Converting Volatile Power from Renewables by Highly Compact and Load-flexible Microchannel Reactors

Load-flexible Power-to-gas Technology

Background

Conversion of volatile power from renewable sources into methane is a solution to overcome the intermittency problem between power production and demand on seasonal and day scales. Furthermore, this process allows to connect the sectors of power, heating, and mobility. The methane produced can be stored in the existing gas grid and can be used as e.g. feedstock for the chemical industry or as fuel for ships, where electrification is difficult due to the energy demand. While hydrogen production is flexible in load, the conversion step to methane should be capable to follow this load; otherwise, large storage capacities for hydrogen would be required. Use of ultra-compact microchannel reactors allows to control the highly exothermic methanation reaction even under conditions of load change.

Key Data

- Feed gas: Syngas with H_2 and CO_2 (and/or CO)
- Product: CH_4
- Nominal power: 100 kW (CH_4 output)
- Pressure: 1 - 20 bar
- Temperature 300 - 500°C
- Total reaction volume 20 Liter
- Skid-based integration
- Side-product water is highly pure (no clean-up necessary)

Facts

- Scalability: 1000 m^3 Methane per m^3 of Reactor and hour
- Methane yield per reactor stage ~90% (two stages for SNG generation)
- Dynamic operation: ramp-up from cold state in less than 30 min; load change from 30-100% per reactor module in less than 1 minute
- Efficiency: from power to methane up to 80%

Advantages of the Technology

The pilot-scale reactor consisting of two modules is designed for 10 m^3/h methane production and was tested in the three-phase methanation plant of Energy Lab 2.0.
The catalyst has the form of fine particles and heat removal is achieved by steam generation. The steam is generated at around 10-20 bar and is available in dry state at overheated conditions of 350°C. This steam can be applied to feed a steam electrolysis unit. As a result, overall power to methane efficiencies of 75%-80% can be reached.

Photos: A. Bramsiepe, KIT

Karlsruhe Institute of Technology

ENERGY LAB 2.0

Load-flexible Power-to-gas Technology

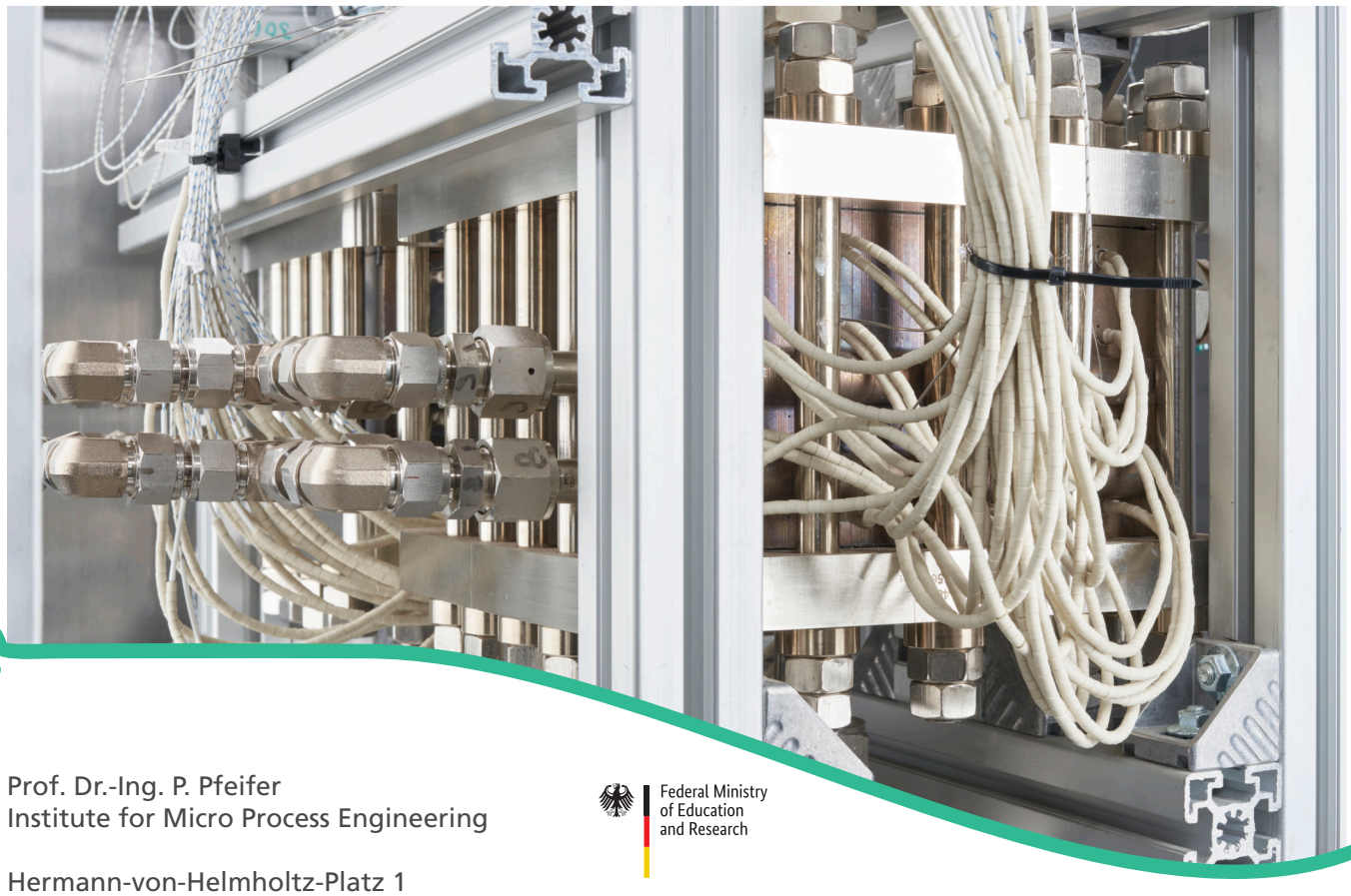
The Reactor as a Key Element

KIT has developed this technology over the last years. The interior design is patented and licensed to the KIT startup INERATEC. The huge advantage of the reactor design is its compactness due to the overwhelming efficiency for heat extraction from the methanation reaction. This allows heat use in the power-to-gas scheme and, thus, much higher efficiency. Moreover, the compactness allows for very short times from cold start to plant operation.

The Vision

Due to the large compactness of the reactor system, plants in the scale of up to 100 MW can be pre-fabricated easily using a skid-mounted approach. So, the time for installation is short, which allows much faster ramp-up of the power-to-gas technology. Presently, society is very concerned about energy and gas supply. Flexible and efficient plants are required to ensure resilience and local energy distribution. They can be developed based on the available technology.

Photo: A. Bramsiepe (KIT)



Prof. Dr.-Ing. P. Pfeifer
Institute for Micro Process Engineering

Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen

roland.dittmeyer@kit.edu

Federal Ministry of Education and Research

Federal Ministry for Economic Affairs and Climate Action

Baden-Württemberg
MINISTERIUM FÜR WISSENSCHAFT, FORSCHUNG UND KUNST

Baden-Württemberg
MINISTERIUM FÜR VERKEHR