

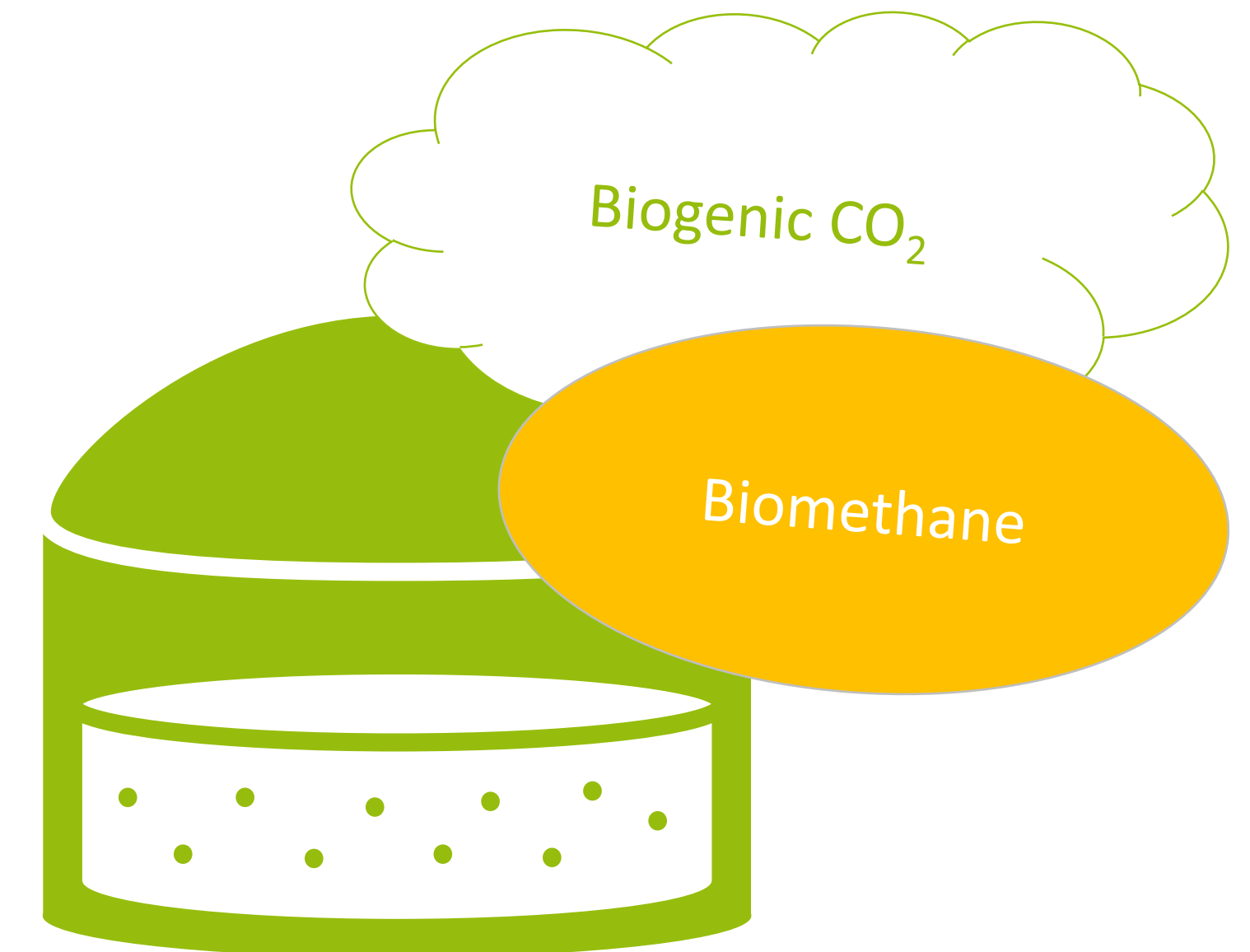
Valorisation of biogenic CO₂ from biomethane plants in Europe: current state and future prospects



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EUBCE 2025

33rd European Biomass Conference & Exhibition

9 - 12 June | Conference & Exhibition

13 June | Technical Tours

Valencia, Spain

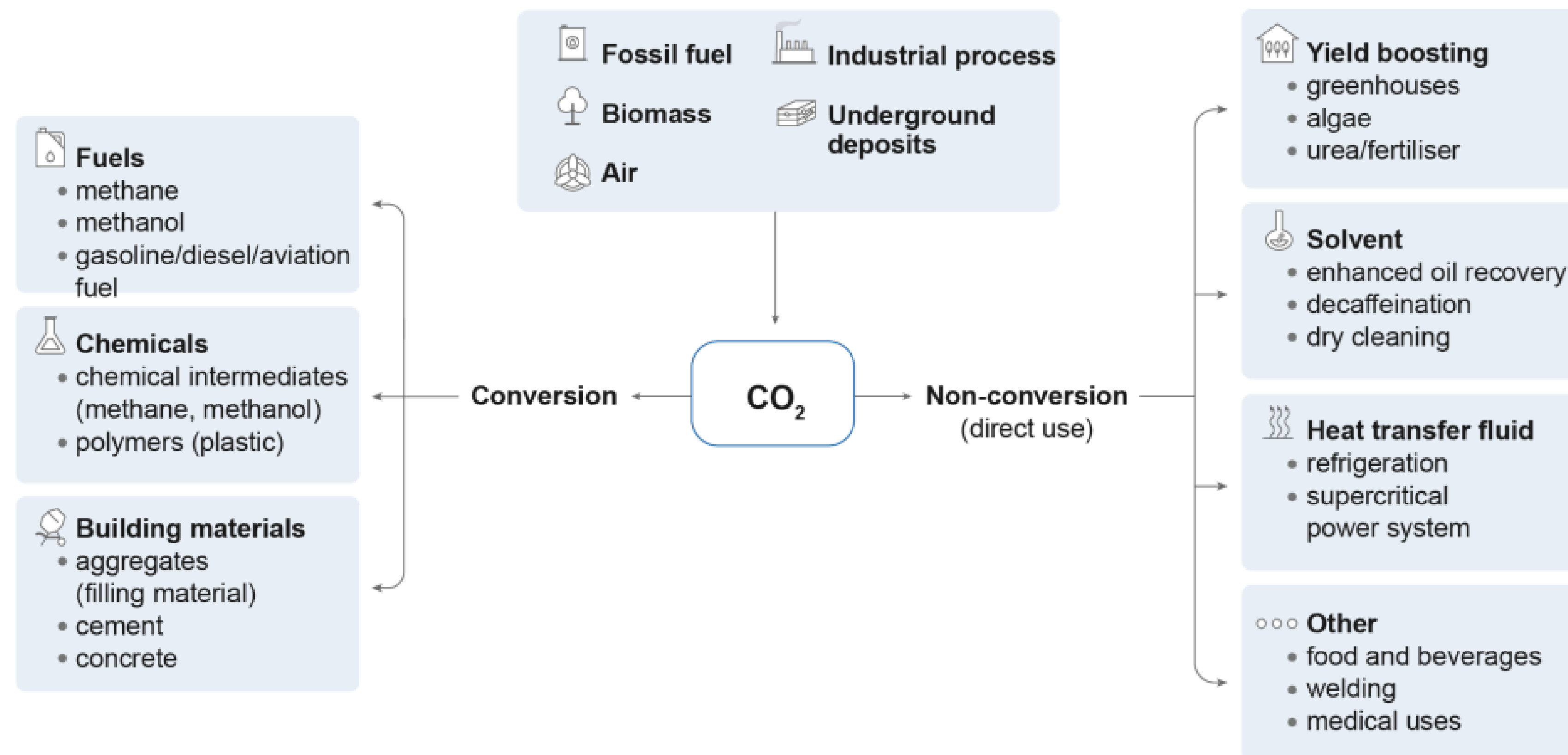


Status quo – biogenic CO₂ utilisation

- Defossilisation in order to achieve the goal of the climate neutrality in the EU by 2050 → sources providing fossil point-source CO₂ will decline
- Valorisation of **biogenic CO₂ from biomethane** represents a **dynamic and steadily growing segment** in Europe
- the **Netherlands and the UK** can be seen as **pioneers in CO₂ valorisation from biogas upgrading** primarily for air enrichment in greenhouses
- **competitive advantage of biogenic CO₂ from biogas upgrading** in comparison to its fossil-derived counterpart
- CO₂ from biomethane, bioethanol plants → cheapest biogenic CO₂-Sources
- food-grade CO₂ from AD based on energy crops on par with CO₂ from yeast-based fermentation (ethanol) (related to ElGA-standard)
- Currently, the biogenic CO₂ is used for air **enrichment in greenhouses, food and beverage industry, and PtX**
- A change towards the production of **high-value biogenic CO₂-based products** cannot be observed yet

Options of CO₂ valorisation

- Many types of industrial uses representing both
- **State-of-the-art** (yield boosting, food and beverage industry) or
- **Future options** (fuels, chemicals, building materials)

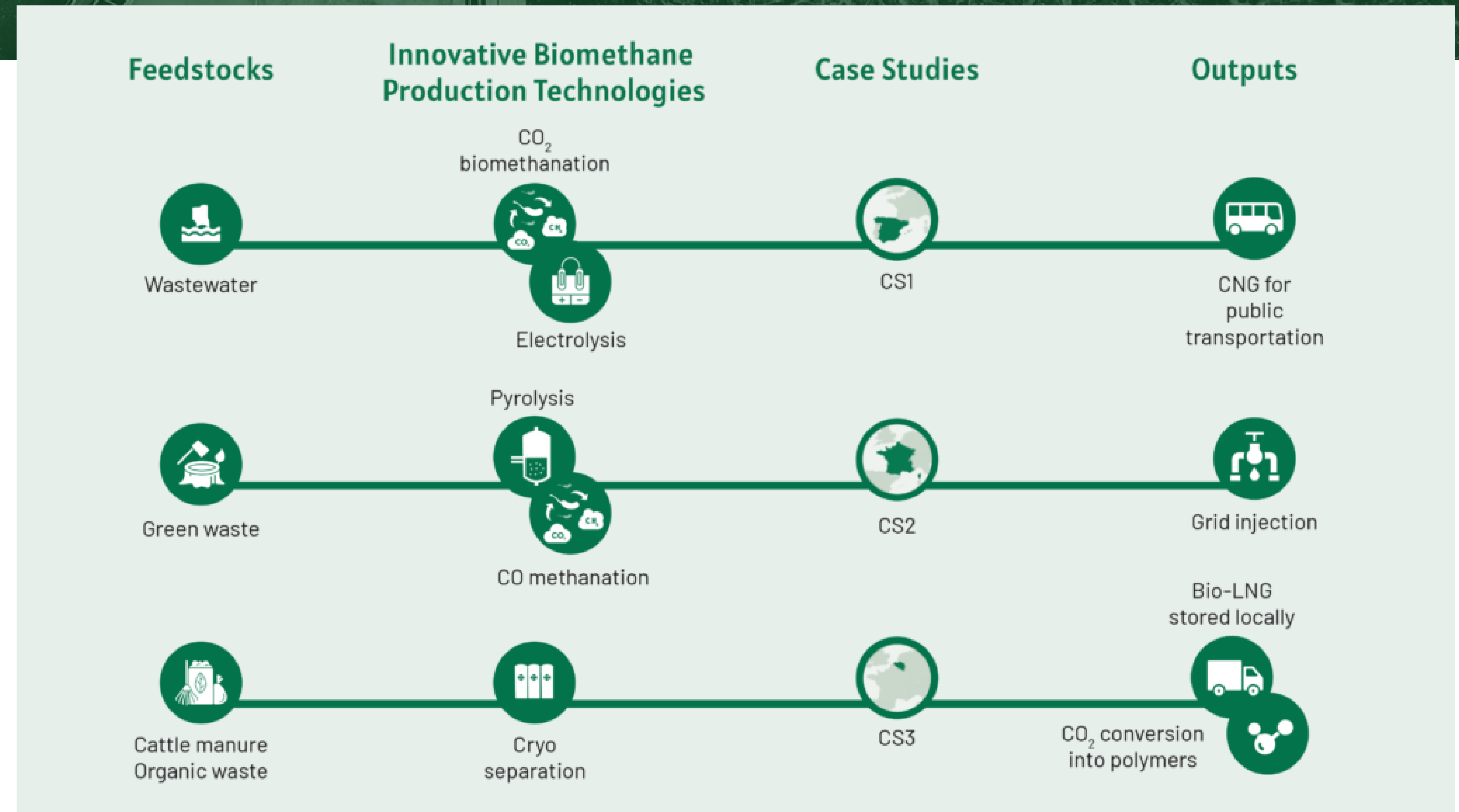


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SEMPRE-BIO (SEcuring domestic PRoduction of cost-Effective BIOMethane) - Case studies



- **CS1:** WWTP, AD 700 m³/h biogas; biogas upgrading to biomethane by innovative technologies: **(1) PEM electrolysis, (2) CO₂ bio-methanation**
- **CS2: combination of pyrolysis and bio-methanation** to produce biogas from woody biomass, biogas upgrading to biomethane (membrane separation)
- **CS3:** upgrading with **cryogenic separation, products: liquid biomethane + liquified CO₂**; value-added products from the liquified CO₂ and hydrogen: biopolymers

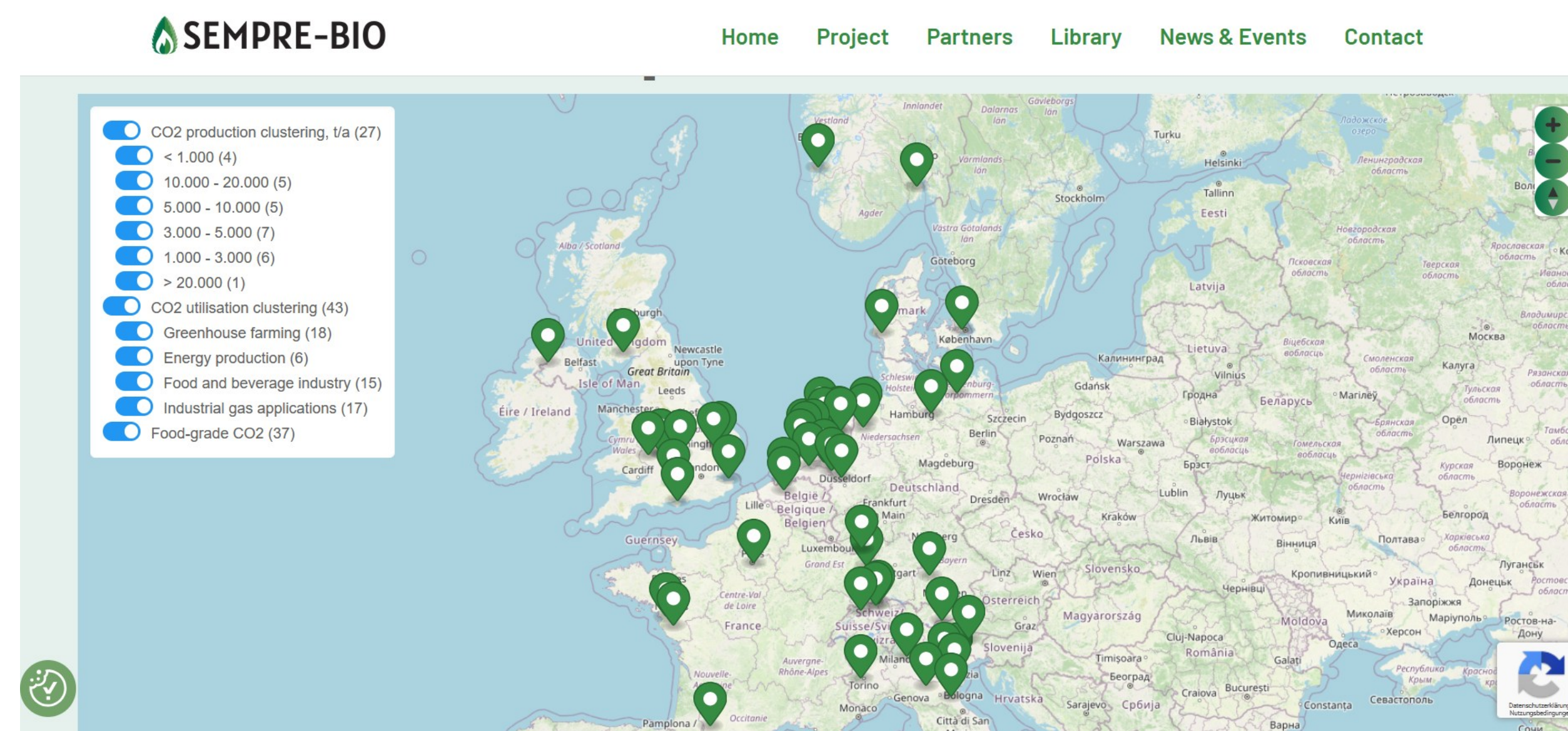


Biomethane plants with CO₂ valorisation in Europe – Report Sempre-Bio

Report by DBFZ & UVIC (D4.1) – submitted 11/2023

- Overview of current CO₂ valorisation from biogas (commercial CCU) in Europe incl. project examples by DBFZ
- Focus UVIC: Production of biopolymers, biochemicals and alternative sources of protein (biological CO₂ valorisation)

[report on CO₂ utilization](#)



<https://sempre-bio.com/co2-plants/>

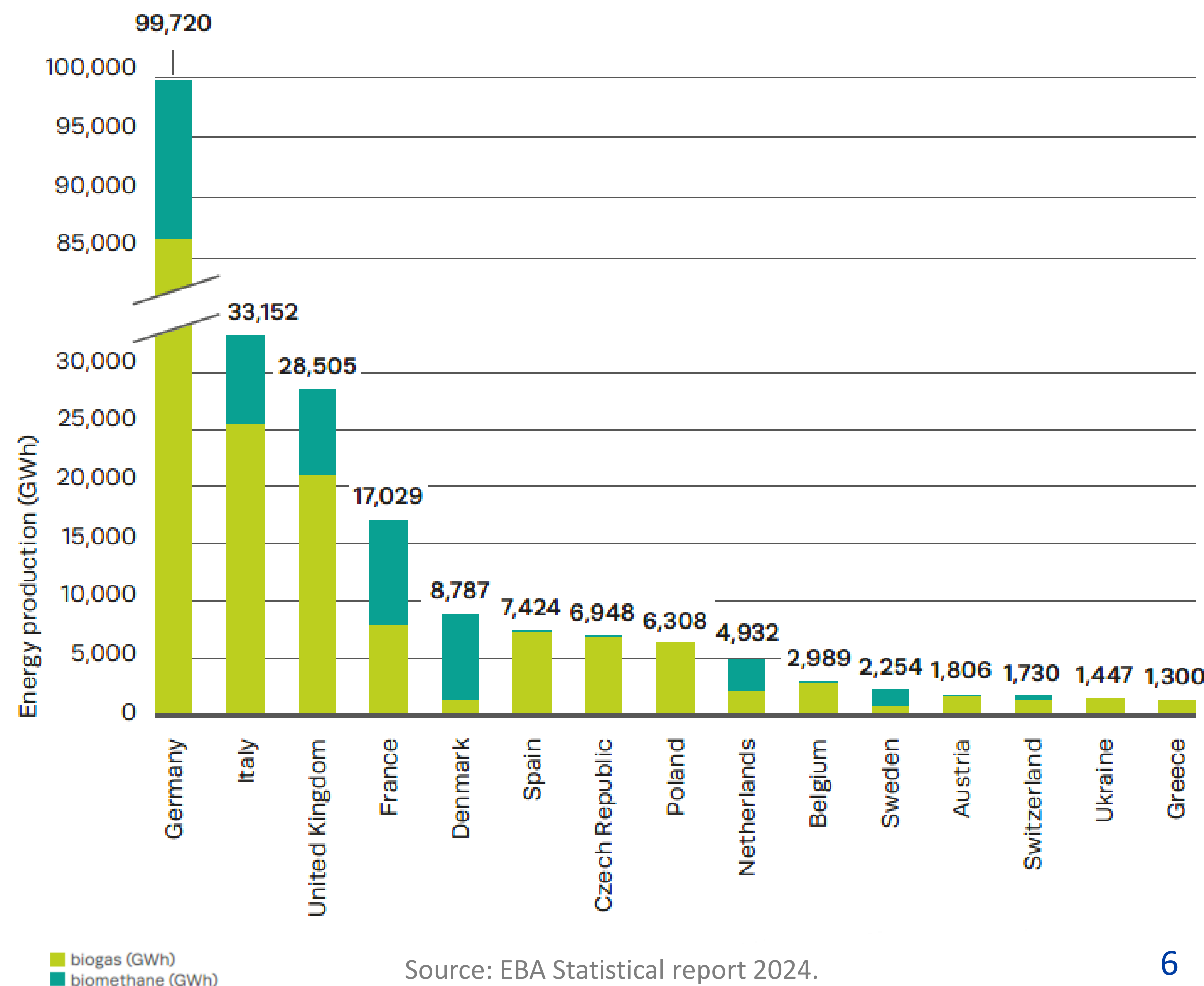
Sources: interactive map – Inveniam for Sempre-Bio website based on: Denysenko, V.; Daniel-Gromke, J.; Binder, P. M.; Foix, L. (2023): Opportunities for the valorisation of CO₂ extracted from biogas. Deliverable 4.1. EU-Projekt SEcuring doMestic PRoduction of cost-Effective BIOMethane (SEMPRE-BIO), GA 101084297, 30.11.2023.

Biogas and Biomethane production (GWh) in 2023 in Europe, top 10 countries

In total: 22 bcm of biogas are produced today in Europe (EBA 2024)

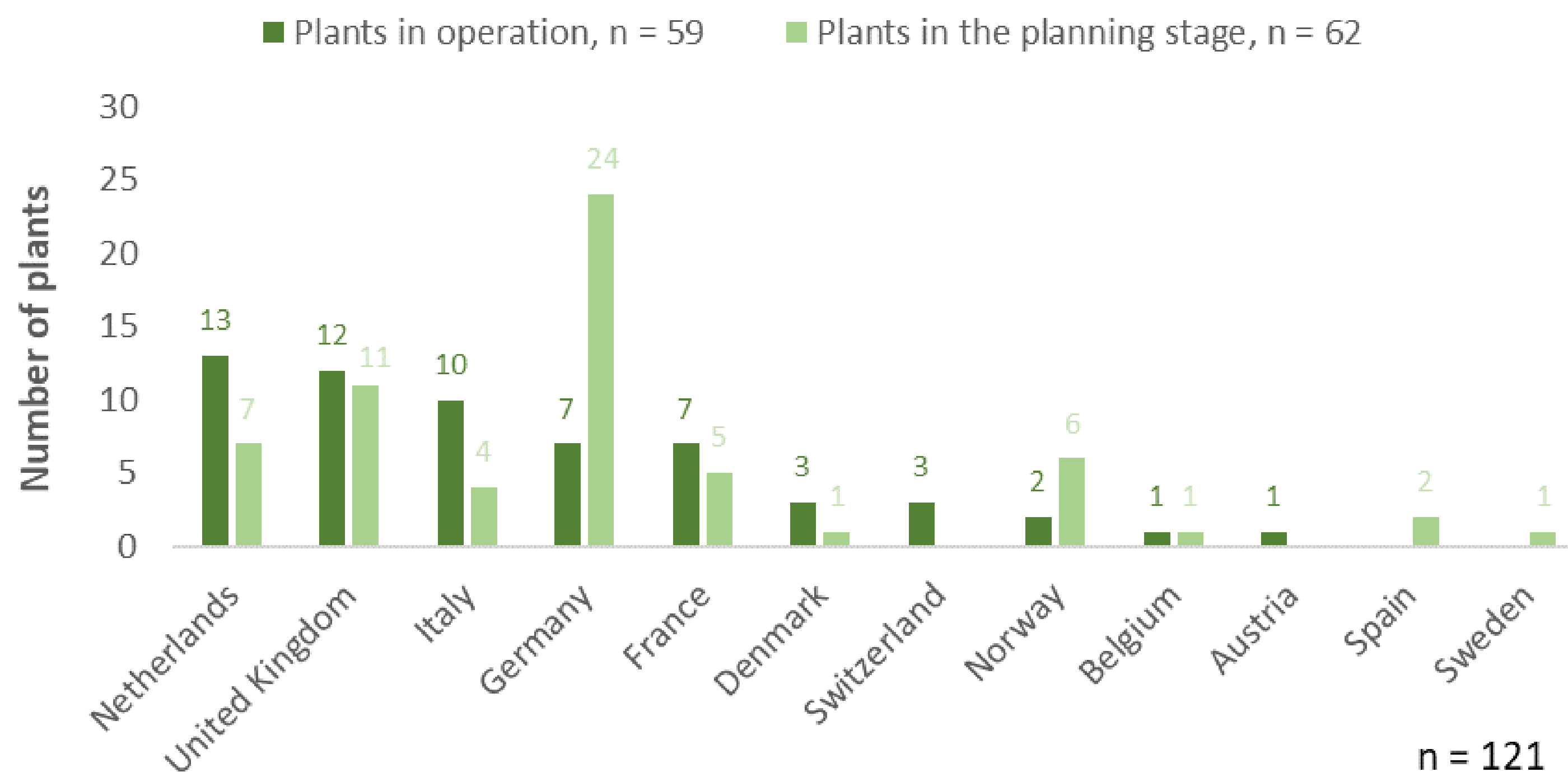
thereof biomethane:

- **1,510 biomethane plants** in Europe
- **4.9 bcm (or 52 TWh) biomethane** production (4.1 bcm in EU-27)
- Top 5 countries: Germany, France, Italy, UK, DK
- France, Italy, Denmark, and the UK are leading the production and **scale-up of biomethane**



Source: EBA Statistical report 2024.

Biomethane plants with CO₂ valorisation in Europe



2023:

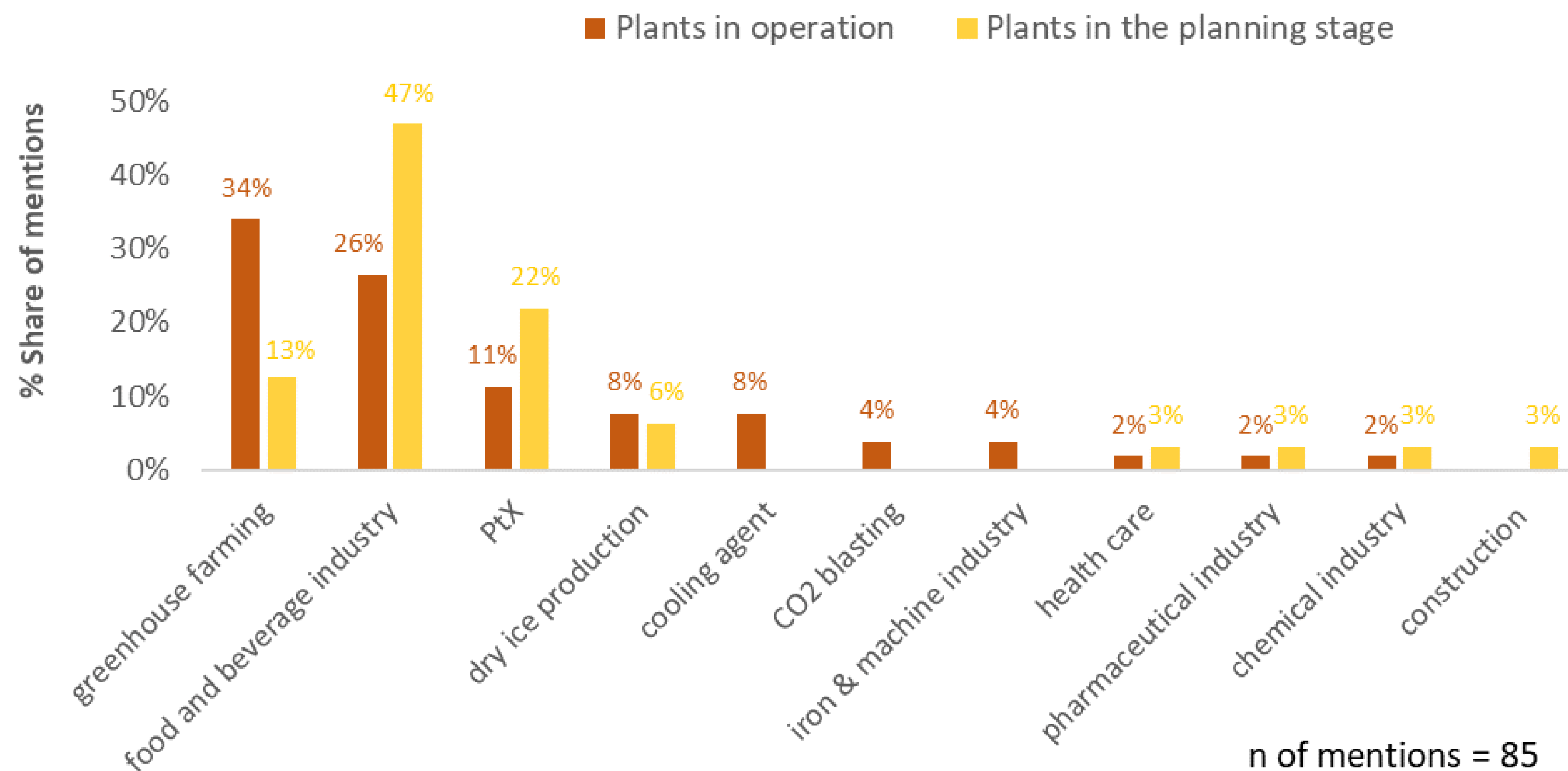
~ 120 plants with CO₂ capture and utilisation,
without CCS (Denysenko et al. 2023):

- 59 plants in operation + 62 in the planning stage
- Estimated CO₂ volume ~800,000 t/year, average ~6,600 t/plant

2025/2026

Estimation < 150 plants with CO₂ utilisation in Europe;
~ 10 % of biomethane plants in Europe with CO₂ capture (in operation and planning stage)

Distribution rate of different types of CO₂ valorisation



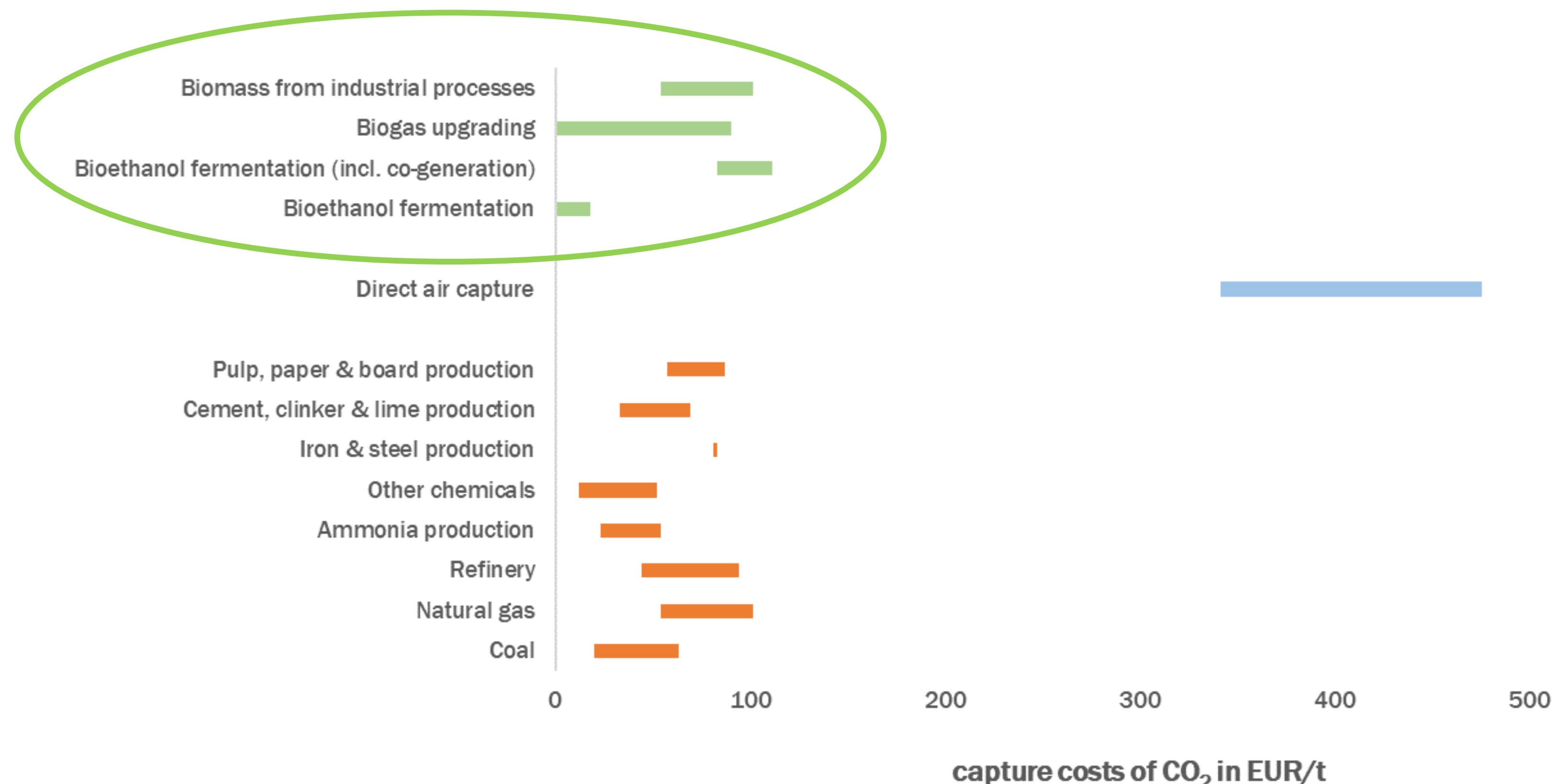
2023:

- different types of CO₂ valorisation at operational and announced CO₂ capture sites at biomethane plants in Europe (**commercial-scale CCU**); number of mentions (Denysenko et al. 2023)
- CO₂ utilisation: (increasing share of) food & beverage, greenhouse farming, PtX
- food-grade CO₂: 72% of all responses

Trend:

- emerging bio-LNG production + CO₂ valorisation
- by 2025, GER, IT + NL leading in the EU
(Source: bio-LNG forecast - European Biogas Association (2022): EBA Statistical Report 2022. 11/2022)

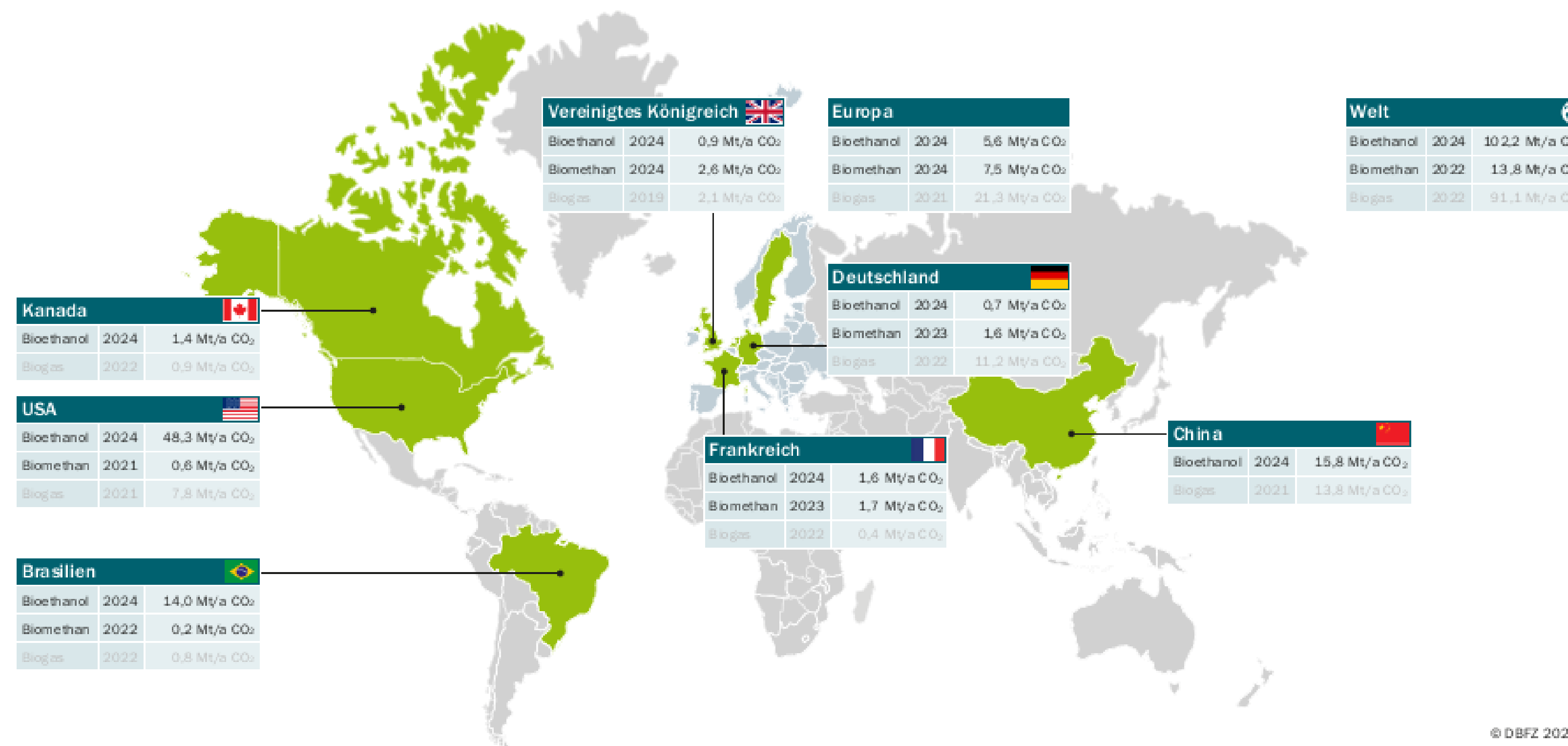
Ranges for the production costs of CO₂ - differentiated by type of sources



Source: own illustration based on Rodin et al., 2020, <https://doi.org/10.1016/j.jcou.2020.101219>

- Ranges for the production costs of CO₂ from various industrial sectors, differentiated by **biogenic**, **natural**, and **fossil** sources of CO₂
- **CO₂ capture from biogas upgrading** (CO₂ concentration 40 vol.-%) **more competitive** than Direct Air Carbon Capture (0.039 vol.-% in the atmosphere)
- price of CO₂ depends on: biomethane plant size and CO₂ capture capacity (economies of scale), State of aggregation (gaseous or liquefied), pressure level, required degree of purity, substrate input, distance to CO₂ production site, etc.

Biogenic CO₂ sources from biomass plants



Based on calculation from plant capacities:

- Bioethanol plants
- Biomethane plants
- Biogas plants (grey)

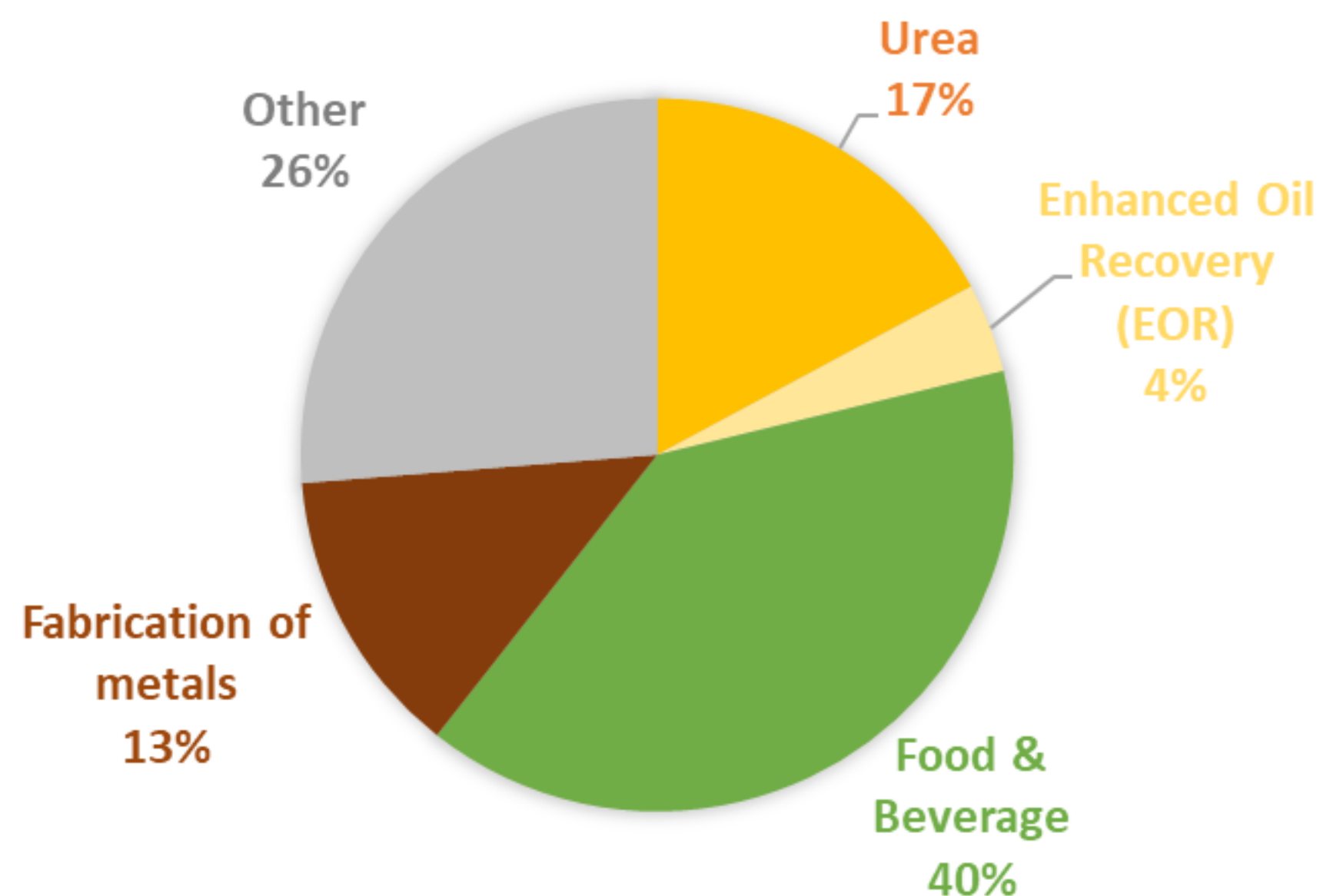
In total biogenic CO₂ from biomass plants (Europe):

- ~ 5,6 Mt/yr (bioethanol plants)
- 7,5 Mt/yr (biomethane plants)
- Additional ~21 Mt/yr possible in case of upgrading biogas to biomethane in existing biogas plants

Schröder & Görsch (ed.) 2025: Erneuerbare Energien im Verkehr. Monitoringbericht. DBFZ 2025. Online: https://www.dbfz.de/fileadmin/user_upload/Referenzen/Studien/Monitoring_Verkehr_DBFZ_2025.pdf

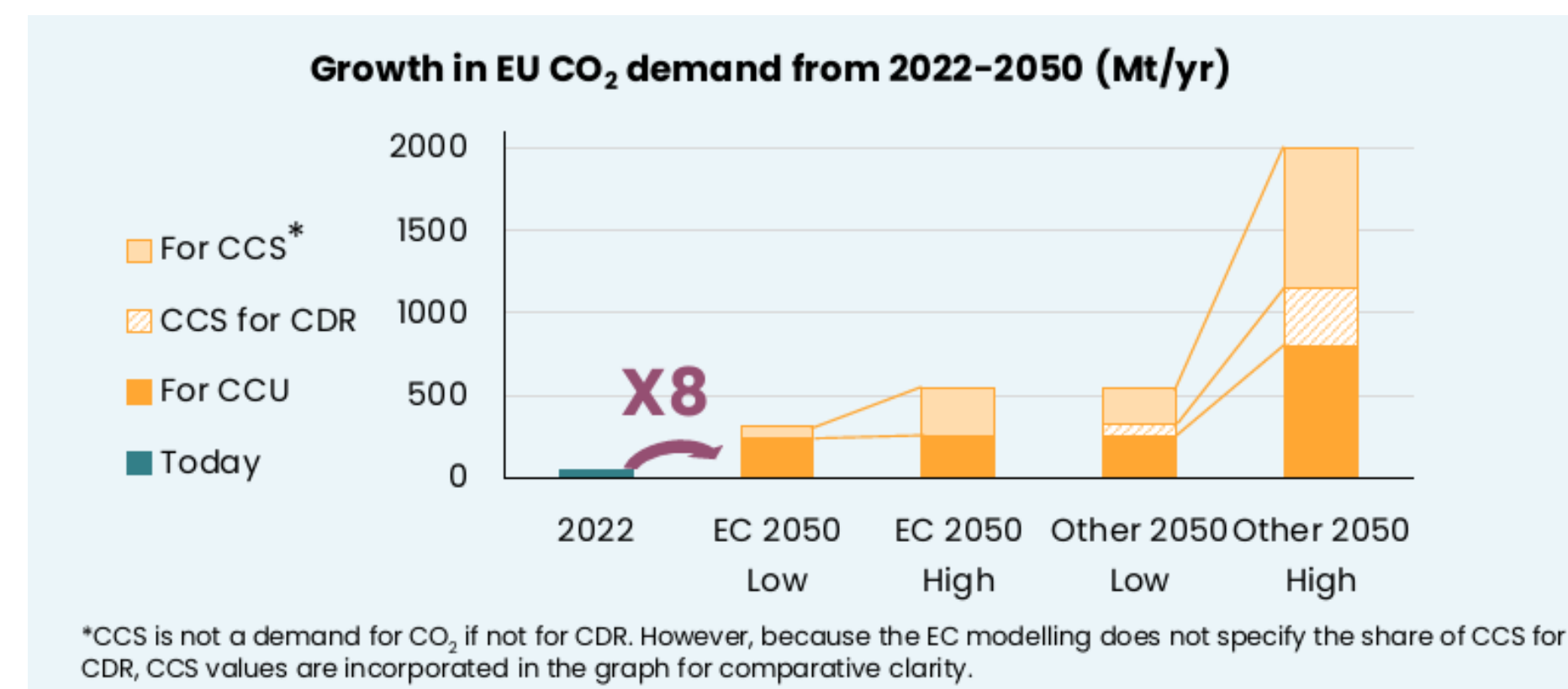
Current and future CO₂ demand Europe

Estimated European CO₂ Demand (2020)



Estimated European CO₂ demand in 2020 (Source: ERM Group, 2022 <https://www.schwenk.de/wp-content/uploads/2022/12/Assessment-of-European-biogenic-CO2-balance-for-SAF-production-v3.0.pdf>)

- Today, about **2 Mt of biogenic CO₂ are captured per year**, with **90 % being captured in bioethanol applications** representing one of the lowest-cost technologies with the high CO₂ concentration in the process gas stream (IEA, 2023)
- **European demand for CO₂ is estimated to be 41 Mt per year** which is 16% of global demand (calculated based on IEA, 2019).
- **CCU demand in 2050 is expected to be more than 6 times higher than the total current CO₂ demand.** Several studies estimating the future demand for CO₂ indicate a large range in the potential EU demand of ~250-800 Mt CO₂/yr for CCU, e.g. for e-fuel production, in 2050 (BIP Europe, 2024)



Source: BIP, 2024 https://bip-europe.eu/wp-content/uploads/2024/04/BIP_Task-Force-4.1_BioCO2-And-Biomethane_Apr2024.pdf

Perspectives

- **46 Mt of biogenic CO₂** could be captured in Europe **by 2030, 124 Mt of biogenic CO₂ by 2050** as a result of the goals to increase biomethane production (EBA 2023)
- competition for **biogenic CO₂ increase** due the higher demand (especially industrial processes)
- emerging market of **bio-LNG production with parallel CO₂ valorisation** in Europe
- change towards the production of high-value biogenic CO₂-based products not yet apparent but expected
- Direct Air Carbon Capture currently cost- and energy-intensive but expected to gain more relevance (long term)
- **Whole value chain to consider** (biomethane, biogenic CO₂, digestate, by-products etc.)
→ overall assessment necessary



Thank you & many thanks to all contributing partners!

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