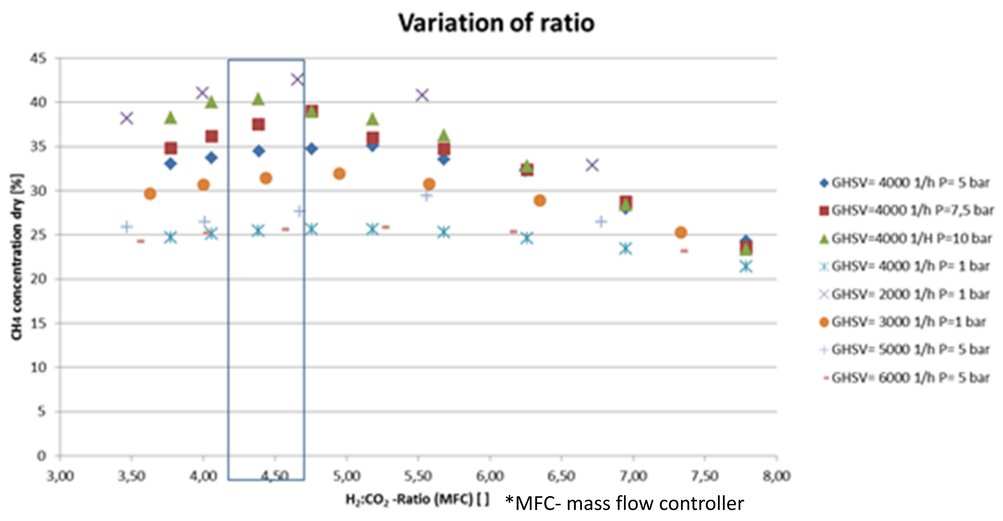
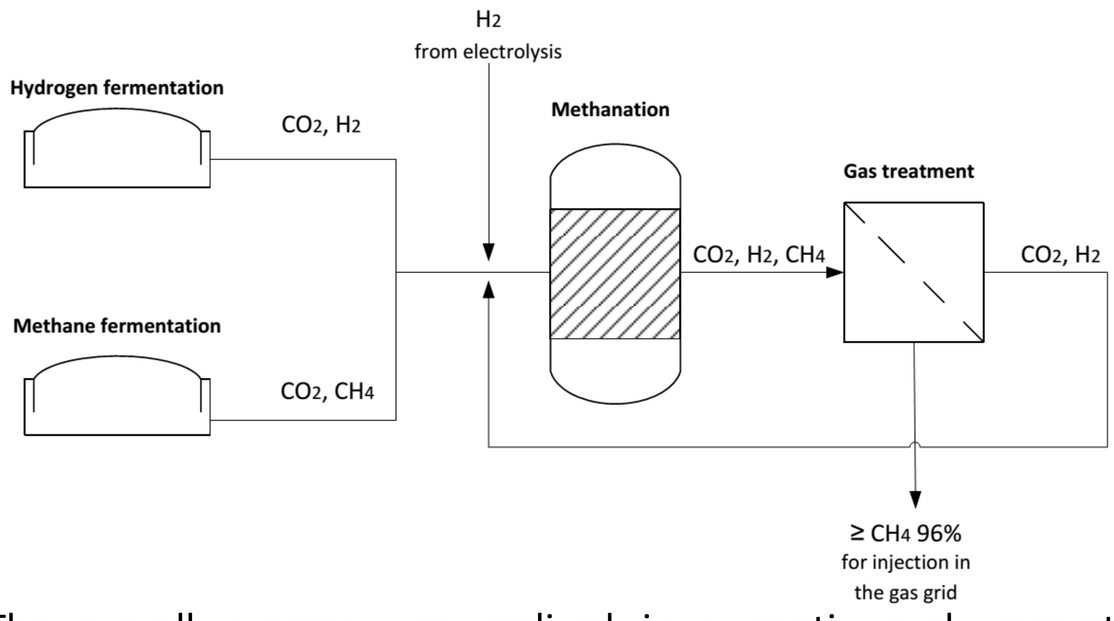


Diagram 1: Methanation results for different H_2:CO_2 ratios

*MFC- mass flow controller

GHSVs between 2000/h and 6000/h; flow rates (8.5; 12.5; 16.7; 21.0 and 25.0) NL/min, pressures (1, 5, 7.5 and 10 bar) and different H_2 / CO_2 ratios were examined.
As seen in the Diagram 1 the best results for the product gas were observed at a slightly over the stoichiometric feed gas ratio of H_2 and CO_2. Additional positive results were noted in experiments with low GHSV which can be explained by longer residence time and high pressures, due to the higher number of moles of reactant as that of product, shifting the equilibrium composition on the product side [4][5].

Proof of concept



Biogas with CH_4, H_2 and CO_2 composition is produced by fermentation of biogenic wastes. Hydrogen from water electrolysis is added to the biogas, and methanation takes place in a catalytic reactor, producing high concentrations of CH_4. In the final step produced gas goes through gas treatment, where the unreacted gases CO_2 and H_2 are return to the process and generated CH_4 can be stored in the natural gas grid. The results provided a good basis for a possible first demonstration plant [2].

The overall process was realized in a continuously operated pilot plant, with cooperation among *Lehrstuhl für Verfahrenstechnik des industriellen Umweltschutzes (MU Leoben), Energieinstitut an der JKU Linz, Institut für Verfahrenstechnik, Umwelttechnik und Technische Biowissenschaften (TU Wien)* and *Christof Industries GmbH.*

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