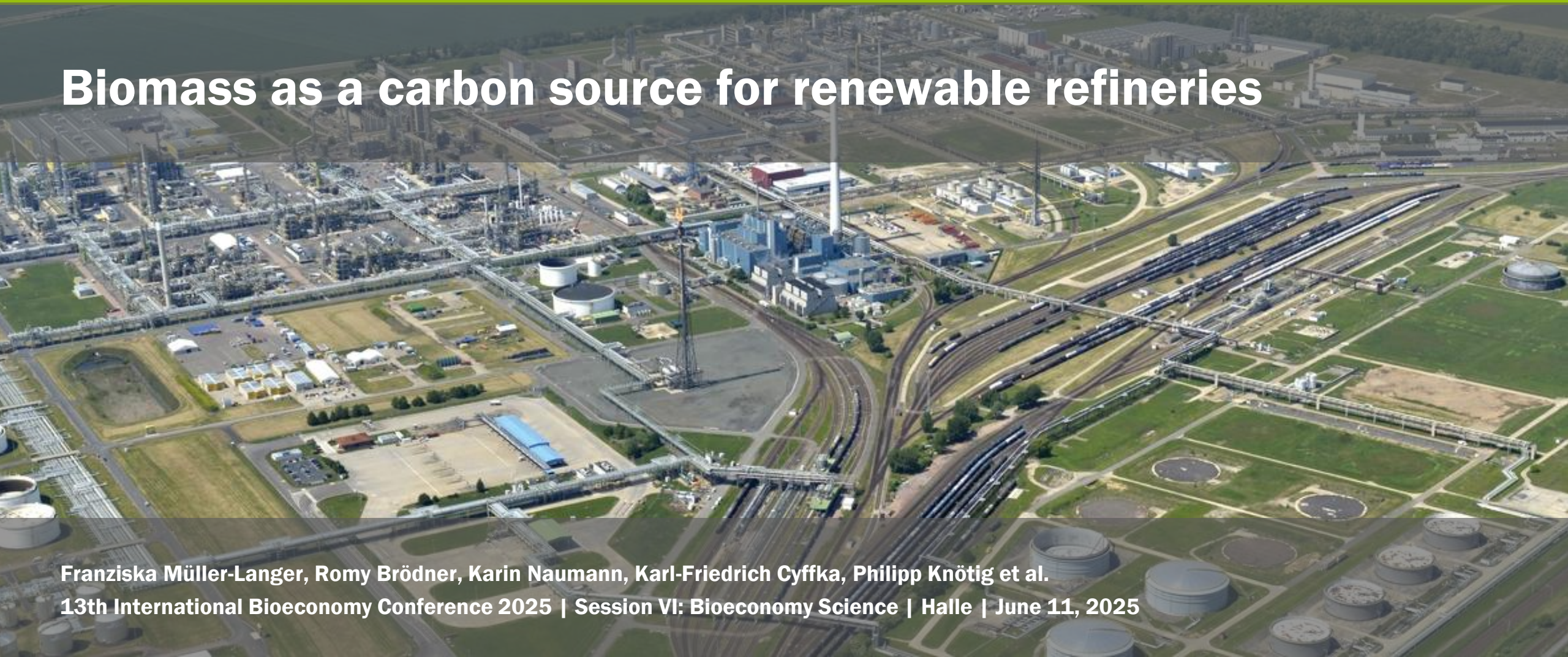
Deutsches Biomasseforschungszentrum

DBFZ

Biomass as a carbon source for renewable refineries

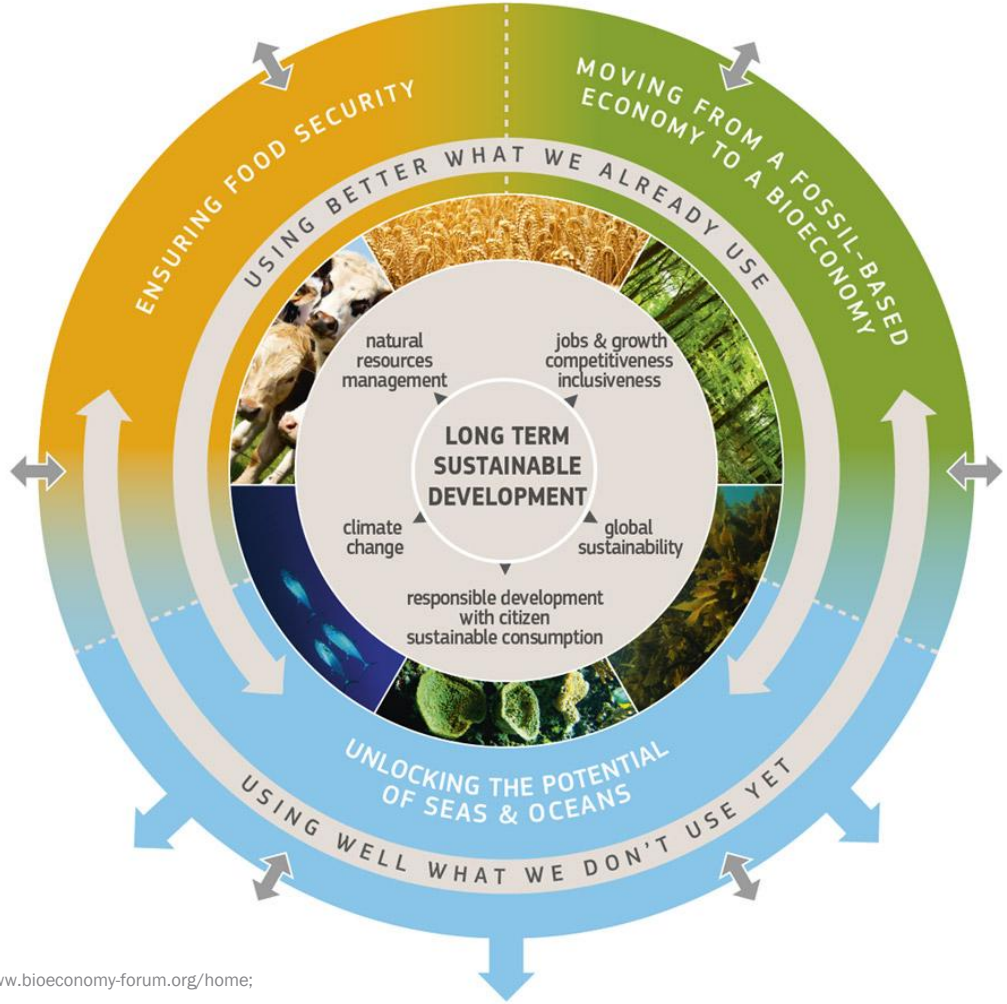


Franziska Müller-Langer, Romy Brödner, Karin Naumann, Karl-Friedrich Cyffka, Philipp Knötig et al.

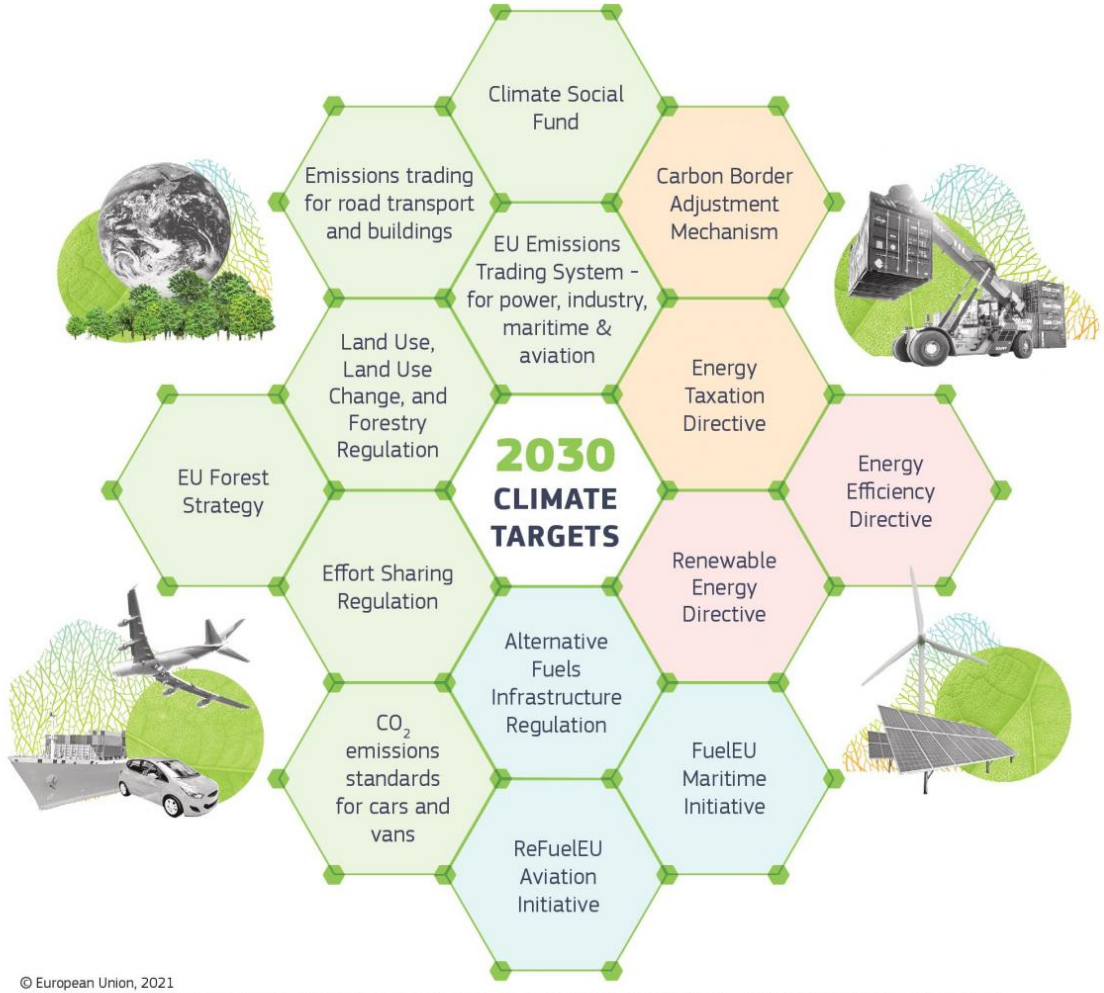
13th International Bioeconomy Conference 2025 | Session VI: Bioeconomy Science | Halle | June 11, 2025

Drivers for sustainable refineries based on biomass

Climate neutrality, ressource efficiency, circular economy



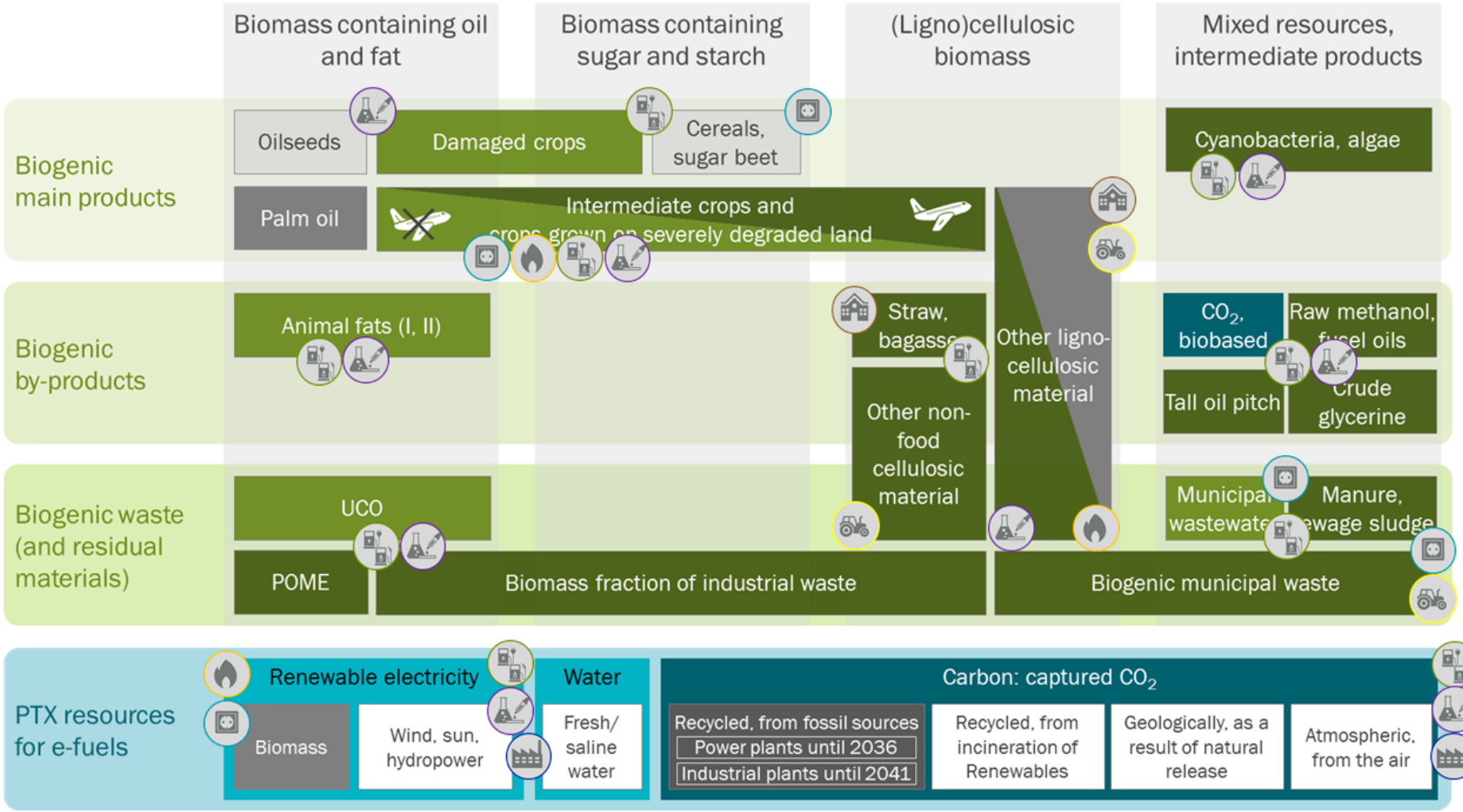
From https://www.bioeconomy-forum.org/home;



» Efficient biomass use as overarching goal in bioeconomy strategies >> carbon with key role for renewable products

Biomass as carbon source

Increasing demand in all sectors



Increasing demand for renewable resources by 2030 with already high utilisation rates; e.g.:

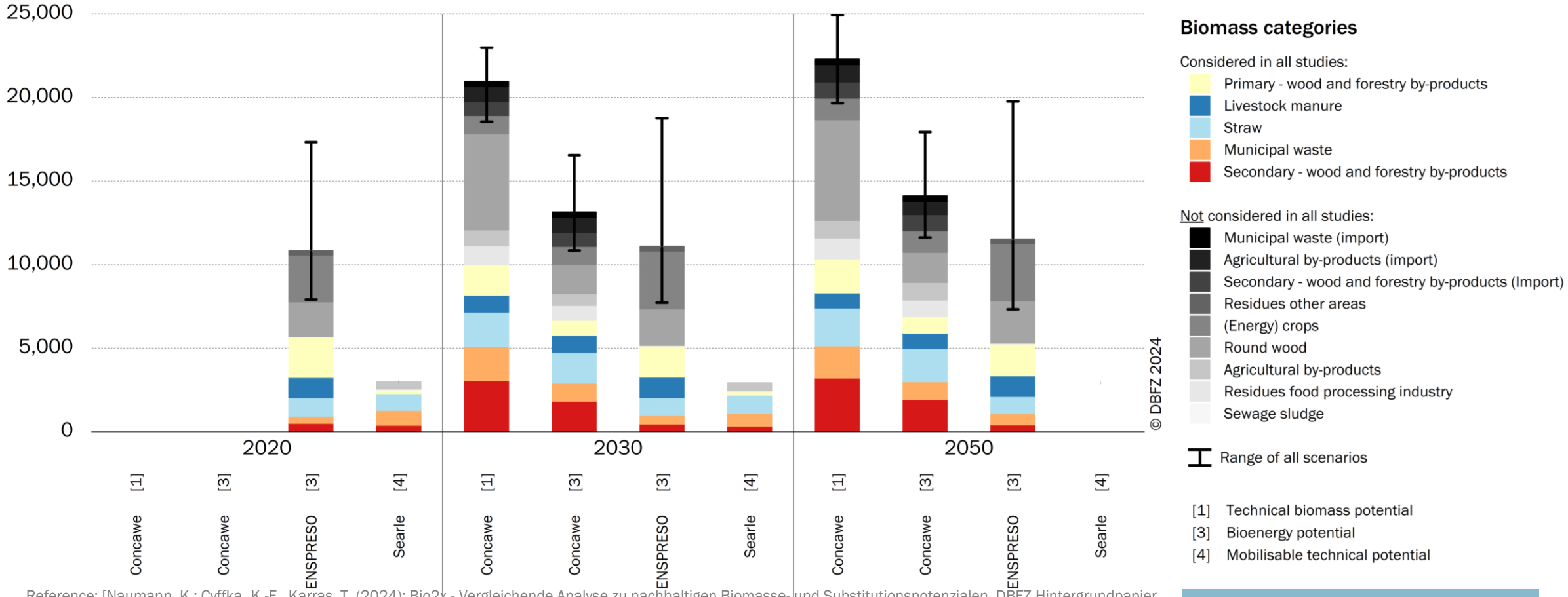
- Heat
- Electricity
- Transport
- Chemical
- Construction
- Industry (e.g. steal /cement)
- Agriculture (e.g. peat replacement)

References: Demand icons based on expert assessment.
[Naumann, K. et al. (2024): Bio2x - Vergleichende Analyse zu nachhaltigen Biomasse- und Substitutionspotenzialen, DBFZ Hintergrundpapier, https://www.dbfz.de/fileadmin/user_upload/Referenzen/Statements/Hintergrundpapier_Bio2x_Okt_2024.pdf]

Significant differences in biomass potentials

Biomass potentials [all types of biomass] in PJ

scenario = medium

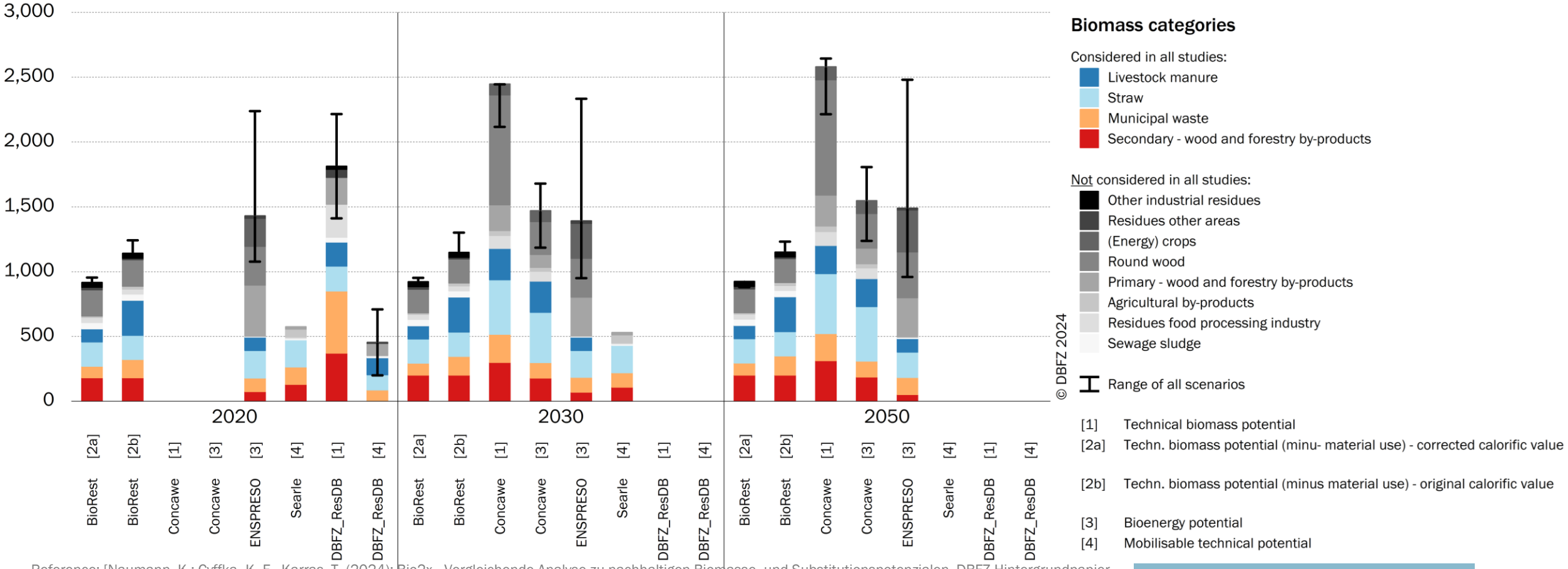


Reference: [Naumann, K.; Cyffka, K.-F., Karras, T. (2024): Bio2x - Vergleichende Analyse zu nachhaltigen Biomasse- und Substitutionspotenzialen, DBFZ Hintergrundpapier, https://www.dbfz.de/fileadmin/user_upload/Referenzen/Statements/Hintergrundpapier_Bio2x_Okt_2024.pdf]; [Naumann, K.; Cyffka, K.-F.; Costa de Paiva, G.; Nieß, S.; Neuling, U.; Zitscher, T. (2025): Ressourcen und ihre Mobilisierung. In: Schröder, J.; Görsch, K. (Hrsg.): Erneuerbare Energien im Verkehr. DOI: 10.48480/w11j-9w27],

+ about 34 Mt biobased CO_2
from ethanol, biogas and biomethane

Significant differences in biomass potentials

Biomass potentials [all types of biomass] in PJ — scenario = medium

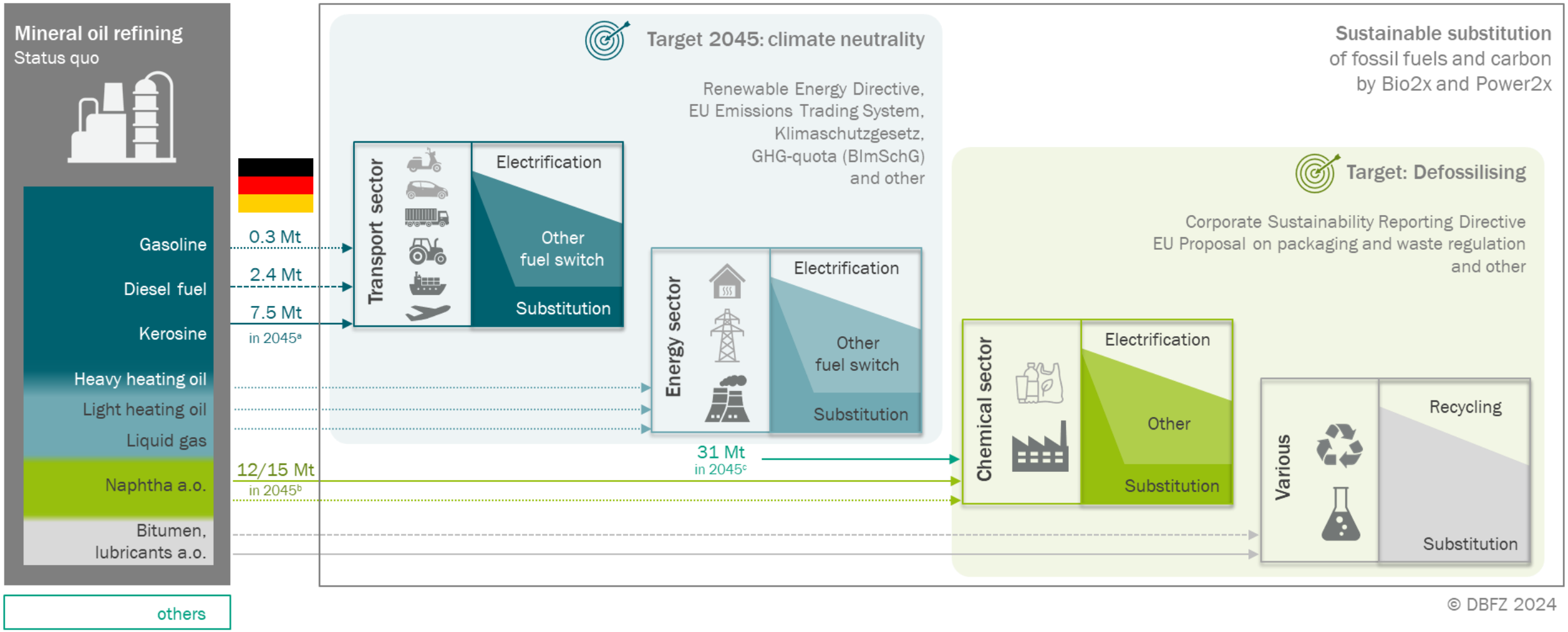


Reference: [Naumann, K.; Cyffka, K.-F., Karras, T. (2024): Bio2x - Vergleichende Analyse zu nachhaltigen Biomasse- und Substitutionspotenzialen, DBFZ Hintergrundpapier, https://www.dbfz.de/fileadmin/user_upload/Referenzen/Statements/Hintergrundpapier_Bio2x_Okt_2024.pdf]; Reference: [Naumann, K.; Cyffka, K.-F.; Costa de Paiva, G.; Nieß, S.; Neuling, U.; Zitscher, T. (2025): Ressourcen und ihre Mobilisierung. In: Schröder, J.; Görsch, K. (Hrsg.): Erneuerbare Energien im Verkehr. DOI: 10.48480/w11j-9w27].

+ about 13 Mt biobased CO_2 from ethanol, biogas and biomethane

Biomass as carbon source

Climate targets and refinery production



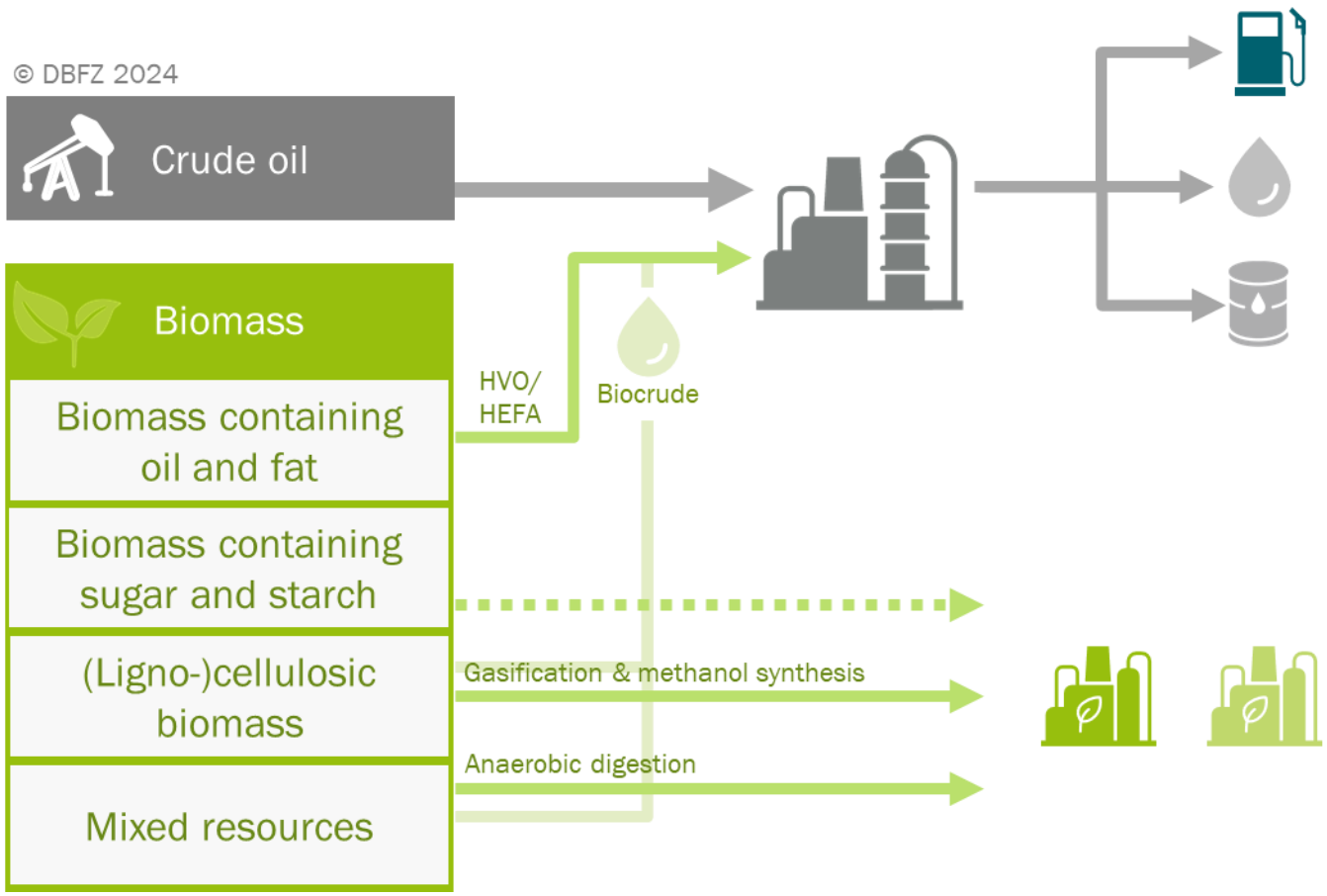
Need for substitution 2045: ⋯▸ hardly relevant, ---▸ moderately relevant, ⟶ highly relevant, | simplified presentation without any claim to completeness

Reference: [Naumann, K. et al. (2024): Bio2x | Vergleichende Analyse zu nachhaltigen Biomasse- und Substitutionspotenzialen. Hintergrundpapier, DBFZ, Leipzig.]

Database: [a] Agora (2021): Klimaneutrales Deutschland 2045, [b] VCI, VDI (2023): Chemistry4Climate, Szenarien 2, 3, [3] VCI, VDI (2023): Chemistry4Climate, Szenario 1 | Mt = million metric tons

Biomass as carbon source

Limited biobased substitution potential



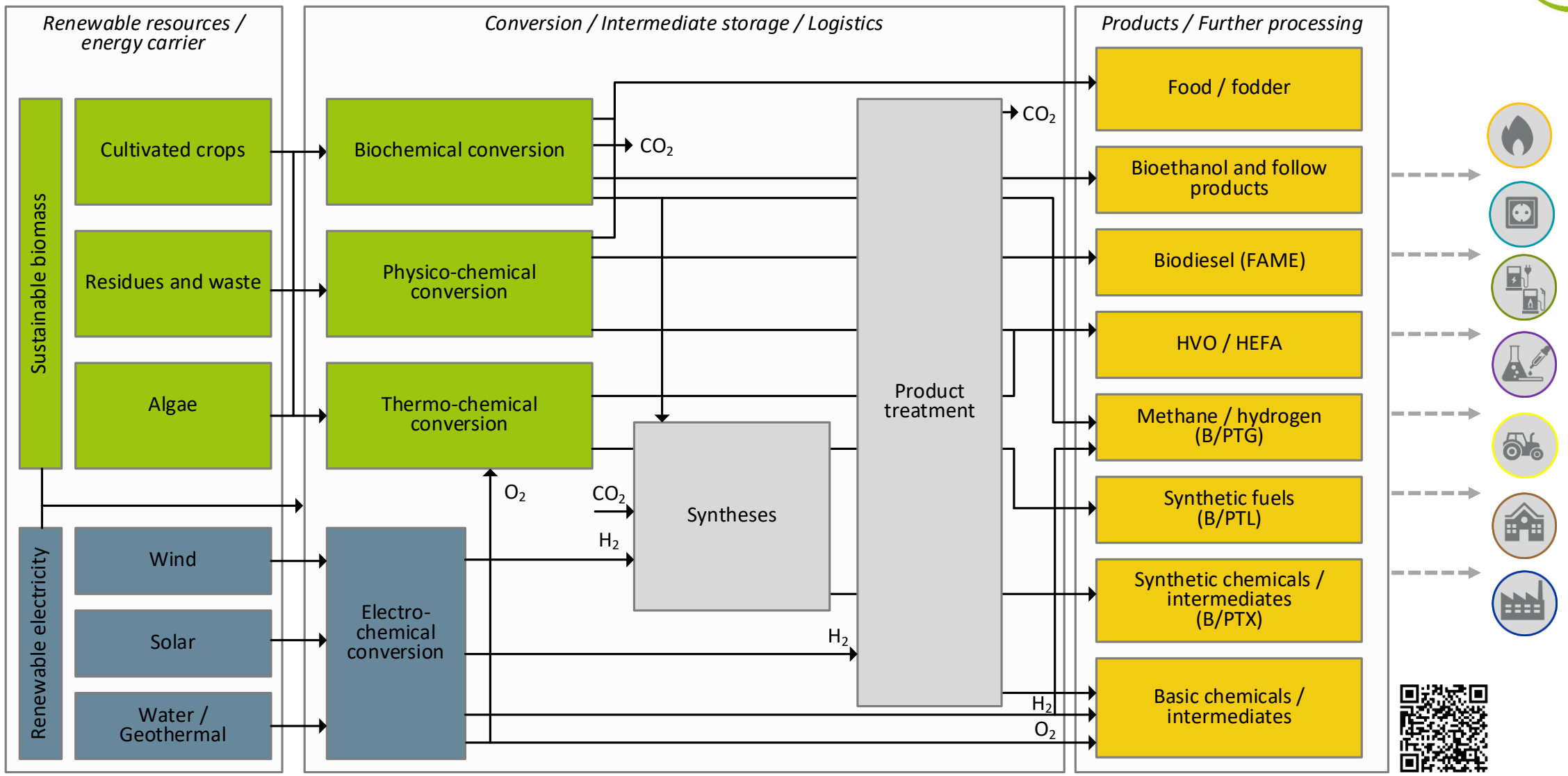
Product potential and substitution				
Diesel fuel	<0.1 Mt	0.1 – 0.3%	0.7 Mt	0.3%
Kerosine	<0.6 Mt	1.5 – 6.0%	3.7 Mt	13.8%
Naphtha	<0.3 Mt	0.6 – 2.3%	1.9 Mt	5.0%
Ethanol				
Methanol	0 - 13 Mt		3 - 91 Mt	
Methane	4 - 15 Mt		31 - 131 Mt	
Techn. potential	**17 – 28%**		**34 – 49%**	
Bioenergy pot.	**7 – 28%**		**10 – 45%**	
Mobilisable pot.	**3 – 9%**		**8%**	
+ up to 9 Mt methanol from biobased CO_2			**+ up to 25 Mt methanol from biobased CO_2**	

Notes: Fuel-specific values: reference to mean values and mean scenarios of the studies (quantities in Mt oil equivalent, 1 kg oil equivalent = 42 MJ) | Total potential bandwidths also include min/max scenarios, resources not considered here: starchy crops, sugar from sugar beet (ethanol) | rape seed, sunflower, soya seed (diesel fuel, kerosine, naphtha) | lignocellulosic crops, stemwood, forest wood (methanol) | Mt = million metric tons

Reference: [Naumann, K. et al. (2024): Bio2x - Vergleichende Analyse zu nachhaltigen Biomasse- und Substitutionspotenzialen, DBFZ Hintergrundpapier, https://www.dbfz.de/fileadmin/user_upload/Referenzen/Statements/Hintergrundpapier_Bio2x_Okt_2024.pdf]

Technology options for renewable refineries

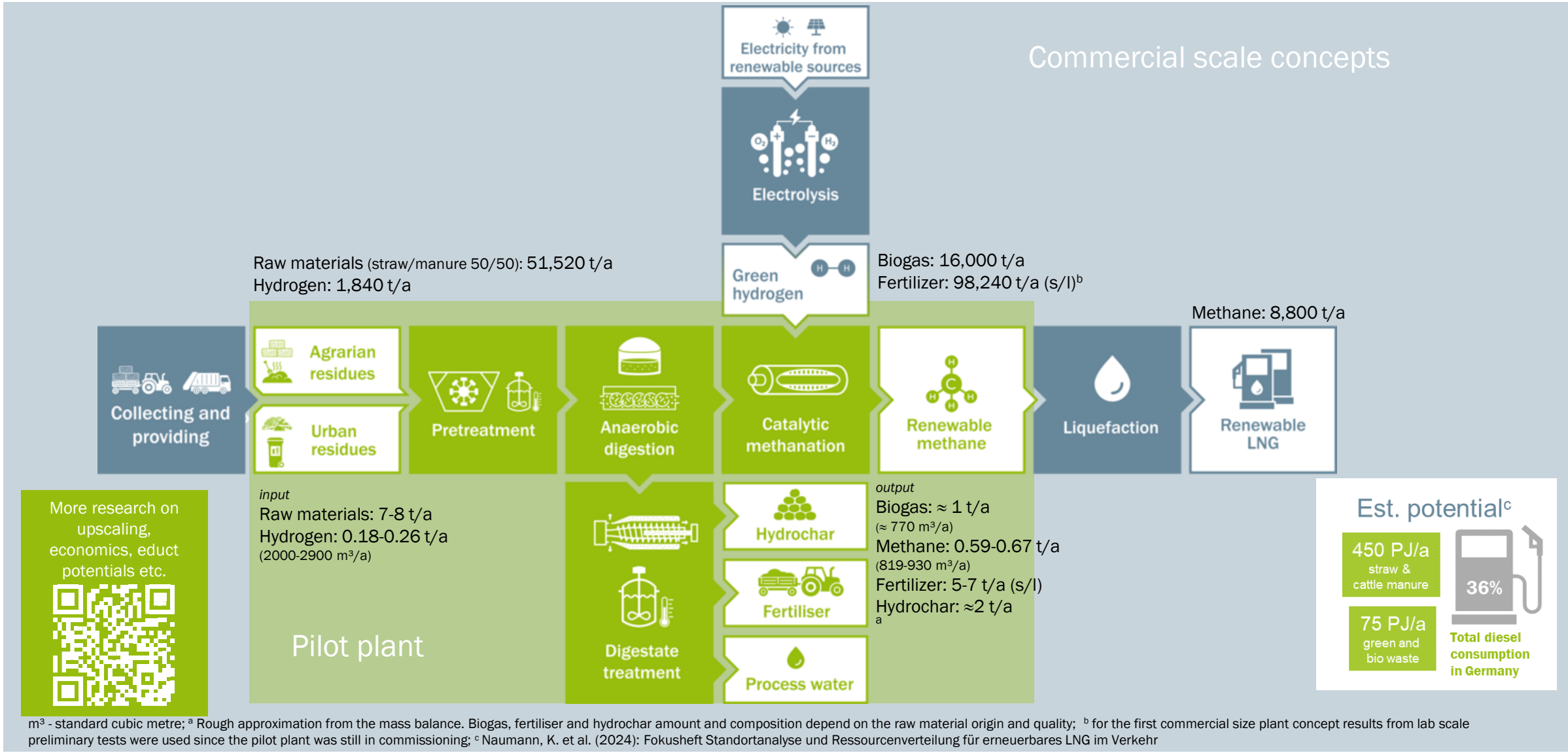
Diverse technology routes, synergies and value networks



SynBioPTX ©DBFZ 11/2021 (w/o entitlement of completeness)
B/PTG – Biomass-/Power-to-Gas, B/PTL – Biomass-/Power-to-Liquids, B/PTX – Biomass-/Power-to-products X; FAME – Fatty acid methyl ester; HEFA – hydrotreated esters and fatty acids; HVO – hydrotreated vegetable oils;

Example Pilot SBG

From biogas plant to a biorefinery | approach



m³ - standard cubic metre; [a] Rough approximation from the mass balance. Biogas, fertiliser and hydrochar amount and composition depend on the raw material origin and quality; [b] for the first commercial size plant concept results from lab scale preliminary tests were used since the pilot plant was still in commissioning; [c] Naumann, K. et al. (2024): Fokusheft Standortanalyse und Ressourcenverteilung für erneuerbares LNG im Verkehr

Reference: Knötig et al (2025) : Operation of a pilot scale biorefinery - for renewable methane and value adding by-products, EUBCE 2025, 3B0.9, 10.06.2025 Valencia

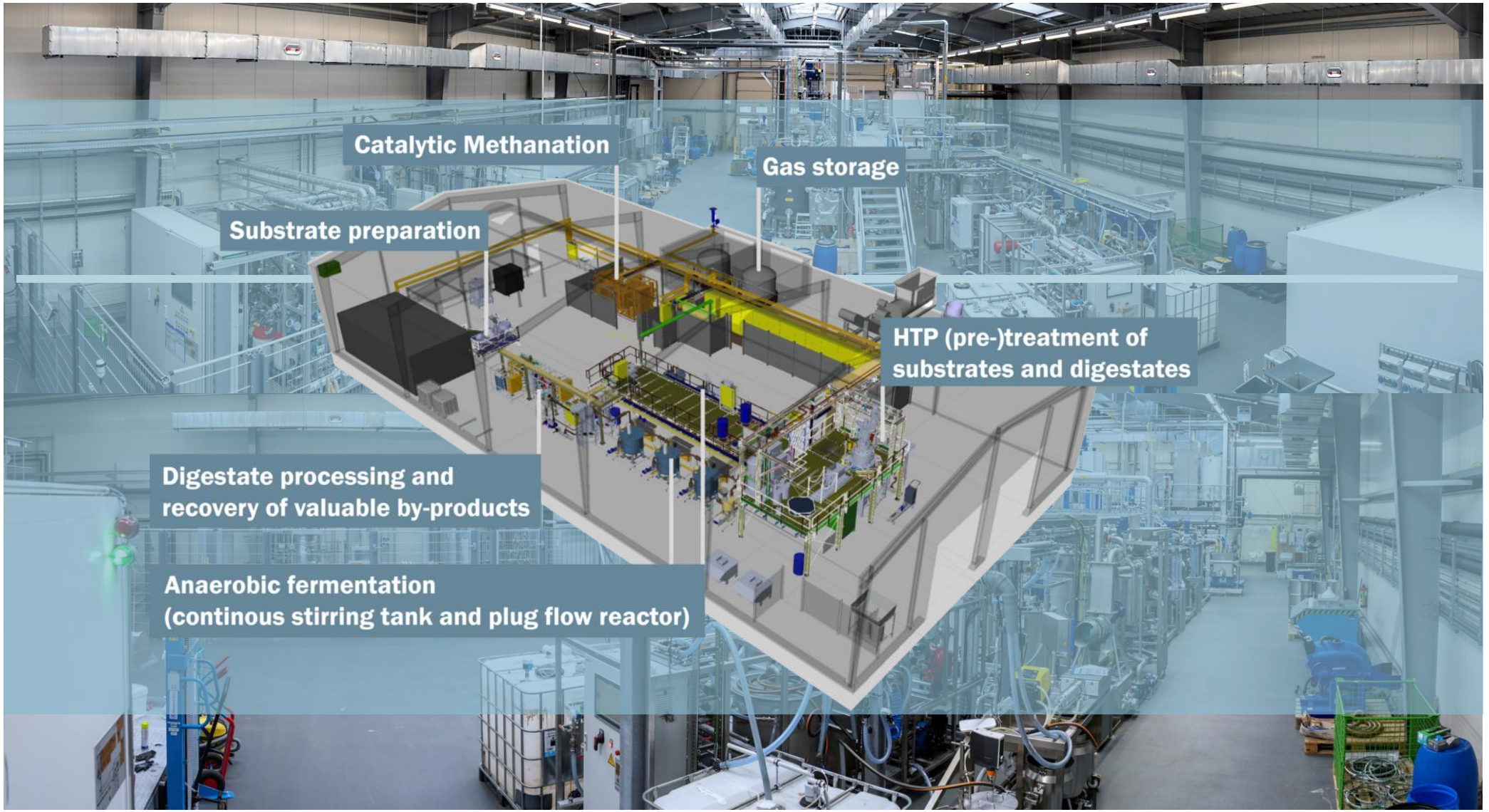
Example Pilot SBG

Automated production in an integrated pilot plant

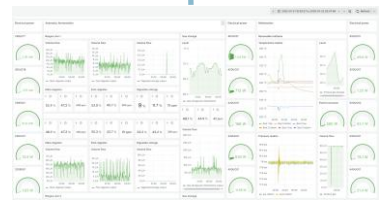
On behalf of: Federal Ministry of Transport

PILOT SBG

DBFZ



Input materials

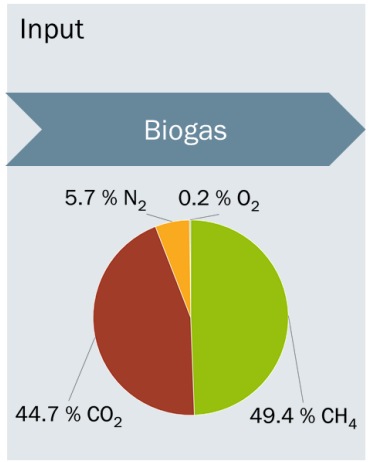


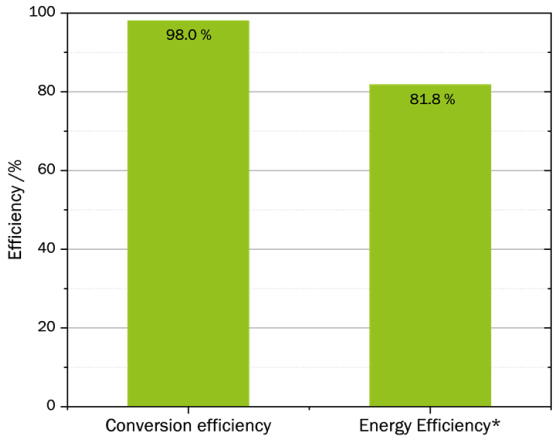
Gas storage & flare

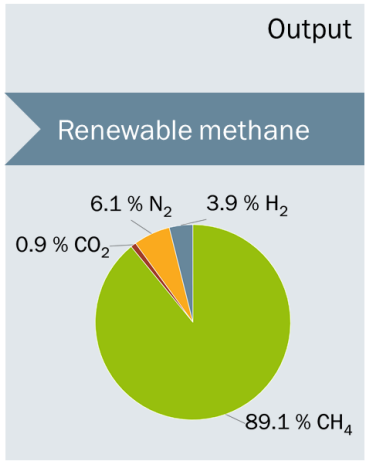
Example Pilot SBG

Insights in results

Catalytic methanation



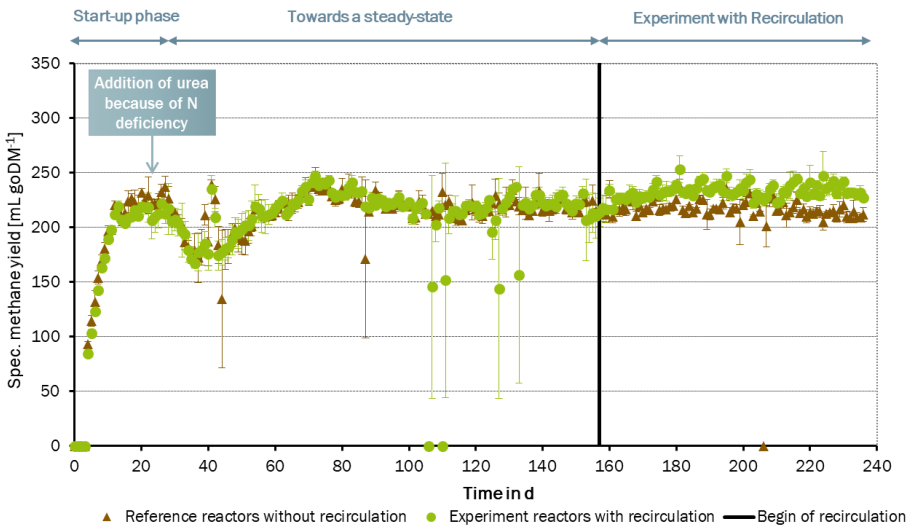




Ru2/Al_2O_3, T = 320 °C, p = 18 bar(g), H_2:CO_2 = 4, $\dot{V}_{biogas}$ = 60 L/h, GHSV = 449 h^{-1}

*Energy efficiency determined from calorific value of product and educt

Liquid digestate recirculation



- Lab scale: digestate recirculation increased methane production by 8.24 ± 0.35% compared to the reference reactors
- Reduction of demand for fresh water and urea
- Decrease of possible waste streams and thus energy intensive cleaning tech

Reference: Knötig et al (2025) : Operation of a pilot scale biorefinery - for renewable methane and value adding by-products, EUBCE 2025, 3BO.9, 10.06.2025 Valencia

Conclusion

Resource and product diversification for net zero by 2050

- Biomass as renewable carbon source of importance
  >> regional and temporal resolution of biomass data as still high bandwidths and large uncertainties in data for future potentials
- Existing and foreseeable sustainability requirements not fully taken into account
  >> improved reliability of the database required for strategic decisions in the bioeconomy context; e.g. expand scope of sustainability aspects (e.g. RED, agroforestry, catch crops, paludiculture, fermentation residue recycling, biobased CO_2).
- Obstacles to mobilisation due to further influencing factors and the impact of cascade effects (i.e. material before energy)
  >> cross-sectoral optimisation and mobilisation strategies for individual resources; esp. design of value cascades
- Previously rather independent sectors increasingly linked (e.g. agriculture and forestry, chemicals, food, P&P, fuels)
- Numerous new, innovative biorefinery concepts developed, often through expansion of the product range at existing plants
  >> biomass- and electricity-based technologies with a number of untapped synergies >> e.g. Pilot-SBG
- Harmonise long-term technology push and market pull policies (incl. steering instruments to lower risks) for GHG mitigation and defossilisation of all sectors >> same frame for renewable refineries independent of product application
- Renewable products essential from an international context
  >> opportunities and risks for new value chains as well as knowledge and technology transfer

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

PILOT SBG

On behalf of: Federal Ministry of Transport

DBFZ

Looking forward to keep in contact

Dr.-Ing. Franziska Müller-Langer
+49 (0)341 2434 423
franziska.mueller-langer@dbfz.de

Philipp Knötig
+49 (0)341 2434 448
philipp.knoetig@dbfz.de