Renewable methane from biomass and green hydrogen

Pilot plant and transfer to commercial scale

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On behalf of: Federal Ministry for Digital and Transport

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Background & project overview

Pilot-SBG

Federal Ministry
for Digital
and Transport

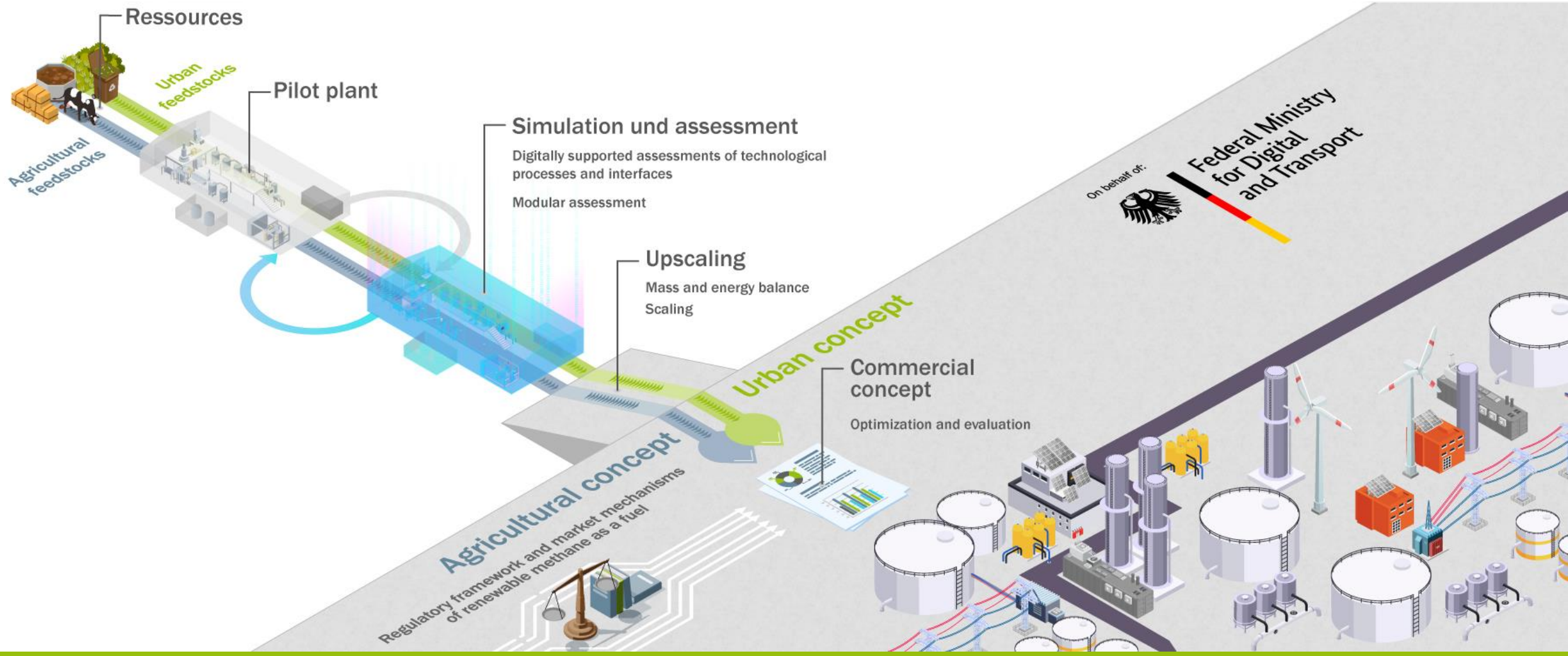
Methane as a fuel

Why **methane**?

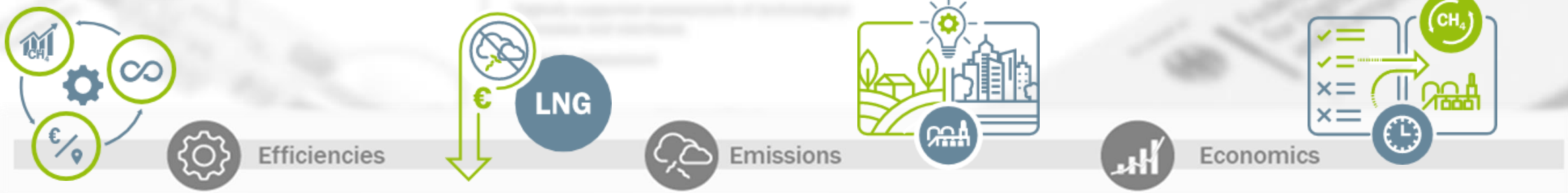
- Energy carrier (9.97 kWh/m³)
  - Hydrogen (3 kWh/m³)*
- High temperature generation
- Fuel with low CO_2 emissions
- Precursor for chemical industry

*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

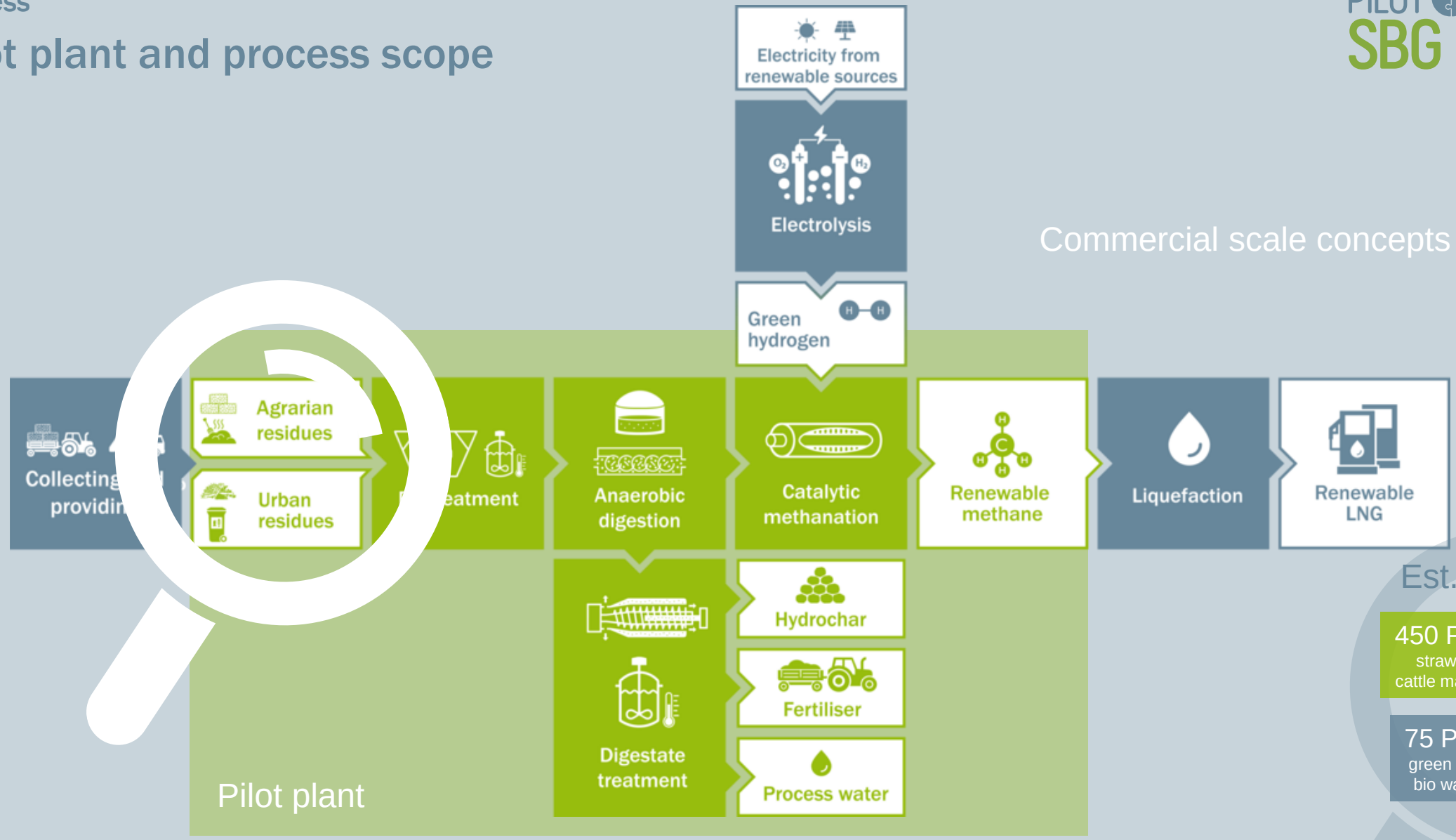
Scope



Process

Interconnection of innovative and state-of-the-art technologies

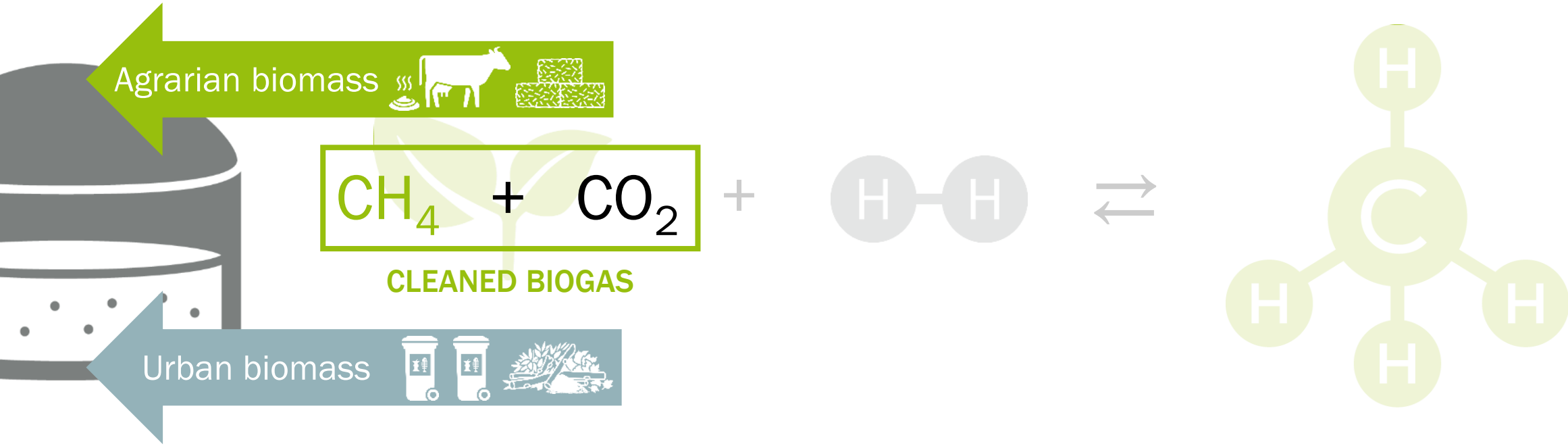
Pilot plant and process scope



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

Bioresources and hydrogen to methane

How does it work?



Which **Bioresources**?

Bioresources and hydrogen to methane

How does it work?

renewable **methane**

Bio | E-fuel

$$CH_4 + CO_2 + 4\,H_2 \rightleftarrows CH_4 + CH_4 + 2\,H_2O$$

CLEANED BIOGAS

from biogas

from reaction

Nutrients and Hydrochar

Pilot plant

Commissioning, preliminary results & challenges

Federal Ministry
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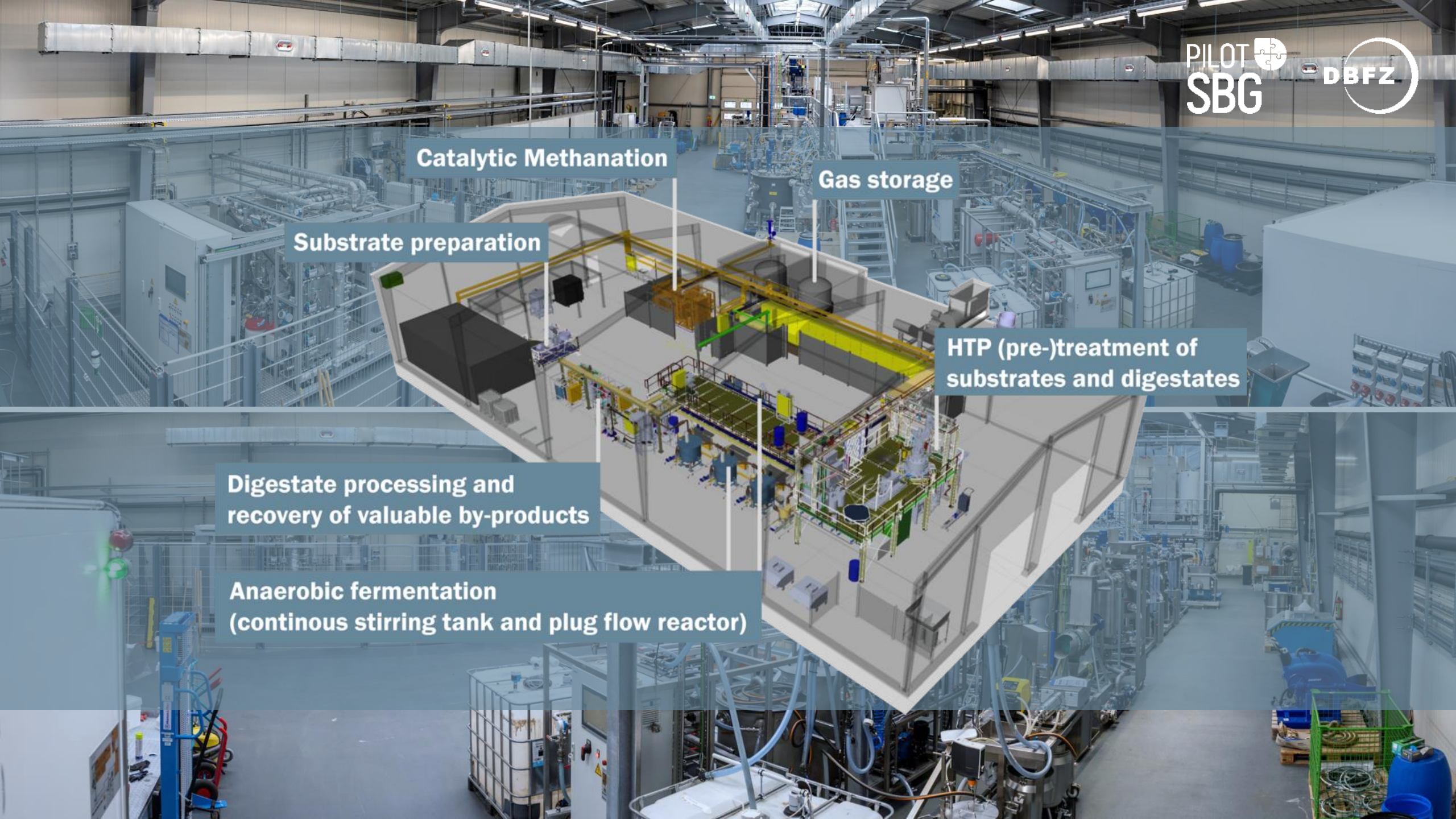

PILOT SBG
DBFZ
Catalytic Methanation
Gas storage
Substrate preparation
HTP (pre-)treatment of substrates and digestates
Digestate processing and recovery of valuable by-products
Anaerobic fermentation (continous stirring tank and plug flow reactor)

Anaerobic fermentation | Line 2

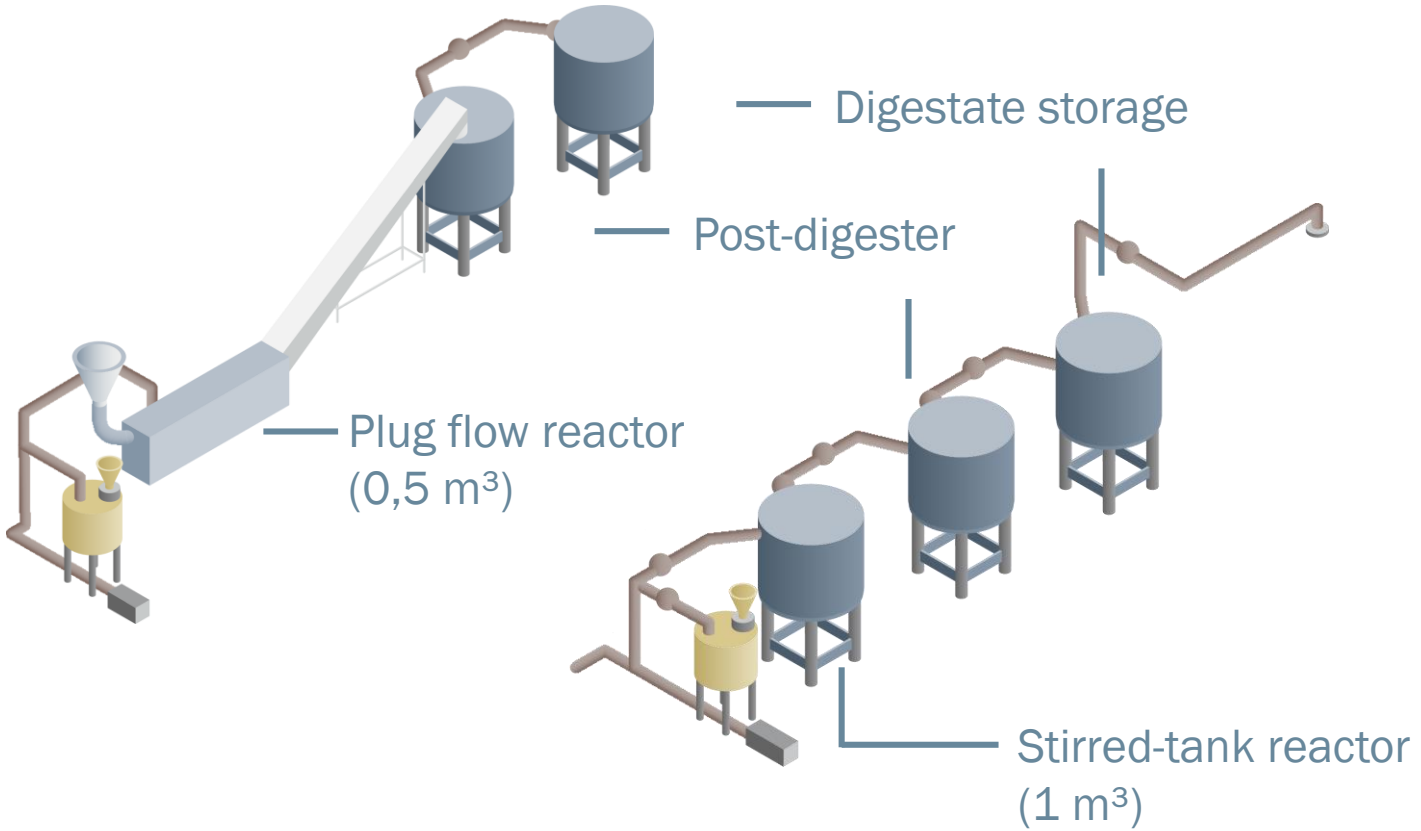
Anaerobic fermentation | Line 1

Anaerobic digestion

Comparison of two reactor lines

Input

Biomass



Output

Biogas

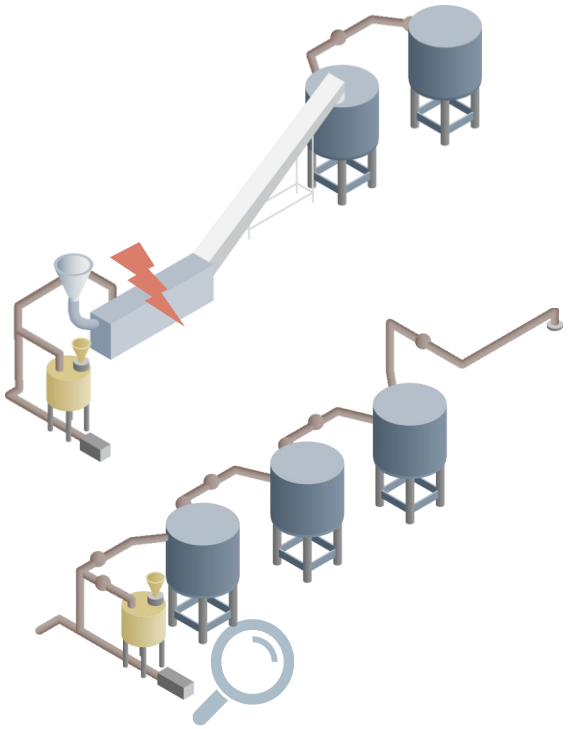
Digestate

Anaerobic digestion

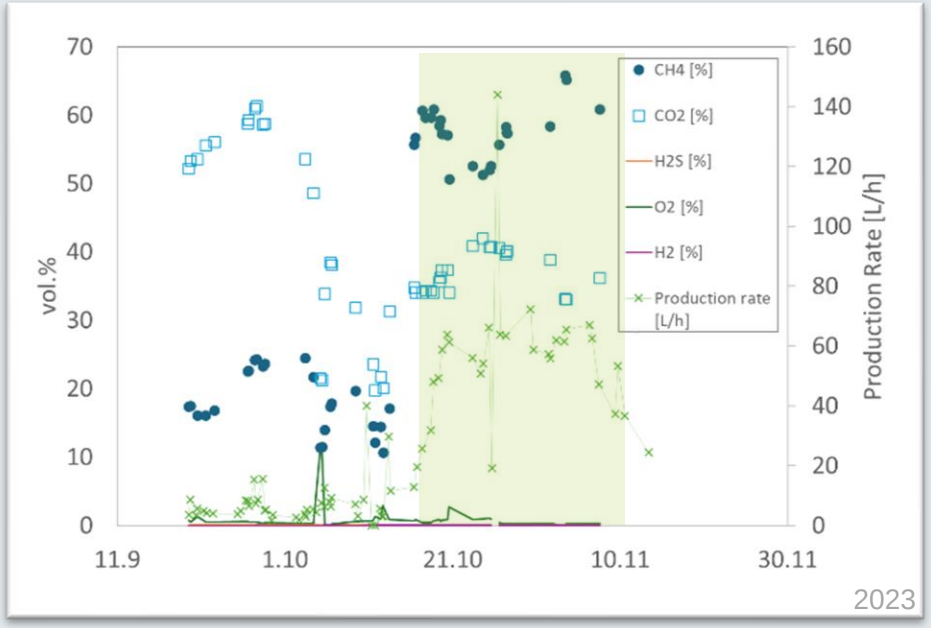
Results from commissioning phase:

Input

Biomass



Output



Biogas

Digestate

Methanation

Gas storage & flare

PILOT SBG

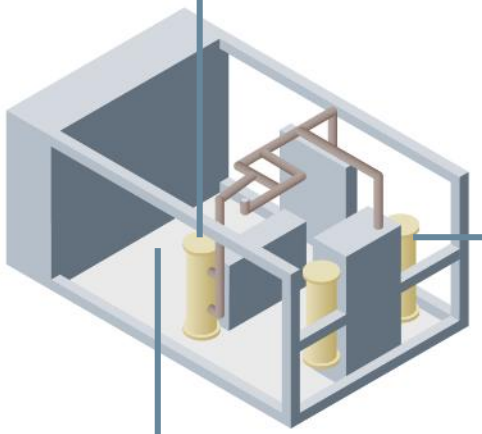
DBFZ

Methanation

Catalytic methanation

Input

Biogas



Stage 1:
Biogas cleaning

Stage 2:
Methanation

Stage 3:
CO_2 removal

Output

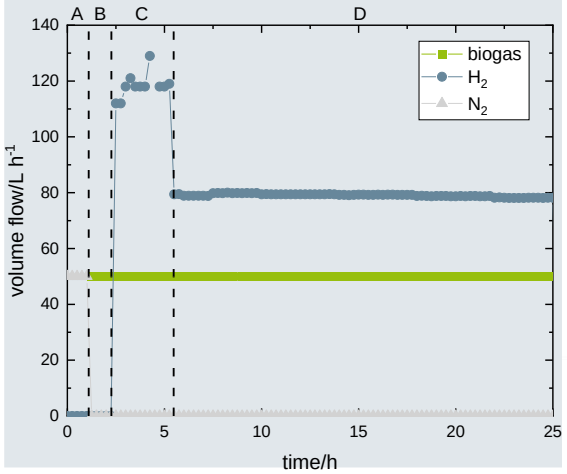
Renewable methane

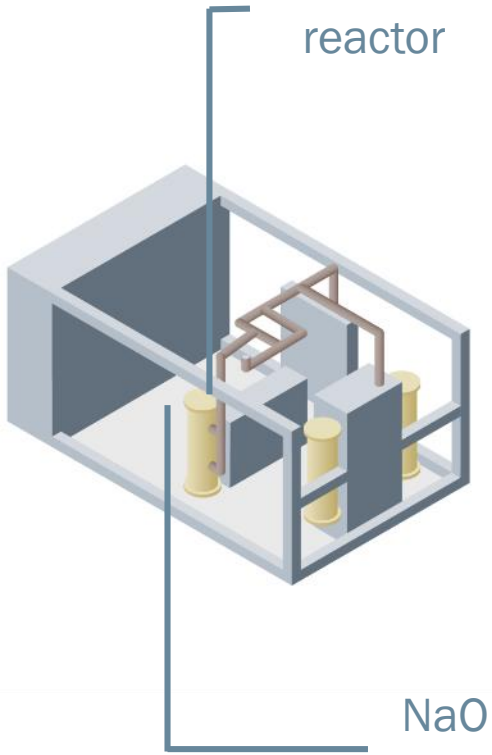
Catalytic methanation

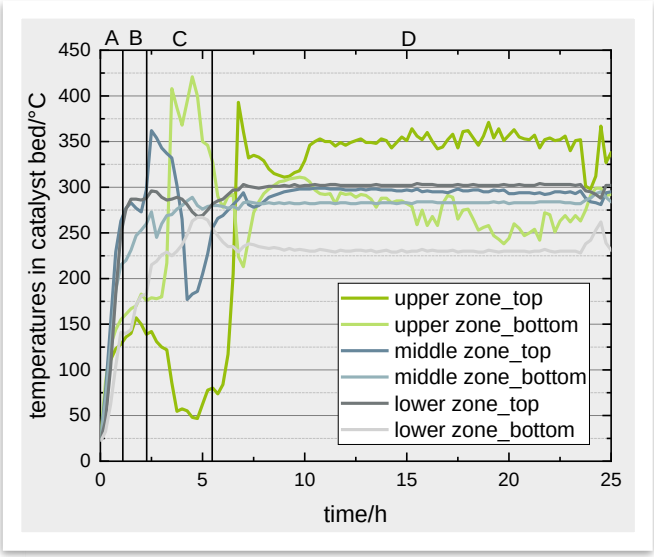
Results from commissioning phase:

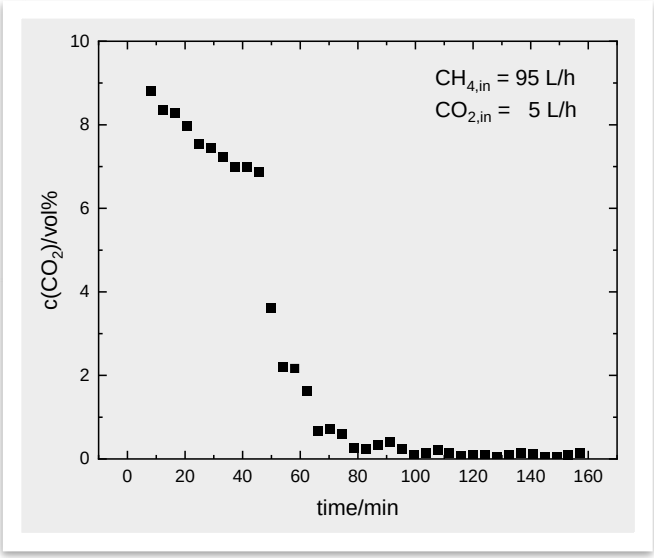
Input

Biogas



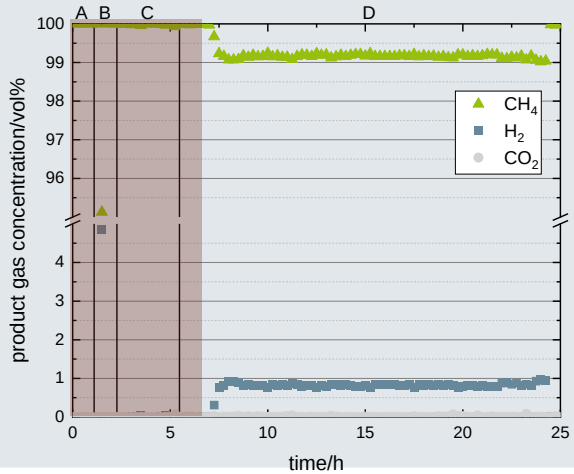






Output

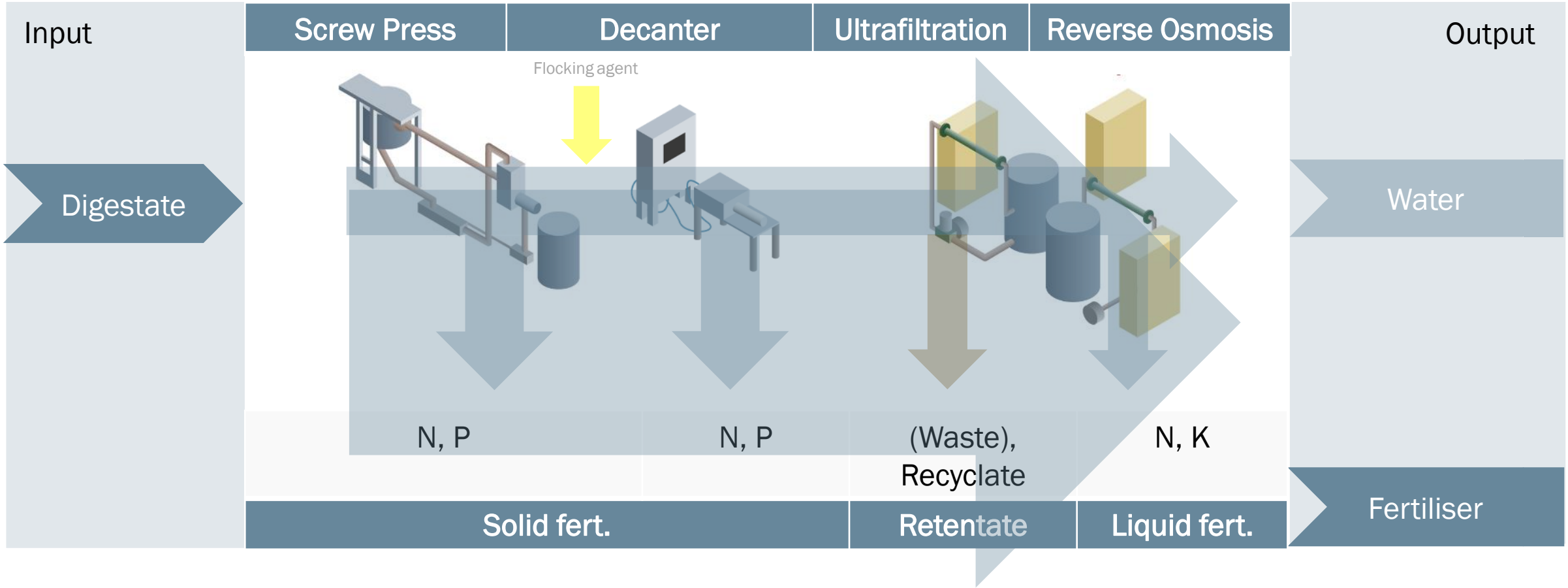
Renewable methane




PILOT
SBG
DBFZ
Digestate treatment


Digestate treatment

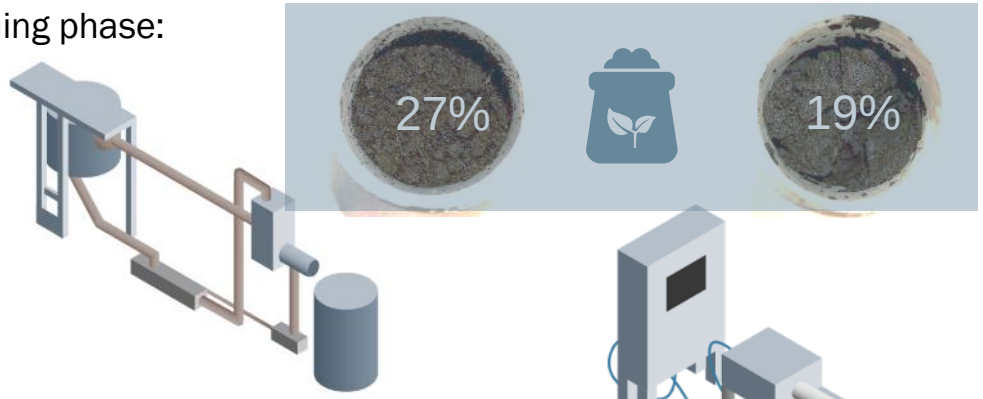
Digestate treatment

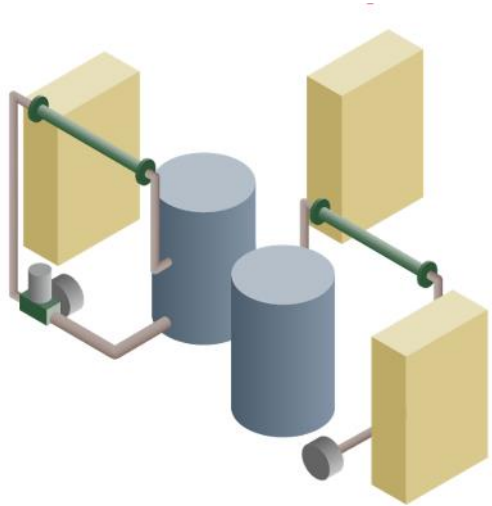


Source: Rückgewinnung von Nährstoffen und Wasser aus anaerob vergorenem Stroh und Gülle; 8. Fachtagung "Stroh, Gras = Biogas" Straubing digital; 7. März 2024; Bomin Yuan

Digestate treatment

Results from commissioning phase:





Input

Digestate

*TS in %

Output

Water

Fertiliser

Hydrothermal (pre-)treatment

Cold storage cell

Hydrothermal pre-treatment and upgrading

0.5 m^3 reactor (net)

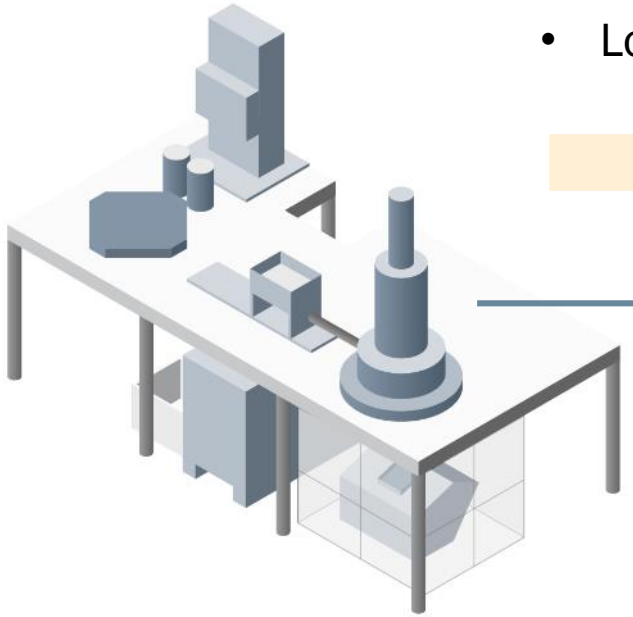
Input

Biomass

Digestate

Biomass pre-treatment:

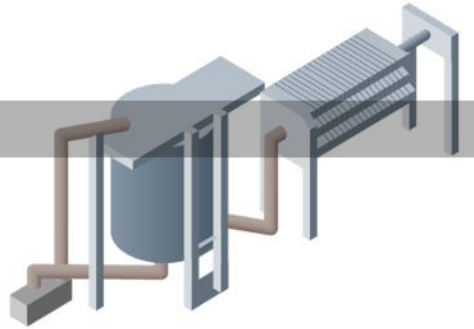
- For difficult-to-access biomasses
- Lower T and residence time



HTP reactor
(up to 240 °C and 40 bar)

Digestate treatment:

- Higher T and residence time



Chamber filter press

Output

to digester

Hydrochar

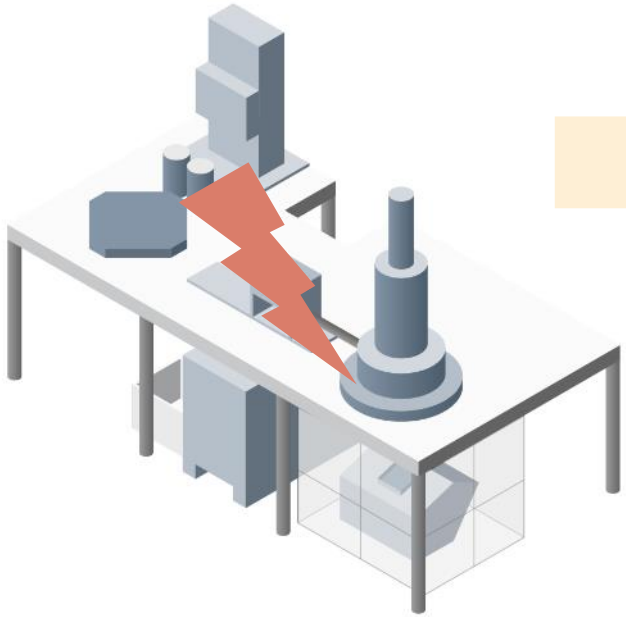
Hydrothermal pre-treatment and upgrading

Results from commissioning phase:

Input

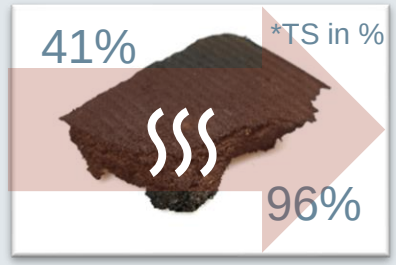
Biomass

Digestate



Output

to digester



Hydrochar

Chamber Filter Press

Scale-Up

and commercial scale concept

Federal Ministry
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and Transport

Commercial size concept

Pilot scale

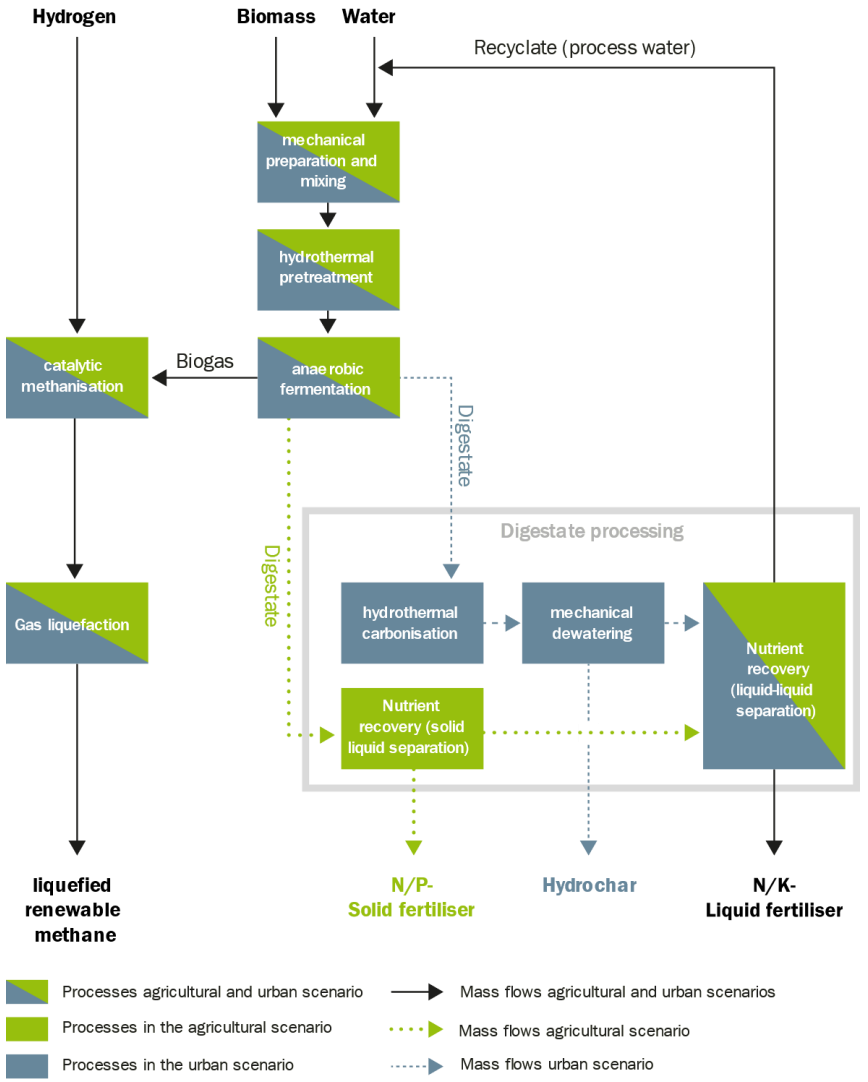
Input

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

Output

- ≈ 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

* 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.



Commercial scale (agrarian)

Input

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

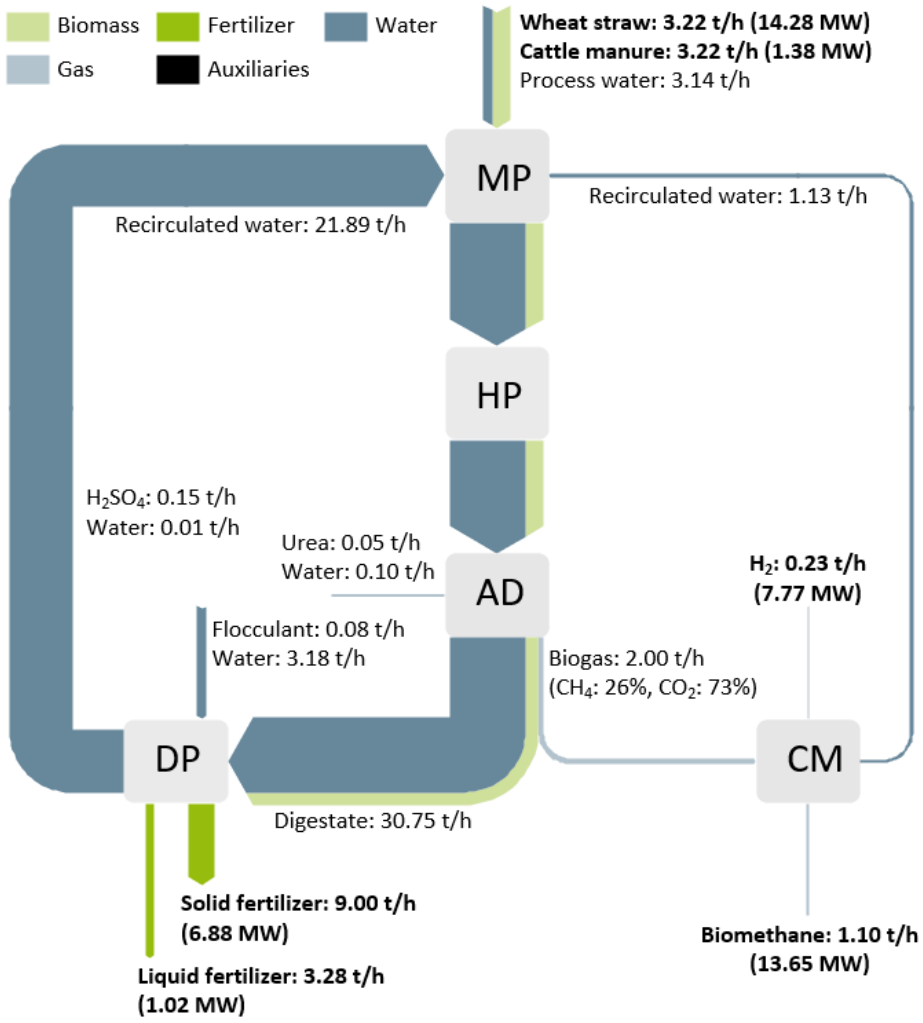
Output

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

* for the first commercial size plant concept results from lab scale preliminary tests were used since thr pilot plant was still in commissioning.

m³ - standard cubic metre

Mass and energy balance | commercial scale



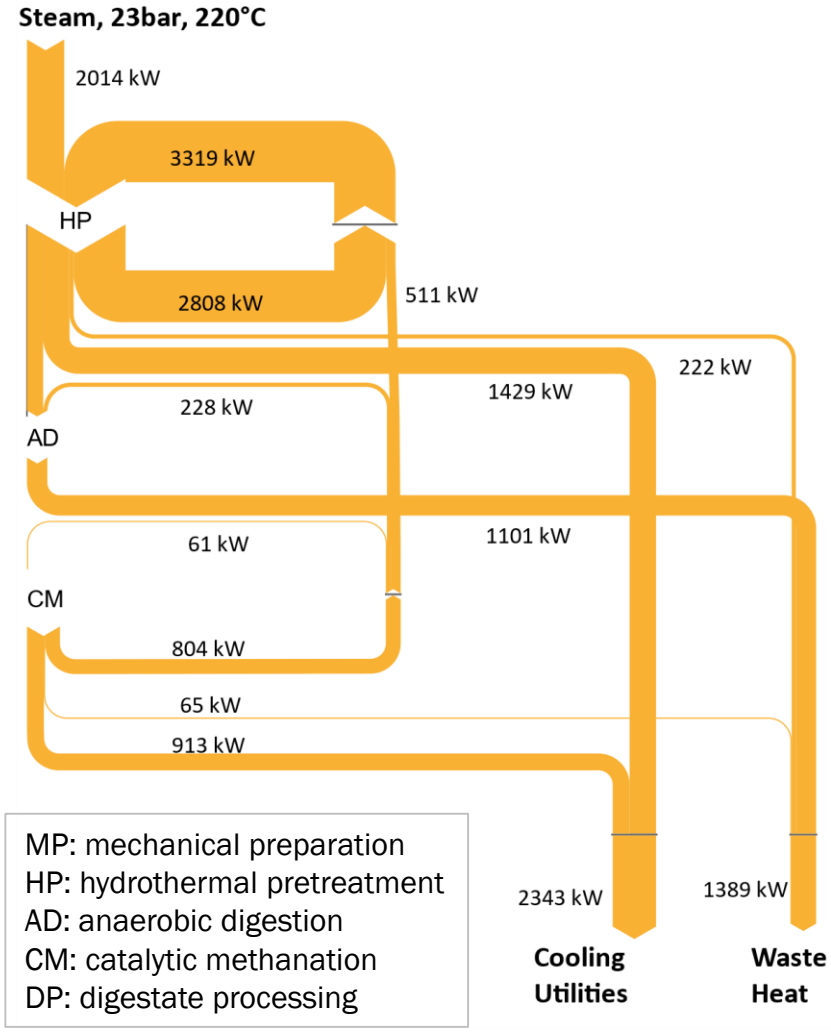
Input

- 25,760 t/a straw
- 25,760 t/a manure
- 25,120 t/a water
- 1840 t/a hydrogen
- 16 GWh/a heat (steam)
- 110 GWh/a electricity

(and some auxiliaries)

Output

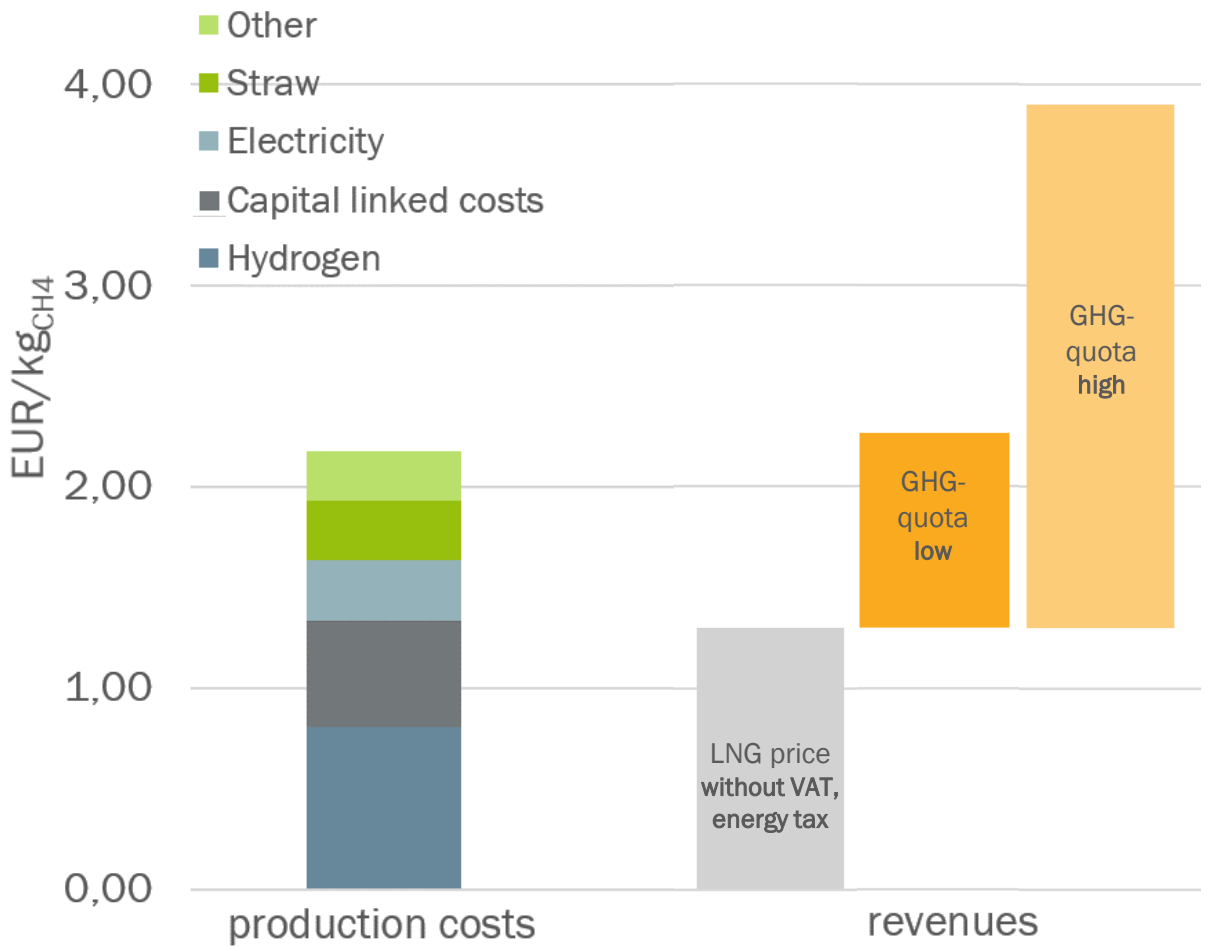
- 8,800 t/a methane
- 98,240 t/a fertilizer



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

Source: H. Etzold, L. Röder, K. Oehmichen, R. Nitzsche: Technical design, economic and environmental assessment of a biorefinery concept for the integration of biomethane and hydrogen into the transport sector. In: Bioresource Technology Reports (2023, under review)

Market | Costs and revenues



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

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

[German version only]

Focus booklets in the Pilot-SBG project

Download:

Renewable methane in transport

- Methanation
- Anaerobic fermentation
- Example concept for the provision of renewable LNG
- Infrastructure for renewable methane in transport
- Market analysis and greenhouse gas quota for renewable methane in transportation

www.dbfz.de/pilot-sbg

Interested? Contact me!

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