Decarbonisation pathways within deep sea shipping:

Outlook and options

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Agenda.

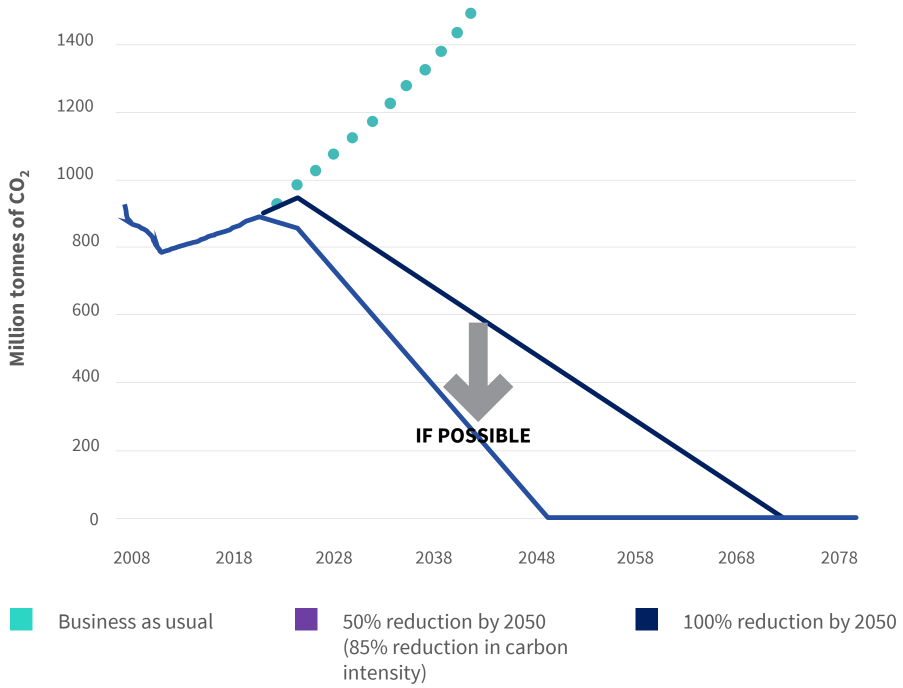
- Initial IMO GHG Strategy
- Zero carbon fuels:
    - Investment Readiness
    - Technology Readiness
    - Community Readiness
- Deep Sea vs IWW
- Q&A

Why are zero-carbon fuels needed for full decarbonisation?

To achieve an absolute reduction in GHG of at least 50% by 2050.

- Shipping emits around **2.3%** of global CO_2 emissions
- Unchecked increase to **10%** by mid-century

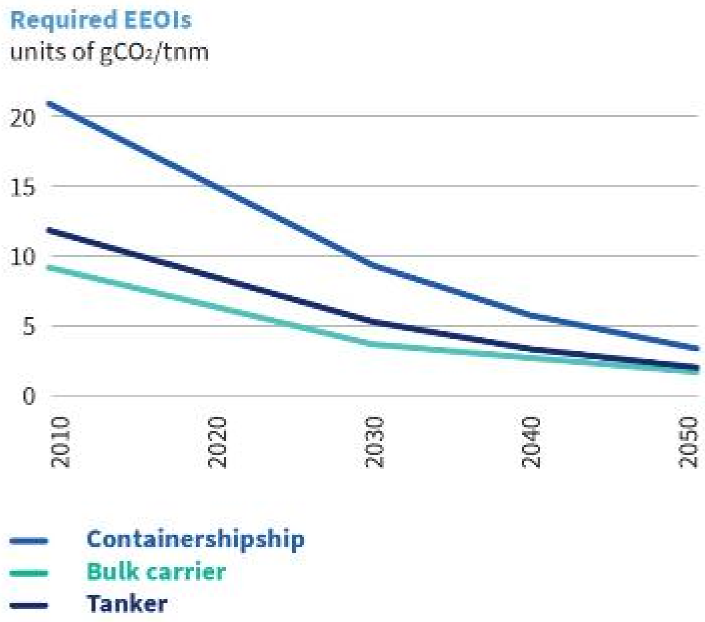
Pathways for international shipping's CO_2 emissions



What is the required reduction in carbon intensity?

- By 2050 shipping emissions will need to decrease by **60-90%** in fleet average carbon intensity in order to accommodate a growing demand of transport

- Efficiency and renewables are not enough to reach the goal
- Zero-emission vessels need to be entering the fleet from 2030



Delivering on the Initial IMO Strategy

- Consensus on goal-based approach to short-term measures to improve the carbon intensity of shipping
- Amendments to MARPOL Annex VI
- Foundation not solution

EEDI (New Ships)

Goal-Based **Operational & Technical** Efficiency Measures (All Ship)

Goal-Based **Technical** Efficiency Measures (Existing Ships)

A Hybrid

Lifecycle Analysis

Methane Slip and VOCs

- Mid- and Long-Term Measures to transition shipping from reliance on fuel oils
- Novel Regulatory Approaches
- Industry Initiative and Ambition

Encouraging Uptake of Low- and Zero-Carbon Fuels

What do we mean by zero-carbon fuels?

Transition to zero emission vessels means phasing out fossil based fuels.

	Zero-carbon fuels				
Energy source	Methanol	Gas oil	Hydrogen	Ammonia	Electricity
Natural gas with CCS			NG-H_2	NG-NH_3	
Biomass	bio-methanol	bio-gas oil			
Renewable electricity	e-methanol	e-gas oil	e-H_2	e-NH_3	batteries

Our ‘Getting to Zero’ model.

Marine product readiness level = Technology readiness level + Investment readiness level + Community readiness level

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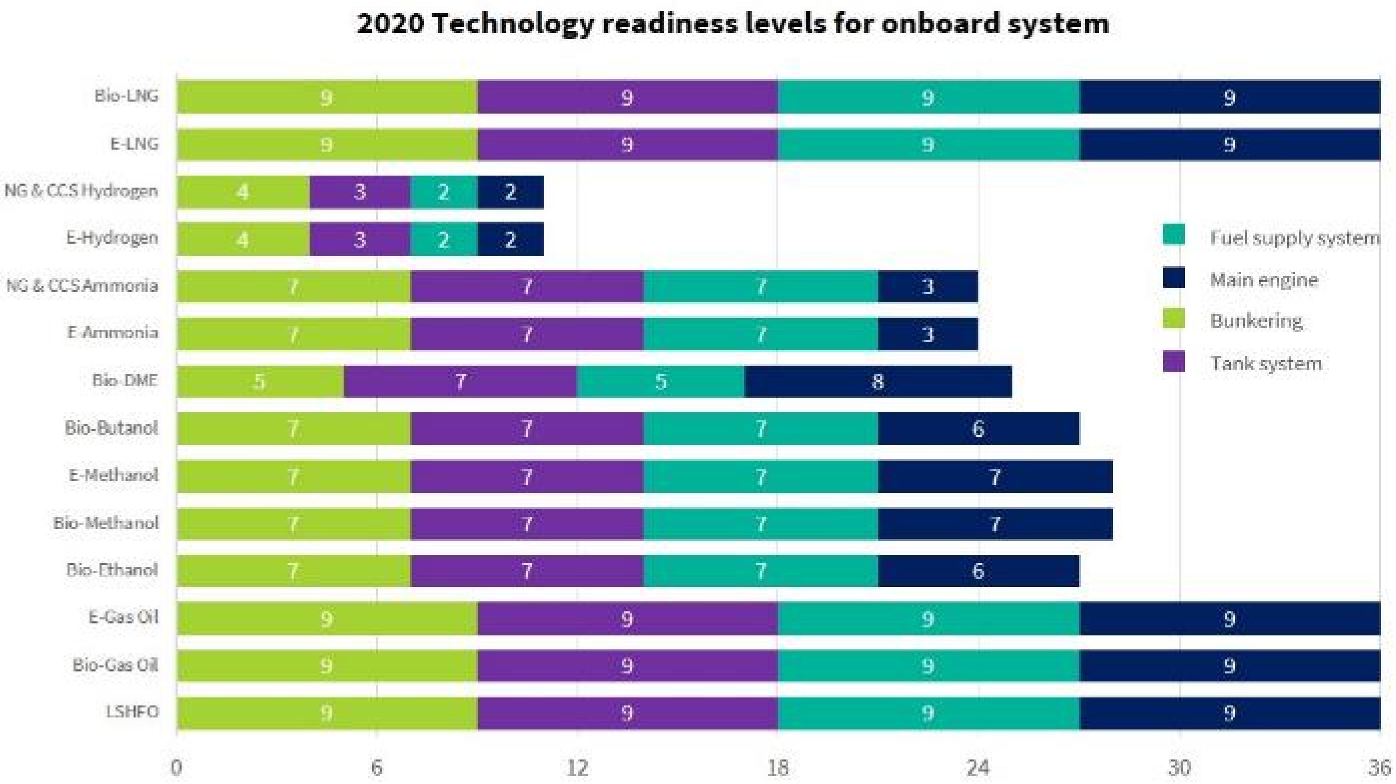
Technology readiness.

Onboard technology systems ready in 2-3 years

- Safety risks can be mitigated
- Experience building phase
- Technology challenge is the supply infrastructure



Comparative energy equivalence.

LNG
Mass ~x0.8
Volume ~x2

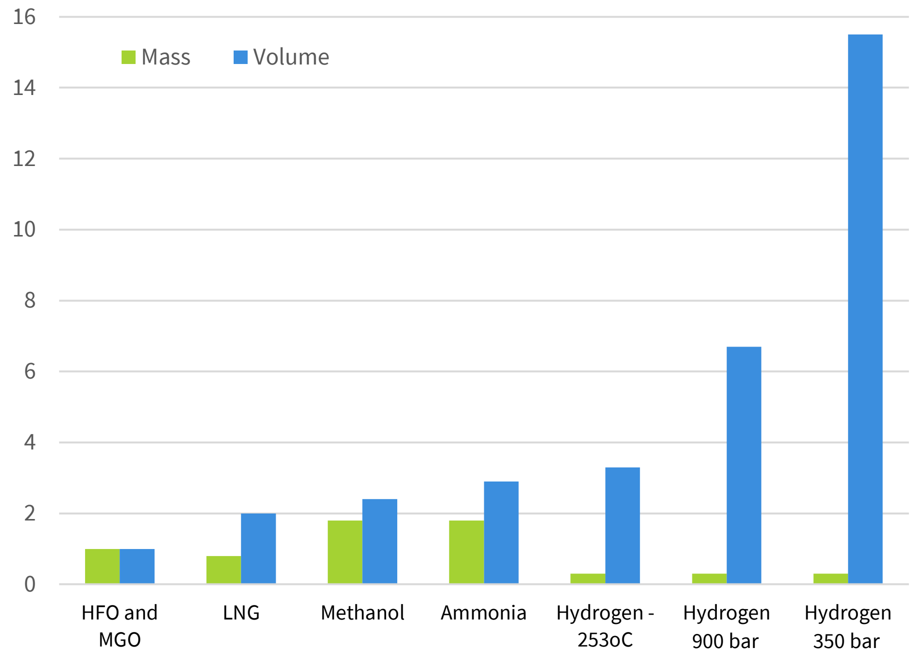
Methanol
Mass ~x1.8
Volume ~x2.4

Ammonia
Mass ~x1.8
Volume ~x2.9

Hydrogen 350 bar
Mass ~x0.3
Volume ~x15.5

Hydrogen 900 bar
Mass ~x0.3
Volume ~x6.7

Hydrogen -253 °C
Mass ~x0.3
Volume ~x3.3

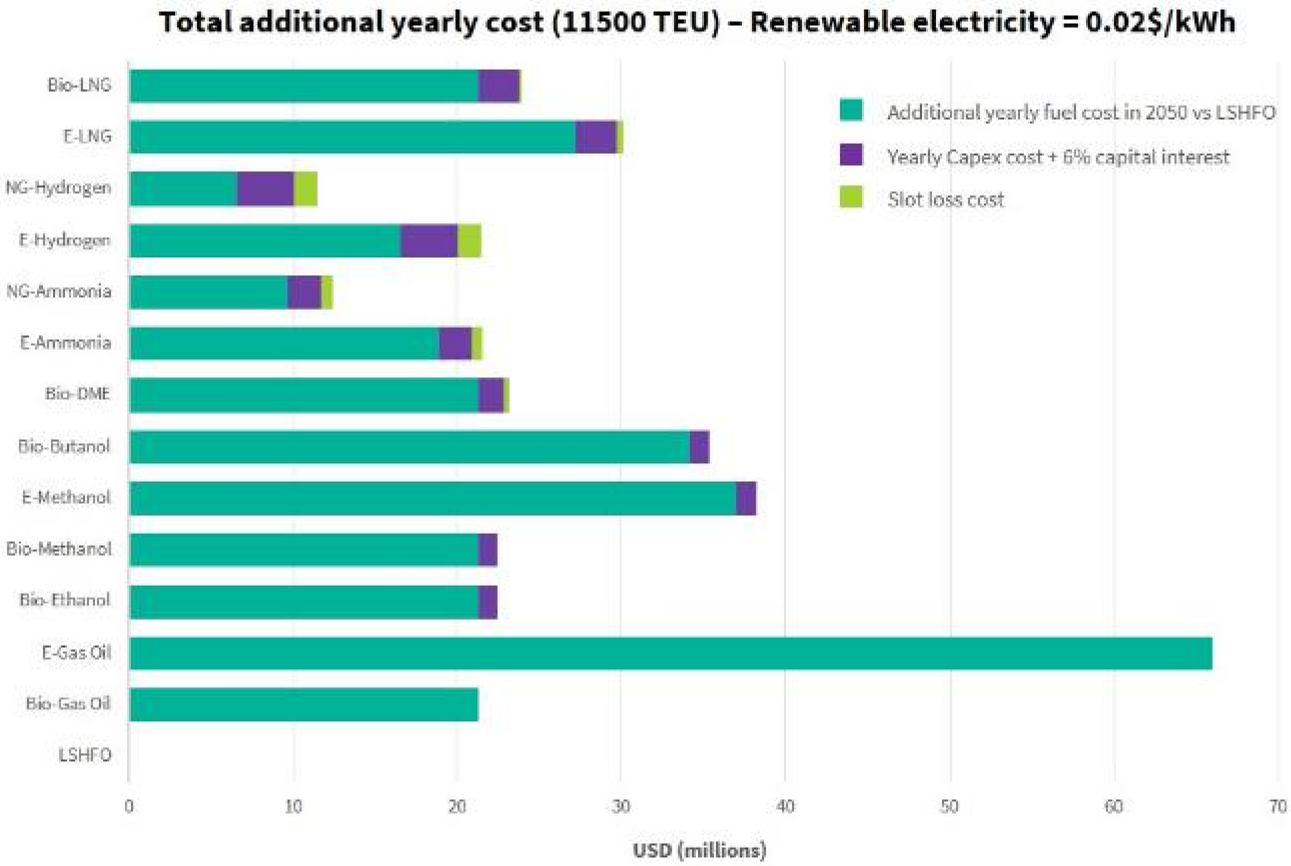


Investment readiness.

The cheapest option is still likely to be 2-3 times the total cost of ownership.

- The main cost driver is fuel price
- Need to reduce the cost of fuel production technologies
- Applying a carbon price makes the investment case more attractive ~ $200-300 / tonne of CO_2

- Uncertainty in future production costs: Direct Air Capture



Community Readiness.

Policy intervention and a fundamental shift to the incentives scheme is needed

- Fossil fuels need to be least attractive and zero-carbon fuels more attractive
- Closely related to how the wider energy system decarbonises
- Competition with other sectors
- Market incentive schemes

IMO

POSEIDON PRINCIPLES

IWW and Coastal Shipping

Differences between Deep Sea and IWW?

Range and Size drive differences in onboard technology feasibility

Feedstock and production availability/cost still key drivers

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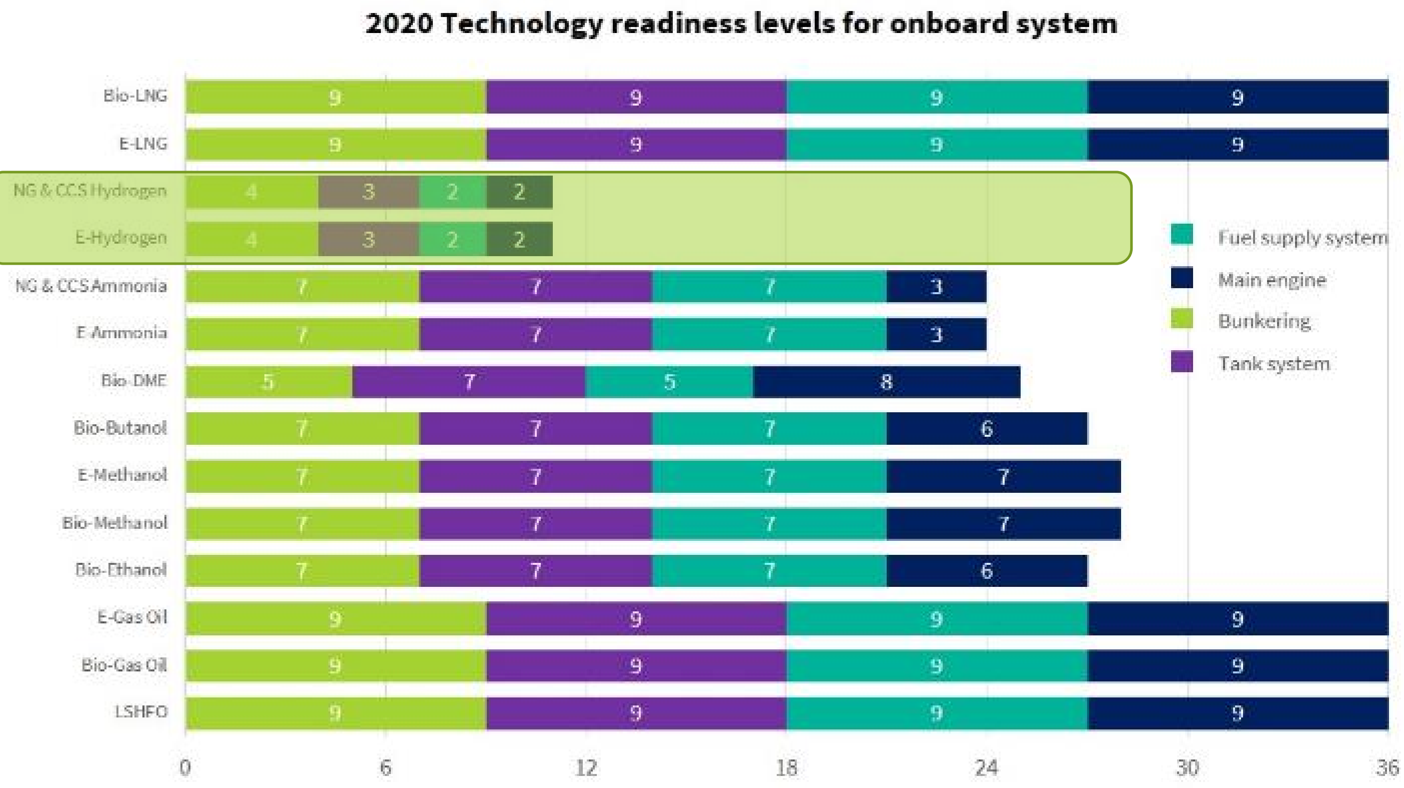
Compressed vs Liquid storage

Hybrid

Fuel Cells: size

Technology readiness: Deep Sea vs IWW

- Safety risks can be mitigated
- Experience building phase
- Primary technology challenge is the supply infrastructure
    - IWW advantages



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Conclusions.

- Certain pathways appear more resilient that others from the perspective of asset longevity
- Fuel price is the predominant factor
- Competitive options in the short-term may become uncompetitive in the long-term
- Many unknowns and uncertainties still exist
    I. Market price development
    II. Competing demand
    III. Technology development for fuel production
    IV. On-board safety
- Much overlap, but some material differences Deep Sea to IWW: IWW to lead Deep Sea?

Thank you.

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