TURNING CO_2 INTO VALUE

FUELS & CHEMICALS FROM SOLAR ENERGY | THE PHOTO2FUEL JOURNEY

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ORGANISED BY: Kneia idener

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The Pursuit of Sustainable CO_2 Utilization Technologies

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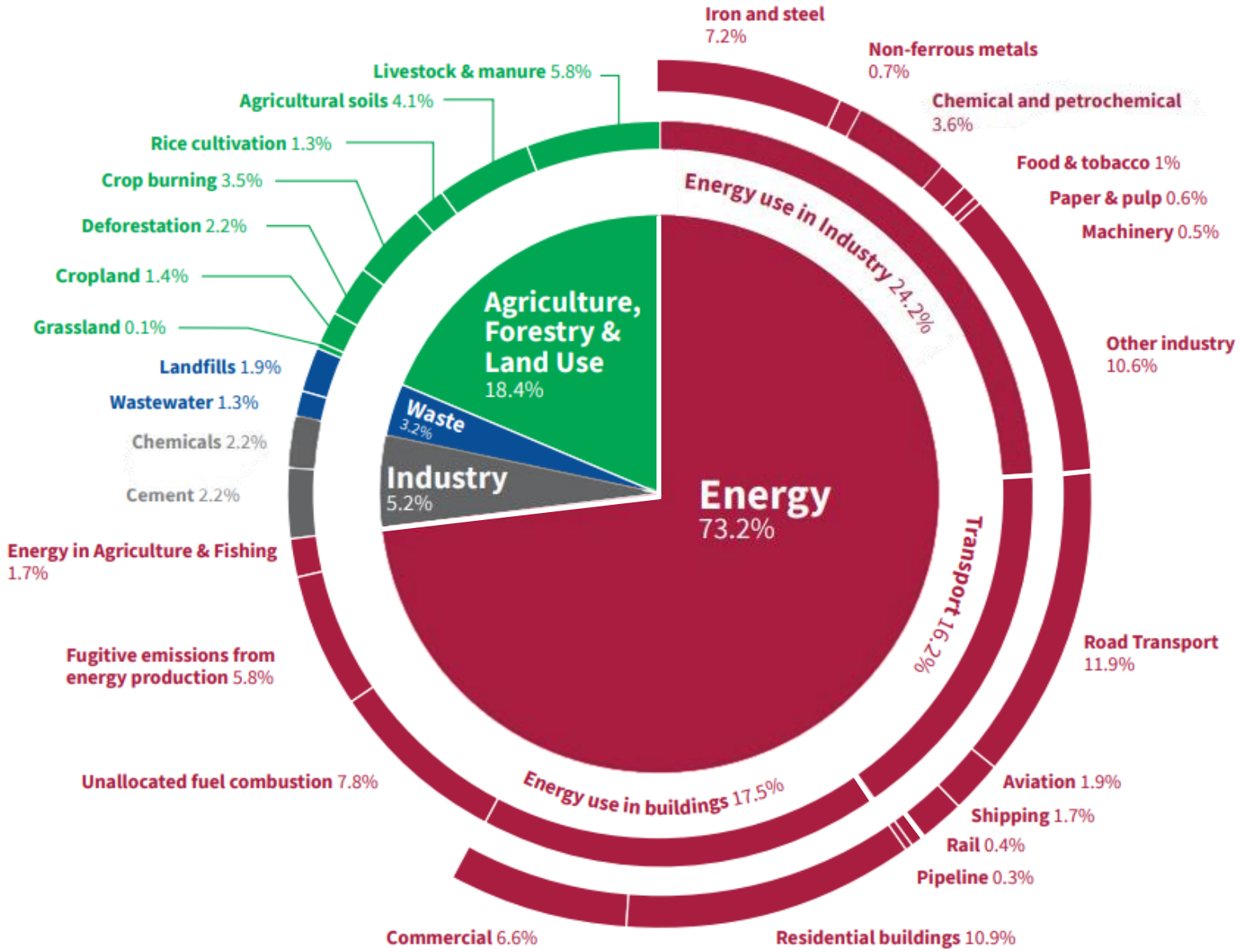
ETH Zurich

Energy and industry account for 80% of global GHG emissions

ETH zürich

The synthesis of chemicals is responsible for 6% of the annual GHG emissions

Reaching net zero emissions by 2050 requires a drastic change



[1] https://ourworldindata.org/ghg-emissions-by-sector, **2020**

Current fossil-based chemical industry is unsustainable

ETH zürich

Fossil carbon and energy

Renewable carbon and energy

[1] Galán-Martín, Á. *et al. One Earth*, **2021** (DOI: 10.1016/j.oneear.2021.04.001)

Decarbonization of chemicals and fuels is resource intensive

Water splitting

Oil extraction

Direct air capture (DAC)

Low material efficiency

Fischer-Tropsch (FT)

Fossil oil

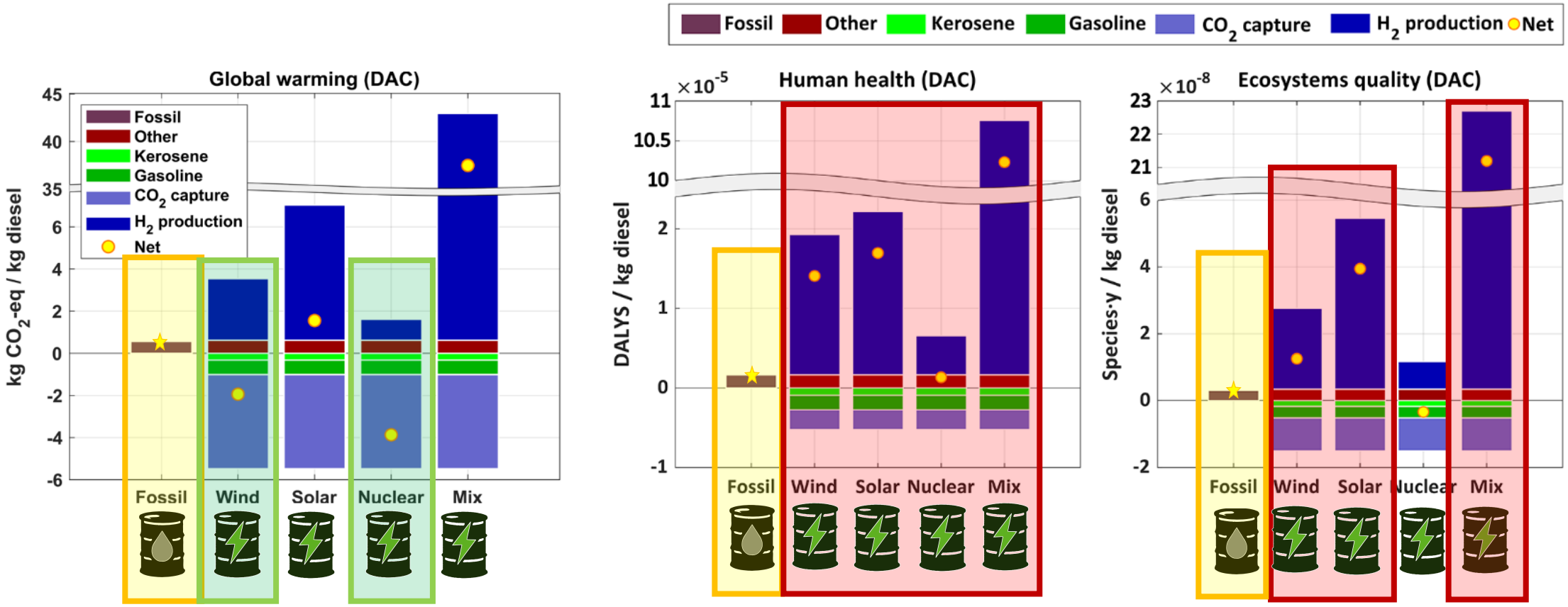
E-Gasoline

E-Kerosene

E-Diesel

High energy demand

Improving carbon footprint comes at a cost

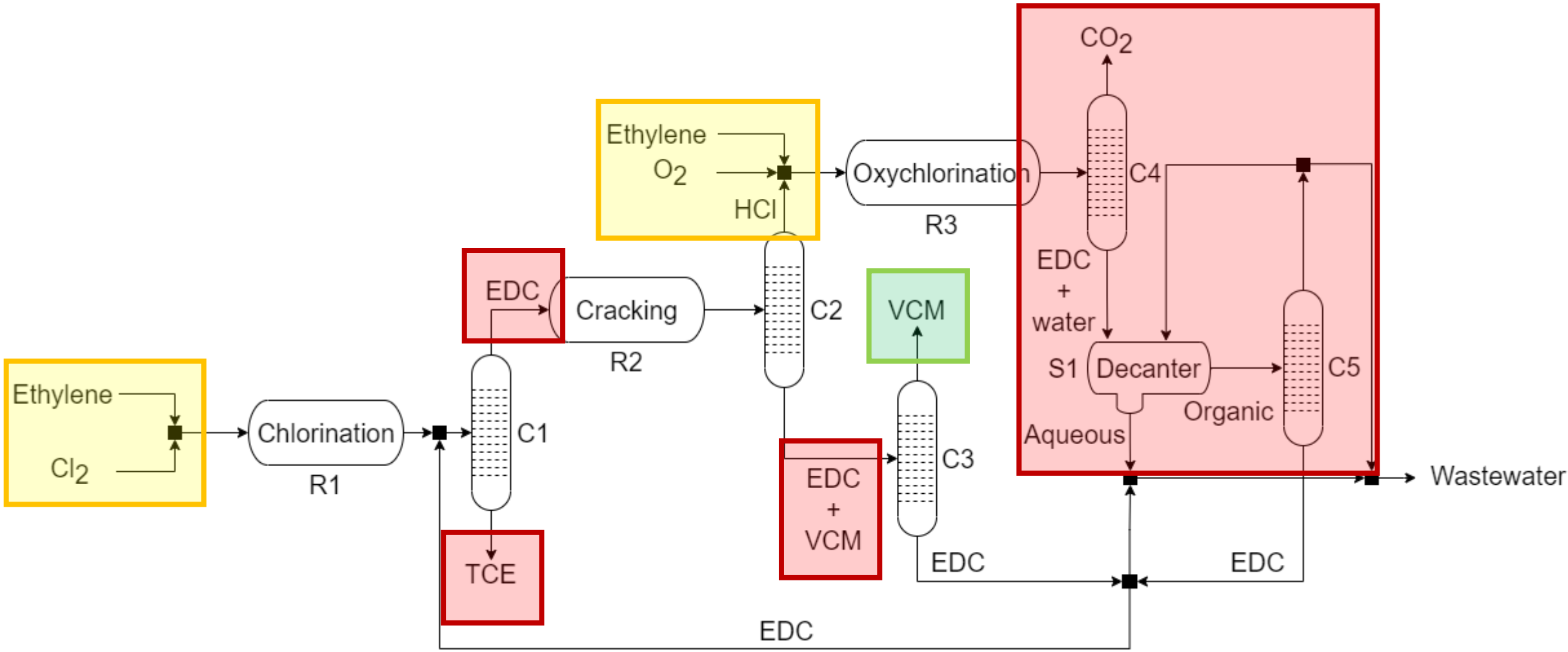


Renewable H_2 and captured CO_2 can reduce the global warming impact of chemicals and fuels synthesis...

... but usually lead to environmental burden shifting

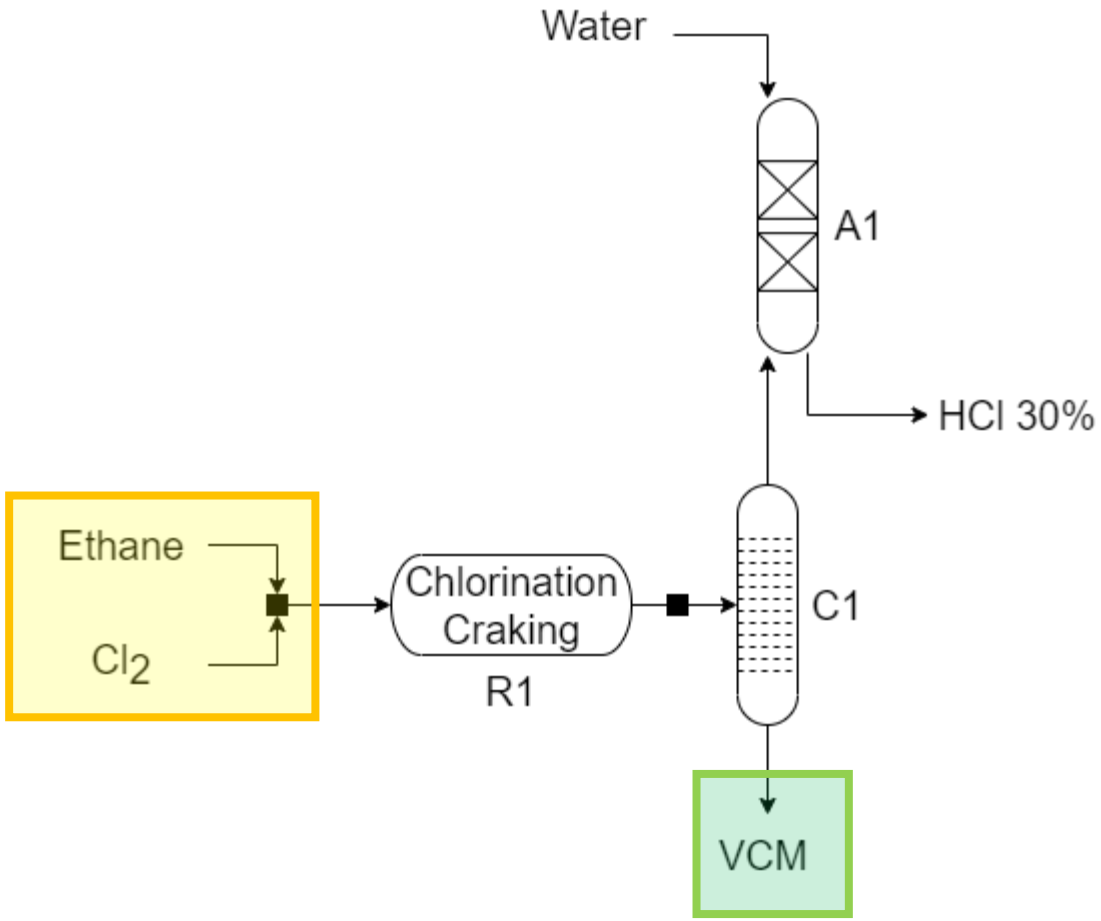
[1] Medrano-García, J. D., et al., ACS Sustain. Chem. Eng., **2022** (DOI: 10.1021/acssuschemeng.2c01983)

Vinyl chloride monomer (VCM) synthesis is energy intensive...



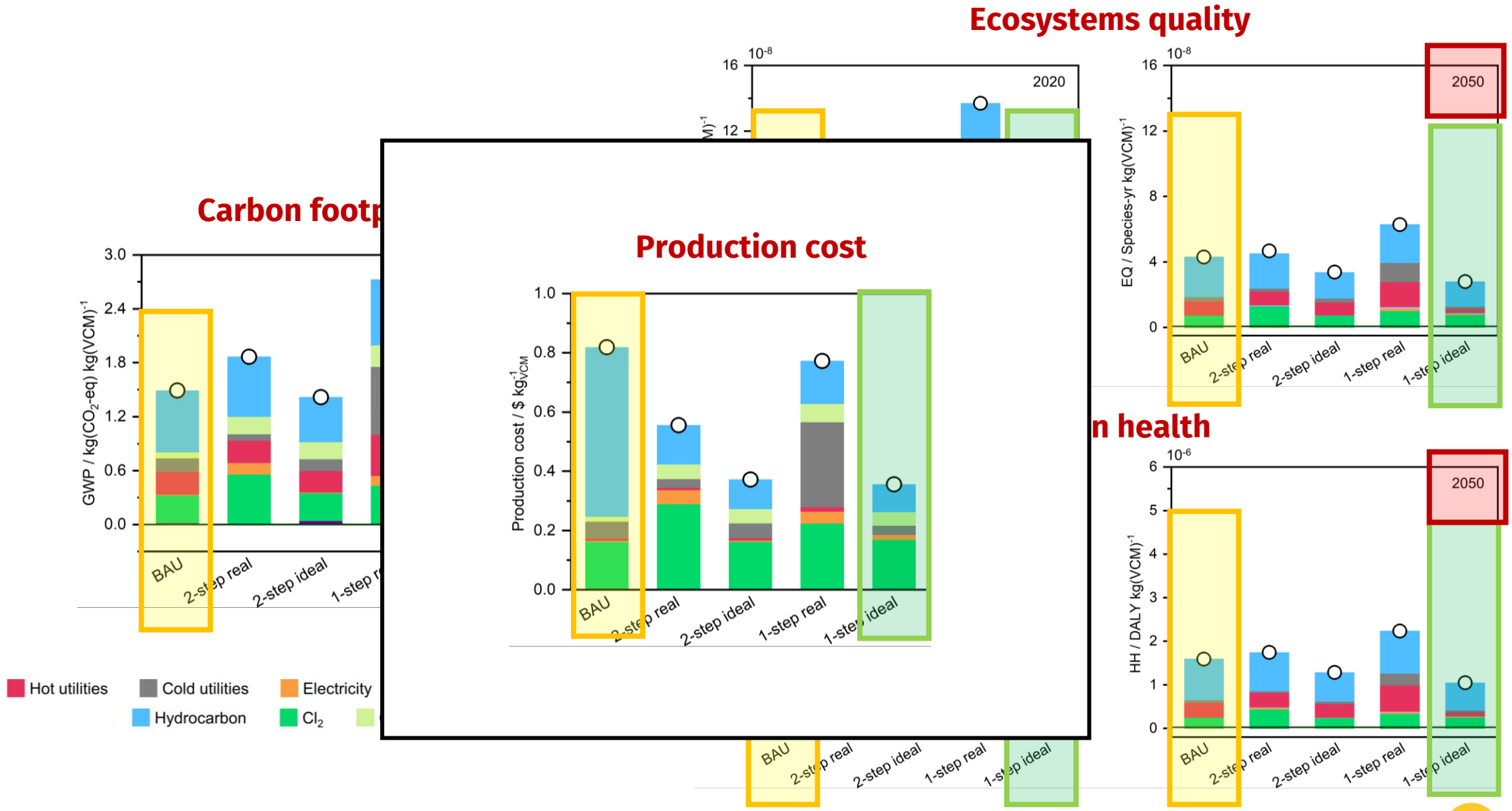
[1] Medrano-García, J. D., et al., ACS Sustain. Chem. Eng., **2023** (DOI: 10.1021/acssuschemeng.3c03006)

… but alternative synthesis routes could be the solution



[1] Medrano-García, J. D., et al., ACS Sustain. Chem. Eng., **2023** (DOI: 10.1021/acssuschemeng.3c03006)

The potential of the 1-step VCM ethane route shows no burden shifting



[1] Medrano-García, J. D., et al., ACS Sustain. Chem. Eng., **2023** (DOI: 10.1021/acssuschemeng.3c03006)

What is Photo2Fuel?

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Photo2Fuel is a European research project that aims to produce biofuels and chemicals from sunlight and captured CO_2

Semi-artificial photosynthesis for efficient 1-step chemical production

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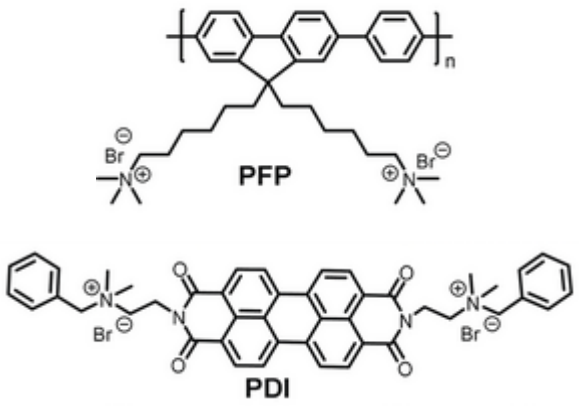
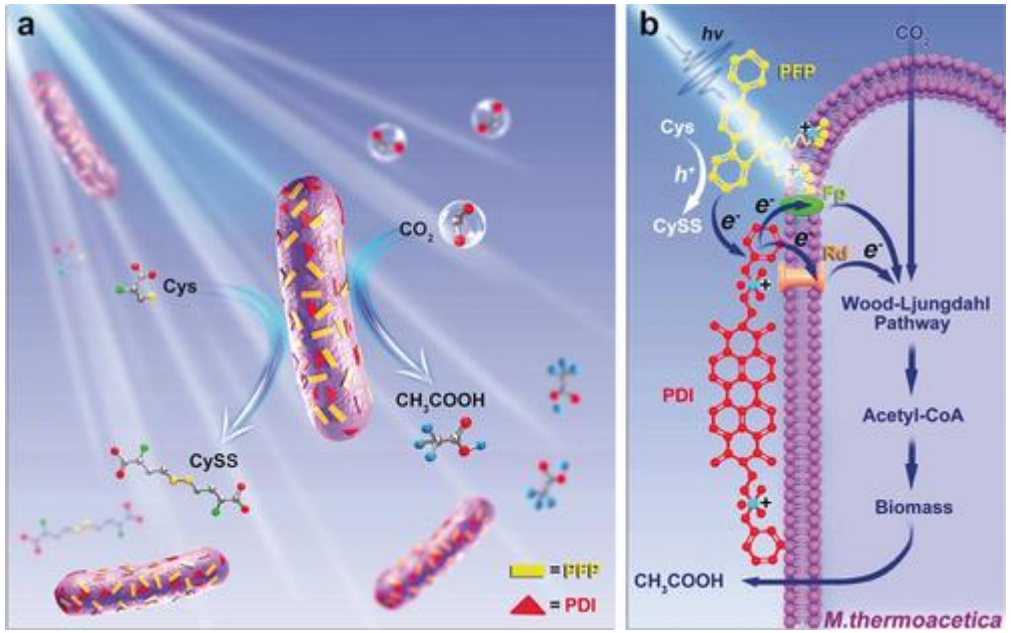
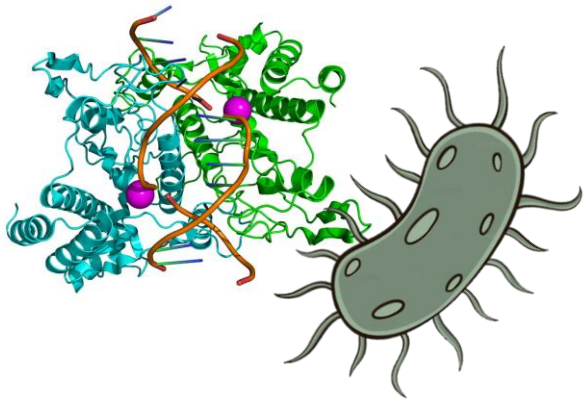
Artificial



Semi-artificial

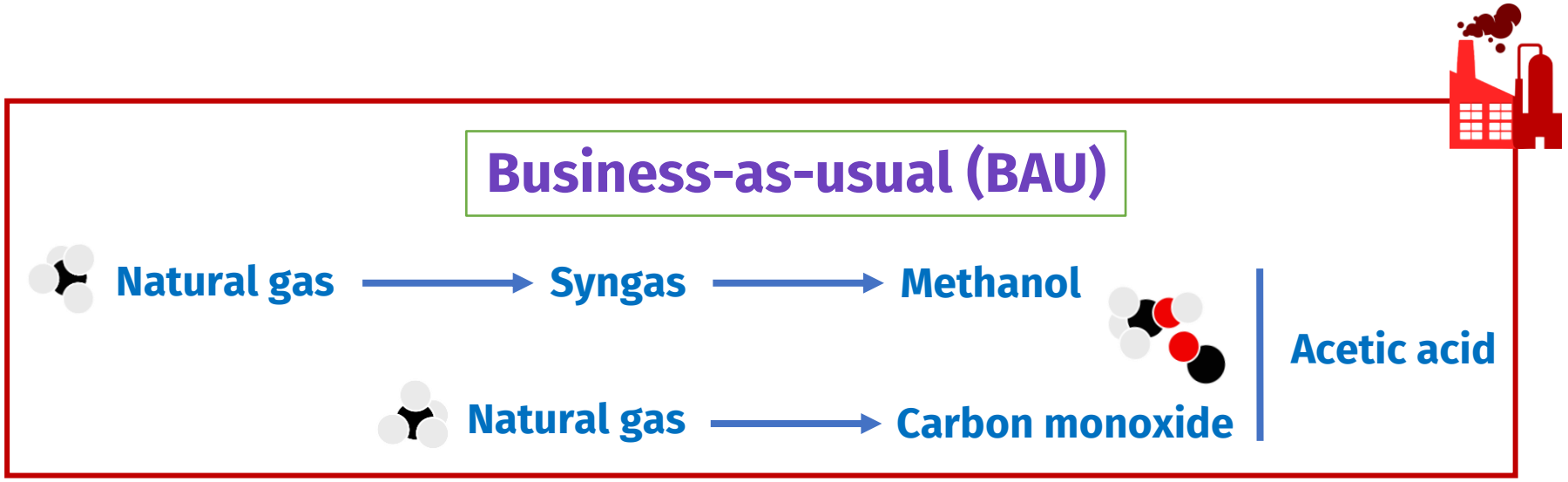


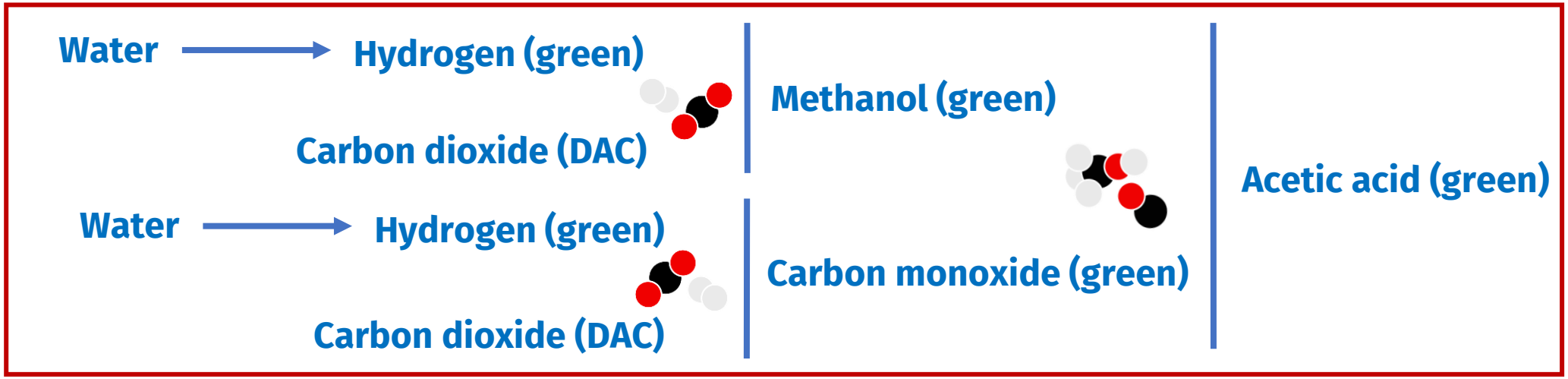
Natural



[1] Gai, P., et al., *Angew. Chemie. – Int. Ed.*, **2020** (DOI: 10.1002/anie.202001047)

Decarbonizing the BAU is resource intensive





[1] Medrano-García, J. D., et al., ACS Sustain. Chem. Eng., **2025** (DOI: 10.1021/acssuschemeng.4c07324)

Alternative and more efficient acetic acid synthesis pathways

Semi-artificial photosynthesis (SAP)

Sunlight
Water
Carbon dioxide

Acetic acid

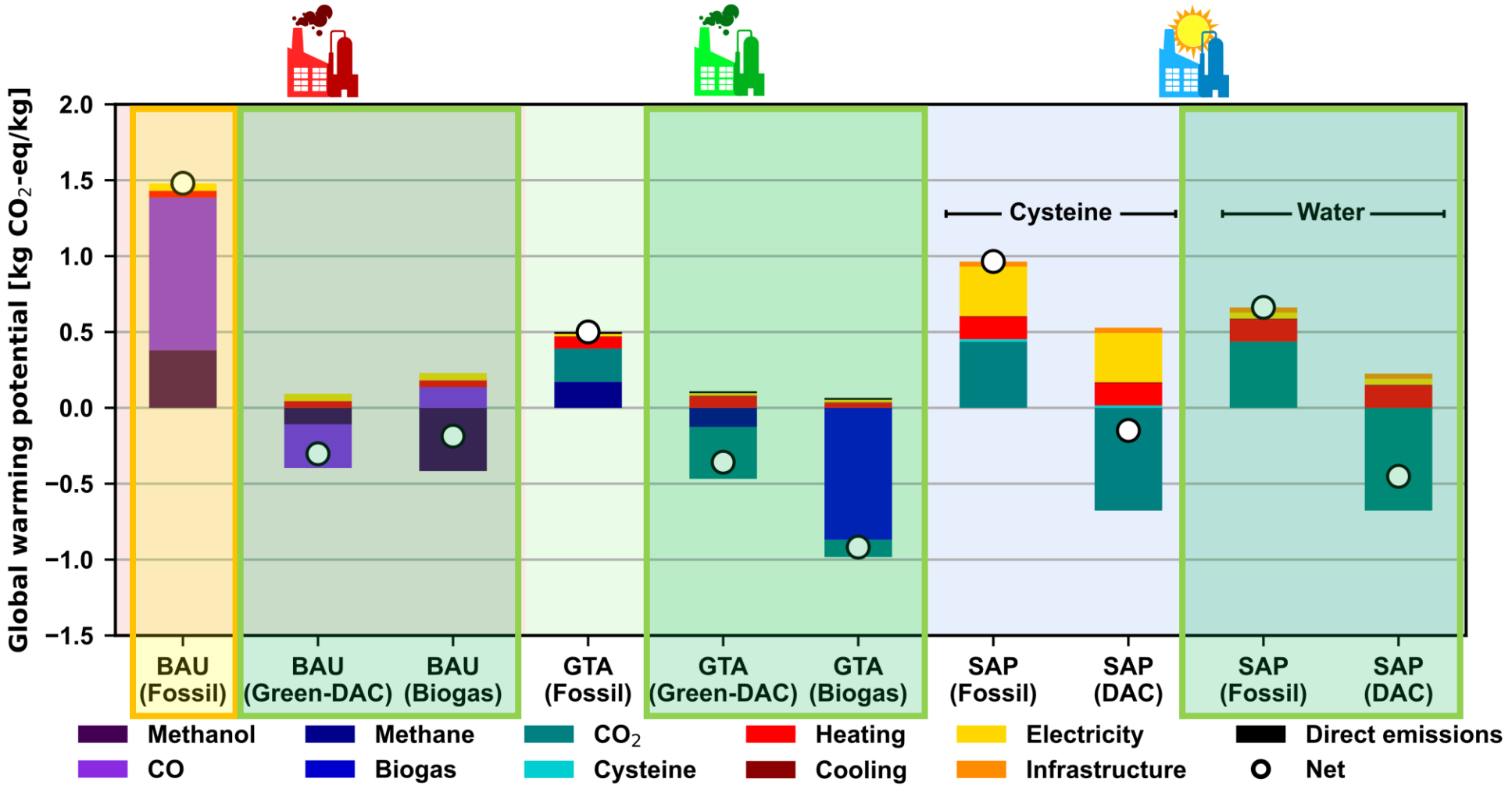
Gas-to-acid (GTA)

Methane
Carbon dioxide

Acetic acid

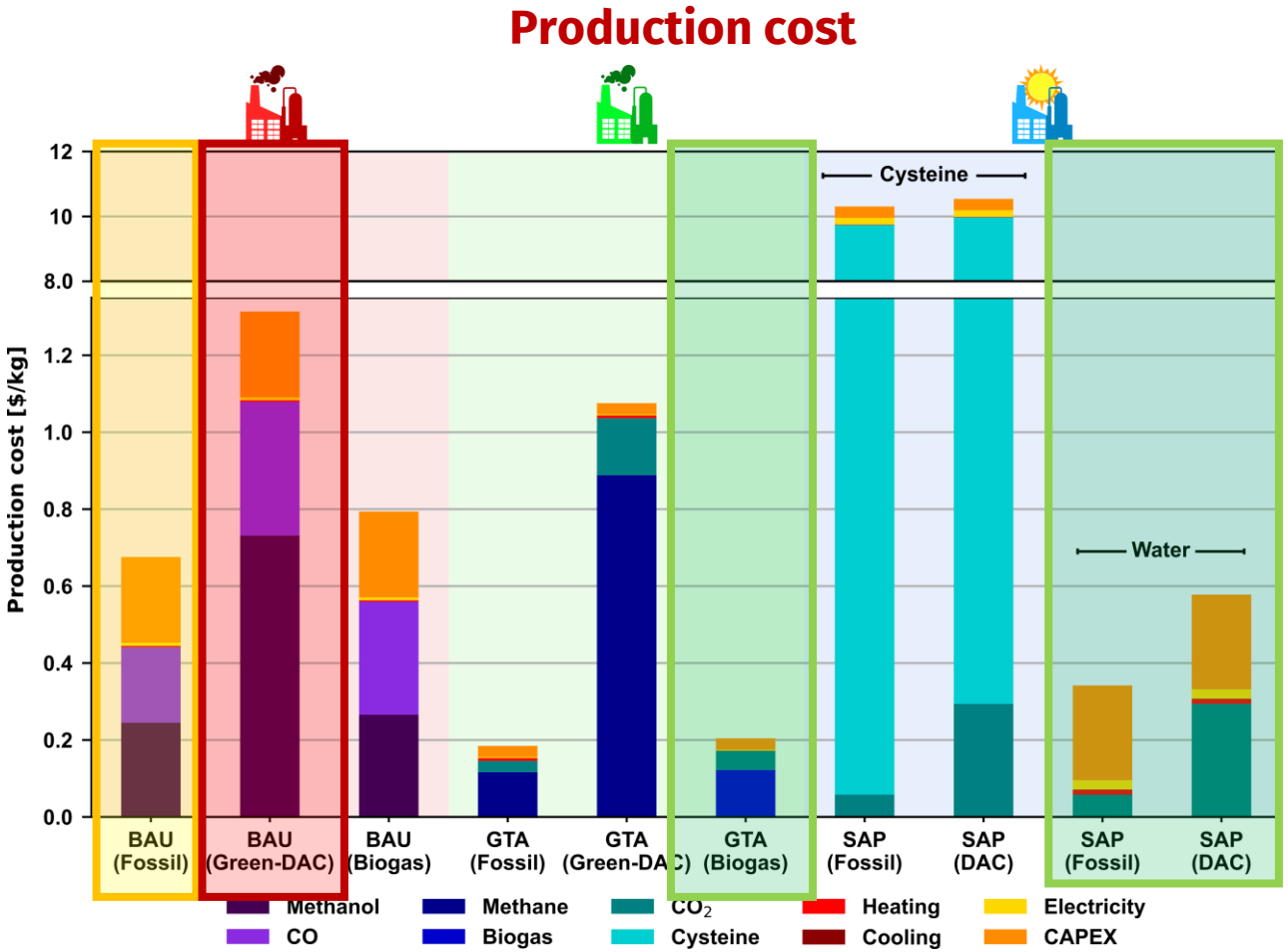
[1] Medrano-García, J. D., et al., ACS Sustain. Chem. Eng., **2025** (DOI: 10.1021/acssuschemeng.4c07324)

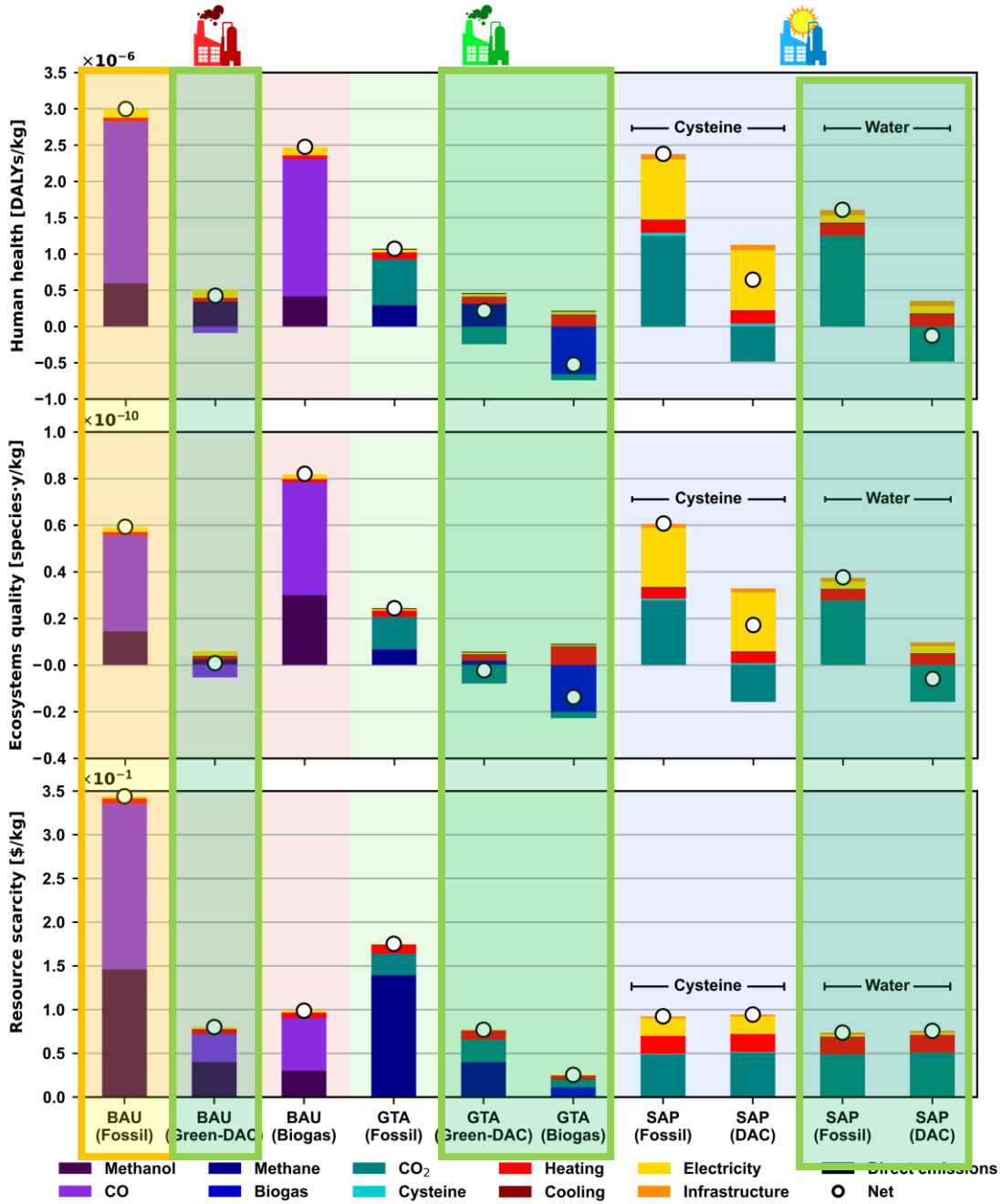
Decarbonizing the SAP only requires swapping the CO_2 source



[1] Medrano-García, J. D., et al., ACS Sustain. Chem. Eng., **2025** (DOI: 10.1021/acssuschemeng.4c07324)

Potential win-win decarbonization





[1] Medrano-García, J. D., et al., ACS Sustain. Chem. Eng., **2025** (DOI: 10.1021/acssuschemeng.4c07324)

Take-home messages

Decarbonizing chemicals and fuels usually results in economic and environmental trade-offs

Nonconventional synthesis routes could bridge a sustainable chemical industry transition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