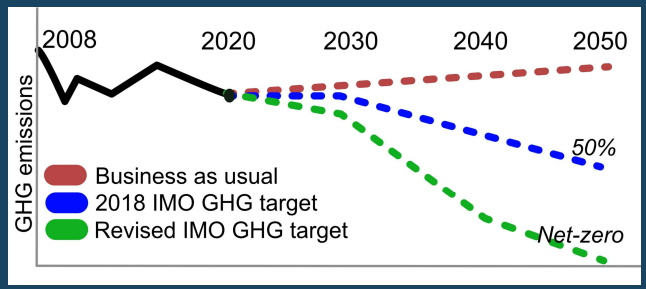
Decarbonizing shipping: the role of biofuels, electrofuels, and blue fuels

How to solve this challenge?



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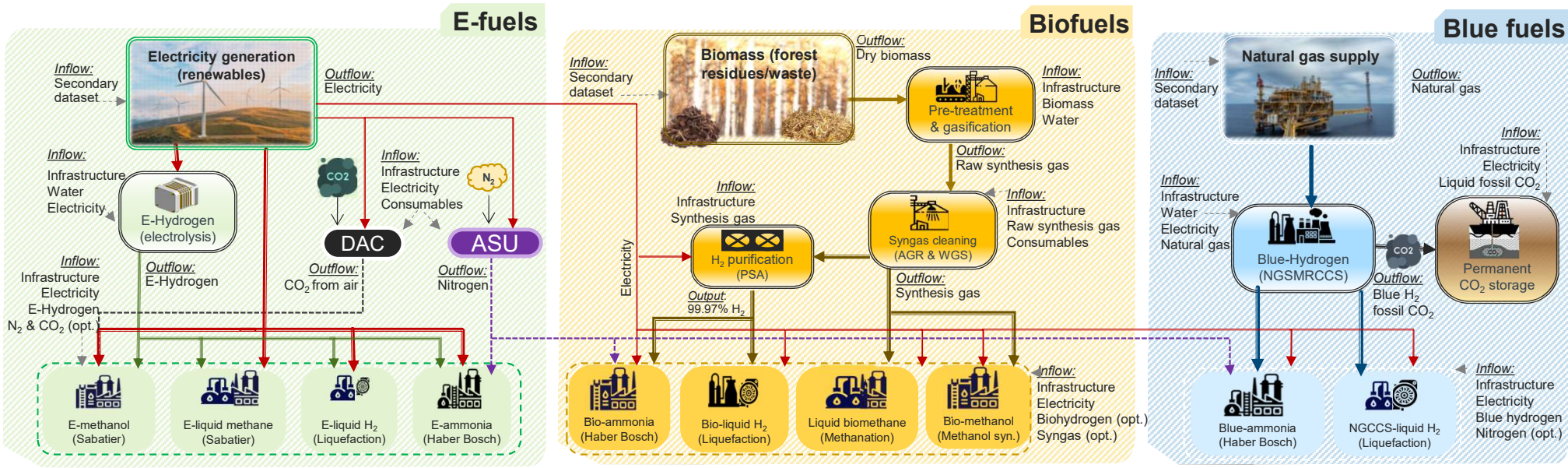
Energy transition pathways



Ammonia

- Liquid e-ammonia
- Liquid bio-ammonia
- Liquid blue ammonia

Liquid hydrogen

- Liquid e-hydrogen
- Liquid bio-hydrogen
- Liquid blue hydrogen

Liquid Methane

- Liquid e-methane
- Liquid bio-methane

Methanol

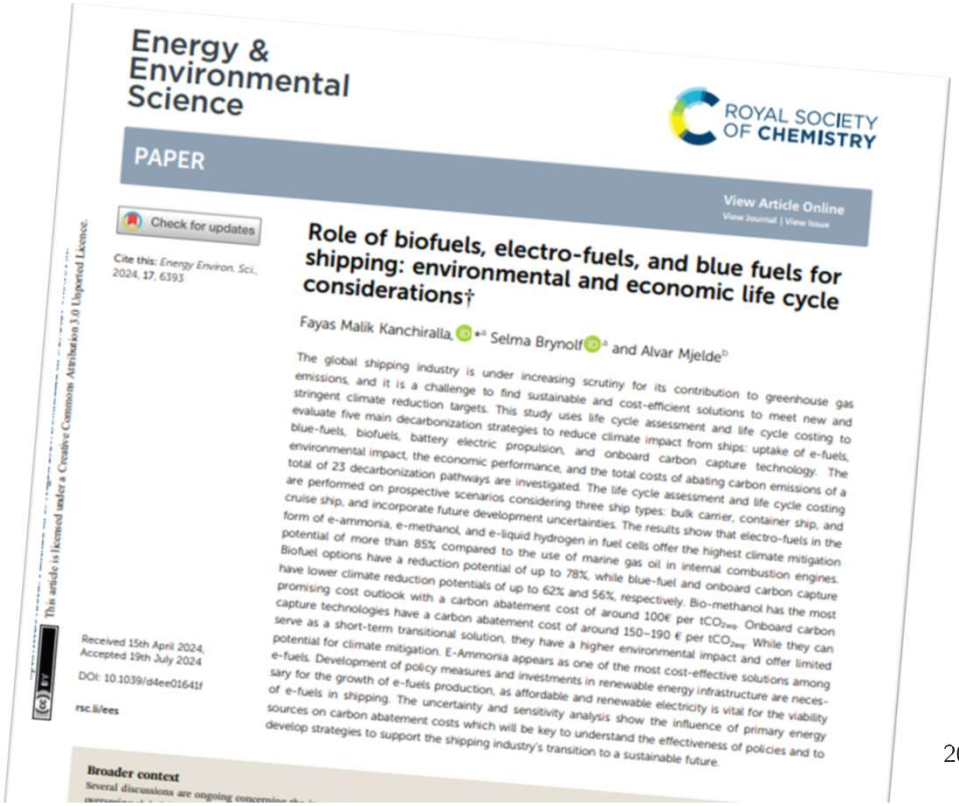
- Liquid e-methanol
- Liquid bio-methanol

Electricity

- Wind power

Role of biofuels, electro-fuels, and blue fuels for shipping: environmental and economic life cycle considerations

Kanchiralla, F. M., et al. (2024 Energy & Environmental Science **17(17): 6393-6418.**



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Role of biofuels, electro-fuels, and blue fuels for shipping: environmental and economic life cycle considerations†

Fayas Malik Kanchiralla, Selma Brynolf and Alvar Mjelde

The global shipping industry is under increasing scrutiny for its contribution to greenhouse gas emissions, and it is a challenge to find sustainable and cost-efficient solutions to meet new and stringent climate reduction targets. This study uses life cycle assessment and life cycle costing to evaluate five main decarbonization strategies to reduce climate impact from ships: uptake of e-fuels, blue-fuels, biofuels, battery electric propulsion, and onboard carbon capture technology. The environmental impact, the economic performance, and the total costs of abating carbon emissions of a total of 23 decarbonization pathways are investigated. The life cycle assessment and life cycle costing are performed on prospective scenarios considering three ship types: bulk carrier, container ship, and cruise ship, and incorporate future development uncertainties. The results show that electro-fuels in the form of e-ammonia, e-methanol, and e-liquid hydrogen in fuel cells offer the highest climate mitigation potential of more than 85% compared to the use of marine gas oil in internal combustion engines. Biofuel options have a reduction potential of up to 78%, while blue-fuel and onboard carbon capture have lower climate reduction potentials of up to 62% and 56%, respectively. Bio-methanol has the most promising cost outlook with a carbon abatement cost of around 100€ per tCO_{2eq}. Onboard carbon capture technologies have a carbon abatement cost of around 150–190 € per tCO_{2eq}. While they can serve as a short-term transitional solution, they have a higher environmental impact and offer limited potential for climate mitigation. E-Ammonia appears as one of the most cost-effective solutions among e-fuels. Development of policy measures and investments in renewable energy infrastructure are necessary for the growth of e-fuels production, as affordable and renewable electricity is vital for the viability of e-fuels in shipping. The uncertainty and sensitivity analysis show the influence of primary energy sources on carbon abatement costs which will be key to understand the effectiveness of policies and to develop strategies to support the shipping industry's transition to a sustainable future.

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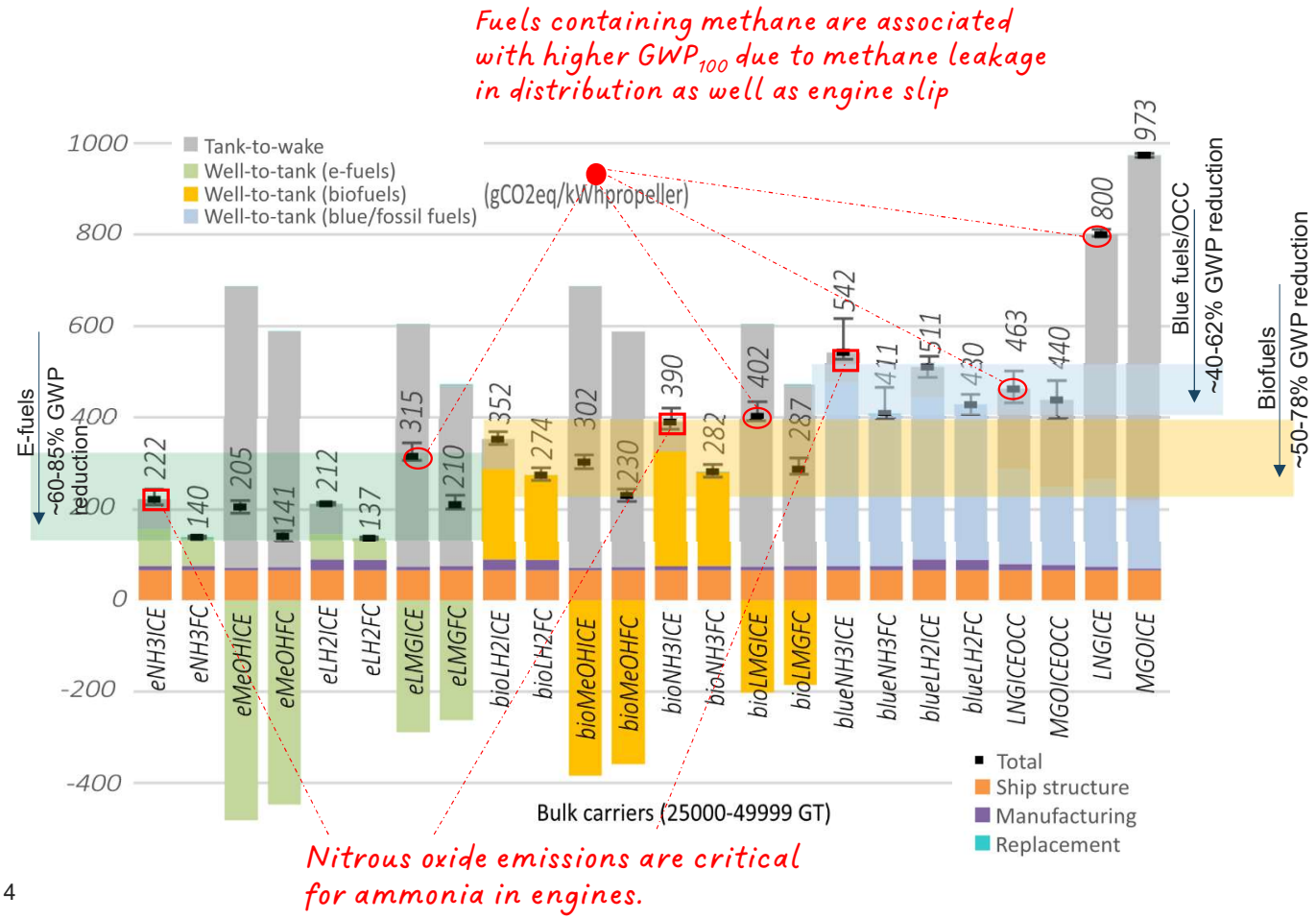
Broader context

Global warming potential (GWP_{100}), Bulk carrier

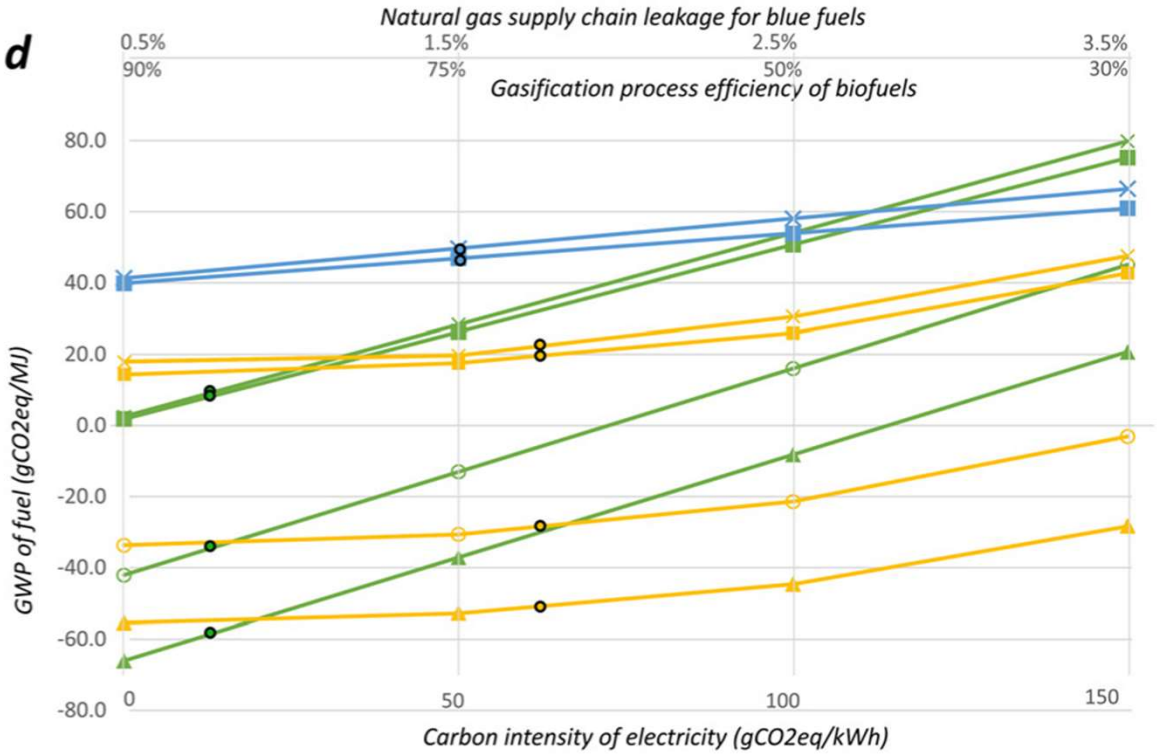


Impact from fuel production is dominant in most cases

Onboard carbon capture and blue fuels have limited potential over the life cycle

Global warming potential (GWP_{100}), Bulk carrier

With higher carbon intensity of electricity production biofuels have lower global warming potential than electrofuels



Concluding remarks

Biofuels:

- Can be important to decarbonize shipping, especially bio-methanol and bio-methane.
- Require sustainable biomass sources.
- Limited quantity and competition from other sectors may affect biomass availability and cost.

Blue fuels and onboard carbon capture:

- Limited climate reduction potential cannot meet IMO 2050 climate targets (without significantly lowered shipping demand).
- Policy support needs to consider these as short-term solutions.

E-fuels:

- Dependent on low electricity prices and low carbon intensity of electricity production.
- High cost makes them it less competitive in the short term.

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