



# Operation and upscaling assessments of a pilot scale biorefinery

producing renewable methane using biogenic CO<sub>2</sub> and value adding by-products from side streams

Philipp Knötig, Dr. Marcel Pohl, Hendrik Etzold, Lukas Odenwald | Biorefineries Department, Deutsches Biomasse Forschungszentrum gemeinnützige GmbH

22.01.2026, 8th Central European Biomass Conference 2026, Graz

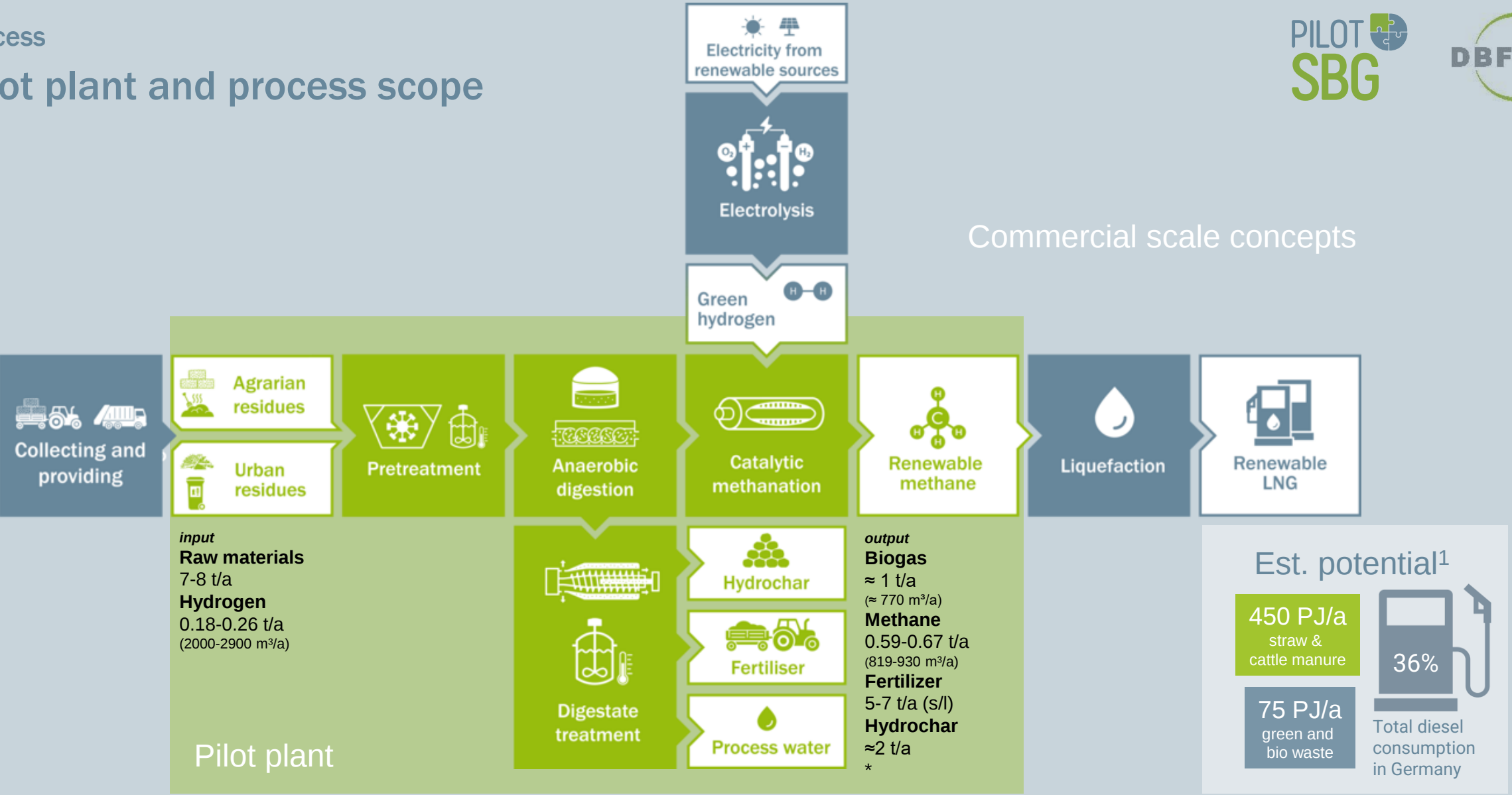
Background & project overview

# Scope



Process

# Pilot plant and process scope



m³ - standard cubic metre; \* Rough approximation from the mass balance. Biogas, fertiliser and hydrochar amount and composition depend on the raw material origin and quality; \*\*for the first commercial size plant concept results from lab scale preliminary tests were used since the pilot plant was still in commissioning.

## Input materials





Anaerobic fermentation| Line 2



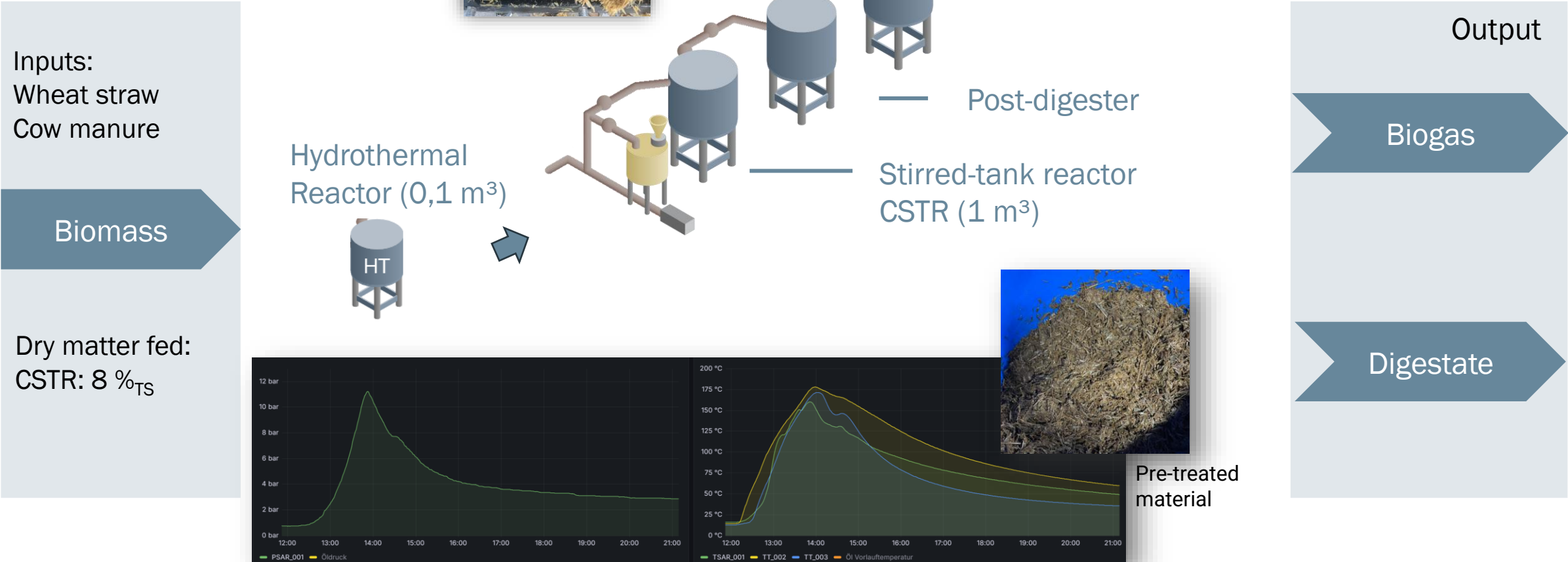
Anaerobic fermentation| Line 1



Operation of a pilot scale biorefinery

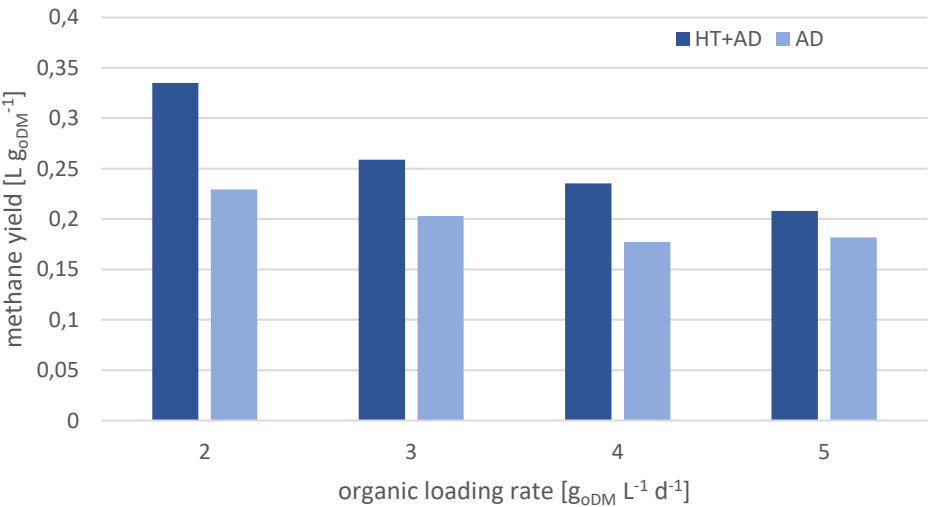
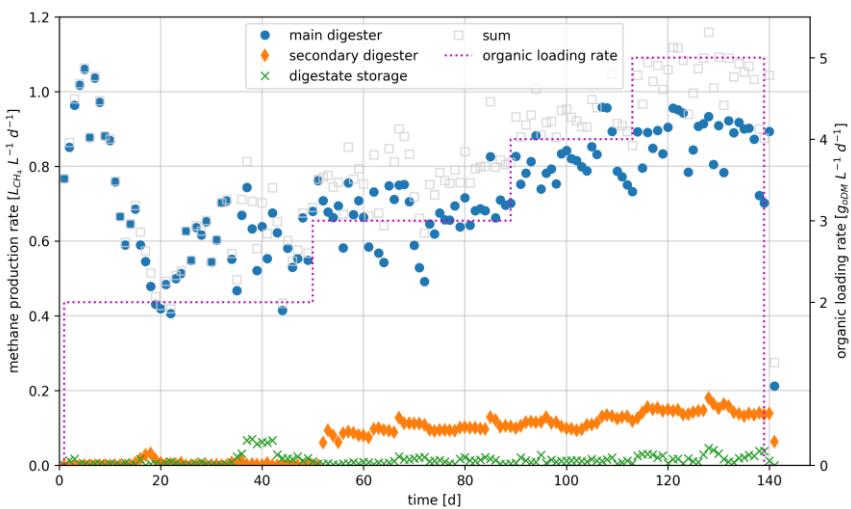
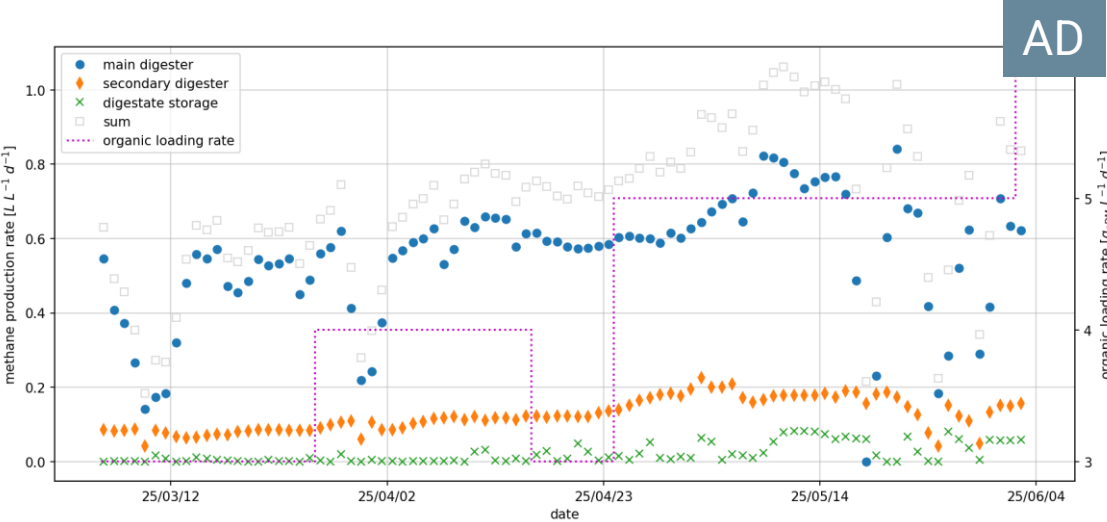
# Anaerobic digestion

Comparison of two reactor lines



Operation of a pilot scale biorefinery

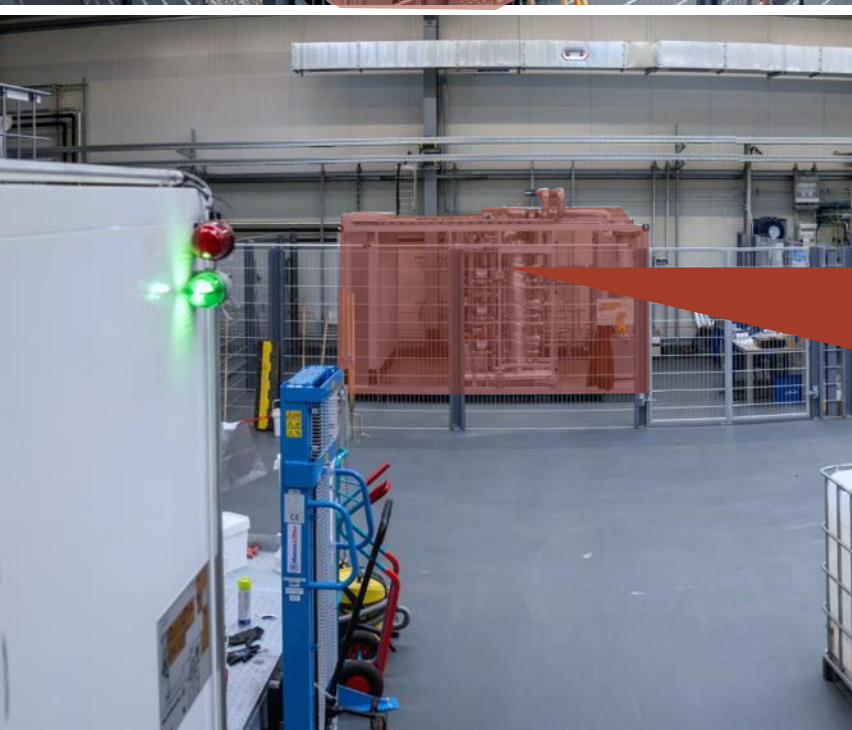
# Effects of hydrothermal pre-treatment the anaerobic digestion\*



Methanation



Gas storage & flare



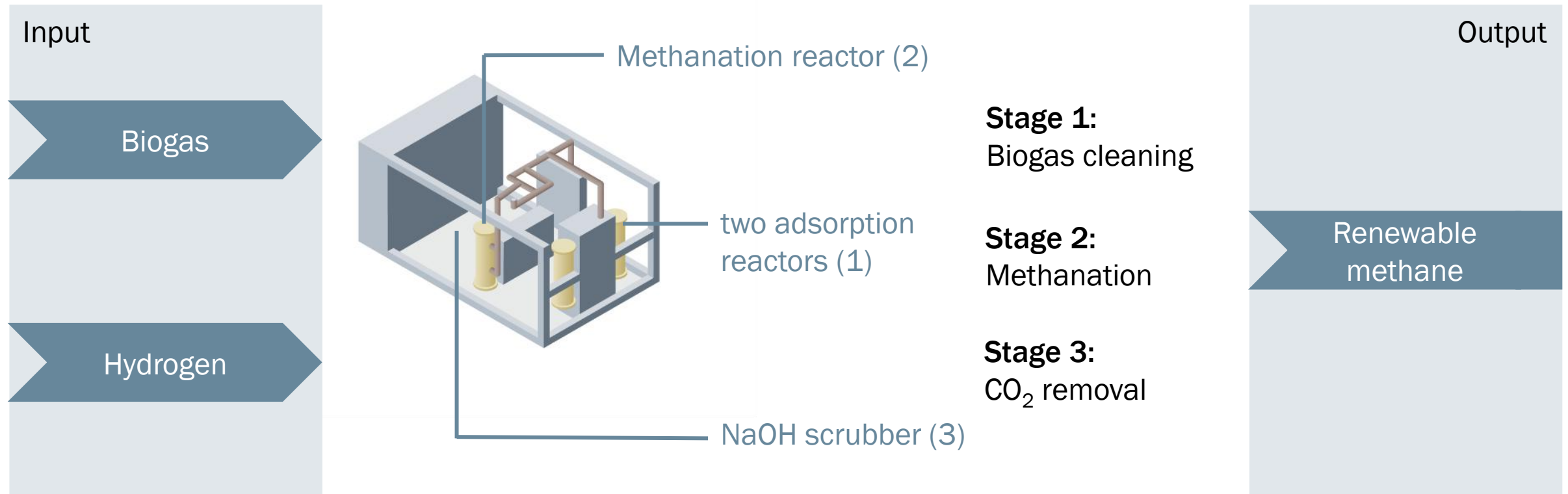
Methanation



# Operation of a pilot scale biorefinery

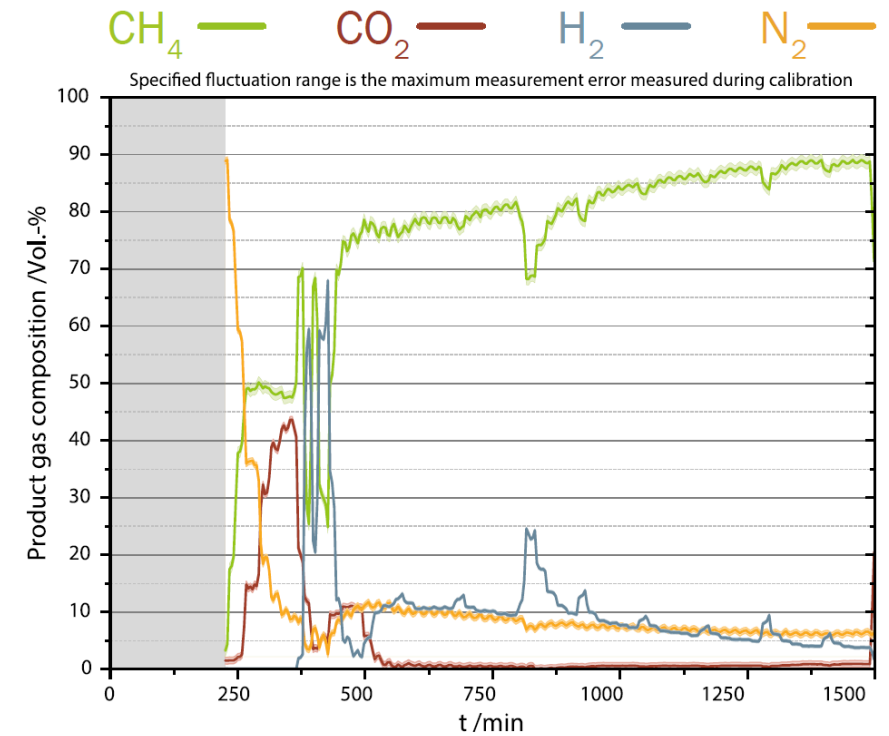
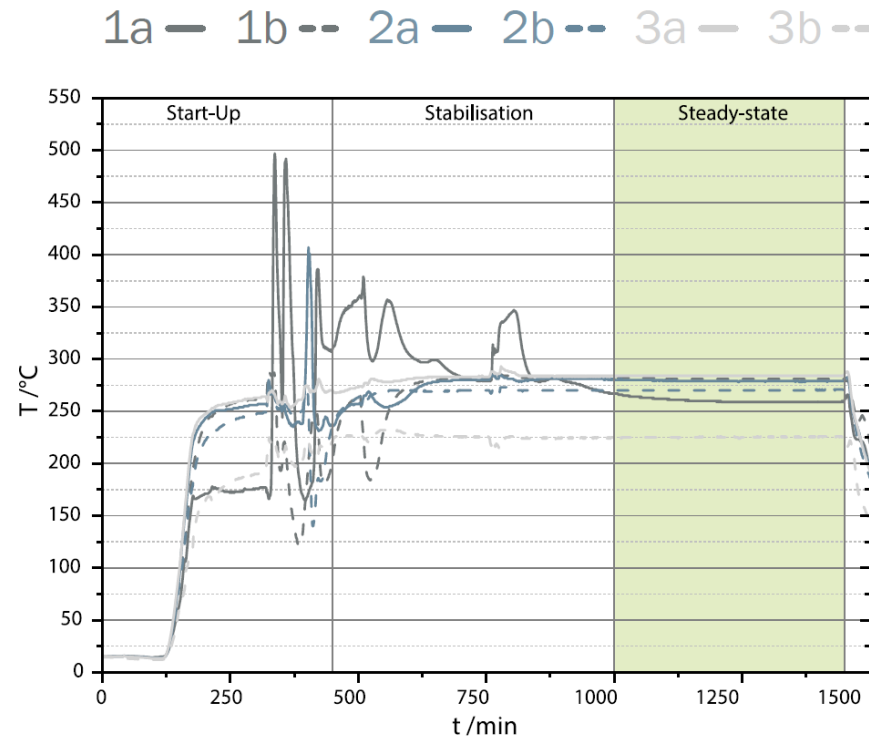
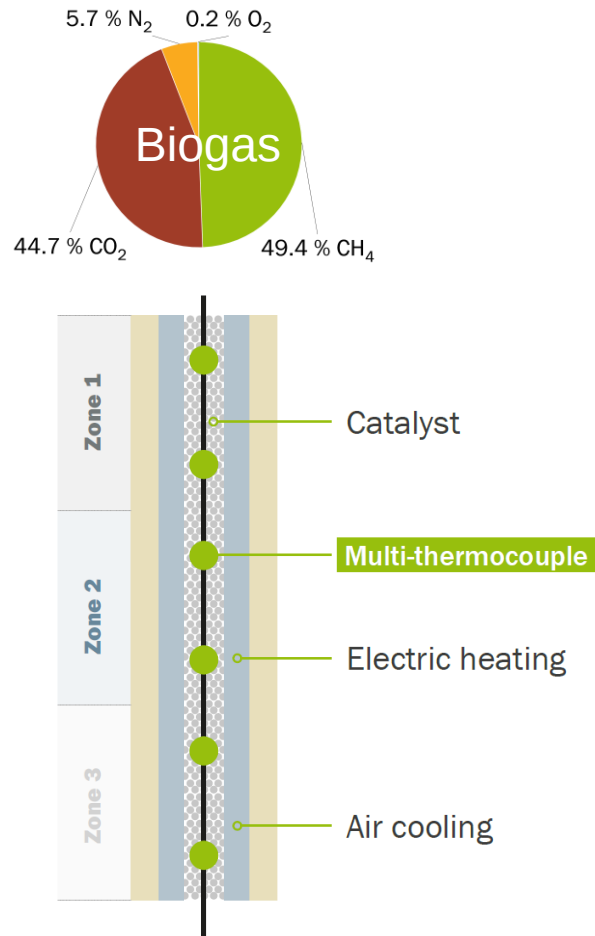
## Catalytic methanation

### Layout & design



# Operation of a pilot scale biorefinery

## Catalytic methanation



$\text{Ru}_2/\text{Al}_2\text{O}_3$ ,  $T = 320\text{ °C}$ ,  $p = 18\text{ bar(g)}$ ,  $\text{H}_2:\text{CO}_2 = 4$ ,  $\dot{V}_{\text{biogas}} = 60\text{ L/h}$ ,  $\text{GHSV} = 449\text{ h}^{-1}$

Digestate treatment

Digestate treatment

## Solid-liquid separation

Screw press



Decanter centrifuge

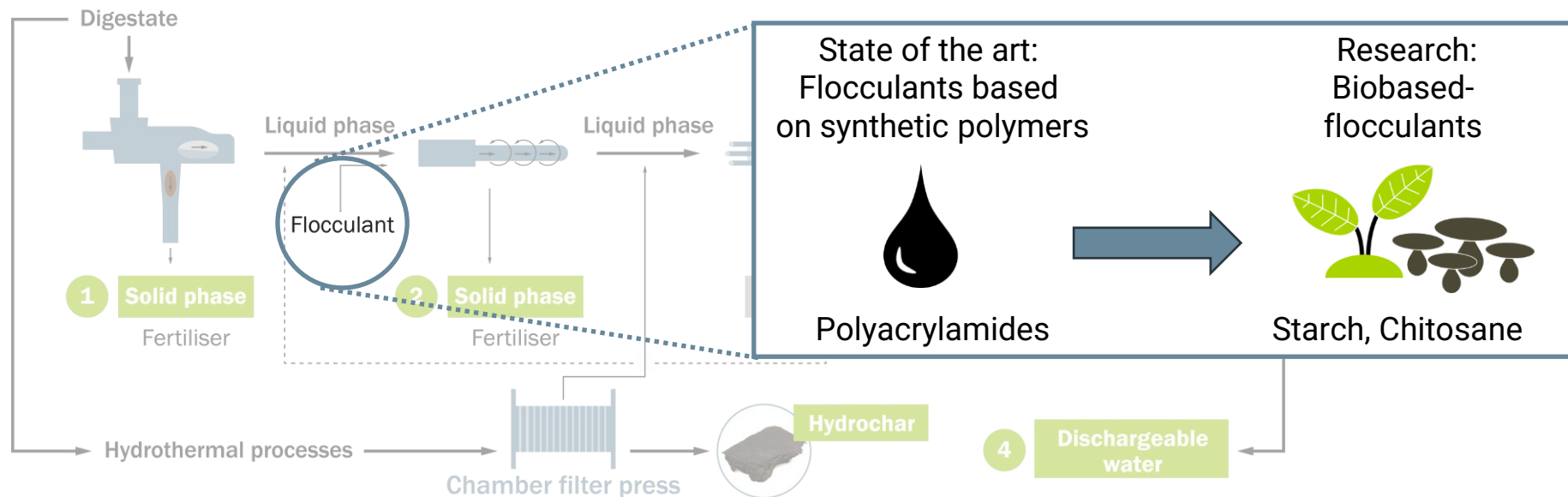


## Liquid-liquid separation

Ultrafiltration

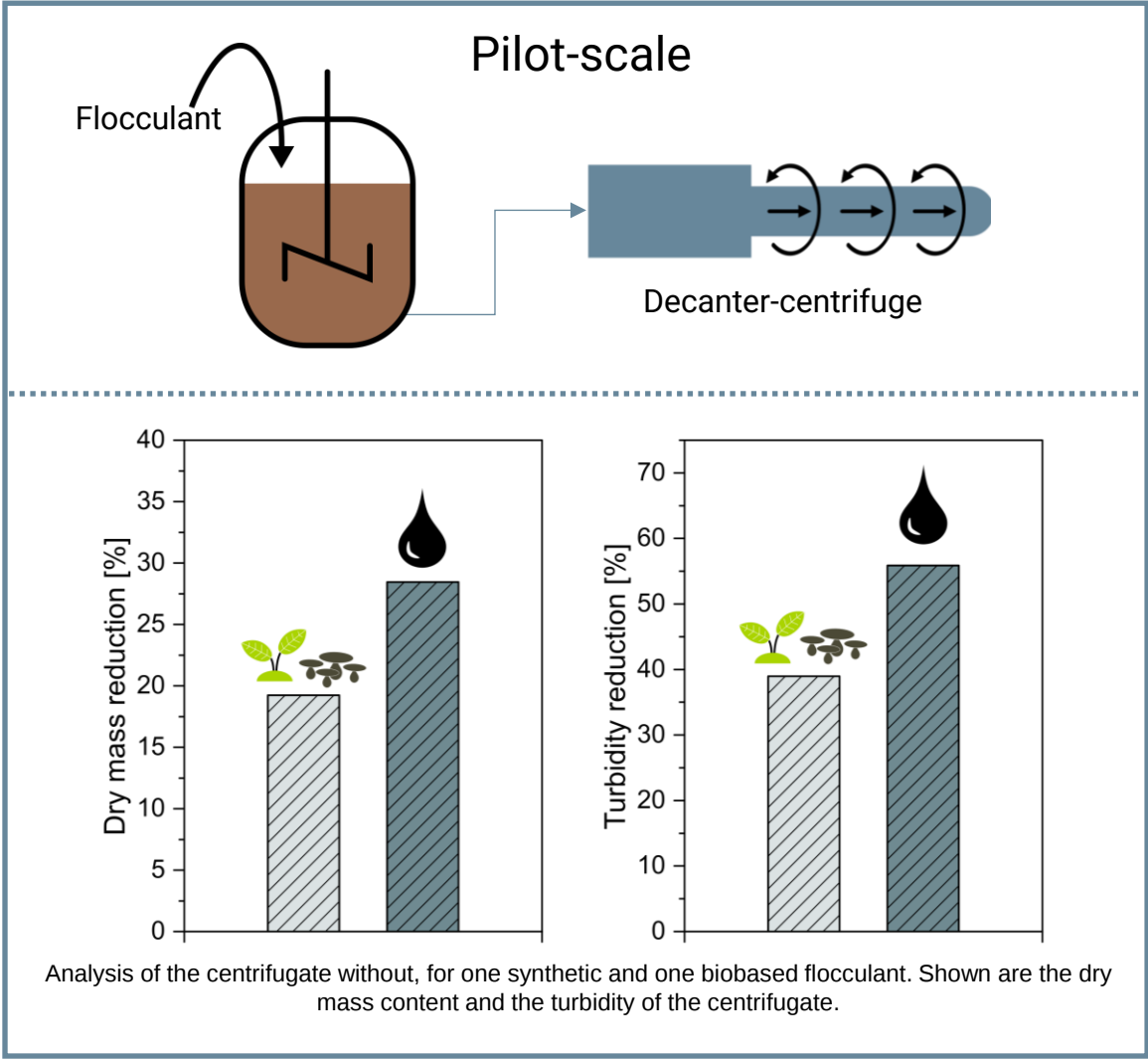
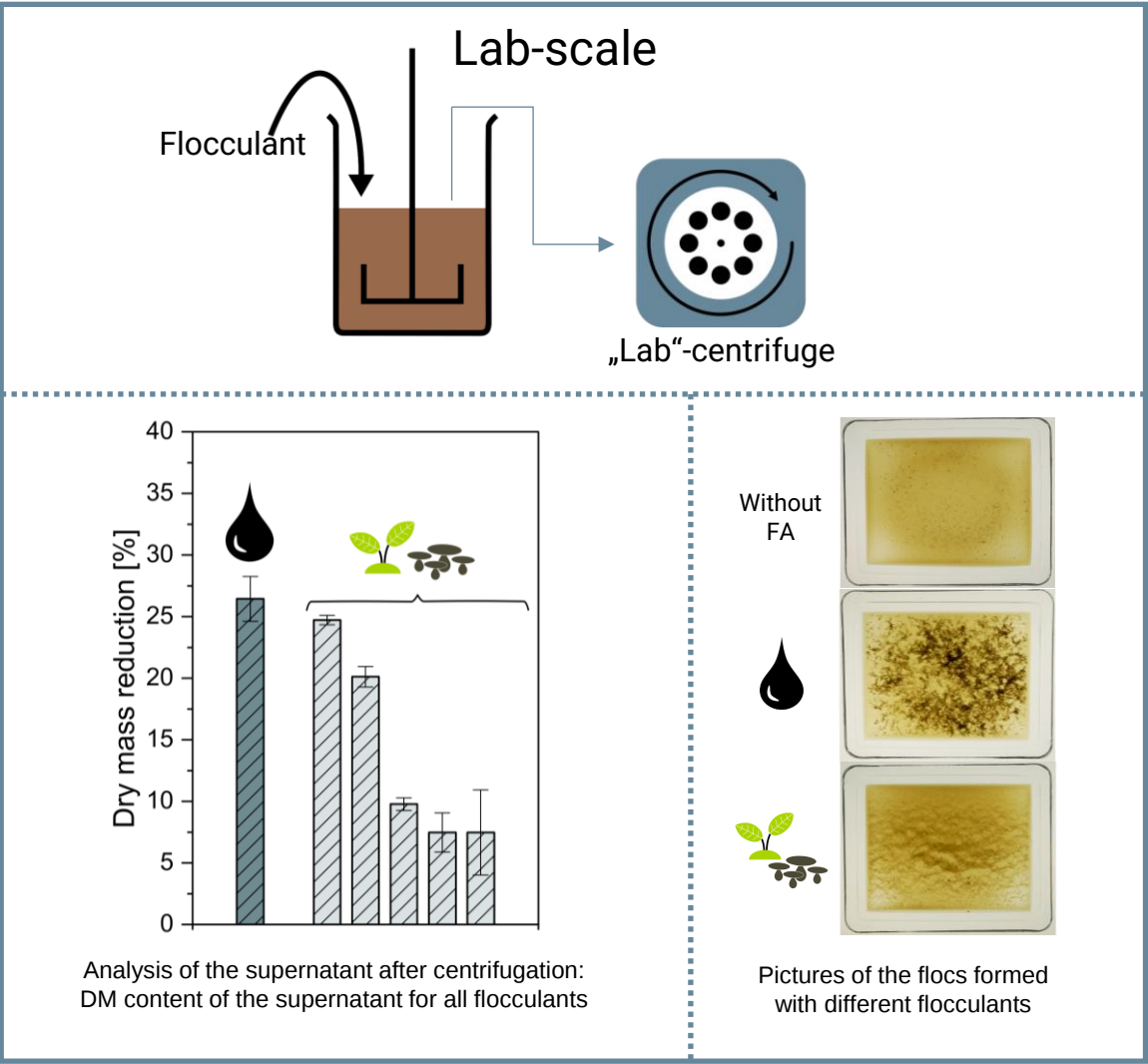


Reverse osmosis



Operation of a pilot scale biorefinery

# Bio-based flocculants for digestate treatment



Scale Up

From pilot to commercial scale

Commercial Scale

25,760 t/a straw  
25,760 t/a manure  
1840 t/a hydrogen

Electricity from  
renewable sources

Electrolysis

16,000 t/a biogas (intermediate)  
8,800 t/a methane  
98,240 t/a fertilizer (s/l)  
\*\*

X 10.000

Collecting and  
providing

Agrarian  
residues

Urban  
residues

Pretreatment

Anaerobic  
digestion

Renewable  
methane

Liquefaction

Renewable  
LNG

Digestate  
treatment

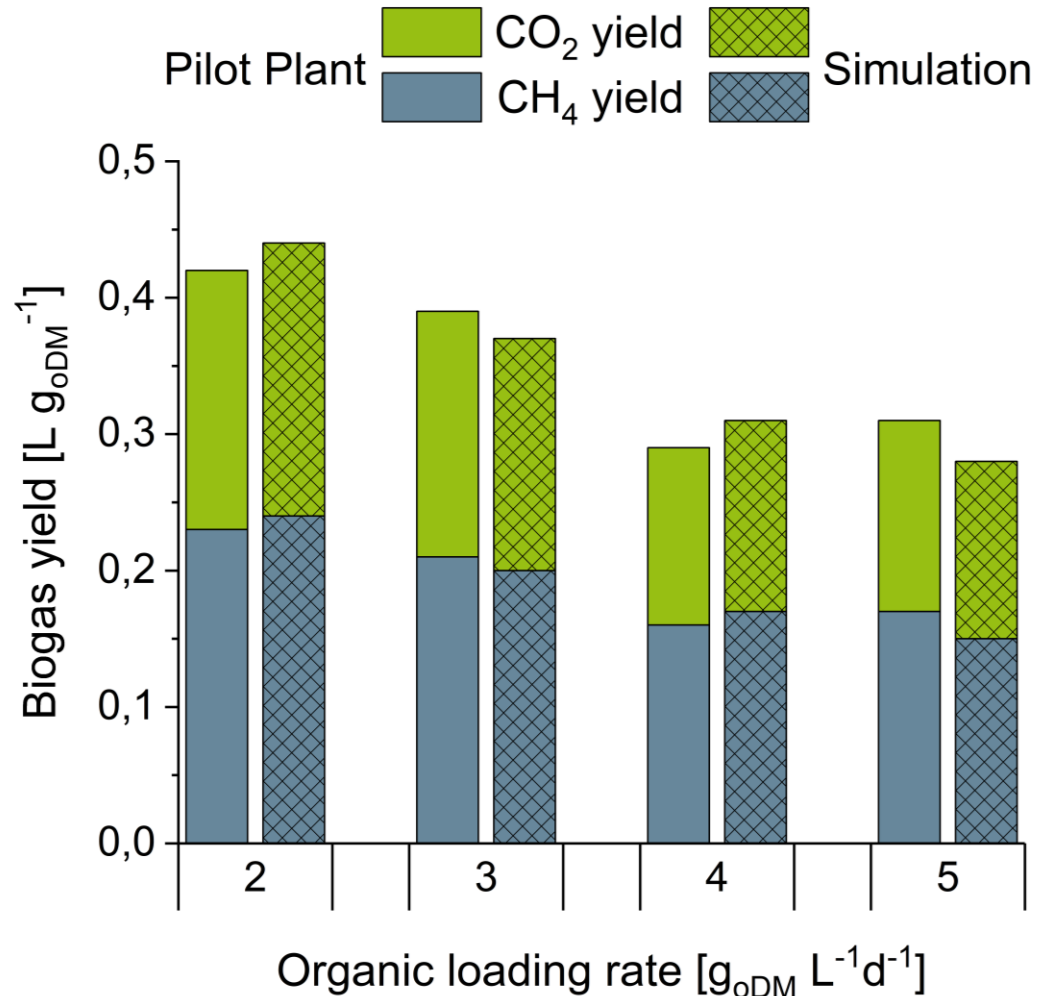
Fertiliser

Process water

Pilot-Scale

7-8 t/a raw material  
0,18-0,26 t/a hydrogen  
(2000-2900 m³/a)

≈ 1 t/a biogas (intermediate)  
(≈ 770 m³/a)  
0,59-0,67 t/a methane  
(819-930 m³/a)  
5-7 t/a fertilizer (s/l)  
≈2 t/a hydrochar  
\*



- Kinetic process simulation of pilot plant in SuperPro Designer

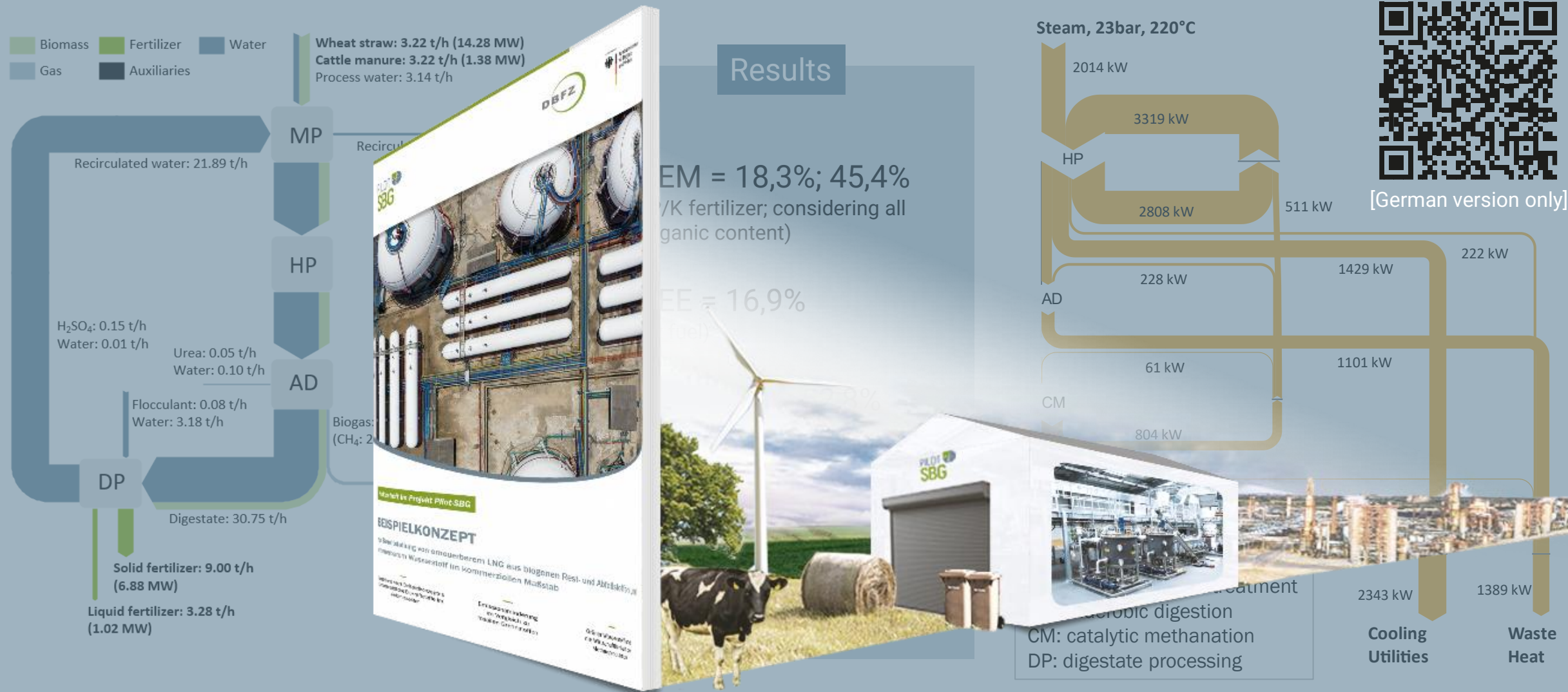
**Equivalent conditions**

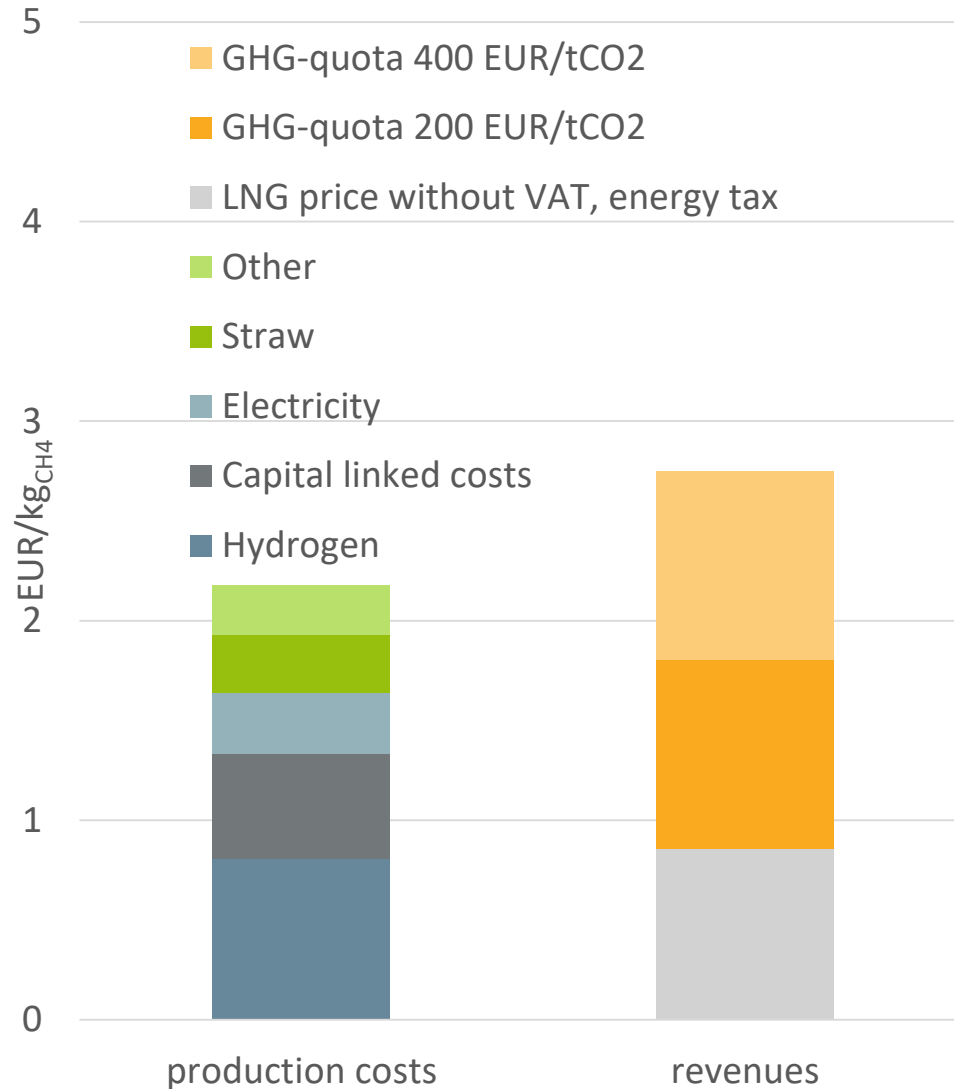
|               |          |
|---------------|----------|
| Manure: Straw | 3:1 [FM] |
| Total solids  | 8 %      |
| C/N           | 20       |

- Biogas kinetics adapted from ADM1-R4<sup>1</sup> & validated
- overall deviation ≤ 1 %
- Base for Scale Up, concept evaluation & comparison for different process operations

Scale Up

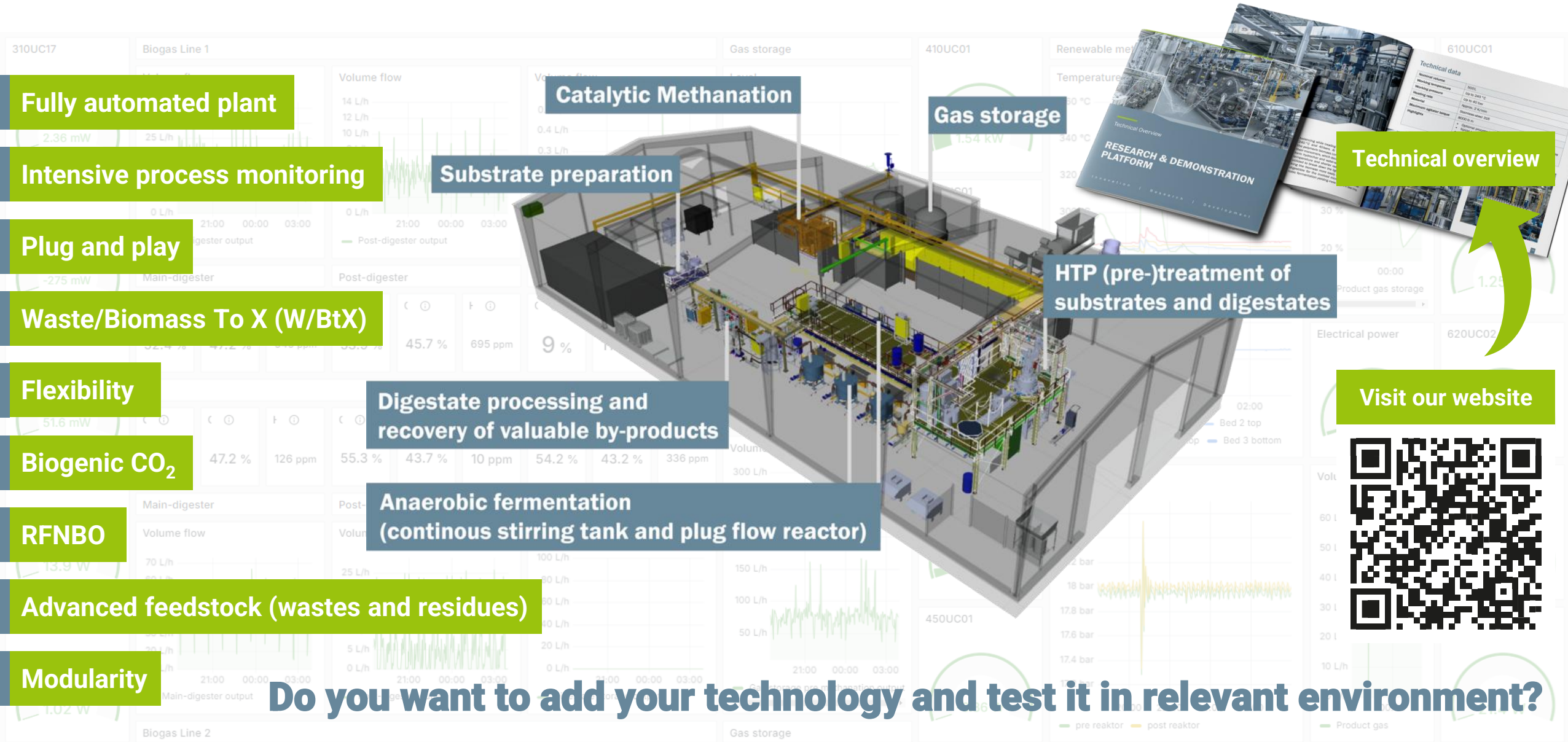
# Mass and energy balance | commercial scale





- GHG quota revenues have a high positive impact on the business case.
- Regulatory changes drive rising prices by end of 2025 (400 EUR/t<sub>CO2</sub>).
- From 2026 onward, double counting for advanced biofuels ends.
- Market prices for 2026 are still under development.

# Technology and fields of research



# Integrated biorefinery for renewable fuels, chemicals and by-products

Flexibility in feedstock and operation conditions with plug and play options

Do you need to scale up your lab scale fermentations?



5x 1m<sup>3</sup> **CSTR**  
1x 0.5m<sup>3</sup> **PFR**



E-fuels from captured CO<sub>2</sub>, biogas,  
syngas; catalyst testing and more ...



**500-L-Reactor** (240 °C / 40 bar);  
with Steam generator  
and high pressure injection

Adsorption unit  
Fixed bed methanation  
reactor  
Product gas cleaning



Technical scale  
research biogas plant

Fully automated,  
**2x 180 m<sup>3</sup> CSTR, 50 m<sup>3</sup> PFR,**  
postdigester + digestate storage,  
mechanical pretreatment ...

Screw press  
Chamber filter press  
Ultra-/Nanofiltration  
Reverse osmosis



You need down streaming for your fermentation broth?

Interested?  
Contact us!

Philipp Knötig  
Department Biorefinery  
Project Lead and Scientific and Technical Coordinator  
of the Pilot Plant

Deutsches Biomasseforschungszentrum gGmbH  
Torgauer Straße 116  
D-04347  
Leipzig

[Philipp.Knoetig@dbfz.de](mailto:Philipp.Knoetig@dbfz.de)  
+49 (0)341 2434-448

[www.dbfz.de/pilot-sbg](http://www.dbfz.de/pilot-sbg)



More research on  
upscaling,  
economics, educt  
potentials etc.

