Maritime Ammonia Fuel – Stepping Forward

Annual AEA Members Conference - Boston

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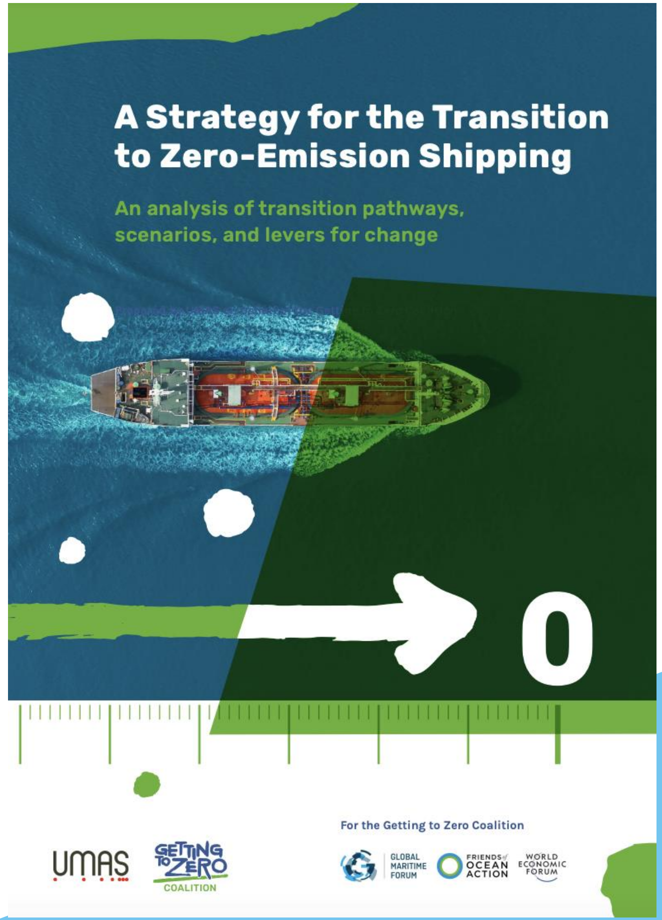
A Strategy for the Transition to Zero-Emission Shipping – by UMAS & Getting to Zero Coalition



Delivered the week before COP26, it offers a detailed analysis of pathways, scenarios and levers for accomplishing shipping's energy transition.

The report underlines that transitions towards zero are in practice fluid, and **outcomes are determined** not by equations, but **by the interplay of actors and their actions** - guiding not just the end point, but **the path to get there**.

UMAS

UMAS *is a partnership between UMAS International Ltd and the University College London (UCL) Energy Institute. The partnership creates a fusion between the consulting expertise of UMAS International Ltd with the academic research and innovation generated at UCL Energy Institute.*

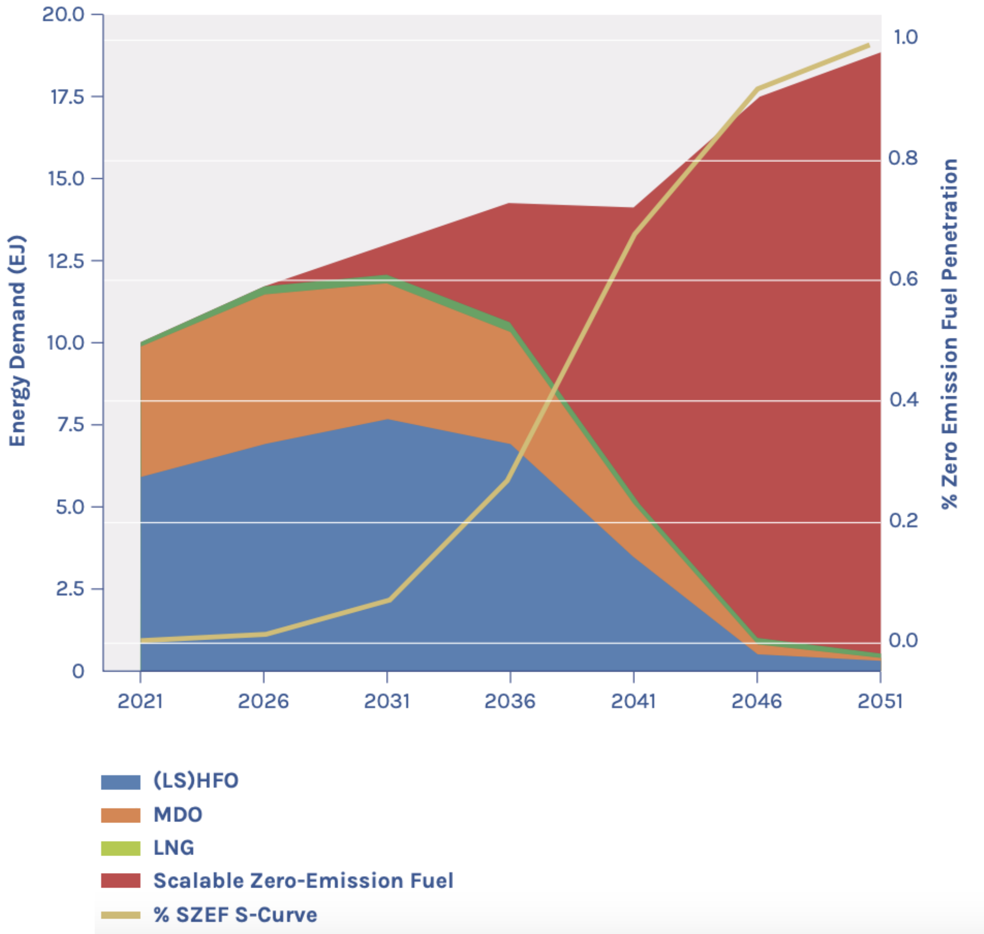
GETTING TO ZERO COALITION

The Getting to Zero Coalition *is a partnership between the Global Maritime Forum, the Friends of Ocean action, and the World Economic Forum. It brings together decision-makers from across the shipping value chain with key stakeholders from the energy sector as well as from governments and IGOs.*

In 2030, 5% of total shipping fuel must be Scalable Zero-Emission Fuel to reach 1.5C

A massive acceleration is needed to reach rapid diffusion by 2030.

Until 2030, a limited adoption of ZEVs will however play a crucial role in proving technical and economic viability, and allow policy environment to coordinate to promote scale and drive performance.

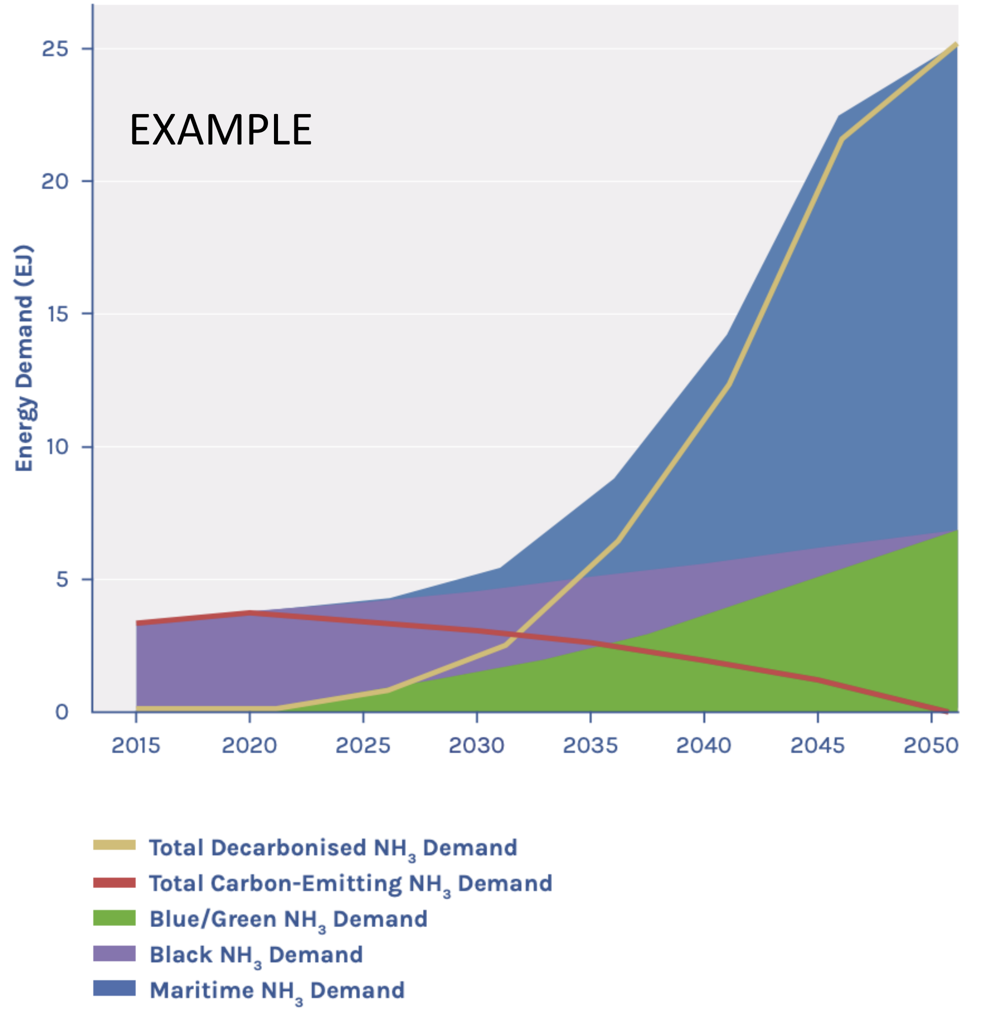


Source: *A Strategy for the Transition to Zero-Emission Shipping*, Oct 2021, UMAS & Getting To Zero Coalition

Shipping's transition could provide a more reliable investment case for other sectors

Maritime demand will create additional pressure for existing ammonia production to decarbonise.

The overlap between shipping's growing demand for ammonia could grow alongside the emerging existing end-use demand for blue/green ammonia.



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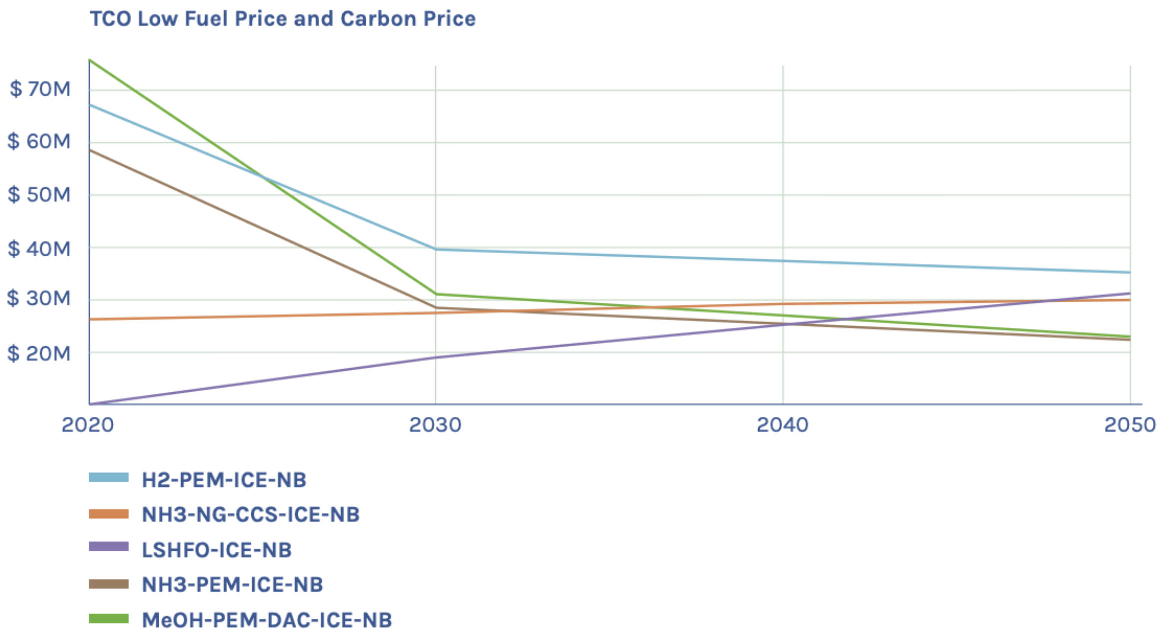
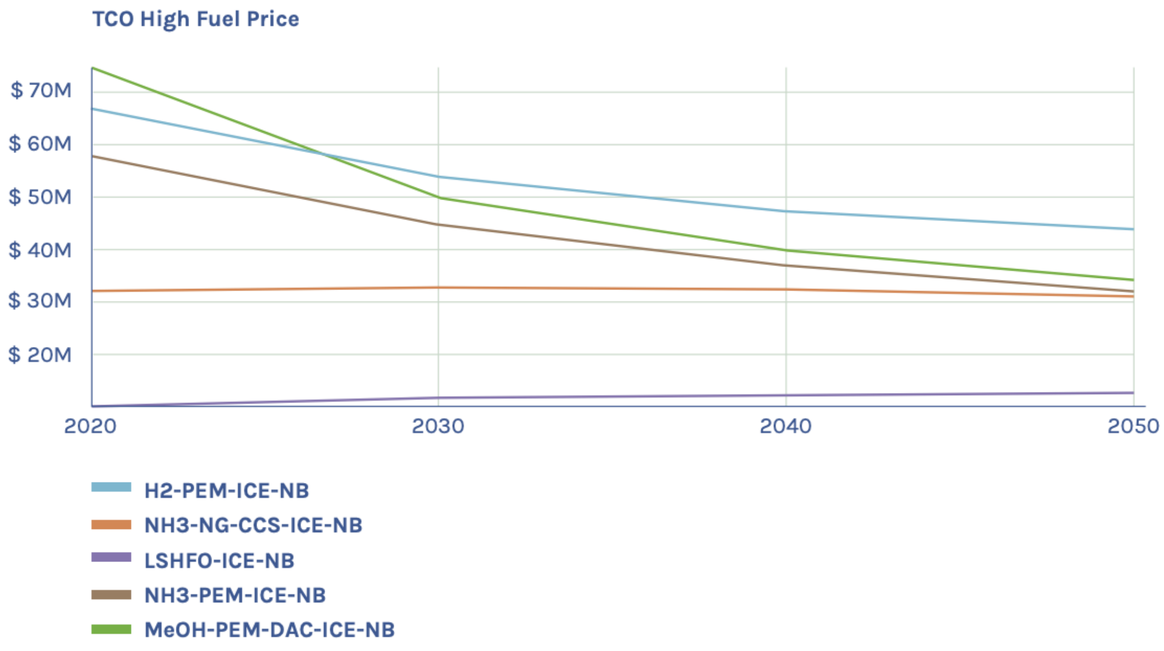
Ammonia has lowest TCO – but technology maturity and acceptance are driving decision

First-of-a-kind trials and dissemination of these results will be critical to reach maturity and acceptance.

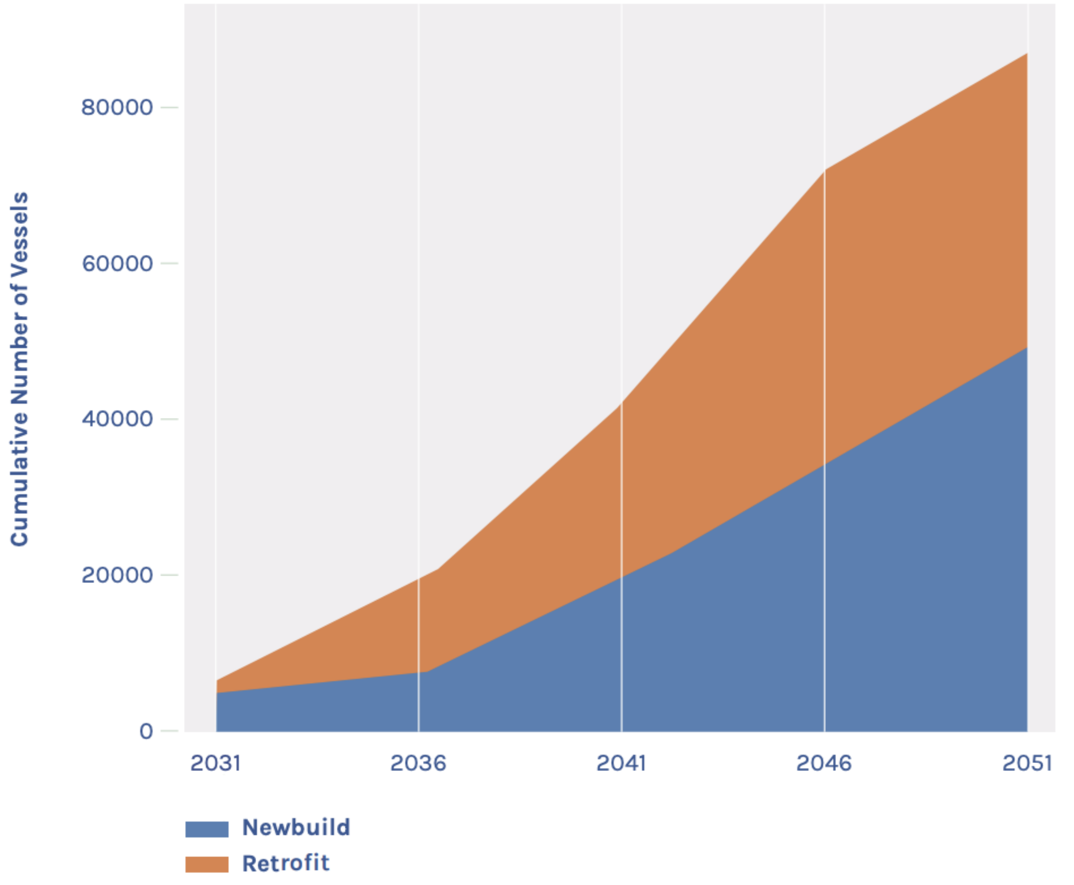




Source: *A Strategy for the Transition to Zero-Emission Shipping*, Oct 2021, UMAS & Getting To Zero Coalition

If trade grows as expected, ammonia retrofit-options could play large role

Unless ship lives are significantly reduced for the fossil fuelled fleet, similar magnitudes of newbuilding and retrofitting to SZEF will be needed.



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First movers need predictability and acceptable risk

The likely key determinants for first mover action will be:

1) the cost and availability of SZEFs; and,
2) the nature of shipping operations, in terms of geography and complexity

Likely first-movers are therefore:

1. A liner route (a ship with a small number of regular port calls)
2. An intra-cluster route (a ship that only operates within a local region)
3. A bilateral route (a ship that shuttles between two ports or clusters of ports)

UMAS has mapped routes and regions of likely first-movers

DOMESTIC ONLY LINERS

Source: *A Strategy for the Transition to Zero-Emission Shipping*, Oct 2021, UMAS & Getting To Zero Coalition

UMAS has mapped routes and regions of likely first-movers

LINERS STOPPING AT TWO COUNTRIES

Source: *A Strategy for the Transition to Zero-Emission Shipping*, Oct 2021, UMAS & Getting To Zero Coalition

UMAS has mapped routes and regions of likely first-movers

BILATERAL TRADE ROUTES BETWEEN PORTS FROM HYDROGEN-ADVANTAGED COUNTRIES

Source: *A Strategy for the Transition to Zero-Emission Shipping*, Oct 2021, UMAS & Getting To Zero Coalition

Cost, speed, dynamics of transition and maturity of technology are determinants

In order to accelerate the ammonia dual fuel pathway, the following is needed:

- The ammonia safety cases (bunkering, onboard use, spill) resolved
- Ammonia technology matures on track to be available by 2023/24/25
- Air emissions risks (NOx/NH3/N2O) are cost-effectively managed
- Hydrogen and ammonia production and supply chains and pilot fuel decarbonising
- Compatible decarbonised pilot fuel (small volume of a different fuel used to improve combustion) being available

Source: *A Strategy for the Transition to Zero-Emission Shipping*, Oct 2021, UMAS & Getting To Zero Coalition

Thank you!

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Appendix

Table 1: Table of actions needed to achieve 1.5°C-aligned and equitable decarbonisation of shipping (black – industry, green – national and plurilateral, red – multilateral).

	Key actions needed to decarbonise shipping	By 2022	By 2025	By 2030	By 2035	By 2040
Policy	Multiple nations make domestic and plurilateral commitments to decarbonise shipping	green				
	Multiple G20 governments commit to funding for RD&D and pilot projects related to zero-emission shipping	green				
	Leading countries publish 1.5°C aligned decarbonisation plans for domestic shipping, with aim to fully decarbonise by end of 2030s	green	green			
	Leading countries set production targets for zero-emissions fuels (intermodal usage)		green	green		
	International agreements on zero-emission shipping route creation (at least 3 global and 3 regional routes)	green	green			
	Most national governments completely phase out fossil bunkers in domestic shipping				green	green
	Intensified effort at IMO to agree long-term measures for shipping (e.g. market-based measures and non-market-based measures)	red				
	IMO Clarify feasibility of retrofitting existing fleet	red	red			
	IMO require new ships to be zero-emission ready, e.g. "GHG Reduction Plan with zero emission propulsion capability"		red	red		
	IMO adopt measures in EEDI, efficiency, other GH gasses & a roadmap to zero	red	red			
	IMO adopt guidelines to estimate well-to-tank GHG emissions and regulation/ incentives for zero-emission fuels	red	red			
	IMO agrees comprehensive decarbonisation strategy and net-zero by 2050 target	red	red			
	Global agreement on gradual phase out and ban of fossil bunkers					red
	Classification societies adopt robust "zero-emission ready" guidelines	black				
	Classification societies research and set operational and safety standards	black	black			
Finance	Increase transparency in ship finance, improve standard usage, and adopt more stringent Environmental, Social and Governance standards	black	black			
	Develop risk-sharing framework (e.g. for first movers) and longer maturities for ship finance (e.g. green bond markets)	black	black			
	Mobilise industry and finance support for large scale demonstration projects	black	black			
	Rapid deployment of investments on international routes in key countries		black	black		
	Mobilise government support (in key nations) for large scale demonstration projects	green	green			
	Increasing public finance (i.e. grants, loans) for zero-emission pilots and RD&D	green	green			
	Key nations provide financial incentives for creation of zero shipping routes (e.g. subsidies, grants, reduced levies)		green	green		
	Other countries ramp up financing for large scale demonstration projects		green	green		
	Spread of finance schemes and market-based mechanisms for shipping globally			green	green	green

	Key actions needed to decarbonise shipping	By 2022	By 2025	By 2030	By 2035	By 2040
Demand	Freight purchasers commit to price premium for zero-emission shipping	black	black			
	Shipowners, charterers and freight purchasers conduct feasibility studies for mid-term SZEF demand with potential producers	black				
	Container freight purchasers participate in system demonstrations	black	black			
	Market/commercialise zero-emission shipping to end customers		black	black		
	Freight purchasers commit to use zero-emission shipping by 2040	black	black			
	Broad coalitions commit to achieving 10 decarbonised deep sea routes by 2030	green	green			
	32 developed nations decarbonise domestic shipping to 30% by 2030	green	green	green		
	Leading countries issue domestic shipping tenders with zero carbon clauses and set out plans for inter-modal zero fuel usage		green	green		
Technology/ Supply	Key shipping industry actors commit to net-zero by 2050 and adopt Science Based Targets	black				
	Cross-industry collaboration to develop smaller zero-emission ships	black	black			
	Scale up green hydrogen supply and reduce electrolysis costs		black	black	black	
	Develop small scale green zero emission fuel production facilities [in leading countries]	black	black			
	Public-private collaboration to scale up affordable renewable energy [in leading countries]	green	green	green		
	Public-private collaboration on large-scale zero-emission demonstration projects [in leading countries]	green	green			
	Public-private collaboration to scale up green zero-emission fuel production [in leading countries]	green	green	green		
	Development of first "Green Corriodors" for zero-emission shipping	black	black			
	Shipping companies commit to buying zero-emission propulsion ready vessels	black	black			
	Large-scale demonstration projects demonstrate viability of zero-emission shipping		black			
	Majority of international shipping is fully decarbonised					black

Table 1: Fuel pathway options characterised.

Pathway	Who is this attractive to?	Why might this be attractive to a broader audience?	What does its narrative rely on?
Methanol dual fuel	Methanol interests Early adopters of "zero", especially those wanting to differentiate from conventional biofuel users	Methanol dual fuel is generally lower additional capex vs. hydrogen-based alternatives Methanol solutions are more mature (already in-use) than ammonia and the safety issues are perceived to be more manageable Methanol dual fuel today can be designed for retrofit to ammonia in the future "Methanol" sounds better than biofuel	Access to sustainable carbon input (e.g., via bioenergy with CCS – BECCS) until direct air capture is feasible Bio-methanol supply and supply chains rapidly scale and reduce in cost during the 2020s DAC (direct air capture) technology matures and is invested in at scale in the 2020s and 2030s Very low price and high volume zero-carbon electricity
Ammonia dual fuel	Hydrogen and ammonia interests (new entrants and existing) Governments with hydrogen production potential or export ambitions	Ammonia is consistently analysed as the lowest cost way to use hydrogen as a marine fuel It is already in widespread use as a commodity, and traded at sea, so there is established ship-shore transfer experience in certain locations, and onboard storage technology, which could be built upon for the bunkering applications Ammonia does not contain carbon so is easily perceived as a zero-emission fuel Future price competitiveness is independent of biomass feedstocks and DAC technology	The ammonia safety cases (bunkering, onboard use, spill) being resolved Ammonia technology matures on track to be available by 2023/24/25 Air emissions risks (NOx/NH3/N2O) are cost-effectively managed Hydrogen and ammonia production and supply chains and pilot fuel decarbonising Compatible decarbonised pilot fuel (small volume of a different fuel used to improve combustion) being available

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Table 3: Forces acting on shipping's transition.

LEVELS	CURRENT SYSTEM	FUTURE SYSTEM
OUTSIDE FORCES	**Dominant market forces:** • Failure to internalise costs of climate change • Prices for oil and gas • Demand for least cost shipping • Values-based drivers: • Emergent climate change movements • Shipping pollution opposition (i.e., SOx, NOx, PM) **International relations:** • Trade and energy security dominant • Climate commitments increasingly important **Finance:** • Small, fragmented financing (public and private) of zero carbon pilot projects • First moves towards transparency on climate alignment	**Dominant market forces:** • Internalisation of climate costs • Transition from fossil fuels • Renewable electricity prices • R&D and economies of scale for SZEFs • Demand for green shipping routes **Values-based drivers:** • Broad awareness of climate change • Increased transparency in shipping operations **International relations:** • Climate commitments overriding priority **Finance:** • Large scale deployment of capital into zero-emission shipping on a commercial basis • Transparency and governance enable engagement of all investor classes
SYSTEMS	**System components:** • Existing bunkering infrastructure and safety rules • Oil & gas production/supply chains • International shipping routes shaped by existing market forces • IMO structures struggle to adjust to required transition • National and supranational (i.e., EU) bodies regulating domestic and regional shipping • Flagging and class systems poorly understood in society • Industry associations fragmented on transition issues	**System components:** • Novel bunkering infrastructure for SZEFs, including handling and safety procedures • Full-scale SZEF production/supply chains including import/export capabilities • Widespread creation of "green corridors" • IMO decisions aligned with transition to zero • Improved transparency and regulation increases industry credibility • Industry associations aligned on decarbonisation
EMERGING FORCES	**Forces driving incremental improvements:** • Energy costs and GHG awareness driving operational efficiency improvements, scrubbers and low sulphur fuels, wind assistance • Changes to meet air pollutant pressures (i.e., SOx/NOx) reformulated in terms of GHG benefits • Fragmented discussions around multiple future fuels and pathways	**Forces driving whole industry transition:** • Decarbonisation, the primary drivers of technological change • Incremental technologies (efficiency, etc.) implemented to enable full decarbonisation • Well-to-wake analysis centres change around SZEFs

hot