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26-29 September | Houston, TX

Alternative fuels & WASP

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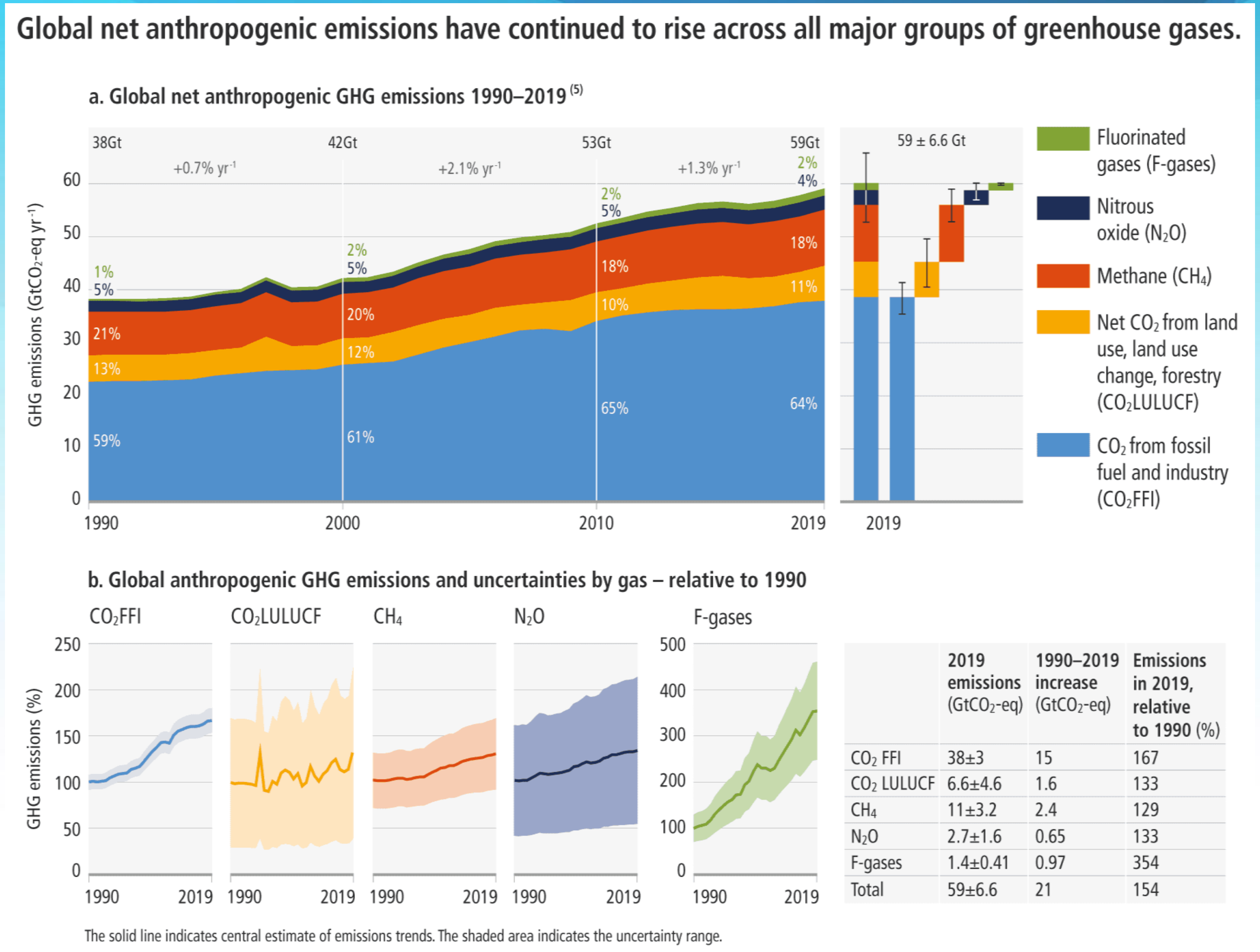
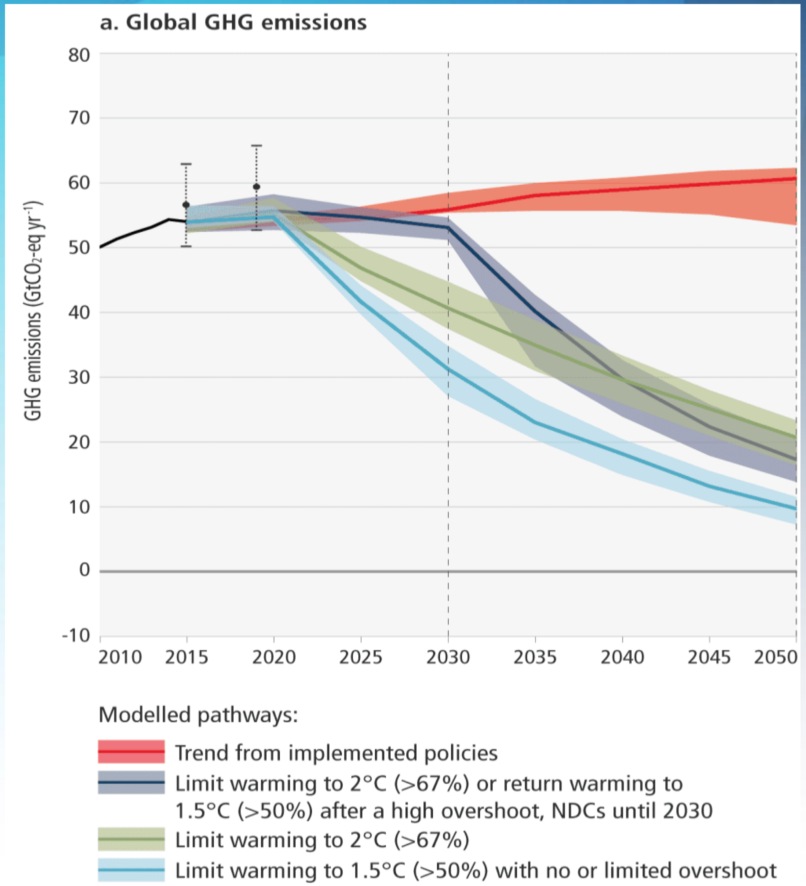
SINTEF

IPCC (2022) highlights the need for rapid Global decarbonization. The big question is: How to make it happen?



	2019 emissions ($GtCO_2$-eq)	1990–2019 increase ($GtCO_2$-eq)	Emissions in 2019, relative to 1990 (%)
CO_2 FFI	38±3	15	167
CO_2 LULUCF	6.6±4.6	1.6	133
CH_4	11±3.2	2.4	129
N_2O	2.7±1.6	0.65	133
F-gases	1.4±0.41	0.97	354
Total	59±6.6	21	154



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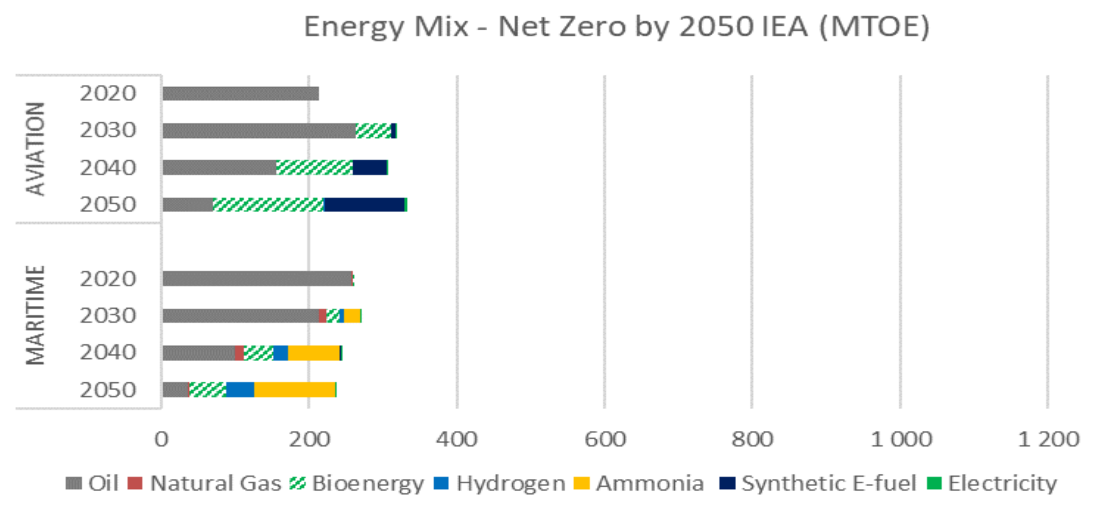
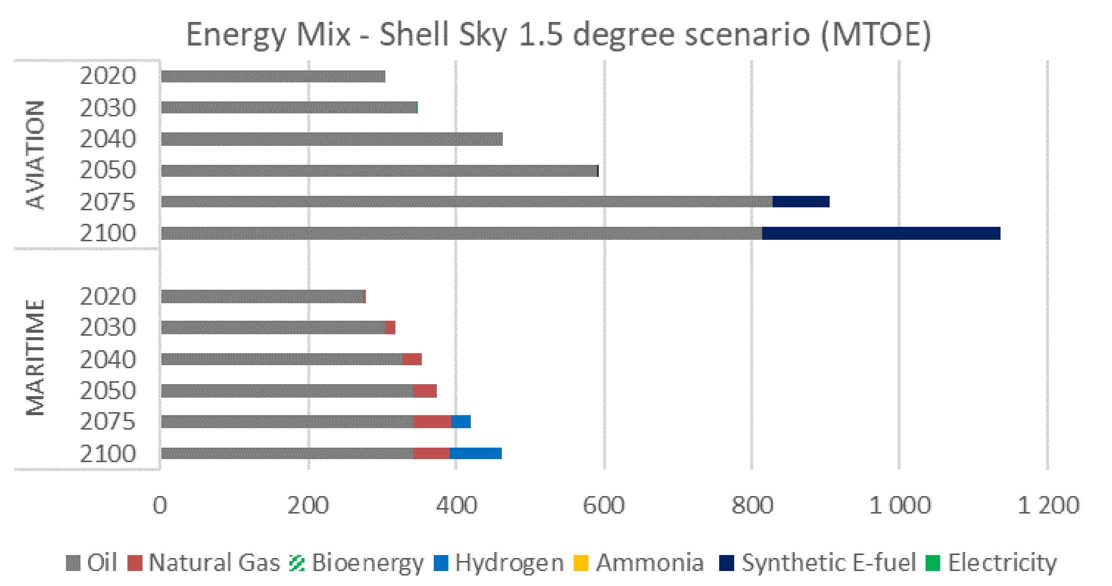
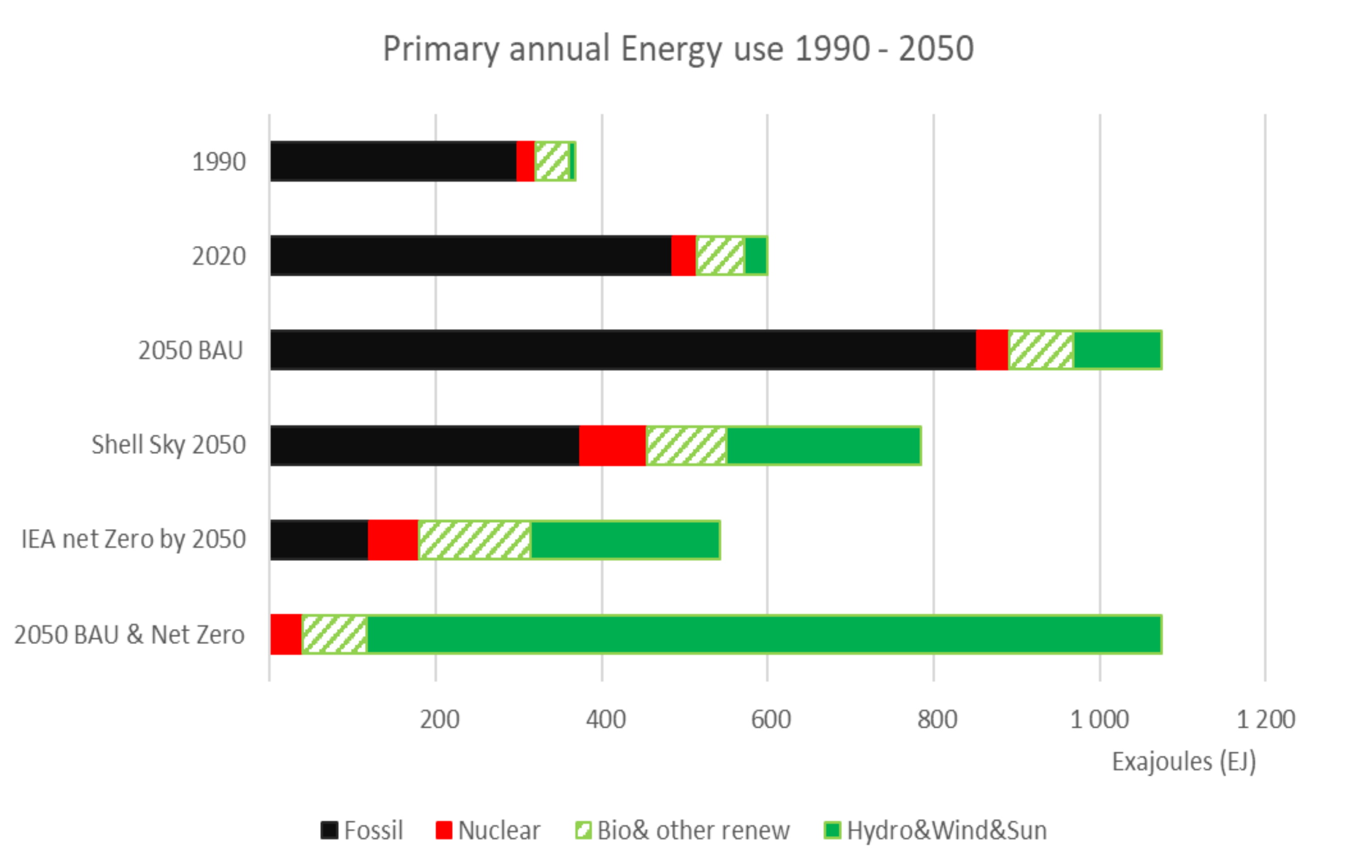
Two major de-carbonizing studies were released in 2021, both keeping a temperature rise below 1.5–2 °C

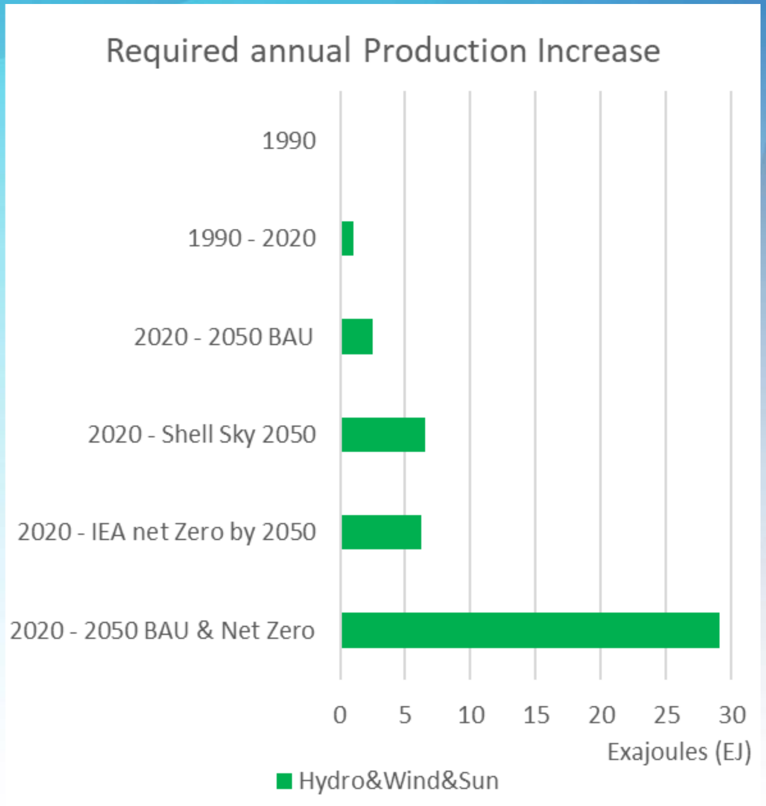
- **IEA assumes nearly a full decarbonization of Maritime and Aviation by 2050** (DNV Maritime Forecast to 2050 with 50% GHG or 100% GHG follows the same pathway)
- **Shell assumes that Maritime and Aviation consumption will be mainly fossil even in 2100** (Elizabeth Lindstad, Sustainability of Zero carbon E-fuels for maritime transport; MT- Marine Technology, July 2022; and the coming Lindstad et al 2022, The need for Wise use of renewable energy within the transport sector -to Minimize Global GHG emissions follows the same pathway)





Common for all decarbonizing scenarios (net Zero GHG) is the need for a large ramp-up of renewable energy production





Source: Lindstad et al. (2021) compiled from The energy transformation scenarios (Shell, 2021), Net Zero by 2050 (IEA, 2021)

Examples of some of my other papers within LCA and Well-to-Wake of fuels

sustainability
MDPI

Article

Decarbonizing Maritime Transport: The Importance of Engine Technology and Regulations for LNG to Serve as a Transition Fuel

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Abstract: Current Greenhouse gas emissions (GHG) from maritime transport represent around 3% of global anthropogenic GHG emissions and will have to be cut in half by 2050 to meet Paris agreement goals. Liquefied natural gas (LNG) is by many seen as a potential transition fuel for decarbonizing shipping. Its favorable hydrogen to carbon ratio compared to diesel (marine gas oil, MGO) or bunker fuel (heavy fuel oil, HFO) translates directly into lower carbon emissions per kilowatt produced. However, these gains may be nullified once one includes the higher Well-to-tank emissions (WTT) of the LNG supply chain and the vessel's un-combusted methane slip (CH_4) from its combustion engine. Previous studies have tended to focus either on greenhouse gas emissions from LNG in a Well-to-wake (WTW) perspective, or on alternative engine technologies and their impact on the vessel's Tank-to-wake emissions (TTW). This study investigates under what conditions LNG can serve as a transition fuel in the decarbonization of maritime transport, while ensuring the lowest possible additional global warming impact. Transition refers to the process of moving away from

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Assessment of Alternative Fuels and Engine Technologies to Reduce GHG

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Current greenhouse gas emissions (GHG) from maritime transport represent around 3% of global anthropogenic GHG emissions. These emissions will have to be cut at least in half by 2050 compared to 2008 as adopted by IMO's initial GHG-strategy to be consistent with the Paris Agreement goals. Basically, the required GHG emissions reduction can be achieved through: Design and other technical improvement of ships; Operational Improvement; Fuels with zero or lower GHG footprint; or a combination of these. Fuels with zero or lower GHG footprints are often perceived to be the most promising measure. The motivation for this study has therefore been to investigate these alternative fuels with focus on their feasibility, energy utilization and cost in addition to their GHG reduction potential. The results indicate: First, that fuels with zero or very low GHG emissions will be costly; Second, that these fuels might double or triple the maritime sector's energy consumption in a Well-to-Wake context; Third, if large amounts of renewable electricity becomes available at very low prices, synthetic E-fuels such as E-diesel and E-LNG which can be blended with conventional fuels and used on conventional vessels, will be more commercially attractive than hydrogen and ammonia.

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Optimal ship lifetime fuel and power system selection

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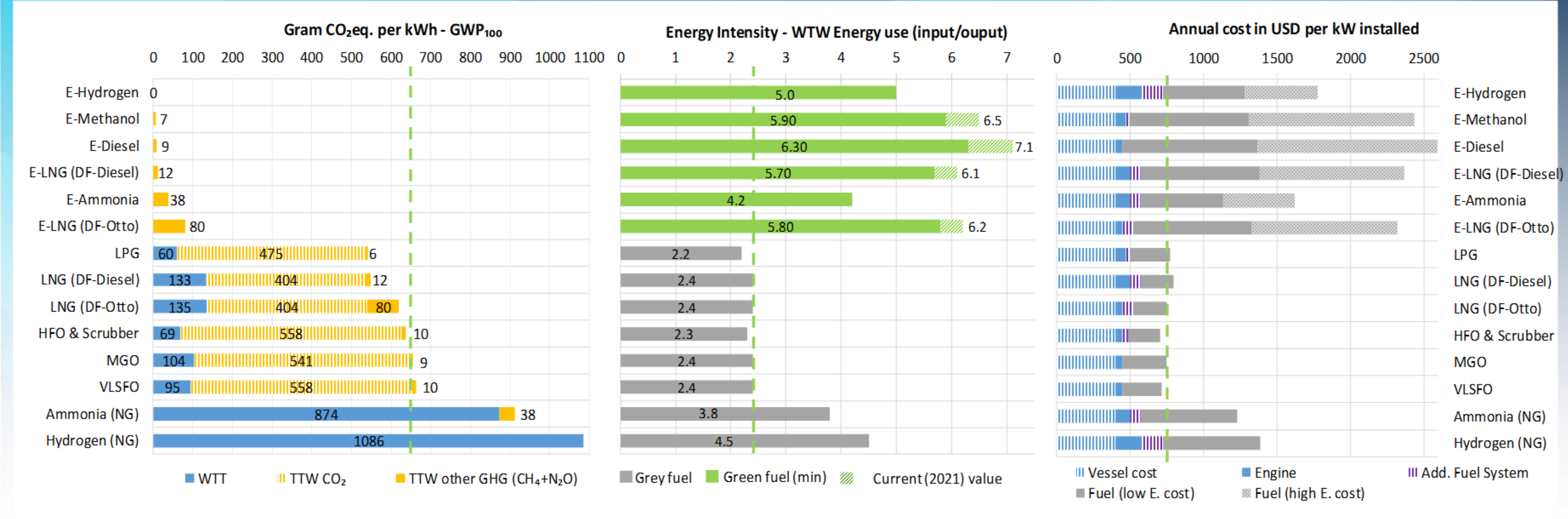
ABSTRACT

Alternative fuels and fuel-flexible ships are often seen as promising solutions for achieving significant greenhouse gas reductions in shipping. We formulate the selection of alternative fuels and corresponding ship power systems as a bi-objective integer optimization problem. We apply our model to a Supramax Dry-bulker and solve it for a lower bound price scenario including a carbon tax. Within this setting, the question whether bio-fuels will be available to shipping has significant effect on the lifetime costs. For the given scenario and case study ship, our model identifies LNG as a robust power system choice today for a broad range of GHG reduction ambitions. For high GHG reduction ambitions, a retrofit to ammonia, produced from renewable electricity, appears to be the most cost-effective option. While these findings are case-specific, the model may be applied to a broad range of cargo ships.

Our method to assess WTW of fuels focusing on: GHG emissions, energy use and total annual vessel cost

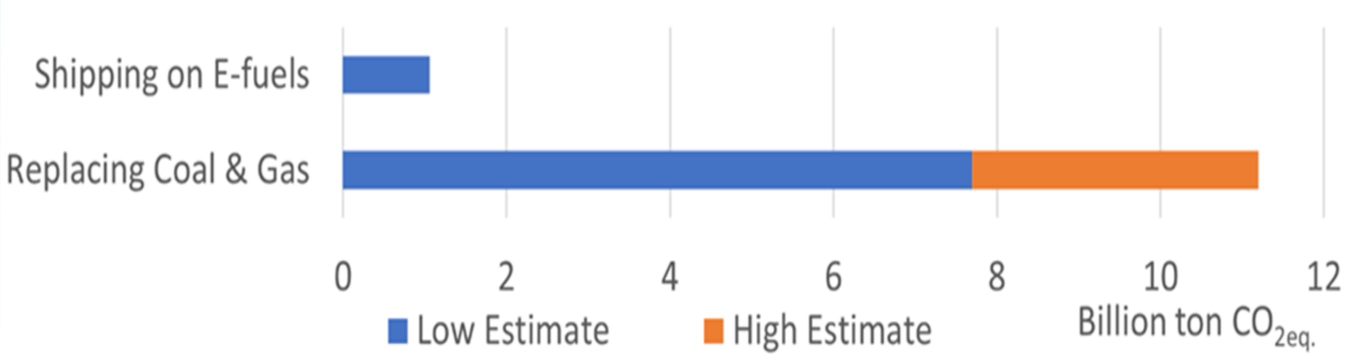


GHG reductions by alternative use of renewable energy

1. Global production of electricity is 84 EJ, of which around 25 EJ comes from renewables

2. Fuelling ships on E-fuel: E-ammonia: 14EJ * 4.2/2 = 29EJ;
   E-diesel: 14EJ * 7.1/2 = 50EJ

1. If that renewable energy instead is used to replace electricity from Coal (around 30EJ) and Natural gas (around 20 EJ) we will get 7 – 10 larger CO_2 reductions, i.e. 20-30% Global CO_2 reductions instead of 3% from shipping.



Source: Elizabeth Lindstad, Sustainability of Zero carbon E-fuels for maritime transport; MT- Marine Technology, in press July 2022.

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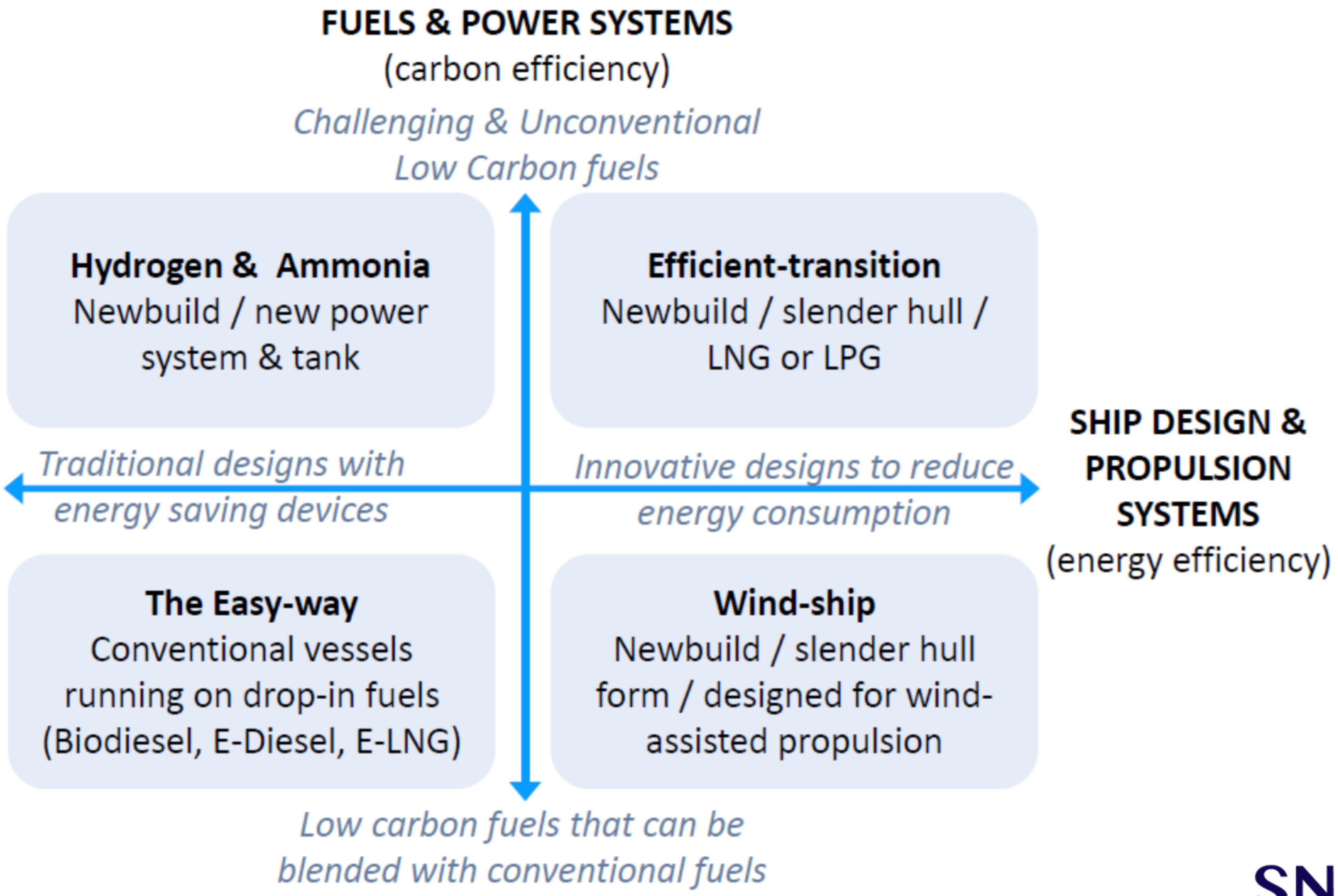
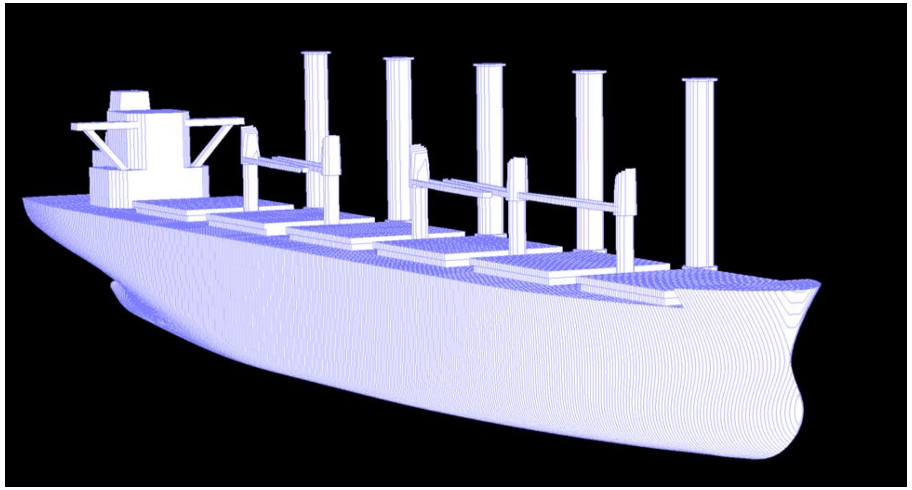
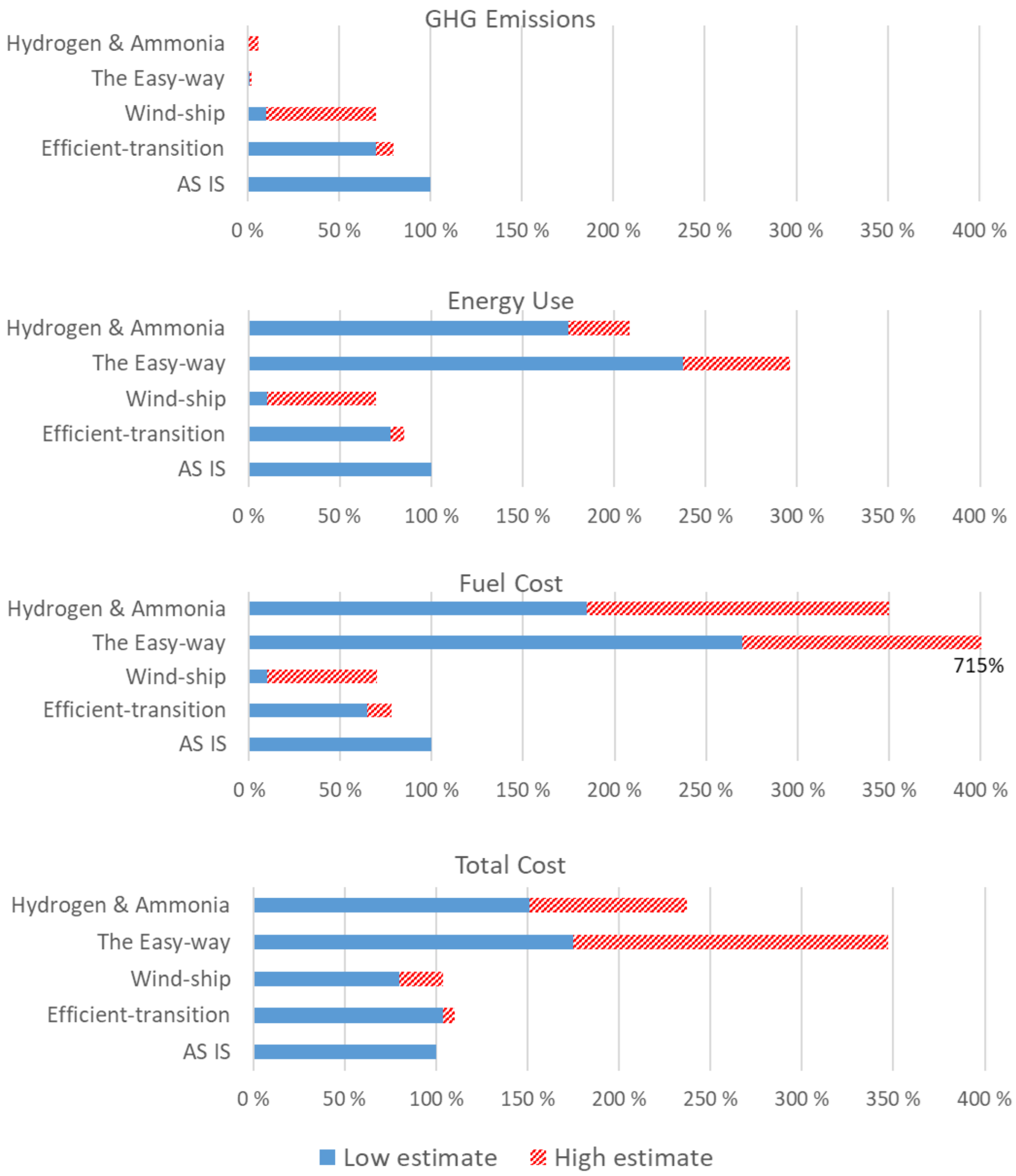
Zero carbon fuels are not the only option to reach the IMO 50% GHG reduction by 2050



Comparing the four shipping Scenarios to reach the 50% GHG reduction by 2050





Source: Rialland & Lindstad, 2021

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Reaching IMO 2050 GHG Targets Exclusively through Energy efficiency measures

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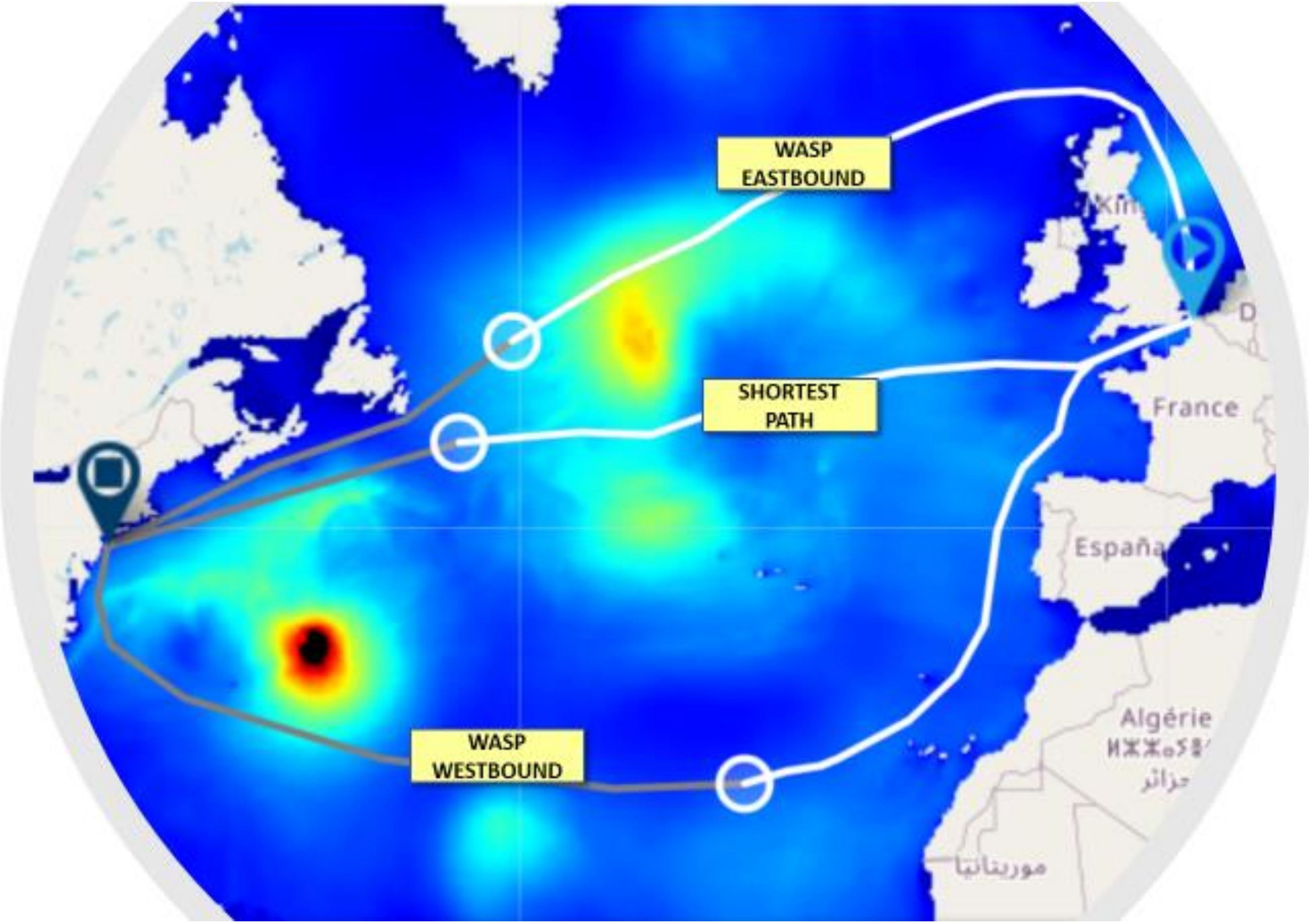
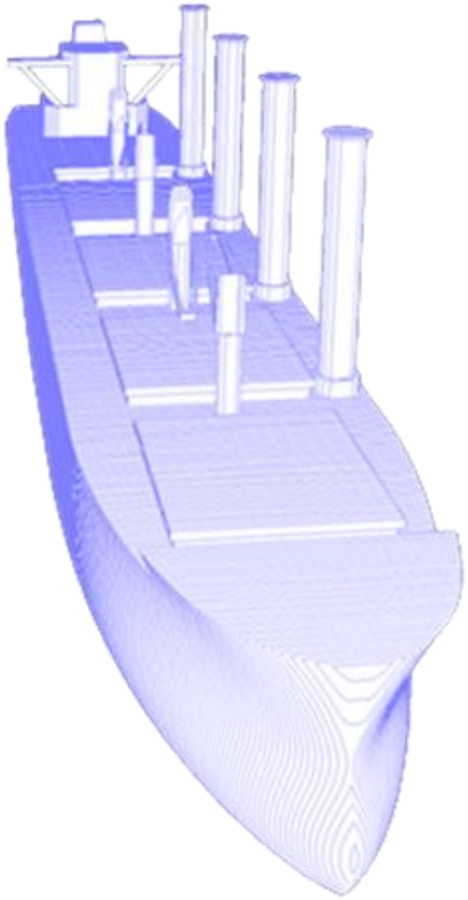
Maritime transport accounts for around 3% of global anthropogenic greenhouse gases (GHG) emissions (Well-to-Wake). GHG emissions must be reduced by at least 50% in absolute values by 2050 to contribute to the ambitions of the Paris agreement signed in 2015. Switching to Zero-carbon fuels made from renewable sources (hydro, wind, or solar) is seen by many as the most promising option to deliver the desired GHG reductions. However, renewable energy is a scarce resource that gives a much larger GHG reduction spent within other sectors. This study explores how to reach the IMO 2050 GHG targets exclusively through energy efficiency measures. The results indicate that by combining wind-assisted propulsion (WASP) with a slender hull form, fuel consumption and GHG emissions can be reduced by 30 – 35%, and transport cost by 5 – 10%. In comparison, GHG reductions through Zero-carbon fuels will increase transport costs by 50-200%.

Sail Ship Routing versus conventional

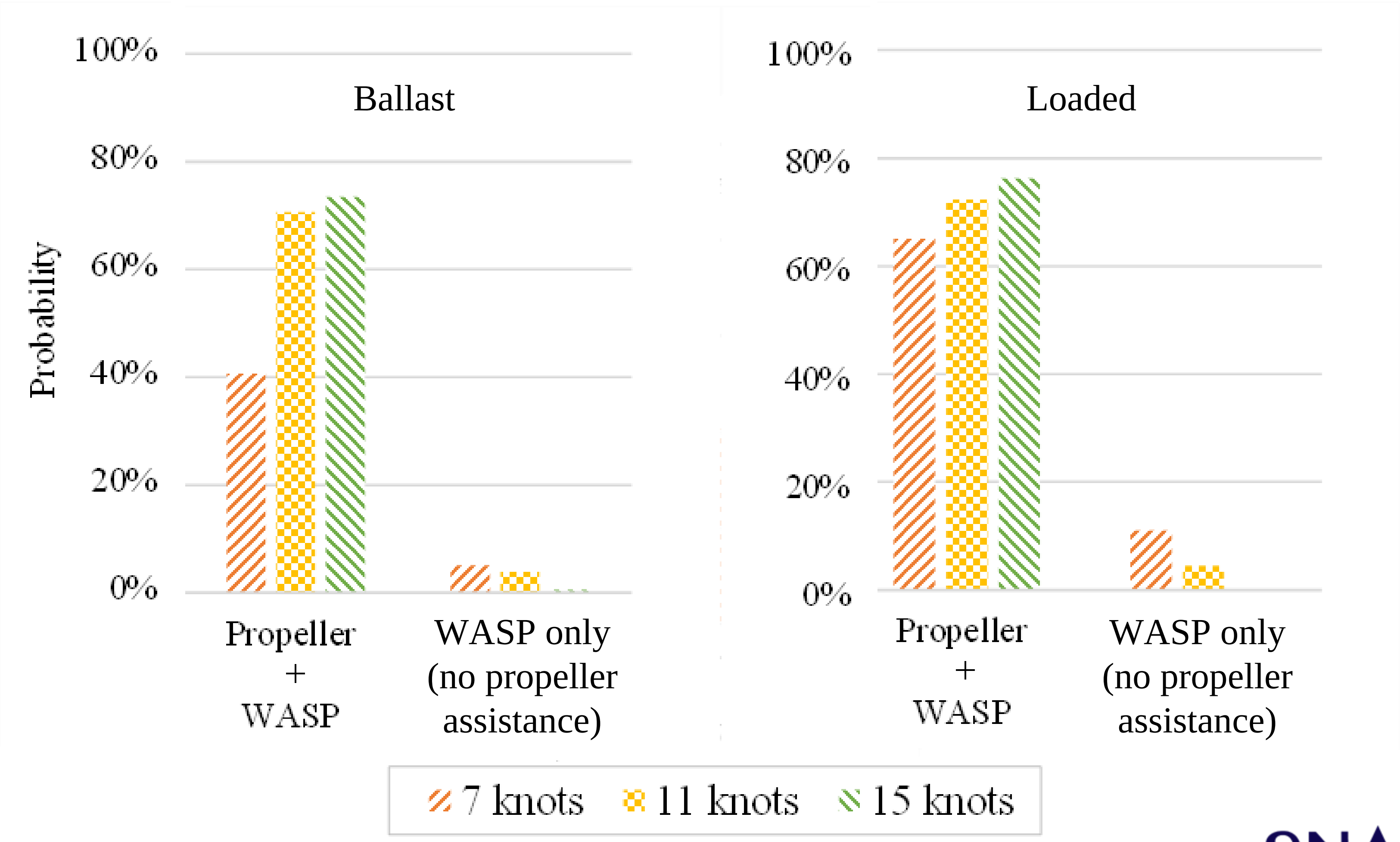


The investigated designs

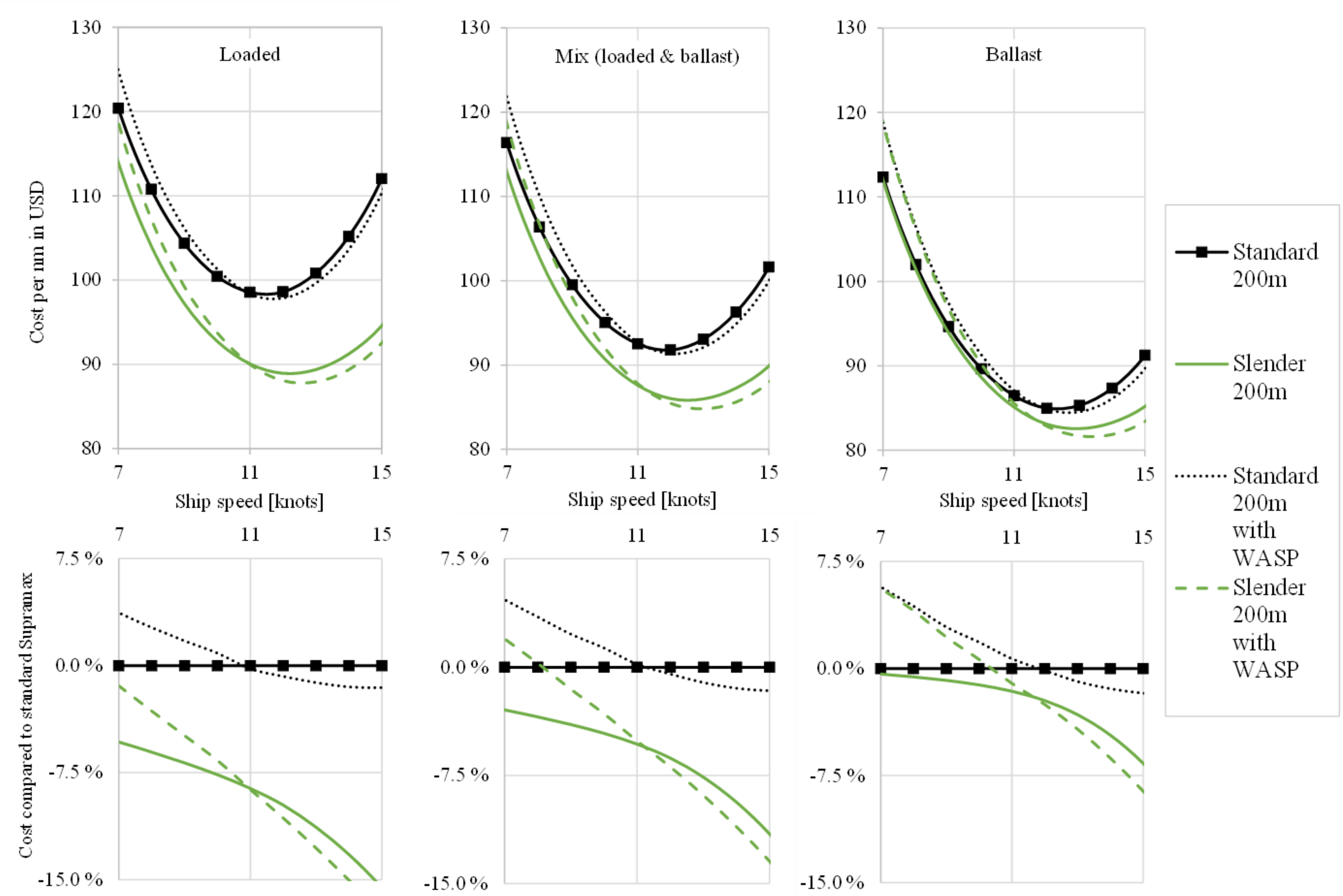
Vessel		Supramax 200m		200m Slender Supramax	
			WASP		WASP
LOA (m)		200	200	200	200
Beam (m)		32.3	32.3	32.3	32.3
Displace-ment (Ton)	11.7 (m)	64 300	64 300	57 900	57 900
	13.4 (m)	73 700	73 700	66 700	66 700
	14.4 (m)			73 700	73 700
Volume capacity (m^3)		79 000	79 000	77 000	77 000
Block – Cb		0.88	0.88	0.79	0.79
Bow length -L_{BWL} (m)		15.5	15.5	38.8	38.8
Boundary speed (knots)		11.7	11.7	15.1	15.1
LDT (Ton)		10 700	10 900	10 700	10 900
Dwt (Ton)	11.7 (m)	53 600	53 400	47 200	47 000
	13.4 (m)	63 000	62 800	56 000	55 800
	14.4 (m)			63 000	62 800
Main Power (KW)		8 500	8 500	8 500	8 500
Newbuild Cost (MUSD)		30	33.5	30	33.5



Probability of WASP operational condition in 50/50 sea conditions for a slender Supramax



Comparing cost



CONCLUSIONS - Reaching IMO 2050 GHG Targets through Energy Efficiency Measures

- **Retrofitting WASP on a standard Supramax reduces fuel consumption by 10 – 20%. Still, that gives even in the best case only marginal economic savings (only a small number of ships has been retrofitted with WASP)**
- **Combining WASP with a slender hull design can reduce ship fuel consumption and GHG emissions by 30 – 35% when operated at speeds between 7 and 15 knots.**
- **Best of all, they come at a 5 – 10% reduction of the total cost, implying a negative abatement cost. In contrast, GHG reductions through Zero-carbon fuels increase total costs by 50-200%.**

Thank you for your attention this concludes the presentation

Questions?