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Optimizing biological CO_2-methanation in a trickle-bed reactor: the ORBIT-Project

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Introduction

Throughout the last years, Power-to-Gas is widely discussed as one of few long-term storage options in convergent energy systems [1]. Depending on the application, pure hydrogen as a product is viable e.g. if gas grid feed-in point has high flow rates or hydrogen can be used directly.
If this is not the case, CO_2-methanation is an option to produce a renewable natural gas substitute which can be technically realized as biological or chemical methanation [2, 3].

$$4H_2(g)+CO_2(g) \rightarrow CH_4(g) + 2H_2O(l)$$
$$\Delta H^0_R = -253\ kJ/mol_{CH4}$$

For this, hydrogen and carbon dioxide, in an exothermic reaction, are converted into methane with water as a by-product.

Problem/Question

Biological methanation, which is more robust against reactant gas impurities and operates at milder conditions than chemical methanation, often is applied in stirred-tank reactors today. Main problems concerning methanation are the selection of suitable microorganisms and process parameters as well as low gas solubility of hydrogen into liquid phase. In general, concerning CO_2-methanation in Power-to-Gas applications, there is a need for standardization e.g. in nomenclature.

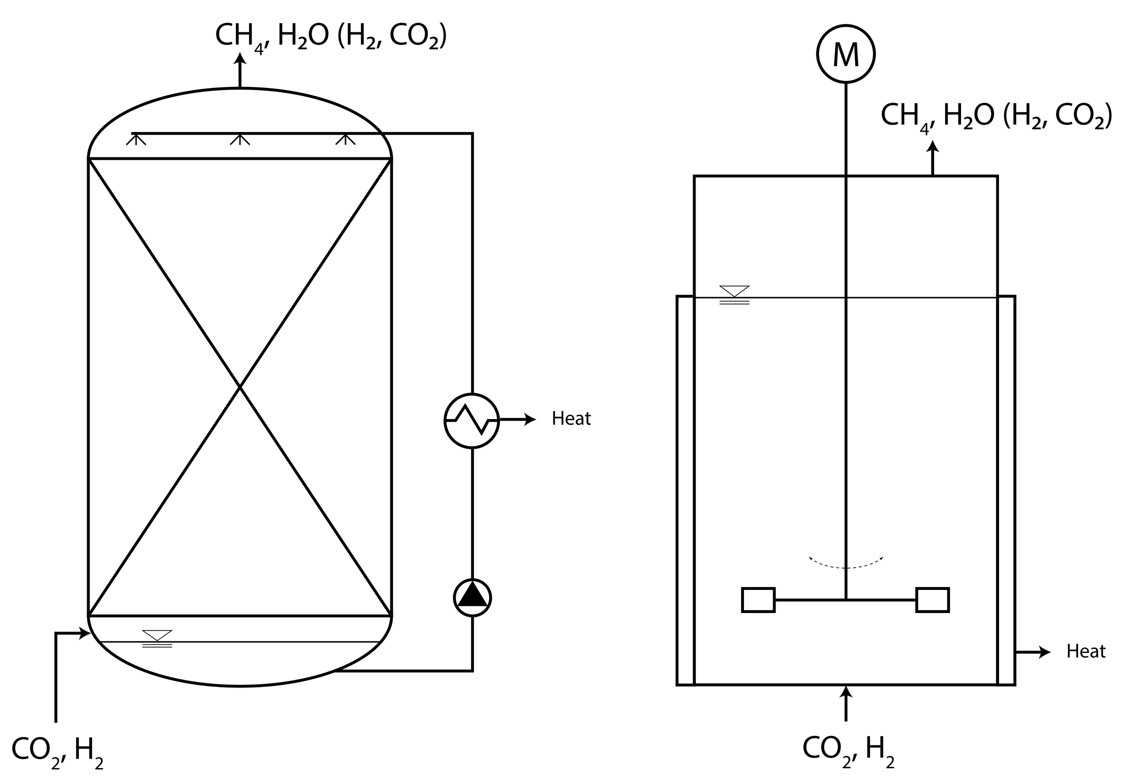

Figure 1: Trickle-bed (left) and stirred-tank (right) reactor concept for biomethanation.

Hypothesis

Stirred tank reactors as often used today, not necessarily fit best for three-phase systems like biological CO_2-methanation.
Better results are estimated to be achievable by the use of trickle-bed reactor concepts. Such a concept is developed, tested and optimized in the research activity "ORBIT".

ORBIT-Project profile

Duration: 07/2017-06/2020
Volume: Euro 1.14 m. (funding rate 88 %)
Project Partners: 8 Partners from research, industry, and standardization bodies.

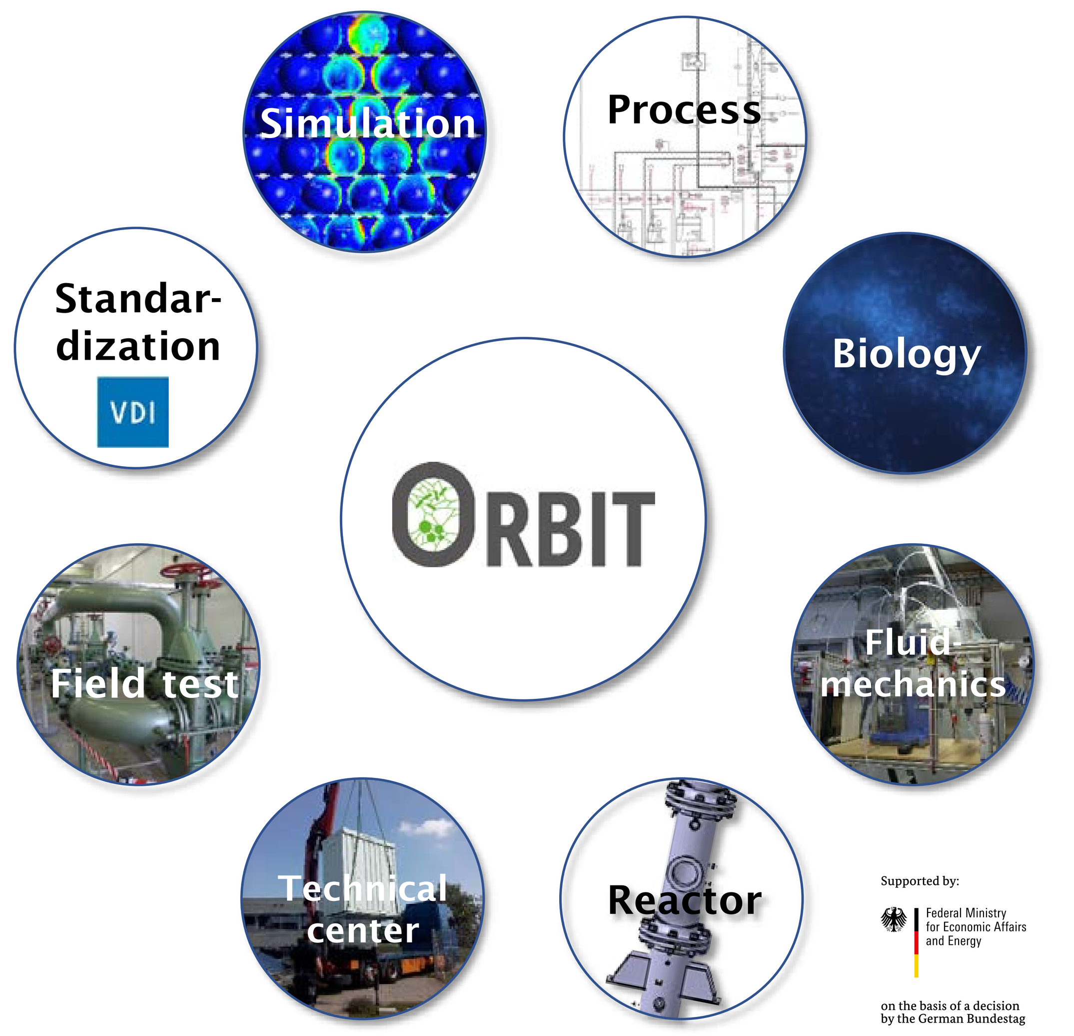

Figure 2: Research areas adressed in the ORBIT-project

Project aims

- Optimization of a biological CO_2-metha nation process and reactor design
- Identification of best-fitting orgnism sur face combinations for Archaea and reac tor packing material
- Standardization in CO_2-methanation [4]
- Simulation of the processes in the reactor
- Studies on dynamic behavior of the system in lab and field tests
- Preparation for scale-up

Research

Biology: Selection of microorganisms from strain bank, pre-tests on toxicity and gas formation, strain-ranking, determination of final strain (combination), behavior in operation.

Engineering: process and reactor design (details in table 1), automation, selection and fluid mechanical tests on reactor packing and behavior, fluid mechanical ranking of packings, determination of final packing material, reactor simulation.

Standardization: initiation of a new standard VDI 4635-1 "CO_2-methanation".

Application/administration: lab tests on dynamic behavior of the system, field test and infrastructure integration.

Table 1: Key characteristics and nominal values of the ORBIT-process.

Gross reactor volume	46 liter
Packing volume	3 x 10.4 liter
Pressure	12.5 bar
Temperature	65 °C
Product gas (CH_4)	0.062-0.104 m^3/h

Up-to-now results

- Process and test site is developed and ready for tests,
- Up to now, five microorganism strains are identified for further tests,
- Three random packings and one structured packing is identified for further tests,
- Standardization committee for VDI 4635 established in October 2018, first appro aches for standardization are prepared.

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References

[1] J. Hüttenrauch et al. Integration fluktuierender erneuerbarer Energien durch konvergente Nutzung von Strom- und Gasnetzen, Abschlussbericht, Freiberg (2017).
[2] M. Götz et al. Renewable Power-to-Gas: A technological and economic review, in:Renewable Energy, 1-20, (2015).
[3] M. Sterner and I. Stadler (Eds.) Handbook of Energy Storage, Demand, Technologies, Integration, Springer, Berlin-Heidelberg (2019)
[4] M. Thema, T. Weidlich, M. Hörl, A. Bellack et al. Biological CO_2-Methanation: An Approach to Standardization. *Energies* 2019, 12, 1670.

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