Anaerobic bioprocesses towards the conversion of carbon dioxide into bio-based products: a short review

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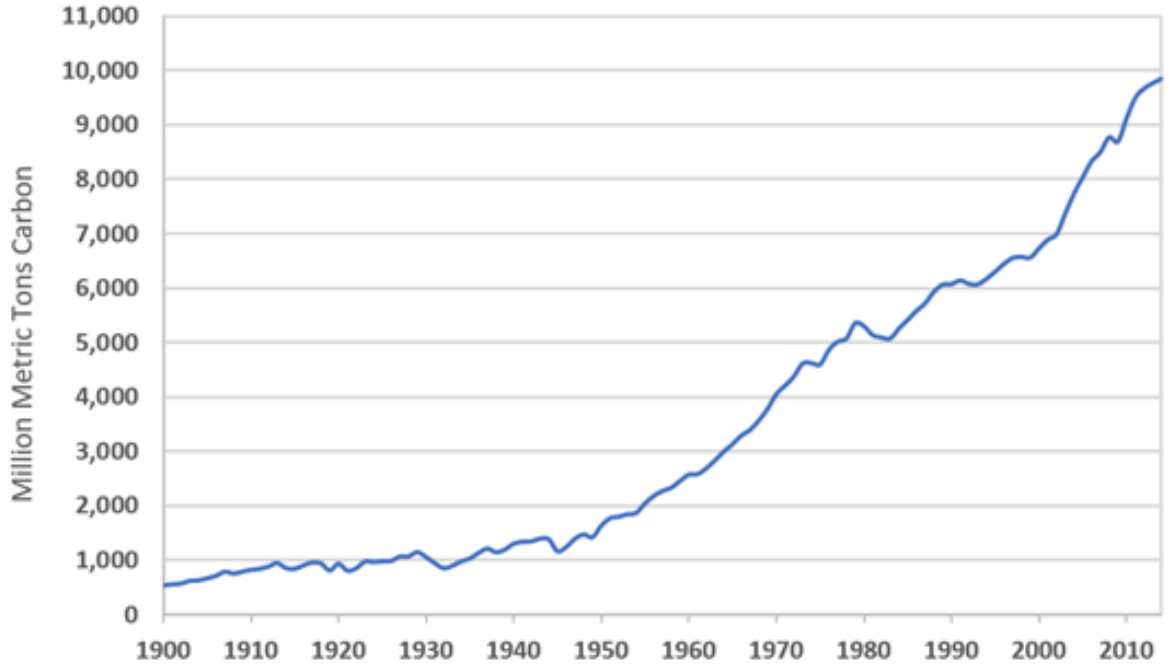
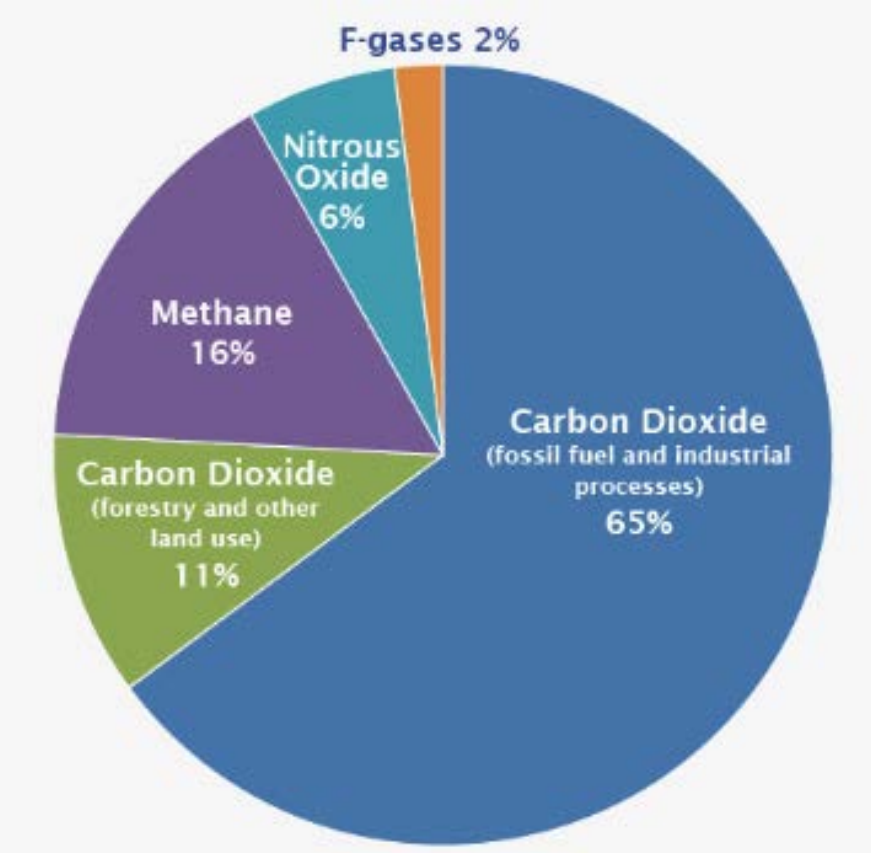
Global Greenhouse Gas Emissions

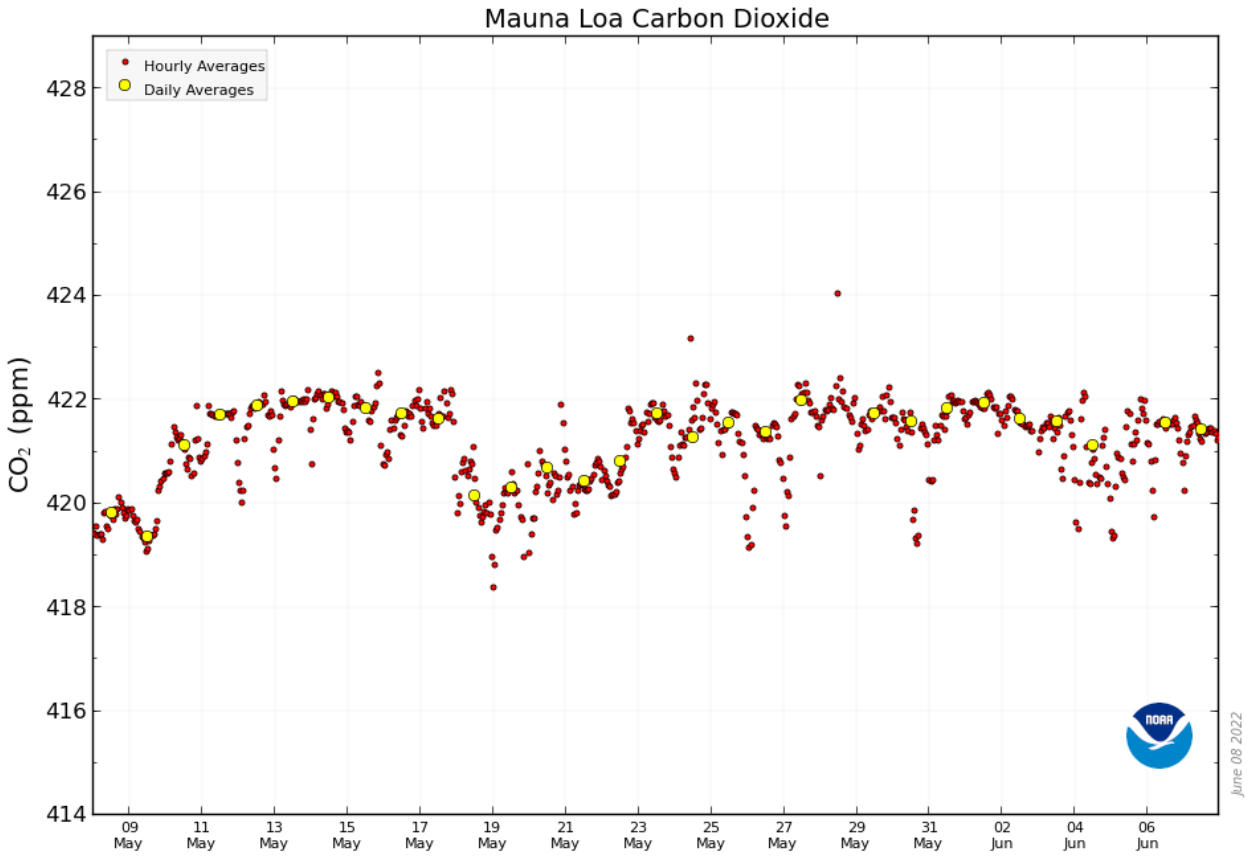


Source: Boden, T.A., Marland, G., and Andres, R.J. (2017). Global, Regional, and National Fossil-Fuel CO2Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. doi 10.3334/CDIAC/00001_V2017.



https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

Daily CO_2 concentration in the atmosphere



Jun. 7, 2022	**421.42 ppm**
Jun. 7, 2021	**419.80 ppm**
1 Year Change	1.62 ppm (0.39%)

https://www.co2.earth/daily-co2

From waste to new resources

- Carbon neutrality by 2050
- Waste, wastewater and activated sludge represent biomass and potential untapped resources
- These can be converted into bioenergy and bio-based products through conversion bioprocesses
- Green Revolution and Ecological Transition

https://ec.europa.eu/info/index_it

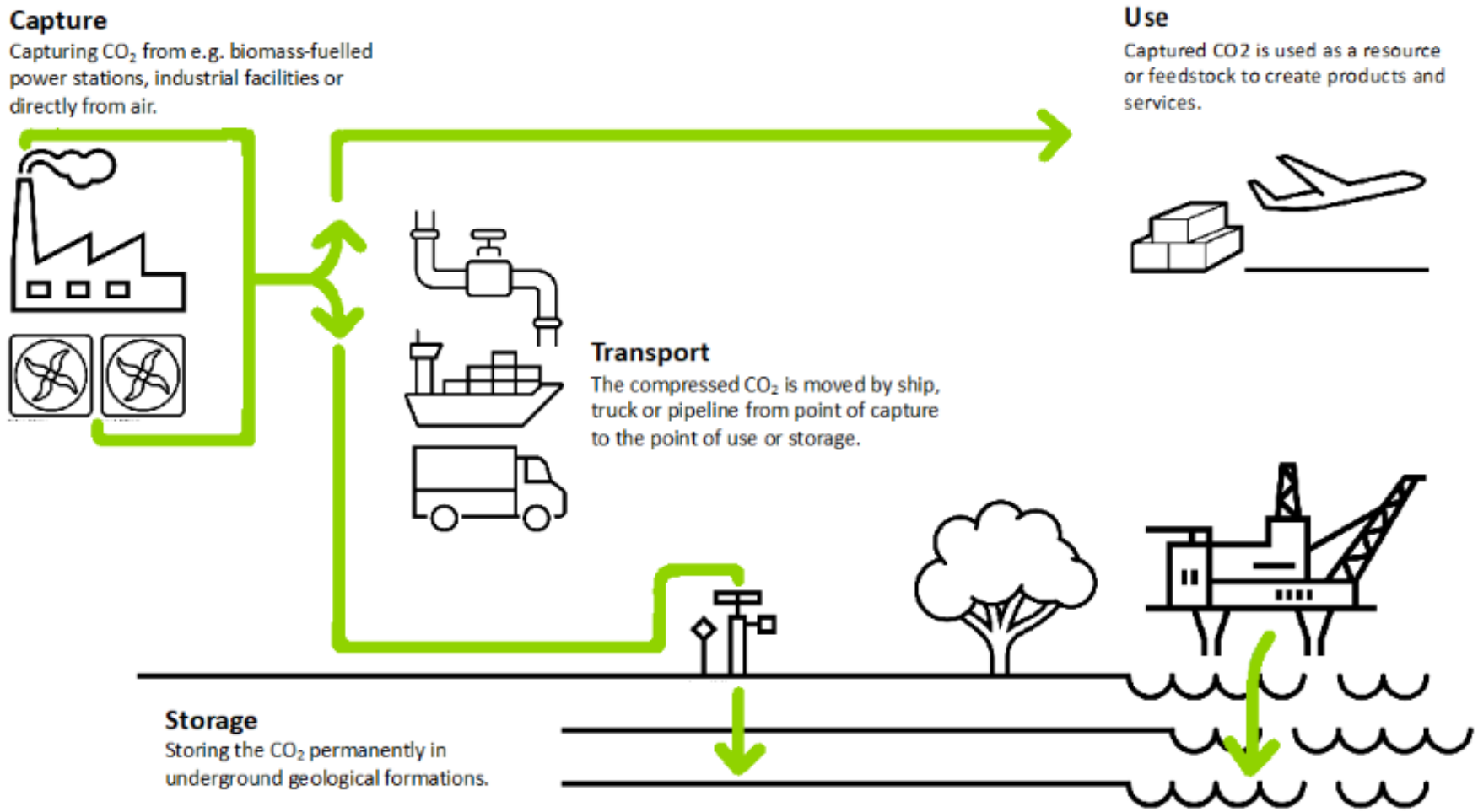
EU Emission Trading System (ETS)

- Mitigation of carbon dioxide (CO_2) emissions
- Reduce emissions through systems that capture them
- The EU Emissions Trading System (ETS), sets a price for carbon and reduces the cap applicable to emissions from certain economic sectors each year

CO_2 market price: around 90 €/ton

EU Carbon Permits - 2022 Data - 2005-2021 Historical - 2023 Forecast - Price - Quote (tradingeconomics.com)

Carbon capture, use and storage

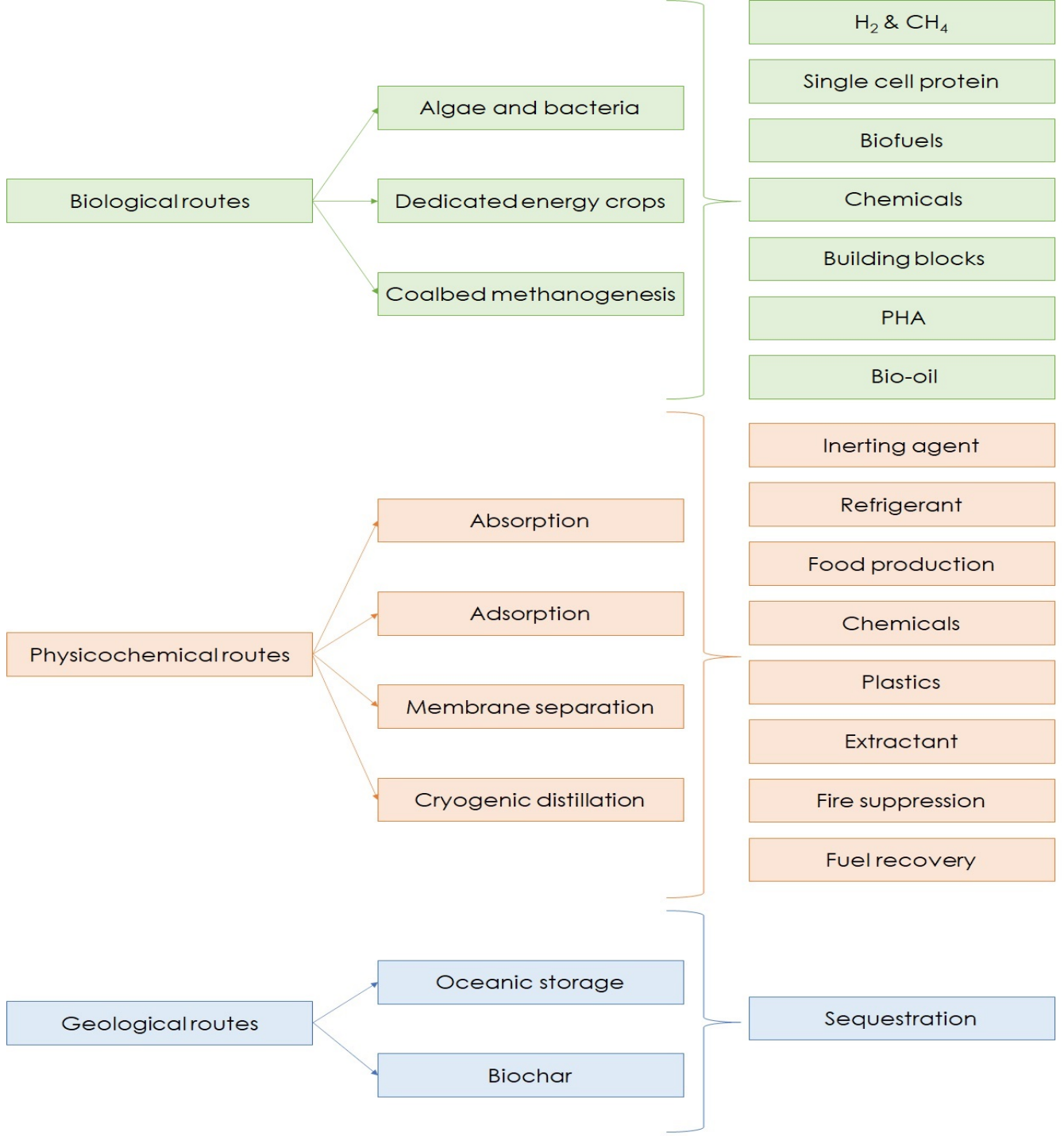


https://ec.europa.eu/clima/eu-action/carbon-capture-use-and-storage_es

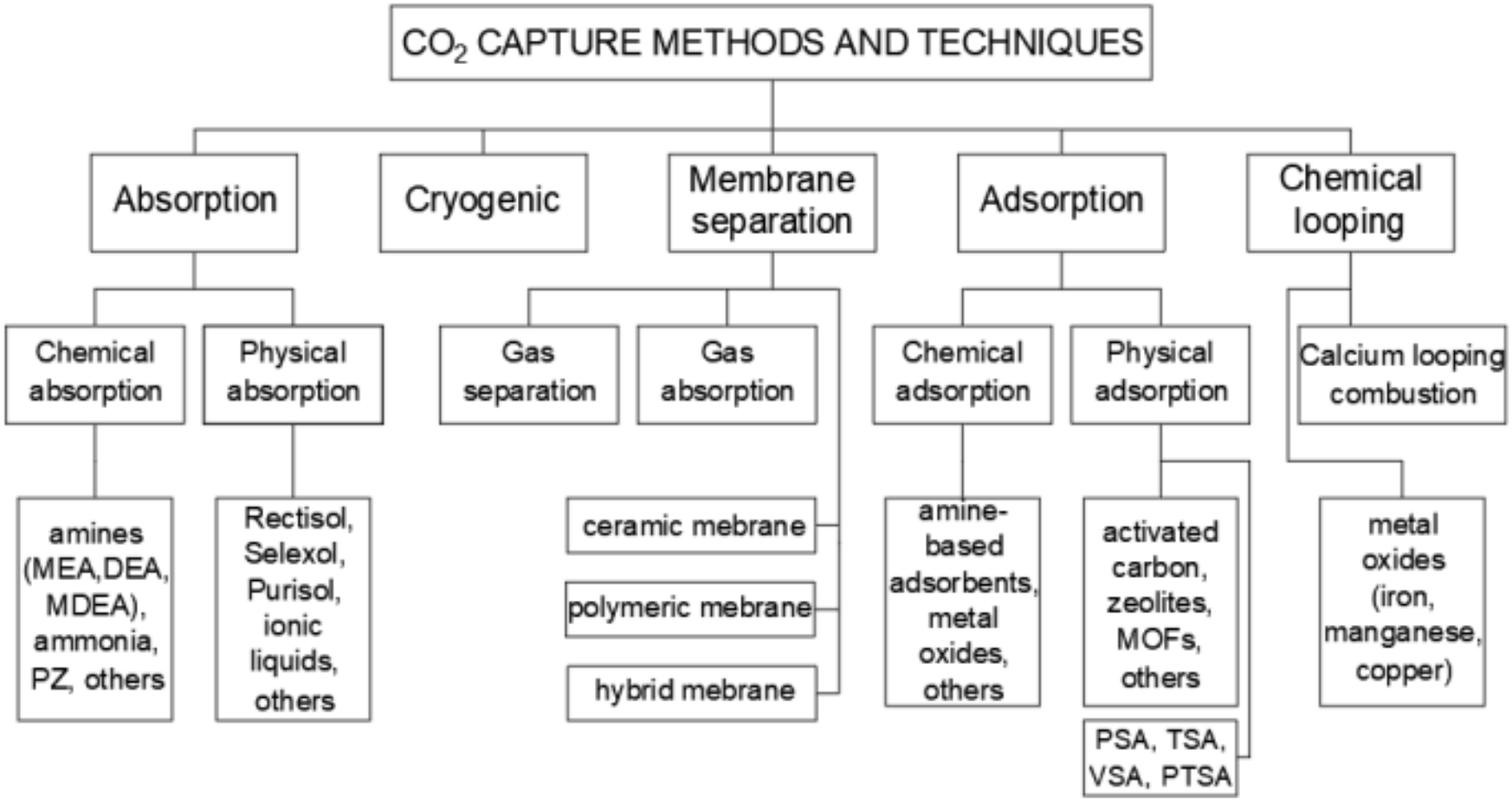
Carbon dioxide capture/sequestration and conversion

- **Capture/sequestration**: geological confinement process of carbon dioxide (CO_2) produced by large combustion plants

- **Conversion** (transformation) of CO_2 into new bio-products of interest



Capture of carbon dioxide through different physicochemical methods

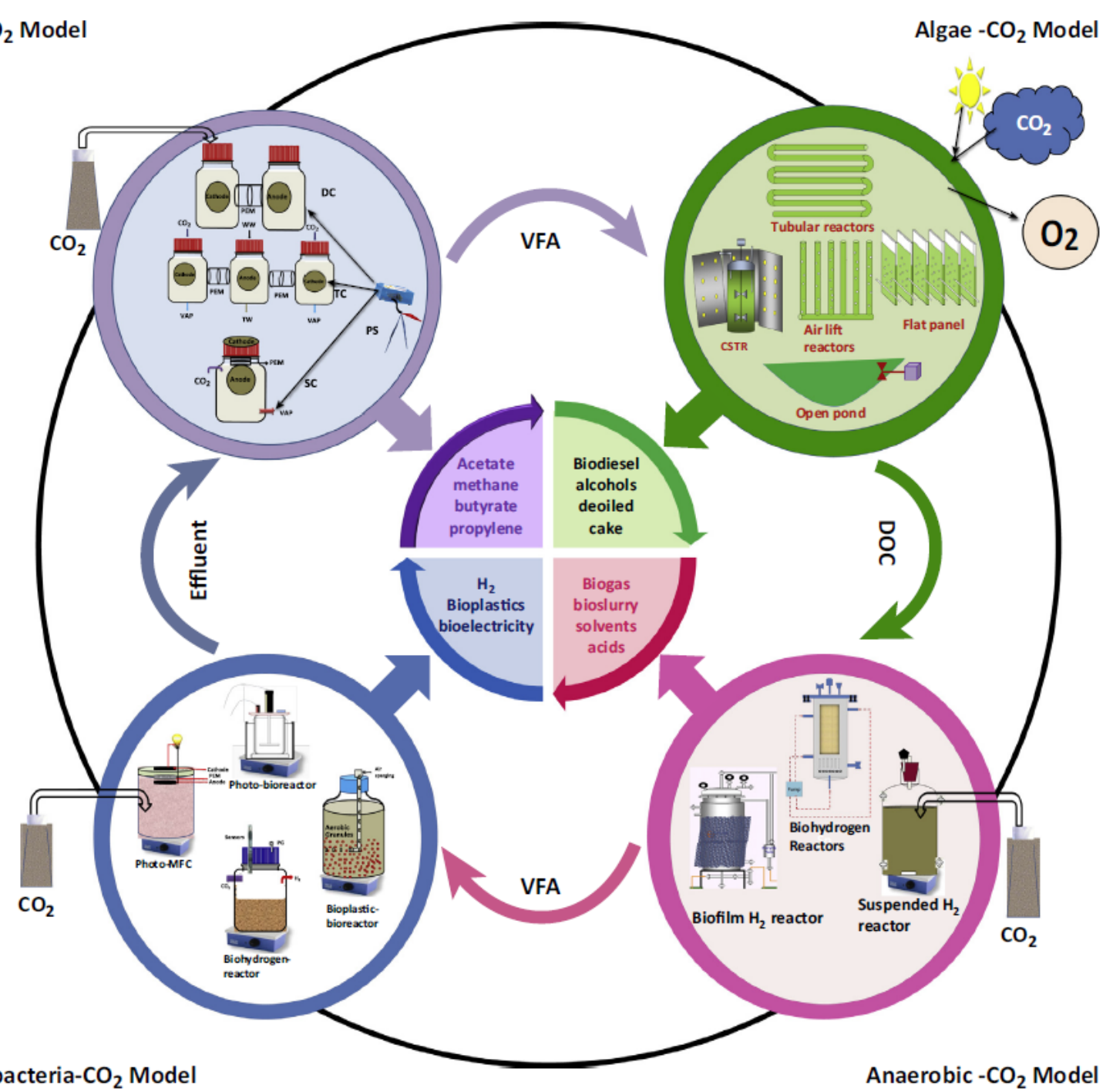


Madejski P, Chmiel K, Subramanian N, Kuś T. Methods and Techniques for CO_2 Capture: Review of Potential Solutions and Applications in Modern Energy Technologies. *Energies.* 2022; 15(3):887. https://doi.org/10.3390/en15030887

Bioconversion of carbon dioxide into bio-based products

Bio-based products:

- Building blocks (eg., VFAs)
- H_2 & CH_4
- Biodiesel
- Polyhydroxyalkanoates (PHAs)
- Bio-oil
- Single cell proteins

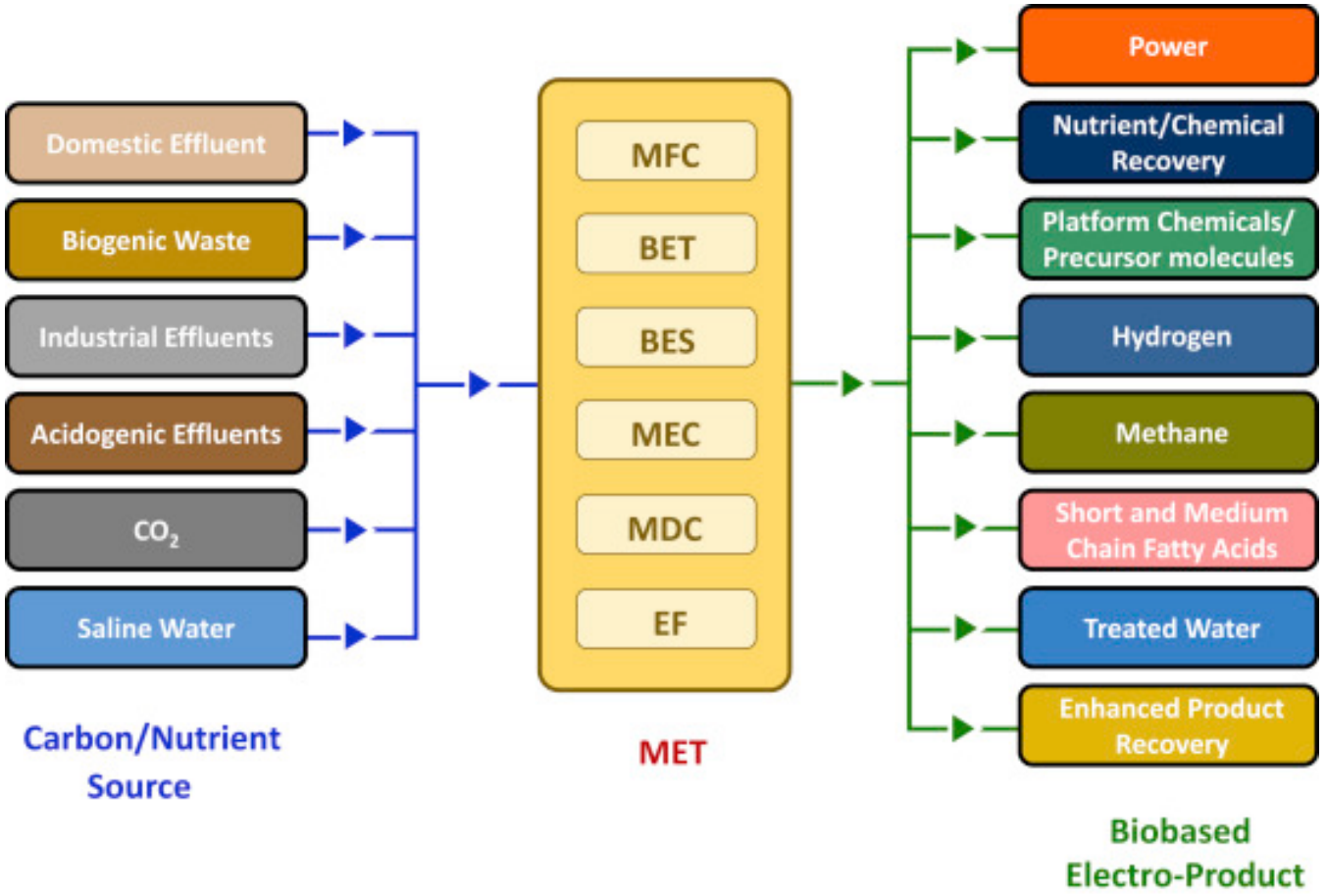


Venkata Mohan S, Modestra JA, Amulya K, Butti SK, Velvizhi G. A Circular Bioeconomy with Biobased Products from CO2 Sequestration. Trends Biotechnol. 2016 Jun;34(6):506-519. doi: 10.1016/j.tibtech.2016.02.012. Epub 2016 Apr 2.

From waste to new products

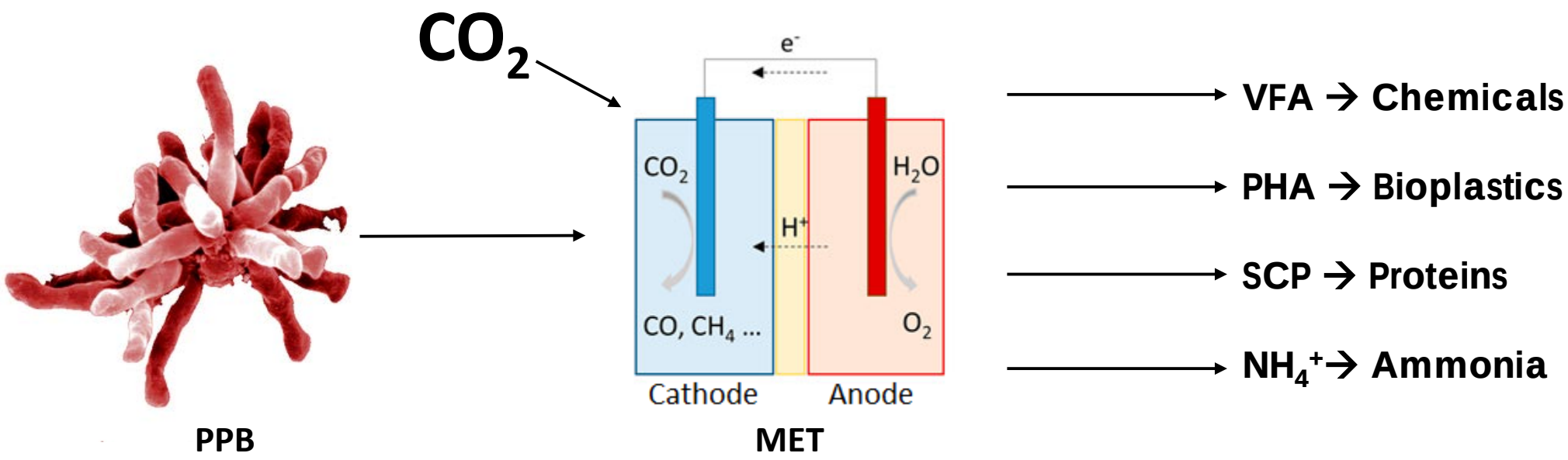
Chemical Processes:
$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$ $\Delta G^0 = -113,5$ kJ/mol
using Ni catalyst

Biological Processes:
$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$ $\Delta G^0 = -130,7$ kJ/mol



S. Venkata Mohan, J. Shanthi Sravan, Sai Kishore Butti, K. Vamshi Krishna, J. Annie Modestra, G. Velvizhi, A. Naresh Kumar, Sunita Varjani, Ashok Pandey, Chapter 1.1 - Microbial Electrochemical Technology: Emerging and Sustainable Platform,

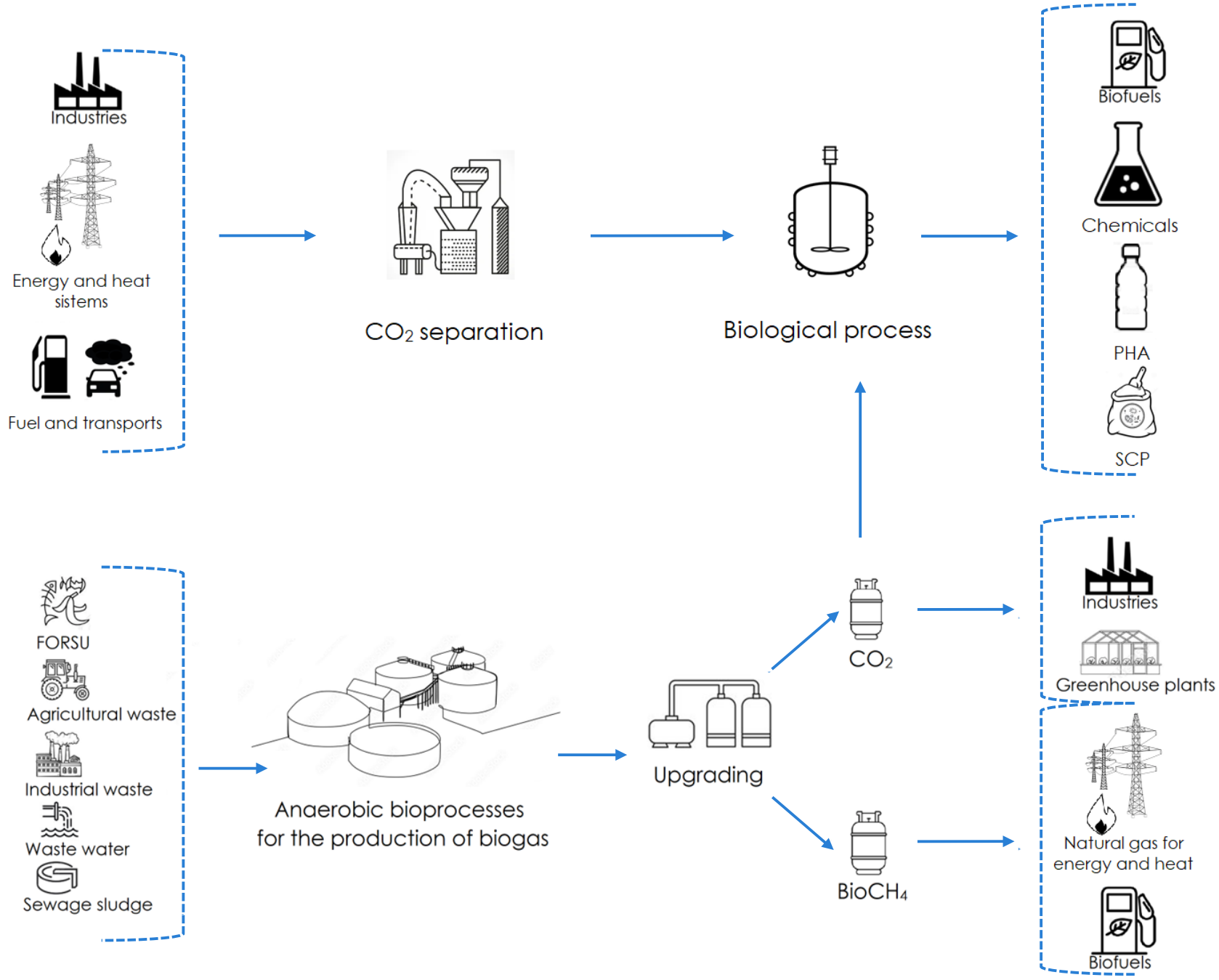
From waste to new products



Purple phototrophic bacteria are versatile microorganisms with multiple metabolisms:

- CO_2 can be converted into several bio-based products
- N_2 fixation can be accomplished during CO_2 conversion

Anaerobic biorefineries



Technical/economical/legislation barriers

Lack of technical expertise
due to long industry chain

Resource usage at scale
removing 1 Gtpa could consume as much as 1.4x the total electricity generation for the EU in 2018

Technology performance
CCS still in developing phase with uncertainty in performance

CAPEX uncertainly
immaturity of CCUS & uniqueness of industrial sites limits replicability & cost estimation

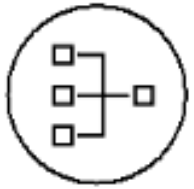
OPEX uncertainty
uncertainty of future oil prices

Risk perception
investors require high ROI due to high risk

Lack of revenue model
due to low CO_2 prices & insufficient utilisation opportunities

Uncertainty in demand
for industrial products

Public resistance
often because of lack of knowledge



Policy uncertainty
lack of comprehensive frameworks and business models to facilitate CCUS

Regulations & infrastructure
admin causes 5-10 year delays and slow the pace of construction

Cross-chain integration
many uncertainties in coordination between many stakeholders, volume risk of CO_2 & CO_2 reliability transfer

https://ec.europa.eu/clima/eu-action/carbon-capture-use-and-storage_en#barriers

Thank you for your attention

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