WE MEAN BUSINESS COALITION

CORPORATE CLIMATE STOCKTAKE: SHIPPING SECTOR

October 2023

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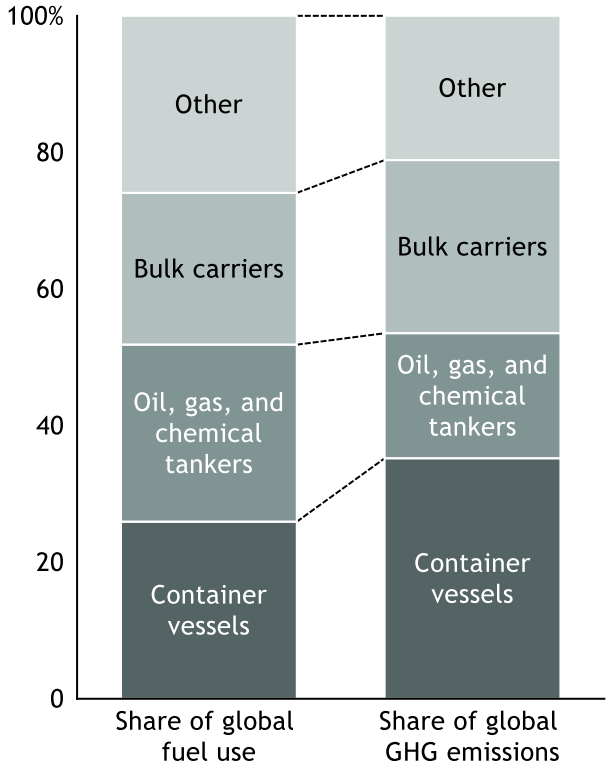
There are 4 primary segments of shipping vessels driving fuel consumption and emissions, with container ships contributing the highest share of activity

There are 4 primary segments of shipping vessels

	Container vessels	Oil, gas, and chemical tankers	Bulk carriers	Other
Type of trade conducted	• Containers	• Tanker trade (e.g., liquids)	• Main bulk (dry)	• Green energy (e.g., hydrogen, ammonia)* • Other dry cargo
Primary vessel types used	• VLCS • LCS • Classic Panamax • Small size	• VLCCSuezmax • Aframax • LR1/2 • MR • SR/Dandies • VLGC/LGC • Midsize • Handysize • Small LPG	• Capesize • Panamax • Supramax / Handymax • Handysize	• Suiso Frontier • Natural gas vessels • General cargo • Multi-purpose • Ro-Ro cargo • Car carriers
Examples of primary products carried	• Meat • Wood • Appliances • Electronics • Paper	• Crude oil • Refined petroleum • Chemicals (e.g., chlorine) • Juice • LNG / LPG	• Iron ore • Coal • Grains	• Liquid hydrogen / ammonia • Dry foods • Furniture • Machinery • Vehicles • Clothing • Rebars • Coils

Container ships drive the most fuel consumption and emissions

Share of global shipping sector by segment (%)

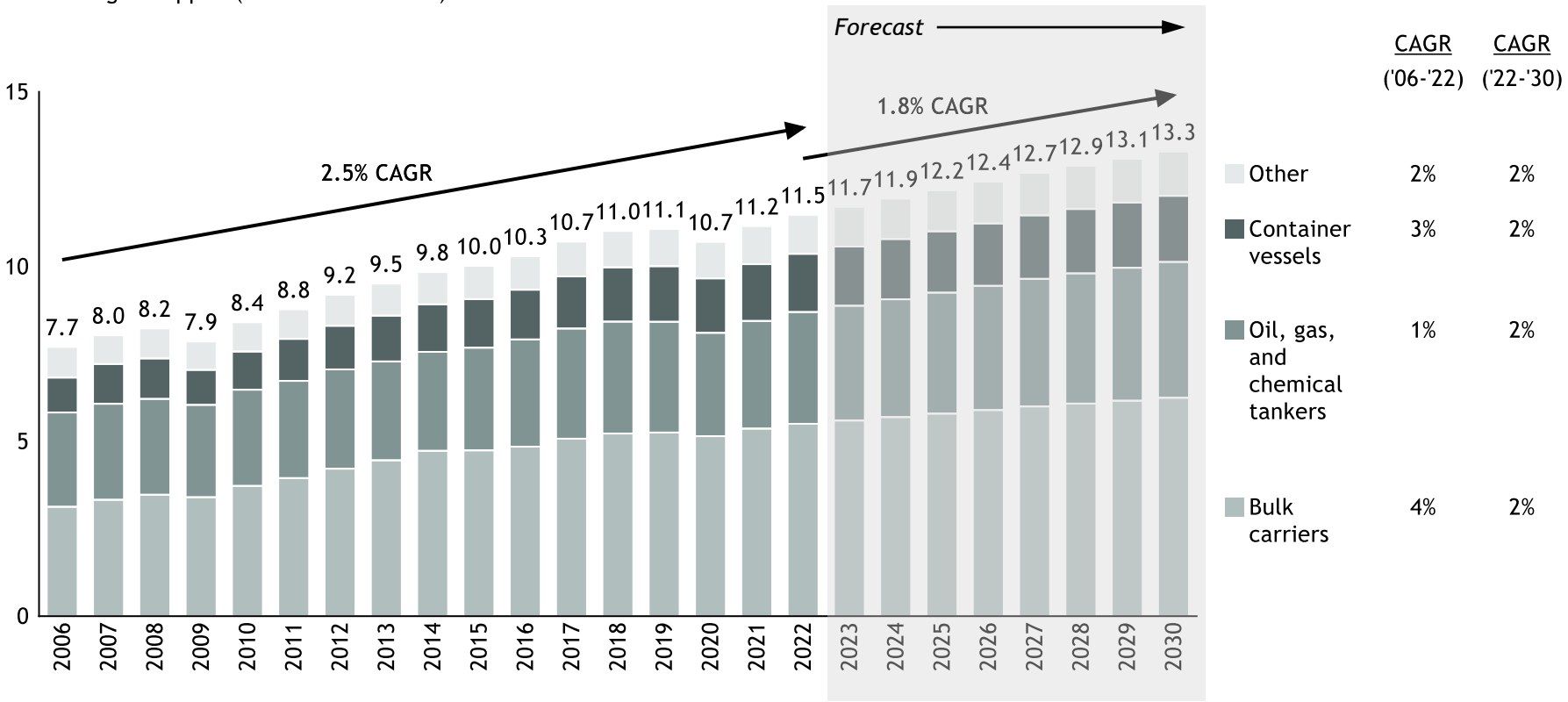


Note: (*) Includes but is not limited transport of hydrogen and related sources (e.g., ammonia); Shipping excludes offshore activities e.g., desalination
Source: BRS, UNCTAD, IEA, MDPI, DNV, Shell, Hayward, Lit. search, Clarkson's

Growth in the Shipping market follows global trade volume, so growth has been steady but cyclical and is expected to slow in the coming years

The shipping market has grown 2.5% annually over the last ~15 years, but growth is expected to slow to 1.8% through 2030

Total weight shipped (in B of metric tons)



	CAGR ('06-'22)	CAGR ('22-'30)
Other	2%	2%
Container vessels	3%	2%
Oil, gas, and chemical tankers	1%	2%
Bulk carriers	4%	2%

Source: UNCTAD, Clarkson's, The Asian Journal of Shipping and Logistics

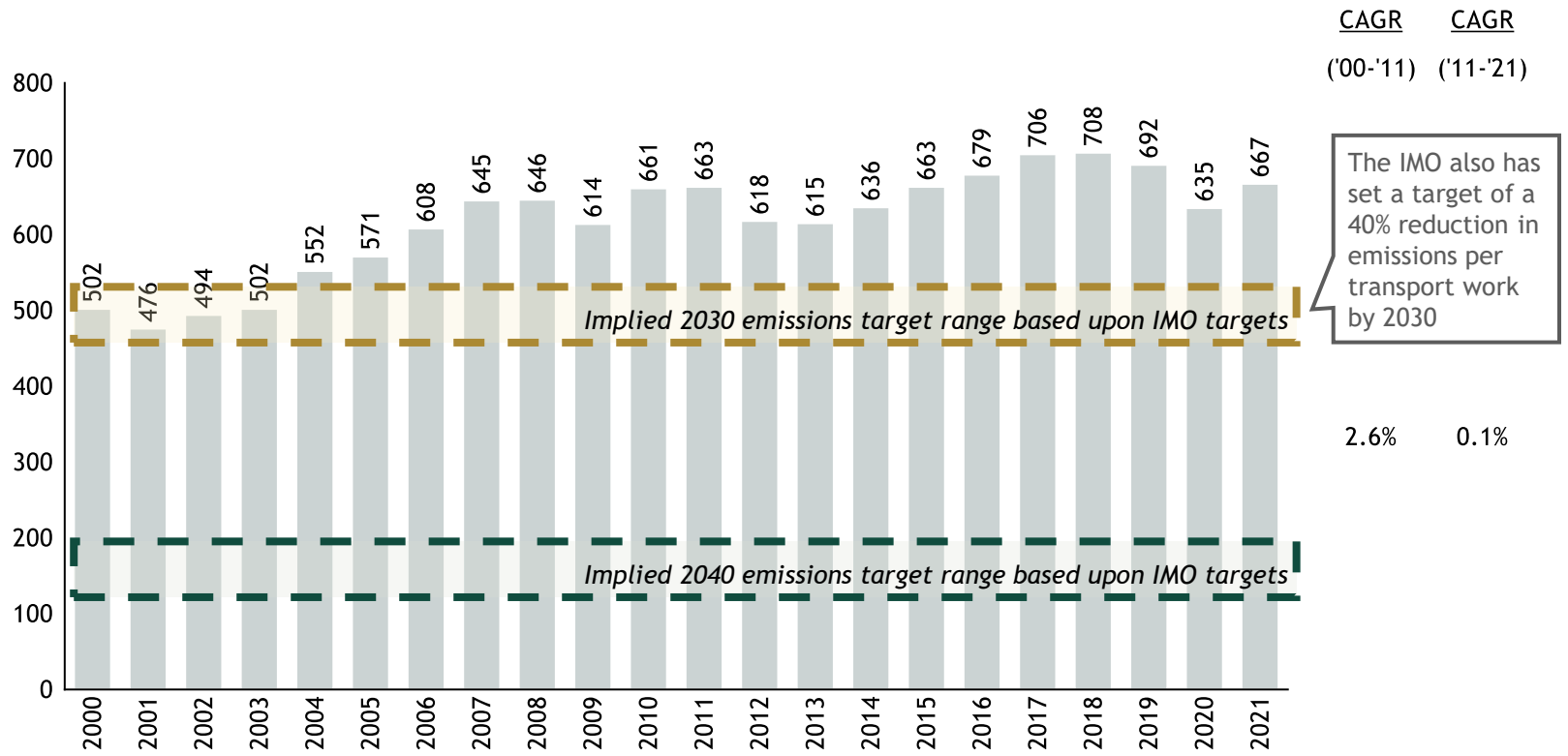
Commentary

- Growth in the shipping market has been **driven historically by global GDP, global trade, and commodity demand**
  - The shipping market has grown and contracted cyclically with global trade
  - Market has previously oversupplied relative to demand
  - Historically witnessed stable growth with dry bulk/container shipping as drivers
- **Moving forward, low single digit growth is forecasted** for the sector
  - **Transport of gas and green energy** are emerging markets and expected drivers of future growth
  - Some industry experts indicate that as 3D printing is widely adopted, manufacturing will potentially become more localized, which could reduce shipping volumes

Market growth has also driven slow increases in Shipping emissions over time, with tankers, carriers, and container ships contributing the most emissions

Emissions from international shipping have grown slowly since 2000

Annual carbon emissions from international shipping (M metric tons of CO2)



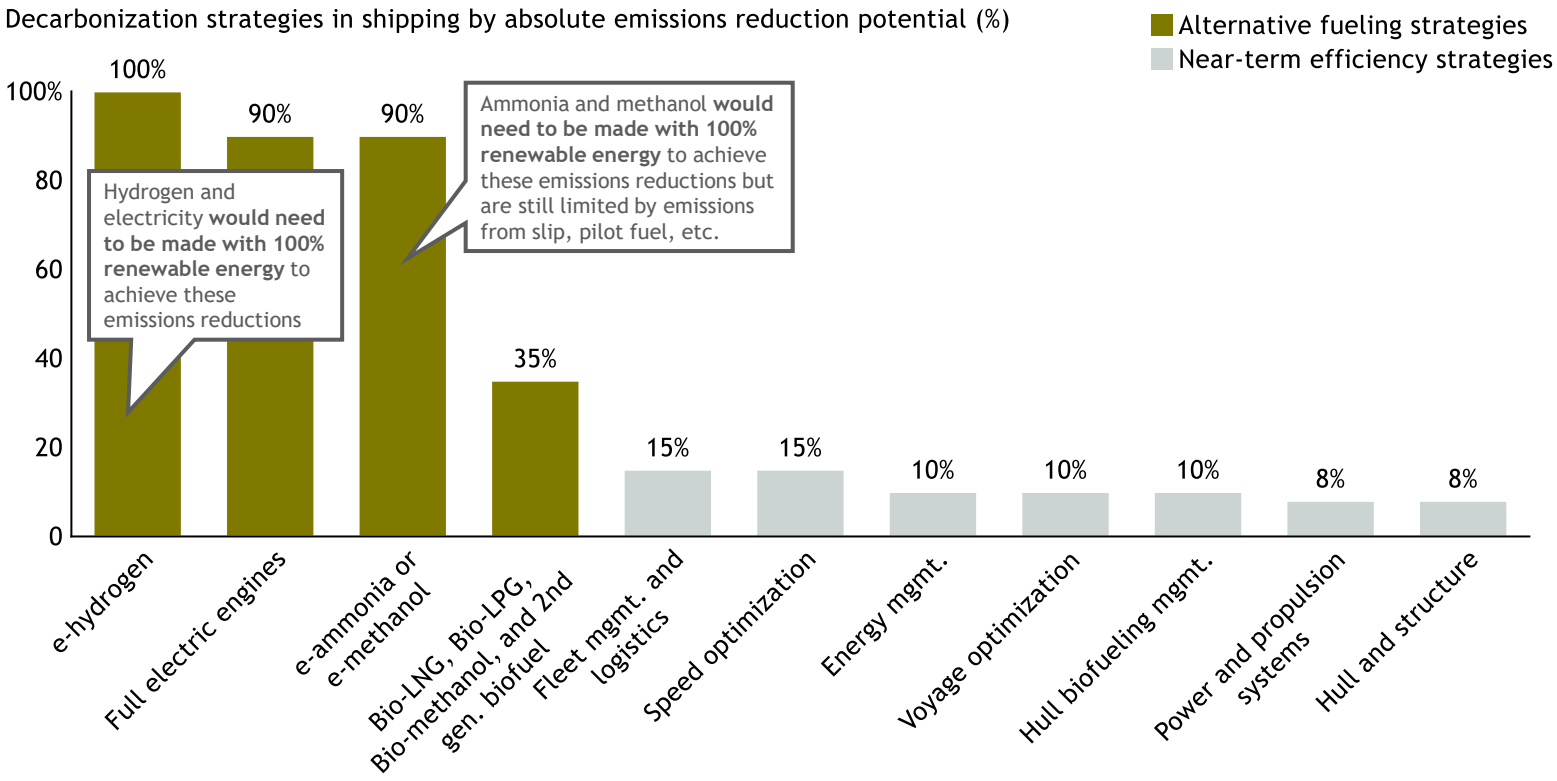
Source: International Energy Agency (IEA), Maersk McKinney Moller Center Maritime Decarbonization Strategy 2021

Commentary

- Despite steady growth in the volume shipped across the global maritime sector, **emissions have remained relatively flat over the past decade**
- In July 2023, the IMO released its 2023 GHG Strategy for the maritime sector, outlining 3 targets for absolute emissions reduction in the sector:
  - **20-30% emissions reduction by 2030** vs. 2008 levels
  - **70-80% emissions reduction by 2040** vs. 2008 levels
  - **Net-zero GHG emissions by or around 2050**
- While emissions have grown more slowly than the shipping market overall, **there are significant gaps to meeting emissions reduction targets**

Alternative fueling strategies present the greatest emissions reduction potential

While alternative fueling presents the greatest decarbonization opportunity, there are many near-term efficiency strategies that can be pursued while the sector transitions

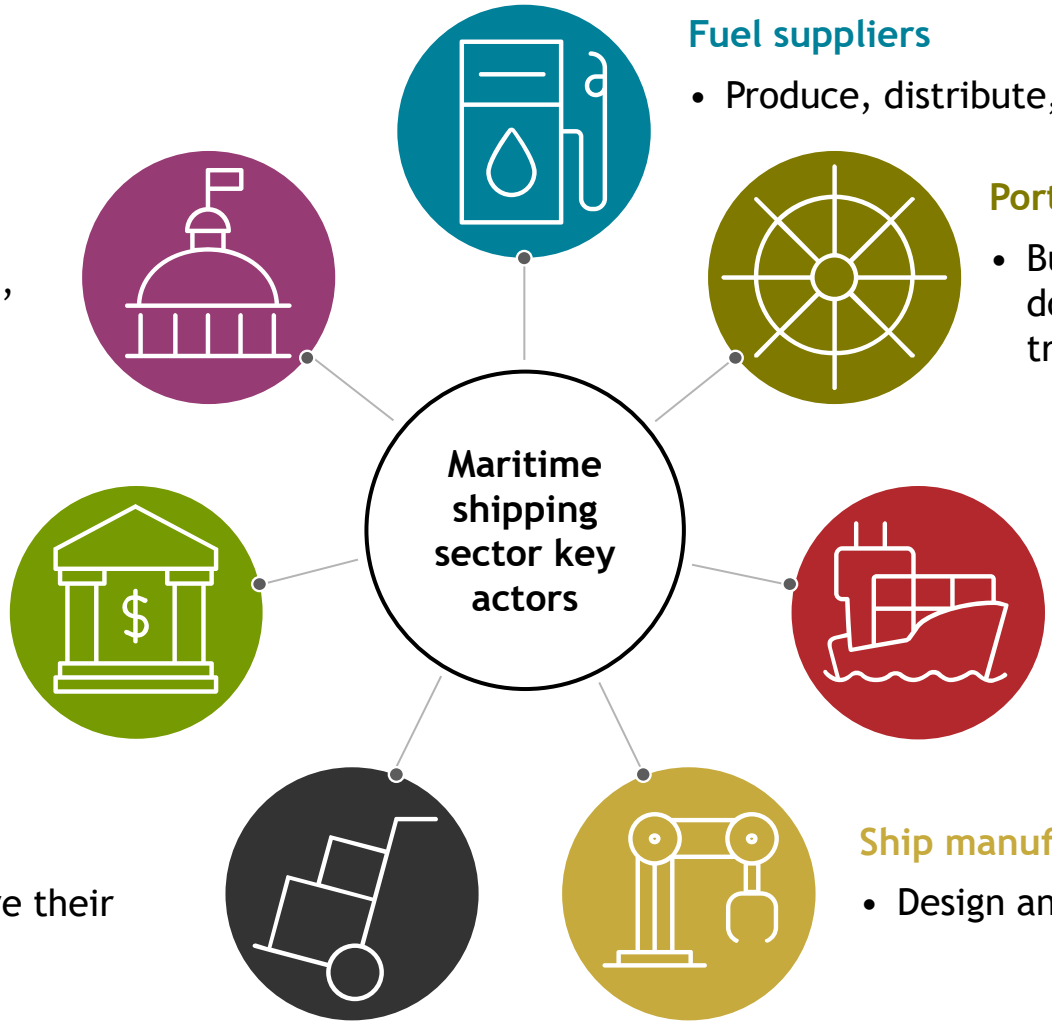


Source: IMO, Maersk McKinney Moller Center Maritime Decarbonization Strategy 2021 and 2022

Commentary

- **Alternative fuels like e-hydrogen, e-ammonia, and e-methanol**, have the greatest decarbonization opportunity for shipping
  - Secondarily, Bio-LNG, Bio-LPG, Bio-Methanol, and 2nd generation biofuels present opportunities for decarbonization, but their potential is limited relative to hydrogen-derived fuels
  - Similarly, full electric engines present large decarbonization opportunities for some fuel types but may be more technically challenging than other fuels
- In the near-term, there are a variety of **efficiencies that the sector can pursue in terms of technical installations and operational practices**
  - These can help to begin the transition while the sector aligns to an alternative fuel strategy
  - While not all fully additive, the sector could expect to achieve ~15%+ emissions reductions even without alternative fueling
    - E.g., fleet management and logistics, speed optimization, energy management, voyage optimization, hull bio-fueling management, power and propulsion system installations, and hull and structure adjustments

Private organizations who can act on decarbonization opportunities in shipping include fuel suppliers, ports, operators, manufacturers, and financial actors



Fuel suppliers

- Produce, distribute, and store fuels used in shipping

Ports

- Bunker fuels used in shipping, facilitate docking of shipping vessels, and host transfer of cargo

Ship operators

- Operate shipping vessels, consume fuels, move cargo, and dock at ports

Ship manufacturers

- Design and manufacture shipping vessels

Governing bodies, class societies

- Provide guidelines, policy, regulation, and other programmatic support to enable action in the shipping sector

Financing, insurance institutions

- Provide products and services to finance operations across the shipping value chain

Cargo owners

- Contract with shipping actors to move their cargo

Source: The Maritime Executive; UNCTAD

At an intergovernmental level, the International Maritime Organization (IMO) is tasked with regulating the shipping industry, including driving decarbonization

The IMO is focused on safety, security, and sustainability of shipping and has a global membership under its purview

- The IMO was established in 1948 as a **specialized agency of the UN** and is headquartered in London, UK
- The IMO consists of 175 member states, including almost all **UN member states that are not landlocked countries**
  - Individual member states implement IMO-generated policies and in their own jurisdictions and determine penalties for violations individually
  - The IMO also includes 66 intergovernmental organizations with observer status & 85 international NGOs in consultative status
- The IMO is a global standard-setting authority that creates a **regulatory framework for the safety, security and environmental performance of international shipping,** with a focus on:
  - Ship design, construction, equipment, manning, operation, and disposal
  - Energy efficiency
  - New technology and innovation
  - Maritime education and training, security, traffic management, and infrastructure development

IMO regulations focus on safety and pollution standards, with goals to target carbon emissions in the future

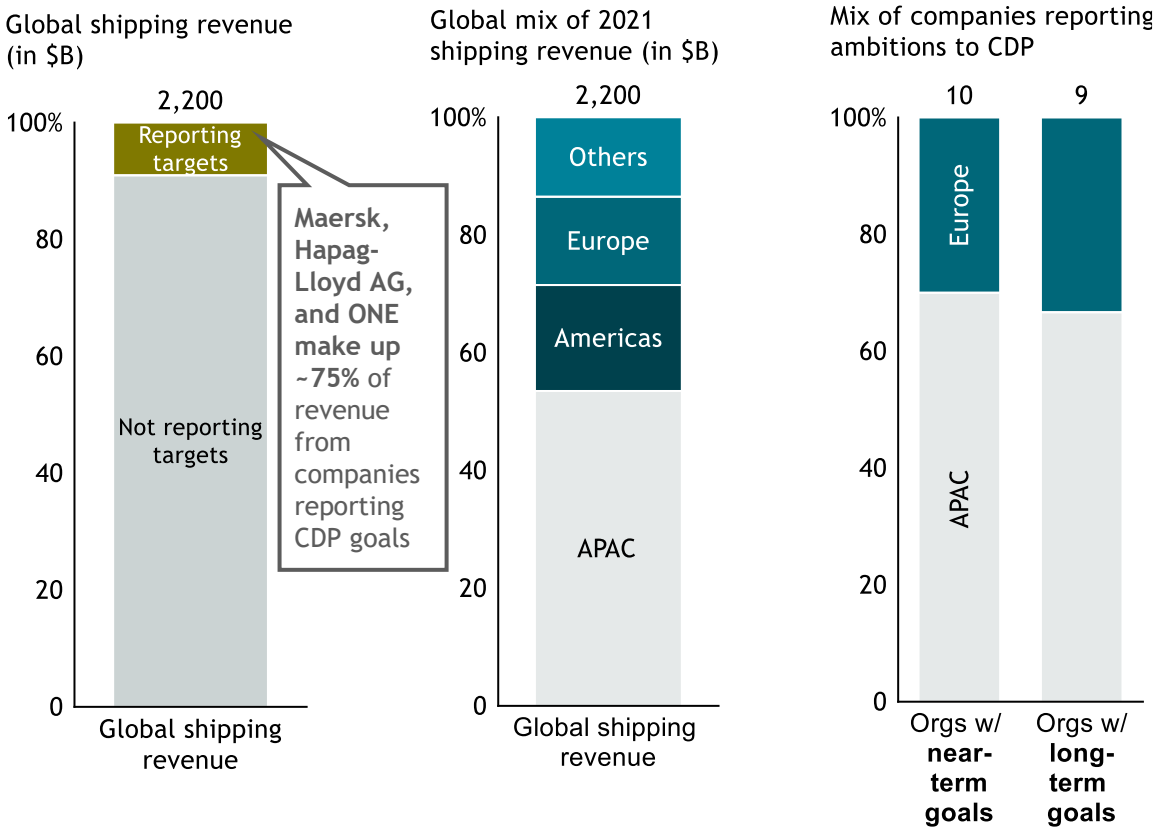
- **1973 – International Convention for the Prevention of Pollution from Ships (MARPOL):** Regulates accidental and operational oil pollution as well as pollution by chemicals, packaged goods, sewage, garbage and air
- **1990 – International Convention on Oil Pollution Preparedness, Response and Co-operation:** Requires parties to establish measures for dealing with pollution incidents
- **2011 – EEDI become necessary to any new ships:** Requires any ship whose contract is made after January 2013, that enters the building phase after July 2013 or those which are delivered after July 2015 to comply with energy efficient standards
- **2023 – GHG Strategy bolsters emissions reduction and low, near-zero, and zero-emissions fuel supply goals, paired with EEXI, CII, SEEMP policies:**
  - Reduce carbon intensity of shipping by at least 20-30% by 2030, 70-80% by 2040, 100% by or around 2050 with 5-10% near-zero or zero emissions fuels supply by 2030
  - EEXI imposes the same restrictions as the EEDI but on existing ships, and CII requires disclosure of carbon intensity of each vessel and commitment to a SEEMP to improve the energy efficiency of that ship
  - Policies to achieve these targets to be determined in coming years, including mandatory measures like DCS*

Notes: EEDI = Energy Efficiency Design Index to evaluate design of new ships, SEEMP = Ship Energy Efficiency Management Plan to evaluate energy efficiency of all ships, EEXI = Energy Efficiency Existing Ship Index with similar goals to EEDI but for existing ships, DCS = Data Collection System for ships to report fuel oil consumption for large ships, CII: Carbon Intensity Indicator to evaluate all ships' carbon intensity
Source: IMO, DNV, Ocean Engineering Journal

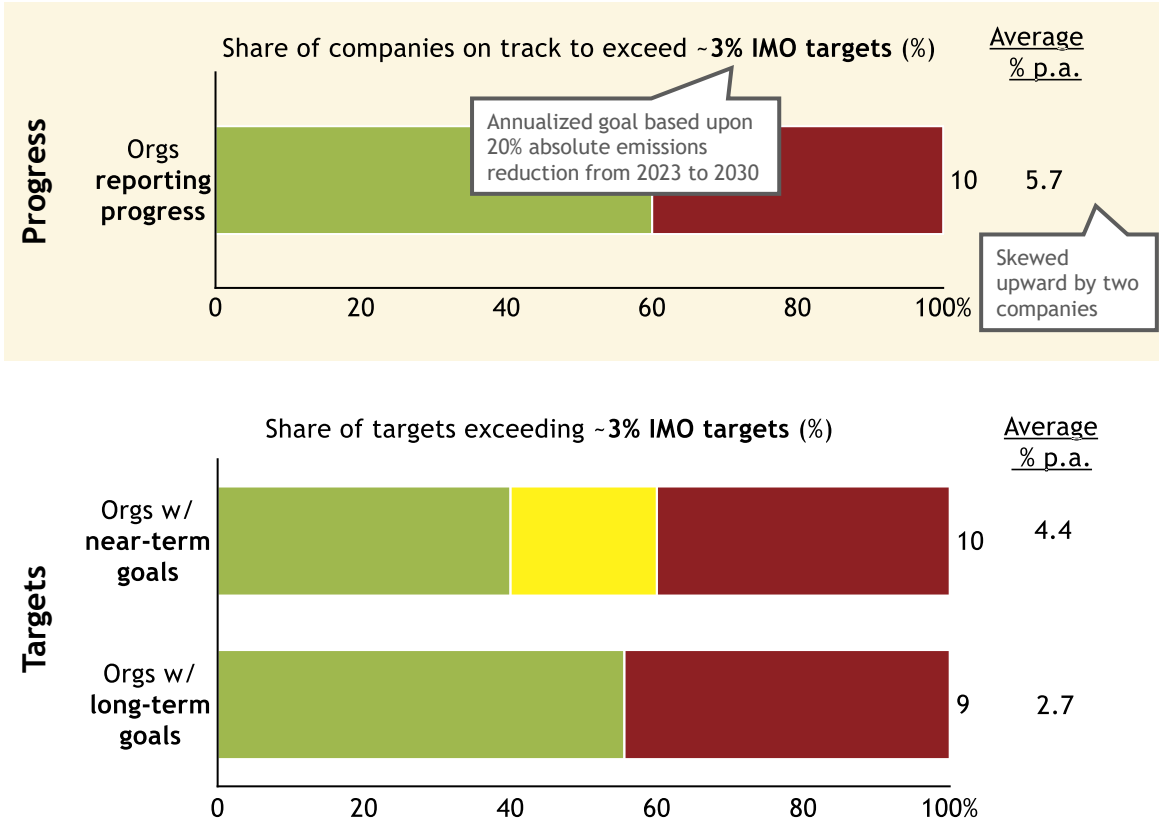
Only a small share of shipping companies are reporting to the CDP, but 60% of those who are reporting are in line with the IMO's milestones

Legend: Company performance vs. IEA — Missed target (<80%) | Near miss (80-100%) | Hit target (+100%)

<10% of market reporting CDP goals, skewed to APAC, Europe



60% of Shipping companies are on track with IMO milestones



Note: Annual reduction ambition shows the % reduction a company will need per year in order to reach their target from the base year (includes underway, new, or revised targets); near-term defined as target year before 2030; Priority countries selected based upon highest emission countries from 2022 Global Carbon Project Data; % reduction refers to an annual percentage and does not take into account compounding; IEA Agenda goals account for Scopes 1+2 only
Source: 2022 CDP Climate Questionnaire Data; 2022 Global Carbon Project; UNCTAD

Executive Summary: The State of the Transition in Shipping

	Near-term efficiencies	Near-term fuel trialing and long-term fuel scaling
Dimension of sector		
Future decarbonization scenario	While the sector's long-term fueling strategy crystalizes, ship operators unlock operational efficiencies to curb emissions and reduce total fuel consumption	Ship operators align on the near-zero or zero-emissions fuels to drive long term decarbonization, and solutions are adopted rapidly across value chains
Indicators of progress towards accelerating decarbonization	**Many ship operators are adopting key efficiency practices such as slow steaming and weather-route optimization** to improve the fueling and cost efficiency of their operations However, **greater adoption of efficiency measures is needed to enable the switch to alternative fuels**	The industry is beginning to coalesce around a few potential long-term alternatives to HFO, with e-ammonia as the frontrunner **That said, high upfront and operating costs in addition to a lack of infrastructure up and down the shipping value chain** present barriers to accelerating a shift to an alternative fuel Without **greater coordination across the value chain from ship operators to ports to fuel suppliers,** accelerating fleet and infrastructure commitments will remain challenging

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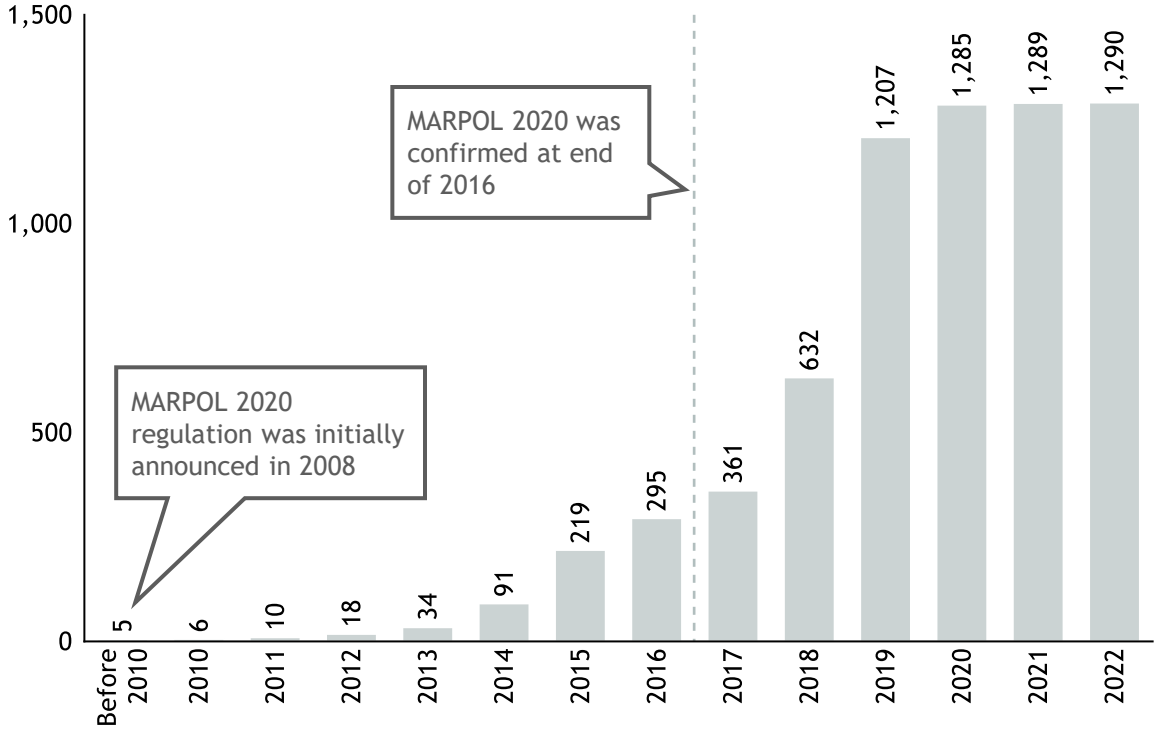
The IMO's MARPOL 2020 regulation drove rapid adoption of scrubbers, demonstrating the influence of policy on ship operator decisions

MARPOL 2020 regulations from the IMO required ship operators to install scrubbers or consume new fuel types

- The IMO's MARPOL 2020 regulation is an amendment to its existing International Convention for the Prevention of Pollution from Ships (1973)
- MARPOL 2020 **reduces sulfur in ships' fuel oil to a maximum of 0.50%** mass by mass (m/m) from the previous 3.5%
  - In designated emission control areas (e.g., Baltic Sea, North Sea, North America), the maximum sulfur limit in fuel oil is 0.10%
- **Prohibits the combustion of non-compliant fuel oil** to support ship propulsion or operation
- Ships can **continue to carry non-compliant fuels if the ship has an approved scrubber fitted**
  - Scrubbers use either sea or fresh water to "wash" shipping engine exhaust gas, **removing >90% of byproducts such as SO_X and NO_X**
    - > Some business leaders feel scrubbers create more adverse affects for the marine environment and are therefore not a viable option
  - These devices **can be used on any type of ship, but they range in cost from ~$400K to more than $2M** depending on the ship
- The regulation is forecasted to induce a **77% drop in overall SO_X emissions** from ships – equivalent to 8.5 million metric tons

Scrubber Example: Upticks in the rate of scrubber adoption over the last decade follow key dates related to MARPOL 2020

Annual scrubbers purchased for shipping globally



Source: Clarkson's, Credit Suisse, SEB, European Commission, DNV

Even without policy incentives, ship operators have demonstrated significant adoption of near-term efficiency practices

Legend: *No adoption* … *Industry standard*

Ship operators have many efficiency practices to pursue to reduce emissions today

Category	Example efficiency practices	Efficiency potential	Current adoption by ship type: Bulk	Tanker	Container	Passenger
Operational: Voyage optimization	• **Weather routing:** Planning routes around expected weather to maximize efficiency • **Hull and propeller fouling management:** Maintenance practices to avoid accumulation of living organisms and debris	10%				
Operational: Fleet strategies	• **Fleet portfolio optimization:** Optimizing mix of different ship sizes to fleet needs • **Scheduling and speed optimization:** Optimizing delivery times and speeds to allow for energy efficient "slow steaming"	15%				
Technical: Hull & propeller efficiency	• **Propeller design:** Optimizing propeller configuration for ship and route needs • **Air lubrication:** Reducing resistance between hull and water using air bubbles	8%				
Technical: Engines & systems	• **Engine technology:** Powering intake and exhaust valves hydraulically or mechanically • **Waste heat recovery:** Recapturing heat from ship operations as a form of energy	5%				
Technical: alternative power systems	• **Wind-assisted propulsion:** Capturing wind surrounding ship during travel as source of propulsion	8%				

Note: Expected efficiency uptick for fuel consumption is correlated with carbon emissions; CII = Carbon Intensity Indicator
Source: Maersk McKinney Moller Center Maritime Decarbonization Strategy 2021 and 2022

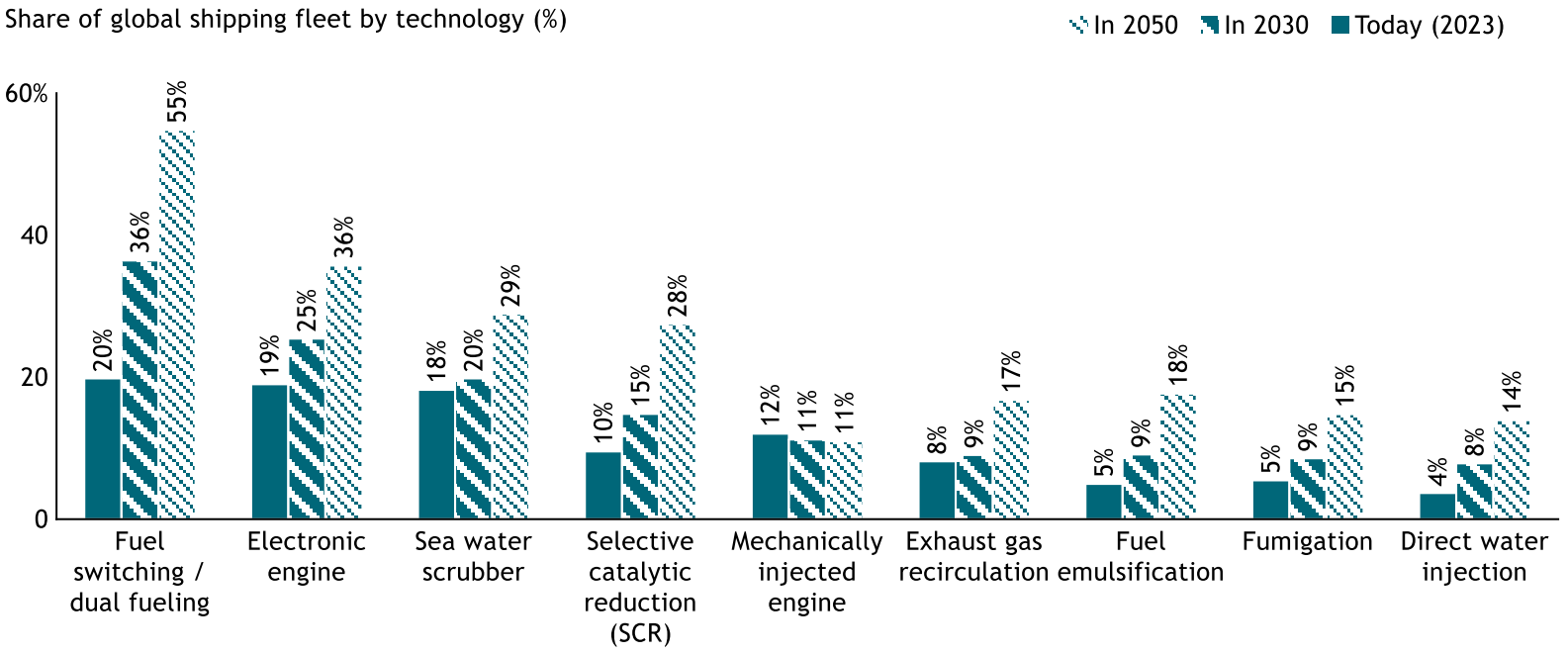
Commentary

- Adoption of efficiency practices is expected to continue to increase, as **ship operators remain motivated by cost savings attributable to reduced fuel use**
- **2023 IMO GHG Strategy may bolster adoption** with carbon intensity and energy efficiency goals becoming policy mandates
  - The EEDI and CII are expected to drive progress toward 2030 goals via greater adoption of efficiency practices
- These efficiency practices have the **added benefit of reducing CO_2 emissions**
- In addition to reducing heavy fuel oil (HFO) usage, these **efficiency practices can reduce the total needs for alternative fuels**

Adoption expectations of short-term retrofitting options are varied, with fuel switching expected to see the highest adoption

Fuel switching capabilities are expected to be adopted by the largest share of ship operators, with a significant adoption of alternative engines, scrubbers, and SCRs as well

*What share of your vessels in operation today have been **installed with each of the following emissions-reducing technologies?** In 2030? In 2050?*



Note: Chart includes data from energy consumers, energy providers, infrastructure providers, and financing providers with expertise in the shipping sector (N = 28)
Source: Bain / WMBC Global Stocktake Survey (N = 215); Corporate interviews

Commentary

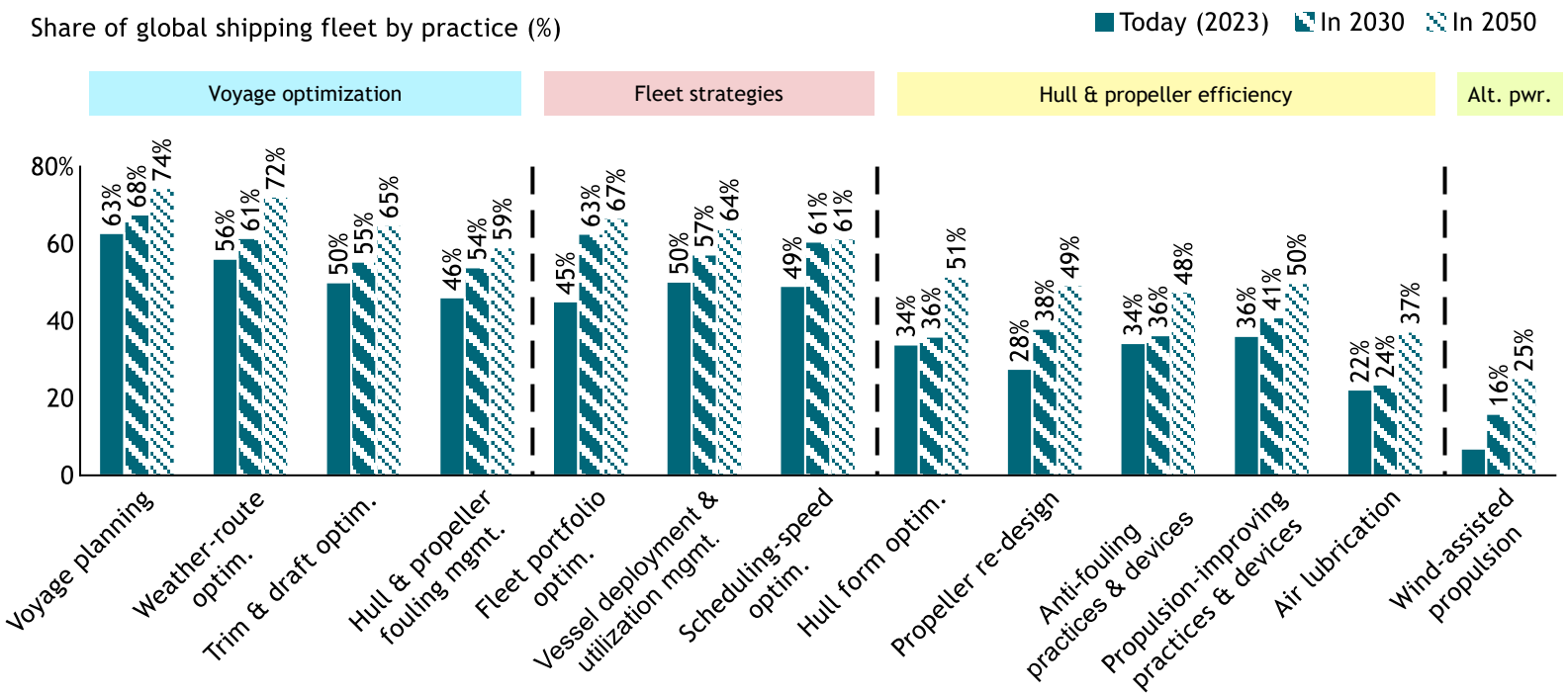
- Ship operators have myriad opportunities to **improve the operational efficiency with varied financial profiles and emissions reduction potential**
  - Despite high capital requirements, technologies where business leaders indicate **highest predicted have the highest emissions reduction potential**
  - Some technologies like sea water scrubbers are questioned by some given **potential for adverse effects on the marine environment despite reducing emissions**
- **2023 IMO GHG Strategy may bolster adoption** if carbon intensity and energy efficiency goals become policy mandates
  - The CII is expected to drive progress toward 2030 goals via greater adoption of operational efficiencies

*"Many efficiency and emissions reduction technologies are **becoming the standard approach as ship operators consider retrofitting investments.**"*
Head of Sustainability, Shipping manufacturer #1

That said, business leaders indicate significant industry adoption of many efficiency practices today, with anticipated increase in adoption through 2050

Voyage optimization, fleet strategies have and will be the most adopted industry practices, with uptake in hull & propeller efficiency practices

*What share of your fleet is **adopting each of the following efficiency practices** today? In 2030? In 2050?*



Note: Chart includes data from energy consumers, energy providers, infrastructure providers, and financing providers with expertise in the shipping sector (N = 27)
Source: Bain / WMBC Global Stocktake Survey (N = 215); Corporate interviews

Commentary

- In addition to potential retrofitting technologies, ship operators have begun **adopting operational efficiency strategies primarily to improve their fuel efficiency and associated costs**
  - By extension, these practices have emissions reduction benefits
- **2023 IMO GHG Strategy may bolster adoption** if carbon intensity and energy efficiency goals become policy mandates
  - The CII is expected to drive progress toward 2030 goals via greater adoption of operational efficiencies

*"Today, ship operators are adopting a number of efficiency practices that, while not game changing, **can reduce emissions up to 15%.**"*
Head of Sustainability, Shipping manufacturer #1

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“There will be multiple fuels in the future in shipping – chosen based upon a number of potential impacts - CapEx, availability, ship size, etc.”

Legend *Near-zero or zero GHG emissions* *Higher GHG emissions*

Fueling option		Description of fueling option	Key constraints
Heavy fuel oil (HFO)		• Residuals from crude oil refining, traditional high energy shipping fuel	• Doesn’t address NO_x and SO_x emissions regulations
Low-sulfur fuel oil (LSFO)		• Fuel oil with sulfur content ~0.5% is LSFO (or ULSFO if <0.1%) • Made from HFO+MGO or HFO desulfurization	• Costly to produce, transport and store relative to other high GHG emissions fuels
Marine diesel / gas oil (MD/GO)		• Made from petroleum distillates	• Low viscosity complicates engine efficacy
Liquified petroleum gas (LPG)		• Made from propane and other hydrocarbons • Lower emissions than HFO, LSFO, and MD/GO	• Costly to produce, transport and store
Liquified natural gas (LNG)		• Highly cost efficient fuel • Lower emissions than HFO, LSFO, and MD/GO	• Costly to produce, transport and store relative to other high GHG emissions fuels • Availability and scalability of production and bunkering capacity globally
Biodiesel / biofuel		• Distilled from edible crops, non-edibles (waste), and algae • Biodegradable and typically lower emissions than HFO, LSFO, and MD/GO	• Degrades over time • Reliant on palm oil
E-methanol	*Each of these options can be a low, near-zero, or zero-emissions fuel only if produced using clean, renewable, zero-emissions power*	• Hydrogen and carbon derived fuel that allows for clean burning	• Costly to produce, transport and store • Availability and scalability of production and bunkering capacity globally • Traceability of feedstocks and production processes (i.e., tracing whether the fuel produced was net-zero) • Technology is still being developed
Battery electric		• Batteries charged through on-shore connection to electric grid	• Costly to produce, transport and store • Technology is still being developed • Range limitations
E-ammonia		• Hydrogen and carbon derived fuel that allows for clean burning • More cost effective and scalable than e-methanol	• Costly to produce, transport and store • Availability and scalability of production and bunkering capacity globally • Limited standards, guidelines, or other policy frameworks to guide production, storage, transport, or consumption • Traceability of feedstocks and production processes (i.e., tracing whether the fuel produced was net-zero) • Technology is still being developed • Flammable, acute toxicity
E-hydrogen		• Can power fuel cells on-board vessels	• Costly to produce, transport and store • Insufficient production and bunkering capacity globally • Limited standards, guidelines, or other policy frameworks to guide production, storage, transport, or consumption • Traceability of feedstocks and production processes (i.e., tracing whether the fuel produced was net-zero) • Technology is still being developed • Lower energy density relative to other low, near-zero, and zero GHG emissions fuels
Nuclear		• Low enriched nuclear material with no GHG emissions	• Costly to produce, transport and store • Insufficient production and bunkering capacity globally • Technology is still being developed • Low social acceptance, need safe disposal process
Dimethyl ether		• Gas produced from methanol	• Costly to produce, transport and store • Insufficient production and bunkering capacity globally • Technology is still being developed

Note: Title quote is from Head of Sustainability, Shipping manufacturer #1
Source: Poten & Partners; International Transport Forum; LNG for Shipping; Black & Veatch; Fuel Freedom Foundation; Marine Trader; DNV GL Report; Marine Insight, Corporate interviews

The industry is starting to turn focus to methanol and ammonia, but there are concerns about these fuels' limitations, which is holding back investment

"There is no silver bullet, and all solutions are a tradeoff. ***The concerns about the scalability of methanol are fair, but our assessments show methanol as a viable solution today with significant potential to scale. It will co-exist alongside other fuels in the future,*** *and we are no by no means closing the door to other fuels and solutions."*

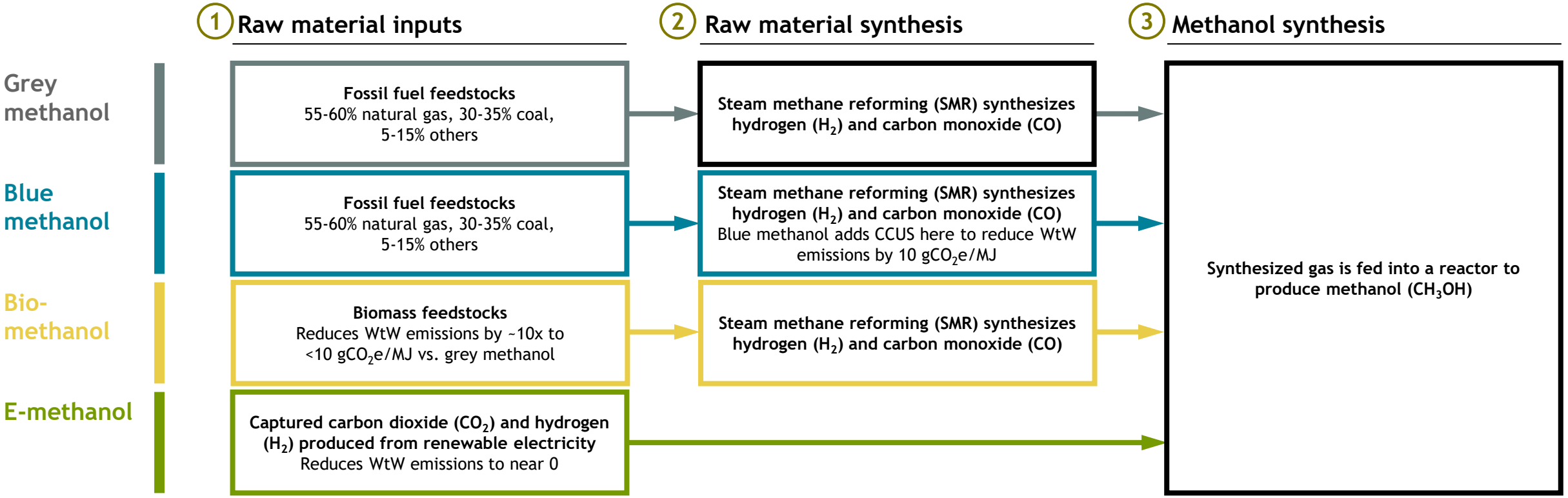
Maersk

"We believe ***methanol will be the next fuel,*** *and* ***by 2050, the shipping industry's primary fuel will be ammonia*** *for ocean-going vessels****."***

Director, Head of Corporate Sustainability & ESG, Ship operator #1

Source: Corporate interviews

Methanol can be produced with various inputs and synthesis processes, but only e-methanol production is net-zero

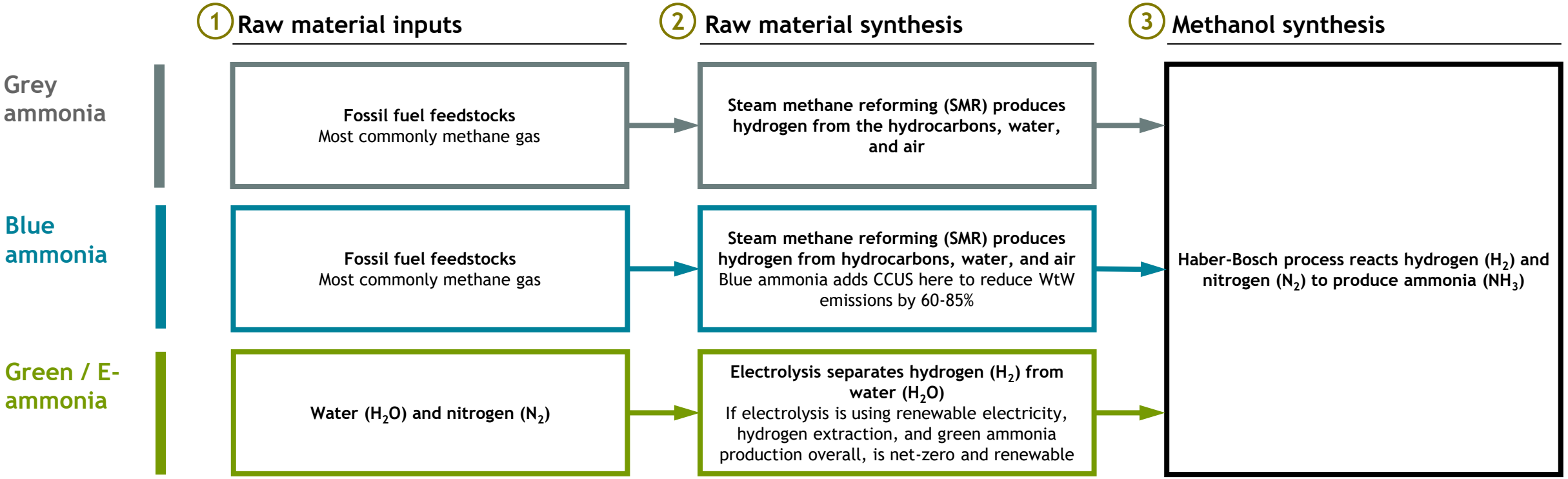


"Methanol is a fuel that needs carbon to be synthesized. The only large volume, sustainable and scalable source of carbon is direct air capture (DAC). Current biogenic feedstocks are available at small volumes, but there is a scientific consensus they can't scale to the volumes shipping needs and meet wider decarbonization demands. ***The techno-economics of DAC mean that methanol using DAC carbon is 30-50% more expensive than ammonia on a 'total cost of operation' basis*** *(e.g., for ship operations) - for the given 'price' of renewable electricity."*

UMAS

Note: WTW - well-to-wake GHG emissions of methanol assuming a slow-speed ship, methanol emissions were estimated using a 100-year global warming potential and GREET 2020
Source: US Dep of Energy, Methanol Institute, ICCT, UMAS

Ammonia can be produced with mixed inputs and production processes, though green / e-ammonia is the only net-zero form of ammonia



*"**If the sector can figure out a way to handle the toxicity, then ammonia will ultimately be cheaper than methanol, but then operators must worry about fugitive emissions with nitrous oxide slippage**. Once the sector works all of that through, ammonia looks like LNG in some ways. It is hard to know right now whether those barriers are surmountable to know how quickly ammonia will displace methanol, if at all."*

Chief Executive Officer, Alternative fuel producer #1

Note: WTW - well-to-wake GHG emissions of ammonia assuming a slow-speed ship, ammonia emissions were estimated using a 100-year global warming potential and GREET 2020
Source: Royal Society, Corporate interviews

Operators are evaluating internal combustion engines vs. fuel cells, considering efficiency vs. dual fueling capabilities, which are only possible with ICE

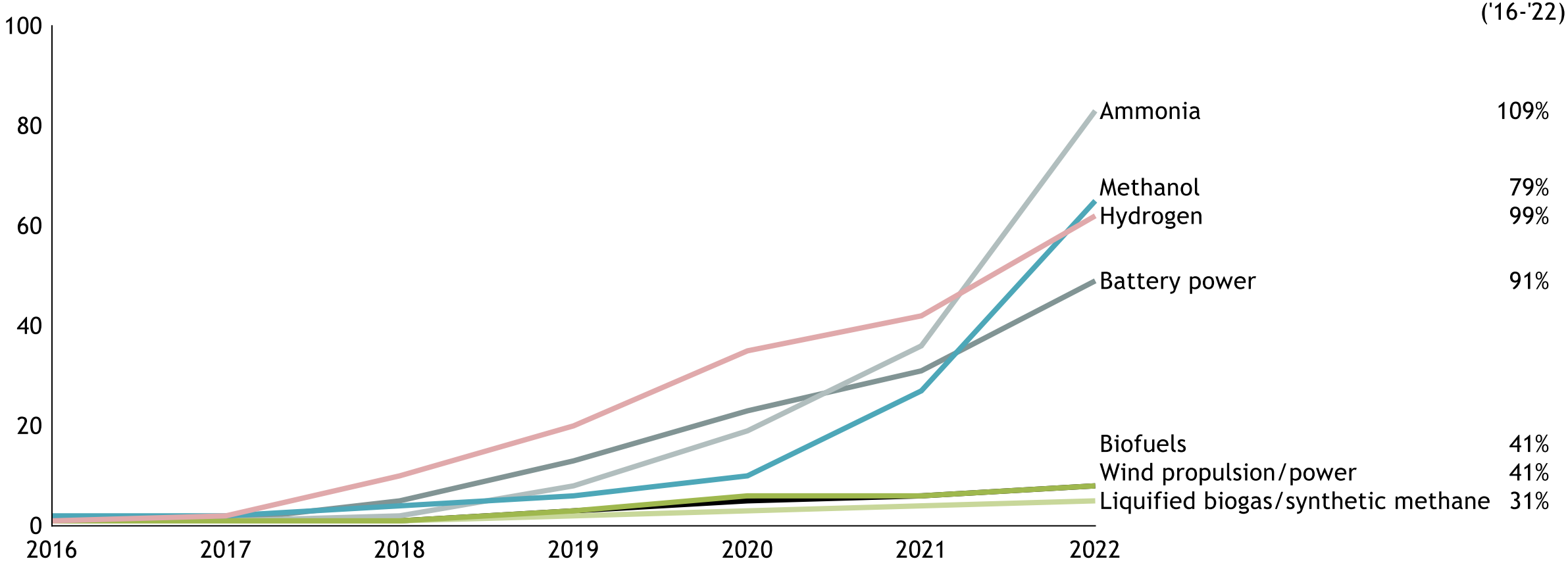
"Fuel cells will become viable for certain applications, but then they can only run on that one fuel – you can't have dual fueling. *That will be challenging with the slow transition to hydrogen-based fuels and will not be trivial from a total system cost perspective."*

Chief Executive Officer, Alternative fuel producer #1

Source: Corporate interviews

To keep with Paris Agreement goals, the next few years will require trialing solutions; ammonia, methanol, hydrogen, battery pilots have the most traction

Number of ship technology projects by fuel focus



Source: Getting to Zero Coalition / Global Maritime Forum "Mapping of Zero-Emission Pilots and Demonstration Projects" Fourth Edition (May 2023)

Given uncertainty, companies need to share risks, support others' efforts, seek government backing, and deploy limited scale trials to test long-term viability

*"**Spreading risk across actors is critical;** you need to guarantee ports they have fuel buyers, and you need to guarantee to operators that ports will have fuel supply."*

Head of Climate, Sustainability, and Environmental Policy, Fleet operator #4

Source: Corporate interviews

“Leading players are not waiting for the silver bullet to emerge before moving forward”

Case Study: Maersk

Overview

- **Description:** One of the world’s largest shipping and logistics company whose business activities include
  - Shipping
  - Port operation
  - Supply chain management
  - Warehousing
  - Logistics
- **Founded:** 1904
- **Headquarters:** Copenhagen, Denmark
- **Ownership:** Public (OTCMKTS: AMKBY)
- **Revenue (2022):** $81.5B USD

Targets (ocean-specific)

2030
- Minimum 25% of cargo transported with green fuels
- 50% reduction in carbon intensity (EEOI) vs. 2020

2040
- 100% green solutions to customers (based on green fuels and/or renewable electricity)
- Net zero GHG emissions across all scopes and businesses
- Aligned with NZ criteria for SBTi and pathway to limit warming to 1.5 degrees, resulting in emissions reductions 90%+ from 2020 levels

Activities

Driving industry-wide changes in vessel procurement practices

A coalition of NGOs including the GMF report **there must be 100 15K TEU container ships fully operating on ZEFs by 2025; Maersk’s efforts are crucial** but insufficient on their own to keep the sector on track

- **Maersk is prompting industry-wide shifts in adoption** with its leading procurement of sustainable newbuilt vessels
  - In 2021, **Maersk committed to only ordering newbuilt vessels that are compatible with green fuels*** and ordered world’s first methanol-run container vessel
  - **Maersk’s commitments prompted changes in global ship vessel orderbook,** which increased to 100+ methanol-run vessels in 2023
  - As of 2023, Maersk had already ordered 25 total e-methanol-enabled vessels to replace existing capacity
- In the meantime, Maersk is also a frontrunner in piloting retrofits of its existing vessels with dual-fueling for e-methanol, partnering with MAN energy solutions for implementation by 2023

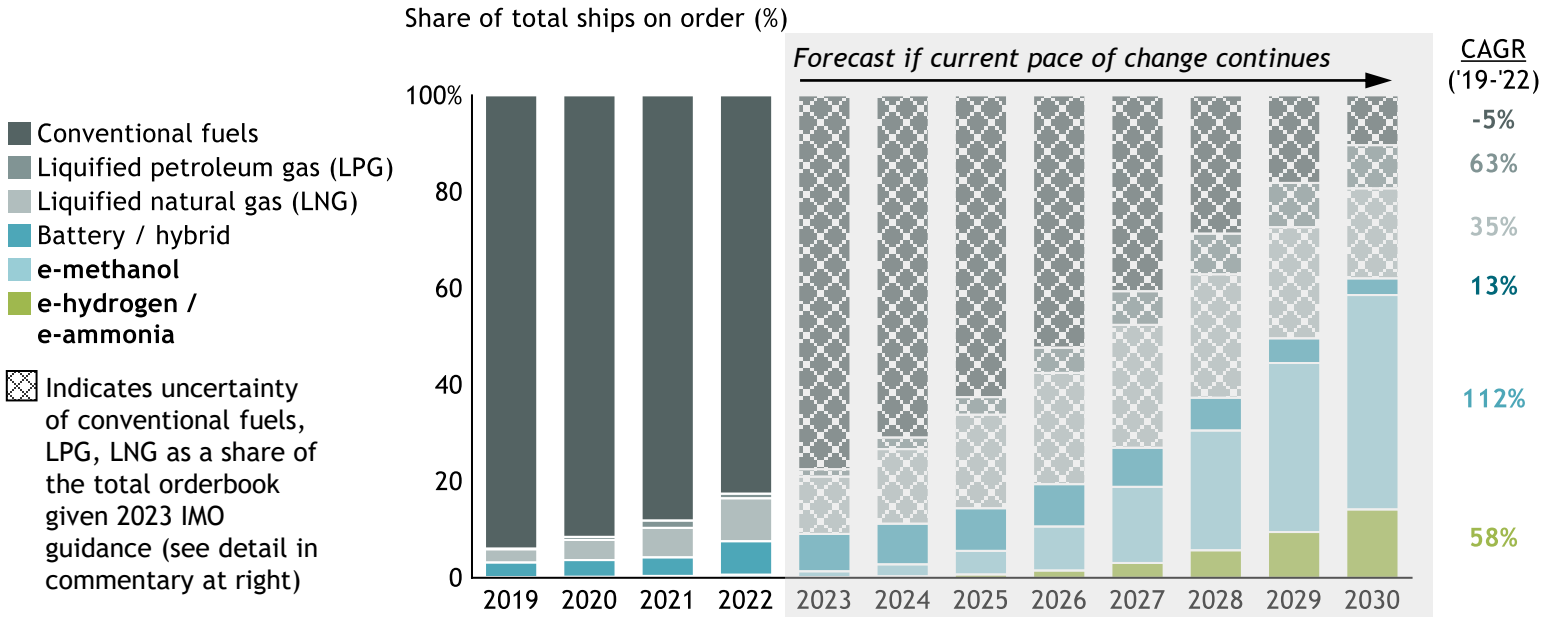
Leading the way on establishing offtake partnerships to ensure methanol supply

- Maersk, recognizing concerns around sufficient methanol supply for ship operators, has **set a precedent for establishing key offtake partnerships**
  - Engaging global partners across America, Europe, and Asia: CIMC ENRIC, European Energy, Green Technology Bank, Orsted, Proman, WasteFuel, Debo, Carbon Sink, Sun Gas Renewables
  - Partnering with OCI Global to provide e-methanol for maiden journey of a 2100 TEU e-methanol-enabled vessel in Summer 2023
    - > 21,500 km from Ulsan, South Korea to Copenhagen, Denmark

Note: Title quote is from Maersk; (*) Maersk defines green fuels as fuels with 65-80%+ lifecycle GHG emissions reductions vs. fossil fuels
Source: Maersk, Corporate interviews

The long asset life of ships indicates that decisions taken this decade on the global orderbook will influence in emissions trajectories for decades to come

Alternative fuels have grown as a share of ships on order from 2019-2022



	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Share of orders low- or zero-carbon alternative	0%	0%	0%	1%								
Total ships on order (in K)	5.8	5.9	5.9	6.0	6.1	6.1	6.2	6.2	6.3	6.4	6.4	6.5
Total ships in operation (in K)	111	112	113	112	113	114	114	115	115	116	117	117
Implied share of ships in operation with carbon-zero fuels	**0%**	**0%**	**0%**	**0%**								

Commentary

- Ships take **1-3 years from order to operation**
- **Many are considering dual-fueling options** to allow flexibility for multiple fuels in the future
- Current orderbooks suggest that ship operators have been pursuing an **LNG strategy due to attractive operational costs and availability**
  - **LNG and LPG** are less carbon intensive than conventional fuels but **are far from carbon zero**
  - The IMO's 2023 GHG Strategy is likely to change the trajectory of the shipping sector orderbook, as **well-to-wake emissions requirements render LNG non-compliant due to methane leakage concerns**
  - Other institutions, including the World Bank, also condemn these options for being non-compliant with Paris Climate Agreement goals
- In the long-term, ship operators and ports alike **risk stranded costs for any LNG-focused assets,** anticipating **methanol or ammonia to become industry standard in the 2030s**
  - **E-methanol, e-hydrogen, and e-ammonia, can be low, near-zero, or zero-carbon** and offer a long-term solution
  - **Regulations aligned with IMO goals,** including 30% GHG reductions and 5% ZEFs by 2030, would require no LNG or LPG and **accelerated adoption of e-methanol, e-ammonia, and e-hydrogen**

Note: Title quote from Head of Sustainability, Shipping manufacturer #1
Source: DNV, UN Review of Maritime Transport, Maersk McKinney Moller Center for Zero Carbon Shipping Industry Transition Strategy Report October 2021, Lloyd's Register / UMAS Zero-Emission Vessels: Transition Pathways, Corporate interviews

Several organizations are establishing private sector niches of leadership on the decarbonization transition in the shipping sector

Science-Based Targets Initiative (SBTi)

- **The SBTi released updated guidance in May 2023,** outlining Shipping-specific steps for operators to set SBTi targets and build transition plans around those targets
- The release also includes **demand reduction guidance and pathways for specific vessel types**
- Shipping operators can **submit their plans to the SBTi to get approval** that they are 1.5⁰ and SBTi aligned

United Nations High Level Expert Group (UN HLEG)

- **In November 2022, the UN HLEG also released guidance** for business leaders to set decarbonization targets and build transition plans for their organizations
- **Unlike SBTi, the UN HLEG guidance is not specific to the Shipping sector,** but rather is more broadly applicable to organizations across sectors
- Like SBTi, **shipping operators, among other businesses, can submit their plans to the UN HLEG to get approval** that they are 1.5⁰ and UN HLEG aligned

First Movers Coalition (FMC)

- The FMC is a **coalition of companies using their purchasing power to create early markets for innovative clean technologies** across eight hard to abate sectors
- **Commitments for Shipping, among other sectors, were launched in November 2021,** at COP26 in Glasgow
- Other activities focus on **supporting members in delivering on their commitments** and creating an enabling environment

Getting to Zero Coalition

- The Getting to Zero Coalition is **an industry-led platform for collaboration that brings together leading stakeholders from across the maritime- and fuels value chains with the financial sector and others** committed to making commercially viable zero-emission vessels a scalable reality by 2030, towards full decarbonization by 2050
- It is **managed by the Global Maritime Forum,** who initially founded the Coalition together with the World Economic Forum and Friends of Ocean Action.

Source: Lit. search

Organizations are also incentivizing actors across the value chain, beyond ship operators, ports, and fuel suppliers, to further emissions reductions efforts

Poseidon Principles (PP)

- The Poseidon Principles establish a **framework for assessing and disclosing the climate alignment of ship finance portfolios**
- They set a **benchmark for what it means to be a responsible bank in the shipping sector** and provide actionable guidance on how to achieve emissions reductions
- Additionally, **the Poseidon Principles for Marine Insurance** create a common global baseline that is consistent with and supportive of society's goals to better enable insurers to assess and disclose their portfolio alignment

Deep dive on next page

Sea Cargo Charter (SCC)

- The SCC establishes a **framework for assessing and disclosing the climate alignment of ship chartering activities** around the globe
- The SCC sets a **benchmark for what it means to be a responsible charterer in the shipping sector** and provides actionable guidance on how to achieve emissions reductions

Zero Emission Maritime Buyers Alliance (ZEMBA)

- **The Zero Emission Maritime Buyers Alliance (ZEMBA) aims to accelerate commercial deployment of zero-emissions ships,** enable economies of scale, and help cargo owners maximize emissions reduction beyond what any one freight buyer could accomplish alone
- Through demand aggregation and forward procurement processes, ZEMBA fosters early access to zero-emissions shipping services and **builds confidence among the rest of the shipping value chain that sufficient demand for zero-emissions solutions exists** to stimulate additional investment

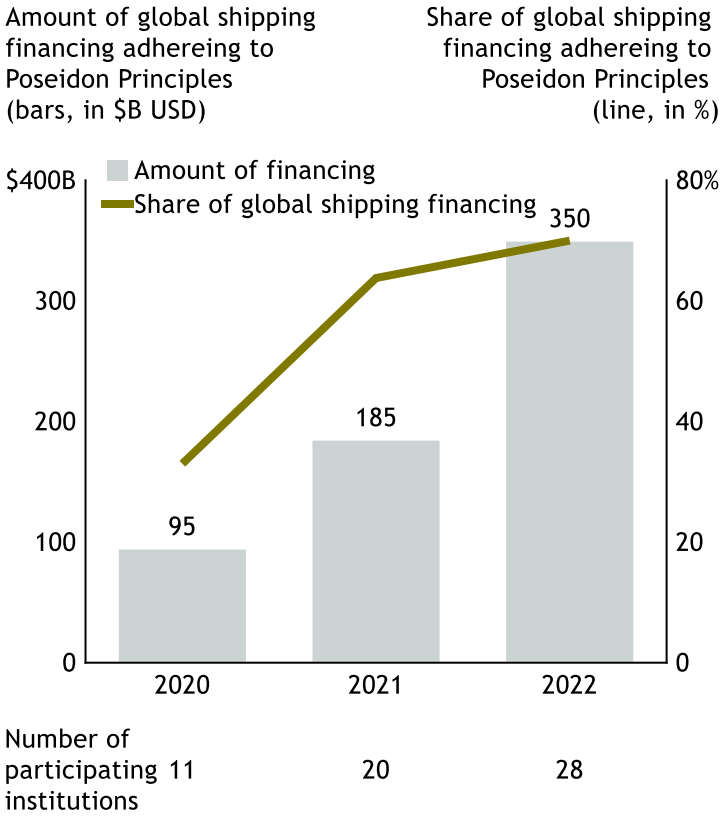
Source: Lit. search

“There is a shipping finance network that needs to be applied at many levels of the sector”

Poseidon Principles are a framework for assessing and disclosing climate goals of shipping finance portfolios

- By becoming Signatories, financial institutions **commit to transparently report their portfolio climate alignment** on an annual basis
- The Principles aim to support financial institutions in **integrating climate considerations into lending decisions** in line with global climate-related goals
  1. **Assessment of climate alignment:** Measure the carbon intensity relative to established decarbonization pathways of their shipping portfolio using the methodology established by the Poseidon Principles
  2. **Accountability:** Rely on classification societies or other IMO-recognized organizations, and mandatory standards established by the IMO for the provision of un-biased information used to assess and report on climate alignment
  3. **Enforcement:** Standardized covenant clauses will be made contractual in new business activities to ensure access to high-quality data
  4. **Transparency:** Portfolio climate alignment scores will be published on an annual basis
- With new IMO guidance from its 2023 GHG Strategy, **the Poseidon Principles are neither 1.5º nor IMO-aligned and are due for revision**
- In parallel, many Shipping organizations (not just financial institutions) are **submitting decarbonization plans to the Science-Based Targets Initiative (SBTi) and the United Nations High-Level Expert Group (UN HLEG)** to confirm their plans meet these organizations’ guidance and are 1.5º-aligned
  - Both the SBTi (in May 2023) and UN HLEG (in November 2022) recently updated their decarbonization plan guidance for the Shipping sector

Commitments to Poseidon Principles have grown in last 3 years



Example signatories

BNP PARIBAS
The bank for a changing world
citi
CREDIT SUISSE
ING
SOCIETE GENERALE
CRÉDIT AGRICOLE CORPORATE & INVESTMENT BANK

Note: Title quote is from Head of Sustainability, Shipping manufacturer #1
Source: Poseidon Principles, Petrofin Index for Global Shipping Finance, Corporate interviews

“Green corridors need to be playing a role here, collaborating with buyers to de-risk fueling trials and broader supply concerns”

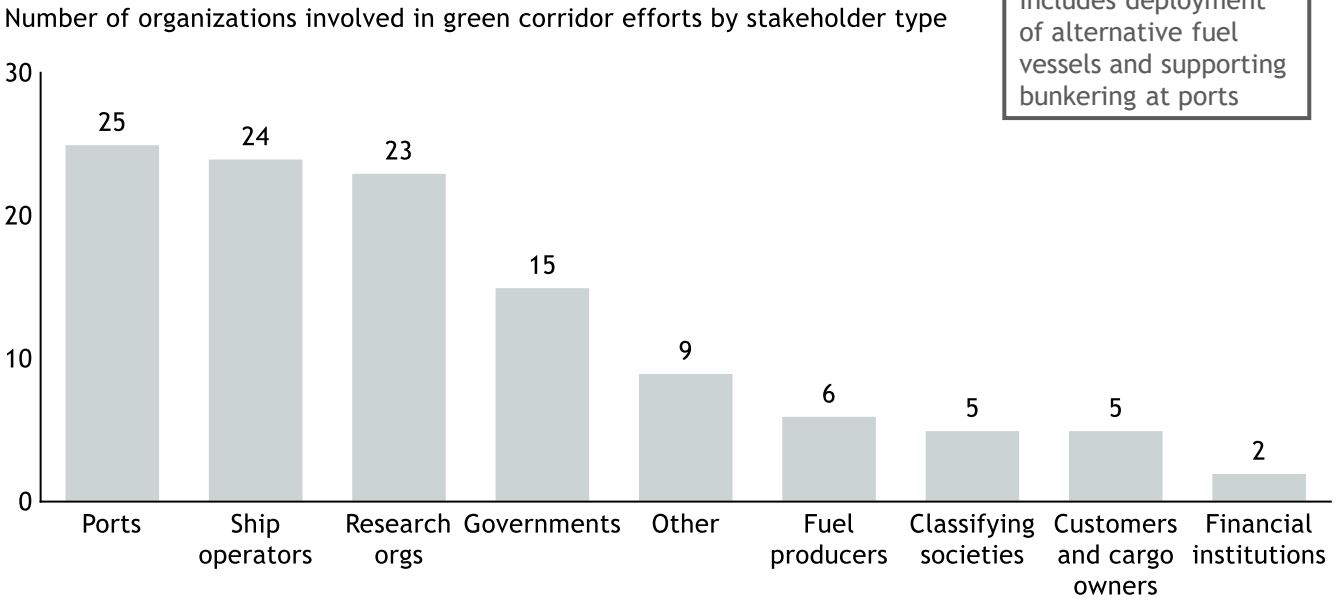
The Clydebank Declaration established first green corridors

- The declaration was **signed by 22 countries and issued at COP26 in 2021**
  - Key signatories include the US, Japan, Germany, Netherlands, Belgium and the UK
  - Declaration states an ambition of **at least 6 green corridors by the middle of the 2020s, with more to follow by 2030**
- Green corridors are broadly defined as **shipping routes where the technical, economic, and regulatory feasibility of low, near-zero, or zero-emission shipping is catalyzed** by a combination of public and private actions
- Green corridor commitments typically include requirements around both **land-side infrastructure and shipping vessels themselves**
  - Designed to accelerate shift in ship capital stock toward ZEVs
  - Aimed to shift fuel supply to **5% low, near-zero, or zero-emission fuels by 2030**

21 green corridors have been established since the Clydebank Declaration, with progress reaching various stages and involving 113 organizations across the shipping value chain

Progress of each green corridor initiative

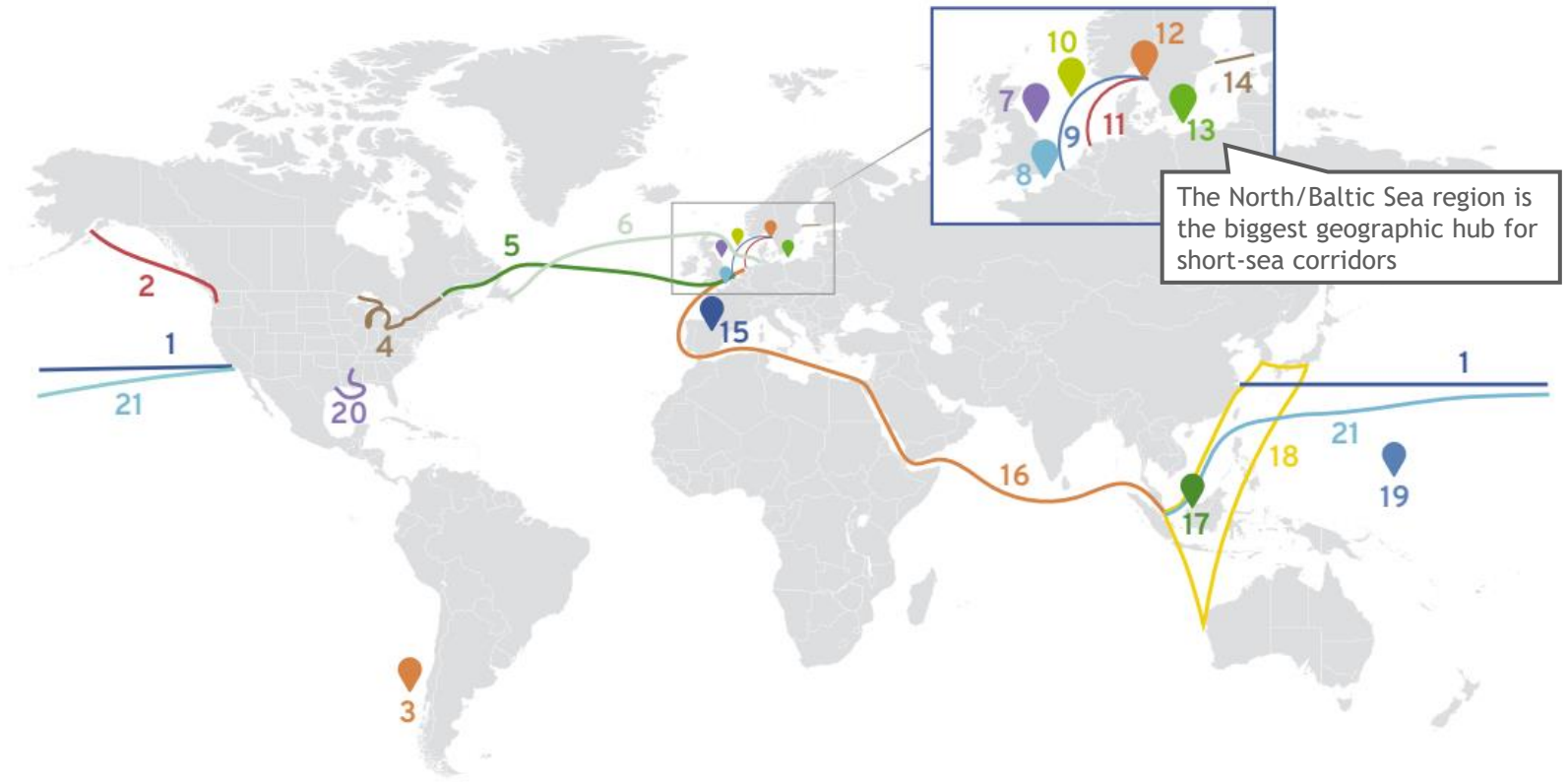
Types of orgs involved



Note: Title quote is from Chief Executive Officer, Alternative fuel producer #1
Source: Wärtsilä, Global Maritime Forum, Getting to Zero Coalition, Corporate interviews

"We believe green corridors will be important to start the sector in the right direction; what countries have done, especially in the EU, is a good start"

21 initiatives for green corridors have emerged globally since the Clydebank Declaration



These corridors cover an extensive set of geographies

- Expected to involve **20 countries across 5 continents**
- 14 of the initiatives address short-sea routes
  - Alaska, British Columbia, Washington (2)
  - Chilean Green Corridor Network (3)
  - Great Lakes-St. Lawrence (4)
  - Clean Tyne Corridor (7)
  - Dover-Calais/Dunkirk (8)
  - Gothenburg-North Sea Port (9)
  - Hydrogen-powered North Sea Crossing (10)
  - Gothernburg-Rotterdam (11)
  - European Green Corridor Network (12)
  - Nordic Regional Corridors (13)
  - Decatrip (14)
  - Green Corridors Spain (15)
  - SILK Alliance (17)
  - Gulf of Mexico (20)
- 7 of the initiatives address deep-sea routes
  - Shanghai-LA (1)
  - Antwerp-Montreal (5)
  - Haifax-Hamburg (6)
  - Rotterdam-Singapore (16)
  - Aus-Asia Iron Ore (18)
  - QUAD Shipping Taskforce (19)
  - Los Angeles-Long Beach-Singapore (21)

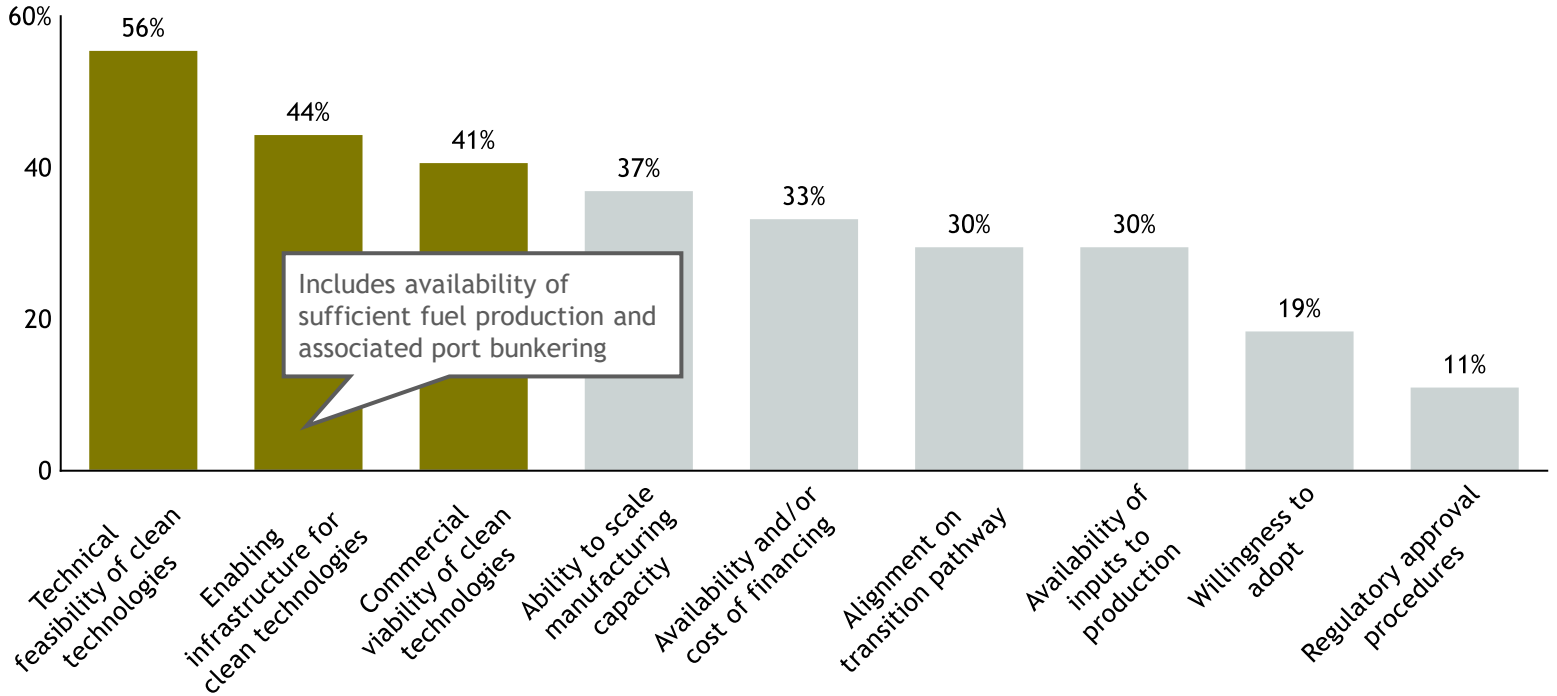
Note: Title quote from Head of Sustainability, Shipping manufacturer #1
Source: Global Maritime Forum 2022 Annual Progress Report on Green Shipping Corridors, Corporate interviews

Shipping: Table of Contents

>50% of operators cite technical feasibility as a top barrier to scaling adoption of alternative fuels, with infrastructure, commercial feasibility concerns too

*As you consider making **investments in vessels that consume fossil fuel alternatives, which of the following are the greatest barriers?** Please select the top 3 most impactful barriers.*

Share of survey respondents selecting barrier in the top 3 (%)



Note: Chart includes data from energy consumers, energy providers, infrastructure providers, and financing providers with expertise in the shipping sector (N = 27)
Source: Bain / WMBC Global Stocktake Survey (N = 215); Corporate interviews

Commentary

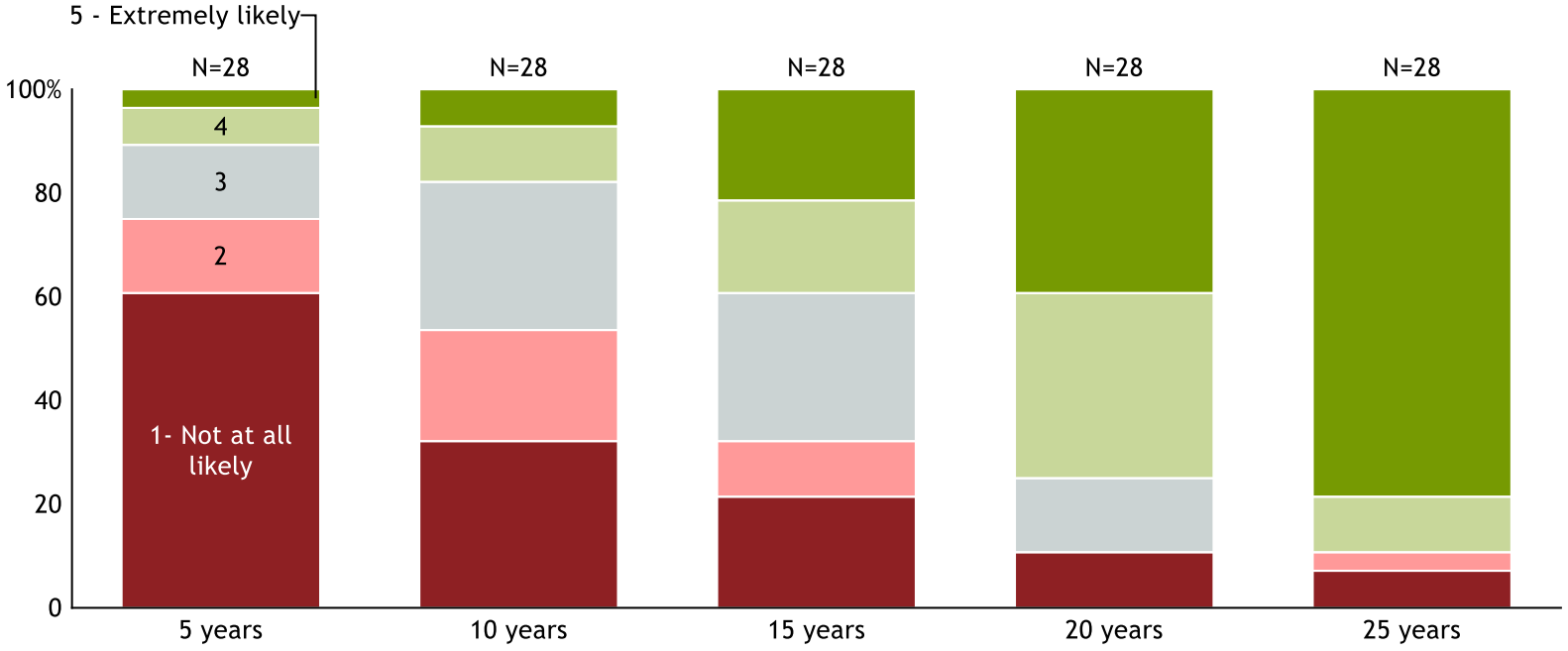
- Shipping business leaders are navigating **barriers from multiple angles** as they push toward an alternative fuel future:
  - Many **technical concerns** remain with some alternative fuels, especially with ammonia and its safety
  - The **infrastructure to support fuel production and bunkering** does not yet justify ship operators shifting their capital stock to alternative fuel vessels
  - Alternative fuels **remain prohibitively expensive for operators to use,** posing ongoing commercial viability concerns
- **2023 IMO GHG Strategy has potential to accelerate the sector through some of its biggest fueling barriers** providing policies to enforce the strategy come into effect and compel stakeholders to accelerate transition

*"We have been entering agreements with fuel suppliers because **we are concerned about** making investments in vessel technologies and then **being at the will of the fuel supply chain.**"*
Head of Sustainability, Shipping manufacturer #1

The speed of the transition will be driven in-part by operators' reluctance to retire existing, high-emissions ships before at least 20 years of service

As we look at opportunities for ship operators to reduce emissions of their existing fleets, there is opportunity to transition to zero-emissions vessels sooner if ship operators are willing to retire some of their ships early. ***How likely would you be to retire a given vessel in operation in favor of a zero-emissions vessel or support investment to transition to a zero-emissions vessel*** *at each of the following timelines?*

Share of ship operators by likelihood to retire a vessel prior to a certain time period (%)



Note: Chart includes data from energy consumers, energy providers, infrastructure providers, and financing providers with expertise in the shipping sector (N = 28)
Source: Bain / WMBC Global Stocktake Survey (N = 215); Corporate interviews

Commentary

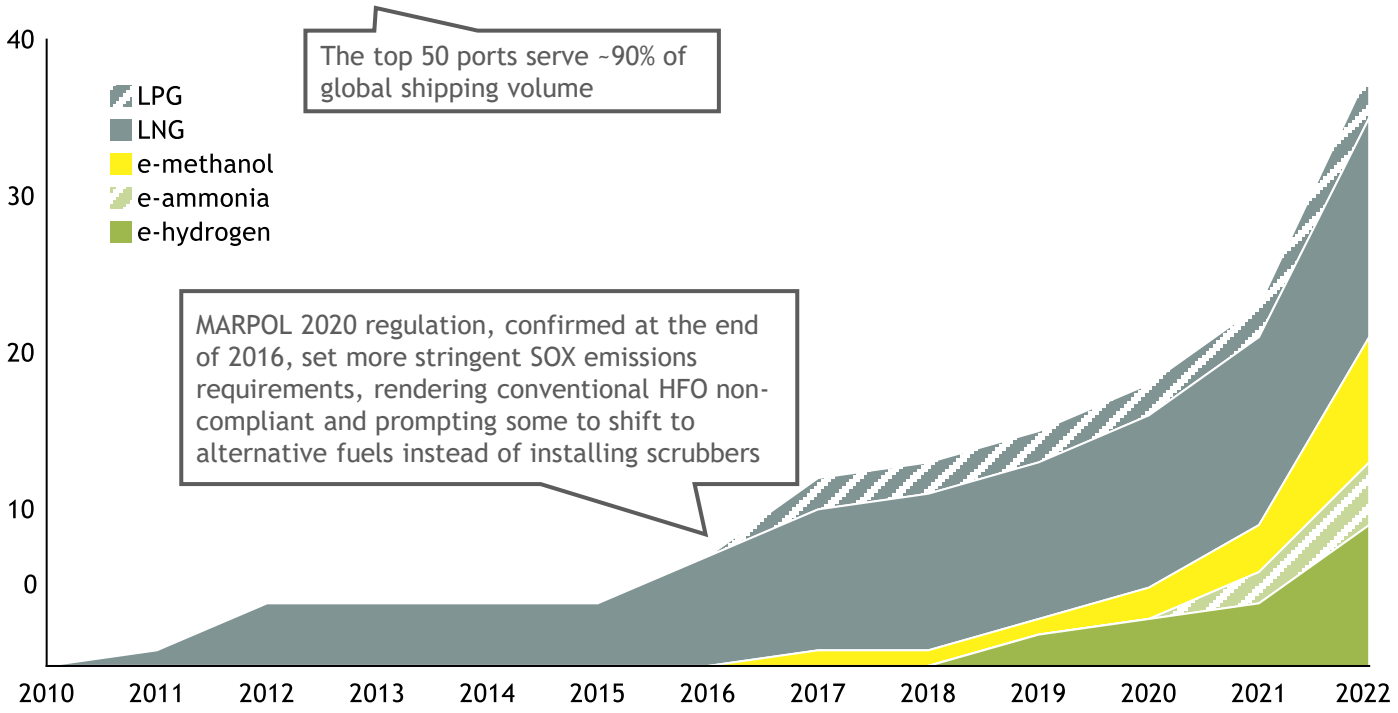
- **Ship operators are faced with tradeoffs in managing their assets** as they consider opportunities for alternative fueling
  - Vessels cost millions of dollars and typically have a **useful life of more than 20 years**
  - For this reason, most ship operators are **uninterested in retiring ships** until they have operated for most of their useful life
  - As a result, business leaders are indicating that **only at the 20 year mark are many willing to consider retiring** a ship
- **Many are considering dual-fueling options** to allow flexibility for multiple fuels in the future, even retrofitting existing assets to open up this optionality today

"Operators are hesitant to move quickly in transitioning capital stock, and ***with only 2% of alternative fuel ships on the orderbook it is clear how long the transition will be.***"
Head of Sustainability, Ship manufacturer #1

“Ports that bet on LNG regret that now; only recently have we seen more H_2-based fuels, but the jury is still out on how wide their adoption will be”

LNG bunkering commitments have grown steadily over the past decade, with hydrogen-based fuel investments growing more recently

Cumulative number of Top 50 port announcing investments in new fuel bunkering by fuel type



Commentary

- As the shipping industry moves to decarbonize, ports are looking to bunker **e-hydrogen, e-ammonia, and e-methanol, but limited fuel supply and prohibitive storage and transport costs** have limited ports’ commitments
  - Some worry about the safety of ammonia given its toxicity
- Even with the uptick in announcements, ports will take **5-10 years from the time of announcement to bunkers becoming operational**
- **LNG has maintained steady popularity** in terms of fuel bunkering commitments over the last decade due to:
  - Fuel supply relative to other alternatives
  - Cost effectiveness relative to other alternatives
  - Some institutions including the World Bank condemn these options for being non-compliant with Paris Climate Agreement goals
- **The policy measures to follow the 2023 IMO GHG Strategy, and its goal of 5-10% near-zero or zero-emissions shipping fuel supply by 2030, may change trends** in fuel bunkering announcements:
  - Accelerating announcements for e-hydrogen-, e-methanol-, and e-ammonia-based bunkering
  - Eliminating announcements for LNG-based bunkering given well-to-wake emissions requirements rendering LNG non-compliant due to methane leakage concerns

Note: Title quote is from Chief Executive Officer, Alternative fuel producer #1; Top 50 ports determined by annual container volume by TEUs as of 2021; Assume 1 TEU = ~26 metric tons
Source: World Shipping Council, Lit. search, Fourth IMO GHG Study 2020, 2023 IMO GHG Strategy, Corporate interviews

There is significant evidence of ambitious alternative fueling investments across the value chain

01 02 03 **04 LONG-TERM FUEL SCALING**

Port of Rotterdam

Case Study: Port of Rotterdam

Overview

- **Description:** Largest port in Europe, run by the autonomous company Port of Rotterdam Authority
  - Gateway port to EU
  - Backed by two shareholders - the Municipality of Rotterdam and the Dutch State
  - Largest biofuel cluster in Europe
- Liquid bulk makes up largest share of cargo, followed by containers, dry bulk, and breakbulk
- **Total Throughput (2022):** 467.4 million metric tons
- **Revenue (2022):** € 825.7 million

Targets

2025
- HyTransPortRTMRotterdam to be first part of >30km national hydrogen network

2026
- Hydrogen and Ammonia import terminals operational

2030
- Annual production capacity of 1.2M metric tons climate neutral hydrogen (e.g., blue and green)
- 90% onshore power use
- Hydrogen network complete, with Rotterdam at head

Activities

Pioneering the start of a national hydrogen network

- **Port of Rotterdam will be starting point for national hydrogen network,** connecting import terminals, hydrogen storage facilities, and major industrial regions in the Netherlands and its neighbors like Germany and Belgium
  - Projecting total buildout cost of ~€1.5B
  - Partnering with energy infrastructure company Gasunie to fund first part of network, based out of Rotterdam, to be completed by 2025
  - Constructing e-ammonia and e-hydrogen import terminal by 2026, with plans to establish supply chain to import e-hydrogen and ammonia from Mauritania
  - Goal to complete national e-hydrogen network by 2030, which will be 1,200km long (85% of which will consist of existing NG pipelines)
- The creation of this network is **encouraged by the Dutch HBE system,** a renewable energy tracking and standards system that helps companies meet their annual GHG reduction obligations

Leading the industry in CCUS installations and other emissions reduction initiatives

- Rotterdam has **launched the Port of Rotterdam CO_2 Transport Hub and Offshore Storage Plan**
  - Air Liquide, Air Products, ExxonMobil, Shell signed contracts with the port to transport and store of 2.5 million metric tons of CO_2 by 2024
- Rotterdam is **scaling its onshore power to 90% of total power use by 2030,** resulting in emissions reductions of ~200K metric tons of CO_2 and ~2.5K metric tons of nitrogen

Offering port fee reductions for sustainable fuel bunkering

- **Port of Rotterdam will offer a substantial port fee reduction for ships that bunker sustainable fuels in Rotterdam,** supporting the recently announced Zero Emissions Maritime Buyers Alliance (ZEMBA) and recognizing front runners in the road to maritime decarbonization

Source: (*) CDP, Lit. search

Governments are setting strong policy pathways to propel alternative fueling within their own borders

01 02 03 **04 LONG-TERM FUEL SCALING**

Case Study: Chile Shipping Ports

Overview

- **Description:** The Ministry of Transport and Telecommunication and Ministry of Defense oversee Chile's public and private ports, respectively, with 8 primary ports spanning Chile's coastline

Targets

2030

- 31 sites producing e-methanol, e-ammonia, or e-hydrogen with a collective annual capacity of 11,813 kt of hydrogen

2050

- 71% of shipping transport to use green hydrogen

Activities

Building a nation-wide "green corridor" and setting the stage for other countries to do the same

- **The abundance of solar and wind capacities in Chile are ideal for the generation of ZEFs at a low cost,** thereby having the potential to play an important role in the global decarbonization of shipping
- The Chilean Green Corridors initiative is therefore central to **realizing Chile's potential as a key export nation for low-carbon fuels**, which has been split into 4 stages:
  - Phase 1: Identifying and shortlisting what are expected to be the most critical routes along the corridor
  - Phase 2: Evaluating the technical, regulatory, and commercial feasibility of scaling ZEF production, bunkering, and consumption along these critical routes
  - Phase 3: Designing the implementation plan to transition critical routes from historical fuel practices to ZEF-focused practices

Looking beyond domestic ports to export ZEFs internationally

- Chile is positioned to not only fuel its own ports with ZEFs but to **export its ZEF supply internationally as well**
- As such, Chile has identified **concentrated production areas across Antofagasta, Atacama, Santiago, Concepcion, and Punta Arenas**
- By 2030, Chile will have 31 sites producing e-methanol, e-ammonia, or e-hydrogen with a collective annual capacity of 11,813 kt of hydrogen
- Production of ZEFs in Chile will be a **critical enabler to help ports secure sufficient fuel supply to support bunkering across major global shipping routes**

Source: Maersk Mc-Kinney Moller Center for Zero Carbon Shipping, Marine Insight

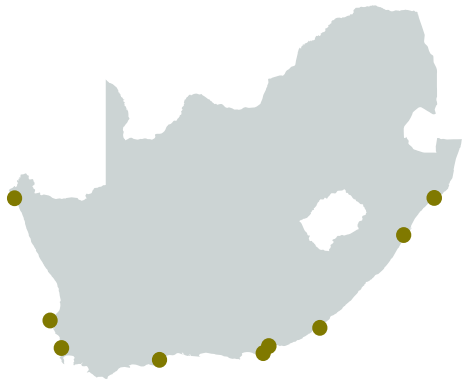
The South African government has also leveraged its ports to anchor its zero-emissions fueling strategy

01 02 03 **04 LONG-TERM FUEL SCALING**

Case Study: South Africa Shipping Ports

Port overview

- **Description:** Situated on one of the busiest international sea routes, South Africa's 9 major ports are privately owned by Transnet National Ports Authority and operated by Transnet Port Terminals



Targets

2025
- 5 GW of electrolysis capacity deployed and supported by 10 GW of renewable energy generation, currently under construction
  - Powered by Tier-1 solar panel and wind turbines

2030
- 10 GW of electrolysis capacity deployed
- ~500 KT of e-hydrogen produced annually

2050
- 4% of the e-hydrogen market captured
- South African port network is a net-zero operation

Activities

Leading the shift of shipping ports to renewable energy and hydrogen-based fuels

- South Africa is aiming to capitalize on **renewable energy resources available in the Northern Cape to jump start a transition to clean energy**
  - At COP26, the Northern Cape Green Hydrogen Strategy launched
  - Boegoebaai is slated to serve as the central, e-hydrogen hub that will be built out to achieve sustainable development and decarbonization goals
  - Port and rail infrastructure will be designed and built for the export of hydrogen and ammonia from this port throughout South Africa

Driving high volume offtake partnerships through international collaboration

- **South Africa is taking a proactive approach to fund their energy transition** towards e-hydrogen and other renewables
  - In 2021, France, Germany, Britain, the United States and the EU pledged $8.5 billion to South Africa for its green transition
  - In 2022, announced a campaign targeted towards private sector investors to introduce renewable energy to its nine major ports
    - > Considering renewable energy sources such as wind, solar, hydroelectric, biomass, geothermal, etc.
    - > Aims for 50 – 80 MW of renewable energy power generation capacity to deploy across the nine ports
  - In 2023, South Africa, Denmark, and the Netherlands launched a ~$1B e-hydrogen fund

Source: International Trade Administration, Reuters, Port Technology International, Environmental Defense Fund, Global Africa Network; GMF / UCL Report on "Shipping's Energy Transition: Strategic Opportunities in South Africa"

But for ship operators and ports, there is not yet sufficient fuel supply to support bunkering HFO alternatives

"A core challenge in advancing hydrogen technology in maritime is chicken-and-egg: ***without off-takers, there's no incentive to develop projects; without projects, there's no incentive to change vessel technology away from prevailing technology like LNG."***

Global Sustainability Lead, Utility company #5

"In shipping, you're going to need to have e-methanol or e-ammonia, but ***the infrastructure does not exist in terms of hydrogen production or port bunkering. Those will be the biggest barriers to adoption*** *in maritime shipping."*

Head of Climate, Sustainability, and Environmental Policy, Fleet operator #4

Source: Corporate interviews

For fuel suppliers, there is limited supply of inputs for some fuel alternatives and uncertainty about the level of downstream demand from ports and ship operators

"Energy companies are hesitant to invest in green fuel production because of the demand and regulatory uncertainty. ***The shipping industry need to give the energy sector stronger demand signals. The sooner we start the transition to greener fuels the sooner the energy sector recognizes the need to start ramping up the production."***

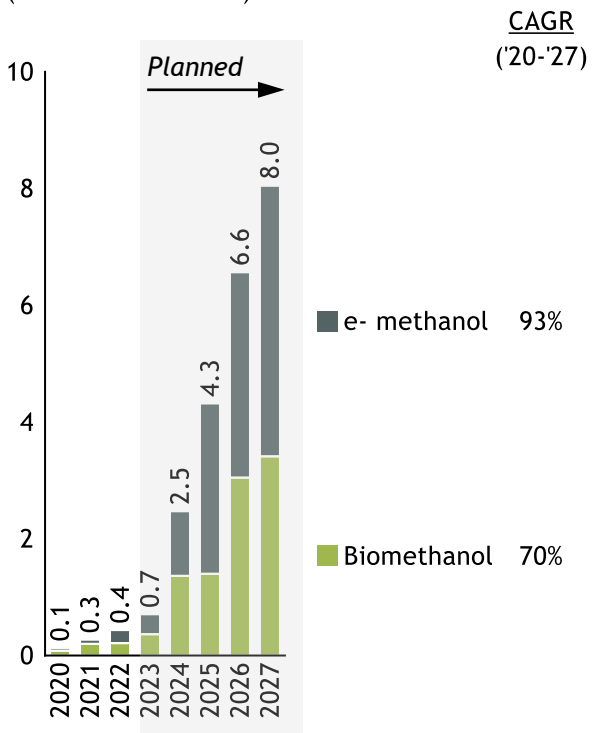
Maersk

Source: Corporate interviews

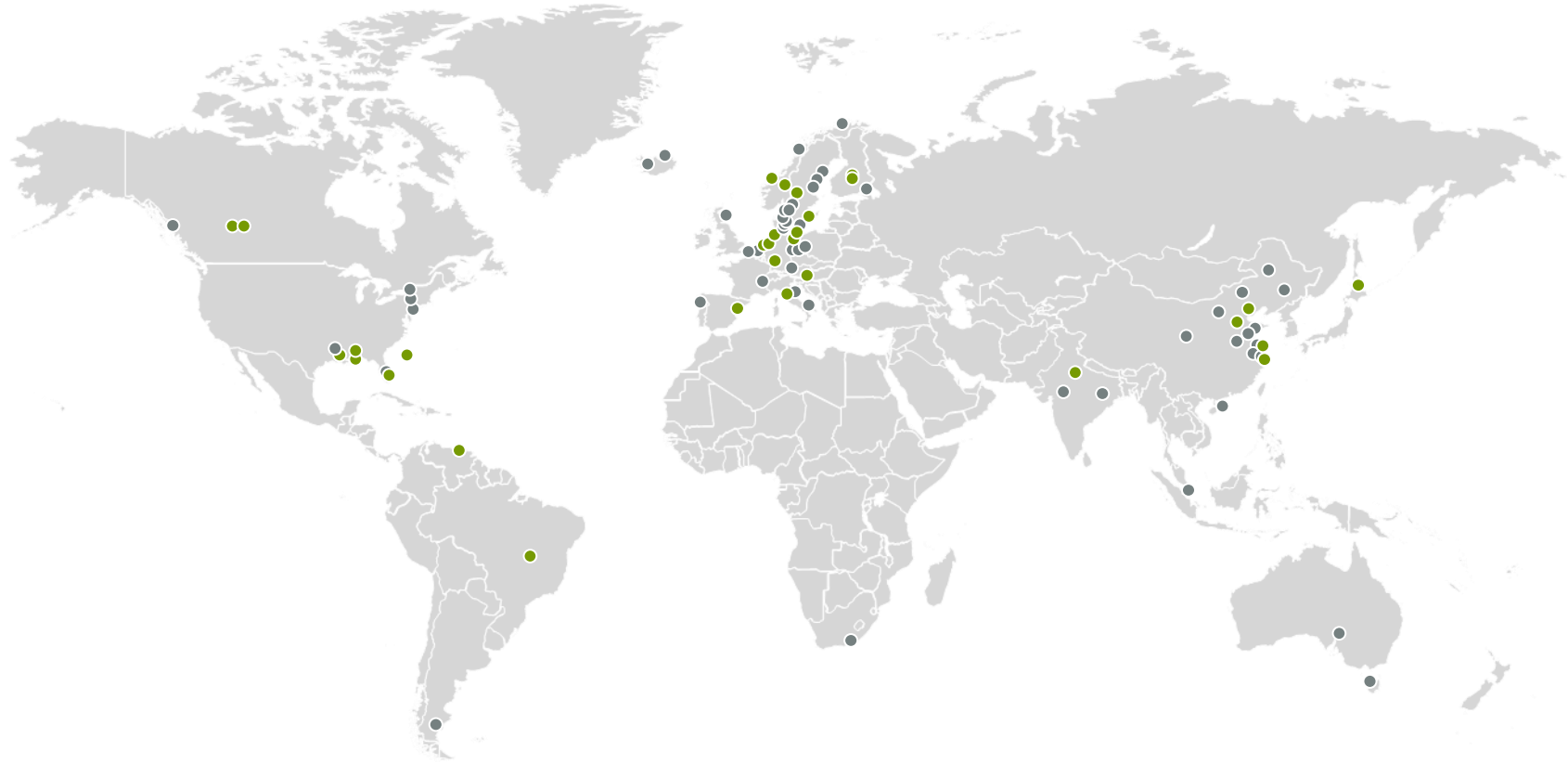
“Sourcing methanol for our fleet has initially proven more difficult and costly than anticipated”

Renewable methanol production is scaling quickly

Methanol production capacity
(in M of metric tons)



Planned production is growing across geographies, with the largest share of production in China and the EU



Note: Title quote is from Maersk
Source: Methanol Institute, Corporate interviews

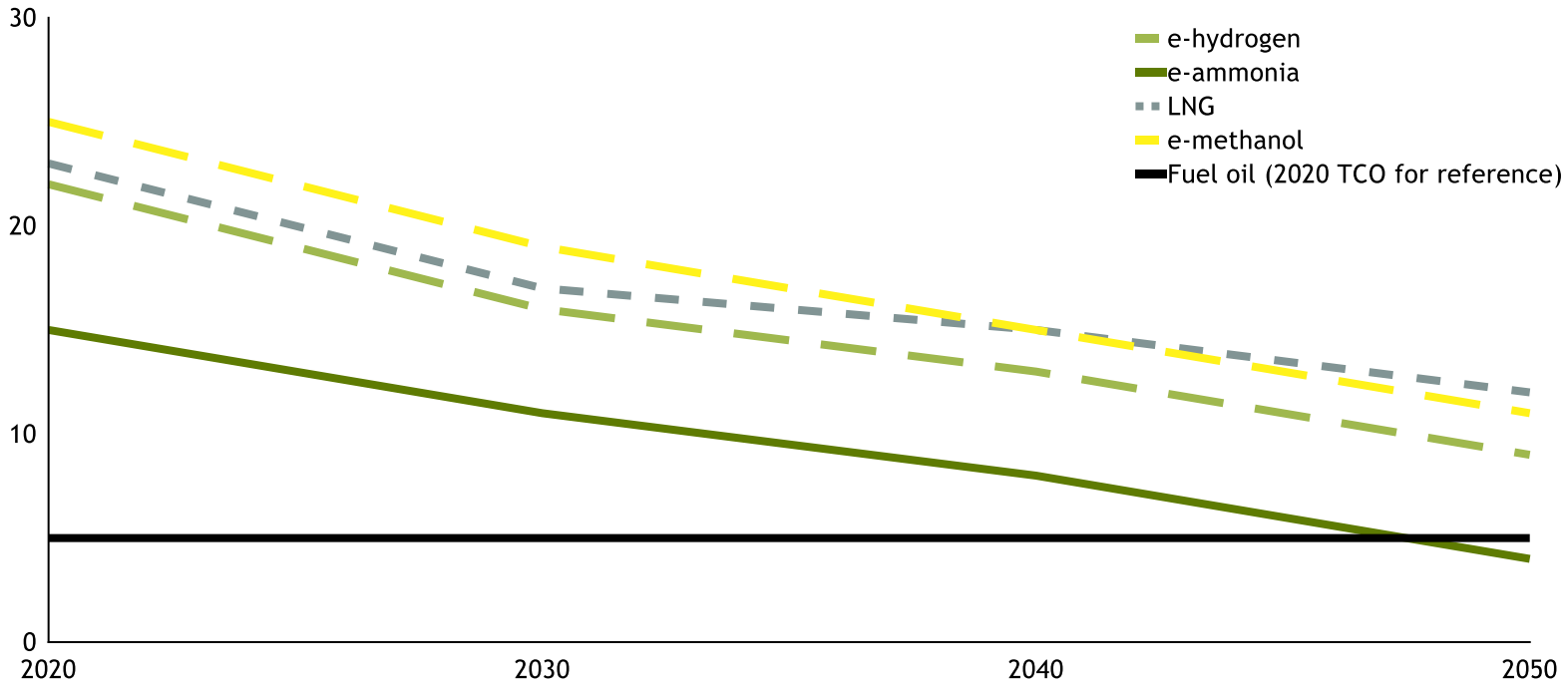
“For ship operators to move to low, near-zero, or zero-emissions vessels comes at a serious cost premium”

Total cost of ownership (TCO) for ships to use alt. fuels expected to improve

- There are **a few significant drivers of TCO:**
  - **Fueling costs** are expected to come down significantly over time due to improvements in production, storage, and handling efficiency
  - Along with fueling costs, the **installations required to support these fuels** will become less capital intensive as technology advances
  - Further, as fuel storage improves, **less revenue will need to be sacrificed** for fuel storage
- **Only certain fuels generated with renewables are viable** to fully decarbonize shipping
  - Hydrogen, ammonia could also be produced using natural gas + CCS, but they would then not be zero-emissions fuels
  - LNG, methanol could also be produced using biomass, but they are also not zero-emissions fuels regardless of their feedstocks
- Each fuel **could use an internal combustion engine or fuel cells,** though fuel cells are expected to be less cost competitive

While each of the fuel alternatives is expected to see an improvement in TCO, ammonia projects to come closest to approaching fuel oil

Total annual cost of operation by fuel type (in 2020 $M USD)



Note: Title quote from Head of Climate, Sustainability, and Environmental Policy, Fleet operator #4; Total cost of operation includes fuel-related voyage costs, additional capital costs of a new engine, additional capital costs for a fuel storage system, and impact on revenue due to the space requirements of the fuel storage system; Biomass and natural gas based fuels are excluded from this analysis; TCO analysis is conducted on an ~82,000 DWT bulk carrier and captures the “low cost scenario” from the Lloyd’s Register / UMAS report; Assumes ICE configuration rather than fuel cell
Source: DNV, Lloyd’s Register, UMAS

“The IMO's most recent guidance is not enough; they need to put some policies around their strategy to see any meaningful action”

01 02 03 **04 LONG-TERM FUEL SCALING**

There are 4 levels of ambition to the 2023 IMO GHG Strategy

1. GHG intensity of the ship to decline through further improvement of the energy efficiency for new ships
2. GHG intensity of international shipping to decline
3. Uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources to increase
4. GHG emissions from international shipping to reach net zero

- **Note:** the strategy considers well-to-wake emissions, which includes well-to-tank and tank-to-wake emissions
  - As a result, concerns like methane leakage are now considered in assessments and render fuels like LNG non-compliant

A timeline has been set to achieve the ambition

2030

20-30% GHG emissions reduction vs. 2008 levels

40% reduction in emissions per transport work

5-10% near-zero or zero emissions fuels supply

While the IMO has not set a formal goal for the 2040 fuel supply, a coalition of NGOs including the GMF report **that >50% of fuel must be ZEF by 2040 for the sector to stay on track**

2040

70-80% GHG emissions reduction vs. 2008 levels

2050

100% net GHG emissions reduction vs. 2008 levels

The IMO indicated plans for policies to drive progress against emissions goals

Standard setting

- A technical element, namely **a goal-based marine fuel standard** regulating the phased reduction of the marine fuel's GHG intensity

Pricing

- An economic element, on the basis of a **maritime GHG emissions pricing mechanism**

Note: Title quote from Head of Climate, Sustainability, and Environmental Policy, Fleet operator #4
Source: 2023 IMO GHG Strategy; Corporate interviews

It is expected that mid-term policies the IMO has indicated it will implement by 2025 will help to alleviate some of ship operators' commercial viability concerns

The IMO has indicated they are targeting adoption of 2 policy measures within the next ~5 years

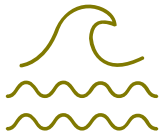
Fuel standard

- A technical element, namely **a goal-based marine fuel standard** regulating the phased reduction of the marine fuel's GHG intensity
- **Provides demand guarantee for fuels of lower GHG intensity and a business case to transition** through the non-compliance of incumbent high GHG fuel intensity fuel

GHG price

- An economic element, on the basis of a **maritime GHG emissions pricing**
- **Helps to close the price gap** between the incumbent fossil fuels and future low, near zero and zero emission fuels

These policies are expected to help drive many alternative fueling options to commercial parity with incumbent fuels



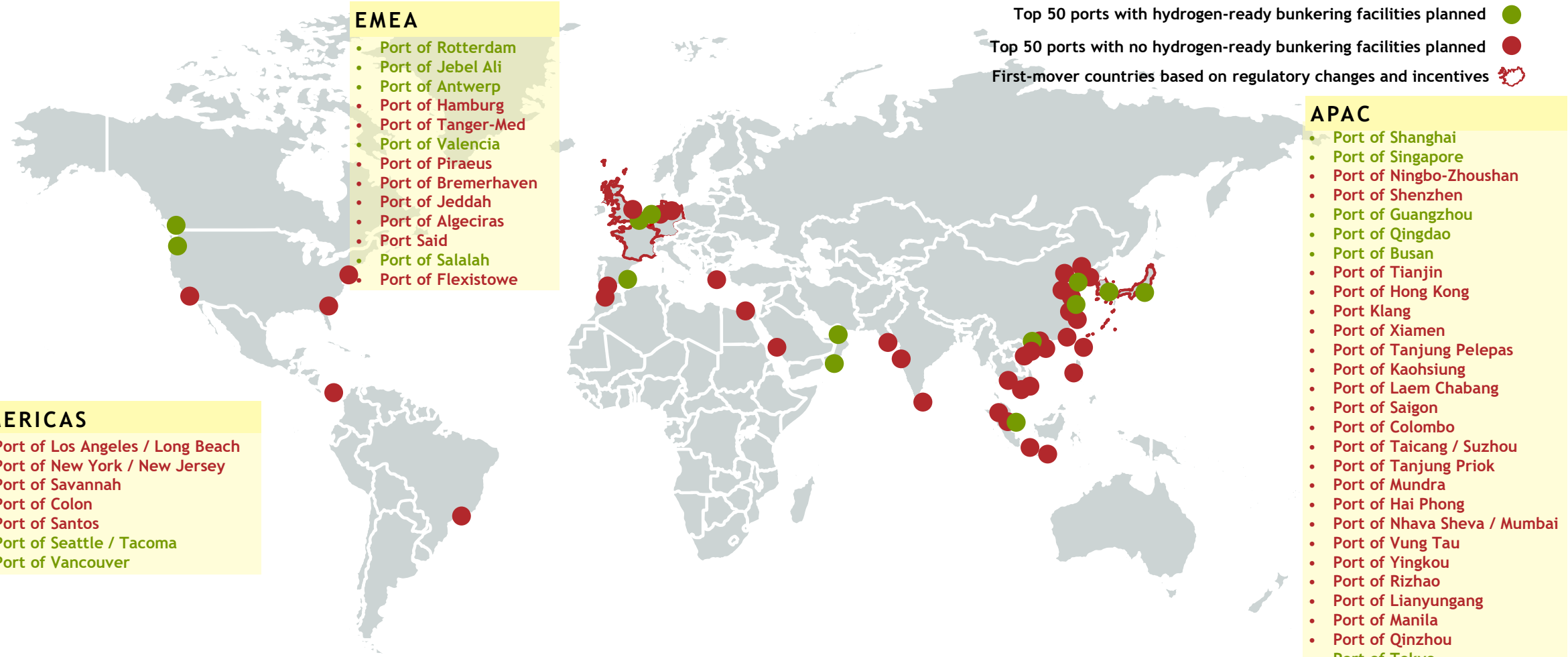
Help to achieve GHG reduction ambitions stated in the 2023 IMO GHG Strategy, including 2030, 2040, and 2050 goals

Promote the energy transition in the maritime shipping sector

Provide ship operators a needed financial incentive to transition their own fleets

Contribute to a level playing field and create a just and equitable transition across economies participating in the global maritime shipping sector

Some companies see “a quicker transition at the biggest shipping hubs; they adopt standards and then need to push the entire sector to do the same”



EMEA

- Port of Rotterdam
- Port of Jebel Ali
- Port of Antwerp
- Port of Hamburg
- Port of Tanger-Med
- Port of Valencia
- Port of Piraeus
- Port of Bremerhaven
- Port of Jeddah
- Port of Algeciras
- Port Said
- Port of Salalah
- Port of Flexistowe

AMERICAS

- Port of Los Angeles / Long Beach
- Port of New York / New Jersey
- Port of Savannah
- Port of Colon
- Port of Santos
- Port of Seattle / Tacoma
- Port of Vancouver

APAC

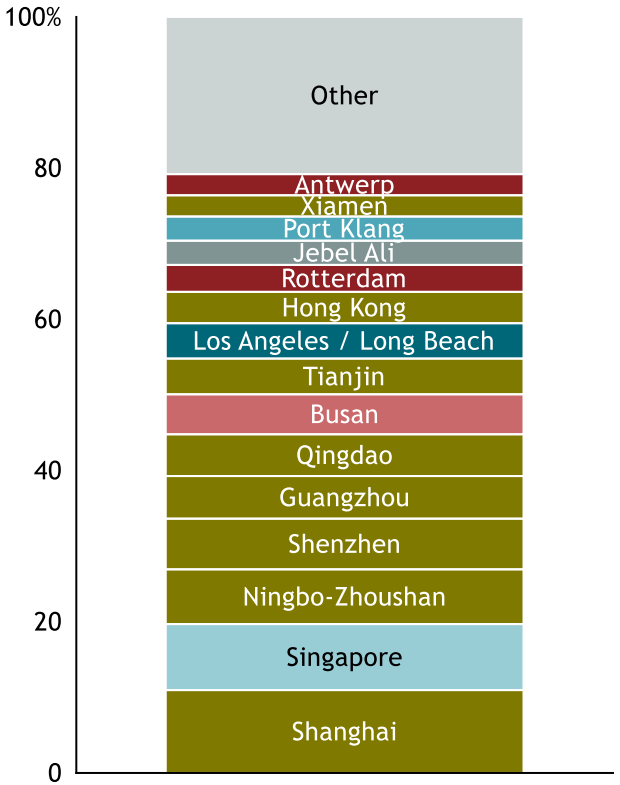
- Port of Shanghai
- Port of Singapore
- Port of Ningbo-Zhoushan
- Port of Shenzhen
- Port of Guangzhou
- Port of Qingdao
- Port of Busan
- Port of Tianjin
- Port of Hong Kong
- Port Klang
- Port of Xiamen
- Port of Tanjung Pelepas
- Port of Kaohsiung
- Port of Laem Chabang
- Port of Saigon
- Port of Colombo
- Port of Taicang / Suzhou
- Port of Tanjung Priok
- Port of Mundra
- Port of Hai Phong
- Port of Nhava Sheva / Mumbai
- Port of Vung Tau
- Port of Yingkou
- Port of Rizhao
- Port of Lianyungang
- Port of Manila
- Port of Qinzhou
- Port of Tokyo
- Port of Tanjung Perak
- Port of Dalian

Note: Title quote from Head of Climate, Sustainability, and Environmental Policy, Fleet operator #4; Top 50 ports determined by annual container volume by TEUs as of 2021
Source: World Shipping Council, Lit. search, Corporate interviews

15 ports, that represent ~80% of global shipping volume, are governed by only 7 governments and could be leveraged to drive more ambitious policy

15 ports serve ~80% of global shipping volume

Share of global shipping volume (in B of metric tons) by port (%)



Source: World Shipping Council, Lit. search,

These 15 ports are regulated by only 7 governments and have each begun to prompt their transition to ZEFs in the Shipping sector through a mix of policies

China

- China has introduced a series of standards, disclosure requirements, subsidies, and pricing schemes to **encourage ship operators to become more energy efficient but has strayed away from mandating specific fuel types,** favoring LNG over carbon-zero alternatives

Singapore

- **Singapore has focused on providing significant government funding to support the transition to carbon-zero fuels,** requiring the sector to be carbon-zero by 2050, providing direct funding and subsidies to ship operators, and releasing guidance for ports to bunker carbon-zero fuels like methanol

South Korea

- **South Korea has focused on providing significant government funding to support the transition to carbon-zero fuels,** requiring 70% GHG reduction and 15% ZEF ships by 2030, providing direct funding and subsidies to ship operators, and deregulating methanol vessels and bunkering

US

- **The United States has focused its policies strictly around ports,** allocating ample direct funding and implementing a 2030 carbon-zero mandate for the sector to decarbonize

EU

- **The EU has introduced a combination of extensive government funding, carbon pricing, and detailed mandates to decarbonize the sector,** with myriad government programs support operators and ports to develop ZEF vessels and bunkering, subjecting Shipping actors to the EU ETS starting in 2024, and setting specific targets for emissions reductions and ZEF supply through 2050

UAE

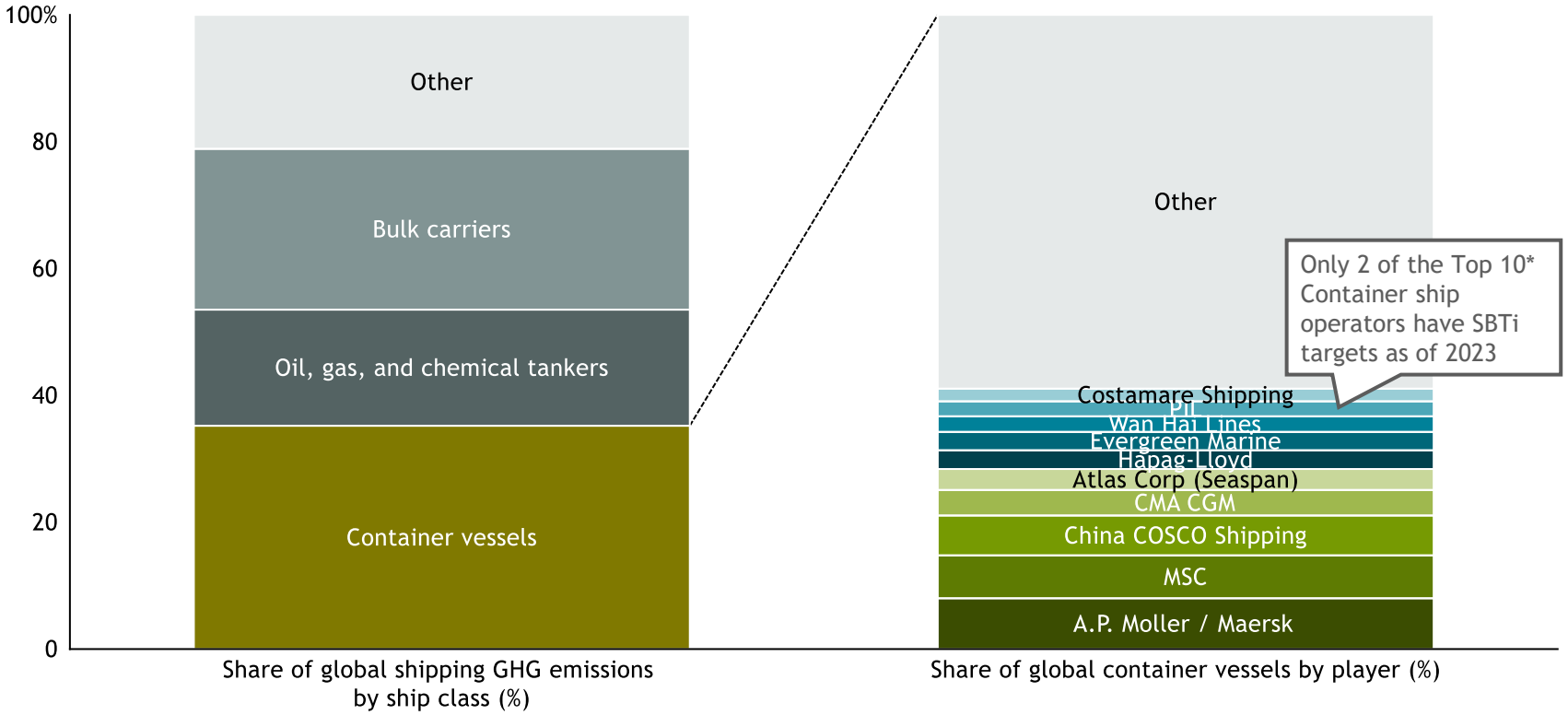
- **The UAE has focused only on its Jebel Ali port,** setting a deadline for the port to become carbon-zero and providing ample funding for the port to build out its bunkering infrastructure and meet government mandated emissions reduction goals

Malaysia

- **Malaysia has only introduced policies specifically proposed by the IMO** and has introduced nothing incremental to decarbonize ports or operators in the country

Container ship operators are a high impact segment of the sector that could serve as an effective starting point for port incentives

Container ships represent ~25% of fuel consumption but ~35% of emissions



Within the container segment, ~10 players represent ~40% of the total market and present opportunity for coordinated commitments

- By focusing on a consolidated segment of the market, **policies can drive high impact by committing just a few players to new practices**
- Once policies are adhered to by just a few players, **new industry practices will be adopted by the long-tail of container players as well**
- Further, many of the top container ship players own vessels across other ship classes and can **expand their practices beyond the container ship segment**

Note: (*) A.P. Moller / Maersk and Evergreen Marine have SBTi targets; the oil, gas, and chemical tankers segment's top 10 players have only ~12% market share, and the bulk carriers segment's top 10 players have only ~15% market share
Source: IEA, MDPI, DNV, Shell, Hayward, Lit. search, Clarkson's

With updated guidance in the IMO's 2023 GHG strategy, the Shipping industry is beginning to align on long-term fuel options to support emissions reductions goals

Technical benefits of fuel alternatives

- Key organizations across the value chain (e.g., fuel suppliers, ports, and ship operators) are still aligning on the best alternative to heavy fuel oil (HFO) when considering **upfront investment costs, ongoing fuel costs, handling costs, and energy density**
- While the industry is **coalescing around e-ammonia as a long-term alternative to HFO,** there are fragmented investments around LNG, LPG, battery hybrid, and e-methanol in the near-term

~55% of business leaders consider technical feasibility to be a top barrier to alternative fuel adoption

Investment profile for the fuel transition

- **Ports and fuel suppliers face high upfront CapEx requirements** to install bunkering infrastructure and build production capacity
- **Sunk costs may be driving further investment in some fuels, especially LNG,** slowing the transition to zero-emissions fuels due to long payback periods
- Recent IMO strategy announcements could prompt a faster switch from LNG investors, as **well-to-wake emissions tracking would render LNG's methane leakage non-compliant** with expected IMO regulation
- **Many are pursuing dual fueling** options to allow flexibility in fuel types

~40% of business leaders consider commercial viability to be a top barrier to alternative fuel adoption

Fuel production & bunkering infrastructure

- For ship operators, there is **not yet sufficient fuel bunkering** for HFO alternatives to justify investment in new vessels that consume those alternatives
- For ports, there is **not yet sufficient fuel supply** to support bunkering HFO alternatives
- For fuel suppliers, there is concern about **limited supply of inputs** for some HFO alternatives (e.g., e-hydrogen)

"Operators are worried about sufficient alternative fuel production, and with only 2% of alternative fuel ships on the orderbook it is clear how long the transition will be."

Head of Sustainability, Ship manufacturer #1

The sector needs to identify ports as starting points to build commitments to green corridors and low-emissions zones

Accelerate the development of scalable zero carbon technology

- While e-methanol can be deployed today, **much greater government attention should be concentrated on accelerating the development and trials of long-term scalable solutions** such as e-ammonia
- **Significant direct government support will be needed to de-risk the deployment of first-of-a-kind ammonia vessels,** and policy will like be needed to support fuel supply (e.g., contracts for difference or other subsidy mechanisms)

Create niche markets for low carbon technologies

- **The creation of niche markets is vital for enabling the early-stage adoption of low-carbon technologies,** but voluntary demand can help; governments can do more to enable the development of these markets through establishing and regulating book and claim systems
- That said, **more significant government intervention is needed** to orchestrate the deployment of low-carbon shipping technologies.
- **Carbon pricing will also be important** but is unlikely to be sufficient to drive this kind of systems change
- In addition, governments will need to **implement stronger standard setting measures** such as GHG regulation (as per the Fuel EU Maritime regulations) that include ratcheting fuel mandates on ship operators, restrictions on port access according to fuel use or GHG emissions, and differentiated harboring fees based upon vessel type

Ensure a level playing field to scale adoption

- **Near-term measures to implement the IMO's ambitious GHG emission reduction strategy would be game-changing** for a fledgling green shipping industry, and international carbon pricing could also enable funding for a just transition
- However, realism is needed – securing agreement across the IMO around sufficiently meaningful measures will not be easy, so **the alignment of more ambitious action across a smaller number of major shipping hubs could be an important intermediate step** given just 15 ports represent ~80% of global shipping volume
- **Such an alliance of governments could pioneer an international framework setting international carbon emissions standards** or fuel mandates and incentivizing investment in bunkering infrastructure for alternative fuels

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