Betrieb einer Bioraffinerie im Pilotmaßstab

zur Herstellung von erneuerbarem Methan aus biogenem CO_2 sowie weiterer wertschöpfender Produkte aus Nebenströmen

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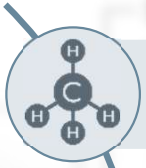
20.11.2025, Statuskonferenz Bioenergie 2025, Leipzig

Methane as a fuel

Why methane?



Energy carrier (9.97 kWh/m³)

Hydrogen (3 kWh/m³)*

High temperature generation

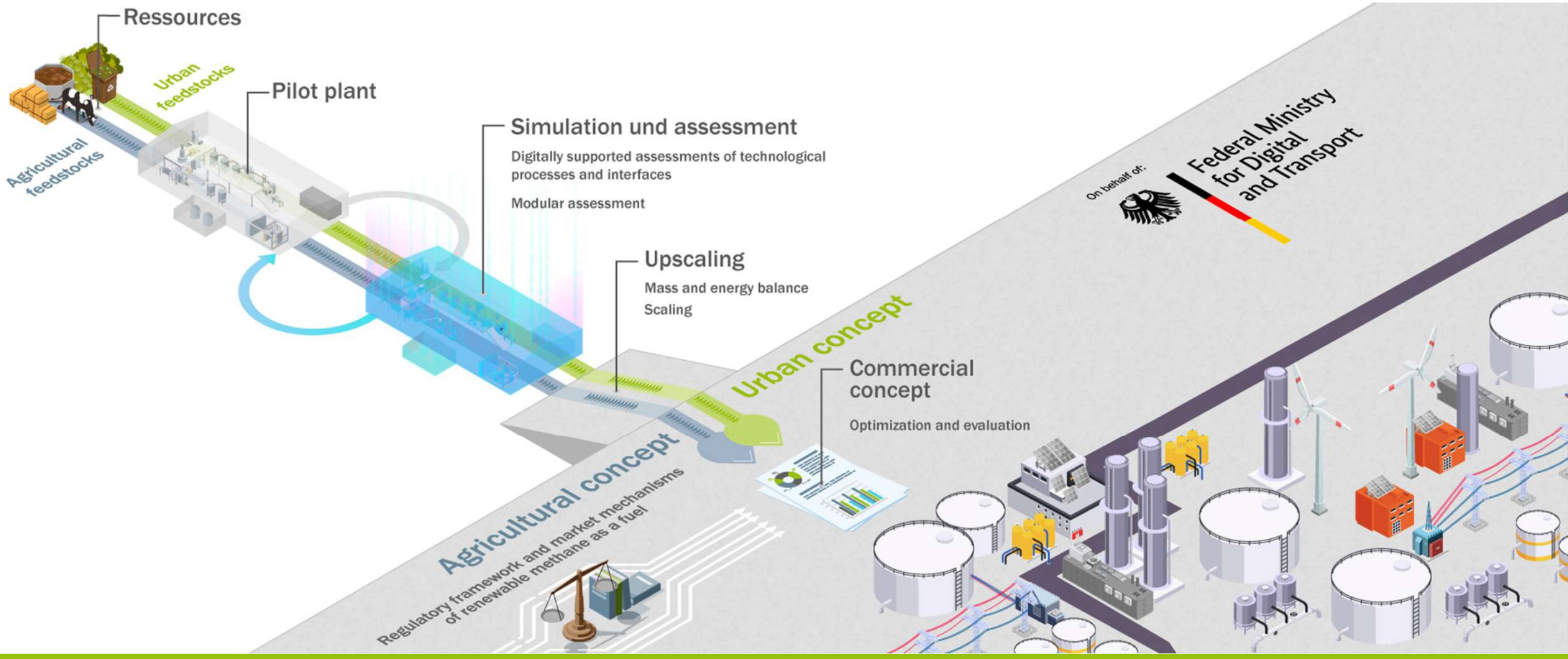
Fuel with low CO_2 emissions

(LNG substitute for shipping and aviation)

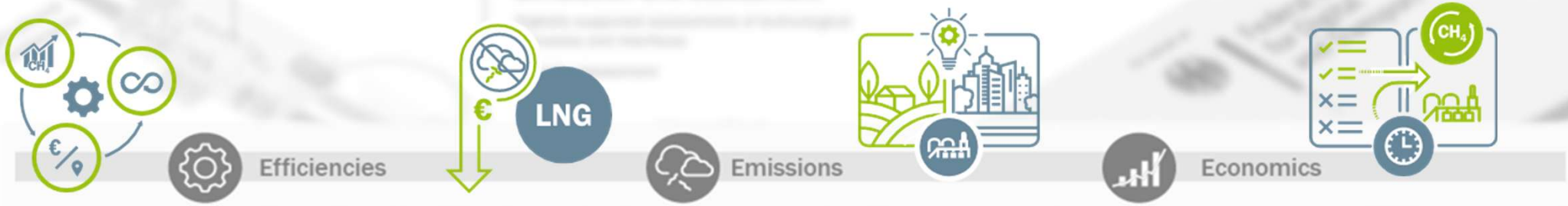
Precursor for chemical industry

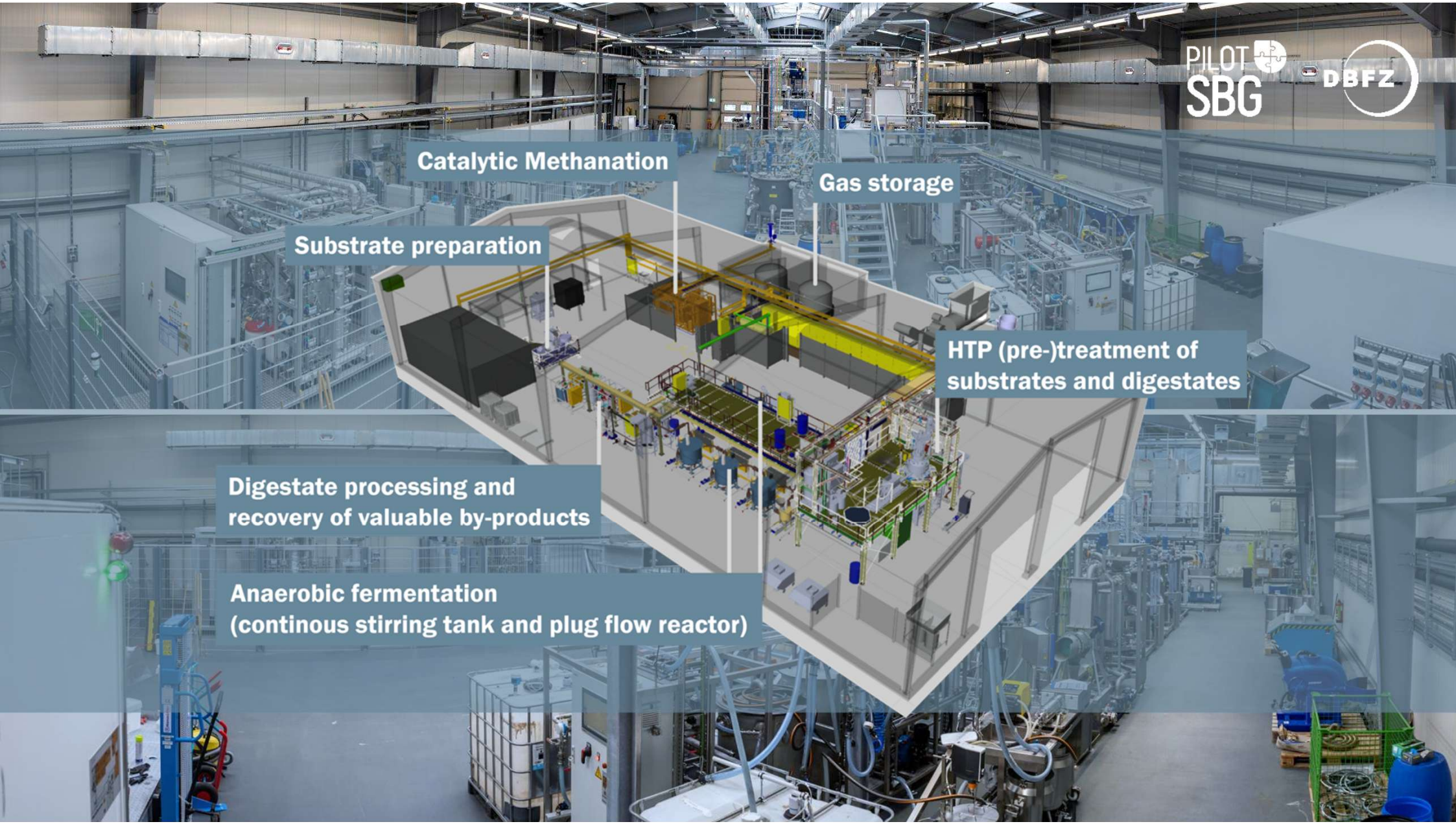
*https://www.linde-gas.at/de/images/1007_rechnen_sie_mit_wasserstoff_V111_tcm550-169419.pdf; m³ - standard cubic metre

Scope


Ressources
Urban feedstocks
Agricultural feedstocks
Pilot plant
Simulation und assessment
Digitally supported assessments of technological processes and interfaces
Modular assessment
Upscaling
Mass and energy balance
Scaling
Urban concept
Commercial concept
Optimization and evaluation
Agricultural concept
Regulatory framework and market mechanisms of renewable methane as a fuel
On behalf of:
Federal Ministry for Digital and Transport

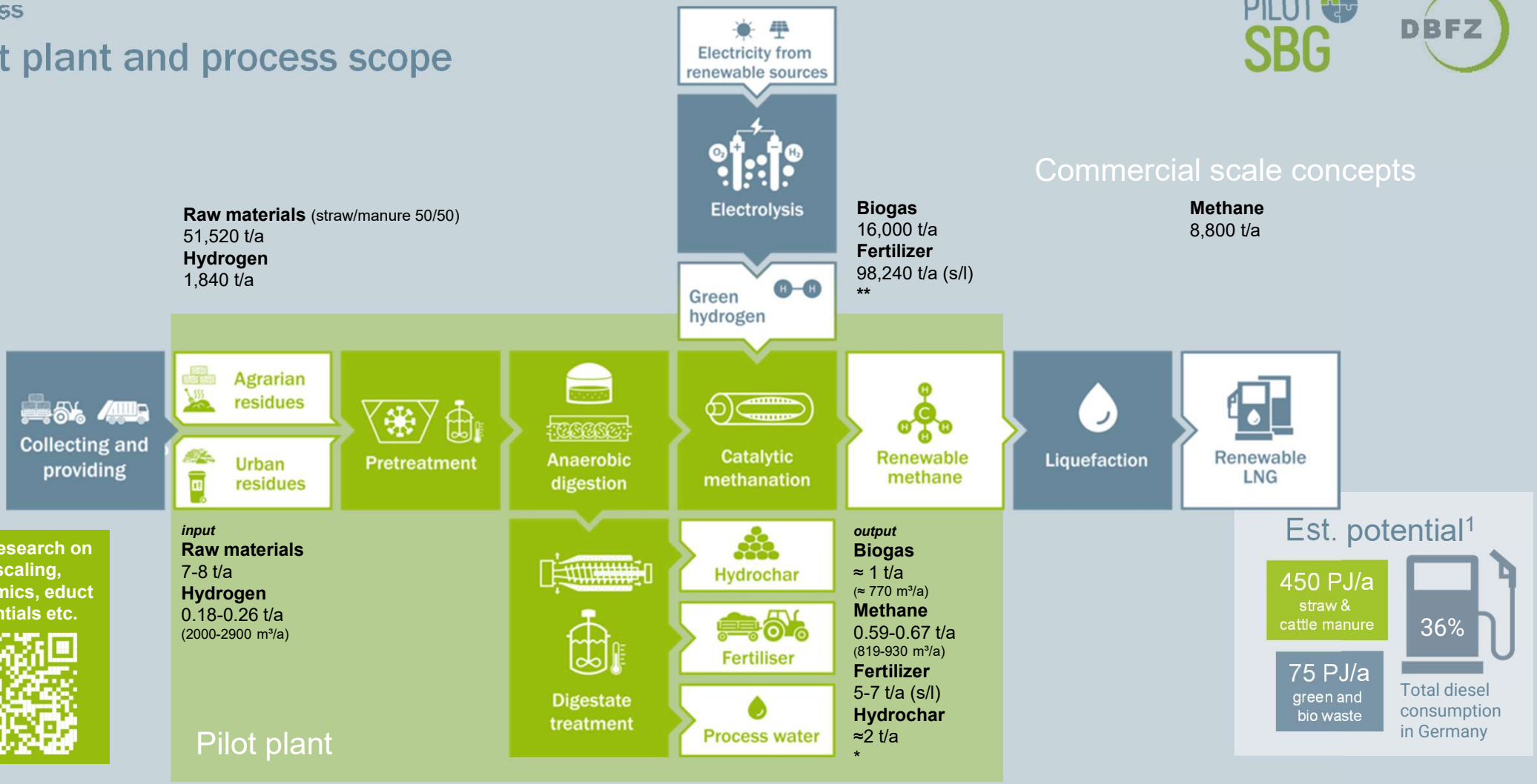
Scope




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)

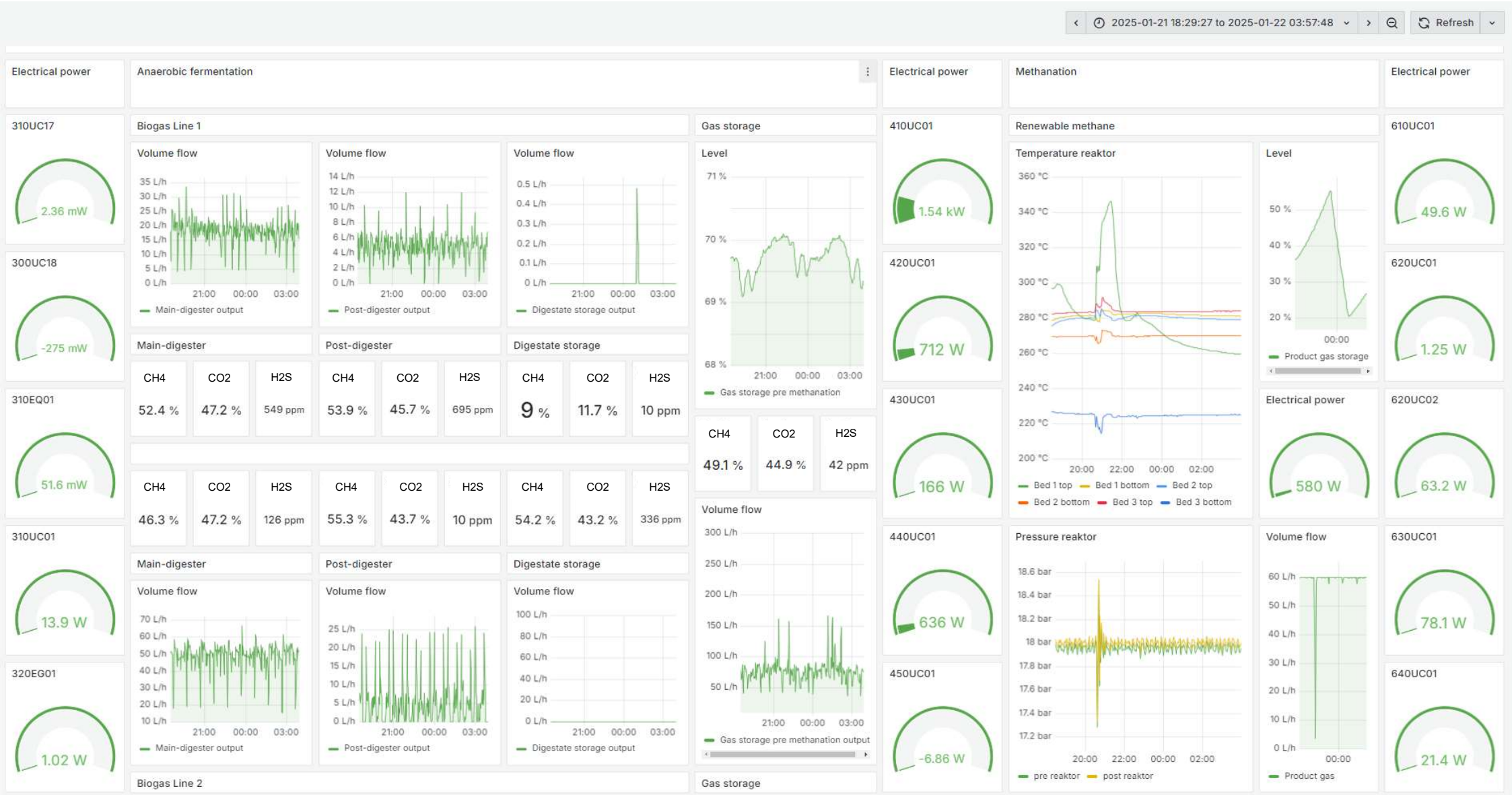
Process

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.

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


2025-01-21 18:29:27 to 2025-01-22 03:57:48
Refresh
Electrical power
Anaerobic fermentation
Electrical power
Methanation
Electrical power
310UC17
2.36 mW
Biogas Line 1
Volume flow
Main-digester output
Volume flow
Post-digester output
Volume flow
Digestate storage output
Gas storage
Level
Gas storage pre methanation
410UC01
1.54 kW
Renewable methane
Temperature reaktor
Bed 1 top
Bed 1 bottom
Bed 2 top
Bed 2 bottom
Bed 3 top
Bed 3 bottom
Level
Product gas storage
610UC01
49.6 W
300UC18
-275 mW
420UC01
712 W
620UC01
1.25 W
Main-digester
CH4 52.4 %
CO2 47.2 %
H2S 549 ppm
Post-digester
CH4 53.9 %
CO2 45.7 %
H2S 695 ppm
Digestate storage
CH4 9 %
CO2 11.7 %
H2S 10 ppm
CH4 49.1 %
CO2 44.9 %
H2S 42 ppm
310EQ01
51.6 mW
430UC01
166 W
Electrical power
580 W
620UC02
63.2 W
Main-digester
CH4 46.3 %
CO2 47.2 %
H2S 126 ppm
Post-digester
CH4 55.3 %
CO2 43.7 %
H2S 10 ppm
Digestate storage
CH4 54.2 %
CO2 43.2 %
H2S 336 ppm
310UC01
13.9 W
Main-digester output
Post-digester output
Digestate storage output
Volume flow
Gas storage pre methanation output
440UC01
636 W
Pressure reaktor
pre reaktor
post reaktor
Volume flow
Product gas
630UC01
78.1 W
320EG01
1.02 W
450UC01
-6.86 W
640UC01
21.4 W
Biogas Line 2
Gas storage

Input materials

KP0

Folie 8

KP0 Neues Foto von HT vorbereiteter Stroh/Gülle Wassermischung
Knötig, Philipp; 2025-11-10T13:53:32.840

KP0 0 Siehe Folie Kampagnen Vergleich mit und ohne HT
Knötig, Philipp; 2025-11-13T09:50:42.700

Anaerobic fermentation| Line 2

Anaerobic fermentation| Line 1

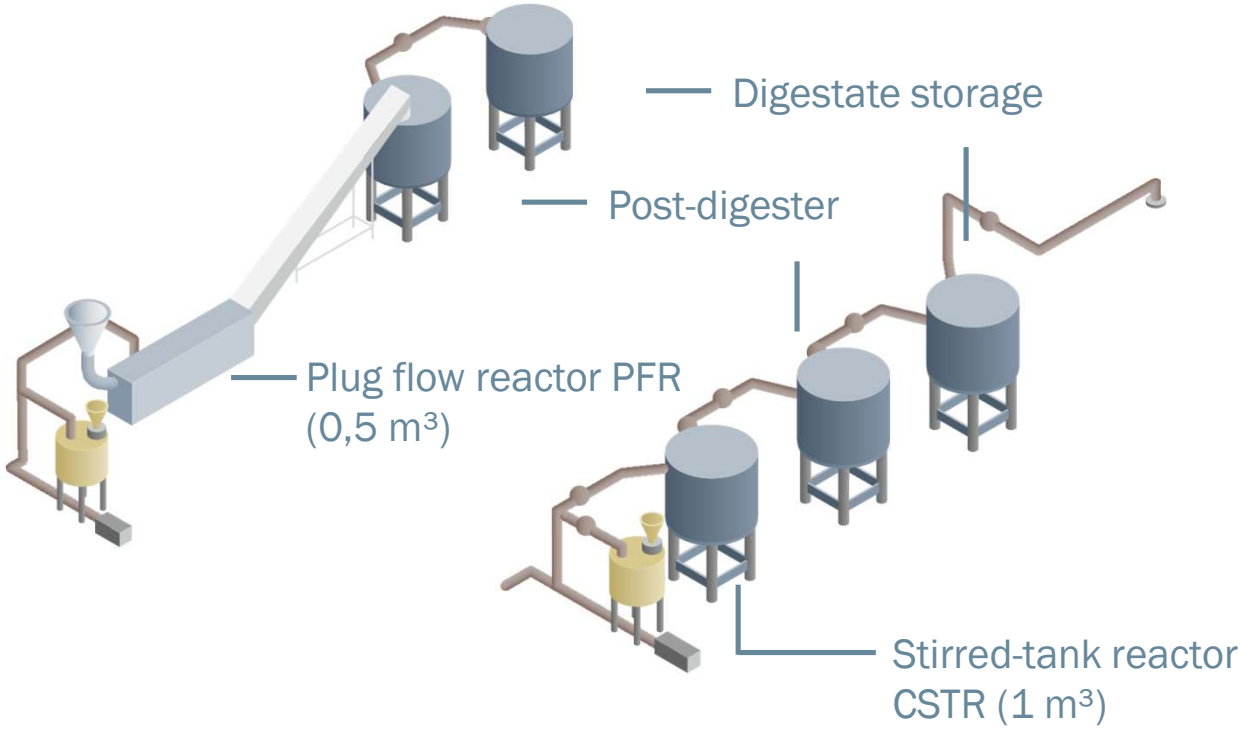
Anaerobic digestion

Comparison of two reactor lines

Inputs:
Wheat straw
Cow manure

Biomass

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



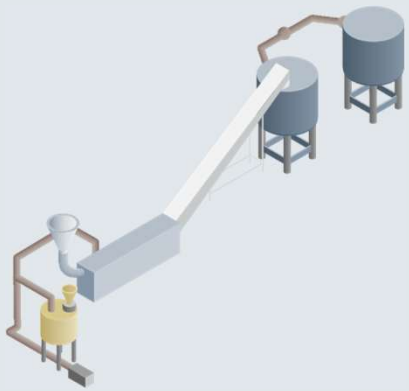
Output

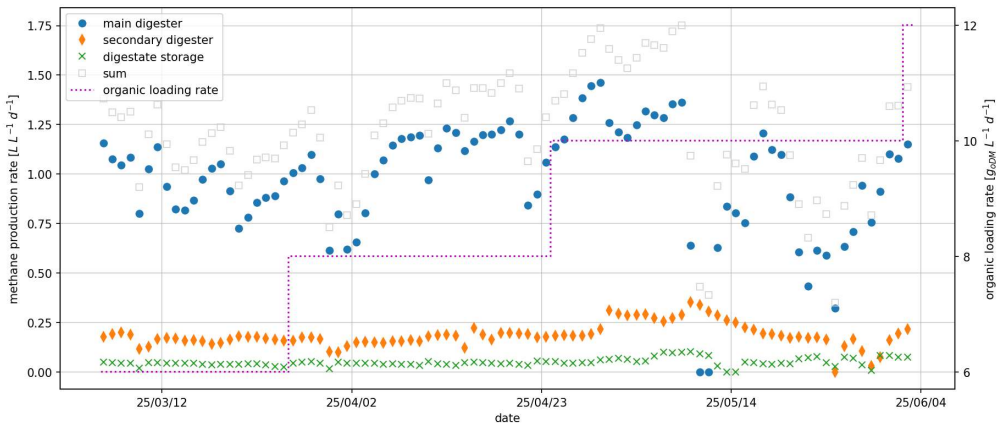
Biogas

Digestate

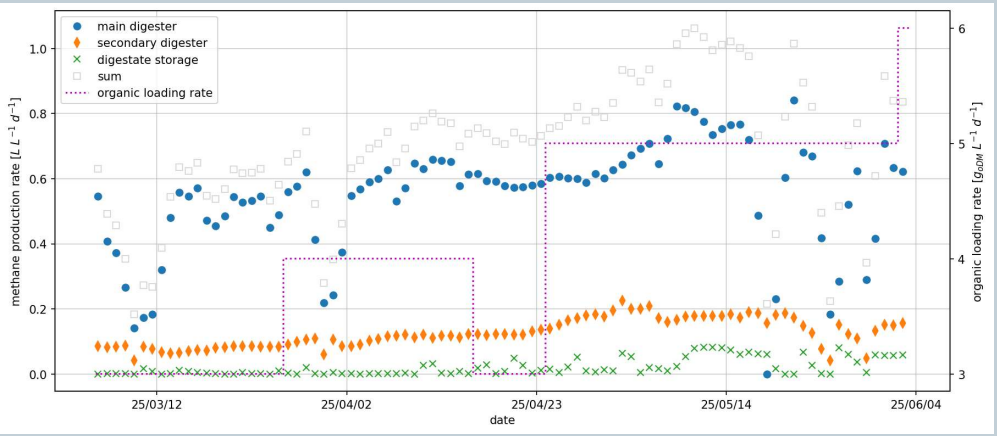
Operation of the anaerobic digestion

PFR

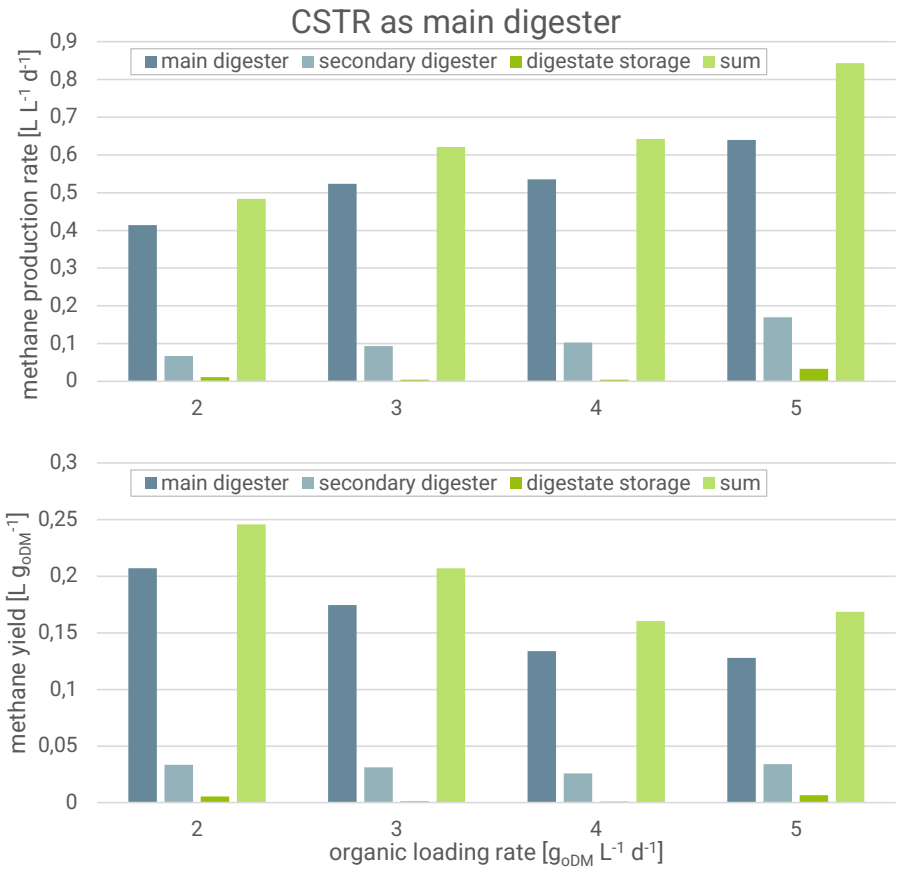


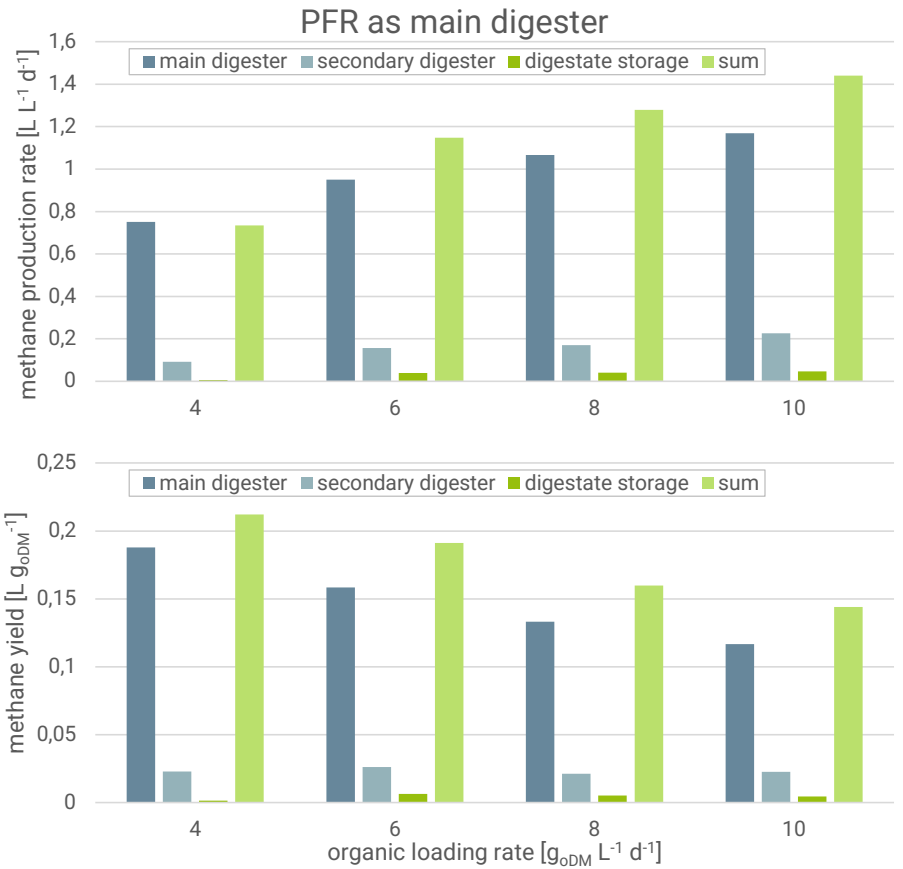


CSTR

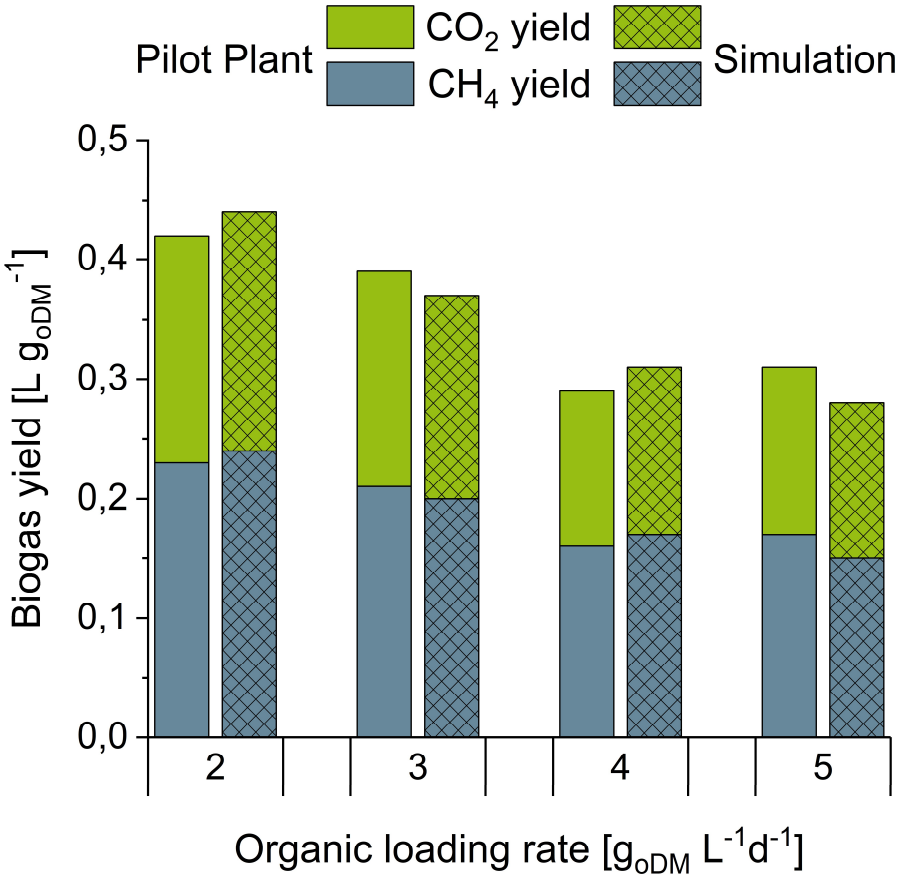


Anaerobic digestion





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

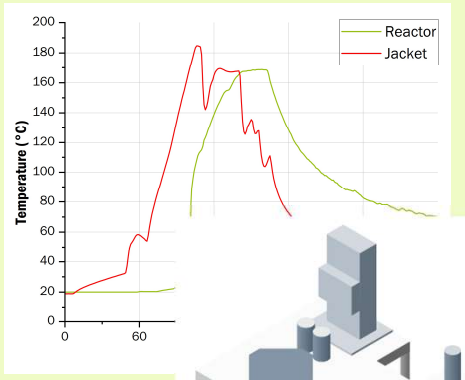
Hydrothermal (pre-)treatment

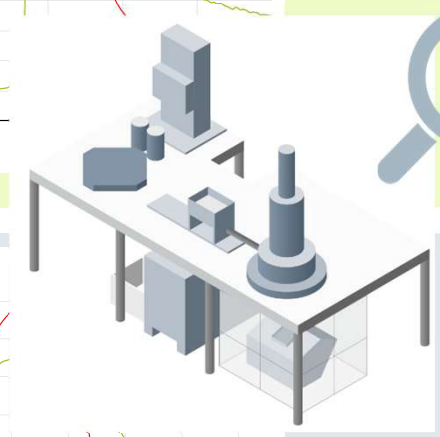
Operation of a pilot scale biorefinery

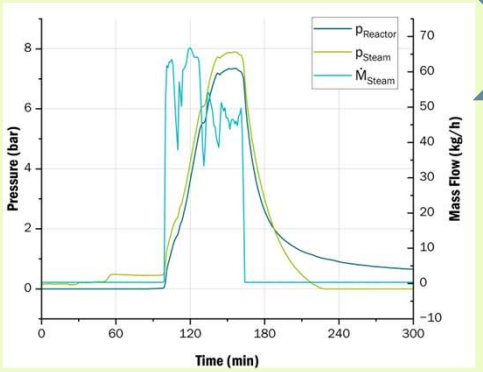
Hydrothermal pre-treatment and carbonization, commissioning

Input **Conversion** **Output**

Biomass

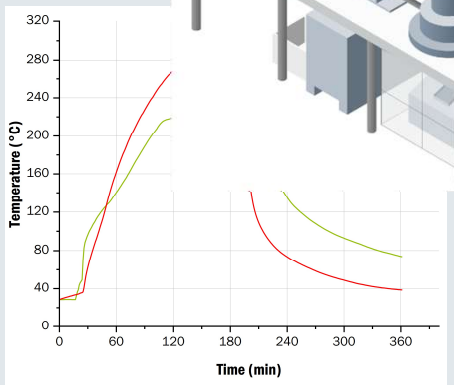


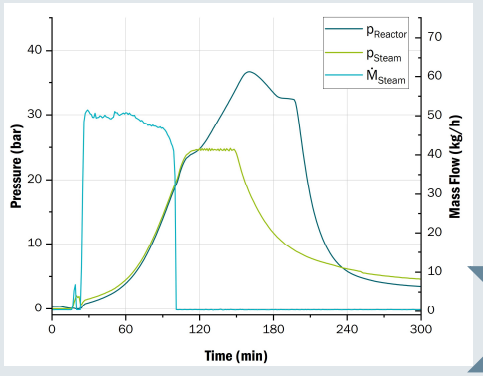




to digester

Digestate





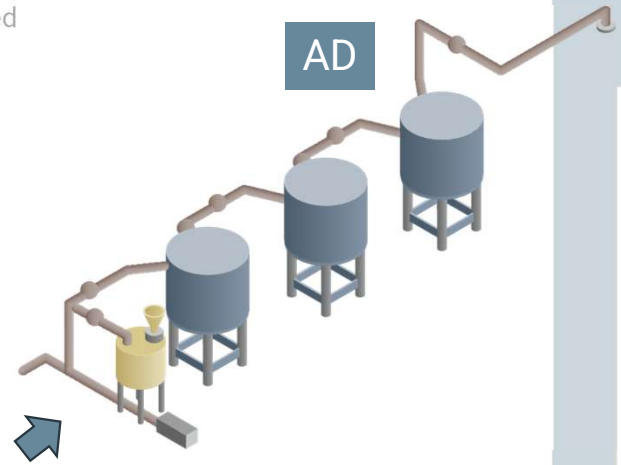
Hydrochar

Effects of hydrothermal pre-treatment

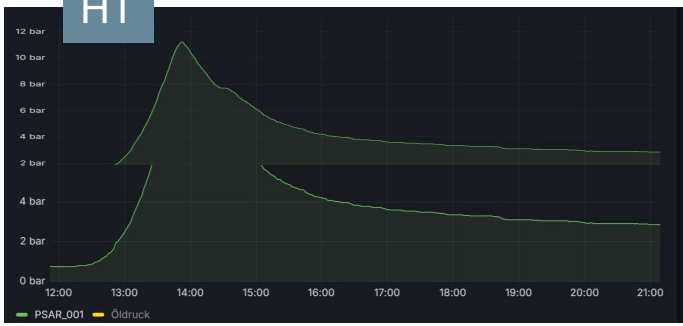
untreated

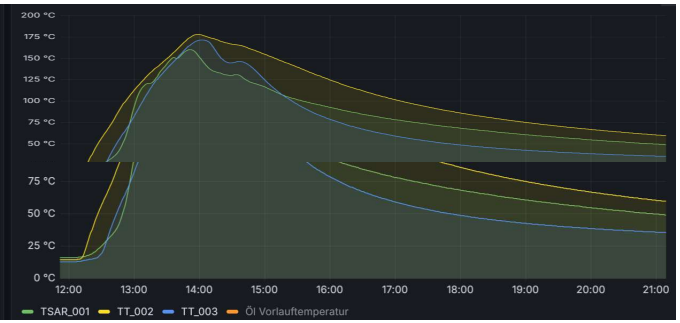
Pre-treated material

AD

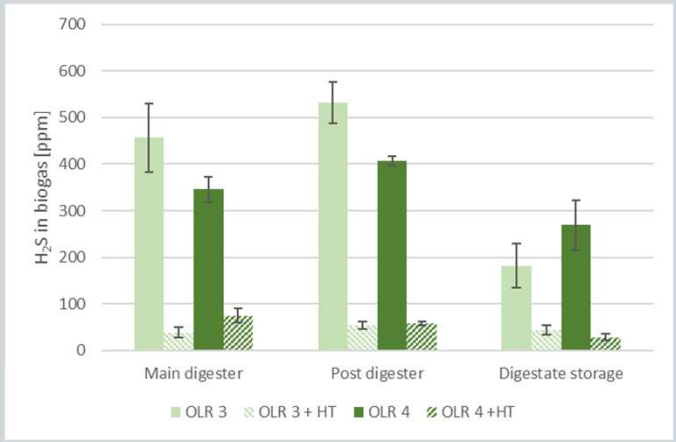


HT





Results*



Reduction of H_2S in biogas (advantage for catalyst based synthesis)

Better handling and storage

Energy input of the pumps reduced

Possible increased methane yield based on organic dry matter

Overall energetic evaluation in progress
(do the advantages outweigh the energetic input into HT?)

*The results presented should be viewed with caution, as they are based on live plant data that are still being collected and analyzed. More comprehensive data and interpretations will be provided in future publications

Methanation

Gas storage & flare

PILOT SBG

DBFZ

Methanation

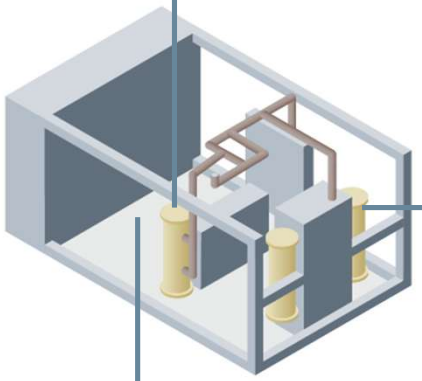
Catalytic methanation

Layout & design

Input

Biogas

Hydrogen



Stage 1:
Biogas cleaning

Stage 2:
Methanation

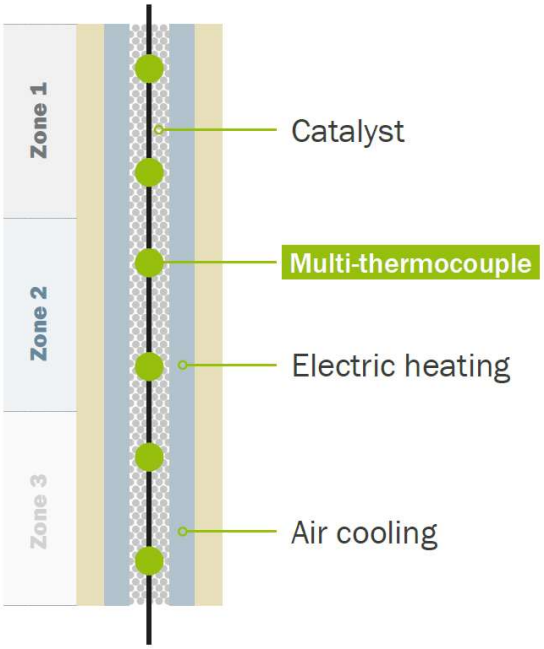
Stage 3:
CO_2 removal

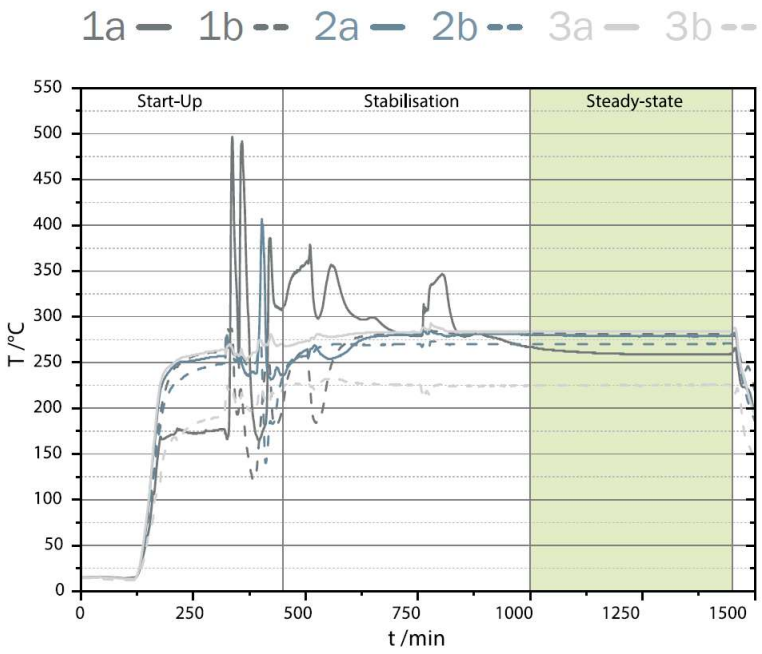
Output

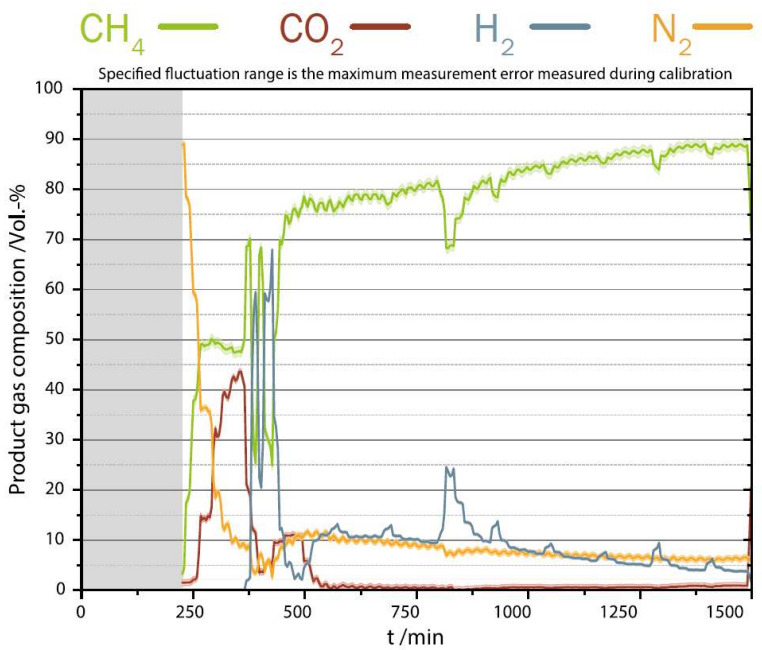
Renewable methane

Catalytic methanation

Start-up process



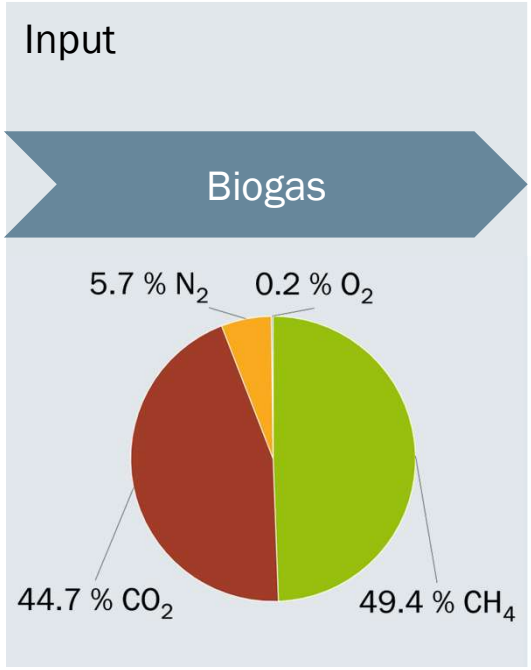


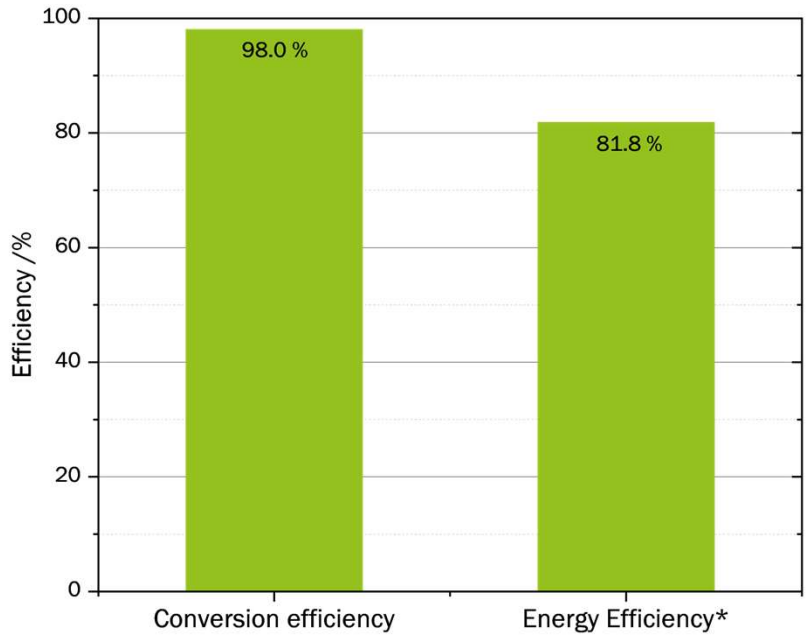


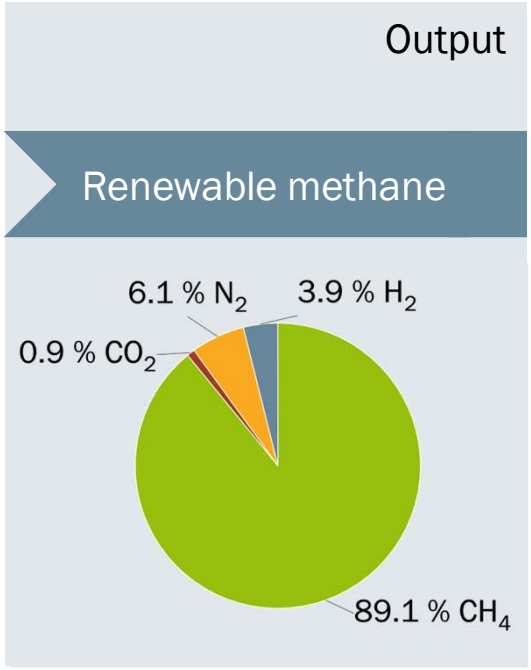
Ru2/Al_2O_3, T = 320 °C, p = 18 bar(g), H_2:CO_2 = 4, $\dot{V}_{biogas}$ = 60 L/h, GHSV = 449 h^{-1}

Catalytic methanation

Previous parameters







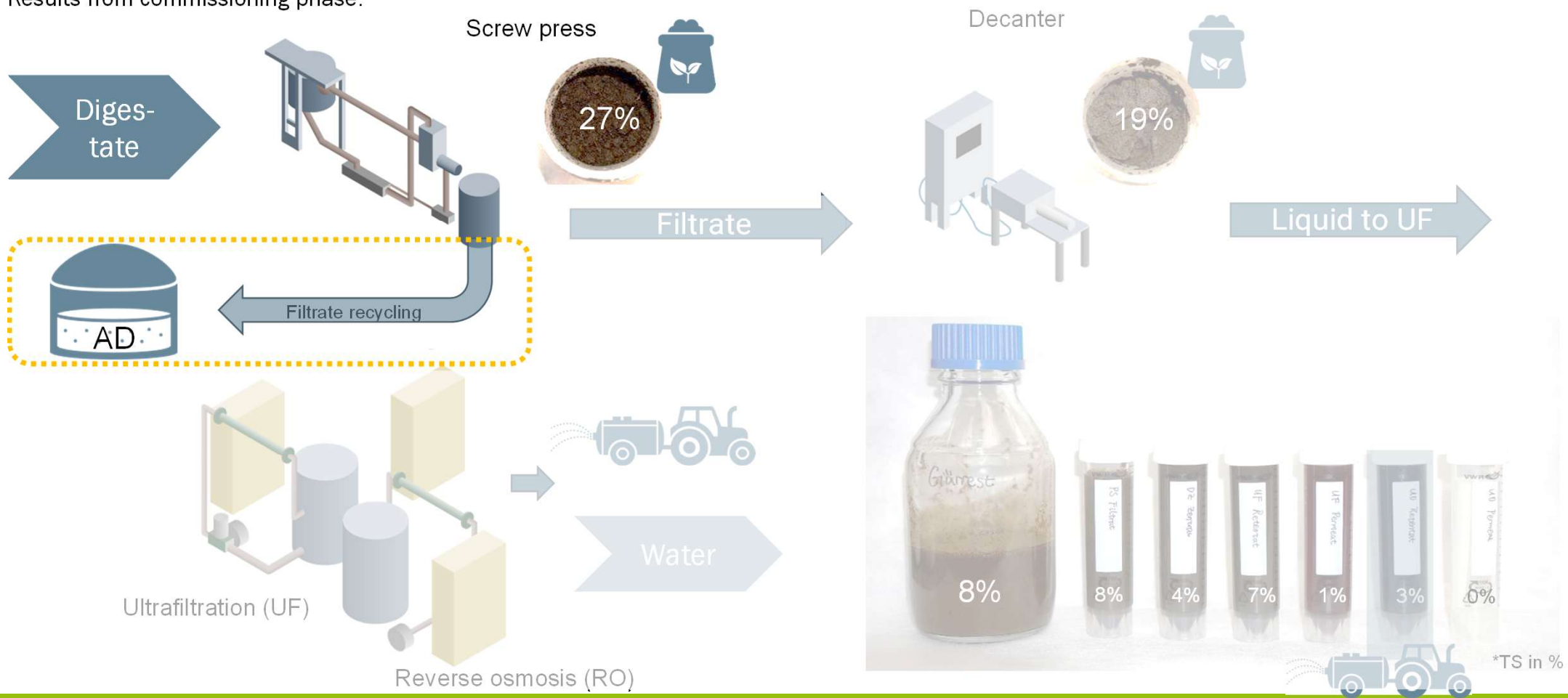
$Ru2/Al_2O_3$, T = 320 °C, p = 18 bar(g), $H_2:CO_2$ = 4, $\dot{V}_{biogas}$ = 60 L/h, GHSV = 449 h^{-1}

*Energy efficiency determined from calorific value of product and educt


PILOT SBG
DBFZ
Digestate treatment
Digestate treatment

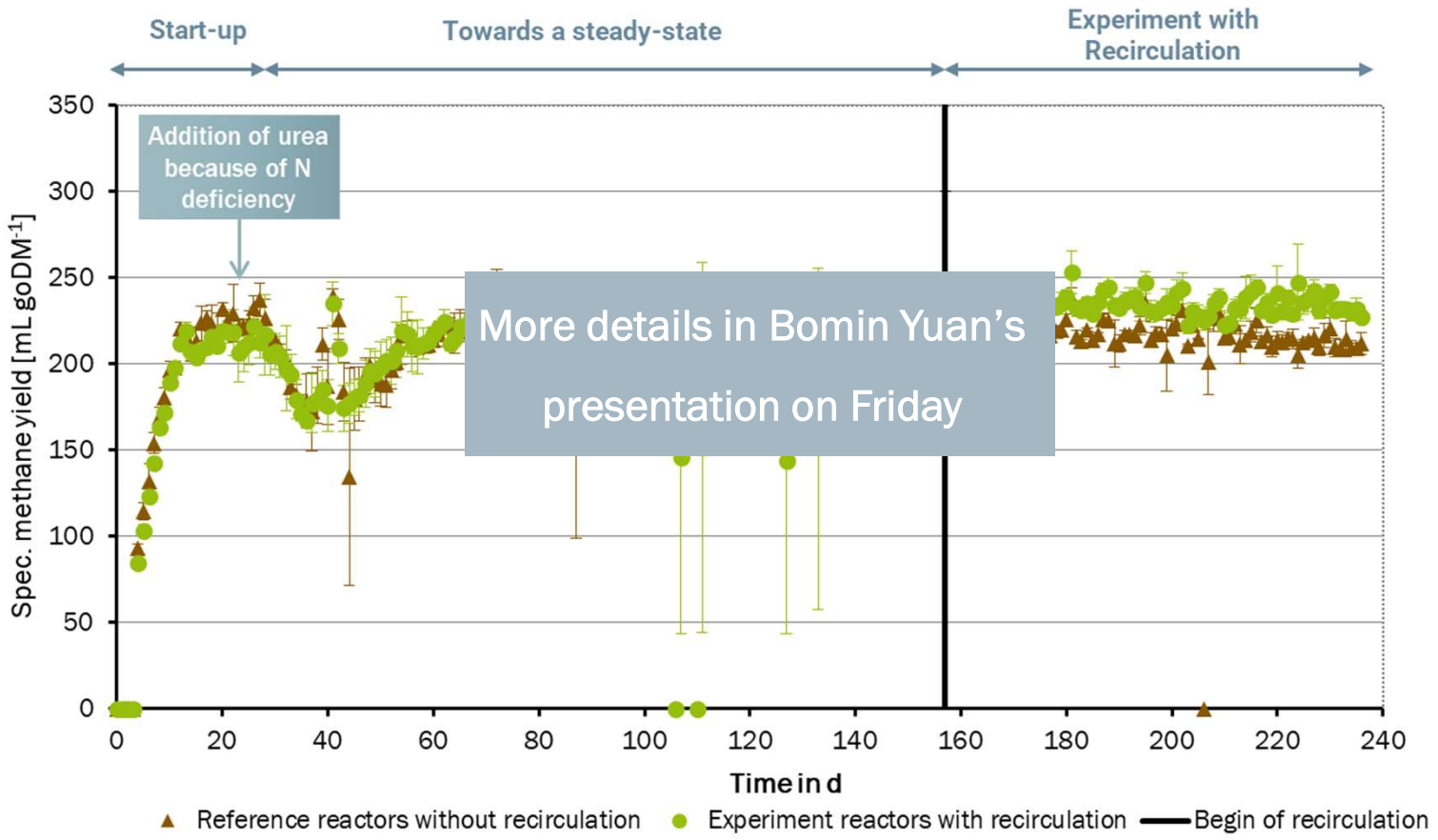
Digestate treatment

Results from commissioning phase:



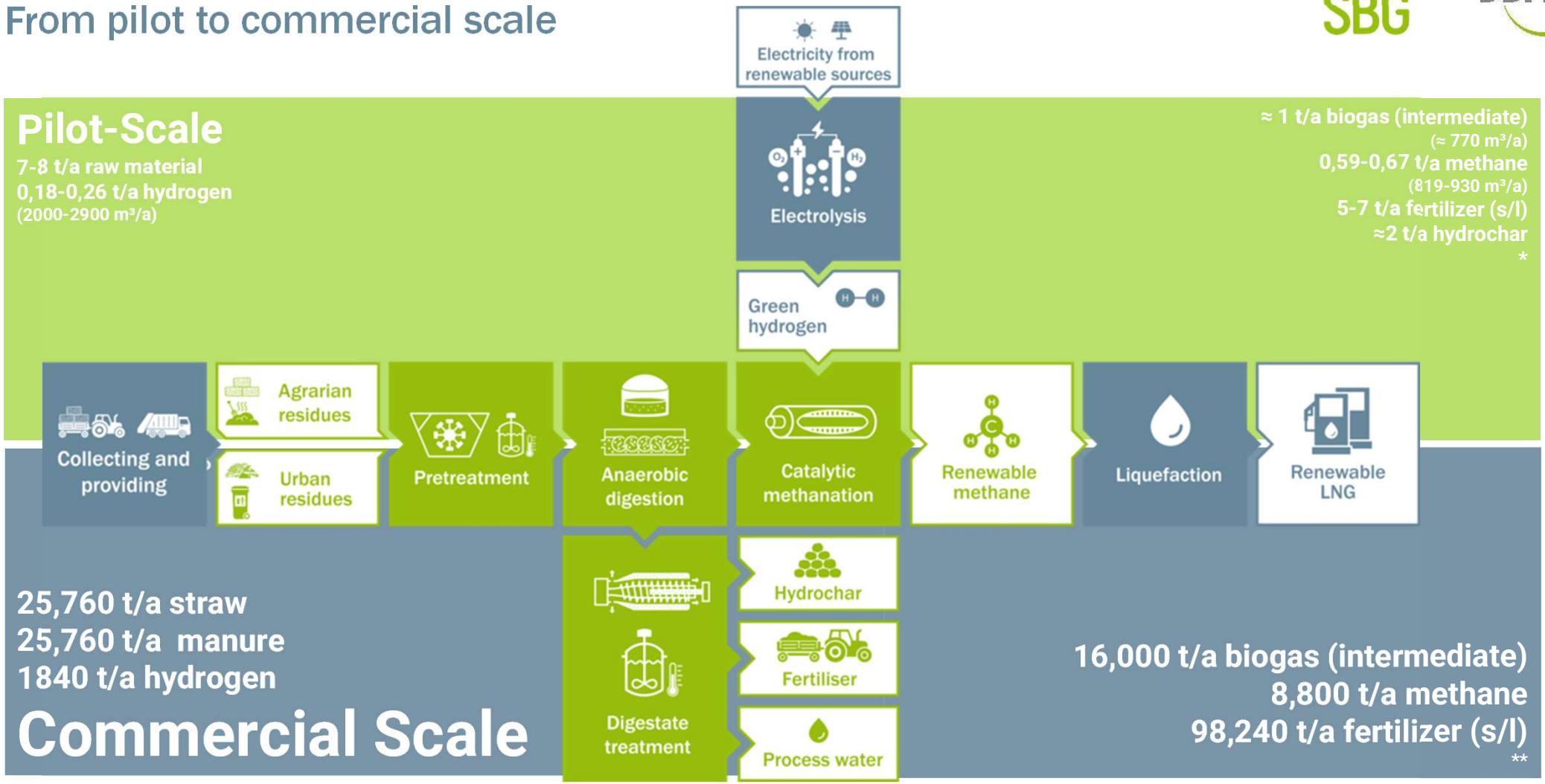
Lab experiment on liquid digestate recirculation

Quantitative evaluation of its effect on methane production



Scale Up

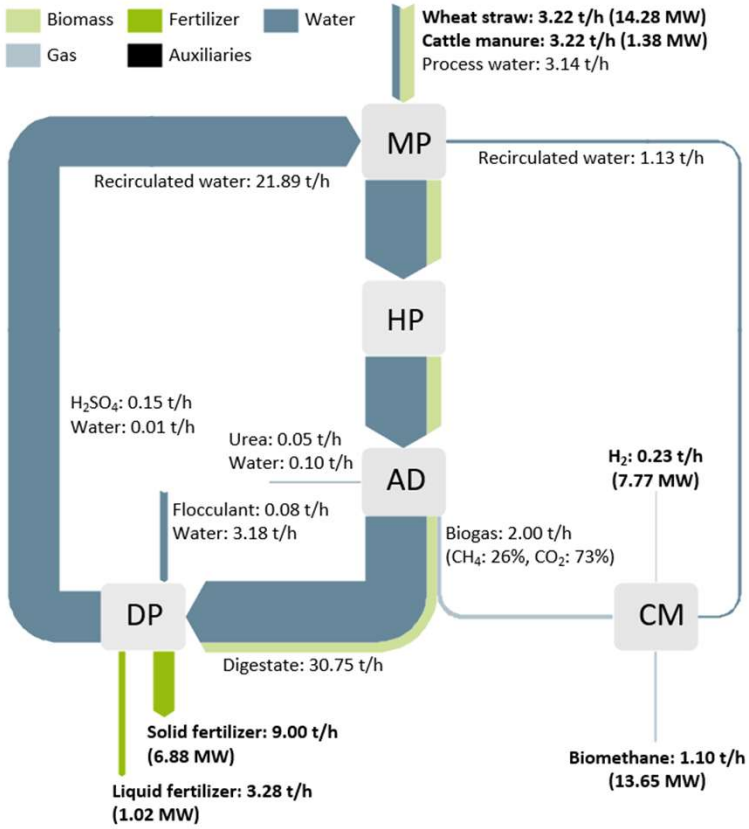
From pilot to commercial scale



m³ - standard cubic metre; * Rough approximation from the mass balance of the engineering phase of the pilot plant. 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.

Scale Up

Mass and energy balance | commercial scale



Results

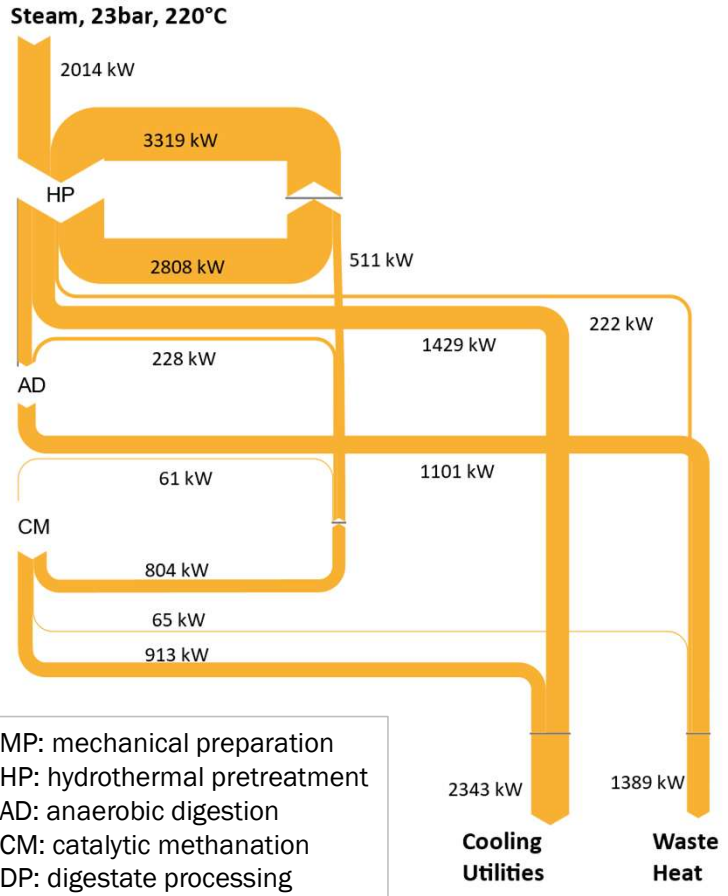
BUEM = 18,3%; 45,4%
(N/P/K fertilizer; considering all anorganic content)

BUEE = 16,9%
(only fuel)

ECE = 33,4; 52,8%
(only fuel; fuel + fertilizer)

BUEE, BUEM = Energetic and Material based biomass utilization efficiency

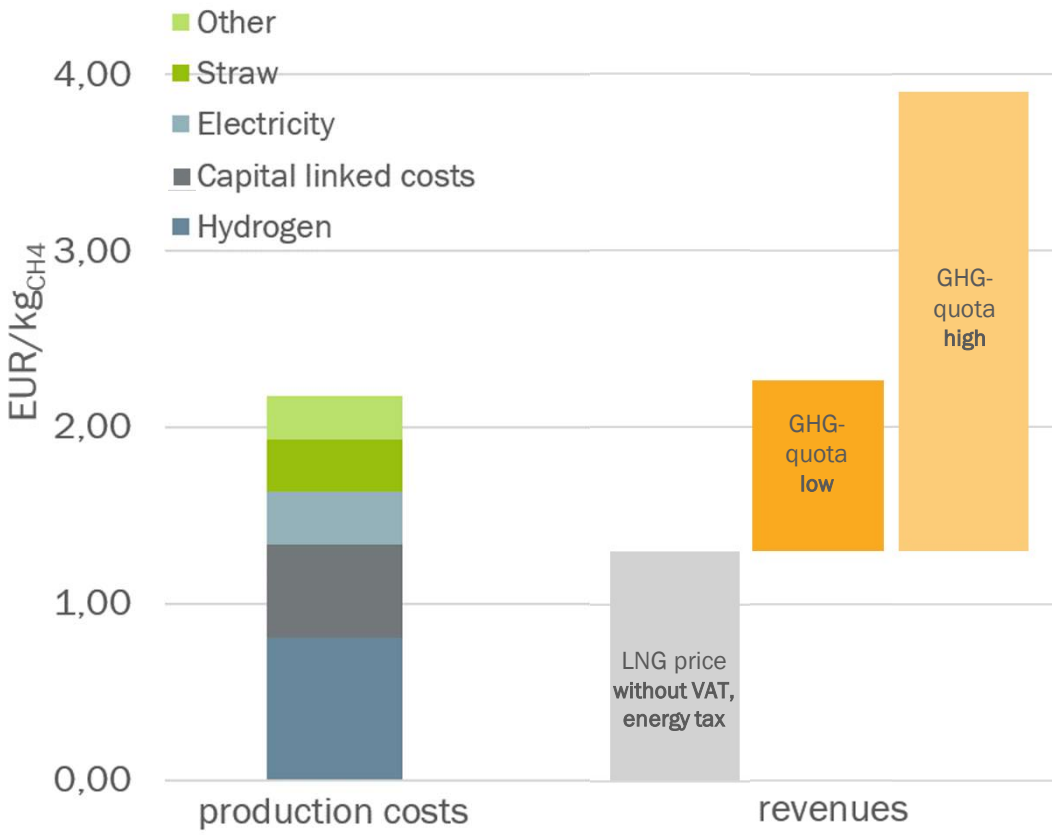
ECE = Energy conversion efficiency



MP: mechanical preparation
HP: hydrothermal pretreatment
AD: anaerobic digestion
CM: catalytic methanation
DP: digestate processing

Source: Röder, L. S.; Nitzsche, R.; Etzold, H.; Oehmichen, K. (2024). Beispielkonzept zur Bereitstellung von erneuerbarem LNG aus biogenen Rest- und Abfallstoffen und erneuerbarem Wasserstoff im kommerziellen Maßstab: Fokusheft im Projekt Pilot-SBG. Leipzig: DBFZ. 31 S. ISBN: 978-3-949807-06-0. DOI: 10.48480/jsct-z879

Market | Costs and revenues

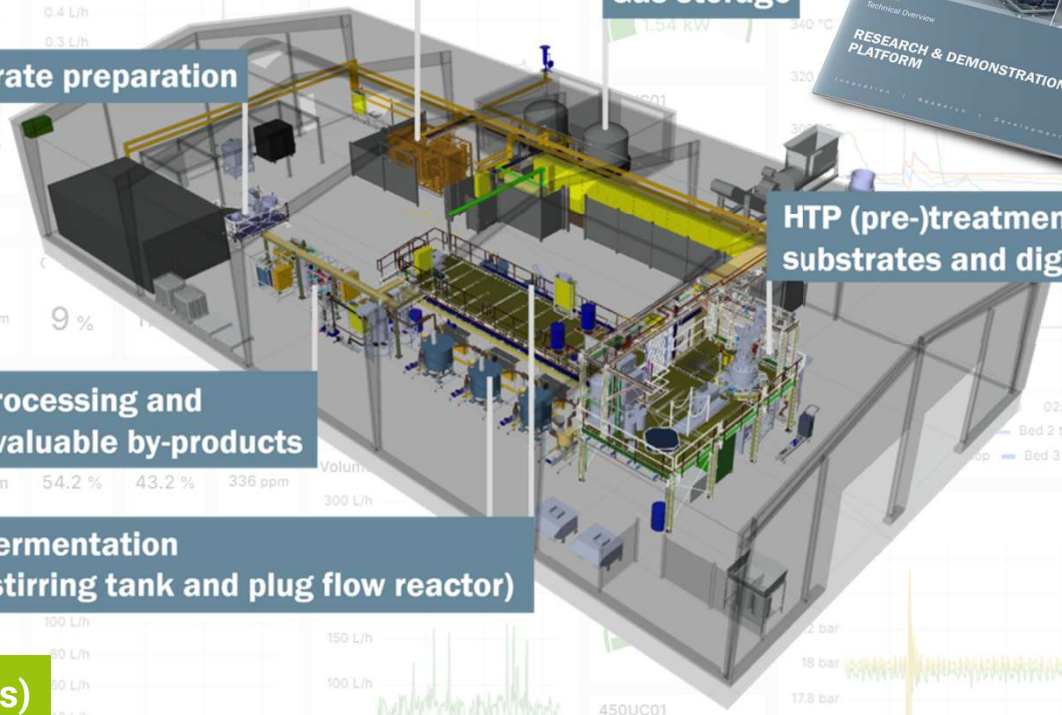


- GHG quota revenues have a high (positive) impact on the business case
- Currently highly volatile and therefore difficult to assume
- double counting for advanced biofuel due to waste and residues as input
- GHG-quota low → 300 EUR/t_{CO2}
- GHG-quota high → 800 EUR/t_{CO2}

Source: Röder, L. S.; Nitzsche, R.; Etzold, H.; Oehmichen, K. (2024). Beispielkonzept zur Bereitstellung von erneuerbarem LNG aus biogenen Rest- und Abfallstoffen und erneuerbarem Wasserstoff im kommerziellen Maßstab: Fokusheft im Projekt Pilot-SBG. Leipzig: DBFZ. 31 S. ISBN: 978-3-949807-06-0. DOI: 10.48480/jsct-z879

Technology and fields of research

- Fully automated plant
- Intensive process monitoring
- Plug and play
- Waste/Biomass To X (W/BtX)
- Flexibility
- Biogenic CO_2
- RFNBO
- Advanced feedstock (wastes and residues)
- Modularity



Technical overview

Visit our website

Do you want to add your technology and test it in relevant environment?

PILOT SBG DBFZ

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 1m³ **CSTR**
1x 0.5m³ **PFR**

Platform chemicals through hydrothermal treatment or char for sequestration.

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

E-fuels from captured CO_2, biogas, syngas; catalyst testing and more …

Adsorption unit
Fixed bed methanation reactor
Product gas cleaning

Screw press
Chamber filter press
Ultra-/Nanofiltration
Reverse osmosis

Technical scale research biogas plant

Fully automated,
2x 180 m³ CSTR, **50 m³ PFR**,
postdigester + digestate storage,
mechanical pretreatment …

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

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