Renewable LNG as transport fuel

The way to innovative concepts

Kati Görsch, Jörg Schröder, Karin Naumann, Selina Nieß, Hendrik Etzold

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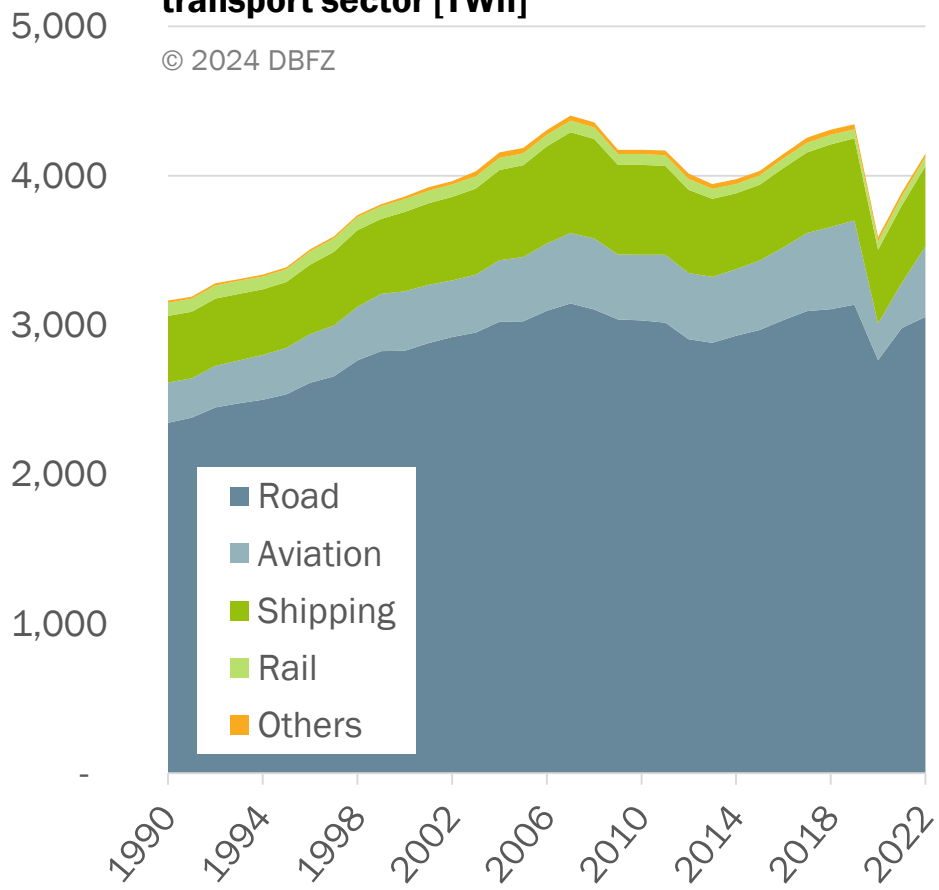
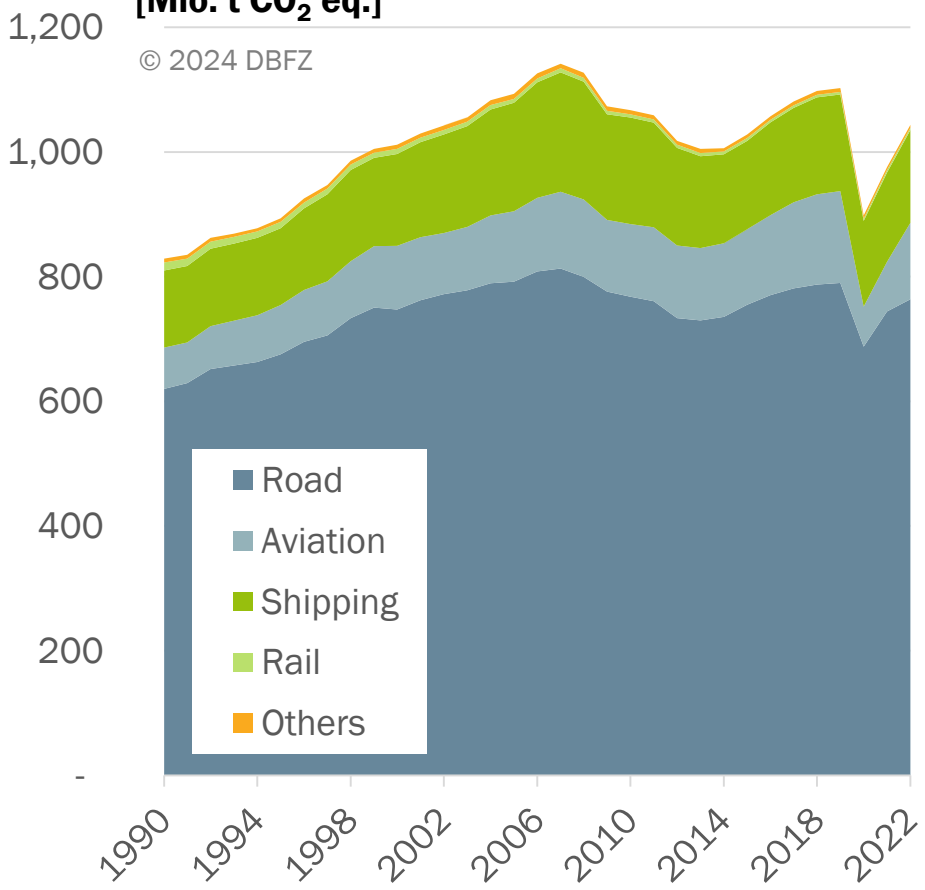
Massive gap between trends and targets in transport

EU-27 | Final energy consumption in the transport sector [TWh]



EU-27 | GHG emissions from the transport sector [Mio. t CO_2 eq.]



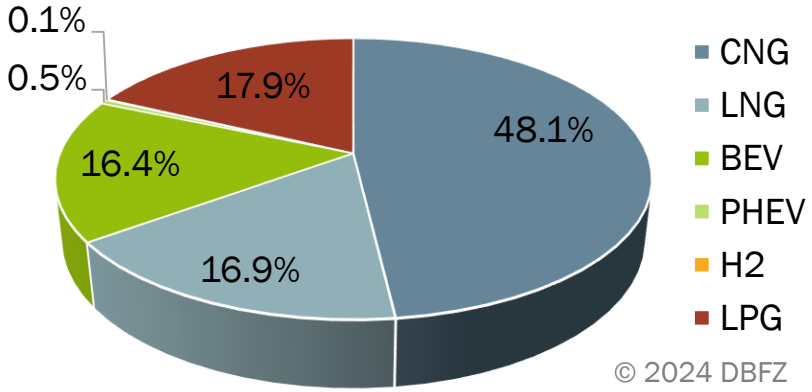
Aviation and shipping = transport within the EU-27 and across EU-27 border

Sources: https://ec.europa.eu/eurostat/databrowser/view/nrg_bal_s__custom_11195970/default/table and https://ec.europa.eu/eurostat/databrowser/view/env_air_gge__custom_11192865/bookmark/table?lang=de&bookmarkId=60492f00-053f-4b67-ae4a-da1f7c13b1c1 (checked 03.05.2024)

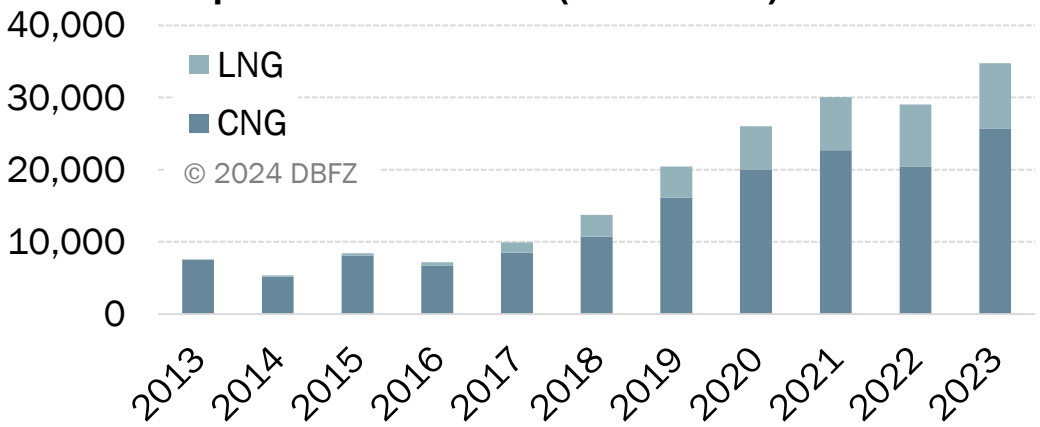
LNG in the heavy-duty transport sector

Further information:
(German version only)

EU | Share of alternative type of drive (N2+N3 fleet) in 2023



EU | Number of vehicles (N2+N3 fleet)



EU | Status quo in 04/2024:

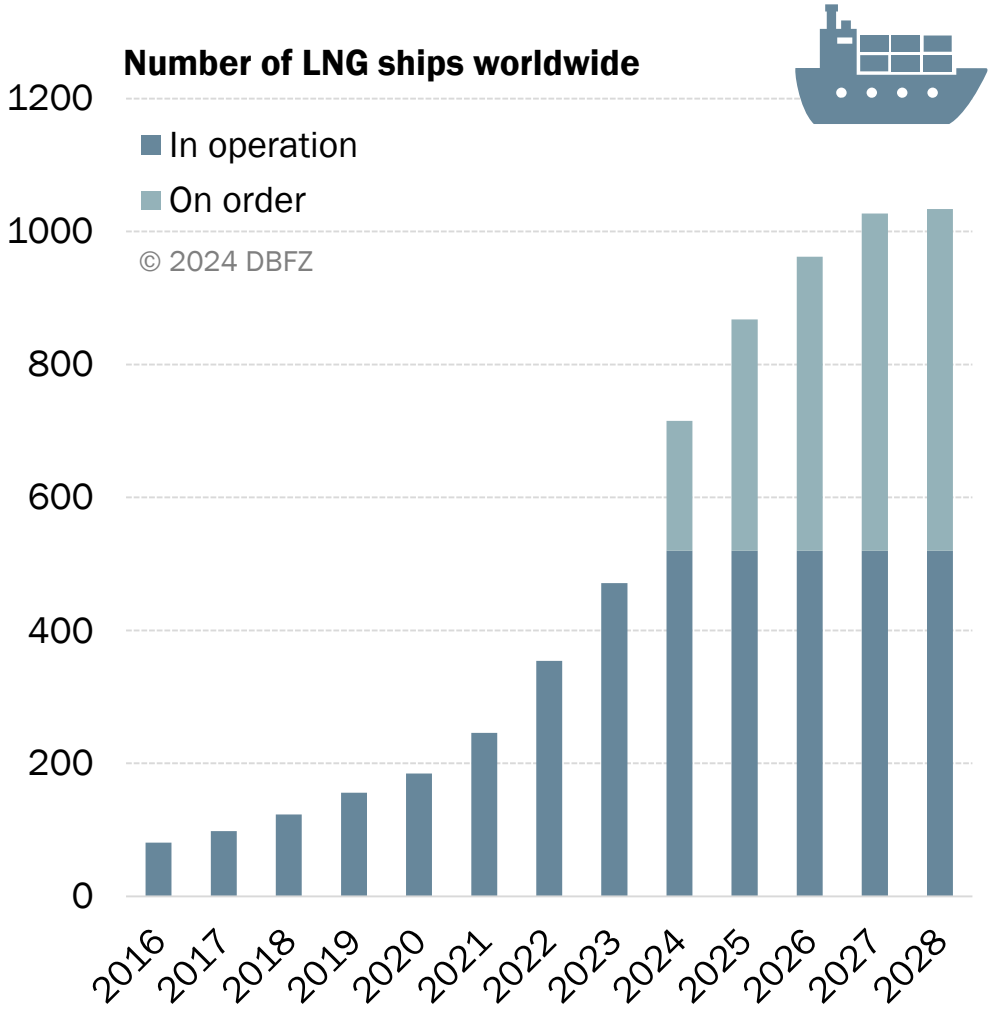
- 712 **LNG filling stations**
- 4,204 CNG filling stations

Source: European Biogas Association Statistical Report 2023. https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/european-union-eu27/vehicles-and-fleet (19.04.2024). NGVA stations map (checked 14.04.2024).

LNG in the shipping sector

Status quo for **Europe** resp. **worldwide**:

- LNG or LNG-ready ships in operation: **500**
- Maritime ports with LNG
  - in operation: **51** resp. **108**
  - planned or under construction: **15** resp. **42**
- LNG bunker vessels
  - in operation: **31** resp. **58**
  - on order: **4** resp. **17**



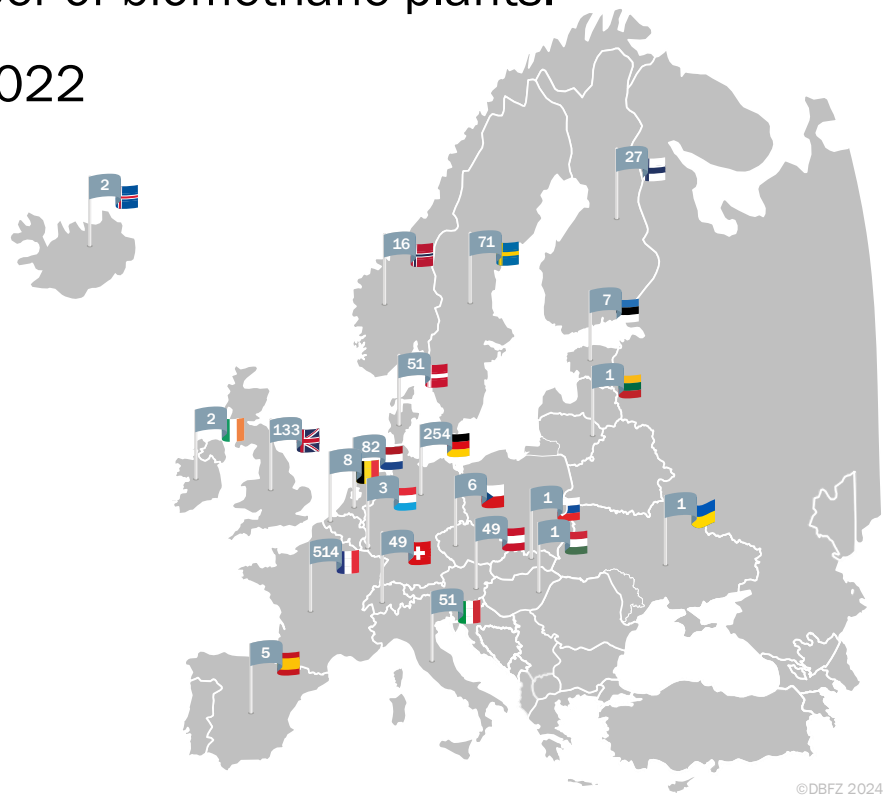
Sources: DNV Alternative Fuels Insights 2023 (checked 13.05.2024), https://www.atlas-mag.net/en/category/tags/focus/the-world-merchant-fleet (checked 23.04.2024)

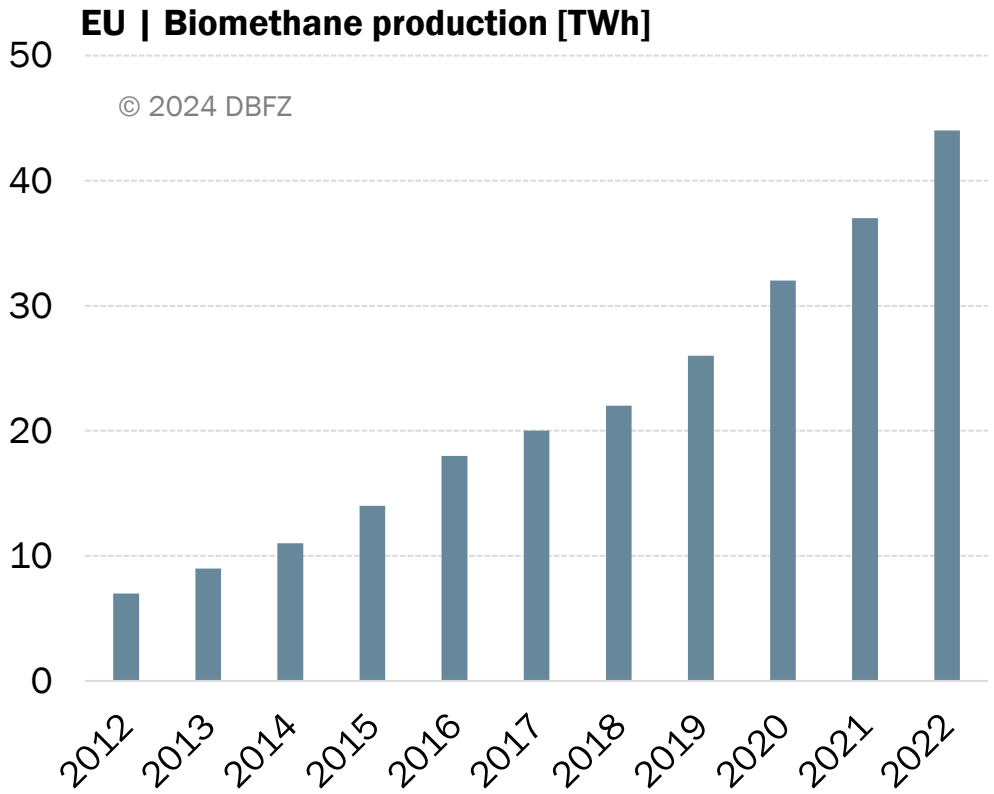
Biomethane plants

Further information:
(German version only)

- Total number of biomethane plants:

  1,323 in 2022



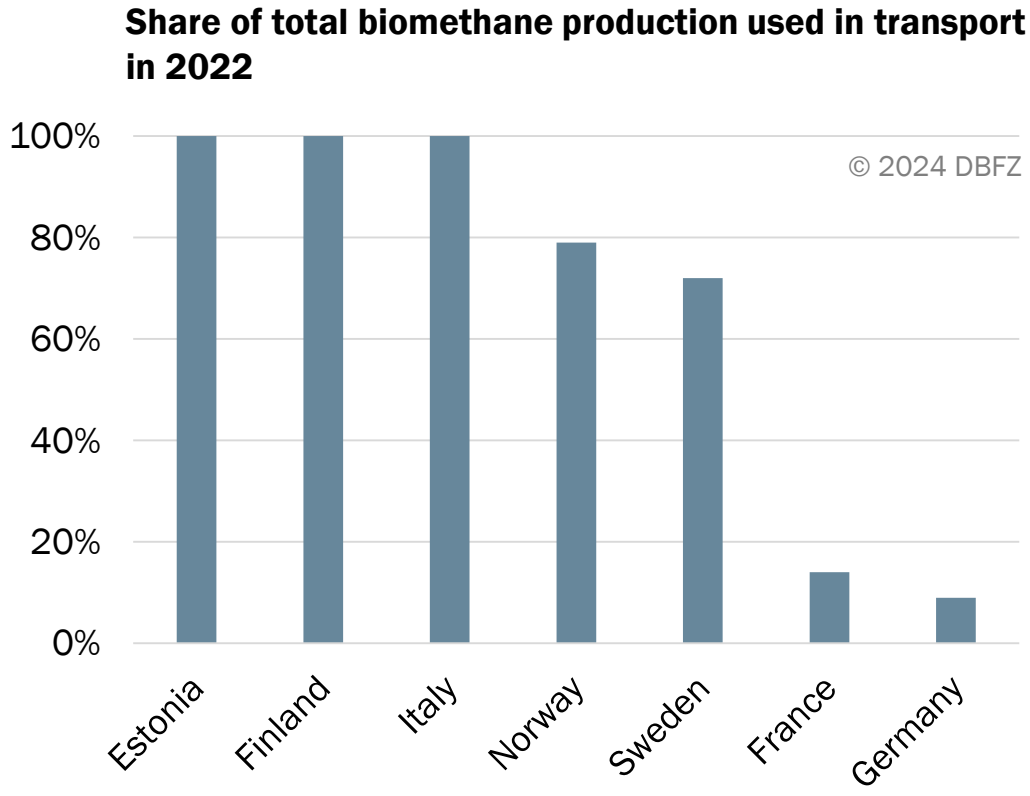


- REPowerEU scope of 35 bcm/a biomethane (371 TWh/a) for 2030 versus 4,2 bcm (44 TWh) in 2022

Source: European Biogas Association Statistical Report 2023.

Use of (bio-)methane in the European transport sector in 2022

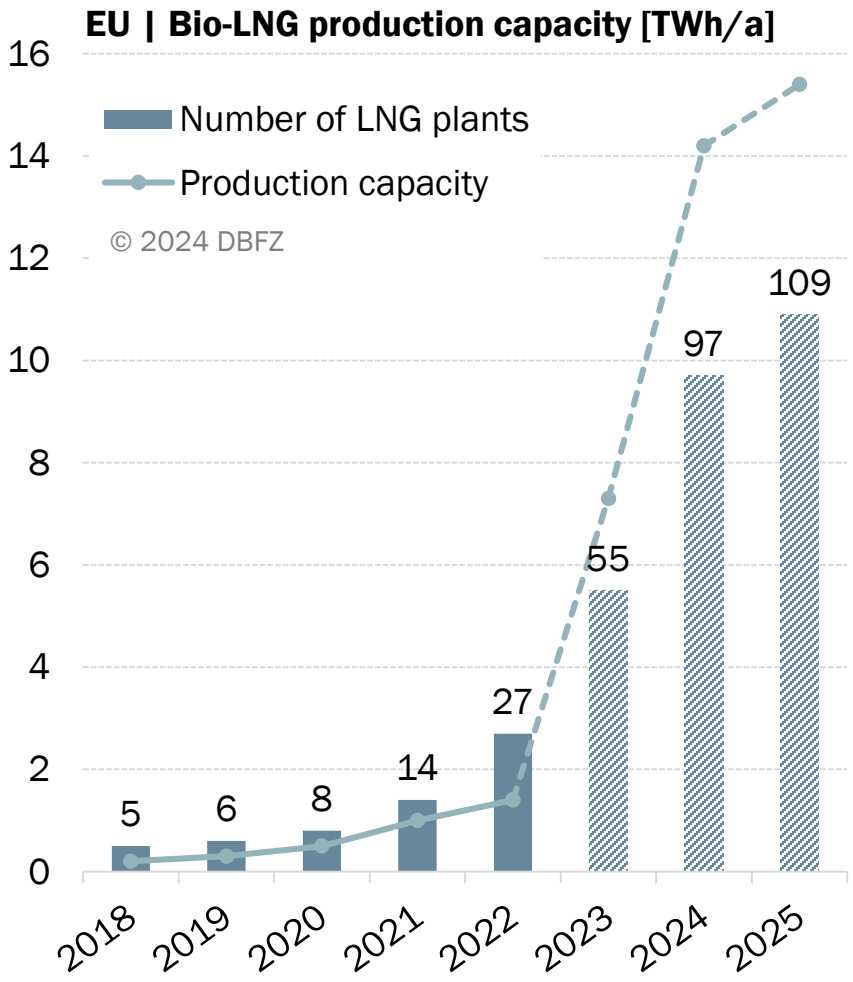
- Total natural gas consumption for transport: 43 TWh = 1.35 % of the total energy consumption for transport (3,196 TWh)
- Biomethane consumption for transport: 8.63 TWh
  = 0.27 % of the total energy consumption for transport
  = 19.6 % of the biomethane production (44 TWh)



Source: European Biogas Association Statistical Report 2023.

Bio-LNG production plants

Further information:
(German version only)



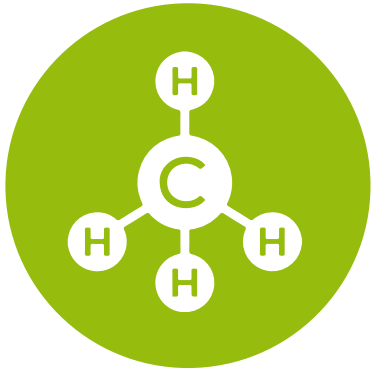
Interim conclusion:

- Approx. 80 % of the methane used in transport is fossil
- Renewable methane can replace fossil methane
- Alternative truck drives: currently CNG/LNG most widely used, but very small share compared to the total number of trucks
- LNG for ships: structure is being established
- Massive expansion of bio-LNG capacities planned

Source: European Biogas Association Statistical Report 2023.

Motivation and approach

Further information:
(Project website)



Climate-friendly, renewable methane as fuel

Innovative process concept according to **Zero-Waste Approach**

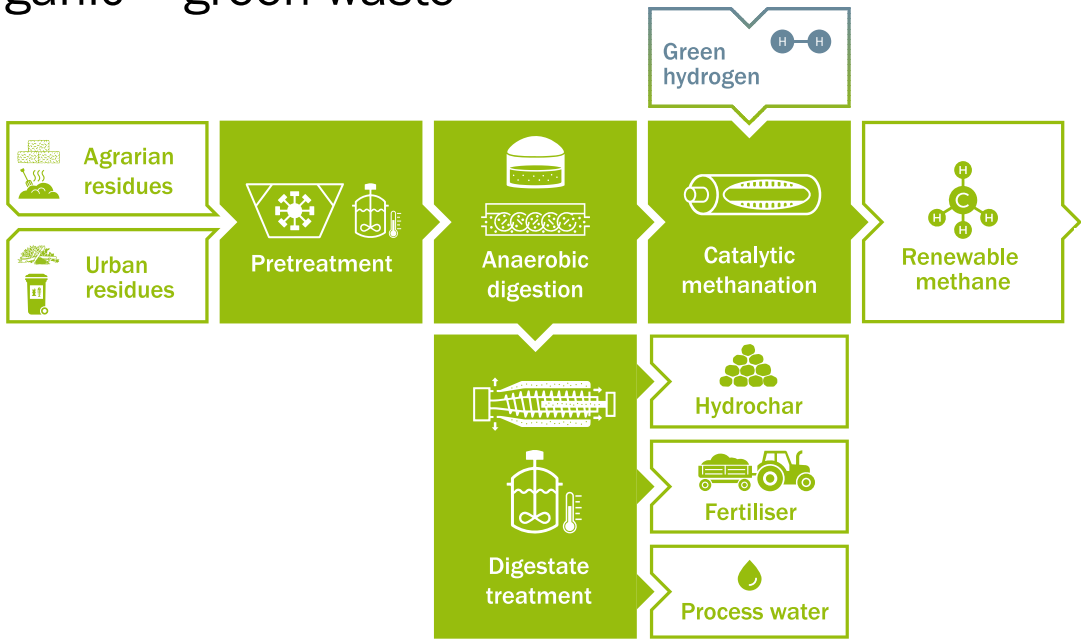
Usage of **advanced resources for biofuel production**

Electricity & green hydrogen

Test phase in pilot scale and concept development

Further information:
(Project website)

- Input: 0.2 – 1.2 t/month
  - Agrarian resources = cereal straw + liquid manure
  - Urban resources = organic + green waste



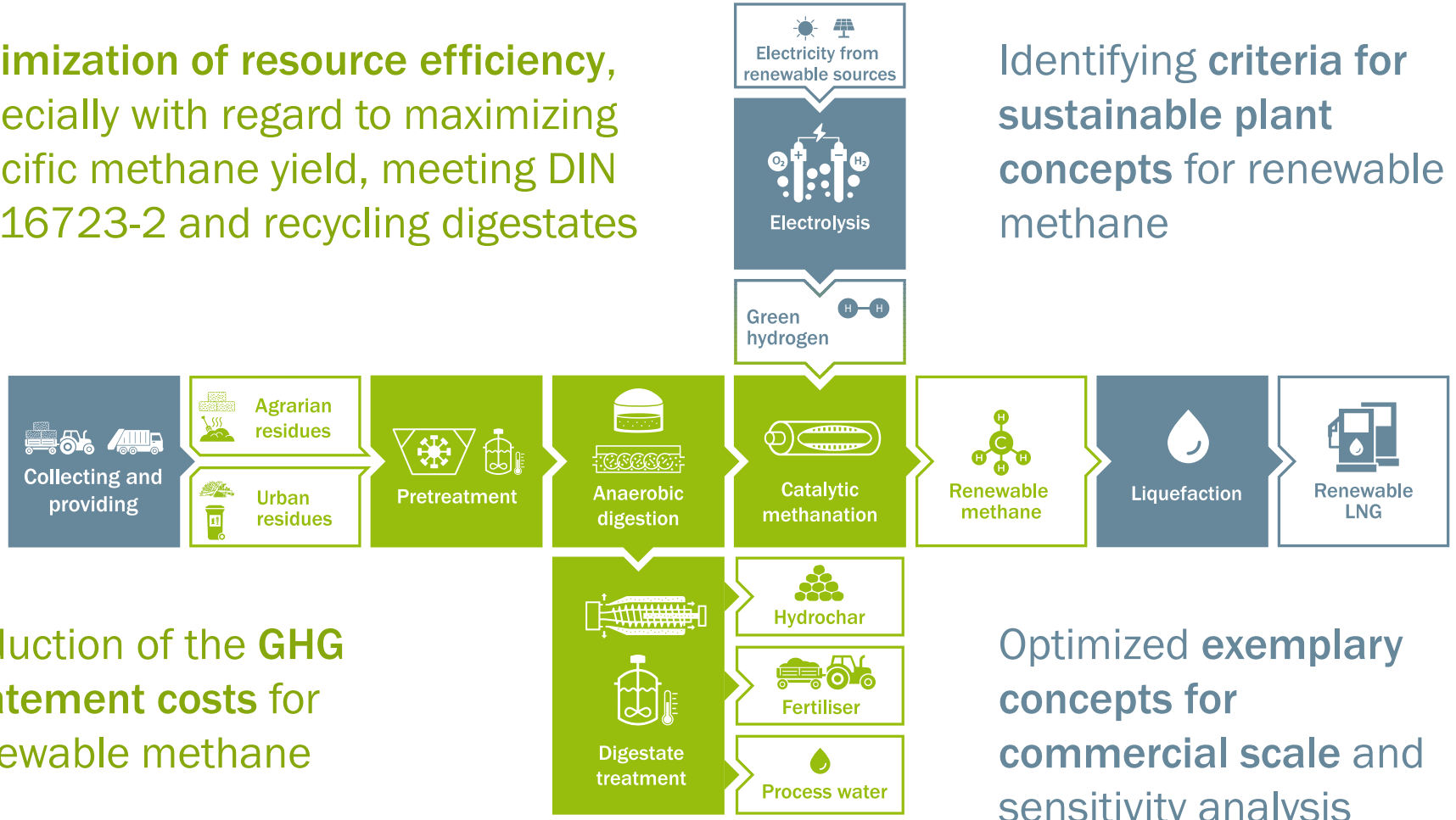
- Output:
  - approx. 75 m³/month product gas with > 95 % renewable methane
  - Fertilizers (NPK)
  - Hydrochar
  - Process water for reuse

Test phase in pilot scale and concept development

Further information:
(Project website)

Optimization of resource efficiency, especially with regard to maximizing specific methane yield, meeting DIN EN 16723-2 and recycling digestates

Identifying **criteria for sustainable plant concepts** for renewable methane



Reduction of the **GHG abatement costs** for renewable methane

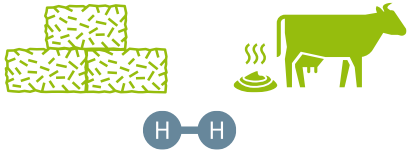
Optimized **exemplary concepts for commercial scale** and sensitivity analysis

Pilot plant (04/2024)

Further information:
(Project website)

Technical potential for renewable methane

- Concept with **agrarian** resources:



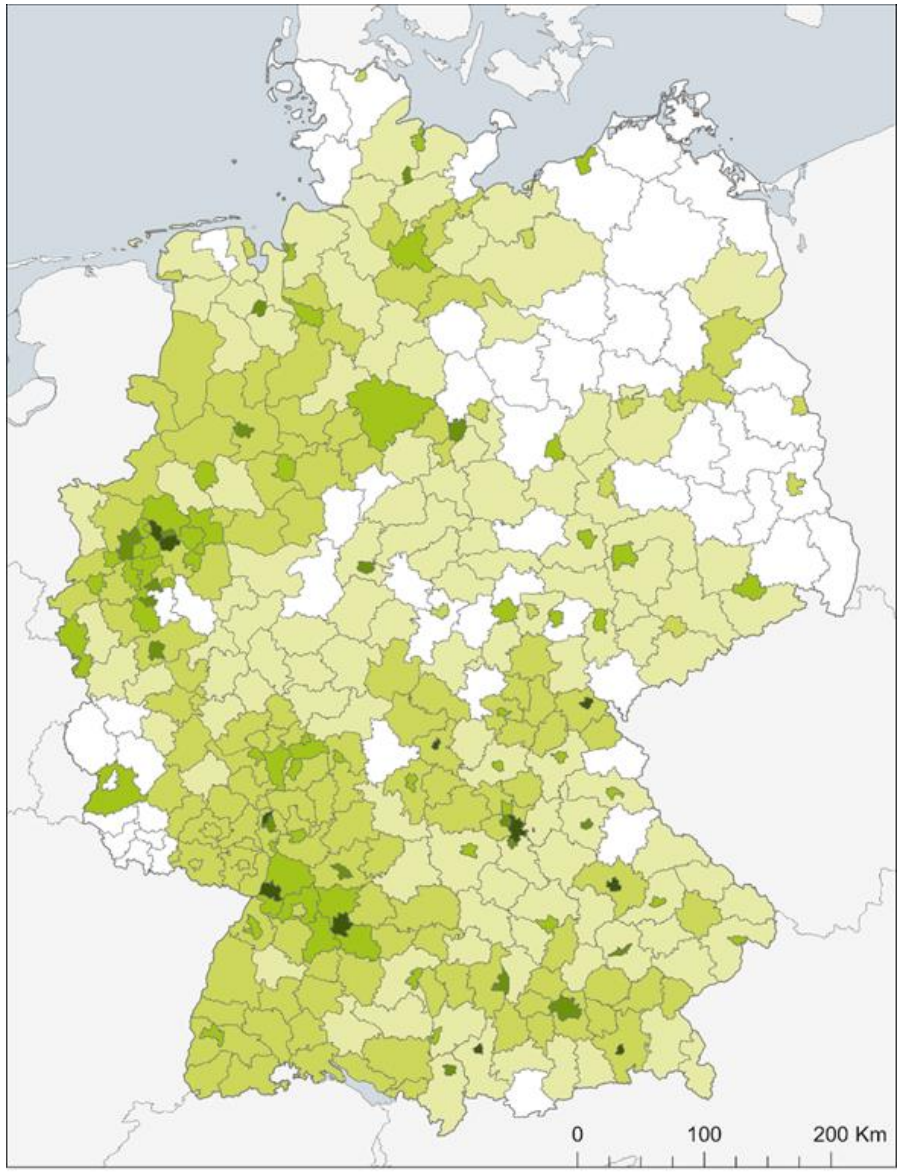
Green hydrogen

= approx. 125 TWh/a

- Concept with **urban** (municipal) waste:

Green hydrogen

= approx. 21 TWh/a

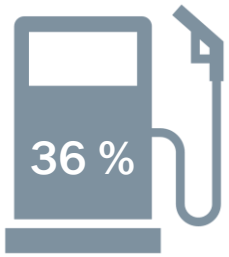


Technical potential of renewable methane from biowaste and green waste
2020, incl. methanation with hydrogen in GJ/km²

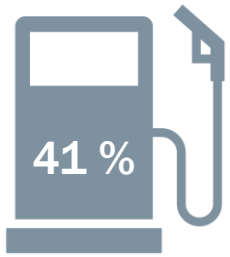
≤ 50 ≤ 150 ≤ 500 ≤ 1.000 ≤ 1.500 ≤ 2.500

Impact on the German transport sector

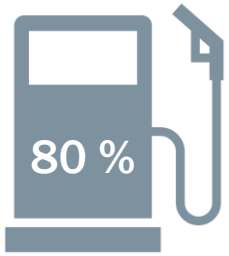
- Substitution potential of 146 TWh methane:



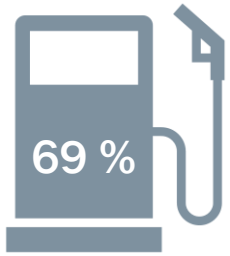
Total diesel fuel



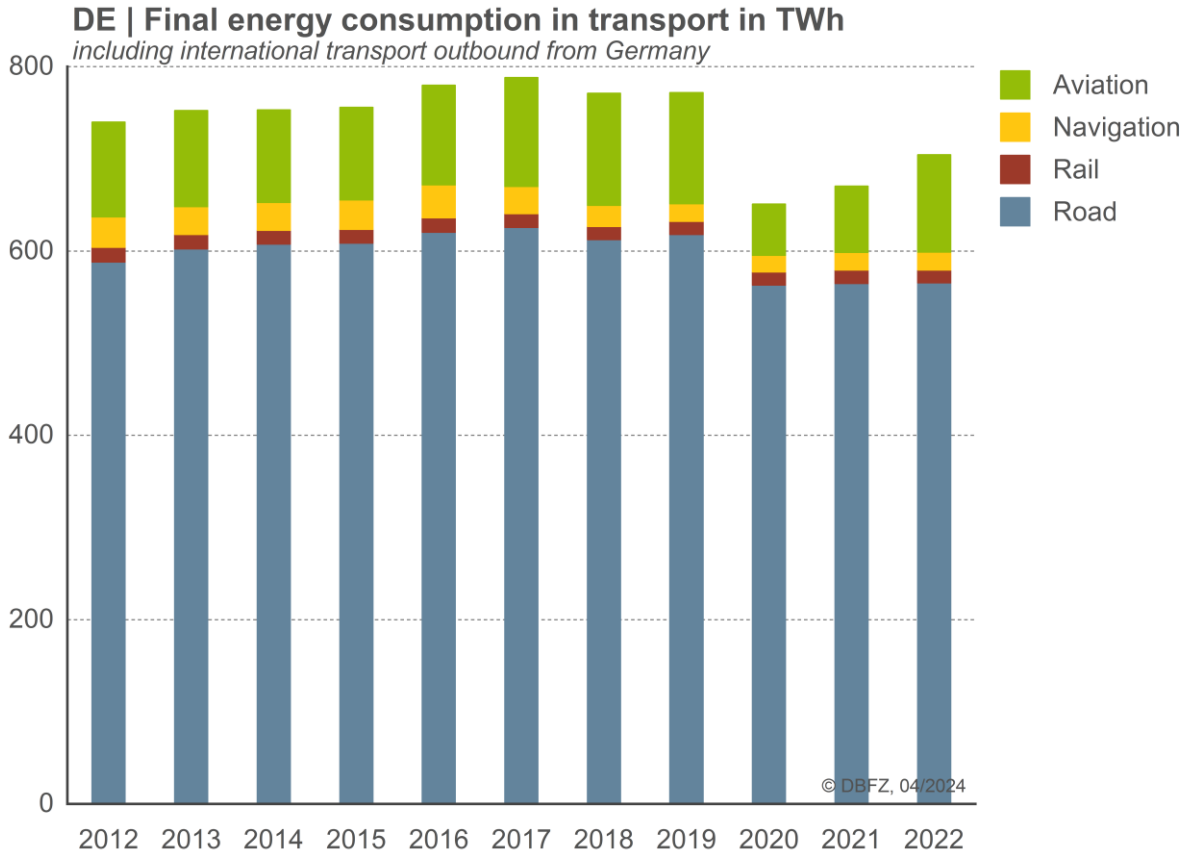
Diesel fuel, used for transport



Diesel fuel, road transport



Diesel fuel, freight traffic + 100 % rail and ship



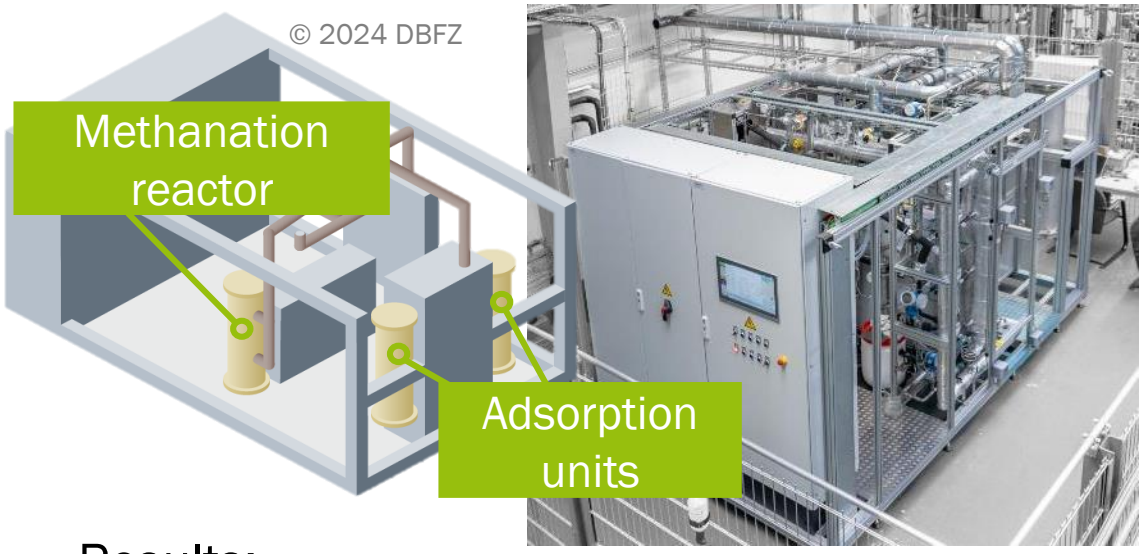
Reference year for substitution potential: 2021, data basis of final energy consumption: Verkehr in Zahlen.

Research on direct biogas methanation

Further information:
(German version only)

Biogas component	Concentration
CH_4	40 – 75 vol%
CO_2	25 – 60 vol%
Traces*	Rest

*Traces may contain catalyst poisons like H_2S, NH_3 and siloxanes.



Special features of direct biogas methanation:

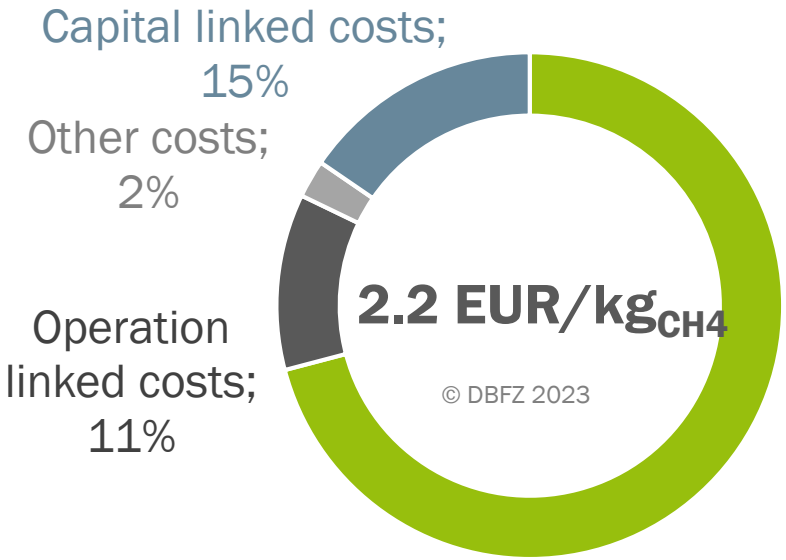
- Biogas cleaning required
- No need to separate CH_4 and CO_2 for methanation if using suitable catalysts

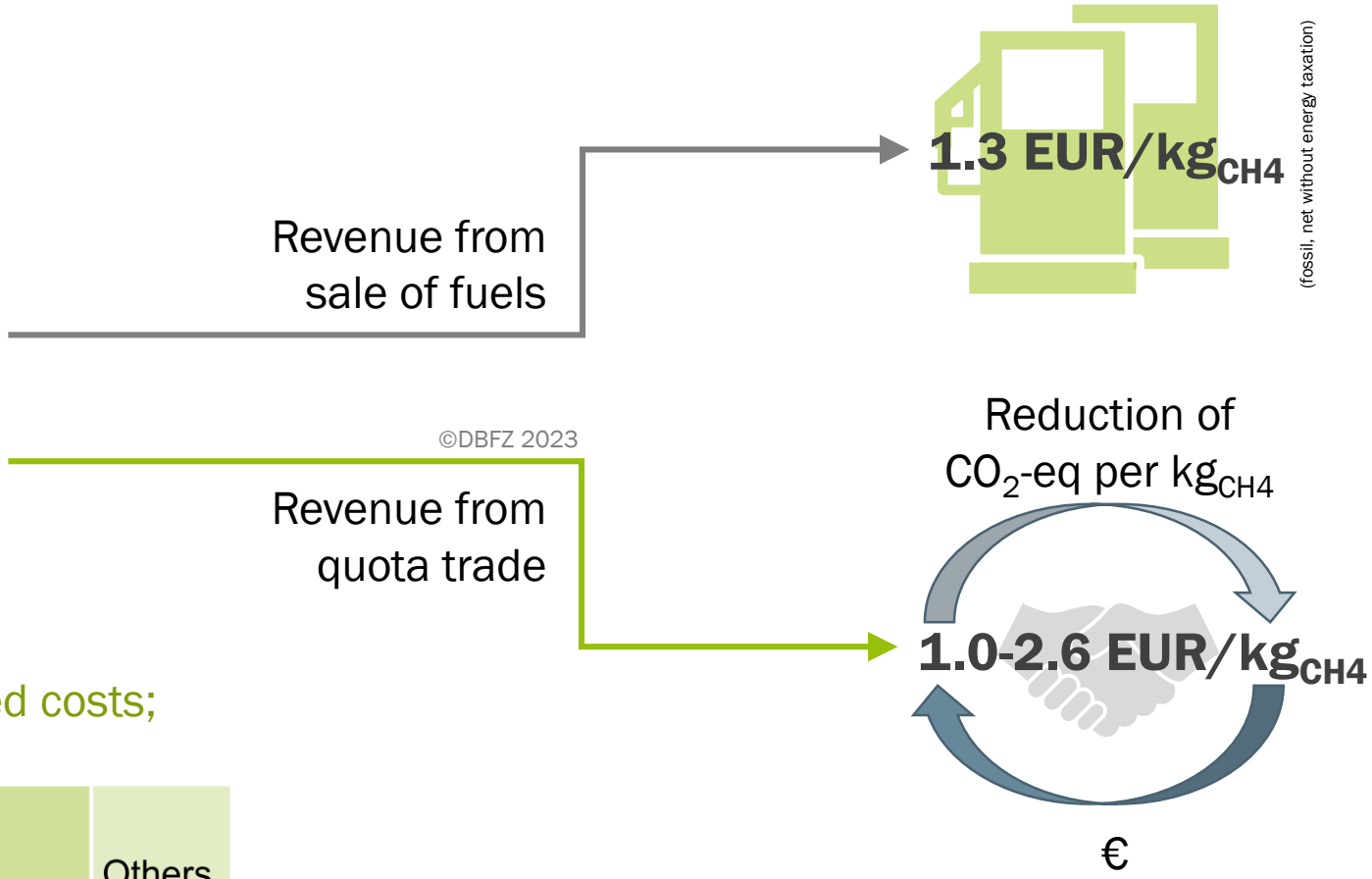
Results:

- CH_4 has no adverse effect
- Fuel conditions (CH_4↑, CO_2↓, H_2 < 2 vol%) met with several catalysts
- Especially promising catalyst: $Ni20/CeO_2$

Production costs for commercial scale (example concept)

Further information:
(German version only)

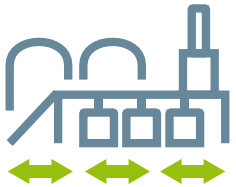




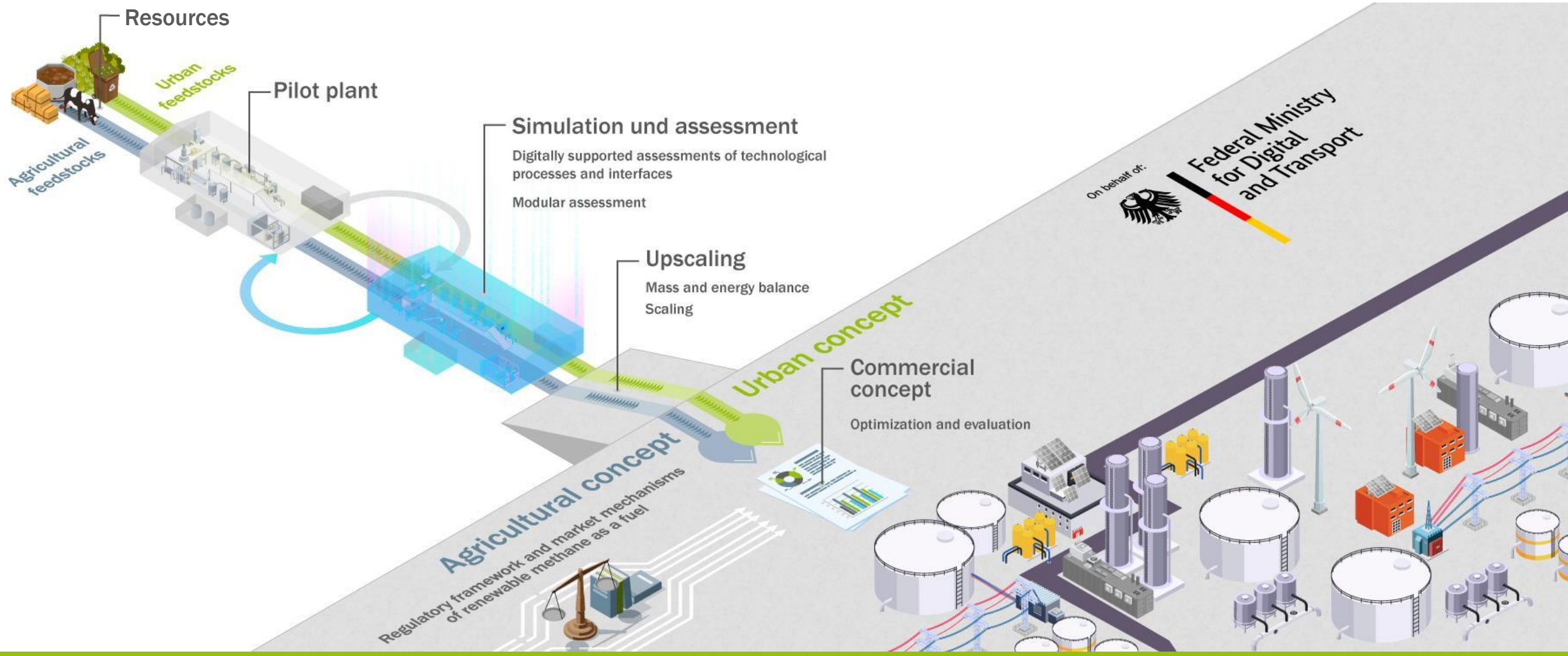
Source: H. Etzold, L. Röder, K. Oehmichen, R. Nitzsche: Technical design, economic and environmental assessment of a biorefinery concept for the integration of biomethane and hydrogen into the transport sector. In: Bioresource Technology Reports (2023, under review) | further information: https://www.dbfz.de/projektseiten/pilot-sbg/

Outlook for the pilot plant

- Next three years:
  - Routine operation of the pilot plant with research campaigns for the selected resources
  - Development of different concepts for commercial scale



Outlook for the pilot plant



Outlook for the pilot plant

- Next three years:
  - Routine operation of the pilot plant with research campaigns for the selected resources
  - Development of different concepts for commercial scale
- Subsequent use as R&D platform:
  - Linkage between pilot plant, biorefineries technical center and research biogas plant of the DBFZ possible
  - Further process development with techno-economic and life-cycle assessment
  - Analyses of resource potentials and suitability of new feedstocks

Project website Pilot-SBG

Dr.-Ing. Kati Görsch
Biorefineries Department
Leader of the working group „Renewable fuels for transport“

Deutsches Biomasseforschungszentrum gGmbH
Torgauer Straße 116
D-04347
Leipzig

kati.goersch@dbfz.de
+49 (0)341 2434-329

Monitoring renewable energies in transport