Biofuels and climate change mitigation: A prospective approach for the maritime transport in Norway and Europe

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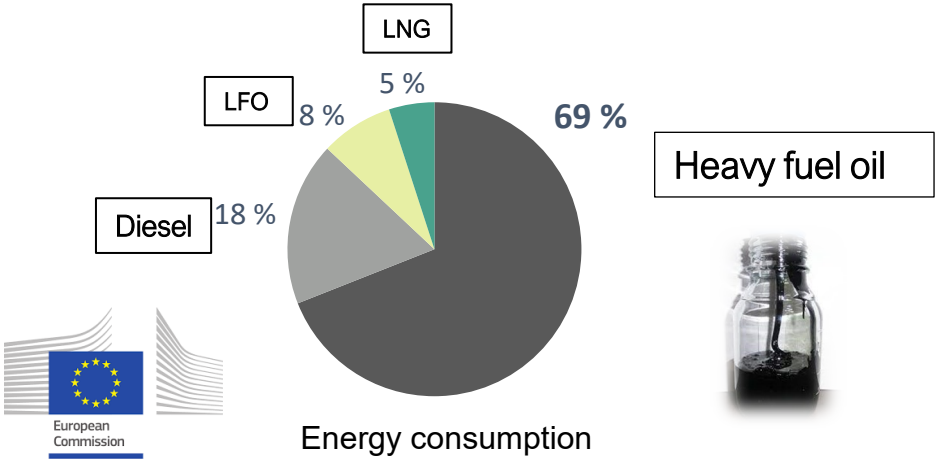
BIO4FUELS Days 2024

Helsinki

Emissions from the European shipping sector

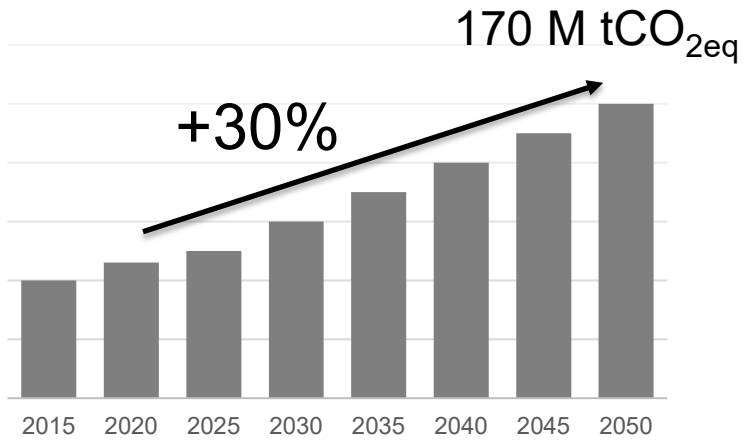
- 4% CO_2 emissions in the EU
- 144 M tCO_2
- **46 M t of fossil fuels**



Energy consumption

Heavy fuel oil

Business as usual, 2050

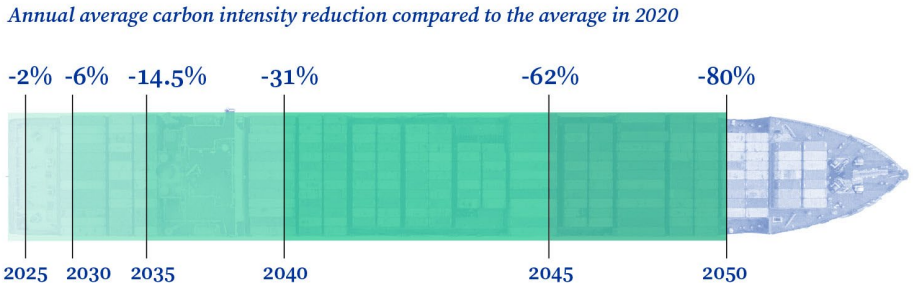


EC, 2020. Report from the Commission 2020 Annual Report on CO2 Emissions from Maritime Transport.

European Green Deal

Fuel EU Maritime Initiative:
55% emissions reduction by 2030
Climate neutrality by 2050

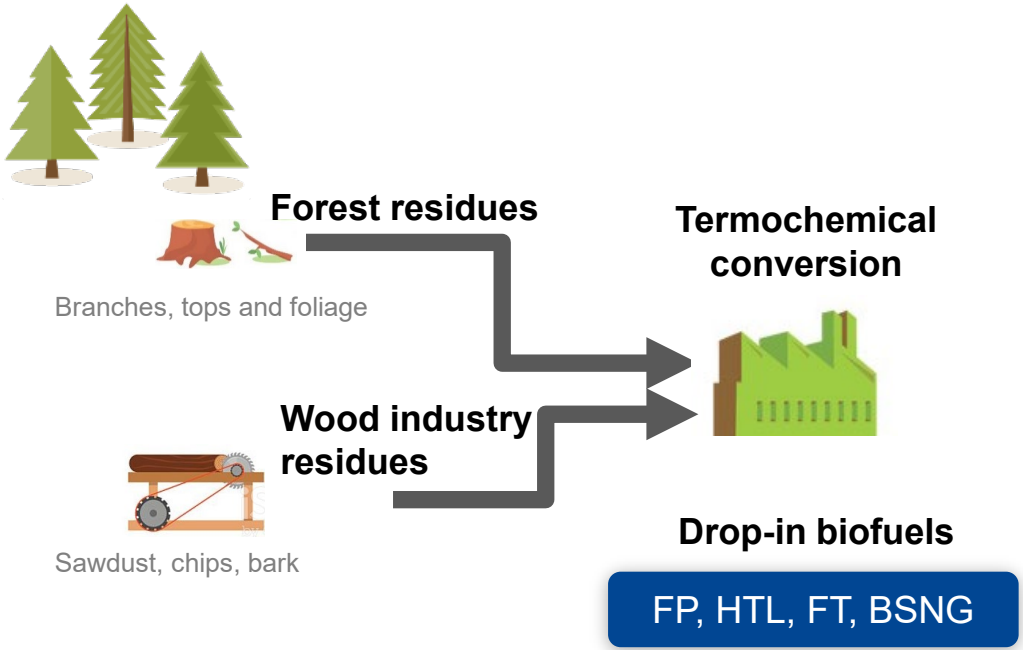
GHG intensity targets (g CO_2 MJ^{-1})

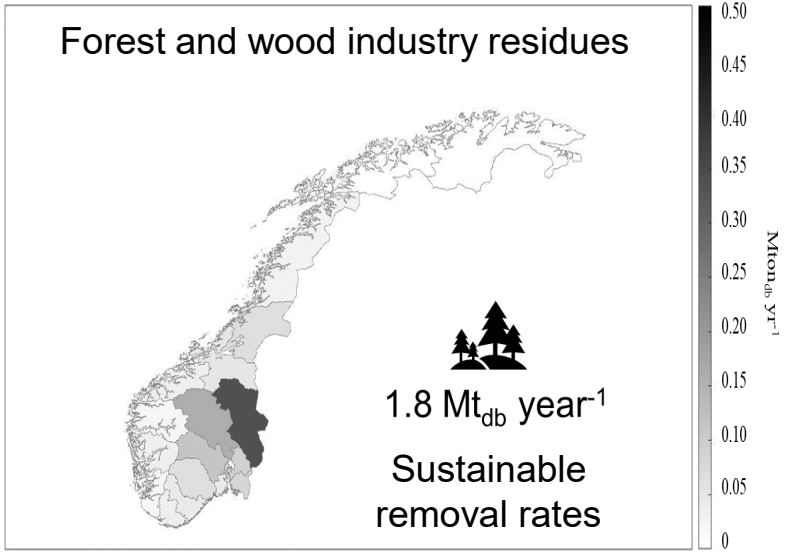


Renewable and low-carbon fuels (RLFs)

Climate change mitigation of drop-in biofuels for deep-sea shipping in Norway

Watanabe et al. 2022. Journal of Cleaner Production





Based on sustainable removal rates (34%) for scots pine, spruce and birch. Industrial residues from the sawmill, pulp and paper industries like chips, sawdust and bark (15% of available residues) according to Cavalett and Cherubini (2018) - Nature Sustainability.

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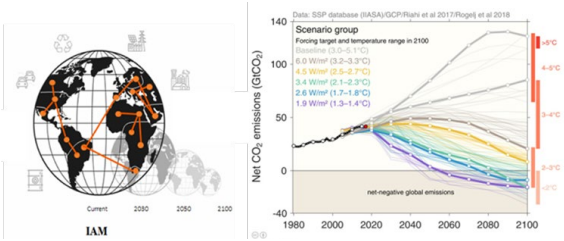
Life Cycle Assessment: a prospective approach



premise

Integrated Assessment Models (IAM)

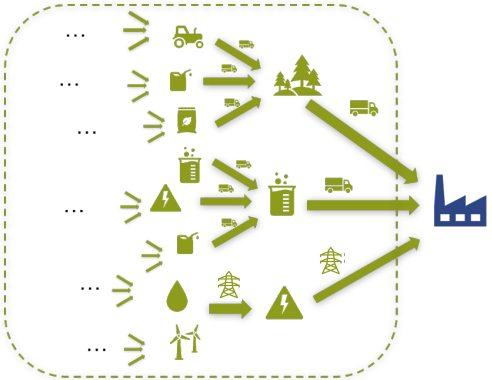
Data input

Energy-intensive sectors

- Electricity
- Transport
- Fuels
- Cement
- Steel
- etc.

Projected technological evolution

Future supply chains up to 2050



Technological improvements in carbon-intensive industries, e.g. following Paris Agreement scenario

Based on Sacchi et al., 2022. Prospective Environmental Impact Assessment (premise): a streamlined approach to producing databases for prospective Life Cycle Assessment using Integrated Assessment Models. Renew. Sustain. Energy Rev

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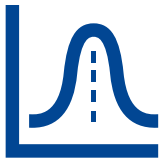
Monte Carlo (Uncertainty Analysis)

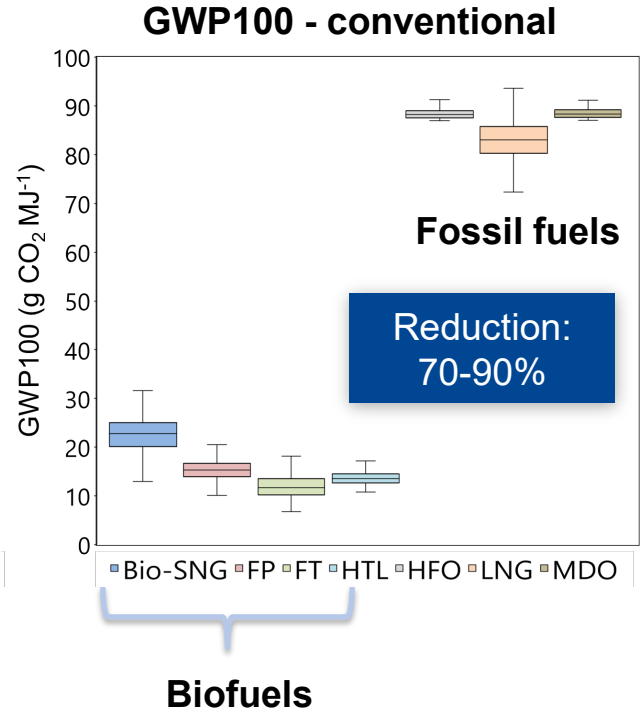


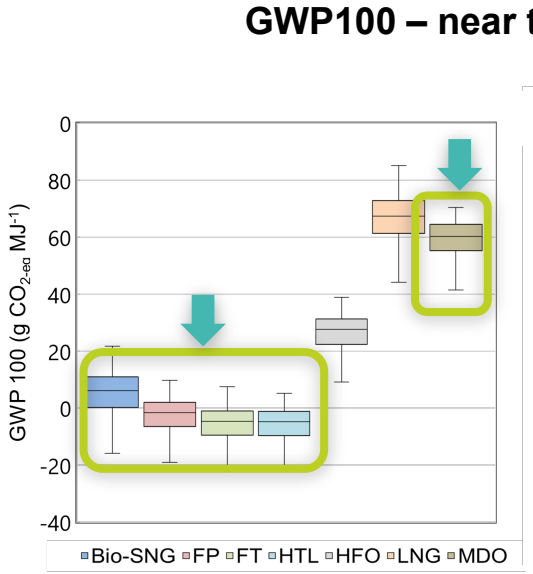
- Biomass transport distances — Forest to the industry
- Biofuel conversion — Biofuel yields — Methane leakage
- Biofuel logistics — Industry to the seaport terminals
- Climate metrics — Characterization factors — (NO_x, CO, VOC, OC, BC)
- Fuel combustion — Engine fuel consumption

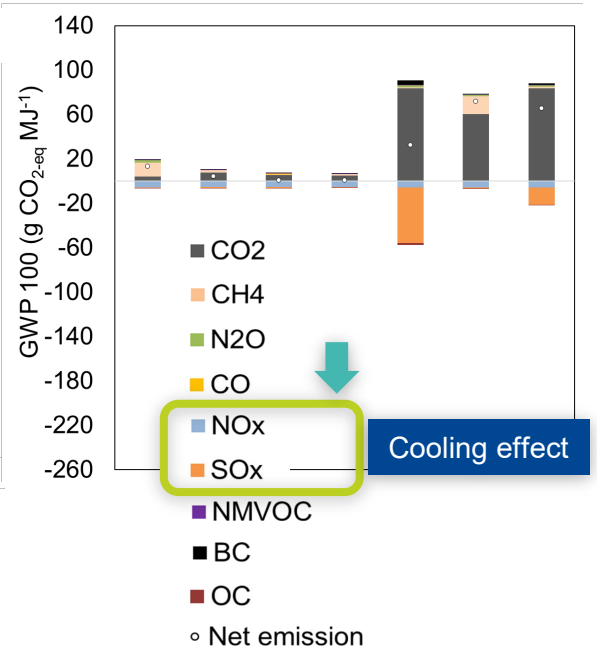
emission factors for CO_2, CH_4 (methane slips), SO_x, NO_x, PM_{10}, N_2O, NMVOC (IMO)

Watanabe et al 2022. Climate change mitigation of drop-in biofuels for deep-sea shipping considering prospective life-cycle assessment. Journal of Cleaner Production.

Climate change (and Near-Term Climate Forcers)







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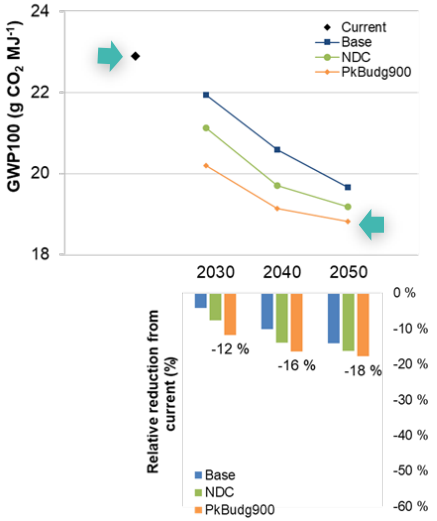
Projected decarbonization in the supply chain (2050)

GHG intensity reduction from improvements in electricity, transport, chemicals and materials

Up to… -18%

a

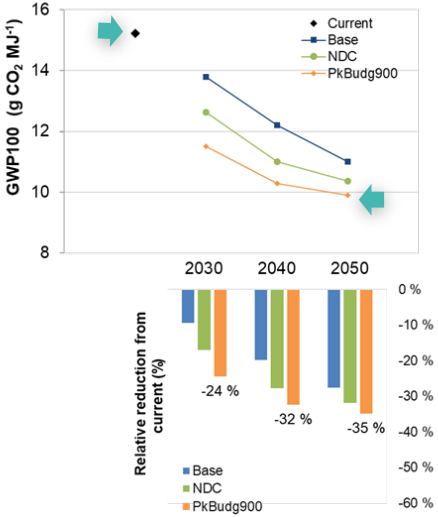
Bio-SNG



-35%

b

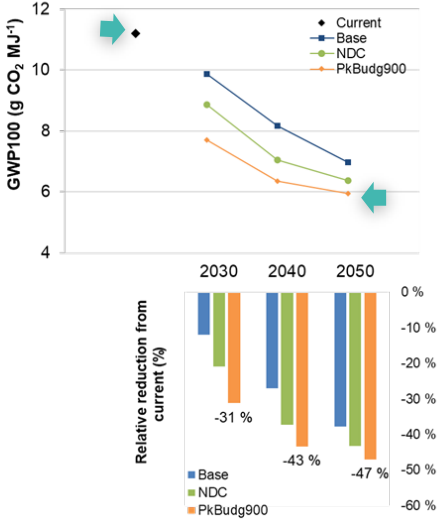
Fast Pyrolysis



-47%

c

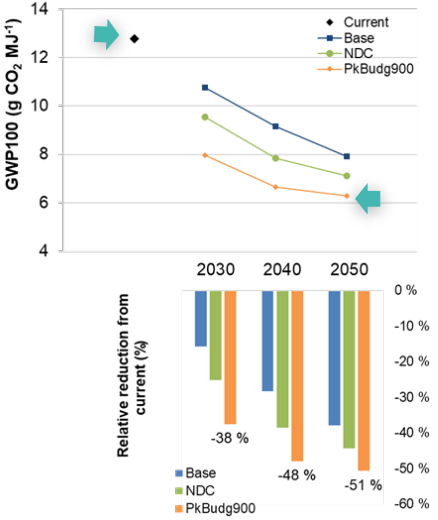
Fischer-Tropsch



-51%

d

HTL



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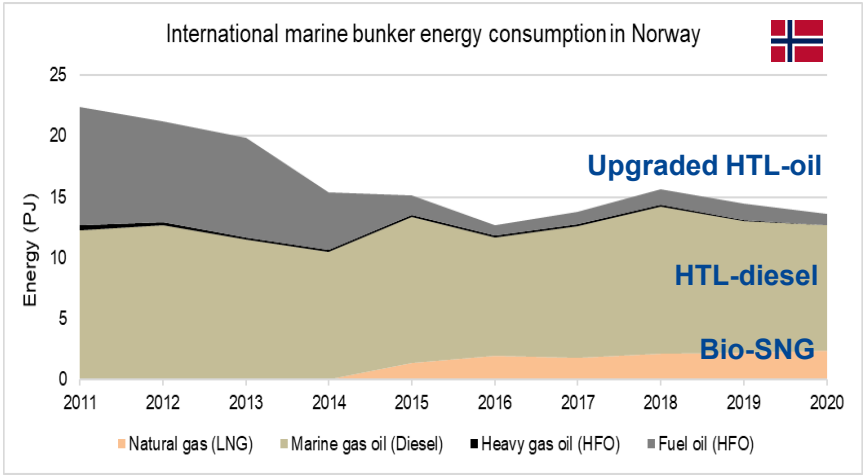
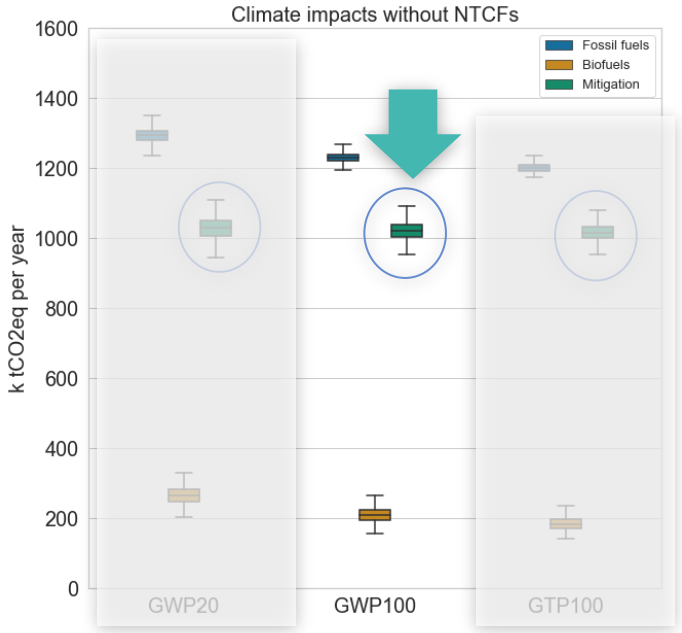
Deep-sea climate change mitigation in Norway

Full substitution of international marine bunker energy consumption

Potential mitigation: 1 Mt $CO_{2\text{-eq}}$ yr^{-1}





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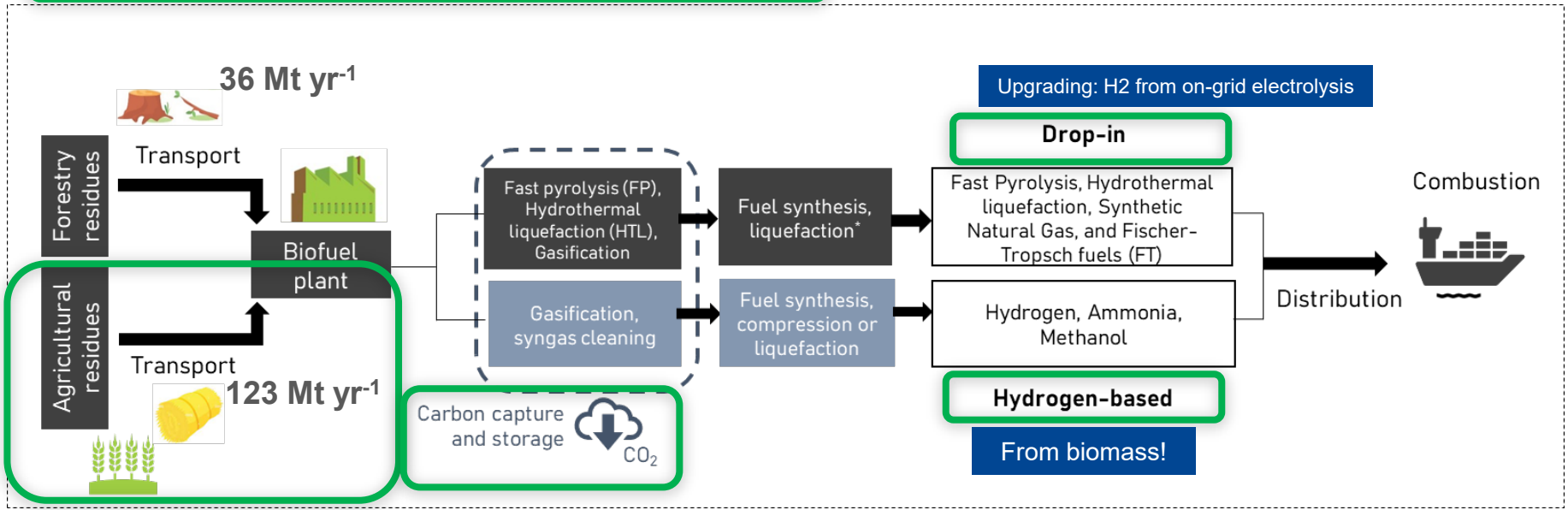
Country-based assessment of climate change impacts in Europe up to 2050

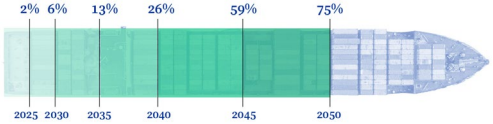
EU-27, Switzerland, Norway and the UK



Sustainable removal rate (ca. 30%)

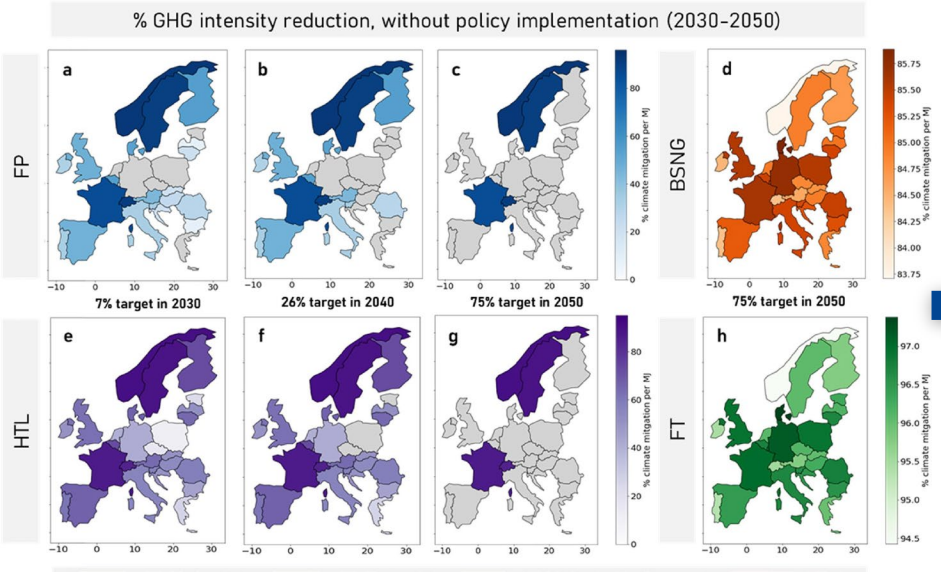
Watanabe et al. 2022. Drop-in and hydrogen-based biofuels for maritime transport: Country-based assessment of climate change impacts in Europe up to 2050. Energy Conversion and Management.

FuelEU Maritime targets

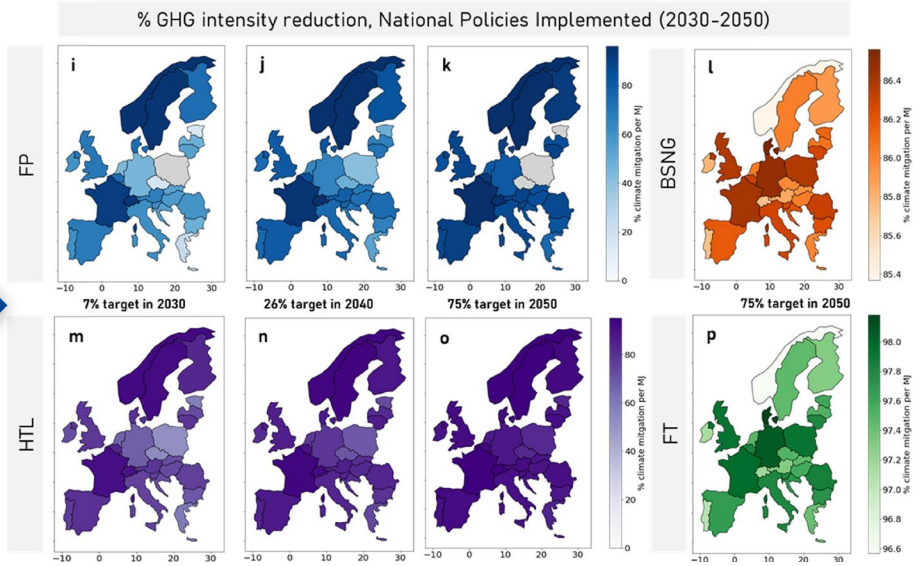


Drop-in fuels

Without national policy implementation



National policies implemented **(supply chain decarbonization)**



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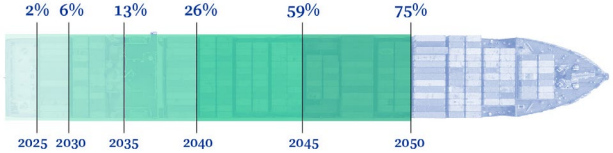
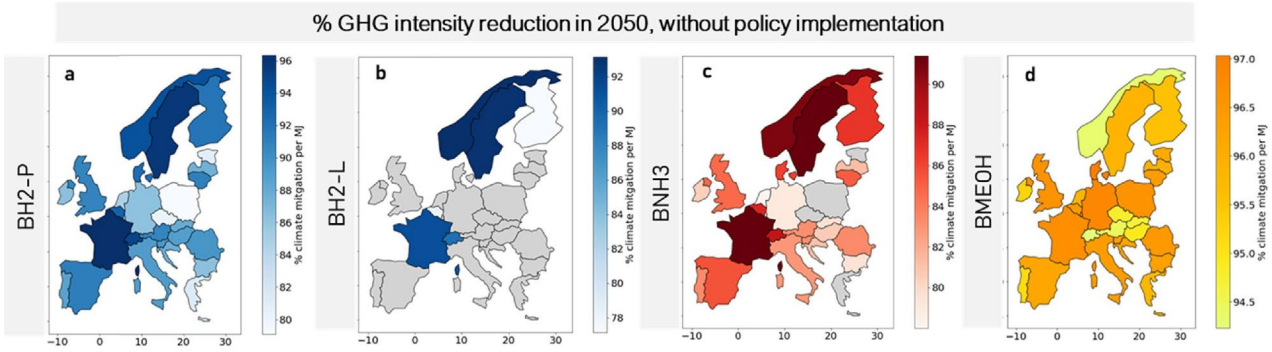
FuelEU Maritime targets

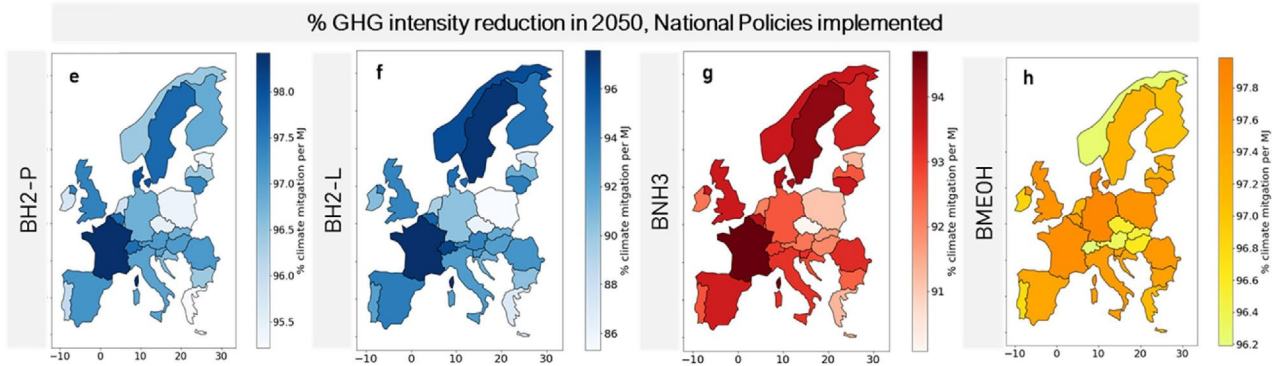


Hydrogen-based fuels

Without national policy implementation



National policies implemented (supply chain decarbonization)



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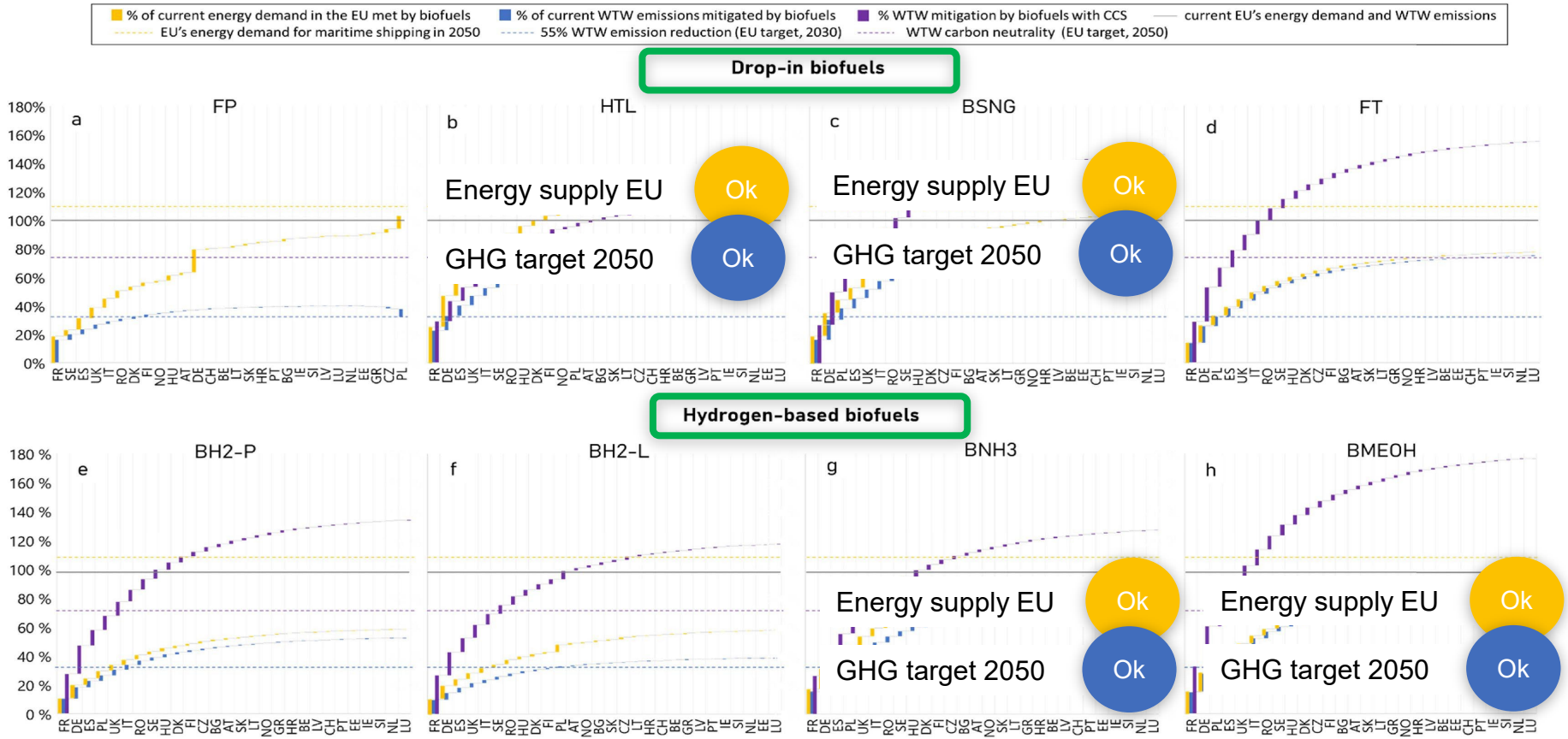
Full deployment of just one technology at European Level



Watanabe et al. 2022. Drop-in and hydrogen-based biofuels for maritime transport: Country-based assessment of climate change impacts in Europe up to 2050. Energy Conversion and Management.

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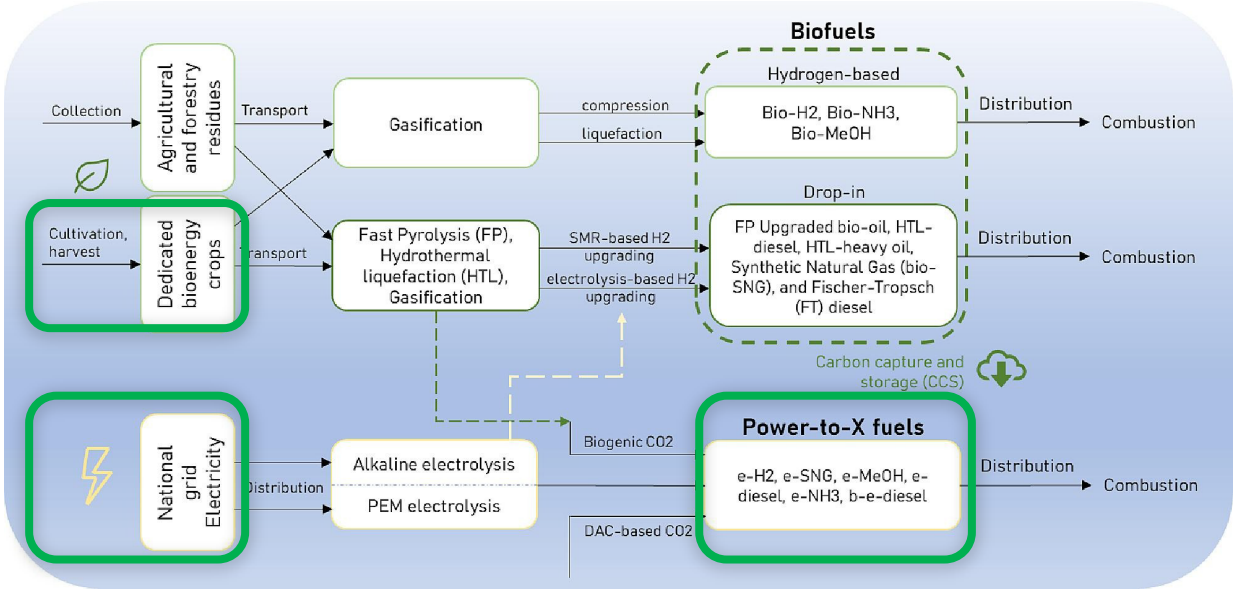
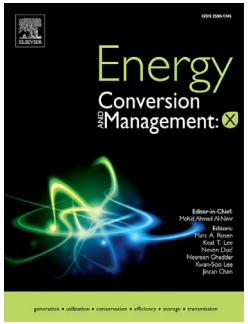
Biofuels or Power-to-X?

Climate change mitigation potentials of on grid-connected Power-to-X fuels and advanced biofuels

Perennial grasses in abandoned cropland: 98 M ton_{db} yr^{-1}

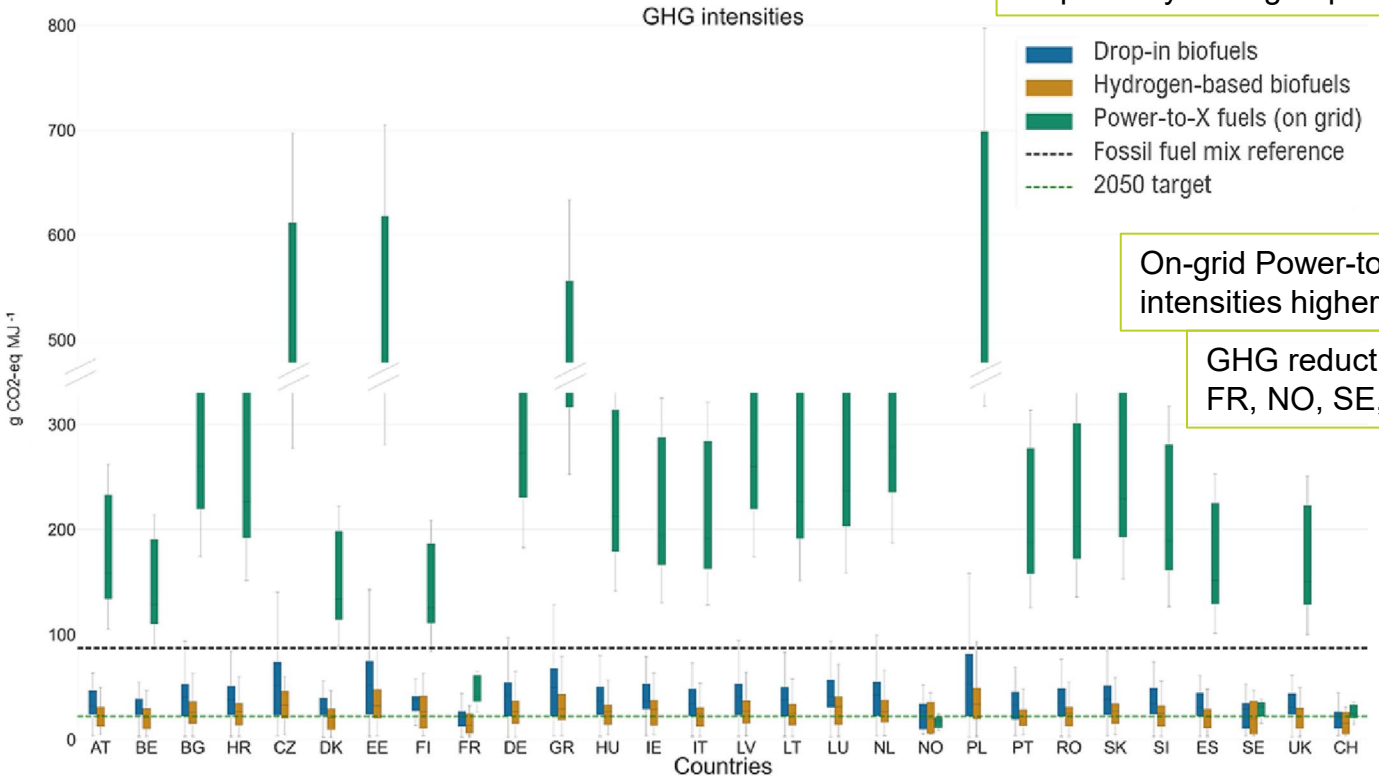




Watanabe et al. 2023. Climate change mitigation potentials of on grid-connected Power-to-X fuels and advanced biofuels for the European maritime transport. Energy conversion and management: X.

On-grid Power-to-X and Biofuels (current situation)

55 pathways in 3 groups:

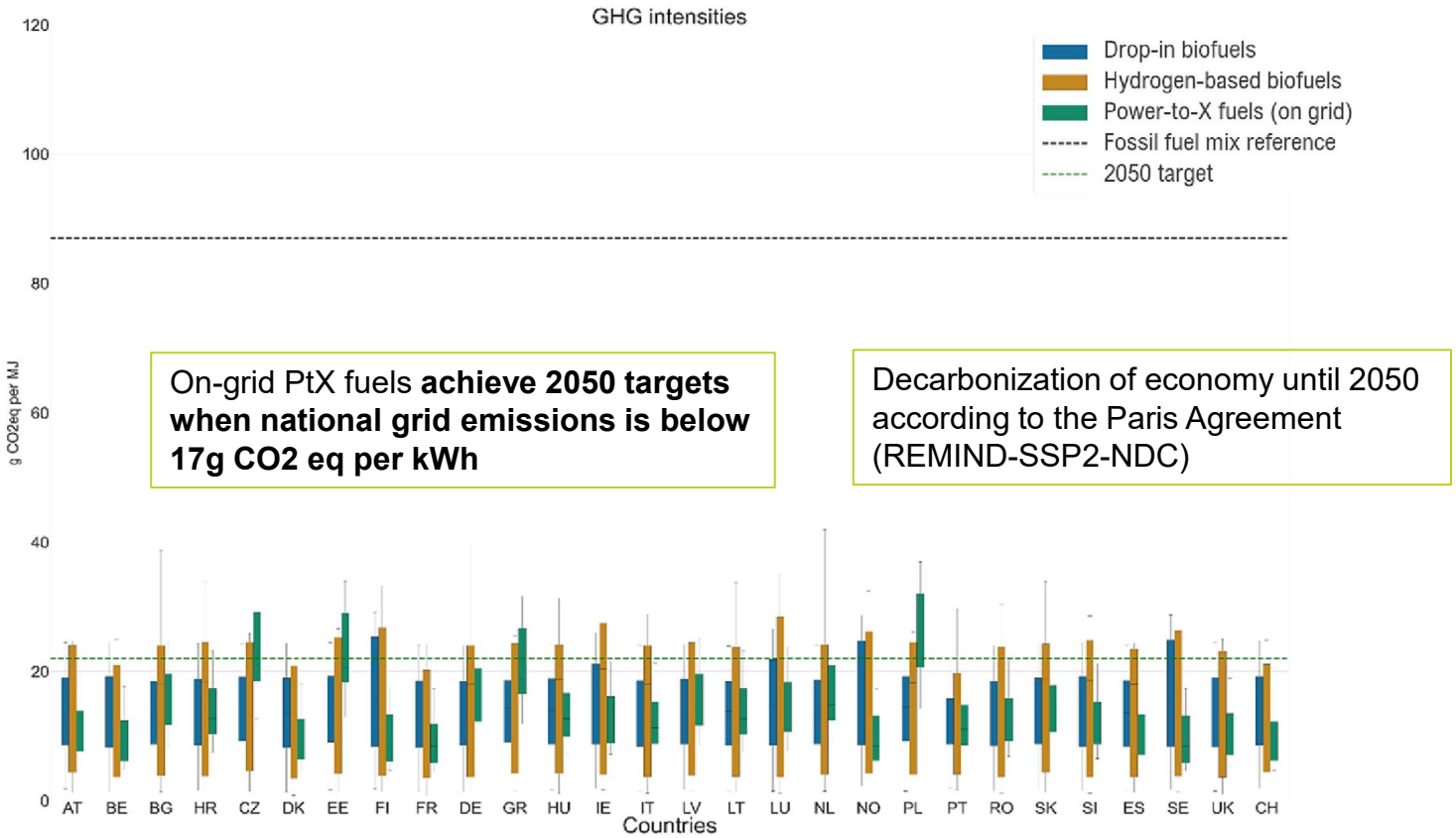


On-grid Power-to-X: GHG intensities higher than fossil fuels

GHG reduction observed in FR, NO, SE, CH

Watanabe et al. 2023. Climate change mitigation potentials of on grid-connected Power-to-X fuels and advanced biofuels for the European maritime transport. Energy conversion and management: X.

‘Decarbonized’ Power-to-X and biofuels in 2050



On-grid PtX fuels **achieve 2050 targets when national grid emissions is below 17g CO2 eq per kWh**

Decarbonization of economy until 2050 according to the Paris Agreement (REMIND-SSP2-NDC)

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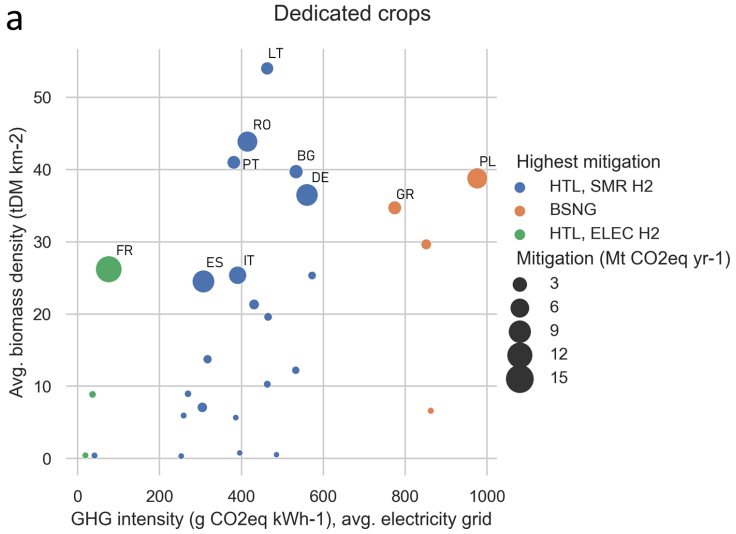
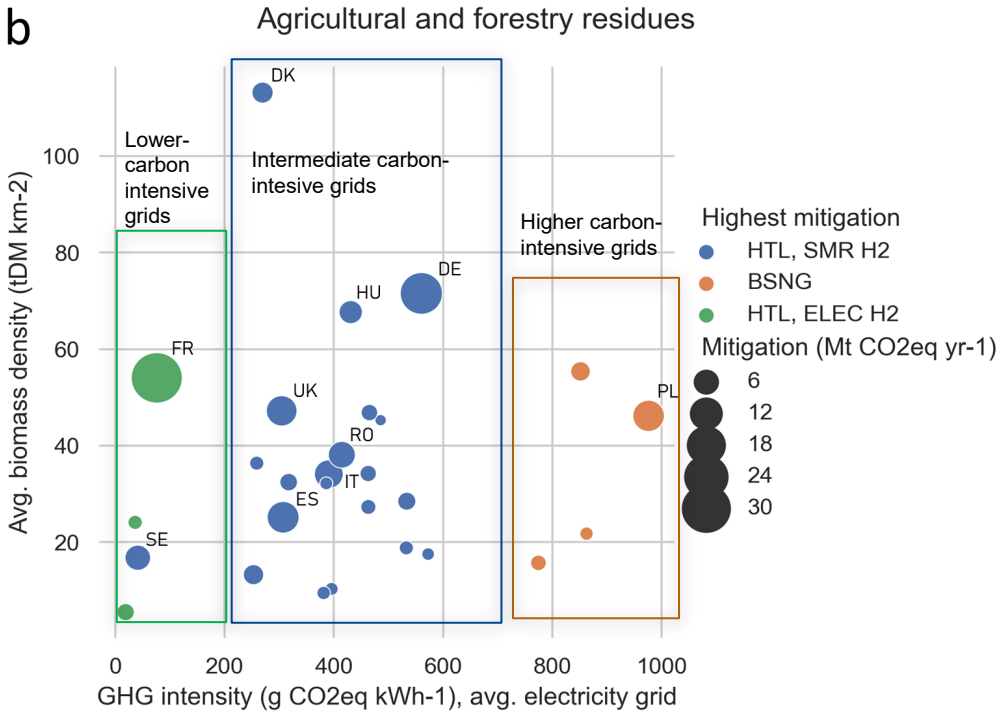
Maximizing climate mitigation in Europe: conversion pathways





Watanabe et al. 2023. Climate change mitigation potentials of on grid-connected Power-to-X fuels and advanced biofuels for the European maritime transport. Energy conversion and management: X.

Final remarks

- In **Norway**, the GHG intensity targets from FuelEU Maritime can be achieved regardless of the conversion route
- In **Europe**, the best climate mitigation strategies will rely on specific conversion routes, feedstocks, and supply chain configurations.
- The **prospective** analysis highlighted the importance of technological evolution in the supply chain when pursuing FuelEU Maritime goals.
- **Economic**, safety, and other aspects associated with transitioning to a new supply chain infrastructure need to be considered

Thank you!

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