Operation of a pilot scale biorefinery

for renewable methane and value adding by-products

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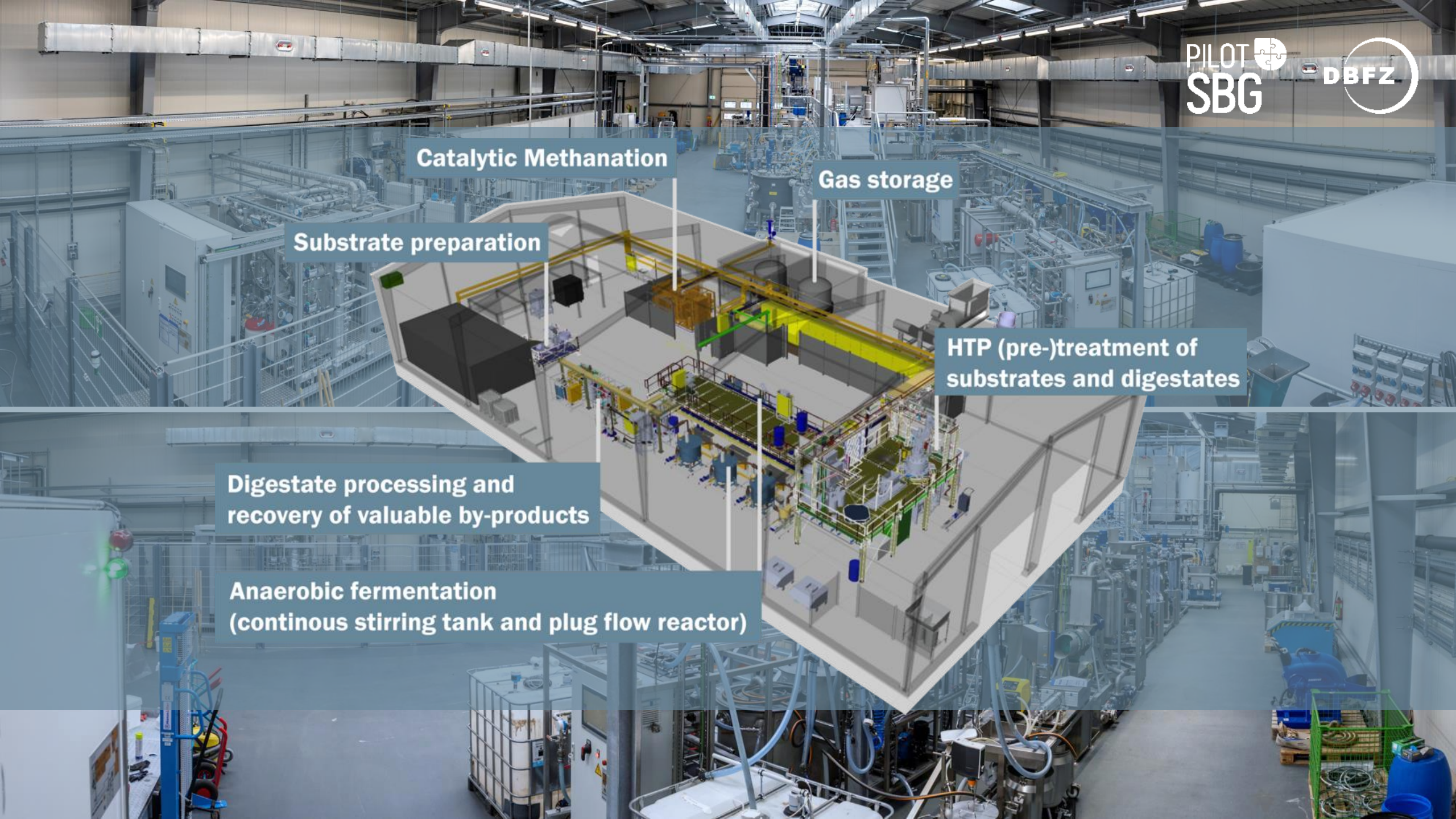
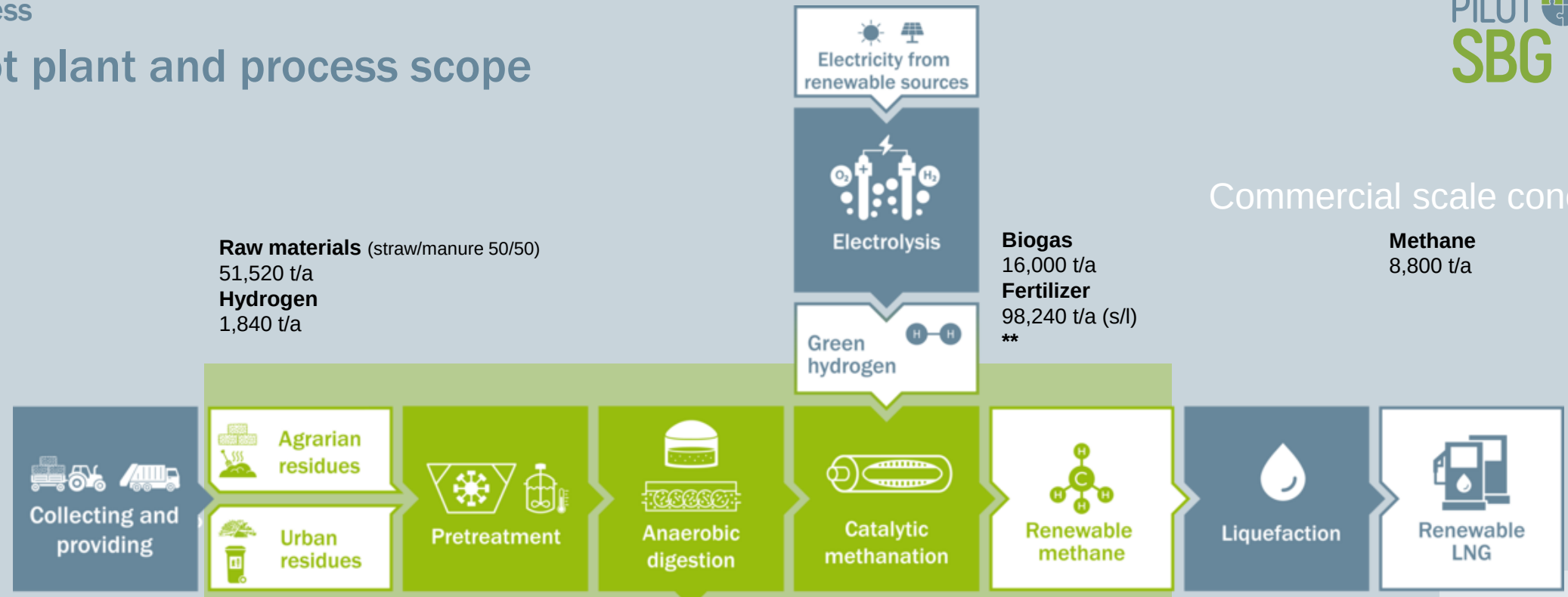

PILOT SBG
DBFZ
Catalytic Methanation
Gas storage
Substrate preparation
HTP (pre-)treatment of substrates and digestates
Digestate processing and recovery of valuable by-products
Anaerobic fermentation (continous stirring tank and plug flow reactor)

Pilot plant and process scope



Raw materials (straw/manure 50/50)
51,520 t/a
Hydrogen
1,840 t/a

Biogas
16,000 t/a
Fertilizer
98,240 t/a (s/l)
**

Commercial scale concepts

Methane
8,800 t/a

input
Raw materials
7-8 t/a
Hydrogen
0.18-0.26 t/a
(2000-2900 m³/a)

output
Biogas
≈ 1 t/a
(≈ 770 m³/a)
Methane
0.59-0.67 t/a
(819-930 m³/a)
Fertilizer
5-7 t/a (s/l)
Hydrochar
≈2 t/a
*

Pilot plant

More research on upscaling, economics, educt potentials etc.

Est. potential[1]

450 PJ/a
straw & cattle manure

75 PJ/a
green and bio waste

36%
Total diesel consumption in Germany

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.

Source: [1]Naumann, K. et al. (2024): Fokusheft Standortanalyse und Ressourcenverteilung für erneuerbares LNG im Verkehr (in preparation)

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Electrical power

310UC17
2.36 mW

300UC18
-275 mW

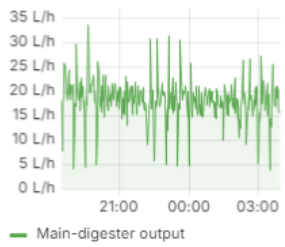
310EQ01
51.6 mW

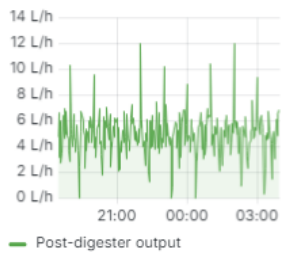
310UC01
13.9 W

320EG01
1.02 W

Anaerobic fermentation

Biogas Line 1

Volume flow


Volume flow


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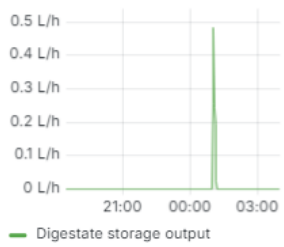


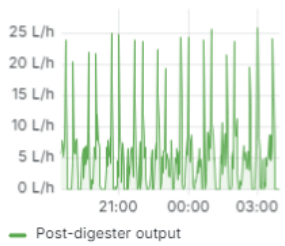
Main-digester			Post-digester			Digestate storage		
CH4	CO2	H2S	CH4	CO2	H2S	CH4	CO2	H2S
52.4 %	47.2 %	549 ppm	53.9 %	45.7 %	695 ppm	9 %	11.7 %	10 ppm

Main-digester			Post-digester			Digestate storage		
CH4	CO2	H2S	CH4	CO2	H2S	CH4	CO2	H2S
46.3 %	47.2 %	126 ppm	55.3 %	43.7 %	10 ppm	54.2 %	43.2 %	336 ppm

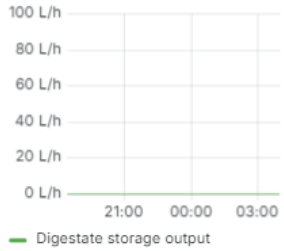
Main-digester

Volume flow


Post-digester

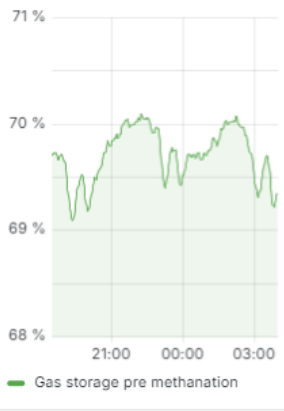
Volume flow


Digestate storage

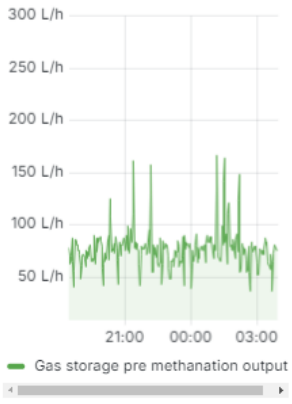
Volume flow


Biogas Line 2

Gas storage

Level


CH4	CO2	H2S
49.1 %	44.9 %	42 ppm

Volume flow


Gas storage

Electrical power

410UC01
1.54 kW

420UC01
712 W

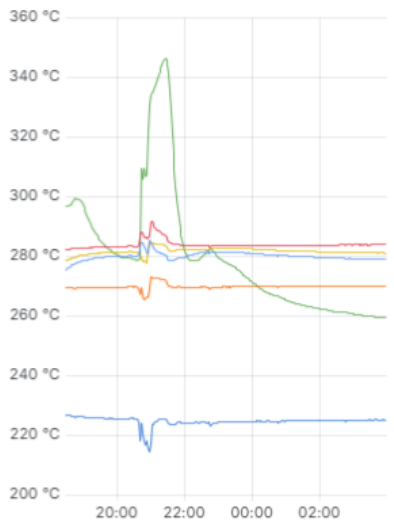
430UC01
166 W

440UC01
636 W

450UC01
-6.86 W

Methanation

Renewable methane

Temperature reaktor


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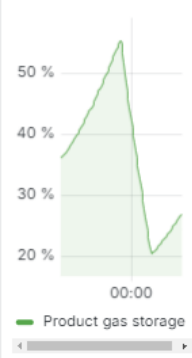
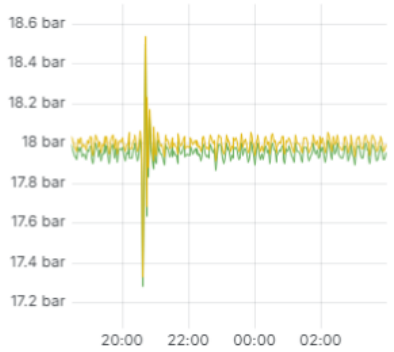
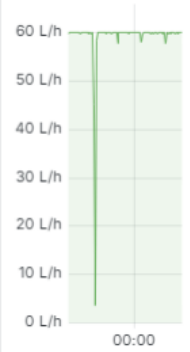


Pressure reaktor


Volume flow


Electrical power

610UC01
49.6 W

620UC01
1.25 W

Electrical power
580 W

620UC02
63.2 W

630UC01
78.1 W

640UC01
21.4 W

Input materials

Anaerobic fermentation | Line 2

Anaerobic fermentation | Line 1

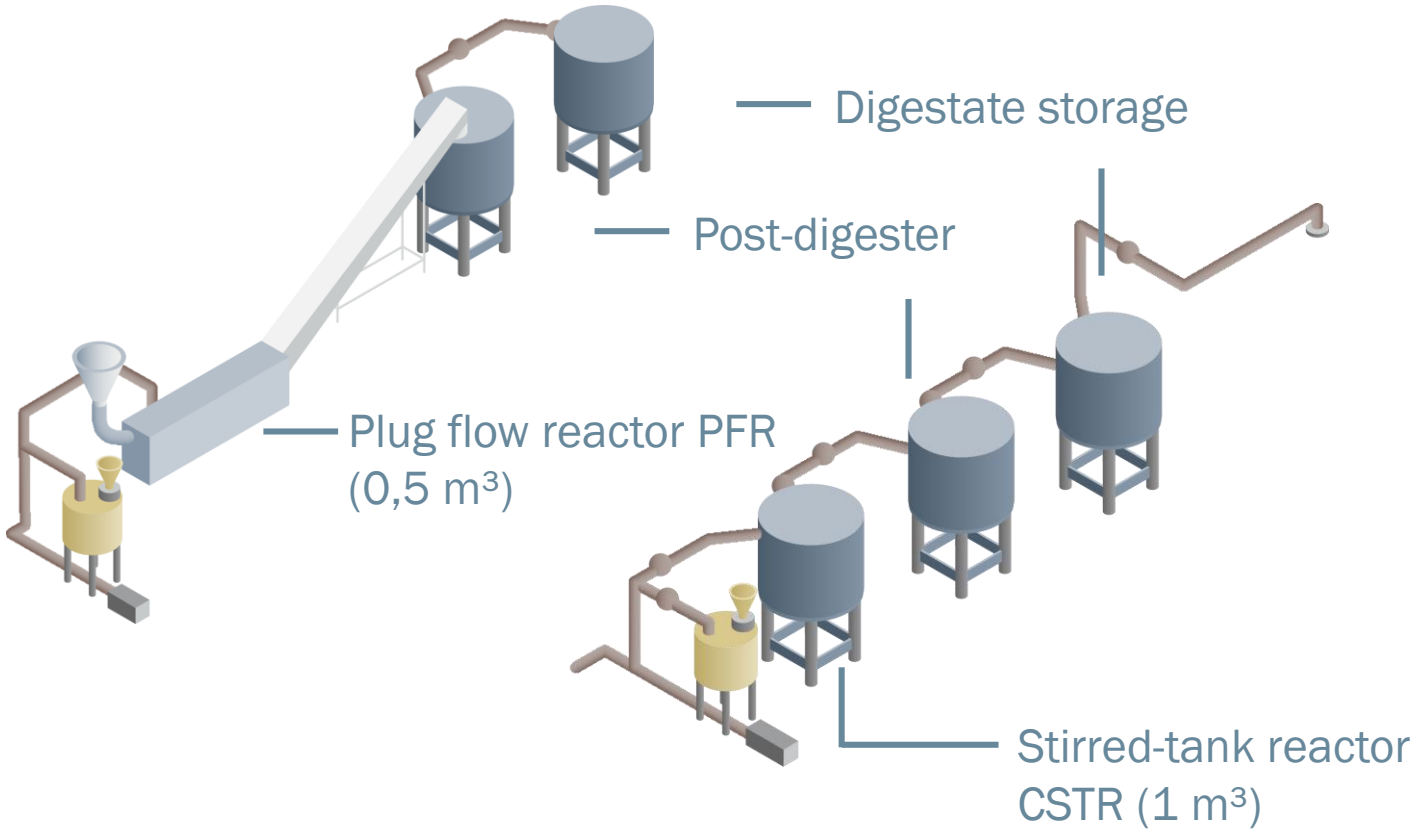
Anaerobic digestion

Comparison of two reactor lines

Inputs:
Wheat straw
Cow manure

Biomass

Dry matter fed:
PFR: 15 $\%_{FM}$
CSTR: 8 $\%_{FM}$



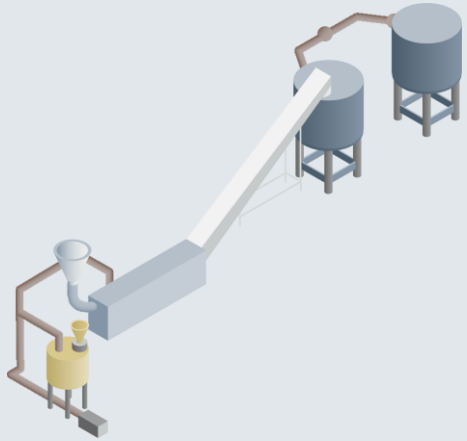
Output

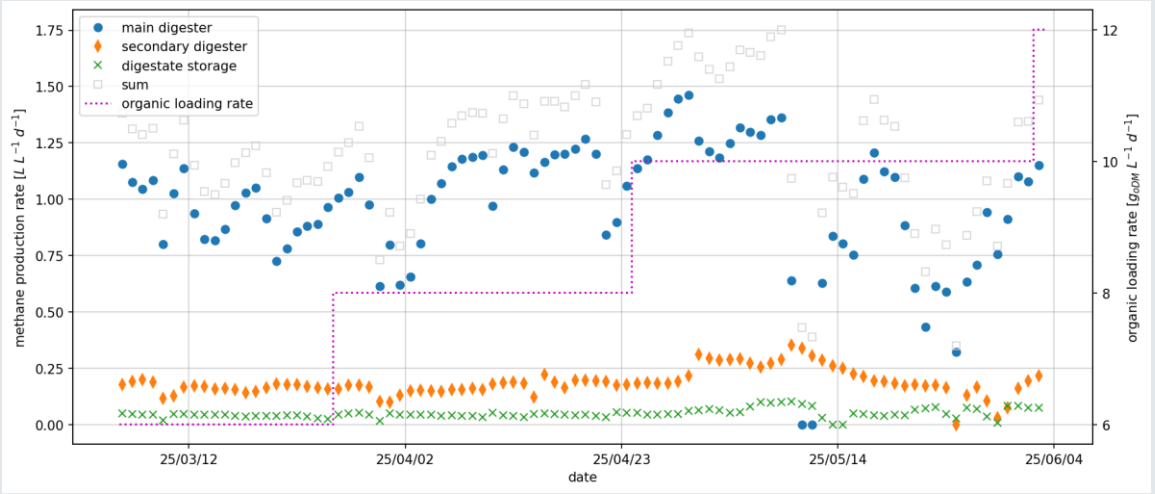
Biogas

Digestate

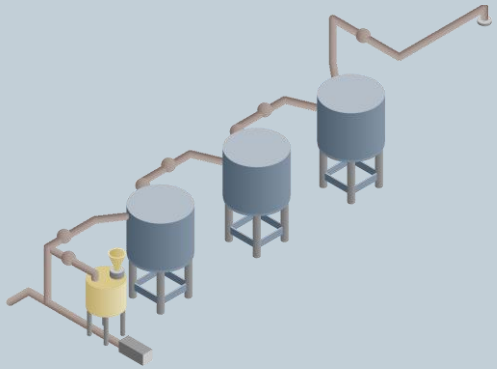
Operation of the anaerobic digestion

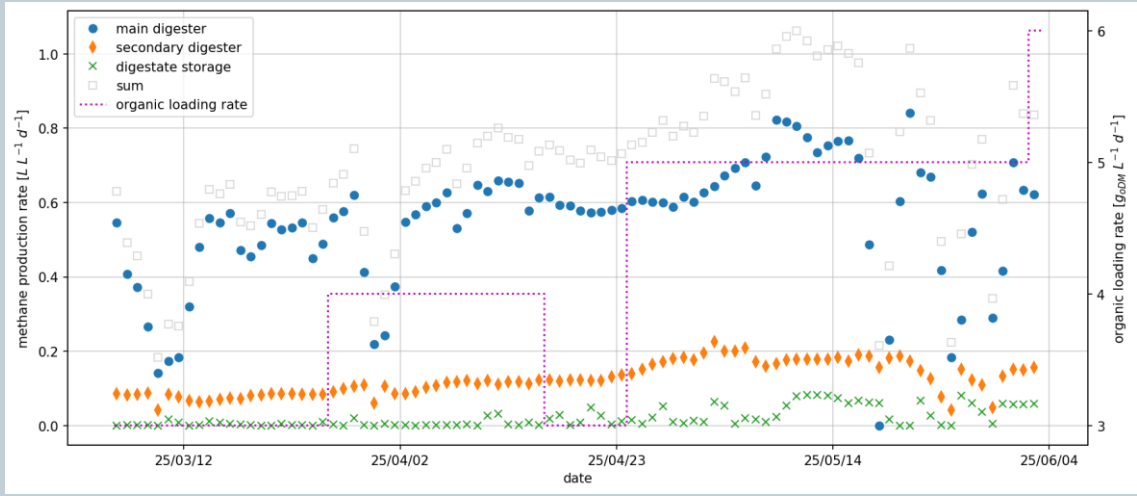
PFR



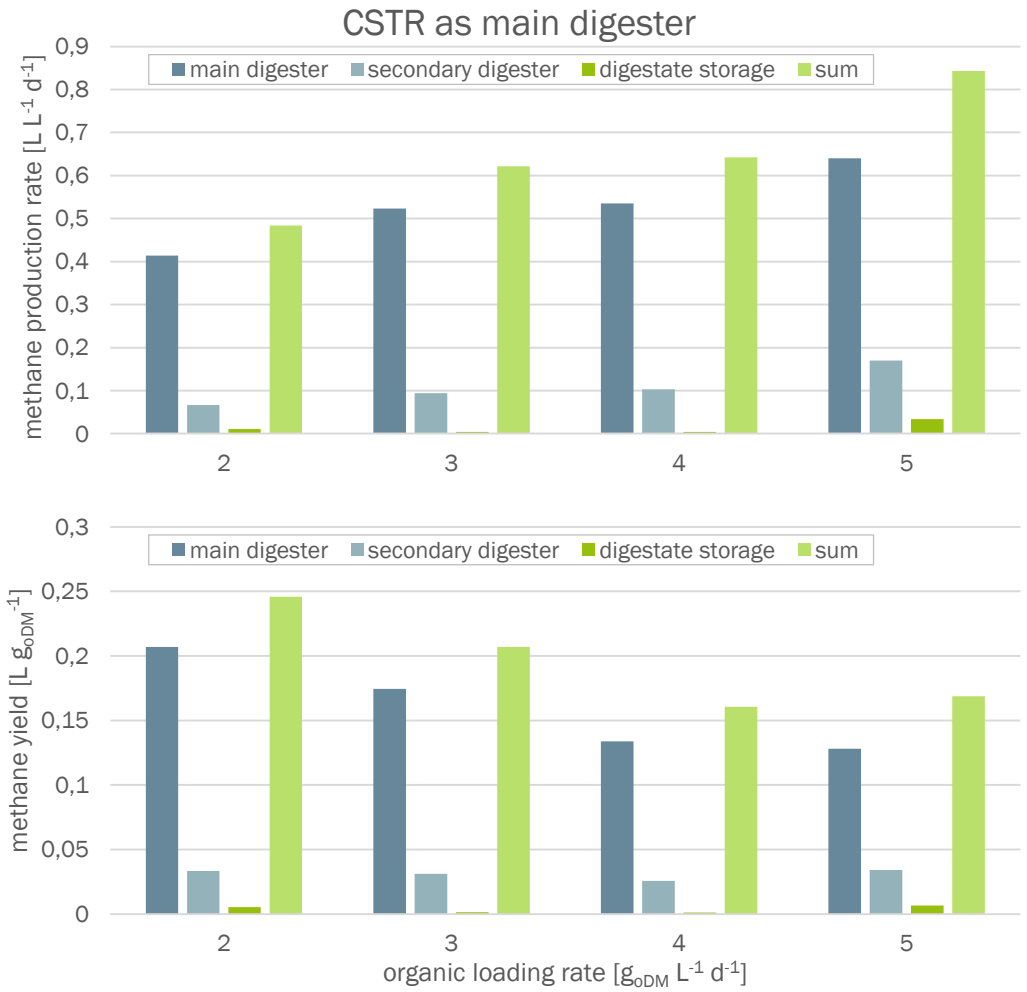


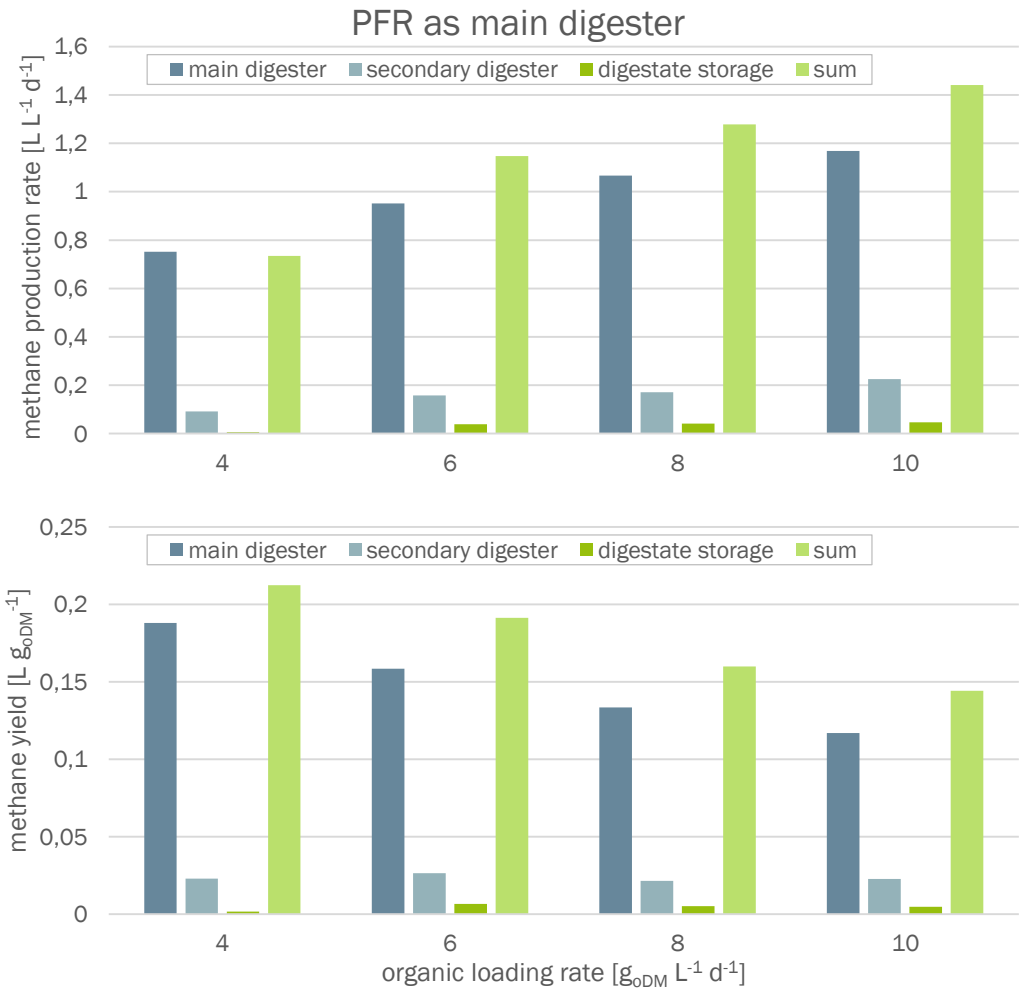
CSTR



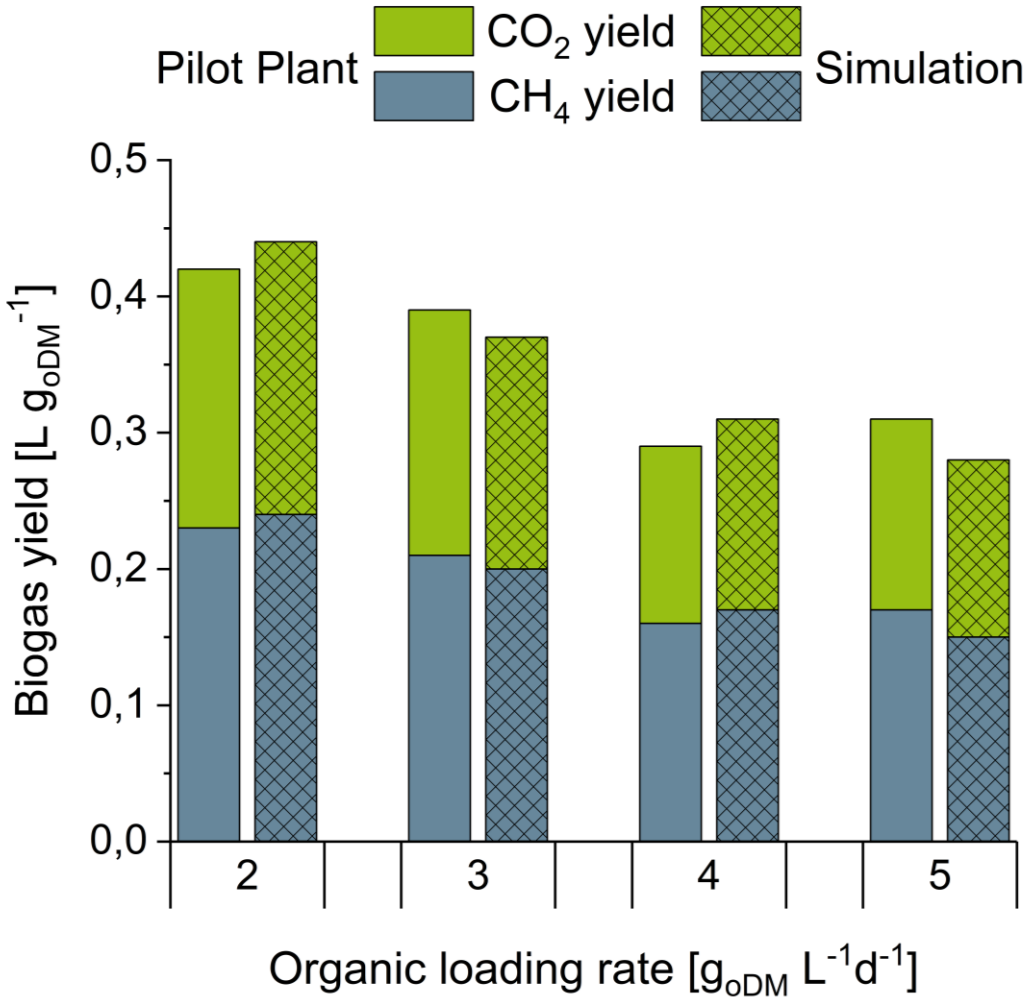


Anaerobic digestion





Digital twin (AD)



- 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[1] & validated

→ overall deviation ≤ 1 %

- Base for Scale Up, concept evaluation & comparison for different process operations

[1] Weinrich, S. (2017): „Praxisnahe Modellierung von Biogasanlagen“; Dissertation (Schriftenreihe Umweltingenieurwesen, Band 76), https://doi.org/10.18453/rosdok_id00002016

Methanation

Gas storage & flare

PILOT SBG

DBFZ

Methanation

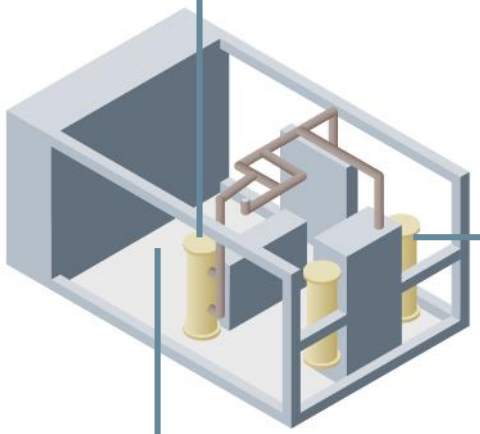
Catalytic methanation

Layout & design

Input

Biogas

Hydrogen



Stage 1:
Biogas cleaning

Stage 2:
Methanation

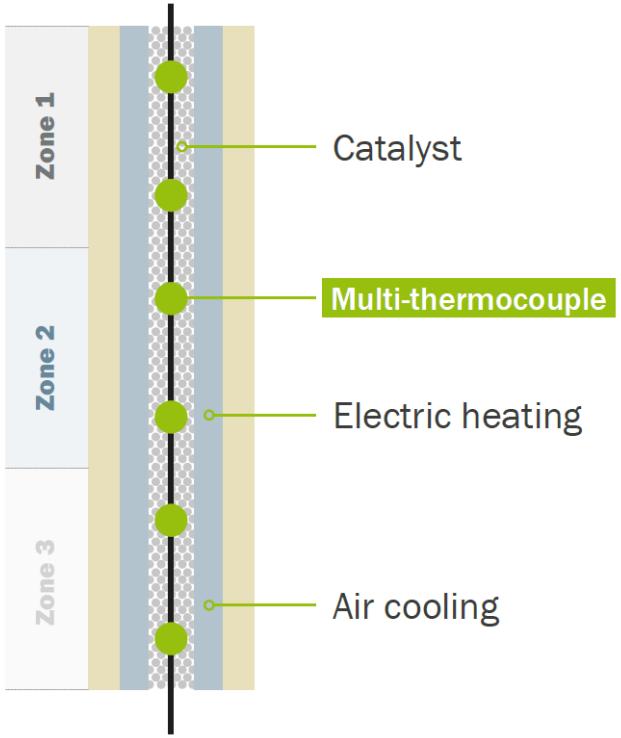
Stage 3:
CO_2 removal

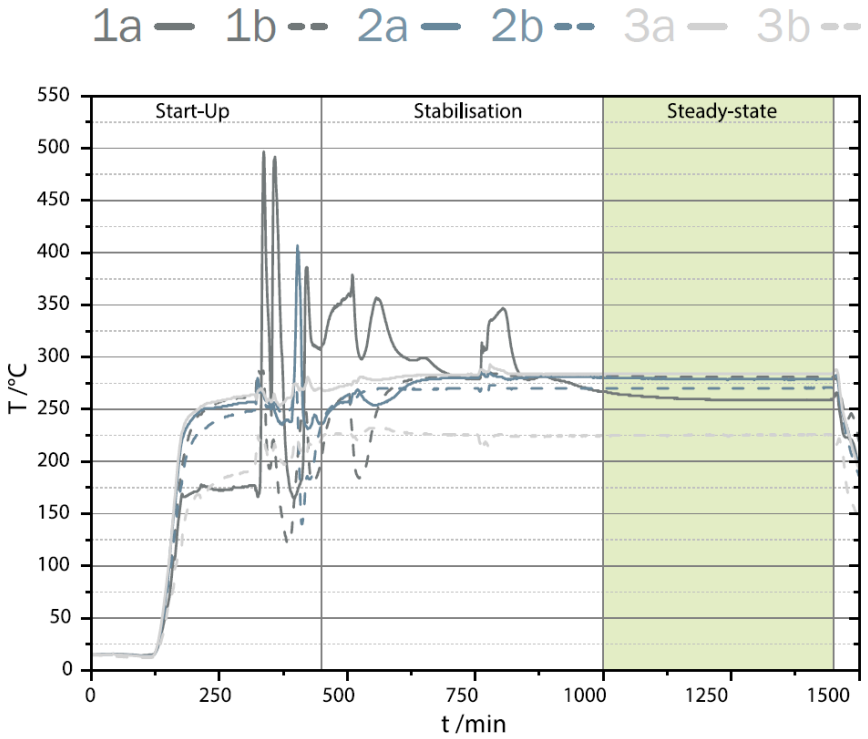
Output

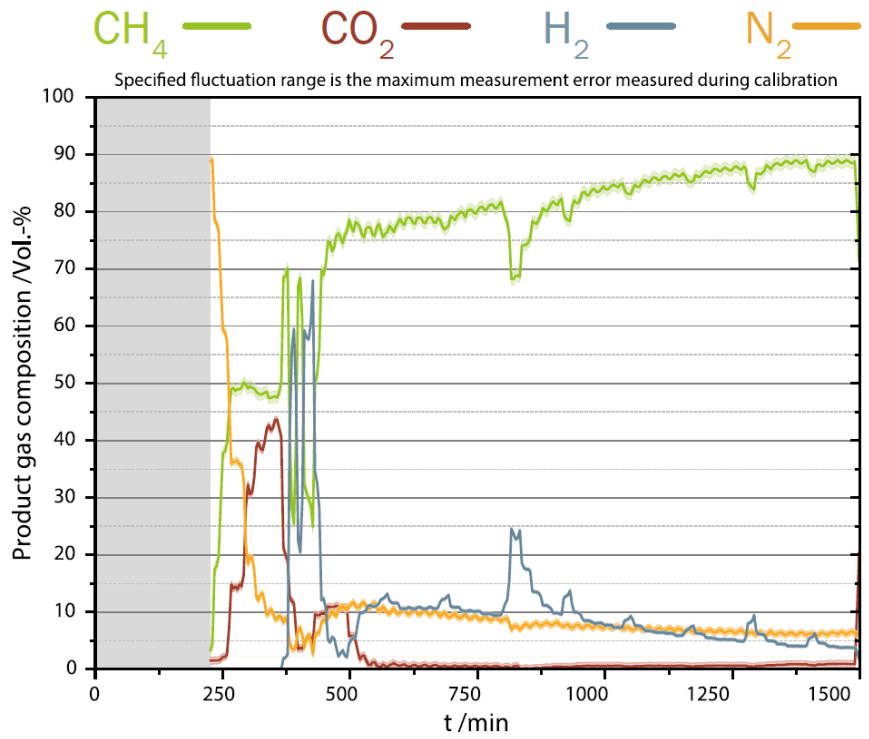
Renewable methane

Catalytic methanation

Start-up process







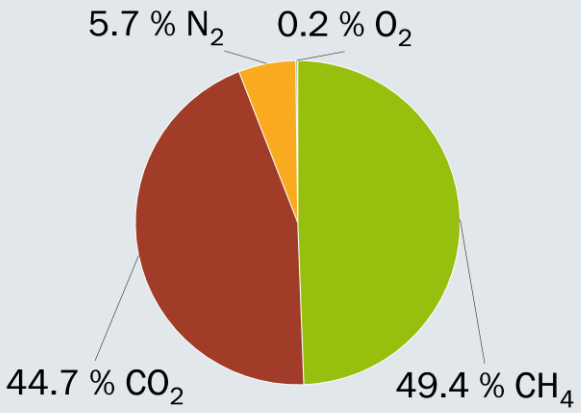
$Ru2/Al_2O_3$, T = 320 °C, p = 18 bar(g), $H_2:CO_2$ = 4, $\dot{V}_{biogas}$ = 60 L/h, GHSV = 449 h^{-1}

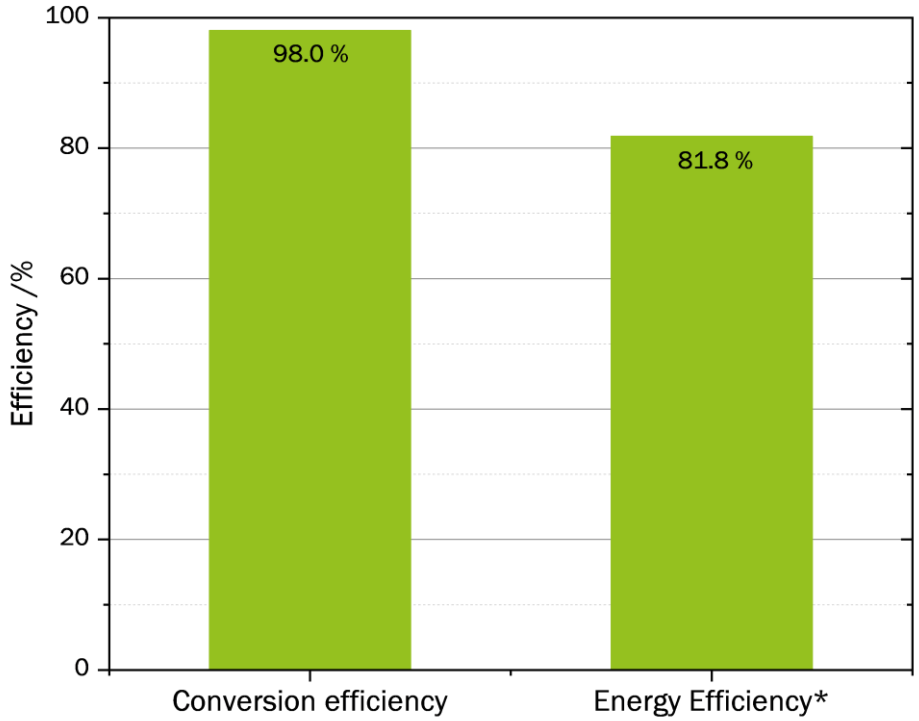
Catalytic methanation

Previous parameters

Input

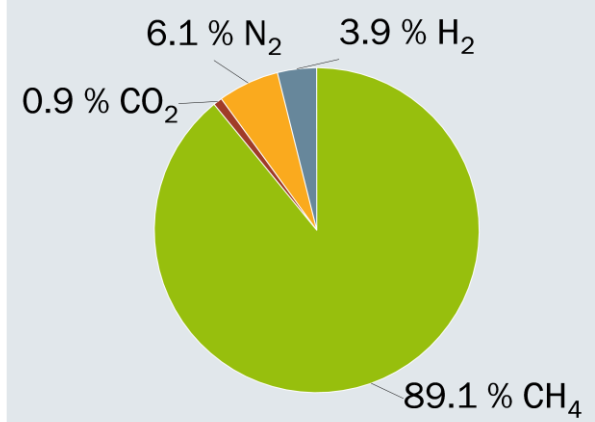
Biogas





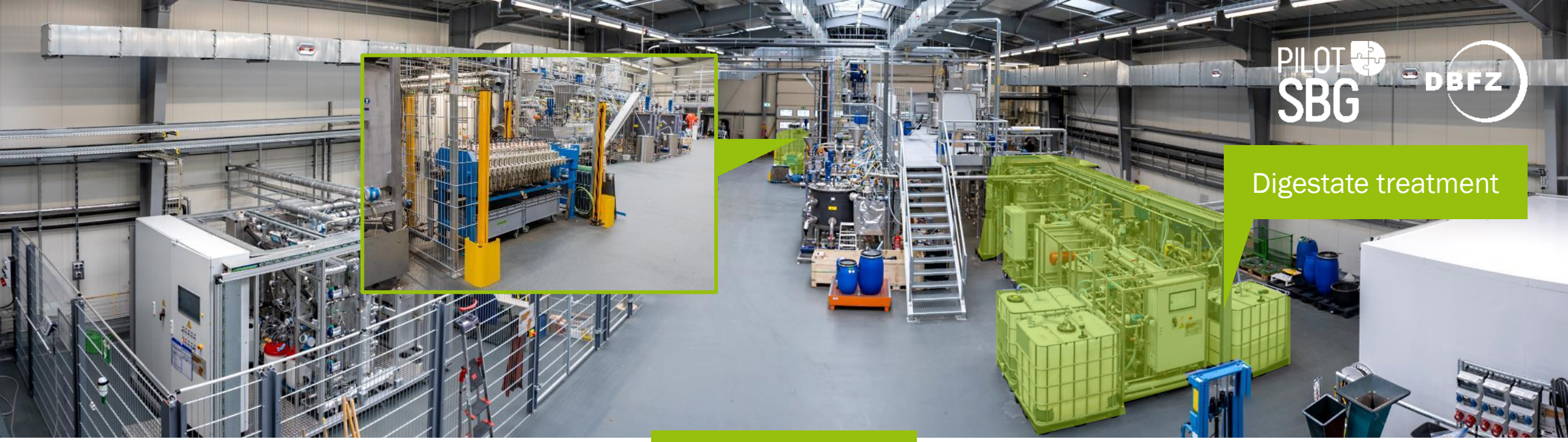
Output

Renewable methane



$Ru2/Al_2O_3$, T = 320 °C, p = 18 bar(g), $H_2:CO_2$ = 4, $\dot{V}_{biogas}$ = 60 L/h, GHSV = 449 h^{-1}

*Energy efficiency determined from calorific value of product and educt


PILOT SBG
DBFZ
Digestate treatment

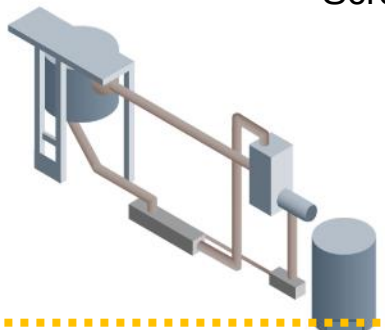

Digestate treatment

Digestate treatment

Results from commissioning phase:

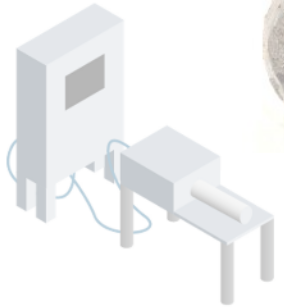
Diges-
tate

Screw press



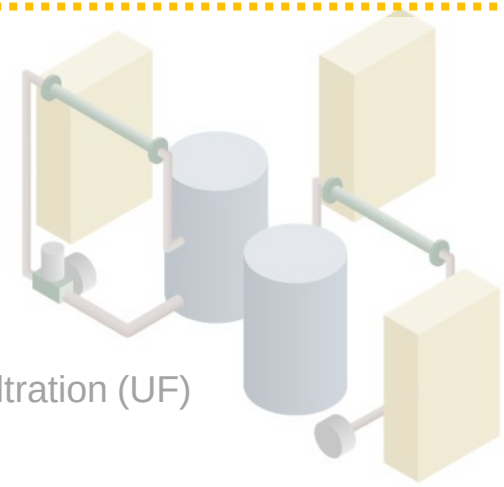
Filtrate

Decanter



Liquid to UF

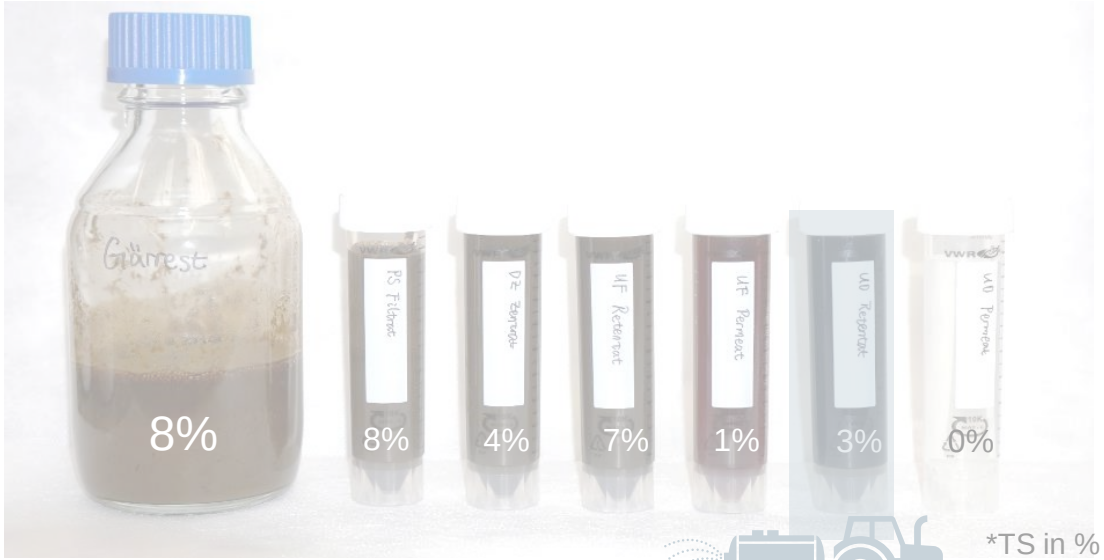
Filtrate recycling



Ultrafiltration (UF)

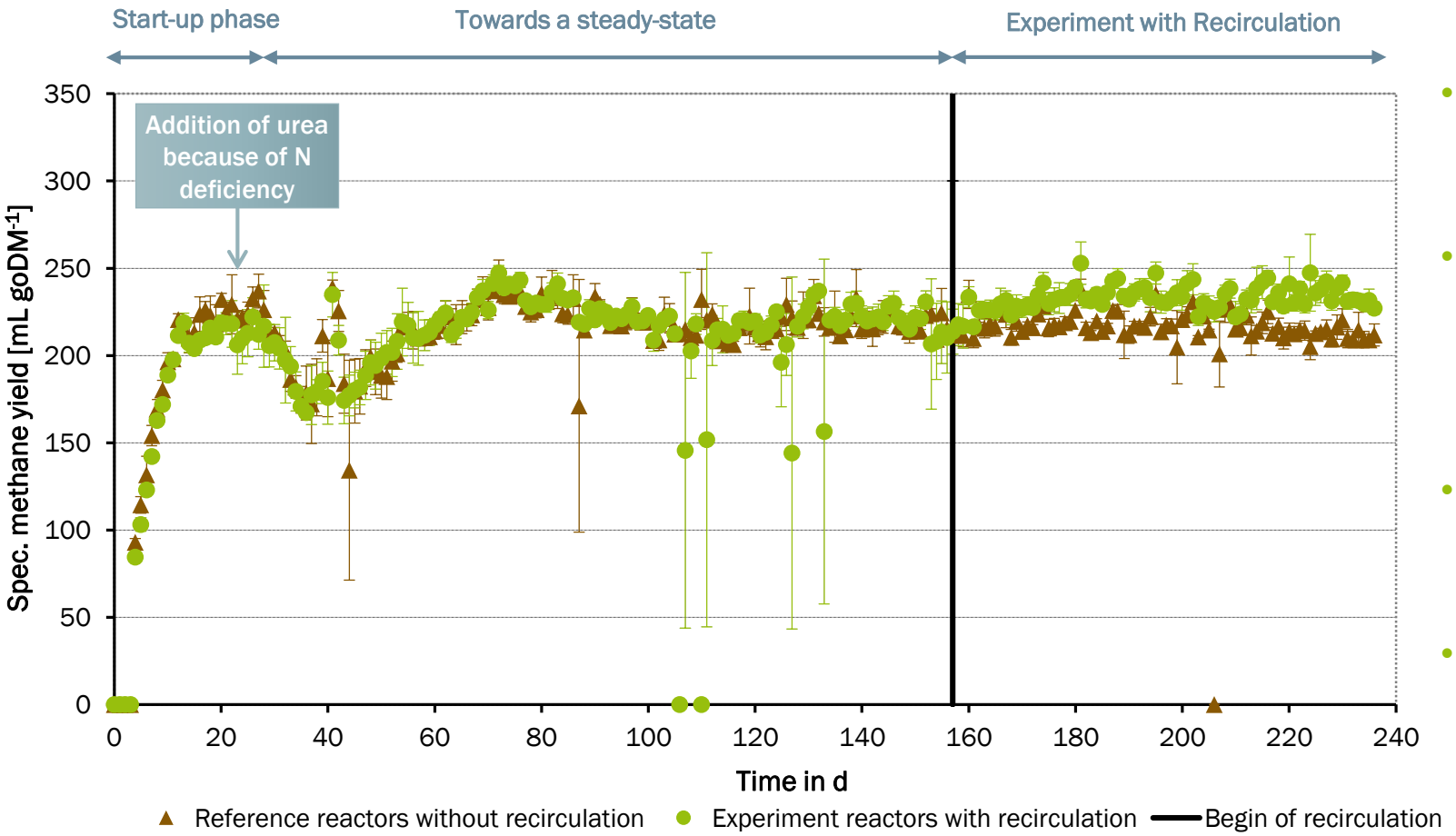
Water

Reverse osmosis (RO)



*TS in %

Quantitative evaluation of its effect on methane production



- The experiment data were statistically evaluated
- Digestate recirculation increased methane production by 8.24 ± 0.35% compared to the reference reactors
- It significantly reduced the demand for fresh water and urea
- Decrease of possible waste streams and thus energy intensive cleaning tech.

PILOT SBG

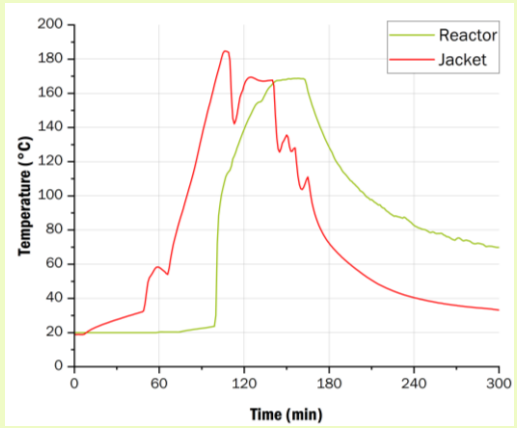
DBFZ

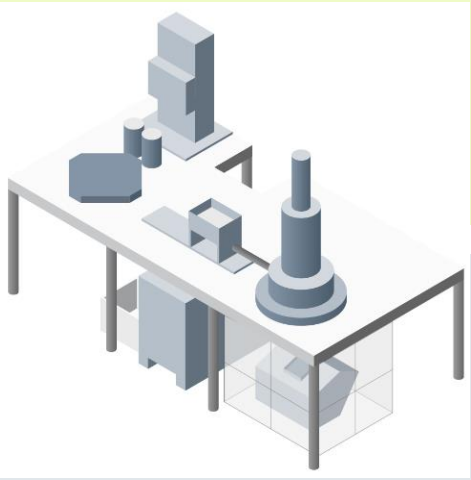
Hydrothermal (pre-)treatment

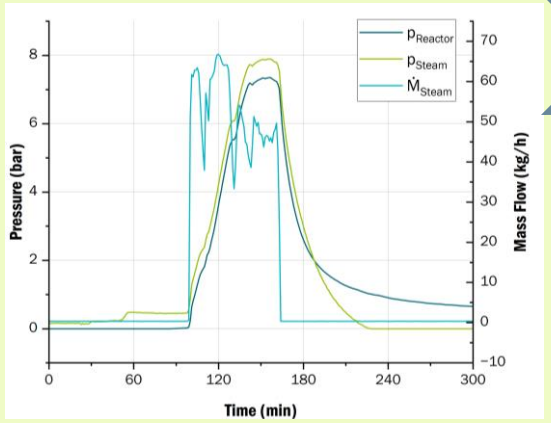
Hydrothermal pre-treatment and carbonization, commissioning

Input | **Conversion** | **Output**

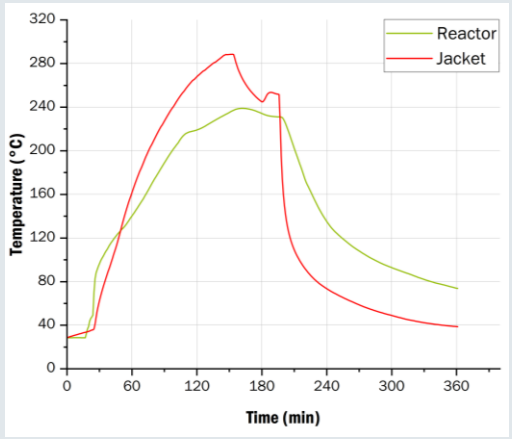
Biomass

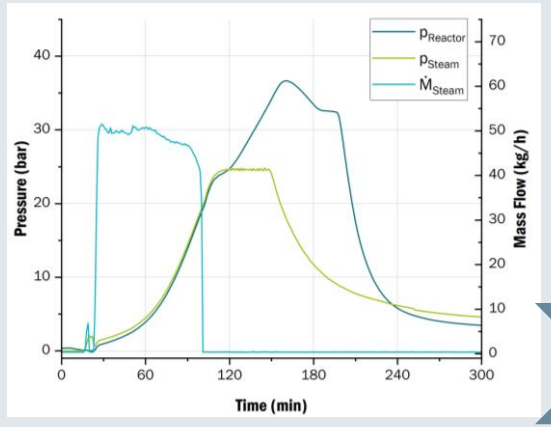






to digester





Digestate

Hydrochar

Status

- We can show an automated 24/7 production of advanced biofuels in an integrated pilot plant

Outlook

- Operation and research campaigns until 12/2026
  - E.g. update of evaluations on commercial size biorefinery
  - Open data

New projects: e.g. FlexBiorefinery (FlexBioref)

- Demand based supply of energy or chemicals (Methanol/Methane) through autonomous decision making
- Looking for partners

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Technical overview

Research & demonstration platform

Innovation | Research | Development

- Methanation
- Digestate treatment
- Anaerobic fermentation
- Hydrothermal processes
- Substrate preparation and storage

Download:

Technical details, processes and application

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Interested? Contact me!

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Scientific and Technical Coordinator of the pilot plant Pilot-SBG

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