Fraunhofer IMM

Dr. Jonas Schramm

Logistic Hydrogen carriers for a sustainable future

Fraunhofer IMM

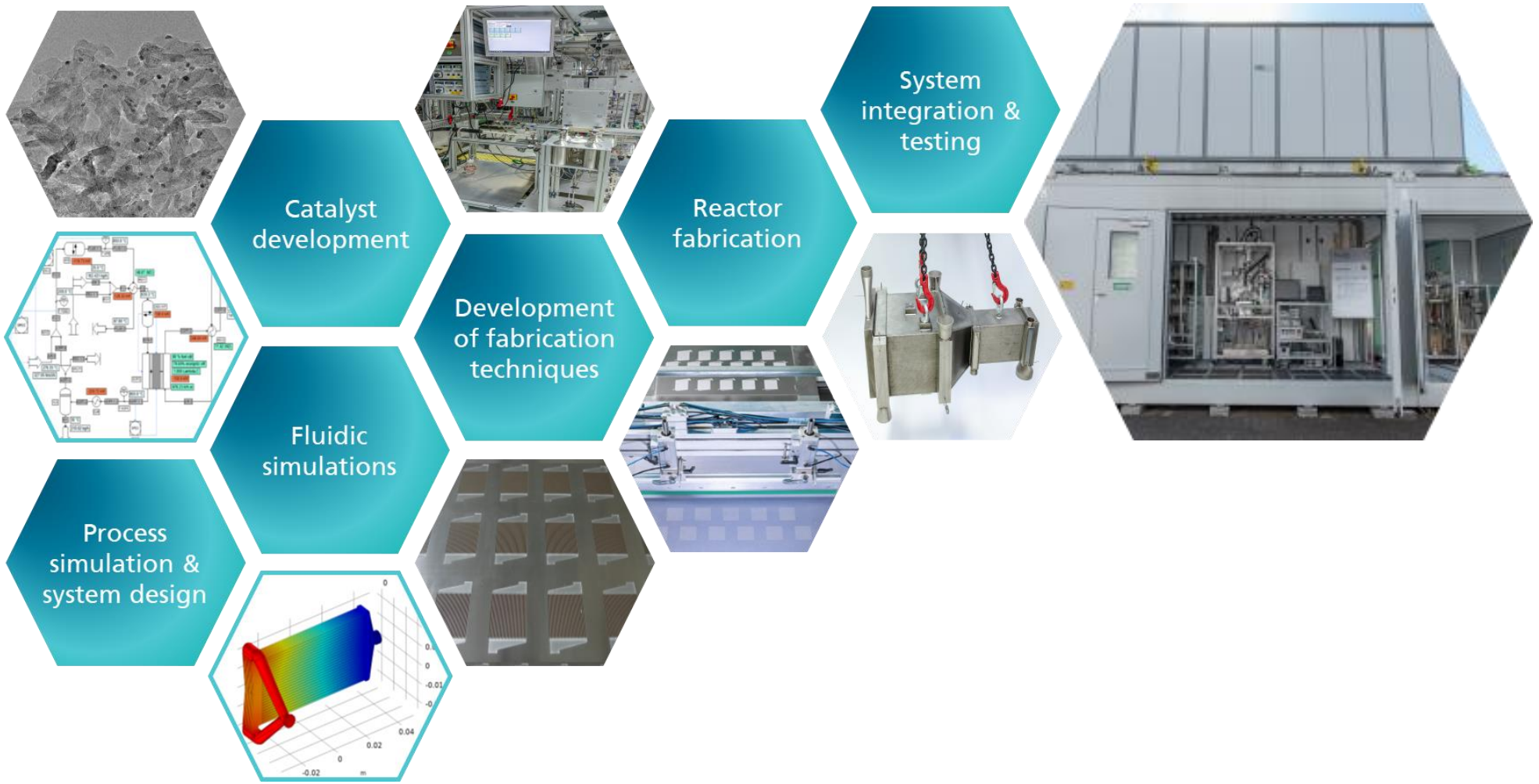
Institute for Microtechnology and Microengineering

Formerly IMM – „Institut für Mikrotechnik Mainz“

- Joined the Fraunhofer society in 2013
- Independent Fraunhofer Institute since 2018
- 140 employees
- Research focus in three divisions:
  - Energy
  - Chemistry
  - Diagnostics

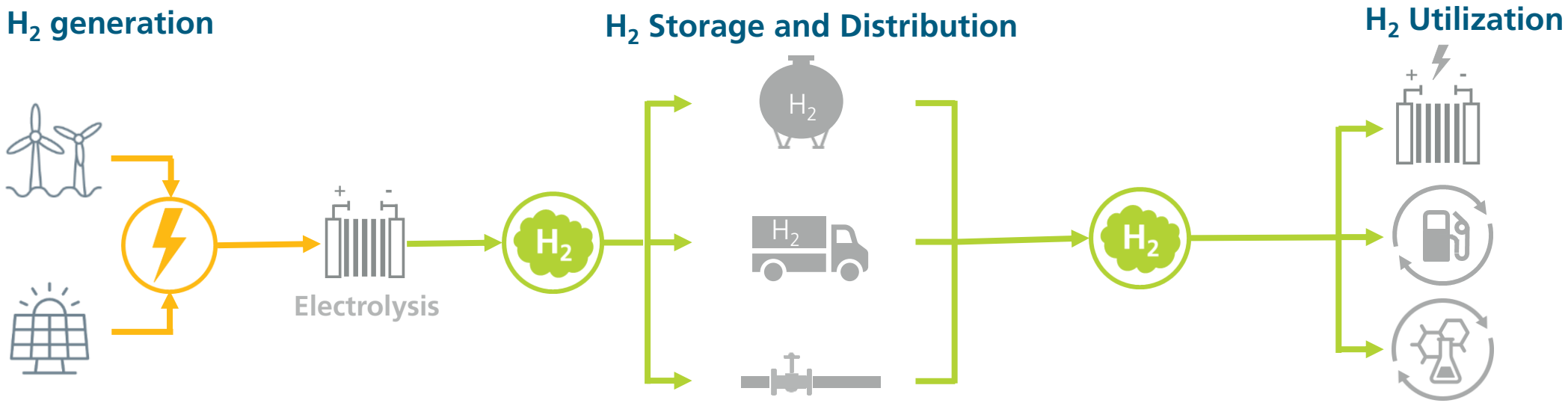
IMM technology for hydrogen generation

Development of integrated and automated systems



The Hydrogen Economy

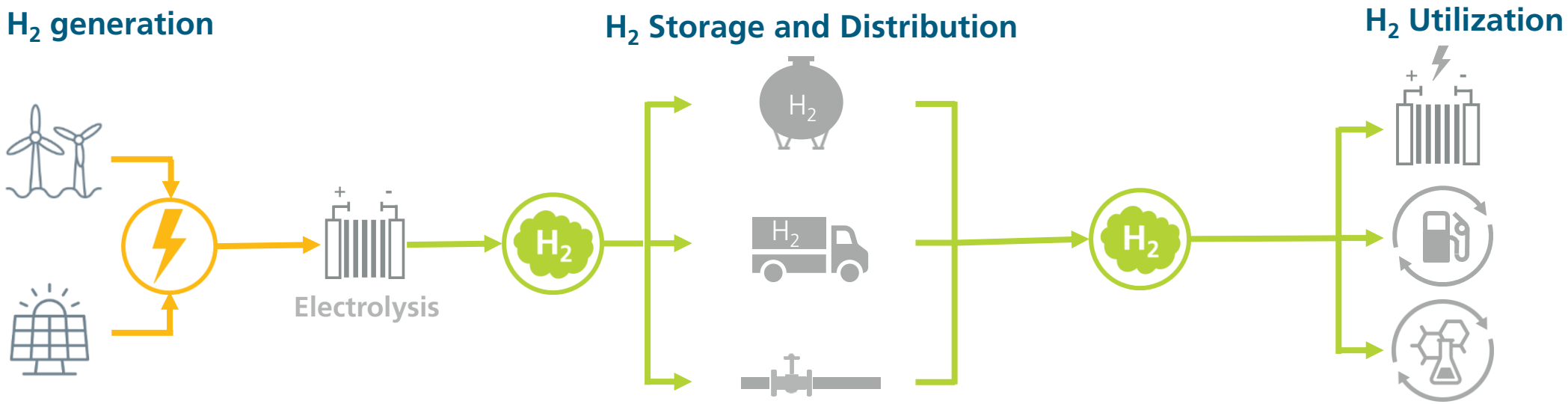
Renewable energy to green hydrogen



- No CO_2 emissions
- Use of unsteady renewable energy
- Enables large scale seasonal storage

The Hydrogen Economy

Renewable energy to green hydrogen

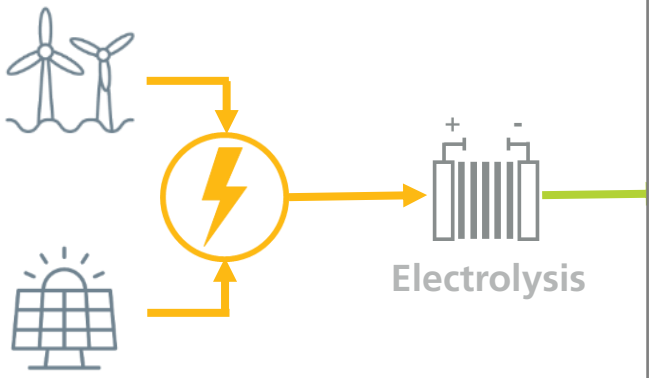


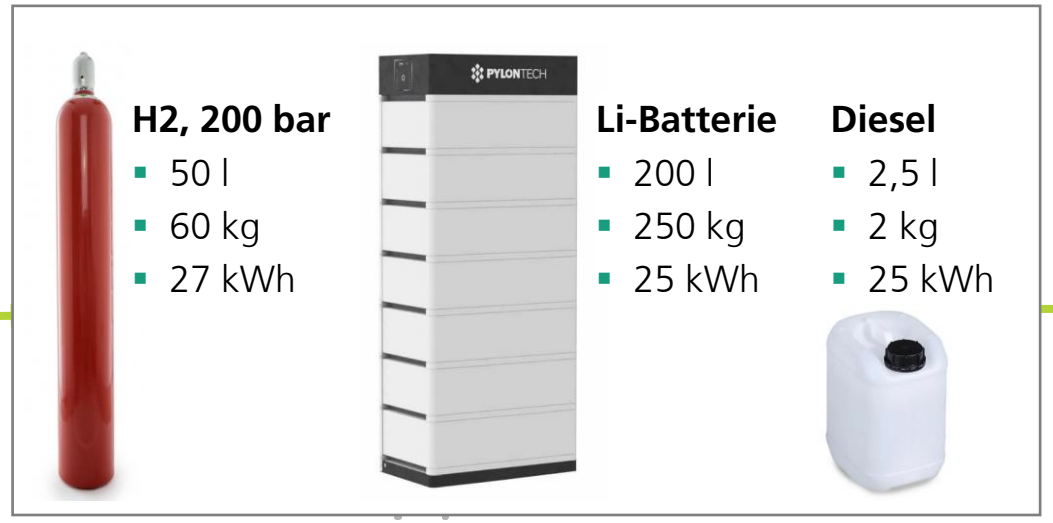
- Low volumetric density
- High pressure storage or energy intense liquefaction
- No established large scale transport modes

The Hydrogen Economy

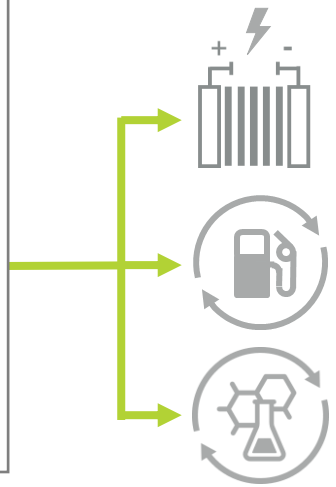
Renewable energy to green hydrogen

H_2 generation





H_2 Utilization



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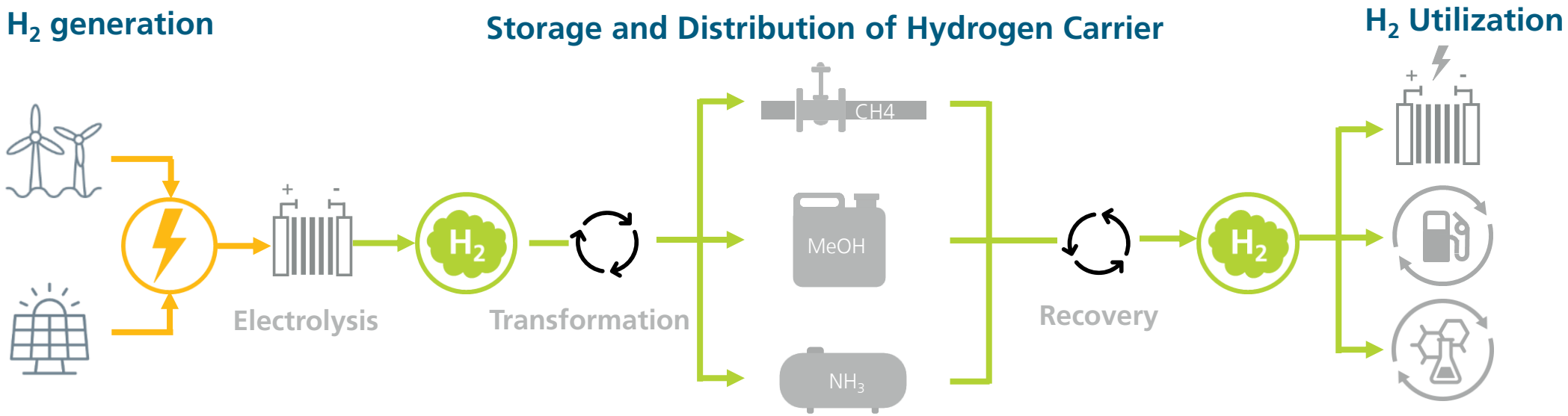
Renewable energy to green hydrogen



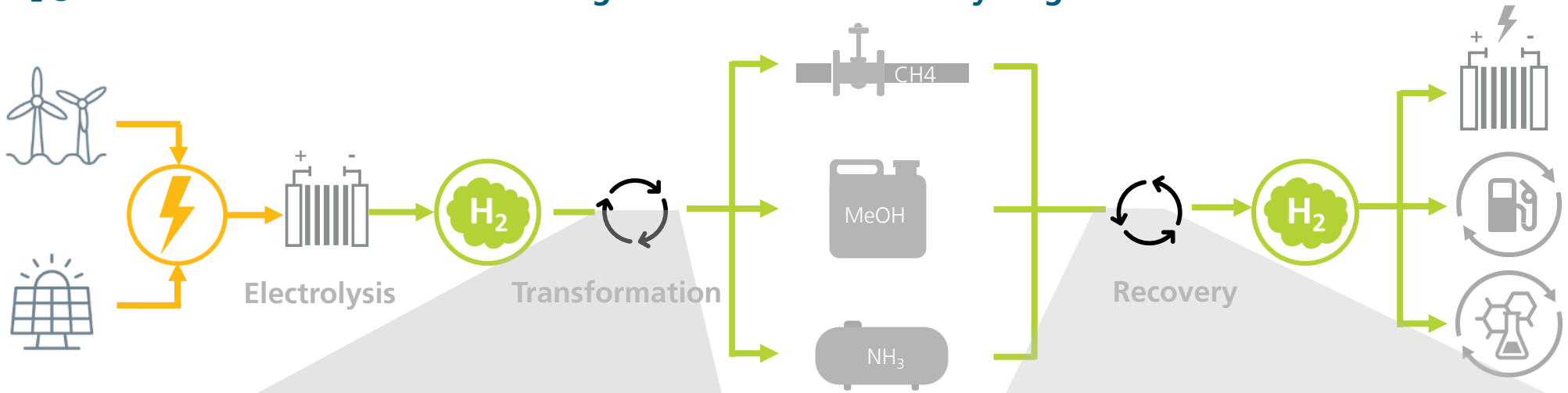
The Hydrogen Economy

Renewable energy to green hydrogen

H_2 generation

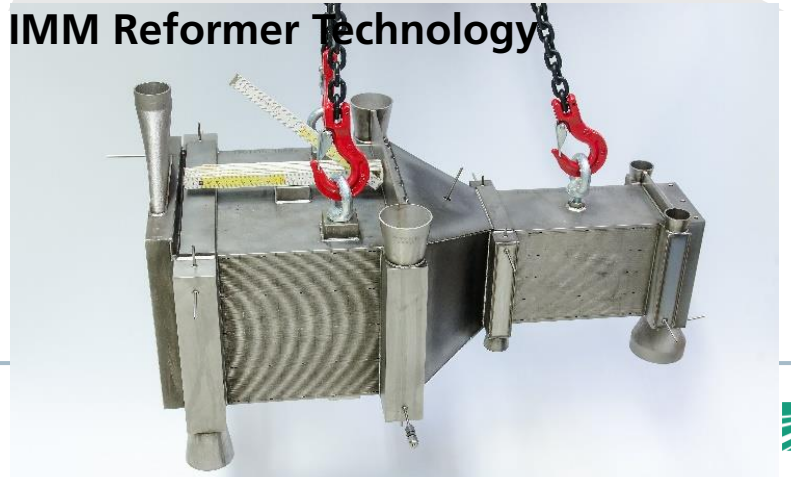
Storage and Distribution of Hydrogen Carrier

H_2 Utilization



IMM Methanation Technology

IMM Reformer Technology



The Hydrogen Economy

Transformation to and from Methane

Green methane as energy storage

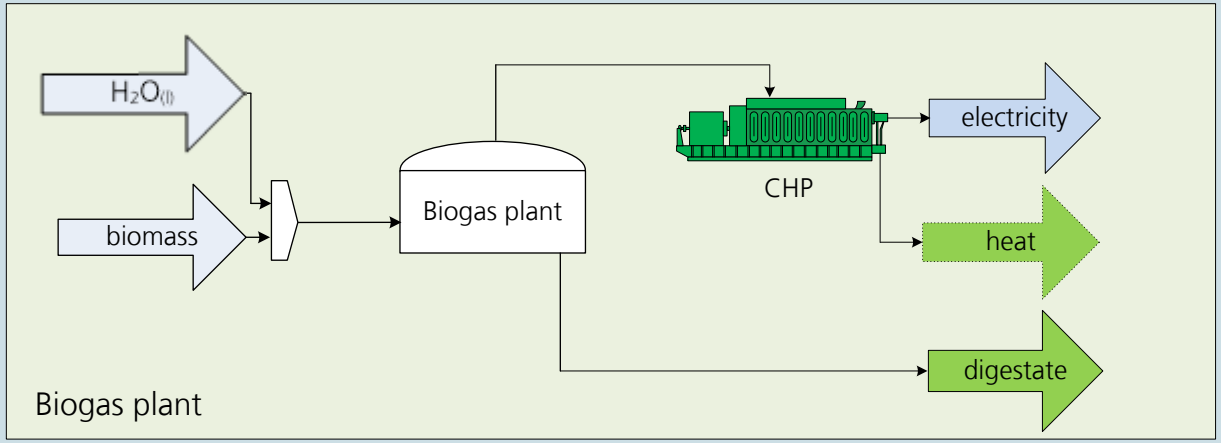
- Established technical solutions for large scale storage and distribution
- Versatile usage e.g. power generation, process heat, municipal heat, mobility
- Established technology for hydrogen recovery
- High density of hydrogen – four molecules H_2 per molecule CH_4

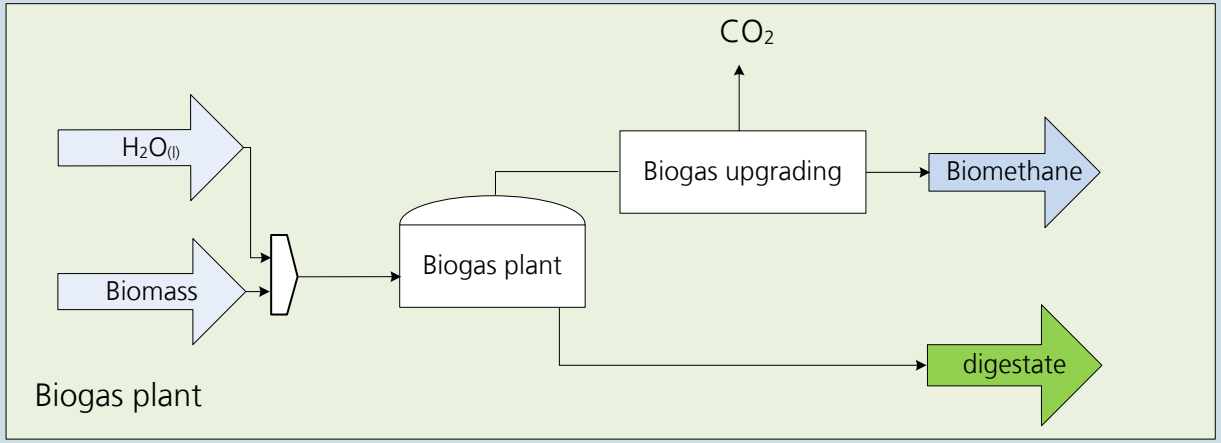
Sabatier equilibrium: $CO_2 + 4H_2 \rightleftarrows CH_4 + 2H_2O$

A prerequisite for green methane production is the availability of biogenic CO_2

Sources of Biogenic CO_2

- The largest source of biogenic CO_2 in Germany comes from biogas plants - more than 70%
- Biogas plants for electricity generation are the largest source of biogenic CO_2
- Other sources of biogenic CO_2 are wastewater-treatment plants and breweries

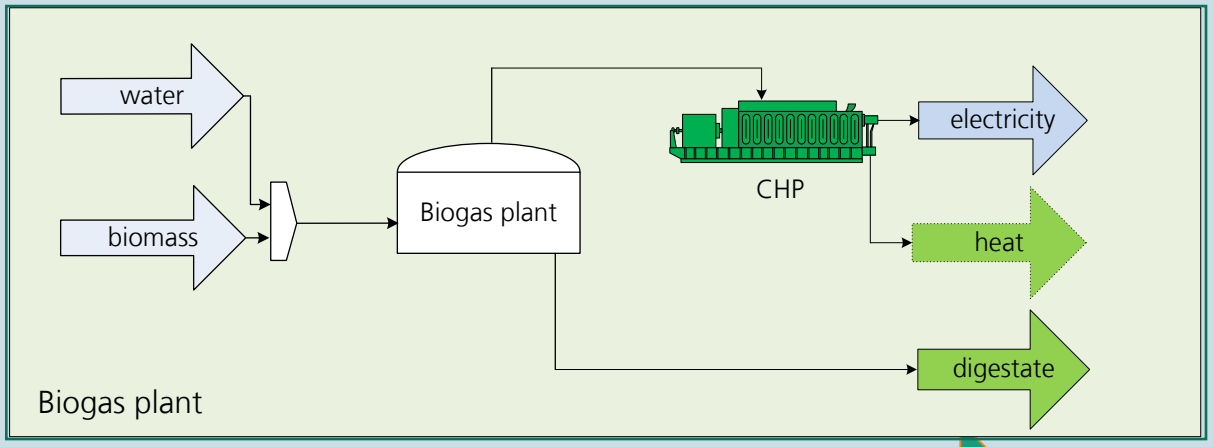




Catalytic Methanation - An Economic Push for Biogas Plants?

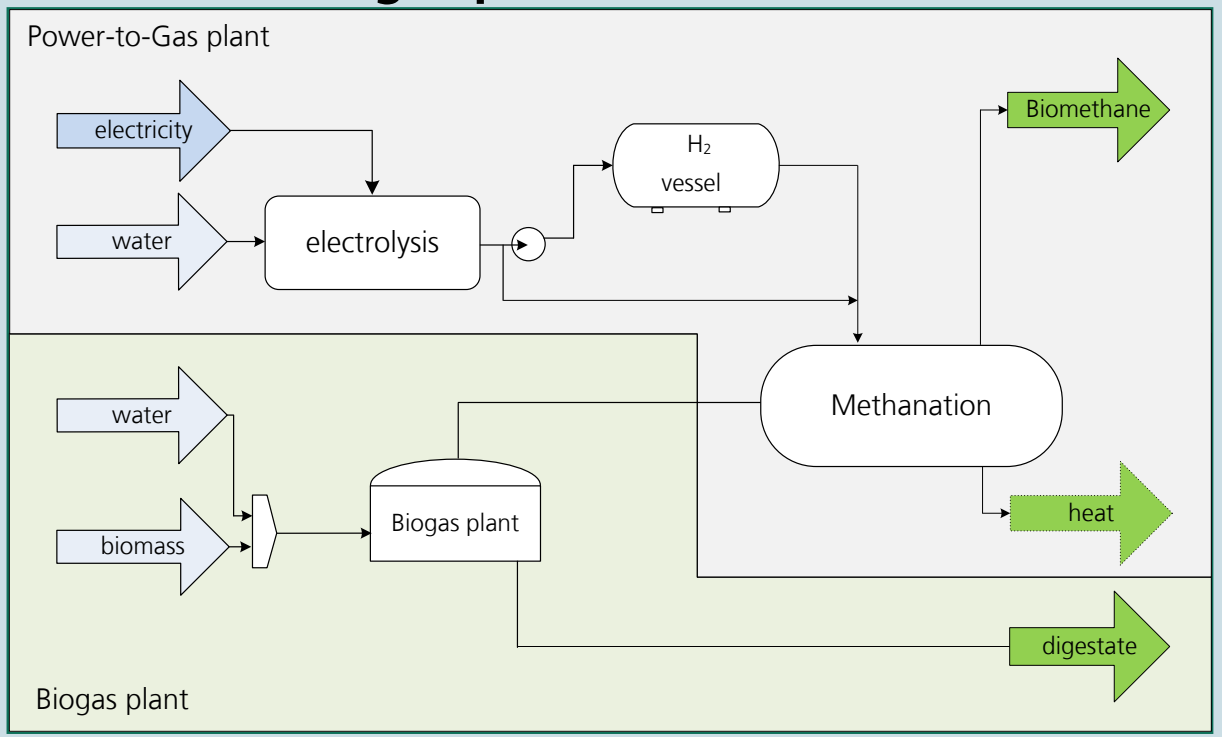
Conversion of biogas plants
from electricity to biomethane production

A biogas plant today



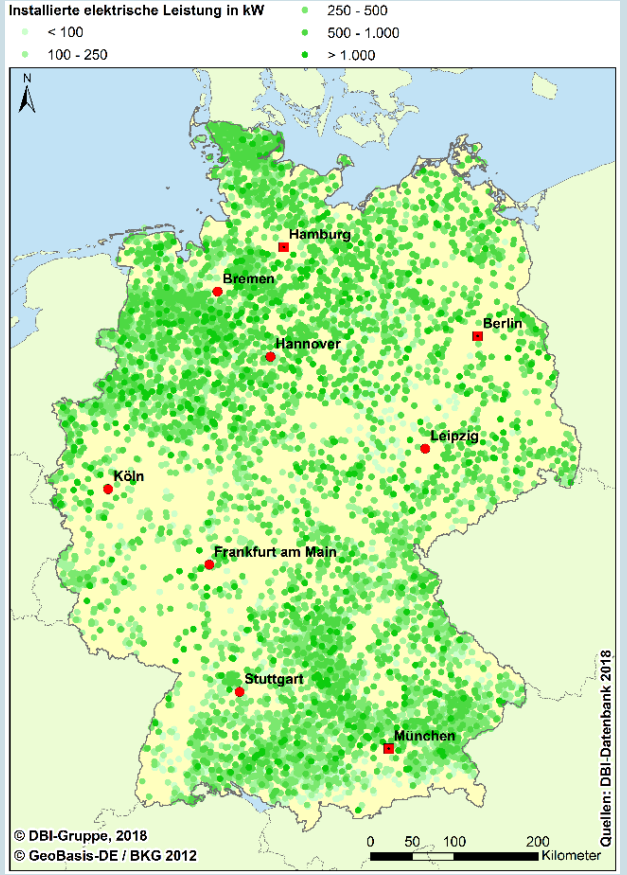
IMM Vision

A biogas plants in the future



Sources of Biogenic CO_2 - Biogas Plants in Germany

- Currently, there are approximately 9,000 biogas plants in Germany in operation producing electricity and heat through CHP systems
- Biogas is used in combustion engines. Electricity is fed into the electricity grid
- A typical capacity of a biogas plant ranges from 120 to 250 m^3/h raw biogas
- The current business model is based on feed-in tariffs regulated by the Renewable Energy Law (EEG)
- The theoretically CO_2 available is approximately 7 million t/y

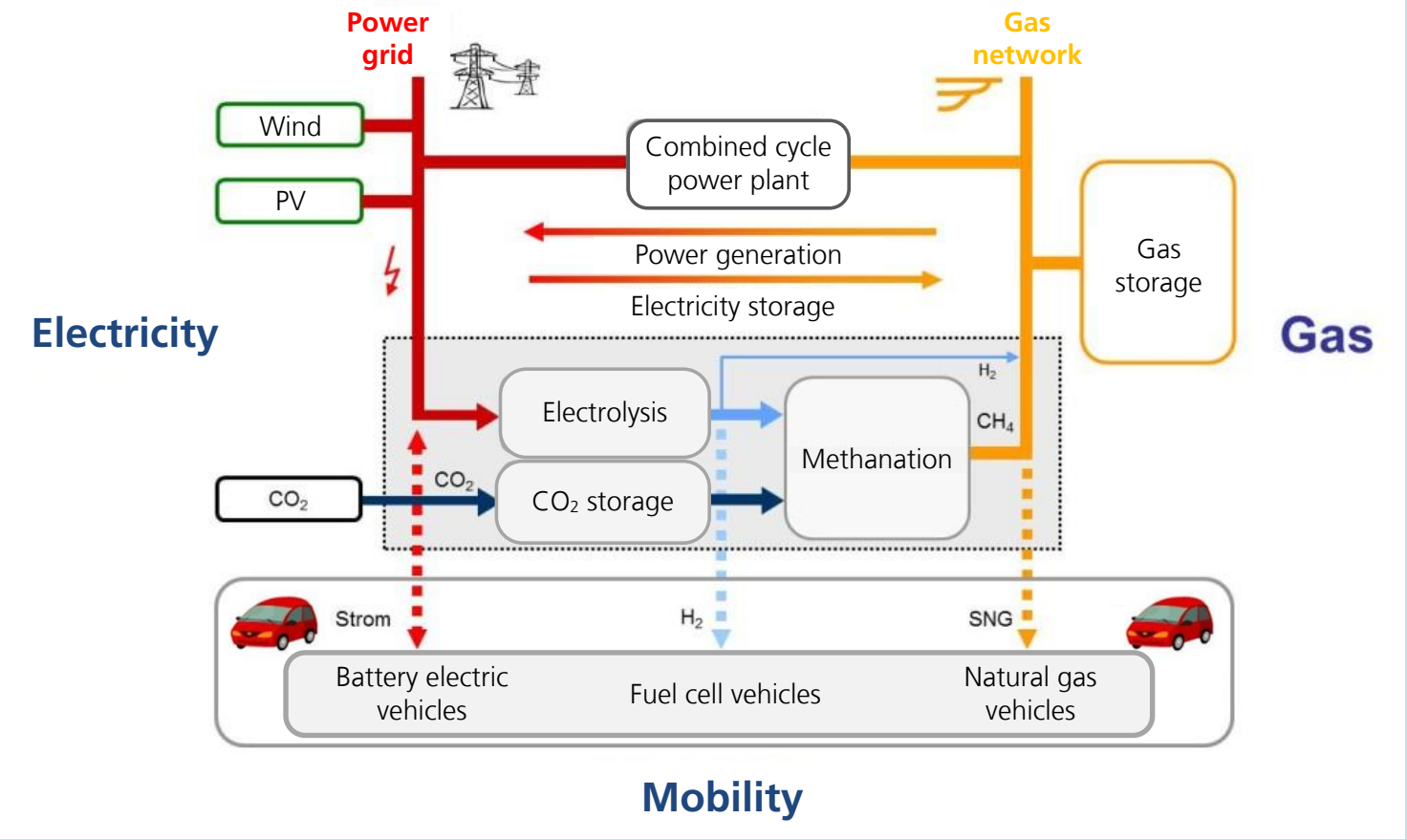


Distribution of CHP biogas plants in Germany

Functionality of Power-to-Methane Systems

A Power-to-Gas system can become:

- A biofuel producer
- A power storage device, i.e. a conventional battery
- A coupling element between the electricity and gas grid

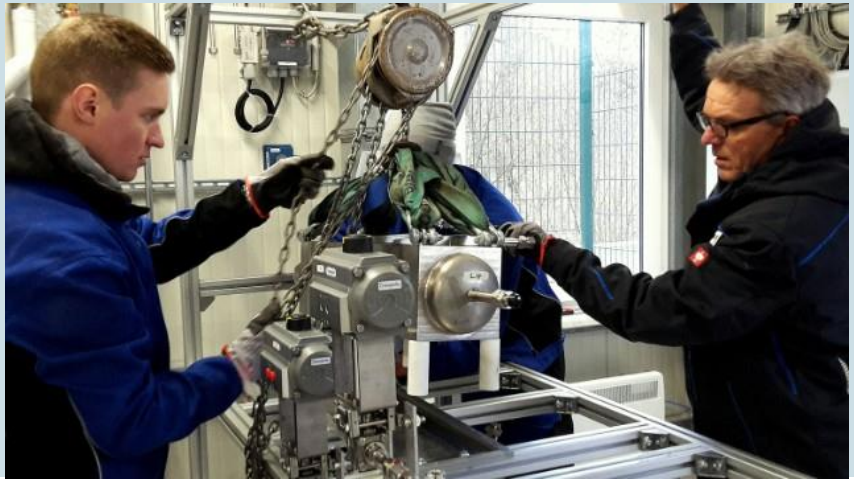


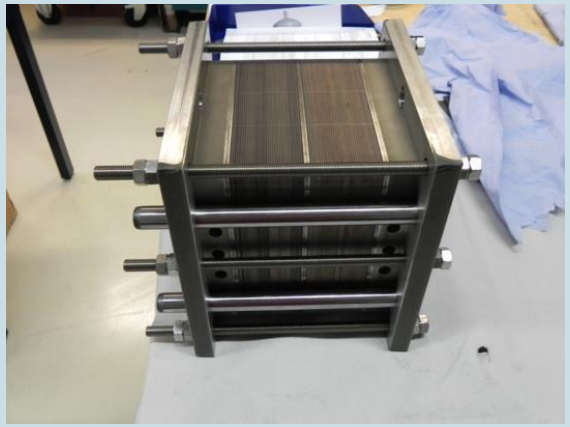
IMM Methanation Technology

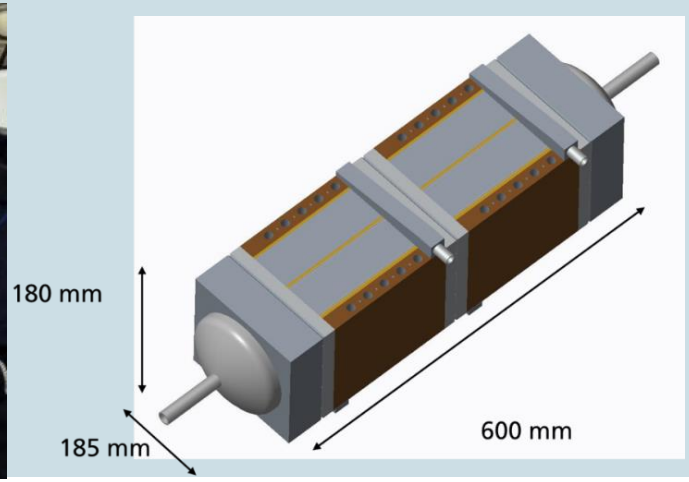
Hydrogen to Green Methane

30 kW-Methanation Reactor

- Microstructured design
- Improved heat management
- No hot-spots
- Flexible load level







Laser-welded plate stack

Two-stage counter-current oil cooling

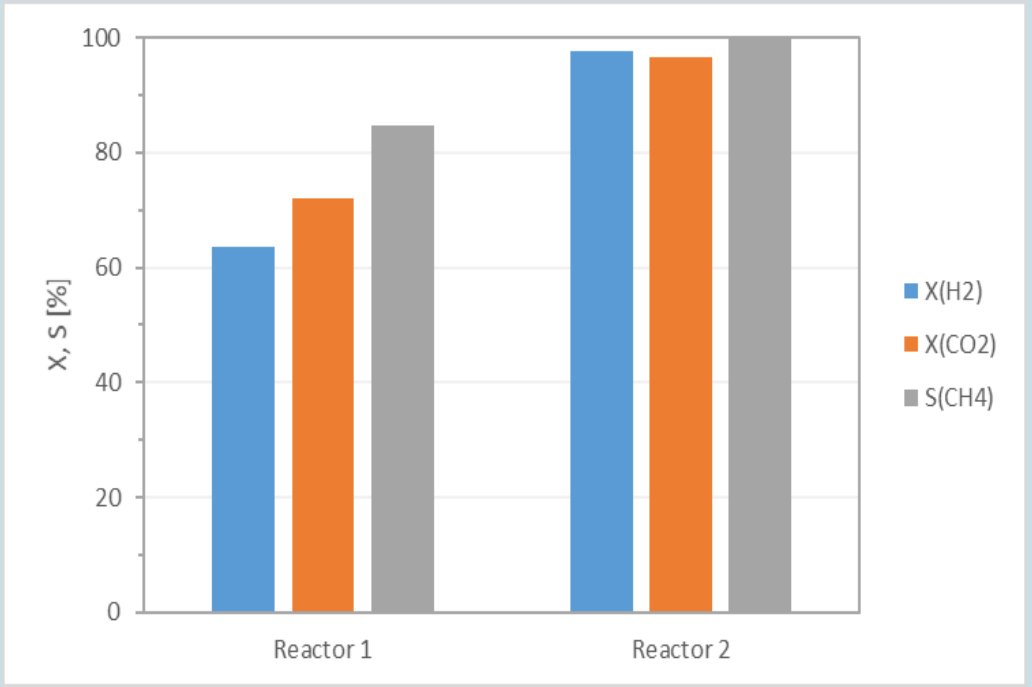
IMM Methanation Technology

Hydrogen to Green Methane

Two stage reactor:

Novel catalyst
High temperatures
Two stage design
High yield

The scaling-up (6 m³/h) of the process started

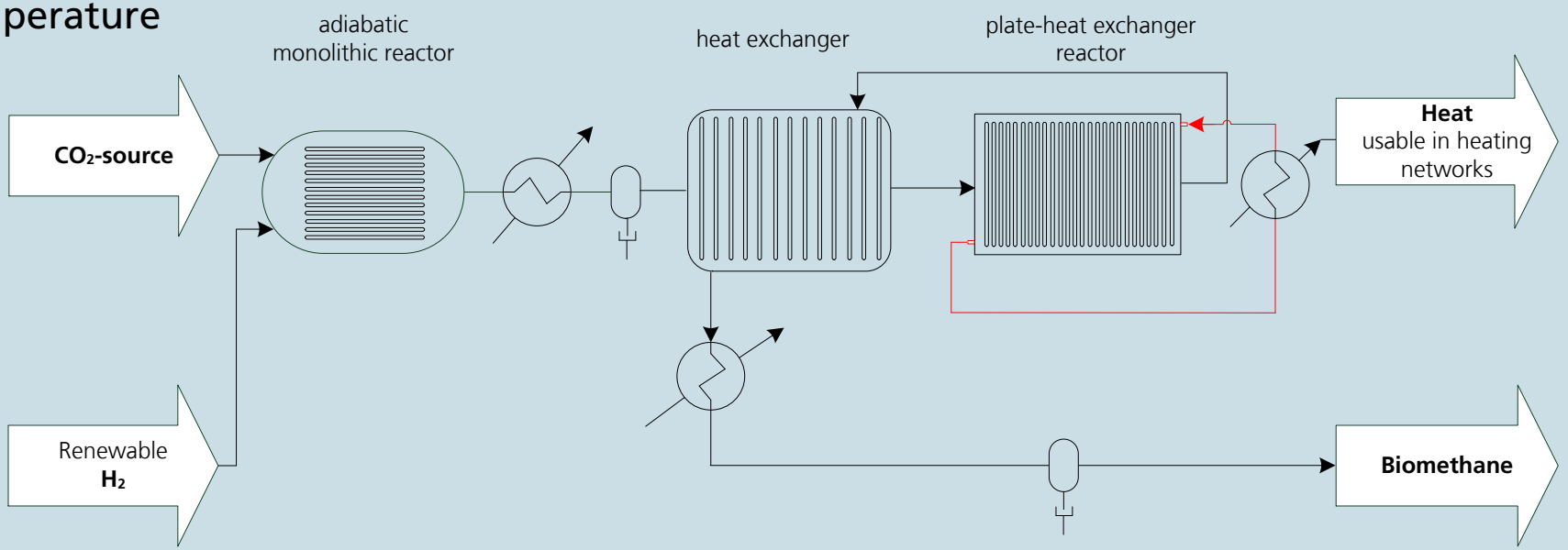


H_2 and CO_2 conversion and CH_4 selectivity
$H_2 : CO_2 : CH_4 = 4:1:1$

IMM Methanation Technology

Reactor concept

- In the first stage, carbon dioxide partially reacts in a monolithic reactor at high temperature
- Afterwards, water is removed and the mixture of reacting gases is reheated to reaction temperature in a heat exchanger using energy from the second reactor stage
- Finally, remaining carbon dioxide is converted into biomethane in air-cooled heat exchanger reactor operated at lower temperature



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