Decarbonising Shipping:
ALL HANDS ON DECK 2.0

Industry Perspectives

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CONTENTS

FOREWORD

Change is often the only certainty we have in the shipping industry. For proof, look no further than how much has changed in the three years since we published our initial *All Hands on Deck* report in collaboration with Deloitte. From the COVID-19 pandemic to the war in Ukraine, and the resulting global, economic instability, shipping – an industry vital to global trade and security – has been forced to withstand a turbulent period. However, amid this change, one constant has remained: the continued urgency to decarbonise.

Decarbonisation requires action, however. And while some of this action has already started taking place, crucially, it has not always been at the pace demanded by the energy transition. As we look ahead to the International Maritime Organization's strategy update, which has an opportunity to deliver an ambitious global policy regime, an acceleration is urgently needed.

Fortunately, stronger regulatory direction has the potential to help drive collaboration, which in turn can provide greater impetus for cross-sectoral investment and innovation. By building these relationships, by bringing this ecosystem together, and by creating solutions that are viable, scalable and economical, we can start to solve the problem ahead of us.

Because, significantly, every actor in the shipping value chain has a role to play – a fact we are acutely aware of at Shell, given the number of roles we ourselves play across the marine sector. Whether through the operation of a large fleet of tankers, the provision of integrated solutions such as marine fuels, lubricants and services or the development of technologies, we see the need for all segments of the industry to pull together. As such, Shell has set a target to become a net-zero emissions energy business by 2050; a large part of which involves working with customers, governments and other industry players to help address emissions in different sectors, including shipping.

I believe that acting now and acting collaboratively will be vital to achieve the much-needed progress. And this report represents both – by listening to industry voices and highlighting the action areas that should drive decision-making in the near-term.

While I hope you will find the insights in this refresher report useful, their value can only be measured by the subsequent actions taken. Therefore, as you read through *All Hands on Deck 2.0*, I encourage you to consider how you might act next, by exploring the solutions and pathways available to you today. I also encourage you to reach out to industry partners like Shell, who can help overcome your decarbonisation challenges. After all, we cannot afford to wait, and it's only by working together that we will secure a net-zero future for shipping.

Melissa Williams
President, Shell Marine

ABOUT THE REPORT STRUCTURE

This report is presented in two main sections. The first provides commentary and analysis on decarbonisation progress, integrates industry perspectives and proposes potential solutions. The Shell response section, as the second part, covers Shell's perspective on these developments, and offers their views on the decarbonisation challenge for shipping.

REPORT HIGHLIGHTS AND RECOMMENDATIONS

Decarbonisation remains a key focus for the shipping sector.

Some progress has been made in the past two to three years, but the magnitude of action and investment needs to step up with speed to achieve the ambition of net zero by 2050[1]. Six critical recommendations are proposed:

1. **Scale up pockets of demand:**
   A key accelerator is to create clearer signals of demand, through natural demand aggregation for low-carbon fuels and low-emission vessels. Joint-purchasing coalitions, grouping of long-term contracts, and book & claim models are some of the tools that could achieve this.

2. **Take a segment-specific approach:**
   Deep-sea shipping cannot be treated as one homogeneous segment. The common characteristics of each segment must be identified, to allow prioritisation and tailoring of solutions, starting with the first movers.

3. **Leverage local/regional regulation for momentum:**
   Effective local and regional regulation is now more commonly regarded as a means to advancing near-term material impact on total greenhouse gas (GHG) emissions for the shipping sector, while anticipating that global regulation will need to quickly follow to achieve a level playing field towards a net-zero target.

4. **Drive clarity on fuel pathways:**
   Deeper understanding of fuel technologies and segment needs has been achieved, and should serve as the stepping-stone for decisions on a dominant set of viable fuel pathways. Increasing demonstration projects and investment in these would support first-mover decision-making for both fuel suppliers and shipowners, and should recognise the complementarity of different pathways.

5. **Adopt an integrated view on asset improvement:**
   Fleet composition is crucial in tackling the decarbonisation challenge, and requires an integrated set of levers including efficiency measures, increased investment in dual-fuel-capable vessels, and faster conversion and increased modularity via retrofits – as well as ensuring sufficient newbuild and repair-yard capacity to undertake these changes.

6. **Activate the first green corridors:**
   Decarbonisation can be led by regional change, where a few specific actors collaborate to drive decarbonisation in a particular geography. Taking the steps to operationalise the first green corridors offers a concrete proof point that can be scaled for inter-regional impact.

[1] Throughout this report, "net zero" is used based on the definition of the Intergovernmental Panel on Climate Change (IPCC), which defines net zero as the state where "anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period". The IPCC notes that its models indicate limiting global warming to 1.5C would require global achievement of net zero emissions by 2050.

INTRODUCTION AND OBJECTIVES

The time for climate action – more than ever – is now. Although change is happening, there is growing consensus that more needs to be done across all sectors to reach net zero by 2050. The shipping sector has a unique role to play: as the backbone of global trade, it is not only a sector that must decarbonise, but also an enabler of global decarbonisation through the transportation of low-carbon fuels. Decarbonisation requires transformational change across the sector, bold leadership, and the involvement of multiple stakeholders.

The first report on decarbonising shipping, *All Hands on Deck*, published in 2020, revealed the barriers to, and readiness factors for, decarbonisation. It highlighted 12 solutions that needed significant action by 2030, and offered a longer-term view on focus areas for net-zero emissions (NZE) by 2050. The report was well received, winning accolades for thought leadership, and becoming a "recommended read" by the Getting to Zero Coalition. It also inspired action, with several partnerships created, such as North America's Blue Sky Maritime Coalition.

All Hands on Deck 2.0 serves as a refresher or "temperature check" across the sector, to assess the prevailing views, sentiments and concerns in the industry. The report aims to provide a **high-level overview of progress** since the publication of *All Hands on Deck "1.0"* in 2020, and **highlight solutions** that the sector can act on without delay. As such, this update adopts a nearer-term view, to emphasise a selection of specific, more immediate actions that enhance the solutions originally identified: what needs to happen right now, and who needs to do it.

To develop this update, more than 25 leaders[2] across all segments of the shipping sector were re-engaged to share their perspectives on the decarbonisation challenge. This update also draws on research[3] and analysis, to give depth to the perspectives shared.

"The past two years were the phase of talking. Today, we need to enter in the phase of concreteness – preparation for investment decisions"

Financier

It is hoped that *All Hands on Deck 2.0* will serve as a call to action for the sector to translate theoretical commitments into practical actions and capital investments. Shipping is motivated to change, and the goodwill of conversations with executives and experts is encouraging, with the consensus view being *"a way can be found to reduce emissions, as long as concrete action by the sector's leaders starts immediately."*

[2] Research participants: 14 CEOs/senior execs/owners, 9 operational sustainability experts, 3 policy experts; 6 shipowners/operators, 4 customer organisations, 4 financiers/legal bodies, 4 port authorities/operators, 6 regulators/standards/NGOs, 2 technology providers; stakeholders representing the APAC, Americas and EMEA regions.

[3] The insights were shared with us through interviews, workshops and desk research, and are not necessarily the views of Shell or Deloitte. All engagements were respectful of competition law boundaries.

A SUMMARY OF PROGRESS

Since *All Hands on Deck 1.0* was launched in 2020, emissions in the shipping sector have not shown significant improvement. Both shipping volumes and CO_2 emissions increased by nearly 6%[4] by the end of 2021, despite a temporary decline of 10% in the period, driven in part by the coronavirus pandemic and disrupted supply chains.

"Gaps cannot be closed by fragmented efforts"

Terminal operator

All Hands on Deck 1.0 identified 12 solutions across six decarbonisation readiness factors: market and customer demand, regulatory incentives, technology alignment, asset replacement, infrastructure replacement, and clarity on roles & decision-making (see Exhibit 1). Analysis and research indicate those readiness factors remain important, and although progress on solutions has generally been limited, there has been some success. Morale continues to be high, alongside cautious optimism and the expectation that *"those who can take the lead should do so"*, but also with a growing acceptance that *"everyone has a role to play."*

Improvement on the readiness factors has been uneven, leaving much impact yet to be realised. This variation in progress can be attributed in part to the different levels of risk associated with the principal stakeholder segments impacting each factor. For example, the risk to a shipowner from ordering a dual-fuel ready vessel (thereby creating a demand signal) is relatively limited, whereas the risk to a fuel supplier to build a facility to produce an alternative fuel at scale is considerable, if the supply remains uncontracted. Exhibit 2 shows a summary of the progress, and reflects the sentiment of the stakeholders engaged, and the analysis of developments in each domain.

[4] As of 2021. Shipping volumes increased by 13 billion ton-miles since 2018 (IMO's Fourth GHG Study). Shipping emissions declined between 2018 and 2020, from 708 Mt CO_2 in 2018 to 635 Mt CO_2 (IEA, 2022: https://www.iea.org/reports/international-shipping).

‘All Hands on Deck 1.0’ solution definitions

Readiness factors	‘All Hands’ solution	Definition
Market and customer demand	Scale-up customer demand	Scaling **customer demand** in low or zero-emissions shipping through **charterers’ and customers’ commitments**
	Green finance	Providing **green financing products** that lower the **cost of capital** and **improve terms** for shipowners
	Investor pressure	Encouraging **large institutional investors** with stakes in shipping and chartering companies, such as pension funds or sovereign wealth funds, to make **public commitments** to green portfolios
Regulatory incentives	Global regulatory alignment	Creating a **level playing field** globally and reducing **uncertainty** around regulations and timeframes
	Port coalitions	Setting **common targets, incentives** and **preferential treatment** by largest ports that have **outsized influence** based on their share of global trade throughput
Technology alignment	Cross-sector R&D	Intensifying **partnerships** to develop zero or low-emission fuels through **joint R&D** across shipping, other harder-to-abate sectors and the energy industry
	Scale-up controlled pilot projects	Launching **pilot projects** focused on **new fuels** and other **emission-reducing technologies** along selected shipping routes, in collaboration with **customers**
Asset replacement	Flexible and modular designs	Creating **flexible or modular propulsion systems** and **ship designs** to reduce the risk of choosing an emerging green fuel and lower the cost of retrofitting the fleet
	Operational efficiency	Developing and implementing **operational improvements,** such as improving fuel and lubricant quality, energy management, digitalisation and smart navigation strategies (e.g. just-in-time)
Infrastructure replacement	Scale-up fuel production	Establishing **strategic partnerships** with **energy companies** to secure the production and distribution of new fuels
	Scale-up bunkering infrastructure	Establishing **strategic partnerships** with **energy and bunkering companies** in the **largest ports** as to secure bunkering infrastructure for new fuels
Clarity on roles and decision-making	Coordinated industry commitment	Increasing the **reach of existing initiatives** by consolidating objectives and strengthening the coordination of various concurrent workstreams

Exhibit 1: All Hands on Deck 1.0 readiness factors and solutions, with definitions

Decarbonisation readiness framework – progress

Progress: High Medium Limited

		Readiness factor	Progress	Summary	Perceived impact of barrier
Why should the sector change?	1	Market and customer demand		▪ Pockets of demand for **alternative fuels** have **grown** ▪ Most signs of **voluntary demand** come from the customer-facing (B2C) **container segment**	Major 100%
	2	Regulatory incentives		▪ Positive steps have been made with **IMO EEXI** and **CII** ▪ Shipping is to be included in **EU-ETS** and alternative fuels will gradually be mandated under **FuelEU Maritime**	Major 100%
Can the sector change?	3	Technology alignment		▪ Greater clarity on the **likely fuel pathways** per segment ▪ Further R&D is required, with focus on demonstrations of **technical viability**	Major 100%
	4	Clarity on roles and decision-making		▪ Stronger collaborations are still needed for the setting of **safety standards, charter party agreements** and driving fair **cost/benefit allocation** of decarbonisation	Major 100%
How fast can the sector change?	5	Ease of asset replacement		▪ **Order book** for zero/low-emission ships has **increased** ▪ **Uncertainty** and **absence of mandates** for accelerated asset replacement impact the **pace of change**	Major 100%
	6	Ease of infrastructure replacement		▪ Little progress, with the exception of **green corridors** and complimentary, **port-led incentives**	Major 100%

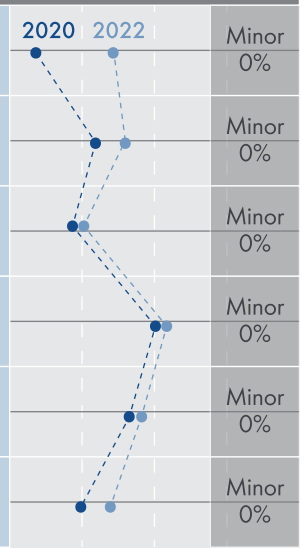

Exhibit 2: Progress on decarbonisation readiness factors in All Hands on Deck 2.0 compared to 1.0

A closer look at the readiness factors reveals that although there are pockets of progress across all dimensions, four areas are worth highlighting, as the observed success and momentum offer additional solutions to complement those identified in *All Hands on Deck 1.0*. These are summarised below.

Market and customer demand

There have been some modest increases in demand for alternative fuels, with most signs of voluntary demand coming from the customer-facing (B2C) container segment – for example, through networks such as the Cargo Owners for Zero Emission Vessels (coZEV). Several stakeholders note that these signals are likely to be strongest where the potential to extract a "green premium" from cargo owners is greatest, and acknowledge that this is not yet universally the case. Nonetheless, there is growing optimism that these demand signals should be robust enough to drive decisions on, for instance, dual-fuel vessel purchases.

Regulatory incentives

Positive steps have been made with two IMO-led measures for design and efficiency: the Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Index (CII), both of which became effective on January 1, 2023. Though a step in the right direction, the potential for these indices to be misused has been raised by several shipowners. Meanwhile, shipping is to be included in the EU Emissions Trading System (ETS) from 2024, and the FuelEU Maritime will come into effect in 2025. The uncertainty surrounding IMO setting a "net zero by 2050" target remains; however, there is speculation this may be addressed in its update to the IMO GHG Strategy (due July 2023).

Technology alignment

The growing maturity of alternative fuel technologies, and clarity on their development timescales, are starting to drive greater certainty on the likely set of dominant fuel pathways for different deep-sea segments. The complex mosaic of fuels being considered in 2020 was a necessary R&D step toward understanding their desktop feasibility. Looking forward, R&D should focus on demonstrations of commercial scalability. This should pave the way for stronger alignment across the sector on what needs to be done in terms of vessel investment, production capacity and associated infrastructure and regulation.

"One of the reasons why IMO has delayed a 'Net Zero by 2050' announcement is because there is no clarity on the fuel pathway"

NGO

Asset replacement

Out of shipping's global orderbook of 71.4m gross tonnage (GT), 61% (43.5m GT) of orders concern vessels that are capable of using alternative fuels such as liquefied natural gas (LNG) and methanol. This represents a notable increase versus existing fleet composition. However, remaining uncertainty and the absence of mandates to accelerate fleet replacement have affected the pace of change. Overall, there is a growing sector-wide sentiment that greater transparency on emissions performance can de-risk investments and stimulate asset replacement.

Against this backdrop, stakeholders were engaged on the topic of potential solutions to address these readiness factors. The result is a revised list of solution-actions (see Exhibit 3), which now incorporates more granular, concrete actions across common themes – for example, market and customer demand and asset replacement – and may serve as forward-looking priorities to step up the rate of sector decarbonisation.

Solution-actions per theme and readiness factor

Readiness factor	Solution themes		'All Hands on Deck 2.0' solution actions
Market and customer Demand	Demand aggregation	1	Group long-term contracts via **joint purchasing coalitions**
		2	**Implement book and claim** models
	Segment-based approach	3	**Identify segment-specific** characteristics
	Financing	4	Apply stricter **lending standards**
Regulatory incentives	Regulation	5	Close potential loopholes in **CII/EEXI**
		6	Advance **regional/local regulations** first, then align through global regulations
		7	Incentivise **low-carbon fuel supply** and succession of **dual-fuel vessels**
Technology alignment	Fuel landscape	8	Prioritize demonstration projects and investments in the **dominant set of fuel pathways**
Asset replacement	Efficiency measures	9	Install available-now **efficiency measures**
		10	Reconfigure contracts terms for **benefit-sharing**
	Resilient fleet replacement	11	Succeed aged vessels with **alternate/ dual-fuel vessels**
	Yard capacity	12	Forecast and adapt **yard capacity**
		13	Prioritise **dual-fuel vessel** builds and retrofits over conventional HFO
Infrastructure replacement	Hubs	14	Align with **energy hubs** for **sector allocation of fuel supply**
		15	Implement port-led **incentives**
	Green corridors	16	Operationalise the **first green corridor(s)**
Roles and decision-making	Health, safety and environment	17	**Commence upskilling** of the future workforce
	Transparency	18	Drive transparency on **emissions performance**

Exhibit 3: Solution actions per theme and readiness factor

In the *"Solutions – deep dives"* that follow, the four readiness factors showing the most momentum since the previous report, together with their associated solutions, are explored in more detail, while *"Solutions – in brief"* are provided for **infrastructure replacement** and **clarity on roles and decision-making**, which recap the associated solutions as well. Throughout the report, the focus is on the deep-sea shipping segment, although a few selected other segments are referenced when relevant.

SOLUTIONS – DEEP DIVES

MARKET AND CUSTOMER DEMAND

In *All Hands on Deck 1.0*, the challenges around market and customer demand included a scarcity of demand signals, and a lack of customer willingness to pay. Although customers had made decarbonisation commitments, few of those had resulted in action. Financiers and investors found it difficult to invest in unproven technologies with higher risk profiles than traditional investment portfolios supported, and the lack of transparency around emissions made it difficult to identify top performers for those customers and investors looking to support drivers of change. Accordingly, the solutions identified were to scale up customer demand, provide green finance and apply investor pressure.

Since then, stakeholders remain aligned that **aggregating demand** is still essential, together with the role of **green finance** and investors in supporting this demand. In addition, stakeholders more strongly voiced the need to take a more **segment-specific approach** to addressing decarbonisation challenges, in acknowledgement that the pace of change is not uniform across segments.

Scaling up pockets of demand

A key accelerator is to create clearer signals of demand, through natural demand aggregation for low-carbon fuels and low-emission vessels. Joint-purchasing coalitions, grouping of long-term contracts, and book & claim models are some of the tools that could achieve this.

Clear demand signals for green shipping are viewed as essential by fuel suppliers, to unlock investment in production capacity for alternative fuels. Creating those signals requires demand aggregation initiatives, which could include **joint-purchasing coalitions, grouping of long-term contracts** and mechanisms such as **book & claim.**

Translation of demand to market signals that fuel suppliers can rely on will be important to trigger action. Joint-purchasing coalitions for alternative fuels – as seen in the aviation sector – could be effective in lowering costs for both suppliers and off-takers, supported by long-term contracts to ensure pay-back for the capital intensity of fuel-production facilities. A shared view on the expected willingness to pay will be critical to ensure "matches" between demand from the shipping sector and suppliers being able to build a business around meeting that demand, which would likely take into account the needs of other sectors beyond shipping, to realise sufficient economies of scale.

"Who owns the emissions, drives the tipping point of incentives"

NGO

Book & claim models, as illustrated in Exhibit 4, could support demand (and supply) aggregation before fuel availability is widespread, by allowing the demand party and the supply party to have a match, without the added emissions impact of shipping fuels around. It is worth noting that some stakeholders see book & claim as complex – especially in the absence of a globally agreed standard for determining which actors can and what fuels are possible to "book" and "claim" in a traceable manner.

Illustrative example of 'book and claim' for alternative fuels

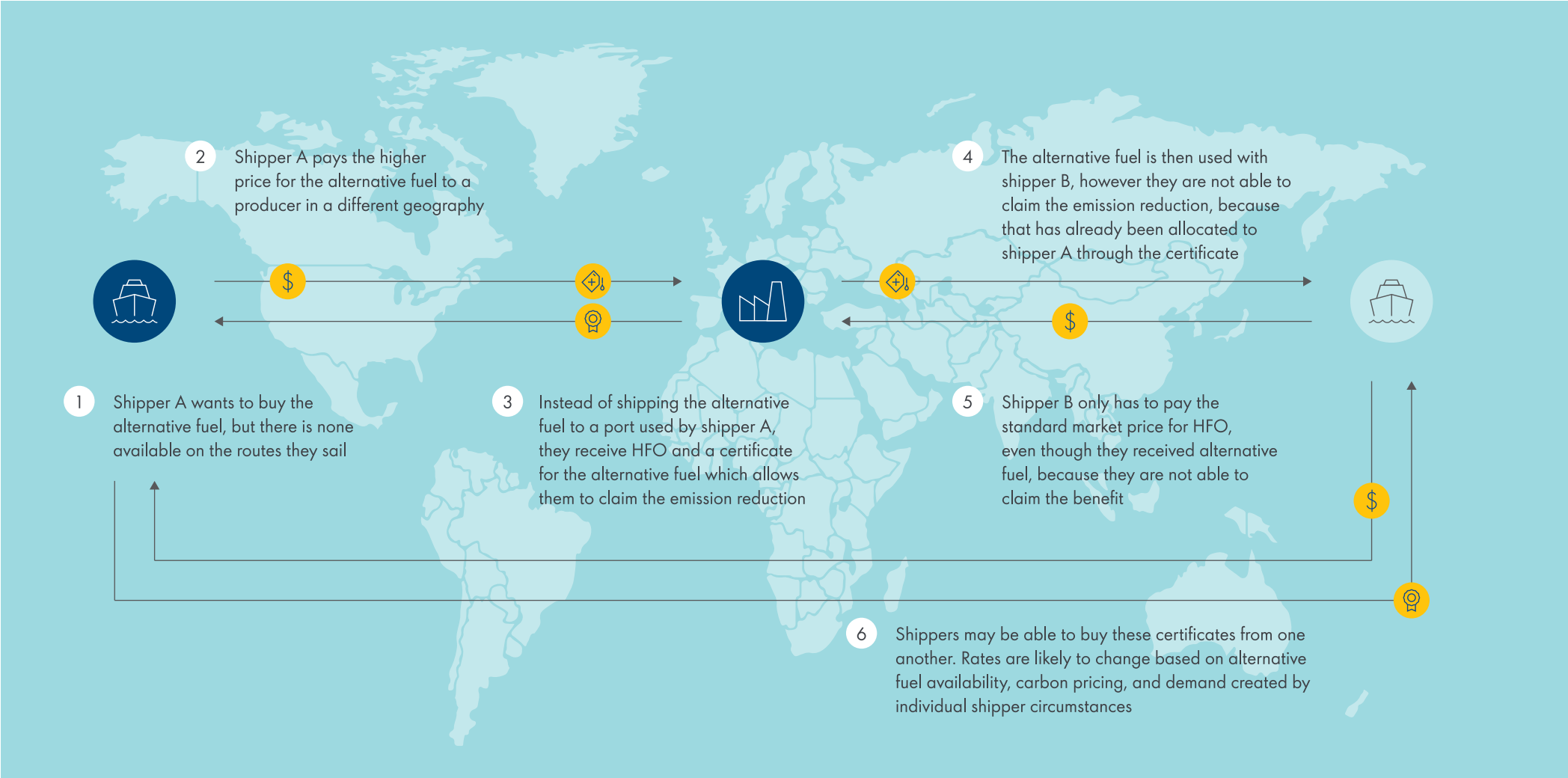

Exhibit 4: "Book & claim" illustration. While this approach requires clarity on who can claim what, some stakeholders argue this could indirectly support the adoption of alternative fuels, by making them more accessible and affordable.

Aggregating demand across many customers will be essential for delivering the scale required to unlock investment in supply. It is most effective in coalitions of customers with shared characteristics, as they offer a more compelling value proposition. One emerging example is in the container segment, with the launch of the Zero Emission Maritime Buyers Alliance (ZEMBA)[5], which focuses on accelerating the commercial deployment of zero-emissions shipping.

Across all these demand-related solutions, it is important to acknowledge that they require a realistic view on expected pricing of these fuels, and a willingness to commit on both the demand and supply sides.

Taking a segment-based approach

The deep-sea shipping sector cannot be treated as one homogeneous segment. The common characteristics of each segment must be identified, to allow prioritisation and tailoring of solutions, starting with the first movers.

The unique character of each shipping segment is now acknowledged by stakeholders across the board. Three segment approaches are outlined below, which highlight how **segment-specific characteristics** can influence which low-carbon solutions are most suitable.

"Shipping is like an orange: in order to help and understand, you need to look at it segment by segment"

Shipowner

[5] ZEMBA was formed to accelerate the commercial deployment of zero-emission shipping, enable economies of scale, and maximise cargo owners' collaborative emissions-reduction potential beyond what any one freight buyer could accomplish alone.

Container segment:
Analysis indicates that the container segment has seen the greatest increase in demand for green shipping solutions, due to multiple factors including its closeness to end customers, branded businesses (cargo), higher profit margins (relative to dry and wet bulk), ability to spread costs over many products and customers, and predictable routes that make implementation easier.

Bulk carrier segment:
This segment has also seen an increase in demand, albeit less pronounced, after two forward-looking mining/commodity companies initiated voluntary pledges. This demonstrates how individual actors that charter at scale can have a disproportionately large impact.

"Many shipping segments, such as containers, have realised a significant financial benefit over the past few years. Some of these are looking to redeploy that capital into supercharging their transition"

Financier

Short-sea and inland shipping:
These segments share the characteristics of shorter routes and proximity to charging infrastructure, lending themselves to electrification – a shift that is also supported by the role of local or port-led mandates for decarbonisation and near-shore air-quality improvements.

The majority of the 240 electric vessels operational today are ferries , but this is expected to extend to other sub-segments such as harbour tugs, crew transfer vessels and windfarm vessels. Electrification of these sub-segments could be further accelerated by mandates from local governments or port authorities, which would support the business case for these vessels to make the switch. However, the impact on sector emissions overall will be limited, given the size of these sub-segments.

Green finance

Since *All Hands on Deck 1.0*, financiers have started to play a more prominent role, recognising that decarbonising the sector will require large amounts of capital. Research indicates some signs of progress, through the advent of new regulatory instruments such as the EU Taxonomy's application to banking, coalitions such as the Poseidon Principles, and individual actions such as green bonds.

Some shipowners and NGOs argue that financiers can help create the right conditions for change in a more direct way. This could come through providing **preferential terms for green projects,** thereby prioritising access to capital for low-emission vessels and projects. However, a few stakeholders argue that **stricter lending standards** would be more effective, which could include requiring minimum asset or operational efficiency levels, or ensuring that borrowing supports specific technologies, such as dual-fuel-capable vessels. Financiers do acknowledge a tension around this – namely, the risk of leakage to other lending institutions with lower standards. Analysis suggests this risk could be decreasing, with one estimate suggesting over 65% of the global ship finance portfolio is sourced from banks that are signatories of the Poseidon Principles[6].

[6] Poseidon Principles Annual Disclosure Report, 2022

REGULATORY INCENTIVES

In 2020, *All Hands on Deck 1.0* noted sector-wide concerns regarding misalignment of global and local regulations, a lack of meaningful and binding emissions regulations, and the complex process to create a level playing field. As a result, **global regulatory alignment** was recommended as a theme to ensure a level playing field, reduce uncertainty and clarify timeframes around regulations.

Now, however, many stakeholders share the recognition that waiting for the IMO to apply such global regulations, including the potential implementation of a carbon levy, could delay the process, and see an opportunity to **advance local/regional regulation in the interim** to drive early progress, even if it involves some temporary complexity.

"Regulation is essential to drive significant change for this sector, else nothing will happen – if some regions want to lead, then they should, and as an industry we will manage"

Ship operator

Leveraging local/regional regulation for momentum

Effective local and regional regulation is now regarded as fundamental to advancing near-term material impact on total GHG emissions for the shipping sector, while anticipating that global regulation will need to quickly follow to achieve a level playing field towards a net-zero target.

The EU is seen as one region ideally placed to create a blueprint for effective regional regulation, a position that has been enhanced further with the announcement that the EU ETS will apply to shipping by 2024. Stakeholders are hopeful that once a regional initiative brings real change and effective decisions, it will instil the confidence and direction for the IMO to bridge and scale through global regulation. Exhibit 5 below highlights the current understanding of a range of regional regulations, although it is acknowledged that some targets may shift as part of the review process for those regulations yet to be formally adopted.

Selection of current and proposed policy

International Maritime Organization (IMO)	European Union (EU)	United States
Regulatory body that sets and aligns global shipping guidelines for shipping, including concerning GHG emissions **GHG targets** ▪ Overall target for global shipping set to 50% total emissions reduction vs 2008 levels by 2050 **EEDI / EEXI /CII** ▪ Mandated energy efficiency minima for aexisting and new vessels	**EU Emissions Trading System (EU ETS)** ▪ **Introduces the CO_2 "cap and trade" scheme** to shipping as of 2024 **Renewable Energy Directive (RED II / III)** ▪ Raises the overall EU target for renewable energy consumption by 2030 to 45% and supports the uptake of alternate fuels for transport e.g. biofuels or methanol **Fit for 55 - FuelEU Maritime** ▪ Mandates shipping companies to reduce carbon intensity by 6% in 2030 and 75% by 2050, for any vessels above 5,000 GT travelling to, from or at berth in EU ports	**Inflation Reduction Act (IRA)** ▪ Includes various incentives to produce low carbon hydrogen, hydrogen derivatives, clean energy and port decarbonisation equipment **Infrastructure Investment and Jobs Act (IIJA)** ▪ Includes significant investments in US port infrastructure

Exhibit 5: Selection of current and near-term policy

The other key European regulation is FuelEU Maritime, which applies to vessels of any flag above 5,000 GT that use ports in the EU. In addition to the proposed mandates around carbon intensity as shown in Exhibit 5, the regulation also focuses on a switch to low-carbon fuels through upcoming GHG-intensity limits by 2025 for shipowners from short-sea and inland segments, and mandates for container and passenger vessels in ports in excess of two hours to connect to onshore power supply or zero-emission technology from 2030.

The US is also increasing regulatory focus on the environmental agenda, including incentives around port infrastructure, but decarbonisation-specific regulations for shipping have yet to emerge.

A welcome trend in the domestic regulatory space is the **implementation of port-led incentives**, including at the ports of Rotterdam and Vancouver, where ships with a lower carbon footprint are offered a discount on their harbour dues. This could be an area of further momentum – for example, by leveraging port authorities' influence on policymaking to encourage sandboxes and bilateral agreements on carbon-intensity measures. Binding targets in such areas would help to provide the critical mass to start creating a level playing field.

Other regulatory developments and opportunities

The IMO mandates now in effect, such as EEXI, CII and EEDI, are already causing some shipowners to invest in efficiency and design measures, as well as commitments for dual-fuel-capable vessels. However, some challenges have been raised by shipowners across multiple segments, which the IMO is expected to consider. These include the claim that CII masks true carbon efficiency: as one shipowner describes: *"If a ship circles in the sea instead of unloading in the harbour, it will have a better CII rating."* Another suggests that there is *"an apparent disconnect between CII and absolute emissions"* and an oversimplification that has yet to recognise *"operational performance factors, including the vessel type, speed or fuel consumption."* Charterers and shipowners will therefore need to align around future CII improvements, to ensure both parties benefit from the outcome and **close potential loopholes**.

Beyond these steps, stakeholders are keen to see more clarity on topics such as the inclusion of well-to-wake (WtW) assessments of emissions as the basis for reduction targets, and/or the introduction of disincentives or penalties, which stakeholders believe would strengthen business cases for investment in decarbonisation. Creating a more level playing field from a regulatory perspective would also help to reduce the potential for geographical imbalances – e.g. charterers shifting less efficient tonnage to other regions and bringing their most efficient to regions with stricter requirements, such as the EU. In the absence of being able to provide clarity on fuel pathways, incentivising or mandating the resilience offered through **dual-fuel-capable vessels** may be another ideal aspect for focus.

Looking at the wider landscape of regulation in the sector, industry stakeholders were somewhat divided on which levers would result in the biggest decarbonisation impact. As shown in Exhibit 6, efficiency targets and carbon-intensity-reduction mandates were seen as more effective measures to affect change on fleet composition and performance, while market-based measures aimed at improving low-carbon-fuel economics also stood out.

Decarbonisation policy measures impact – industry view

Industry view on priority: High | Moderate | Limited

		Measure		
Stakeholder	**What gets regulated?**	**Mandate**	**Market-based**	**Subsidy**
Engine and ship manufacturers	Engines and ships	· Minimum efficiency standards		· R&D incentives
Ship owners and charterers	Fleet ownership	· Fleet carbon intensity reduction targets		· Scrapping benefits for HFO ships · Net-zero newbuilds and retrofit subsidy
	Fuel bought	· Carbon offsetting requirements	· Carbon-based fuel levies · Emission trading scheme	
	Route	· Route optimisation mandates · Sailing velocity cap		
	Freight price		· Environmental tax on freight	
			· Differentiated port fees and access	
Fuel providers	Fuel sold	· Biofuel blending mandates	· Fuel cost contracts for difference (CfD)	· Tax credits on alternative fuels
Ports and fuel providers	Infrastructure	· Scarce input allocation over sectors		· Direct funding for fuel production
		· Alternative fuel safety standards		
Financiers	Financing	· Mandatory ESG criteria in lending		
		· Minimum share of sustainable lending		

Exhibit 6: Industry view of policy measure impact

Some stakeholders acknowledged inherent tensions between what different regulatory mandates could require. For example, a push for a mandate on accelerating the change to dual-fuel-capable vessels without a corresponding increase in yard capacity would result in an unrealistic ambition, and limit the effectiveness and credibility of regulation, at least in the near-term. For this reason, it is vital that regulators consider the full domino effect when setting an appropriate mandate.

TECHNOLOGY ALIGNMENT

The growing maturity of alternative fuel technologies, and clarity on their development timescales, is driving greater clarity on the likely set of dominant fuel pathways. For example, it is increasingly clear that LNG is a viable solution that can support near-term shifts away from heavy fuel oil (HFO), and will remain a relevant pathway in the longer term via bio-LNG and synthetic LNG, which would enable vessel compatibility and make investments more resilient.

"Different fuels and affordability support different segments; however, there is now a crisper timeline of the dominant fuels mosaic: green methanol, LNG, then hydrogen derivatives beyond 2035"

Shipowner

Driving clarity on future pathways

Deeper understanding of fuel technologies and segment needs has been achieved, and should serve as the stepping-stone for decisions on a dominant set of viable fuel pathways. Increasing demonstration projects and investment in these would support first-mover decision-making for both fuel suppliers and shipowners, and should recognise the complementarity of different pathways.

In 2020, the prevailing view was that too many fuel technologies were being considered, with no clarity on how the preferred fuel(s) would be chosen. Furthermore, many were perceived to be technically limited, economically challenged, unproven, or unsafe. Many of these views were rooted in the recognition that HFO remains commercially attractive and available at scale.

The complex mosaic of fuels being considered in 2020 was a necessary step toward understanding the available options. Today, it is recognised that different pathways present options to different segments, and therefore will likely remain part of the future solution set, rather than convergence to a single technology choice. Exhibit 7 reflects this increasing clarity, illustrating a view across stakeholders on the outlook of different fuel technologies, albeit with some important limitations to be solved in order to scale.

Deep-sea shipping decarbonisation pathways

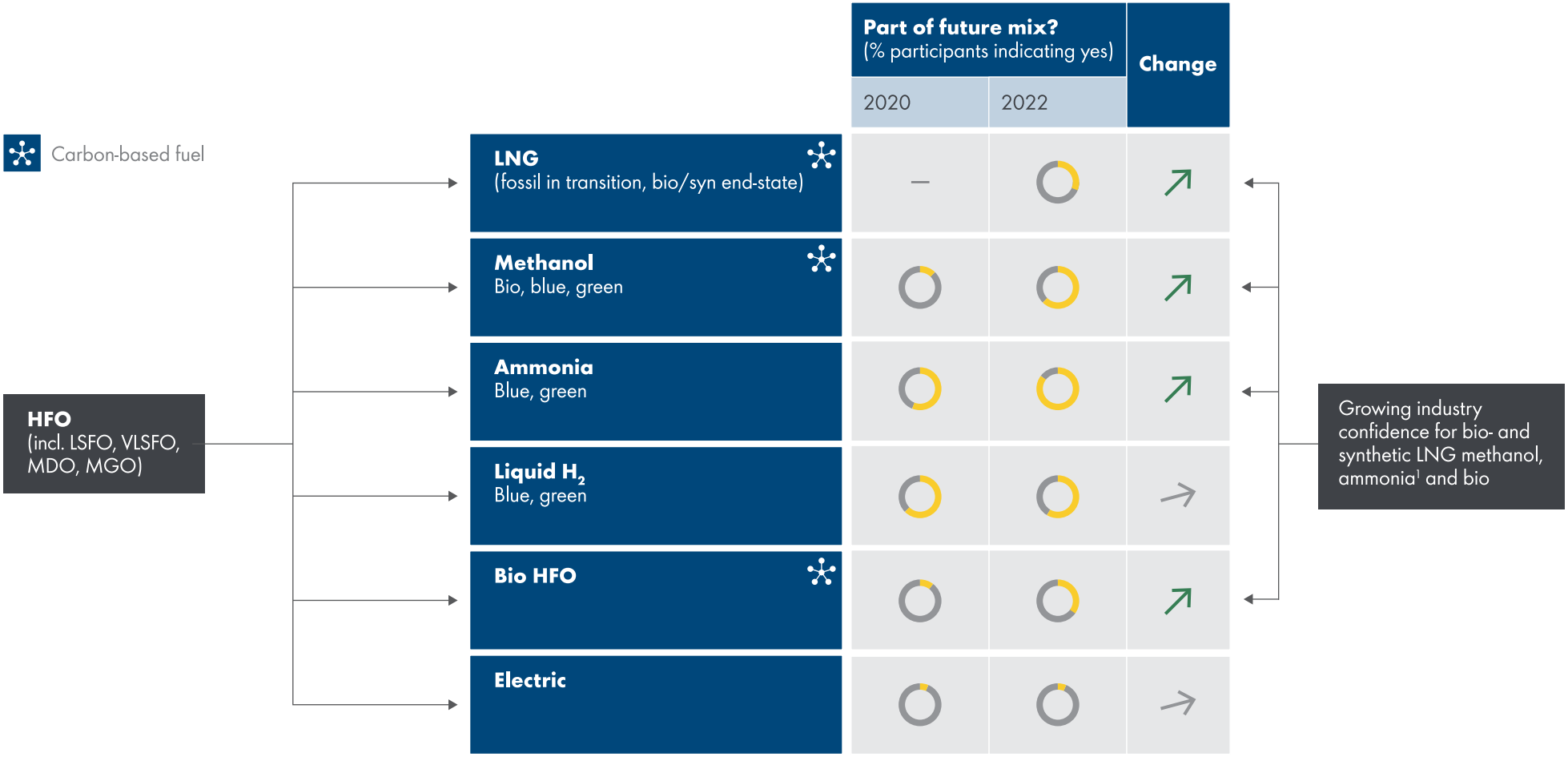

Exhibit 7: Deep-sea shipping decarbonisation pathways
Note: 1) Results for ammonia are conditional on if a solution is found for the significant toxicity challenge

Source: Expert interviews

This view acknowledges that near-term choices such as LNG and methanol preserve a broader set of options longer term, through bio or synthetic production methods. For example, the immediate benefits of LNG and methanol produced from renewable energy sources (where available) are now clearer, as evidenced by growth in the orderbook for LNG-capable vessels. Interviews and analysis of planned investments suggest that ~60% of new decarbonisation initiatives within shipping globally (beyond LNG-related investments) are focused on low-carbon methanol and ammonia, although most remain at an early stage.

Other hydrogen derivatives (including ammonia) could unlock more low-carbon fuel supply beyond 2035, but challenges will need to be overcome. For liquid hydrogen, the lack of existing infrastructure will be a barrier to scaling near-term. Safety concerns about ammonia's toxicity are widely acknowledged, and although sentiment around ammonia's increased role in the future energy mix has improved, mitigating the safety concerns will be essential, if it is to be used at scale.

"If we just have one fatal accident with ammonia, then it will stop being considered"

Financier

Despite the evolution of the fuel mosaic, **prioritising demonstrations and investments among the dominant set of fuel pathways** for specific vessels, routes and alternative fuel types could accelerate the rate of adoption.

Next to increasing technology maturity, a clear business case for transition towards alternative fuels will be a vital driver of change. Exhibit 8 illustrates the comparative cost of ownership for vessels using alternative fuels, compared with HFO. This outlook is illustrative, rather than intended to offer price predictions, as it relies on a few key assumptions. The first is that this analysis assumes an increasing carbon price on emissions over time, which has the effect of creating a "tipping point" effect that could result in a shift away from HFO. A second important note is that capital investments in bunkering infrastructure are excluded from this view, as these future costs still have a high level of uncertainty. As such, the implication of being able to reuse existing infrastructure for some alternative fuels is not incorporated.

"Changes can be pushed fast in this sector, which can drive changes in other hard-to-abate sectors"

NGO

One final note is that the availability of supply for the various alternative fuel technologies will also be impacted by demand from beyond the shipping sector. This could have both positive and negative impacts on supply availability and pricing. For example, the ability to share the cost burden of new supply infrastructure developments over multiple sectors beyond shipping could have positive impacts on prices for widely used fuels. On the other hand, the potential for supply limitations – particularly during the period where supply infrastructure for alternative fuels will still be expanding – creates the risk that some shipping segments will be unable to secure access at a viable price for their business models, compared with other sectors where there may be a higher willingness to pay. In addition, it will take time for learning effects and scale to lower fuel production costs.

There are different views on how best to ensure the shipping sector has sufficient access to the market when supply is scarce. One perspective is that those hard-to-abate sectors with very limited options to decarbonise should be prioritised for access to alternative fuels, to maximise global decarbonisation impacts, versus dedicating some supply for shipping. The other perspective raises the point that shipping needs to be recognised as a critical enabler of global trade, and a potential driver of change for other hard-to-abate sectors, which could support the case for ringfenced supply. **Alignment with energy hubs** could drive clear sector-aggregated demand signals, to help drive down costs and increase accessibility.

Cost of ownership comparison of alternative fuels ($/k tonne-mile)

	HFO			LNG			Synthetic LNG (green)			Synthetic methanol (green)			Ammonia (green)			Liquid hydrogen (green)		
Vessel CapEx	3.0	3.0	3.0	3.5	3.5	3.5	3.5	3.5	3.5	3.3	3.3	3.3	3.5	3.5	3.5	6.0	6.0	6.0
	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050
Vessel OpEx	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.5	0.5
	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050
Energy	1.9	1.6	1.3	1.0	1.0	0.9	2.7	2.0	1.2	2.4	1.7	1.1	2.3	1.7	1.1	2.5	1.8	1.1
	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050
CO_2 input							1.1	0.8	0.6	1.3	1.0	0.6						
							2030	2040	2050	2030	2040	2050						
CO_2 emissions	1.2	2.0	2.9	0.6	1.0	1.4												
	2030	2040	2050	2030	2040	2050												
Cost of end product	6.3	6.9	7.4	5.3	5.7	6.1	7.6	6.5	5.5	7.2	6.3	5.3	6.1	5.4	4.8	8.9	8.3	7.6
	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050	2030	2040	2050
Price premium				-15%	-17%	-18%	+20%	-5%	-16%	+15%	-9%	-29%	-4%	-21%	-35%	+42%	+22%	+4%

Exhibit 8: Cost of ownership for HFO and alternative fuels

Notes: Based asset lifetime of 50B tonne-miles and capex of $150M for HFO, $174M for LNG, $167M for methanol, $174M for ammonia and $300M for hydrogen; opex of 0.15% of capex, GJ / k tonne-miles of 0.148 oil for HFO, 0.102 for LNG, 0.12 hydrogen +0.002 electricity for synthetic LNG (incl liquefaction), 0.099 hydrogen +0.02 electricity for methanol, 0.94 hydrogen + 0.03 electricity for ammonia and 0.10 hydrogen +0.03 electricity for hydrogen (incl liquefaction; tank-to-wake CO_2 emissions in kg CO_2 / GJ of 0.0774 for HFO and 0.0562 for LNG; CO_2, feedstock need in kg CO_2 / k tonne-miles of 5.6 for synthetic LNG and 6.3 for methanol; CO_2 feedstock assumed from Direct Air Capture at $200/t by 2030, moving down to $100/t by 2050

Sources:
MMMC, Dechema, PBL, Netherlands Enterprise Agency, EverLoNG on-board carbon capture, Ali et al. - Liquefied synthetic methane from ambient CO_2 and renewable H_2O – A technoeconomic study, Deloitte analysis

ASSET REPLACEMENT

Fleet composition is an essential lever to tackle the decarbonisation challenge. This covers the emissions profile of the current fleet, and the rate at which new vessels are added and existing vessels are scrapped. This section takes a "working back from 2050" lens, to explore the available options and the role each can play to hit 2050 targets.

Adopting an integrated view on asset improvement

Fleet composition is crucial in tackling the decarbonisation challenge, and requires an integrated set of levers including efficiency measures, increased investment in dual-fuel-capable vessels, and faster conversion and increased modularity– as well as ensuring sufficient newbuild and repair-yard capacity to undertake these changes.

In 2020, the lack of clarity around future fuels and regulations meant that shipowners were reluctant to invest in new low-emission vessels. With a typical ship lifespan of approximately 30 years, and an average vessel age of 10 years[iii], such investment decisions remain a long way off for many owners. *All Hands on Deck 1.0* recommended two solutions: operational efficiency, including fuel/lubricant quality, digitalisation and just-in-time arrivals; and flexible and modular designs, to reduce the cost of retrofits.

Although there has been an increasing focus on new dual-fuel-capable ships in some segments, by working back from 2050, a deeper understanding of the different levers and the relationships between them can be gained.

These levers range from acting on **installation of available-now efficiency measures**, to **succeed aged vessels with alternative/dual-fuel vessels** based on a resilient fleet replacement mantra, and facilitating the timeliness of the transition by **forecasting adapting yard capacity accordingly.**

Exploring fleet emissions-reduction levers

The first fleet composition factor – commonly perceived as "low-hanging fruit" – refers to **efficiency measures.** These comprise a broad range of levers that include engine efficiency, vessel design, vessel operations and fleet operations (see Exhibit 9). Industry experts who were interviewed estimate that, combined, these could deliver at least 15–20% improved efficiency/ emissions-reduction. Improving the efficiency of the existing fleet presents the greatest opportunity for short-term emissions reduction given that every year approximately 3% of the existing fleet is replaced by newbuilds. This solution is made even more compelling by the fact that many efficiency-improvement measures are available now, and offer immediate savings potential for operators.

Many of these solutions existed in 2020; however, they were relatively untested, regulations such as EEXI had not been introduced yet, and there was less drive from customers to reduce supply-chain emissions. Changes to these factors over the past two years have resulted in a consequent increase in the focus and adoption of efficiency opportunities: "*If you don't invest in making ships more efficient, EEXI means you might wake up one morning with vessels that cannot trade.*" (Financiers and Legal).

Efficiency measures

Engine efficiency measures			• Powertrain maintenance and lubrication • Improved fuel combustion timing optimisation • Hybrid electric engines
Non-engine Efficiency Measures		**Vessel Design**	• Hull coating, air lubrication and cleaning • Sails • Propeller upgrades
		Vessel Operations	• RPM optimisation / slow steaming • Route optimisation • Just in time arrivals
		Fleet Operations	• Improved cargo space utilisation • Capacity sharing between vessels

Exhibit 9: Efficiency measure categorisation

Notes: This solutions set is not exhaustive.

The efficiency measures that have gained the most attention since 2020 include high-performing hull coatings; digital optimisation solutions applied to routing, arrivals and utilisation; and air lubrication. As an example, there are now more than 100 orders for air lubrication installations, with more shipowners committing to install the technology for future vessels[iv]. More-radical innovations such as wind propulsion have also been discussed, but despite wind power having the potential to offer significant efficiency gains, it is less tested, and also contingent on factors including the type of vessel and route.

In addition to installation on existing fleet, these measures should be applied as standard features on all newbuilds. The investment case can be rationalised when there is limited incremental downtime for installation, an increase in long-term savings, and a more attractive emission profile for customers.

To translate such measures into practical solutions, contract terms should be drawn on verifiable information about efficiency gains under different conditions. Such information should continue to be shared publicly, to support decision-making and enable shipowners to assess the relevant measures for their own fleet. Shipowners should also **reconfigure contract terms** with charterers, to ensure fair sharing of the costs and benefits.

Finally, although slow-steaming can have an immediate impact on emissions-reduction, it should not replace or preclude investment in efficient design or dual-fuel vessels, to avoid shipping capacity constraints that could arise due to a large proportion of vessels all travelling at lower speeds.

Resilient and timely fleet replacement

Flexible and modular designs continue to be important for all new vessels, but pace must be accelerated. Interviewees from *All Hands on Deck 1.0* noted a reluctance to invest in newbuilds, citing uncertainty around future technology pathways and regulation. Accelerating and **prioritising investment in dual-fuel-capable vessels** can resolve this challenge while providing resilience against risk and uncertainty. Although interest has increased in vessels that are dual-fuel ready or capable (LFO/LNG, HFO/methanol, LNG/ammonia), the exact definition of "ready" and "capable" has significant implications for the cost, timing and scale of retrofitting work.

Dual-fuel ready vessels – despite the term – are often a long way from being able to be run on the alternative fuel(s). Many vessels with space allowances and no hardware to manage alternative fuels are categorised as dual-fuel ready. Clarity around definitions, and increased transparency, would help reduce the risk of greenwashing and anticipate future retrofitting costs. Exhibit 10 indicates that demand for yard capacity is expected to increase towards 2040, and the cost of retrofitting can be expected to increase over time. This should serve to incentivise front-loading capital investment into dual-fuel vessels, and avoid future rate hikes or yard-capacity constraints.

"Many dual-fuel vessels today are just pushing the risk out. I don't want to end up in a situation where a regulation forces me to convert my vessel and there is no yard capacity to do it"

Shipowner/operator

Yard capacity

Even in the most ambitious scenario, net zero cannot be achieved without measures to **increase yard capacity** and materials production (green steel, precious metals, etc). The key issue is therefore how to accelerate early asset replacement while accommodating the associated yard capacity for new vessels and retrofits.

The option of early scrapping needs to be considered case by case, and take account of the available fleet capacity, economics, emissions impact and the environmental cost of scrapping itself. However, new regulations – as described in Regulatory incentives – are expected to provide clarity.

"We always hear that the sector needs demand signals – dual-fuel new ship orders are exactly that signal; companies want to change, so now is the time to make it happen"

NGO

Taking into account structural growth (i.e. increase in shipping trade volumes), retrofits and new vessel builds, analyses suggest that the demand for yard capacity by 2040 will be roughly twice the current capacity (85m DWT). This is equivalent to approximately 52,000 new vessels being built and 27,000 vessels being scrapped between 2022 and 2050.

"We need to address the existing asset base; it is too large, and the new ships are coming in at drop-feed rate"

Financier

Given the demand, focus will need to be given to material sourcing and recycling, and how to prioritise yard capacity. As yards will likely continue to be driven by profitability/utilisation, financiers and regulators have a key role to play to enable this. Yards that have made their own net zero commitments should also work more closely with early adopters to enable this.

Shipyard demand and capacity (million DWT)

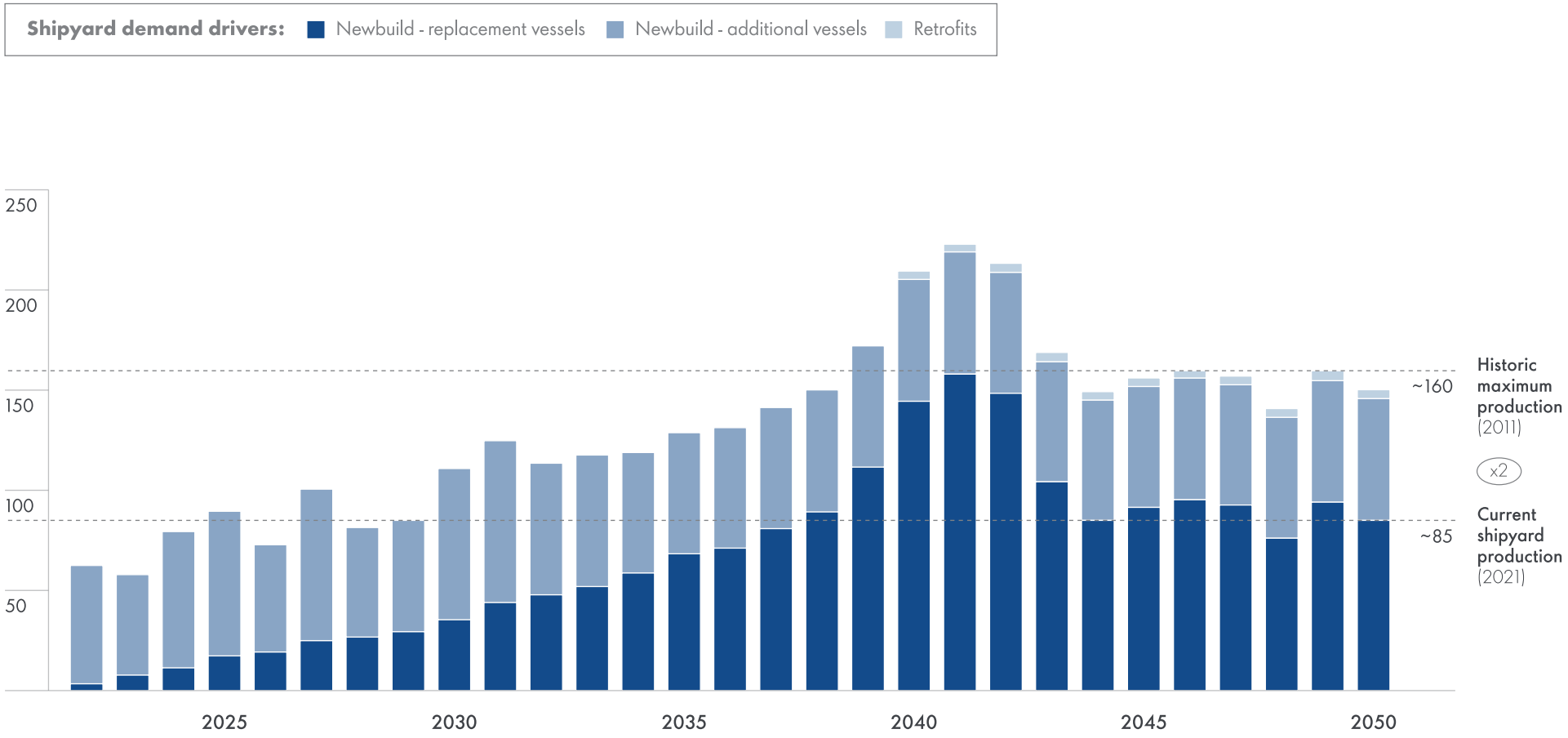

Exhibit 10: Shipyard demand and capacity (million DWT)

Note: Assuming retrofit shipyard capacity demand in line with retrofit cost

Sources: BRS Annual Review; IMO; IEA; Deloitte analysis

Impact of various measures on global fleet GHG emissions – illustrative scenario, MT CO_2 equivalent

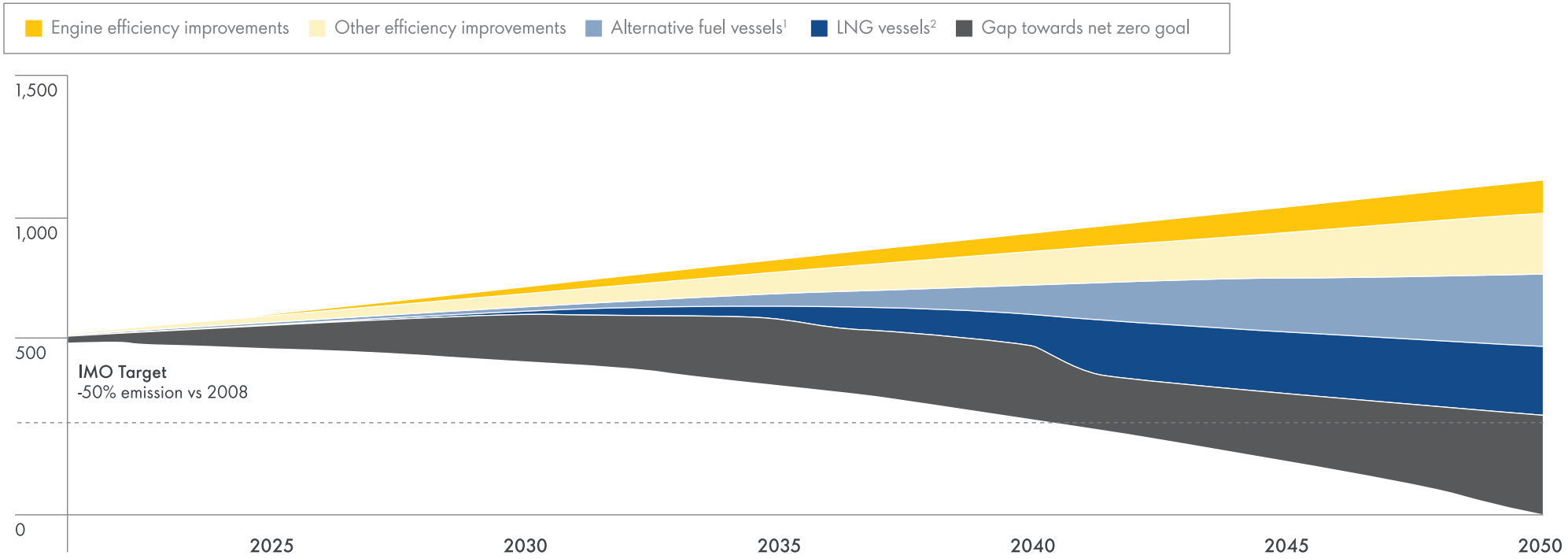

Exhibit 11: Global fleet GHG emission development (MT CO_2 equivalent) **Notes:** 1) Aggregate effect of multiple alternative fuel pathways (bio, blue and green methanol, blue and green ammonia, blue and green liquid hydrogen, others) 2) Fossil in transition, bio and synthetic in end state

Adopting an integrated view on impact

An integrated approach must be used to understand the emissions impact of efficiency improvements from available technologies, newbuilds and retrofits. Yard capacity must be understood too. Scenarios can be built to measure the impact of different combinations of these levers on decarbonisation targets. Exhibit 11 is one, indicative scenario of what this interplay could deliver, relative to the current IMO targets articulated for 2050 of a 50% reduction by 2050, and relative to 2008 levels.

In this scenario, four critical assumptions were made about how the global fleet could evolve (on a DWT basis).

- The "business as usual" level is driven by expected global trade growth to 2050 .
- Efficiency measures – both engine and non-engine – are then applied.
- The proportion of new dual-fuel ready and dual-fuel capable vessels is based on an outlook in which alternative fuels are increasingly available from 2030 onwards. Conventional LNG plays an early role, and is succeeded by synthetic LNG in the long run (2040+).
- To account for technical limitations and uncertainties, none of the fuels is considered completely GHG emission-free.

The outcomes of this scenario result in positive momentum towards IMO targets, but based on the assumptions used, the sector would not get there by 2050.

Sources: BRS Annual Review; IMO; IEA; Deloitte analysis

Impact of various measures including retrofits on global fleet GHG emissions – illustrative scenario, MT CO_2 equivalent

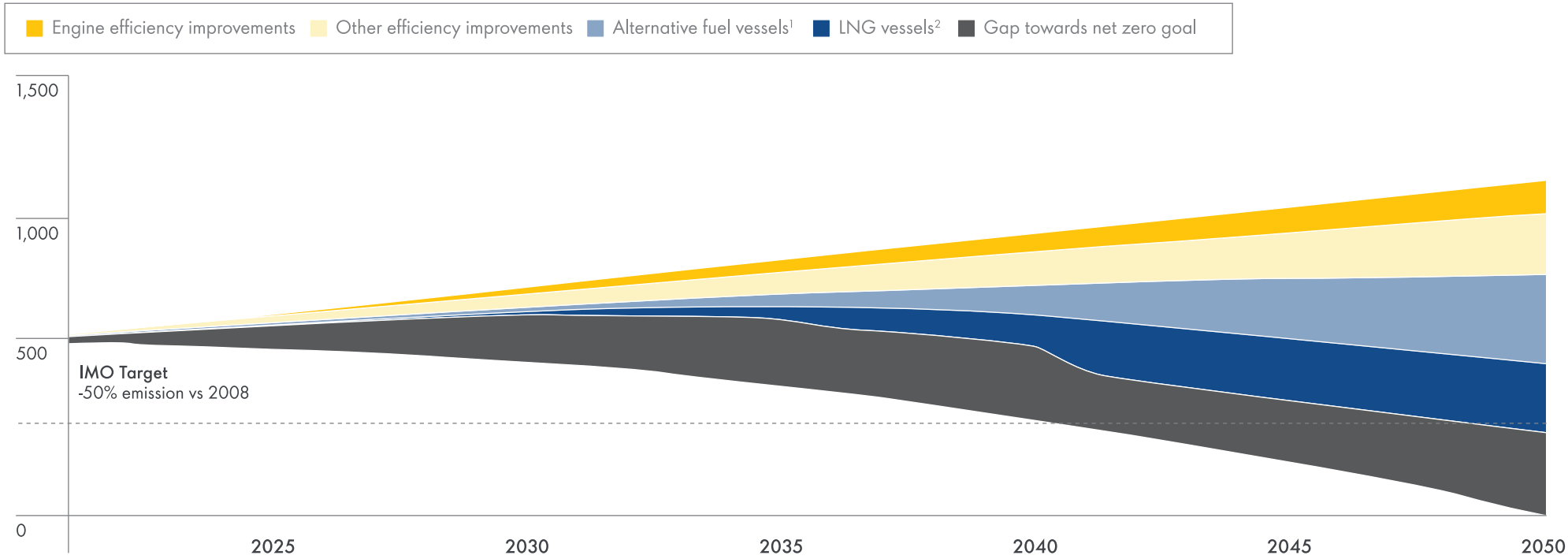

Exhibit 12: Global fleet GHG emission development – Including retrofits (MT CO_2 equivalent)

Notes: 1) Aggregate effect of multiple alternative fuel pathways (bio, blue and green methanol, blue and green ammonia, blue and green liquid hydrogen, others) 2) Fossil in transition, bio and synthetic in end state

A second scenario, Exhibit 12, assumes more aspirational steps towards fleet replacement, including retrofitting all dual-fuel ready ships to dual-fuel capable by 2050. Under this scenario, IMO targets could be achieved by 2050.

Cost analysis indicates the potential for HFO use to become more expensive over time, as carbon prices increase and expand[7]. This could provide the economic headroom to consider more aggressive measures explored in this section. HFO-only to dual-fuel-capable retrofits should be explored for existing vessels, as well as considering incentives for early scrapping of the older, high-emissions vessels in the fleet.

Although these are only two non-unique scenarios among many, it is clear that even the IMO 50% reduction targets will be difficult to achieve, unless leaders among actors along the value chain agree to radically increasing their commitment levels.

Sources: BRS Annual Review; IMO; IEA; Deloitte analysis

[7] See Exhibit 8 for more detailed discussion on the impact of carbon pricing on cost of ownership over time.

SOLUTIONS – IN BRIEF

INFRASTRUCTURE REPLACEMENT

There has been little progress in infrastructure replacement, with the exception of **green corridors** and complementary, **port-led incentives**, such as preferred port fee structures for lower-emission vessels, and more active involvement in investments to support low-carbon fuel infrastructure within port ecosystems.

"Green corridors is the latest buzzword – but what does it really mean for us to get started?"

Shipowner

Activating the first green corridors

Decarbonisation can be led by regional change, where a few specific actors collaborate to drive decarbonisation in a particular geography. Taking the steps to operationalise the first green corridors offers a concrete proof point that can be scaled for inter-regional impact.

The concept of green corridors has been extensively discussed in other publications; this report focuses on how to **operationalise the first green corridors** in practical terms.

A green corridor is characterised in this context as a geographically delineated route between two or more ports, in which several decarbonisation measures have been implemented across the supply chain. The specific measures to reduce emissions may vary, but are expected to evolve.

In prioritising which green corridors could be activated for greatest impact[8] to create a blueprint for the way forward, some key principles are identified:

- a route with high traffic volumes and high emissions[9];
- a shipping segment with clear demand for low-emission shipping solutions;
- a route with a limited number of actors for collaboration;
- ports with the capacity to facilitate bunkering infrastructure; and
- routes/ports that cover regions with a regulatory base addressing decarbonisation[10].

Exhibit 13 shows an illustrative example of the Singapore–Rotterdam corridor, and the tangible actions needed to establish a successful green corridor between the two. The container segment is an ideal focus, as it has the will to change, a (developing) positive business case, and the scale and ability to make a significant difference. This corridor is also one with high shipping volumes between two of the world's busiest ports, to maximise the impact on emissions. Emerging regional regulation along this corridor would also support developing a clear view on the role of regional agencies.

[8] Impact includes but not limited to: reduction in absolute emissions; reduction in carbon intensities; scale and aggregation of demand; centralisation of solutions in a fragmented sector; and serving as a blueprint for subsequent green corridors and regulations.
[9] A significant volume of global containerised trade is related to the main east-west routes.
[10] Regulatory base examples may include port-led incentives such as rate reductions for lower-emission vessels, or the Emissions Trading Scheme (ETS).

Operational green corridor user journey

Responsibility: ■ Lead role ■ Enabling role

	What needs to be true	Shipowners/ operators/charterers	Cargo owners	Regulators	Financiers	Ports	Fuel suppliers	Shipyards	Crew
1	Establish joint buyer's coalition and long-term contract groupings for the alternative fuel(s)	■					■		
2	Aggregate cargo owner demand via book and claim	■	■						
3	Invest, build and operate dual-fuel capable container vessel(s)	■			■			■	
4	Accommodate and invest in alternative fuel supply and bunkering capacity at both Ports				■	■	■		
5	Implement route and schedule optimisation for just-in time arrival and slow-steaming	■				■			
6	Provide regional regulatory approval for port infrastructure			■		■			
7	Provide preferential berthing rights for low emission vessels			■		■			
8	Train on- and off-board crew according to new operational and safety standards	■		■		■			■

Exhibit 13: Operational green corridor user journey – Singapore–Rotterdam example

CLARITY ON ROLES AND DECISION-MAKING

Coalition activity and pledges have increased since *All Hands on Deck 1.0*, highlighting the recognition across the sector that shared responsibility and collaboration are required. Examples include the 2021 formation of the Global Centre for Maritime Decarbonisation, which focuses on accelerating the deployment and adoption of low-carbon shipping technologies; the collaboration between Shell and MSC (Mediterranean Shipping Company) for decarbonising shipping technologies; and the intention to establish the green corridor between Singapore and Rotterdam[vi]. The enabling role of disclosure and transparency is gaining more focus – particularly through the Clean Cargo Partnership, as well as the Sea Cargo Charter, which establishes transparency requirements for signatories, in line with its four principles, to enable assessment of climate alignment, accountability, enforcement and transparency.

Some stakeholders argue that stronger collaborations are still needed for the setting of safety standards, charter party agreements and driving fair cost/benefit allocation of decarbonisation.

"It only takes one accident with ammonia or new fuels; one fatality, and the license to operate will fall overnight"

Shipowner

Several stakeholders also shared the view that specific topics require particular combinations of stakeholders playing critical roles, as illustrated in Exhibit 14. New solutions identified by stakeholders include **beginning the upskilling of the workforce** and **driving transparency on emissions performance** through various mechanisms, to improve customer choice, support better lending decisions, and improve knowledge-sharing.

Releasing Scope 1 and 2 emissions data into the public domain for instance, can serve as a catalyst to stimulate customer demand for green shipping, improve lending risk profiles, stimulate new sources of capital, and provide confidence for first movers to capture value from their decarbonisation investments. These would need to be complimented by the right mechanism to create a financial level playing field, which would support business cases for both borrowers and lenders.

Stakeholder responsibility matrix

Responsibility: ■ Lead role ■ Enabling role

Barriers		2.0 solution themes	Owners /operators	Charterers	Cargo owners	Regulators	Financiers	Ports	Fuel providers	Shipyards	Crew
Market and customer demand	1	Aggregate demand	■	■	■	■					
	2	Segment-based approach	■	■	■	■					
	3	Green finance				■	■				
Regulatory incentives	4	Regulation				■	■	■			
Technology alignment	5	Fuel landscape				■			■		
Asset replacement	6	Efficiency measures	■	■	■					■	■
	7	Resilient fleet replacement	■	■						■	
	8	Yard capacity								■	
Infrastructure replacement	9	Hubs				■			■		
	10	Green corridors	■	■	■	■	■	■	■		
Clarity on roles and decision-making	11	Health, safety and environment	■	■		■					■
	12	Transparency	■			■		■	■	■	■

Exhibit 14: : Stakeholder responsibility matrix

SHELL RESPONSE

SHELL RESPONSE

The contributions and reflections shared in this refresher report provide valuable guidance from industry on the prevailing headwinds and tailwinds influencing the pace of change. We will continue to use these insights to test our own assumptions as we work closely with our customers in search of a decarbonised future for the whole shipping ecosystem.

Our action:
Memorandums of understanding (MoU) signed with CMA CGM, Hapag-Lloyd, Kongsberg Digital and others to collaborate on decarbonisation.

While the report shows that pockets of progress exist, with early signs of market and customer demand alongside promising shifts for regulatory incentives, shipping is simply not moving quickly enough. And when we look back at the 12 solutions identified in All Hands on Deck 1.0, it is clear that only limited progress has been made. Cautious optimism persists though, and progress is in reach, with a growing commitment and understanding from those within shipping on the changing roles we have to play during the energy transition.

Market and customer demand

Shipping will compete with other sectors for the supply of low-carbon fuels – it will not drive the demand for fuels in isolation. Fuel suppliers will therefore pursue aggregated demand from multiple sectors as part of the broader energy transition – providing greater assurance and a stronger business case for the scale of investment required. While uncertainty remains, however, demand signals will need to be significant and long-term. What's more, cost remains a barrier given that low-carbon fuel options remain significantly more expensive than conventional marine fuels.

Our action:
Acquired Nature Energy – the largest renewable natural gas (RNG) producer in Europe – to grow Shell's low-carbon offerings to customers across multiple sectors.

Though greater clarity is slowly forming, even closer collaboration between shipowners and fuel suppliers will be needed in order to: understand the challenges; determine which fuels suit which routes; and to establish a shared business case.

Regulatory incentives

Shipping is regulatory-driven and as such, this report has recognised global regulatory alignment as a key solution to help drive decarbonisation in the sector. Shell welcomes the great strides made by the EU in introducing a basket of measures with FuelEU Maritime and EU ETS, which will support the much-needed development of a robust

regulatory framework. However, there is clearly more work to be done; namely, a global policy regime is required that targets NZE by 2050 to drive decarbonisation and prevent distortion and fragmented regulatory requirements.

Our action:
From future fuels to electrification, from energy efficiency solutions to building industry collaborations, Shell is using its scale and expertise to develop pathways that will help increase the appetite for more ambitious policy regimes by showing that a net-zero future for shipping is possible.

We look to the IMO's 2023 strategy review to set the pace of change and raise the ambition level to NZE by 2050, supported by ambitious and robust interim targets for 2030 and 2040 that can kick-start action from first movers. Ultimately, only a global framework will level the playing field and provide sufficient clarity on the business case for investment. The later this progress is made, the more aggressive and costly the transition will need to be.

Fuel & technology alignment

Our view that a "poly-fuel" scenario or fuel mosaic is needed to replace today's almost complete dominance of fuel oil has not changed, with liquid biofuels, LNG, methanol and hydrogen all with potential to support shipping decarbonisation. Progress has been made in understanding these different fuel options, with shifting signposts since our last report:

- **Biofuels,** including fatty acid methyl ester (FAME): Increased demand observed but not enough sustainable supply to meet cross-sectoral competition.
- **LNG**: Mature technology and an increasing bunkering network have helped cement its position as the leading alternative fuel, with bio and synthetic LNG offering a long-term pathway.

Our action:
- Performed first bio-LNG bunkering in Rotterdam with CMA CGM, and our LNG bunkering infrastructure now covers 12 countries and 17 bunkering locations.
- Signed long-term LNG supply deals with Anglo American, CMA CGM, Hapag-Lloyd and ZIM.
- Methane measurement campaign on Shell's fleet and R&D of slip abatement technologies.

- **Ammonia**: Safety concerns persist regarding toxicity mitigation and with limited development of propulsion technology. Until advances are made that can address these concerns, Shell does not believe ammonia will be a viable bunkering fuel for shipping.
- **Methanol**: Both positives (ease of implementation) and negatives (storage requirements) exist, and though interest is rising, more work is required to scale significantly and balance supply and demand for low-carbon methanol.
- **Hydrogen**: Remains an important building block for long-term decarbonisation across several sectors, including shipping. A key challenge will be establishing scale and new supply chains, though R&D and pilot projects show promise.

Our action:

- Exploring fuel cell technologies with proton-exchange membrane (PEM) trials to start in 2023 and solid oxide fuel cells (SOFC) to be tested on a Shell-chartered vessel in 2025.
- Participating in the HyEkoTank project to retrofit a fuel cell and hydrogen storage system on a tanker vessel and the HySTRA project to help develop a global hydrogen supply chain.
- Maintaining a primary focus on safety - developing the "Handbook for Hydrogen-fuelled Vessels" as a project partner with DNV and major industry stakeholders.

Despite developments, there has not been a breakthrough moment or significant convergence yet, so we will continue to explore the variety of fuels, technologies and solutions that can help decarbonise shipping.

Asset replacement

As a fuel supplier, we welcome the progress of early demand signals with the growing orderbook for dual-fuel vessels. Meanwhile, increasing signs of voluntary demand within the container segment help maintain its leading position, as the recently announced buyers' alliance ZEMBA shows. The business case to invest in dedicated supply to the marine sector, however, remains challenging.

Our action:
Successfully delivered more than 1,000 safe, ship-to-ship LNG bunkering operations to date.

Next steps

The shipping industry is under no illusion of the scale of the challenge ahead. At Shell, however, we are proud of the progress we have made with our customers and partners since All Hands on Deck 1.0.

In consideration of the recommendations put forward in this industry report, we see continued collaboration as remaining integral to the success of shipping's energy transition. In fact, this interconnectivity across the shipping value chain – between fuel suppliers, shipowners, class societies, financiers, ports and regulators – could not be at a more critical juncture.

Our action:
MoUs signed with MSC, the ports of Galveston, Houston, Singapore and others to collaborate on decarbonisation.

As we look ahead, shipowners and fuel suppliers will need to work in close partnership on: the availability of their preferred fuel pathways; the scaling and roll out of technology solutions; and shared carbon reduction targets over the next 5-10 years. With a recognition that, while the green premium in shipping could be mitigated through carbon pricing, the price differential between fossil and alternative fuels will likely remain to some degree over the long term.

Despite limited progress in infrastructure replacement, it is encouraging to see the expansion of the early stages of green corridor initiatives, which Shell believes hold significant potential to reduce the total cost of ownership to support demand aggregation for low and zero-carbon solutions. These initiatives provide an opportunity for first movers to pave the way for fast followers, as proof that progress can be made.

Our action:
Joined the Rotterdam to Singapore Green and Digital Corridor to test the ecosystem and support the development of a commercially viable framework.

Ultimately, the shipping value chain needs clear guidance on book & claim, well-to-wake GHG emissions and reduction targets. However, as the industry still works to establish clarity over a clear path ahead, this should not obscure the viable fuel and technology pathways available today for deep-sea shipping. Efficiency (energy and operational efficiencies) is a vital lever to reduce fuel consumption and associated emissions, and should be the first priority for shipowners. We should then reduce emissions through the viable lower-carbon fuels available at scale today, this includes biofuels as a drop-in solution alongside the role of LNG, while the industry works towards future hydrogen-derived fuels.

Our action:
We partner with customers to understand their needs, and then customise solutions that are practical for today, to help meet their long-term decarbonisation goals.

In closing, this report has often referred to signals and how they can help to steer the shipping value chain through uncertainty as it begins to make waves of progress towards a decarbonised future. However, the strongest signal outlined across the preceding pages is that, with only pockets of progress having been made since All Hands on Deck 1.0, there is a clear need for regulators to help increase the pace of change and incentivise action with effective regulation and an ambitious global policy regime. And equally, there is a clear need to prioritise end-to-end collaboration throughout this change. After all, only by working together can shipping effectively develop and deploy the solutions required to support a net-zero future.

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This report contains forward-looking statements (within the meaning of the U.S. Private Securities Litigation Reform Act of 1995) concerning the financial condition, results of operations and businesses of Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management's current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Shell to market risks and statements expressing management's expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as "aim", "ambition", ''anticipate'', ''believe'', ''could'', ''estimate'', ''expect'', ''goals'', ''intend'', ''may'', "milestones", ''objectives'', ''outlook'', ''plan'', ''probably'', ''project'', ''risks'', "schedule", ''seek'', ''should'', ''target'', ''will'' and similar terms and phrases.

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Shell's net carbon intensity

Also, in this report we may refer to Shell's "Net Carbon Intensity", which include Shell's carbon emissions from the production of our energy products, our suppliers' carbon emissions in supplying energy for that production and our customers' carbon emissions associated with their use of the energy products we sell. Shell only controls its own emissions. The use of the term Shell's "Net Carbon Intensity" is for convenience only and not intended to suggest these emissions are those of Shell plc or its subsidiaries.

Shell's net-Zero Emissions Target

Shell's operating plan, outlook and budgets are forecasted for a ten-year period and are updated every year. They reflect the current economic environment and what we can reasonably expect to see over the next ten years. Accordingly, they reflect our Scope 1, Scope 2 and Net Carbon Intensity (NCI) targets over the next ten years. However, Shell's operating plans cannot reflect our 2050 net-zero emissions target and 2035 NCI target, as these targets are currently outside our planning period. In the future, as society moves towards net-zero emissions, we expect Shell's operating plans to reflect this movement. However, if society is not net zero in 2050, as of today, there would be significant risk that Shell may not meet this target.

Forward Looking Non-GAAP measures

This report may contain certain forward-looking non-GAAP measures such as cash capital expenditure and divestments. We are unable to provide a reconciliation of these forward-looking Non-GAAP measures to the most comparable GAAP financial measures because certain information needed to reconcile those Non-GAAP measures to the most comparable GAAP financial measures is dependent on future events some of which are outside the control of Shell, such as oil and gas prices, interest rates and exchange rates. Moreover, estimating such GAAP measures with the required precision necessary to provide a meaningful reconciliation is extremely difficult and could not be accomplished without unreasonable effort. Non-GAAP measures in respect of future periods which cannot be reconciled to the most comparable GAAP financial measure are calculated in a manner which is consistent with the accounting policies applied in Shell plc's consolidated financial statements.

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Endnotes

[i] Clarksons (2023) "World fleet monitor", accessed 14 Mar 2023.
[ii] DNV Veracity Alternative Fuel Insights platform, accessed 2022.
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