Decarbonising Shipping:

ALL HANDS ON DECK

Industry Perspectives

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CONTENTS

FOREWORD

The world today is going through extraordinary change. For the energy industry, there are great challenges, from the longer-term effects of climate change to the immediate shock and uncertainty of the global pandemic. But if there are risks, there are opportunities too – as long as industries work with wider society to take urgent action.

Huibert Vigeveno
Downstream Director

The shipping sector is vital to the global economy and never more so than in recent months, when it kept up the supply of essential goods. It accounts for about 80% of the volume of global trade. If the world is to achieve the goals of the Paris Agreement to tackle climate change, it is crucial that sectors such as shipping cut their carbon emissions and do so fast.

The International Maritime Organization has set the ambition of reducing the shipping industry's greenhouse-gas emissions by at least 50% by 2050, and reducing the carbon intensity of emissions by 40% by 2030 and 70% by 2050, compared to 2008 levels. The scale of the challenge means that any solution needs to be comprehensive and involve every aspect of shipping. As well as cleaner fuels, it should focus on factors such as regulation, government action and societal shifts. No sector can do this alone. This report is driven both by urgency and the need for collaboration.

Based on more than 80 interviews across the industry, from CEOs to financiers and ship builders, the report identifies practical measures to cut carbon emissions. It asks questions such as: what role will the world's major ports play? How do you adapt assets with a 20-year lifespan? How do you transform a sector so dependent on heavy fuels? The answers are pragmatic, they show a will to work together and they are optimistic.

The report identifies 12 possible solutions. Operational efficiency is crucial, while others include co-ordinating industry commitments, increasing research and development across sectors, and expanding the infrastructure to supply and store cleaner fuels.

As an operator of a large fleet of tankers and a supplier of marine fuels, lubricants and services, Shell has a stake in the future of shipping. We have announced our own ambition to be a net-zero emissions energy business by 2050 or sooner, in step with society, and our shipping operations must be part of this. We continue to work with our customers on alternate fuels such as biofuels, liquefied natural gas and hydrogen.

As the head of Downstream, which is responsible for shipping, I am buoyed by the optimism of this report and I relish the prospect of working with customers, partners, suppliers and wider society to achieve lasting change.

INTRODUCTION

Shipping has a dual challenge. It must meet the demand of the world's growing population, with more ships and more voyages, while radically reducing its emissions. Achieving both will require a transformation, but there are lessons we can take from experiences in the industry to help us.

Grahaeme Henderson
Vice President
Shipping & Maritime

In Shell Shipping & Maritime, a key focus area has been on improving safety across the industry. The aim is a zero-incident industry where every seafarer returns home safely. This has not been easy and there is more work to do, but huge progress has been made.

To improve shipping's safety performance, the industry had to first work together to understand the problem; what are the underlying factors that prevent us being safer? And then, armed with that information, take collective action.

Our objective with this report is to do the same for decarbonisation; we want to catalyse action by creating a common understanding of barriers the industry faces and the solutions that will be most effective.

I have been extraordinarily encouraged by the response. Despite being conducted between January and June 2020, a period that coincided with the COVID-19 pandemic across the world, leaders were keen to participate and were engaged in their responses. This is a testament to the industry's commitment to tackle the challenge, and I would like to thank them all for their time and contributions.

With this research, the industry has given its view, and now we must all get to work to move from deadlock to decarbonisation. At Shell, we will continue working with our customers as they adopt new fuels and technologies that help them reduce emissions. We will develop the business case for investment in solutions which reduce emissions today as quickly as possible, and we will continue to collaborate and contribute in research which accelerates progress to zero emission fuels.

What is evident is that, despite the complexity, the industry sees that viable net-zero carbon shipping is achievable. It cannot be just one company or sector, but with all hands on deck, we can make it happen together.

Report Objectives

This research reflects the perspectives of 82 senior shipping leaders that represent almost all segments of the shipping industry (see Exhibit 1). It was developed with the following objectives:

- **Take a Comprehensive View**: Most existing shipping decarbonisation studies focus on specific challenges in isolation, such as potential future fuels. Given the scale of the decarbonisation challenge, a more thorough framing is needed that also includes economic, regulatory and organisational factors.
- **Reflect the Voice of the Industry**: Ultimately, those within the industry will together play the most instrumental role in decarbonising shipping. Accordingly, it is essential to collect, understand and build on their views as we seek to identify solutions that drive progress.
- **Clarify a Practical Way Forward**: Shipping leaders who participated in this research looked beyond the challenges of today to explore the solutions of tomorrow. Together they converged on a set of actions and a roadmap that can help overcome the inertia that many see in the sector.

The primary motive of publishing this research is to highlight those insights shared with us through interviews, workshops and desk research; not the views of Shell or Deloitte. All engagements with participants were conducted in a manner that respects competition law boundaries.

01 **Research Participants**

82 shipping leaders in **74** interviews and **10 hours** of collaborative workshops (30 participants)

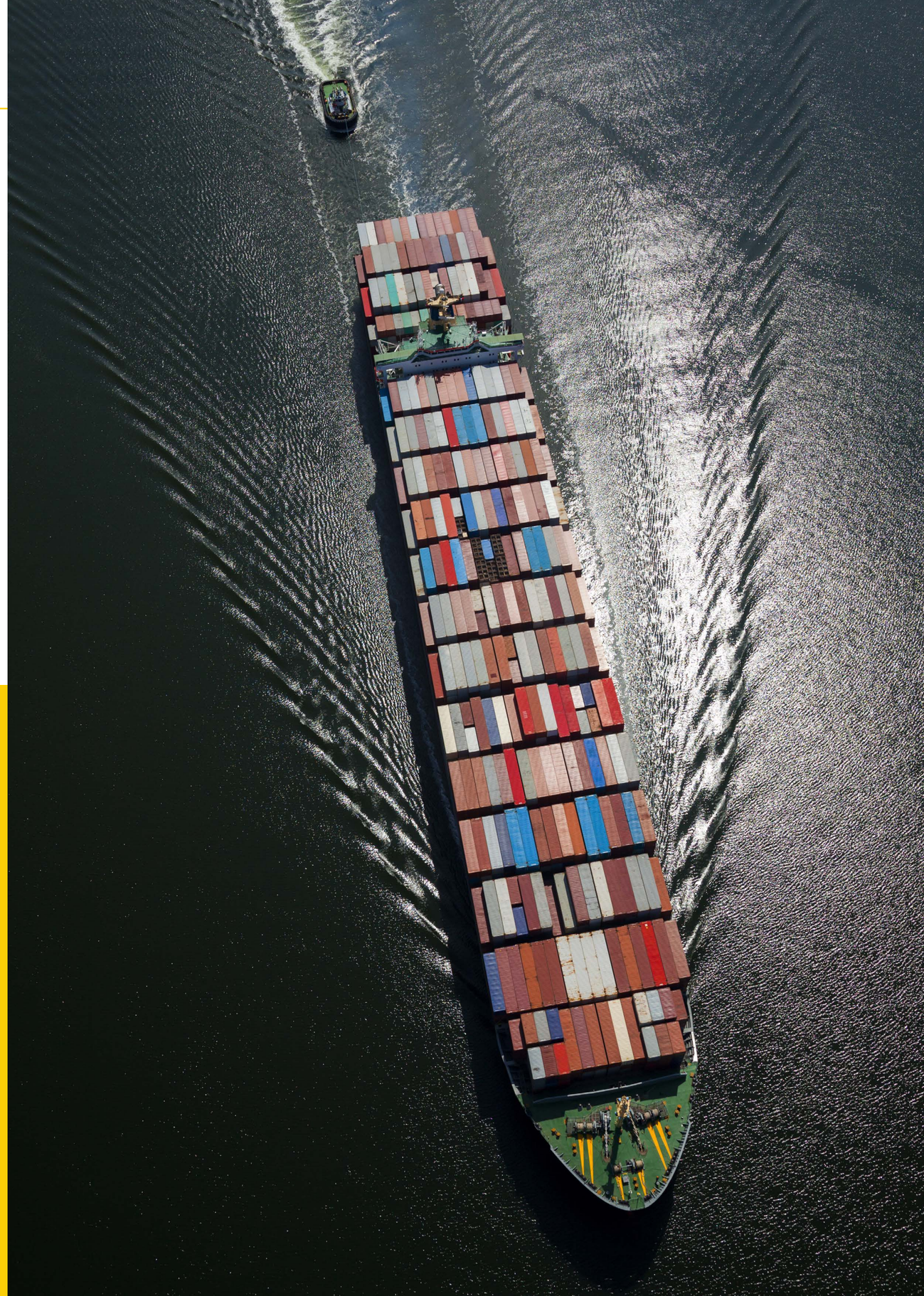
33 CEOs	**32** Vice Presidents, Unit Heads and Directors	**17** General Managers, Managers and Specialists

4 of top **10** bulk and tanker	**4** of top **10** container	**3** of top **5** cruise	**3** of top **5** ship financiers	**2** of top **5** shipbuilders	**8** ports, incl. 1 of top 10

52 Europe, Middle East & Africa	**13** North & South America	**17** Asia & Pacific

32 Ship owner and operators	**15** Charterers and shipping customers	**8** Port authorities and operators	**10** Technology providers and ship builders	**11** Regulators, classification societies and academia	**6** Financiers and investors

Note: Regions indicate organisations' headquarters. Most organisations involved operate globally



EXECUTIVE SUMMARY

Shipping is the backbone of the global economy. It is by far the most efficient mode of freight transport[1] and moves approximately 80% of world trade volumes[2]. Simply put, the scale of global development seen over the last century would not have been possible without shipping playing a key role. However, as the global economy grows, so too will carbon emissions from shipping.

The shipping industry recognises the importance of decarbonising to help reach the goals of the Paris Agreement, and it has already started to mobilise. The International Maritime Organization (IMO) has announced an ambition to at least halve international shipping greenhouse gas (GHG) emissions by 2050, while reducing CO_2 emissions intensity by at least 40% by 2030, and pursuing efforts towards 70% by 2050, relative to a 2008 baseline[3]. These ambitions send a signal to the industry that change is coming, and all parties involved need to prepare.

Conversations with over 80 leaders across the shipping industry highlight the daunting challenge of shipping decarbonisation. It will be difficult, and shipping leaders feel that uncertainty about where to begin has created what one interviewee described as a *"deadlock"*. At the same time, many of those interviewed have a positive outlook. As one CEO stated, *"decarbonisation is one of the biggest challenges we face as an industry. However, we have never been more united around a problem, and there is optimism that we can make it happen."*

Growing pressure to reduce carbon emissions across the global economy has opened new opportunities. The industry has already started uniting, forming coalitions, launching pilot projects and exploring new ways to lower shipping emissions. A new paradigm is emerging and there is an opportunity to accelerate change through a set of manageable, practical solutions that will break the deadlock and unlock progress. Making this happen requires collaboration within the shipping industry itself, across the broader shipping ecosystem and with other sectors.

The Deadlock

Shipping is a capital-intensive industry characterised by large, long-life assets, thin margins and a high-dependence on a global supply of energy-dense fuels. These characteristics make decarbonisation complex and expensive, with one study estimating the total cost at $1.65 trillion by 2050[4]. Consequently, decarbonising the industry needs sufficient regulatory and market incentives and an abundant supply of low or zero-emission fuels.

"Too many alternatives and not one viable solution"

Shipping Operator

The lack of a global regulatory framework and limited customer demand for lower-emission shipping are significant barriers to activate much needed industry investment. Electric vessels may be an option for inland and short-sea routes,

but for deep-sea shipping – which accounts for around 85% of emissions[5] – there is currently no viable alternative fuel that makes it possible to reach the IMO's 2050 ambition. The industry is currently exploring several alternative fuels – including hydrogen, ammonia, methanol and biofuels – but shipping leaders say that they all have commercial and technical limitations. Costs are significantly higher than today's dominant shipping fuel and most potential alternatives have lower energy density, extensive storage and safety requirements and limited infrastructure. New technologies such as propulsion systems and storage tanks need to be developed to resolve these barriers and enough fuel production capacity is needed to meet the 3.3 petawatt hours (12 exajoules[6]) annual energy demand from shipping. To put that figure in perspective, energy required to power shipping for one year would be enough to power New York City for over 60 years[7].

This is the "deadlock". However, there is a growing view that now is the time to act if the industry is to meet the IMO's ambition. To reach it, many shipping leaders believe that the first net-zero ships will need to start entering the global fleet by around 2030 – and that creates a real sense of urgency.

"2030 is tomorrow, 2050 is one ship lifetime away"

Shipping Technology Provider

A New Paradigm

Perspectives regarding decarbonisation are evolving and opening opportunities that were not available a few years ago. Social pressure to reduce emissions is intensifying. Governments, investors and businesses are making commitments and starting to act. Notably, extensive levels of sustainable investments are included in stimulus packages announced in relation to the COVID-19 global pandemic[8]. Technologies are continually evolving and creating new potential avenues to lower emissions. As one CEO told us, *"the situation is not all doom and gloom."*

The leaders of the shipping industry acknowledge this new paradigm. Over 90% of interviewees involved in this research highlighted decarbonisation as important or a top priority for their organisations, noting its importance has increased significantly over the past 18 months. This sentiment reflects increasing action as new coalitions and pilot projects have been established to address barriers to decarbonisation. Even with the impacts of the COVID-19 pandemic in the first half of 2020, almost all shipping leaders that we interviewed saw the resulting economic disruption as an opportunity to accelerate progress.

"The discussion has finally become serious"

Shipping Owner

Most shipping leaders believe that a novel decarbonisation approach is needed and should be based on three main principles:

- Adopt an ecosystem perspective
- Think big, start small, scale fast
- Focus on behaviours and triggers

The first, *"adopt an ecosystem perspective"* recognises that the challenge is too large for any one organisation alone. It calls for a holistic and integrated perspective, with each industry stakeholder having a role to play and a set of activities to focus on. The second, *"think big, start small, scale fast,"* is based on the premise that small, incremental steps are the best way to solve a challenge of such magnitude. The third principle, *"focus on behaviours and triggers,"* underscores the importance of supporting solutions with the right incentives. Incentives should be based on an understanding of what will motivate stakeholders across the value chain to take a long-term perspective.

"Real commitment from customers would go a long way to unlock investment"

Shipping Owner & Operator

Based on these three principles, this report focuses on 12 solutions, or recommendations for action, that emerged from research, interviews and workshops. These solutions streamline what some view as an insurmountable problem into several manageable phases that address specific barriers and enable the industry to have the first net-zero ships in the water by around 2030. The first five solutions aim to *"unlock"* progress in the next two to three years.

1. **Scale-up Customer Demand**: Create scale in demand for low or zero-emission shipping through charterers' and customers' commitments that include long-term contracts and green procurement criteria. Natural candidates to lead this solution are state-owned and publicly listed companies with proximity to end consumers (e.g. containers, food bulk), and others with ambitious scope 2 and 3 net carbon footprint commitments[9].

2. **Global Regulatory Alignment**: Create a level playing field globally and reduce uncertainty regarding regulations and timeframes. New IMO guidelines due in 2023 should provide clarity and should be aligned with leading local and regional regulatory bodies (eg. EU, China and US). Short-term regulatory incentives should also be considered.

3. **Cross-sector Research and Development**: Intensify partnerships to develop zero or low-emission fuels through joint research and development (R&D) across shipping, other harder-to-abate sectors and the energy industry. Create a much larger pool of capital and expertise to evolve new technologies and increase the likelihood that production and transportation infrastructure will be available once future fuels are commercially viable.

4. **Scale-up Controlled Pilot Projects**: Increase R&D effectiveness by running end-to-end green pilot projects involving customers, charterers, operators, owners and ports on specific routes and vessel types. Operators that follow a predetermined schedule, such as container ships especially on shorter and busier routes, are likely candidates for pilot projects.

5. **Coordinated Industry Commitments**: Increase the reach of existing initiatives – such as the Getting to Zero Coalition, the Clean Cargo Working Group and others – by consolidating objectives and strengthening the coordination of various concurrent workstreams. A body with a specific mandate, formed with dues from the industry, could accelerate the shift from ideas to action and help break the deadlock.

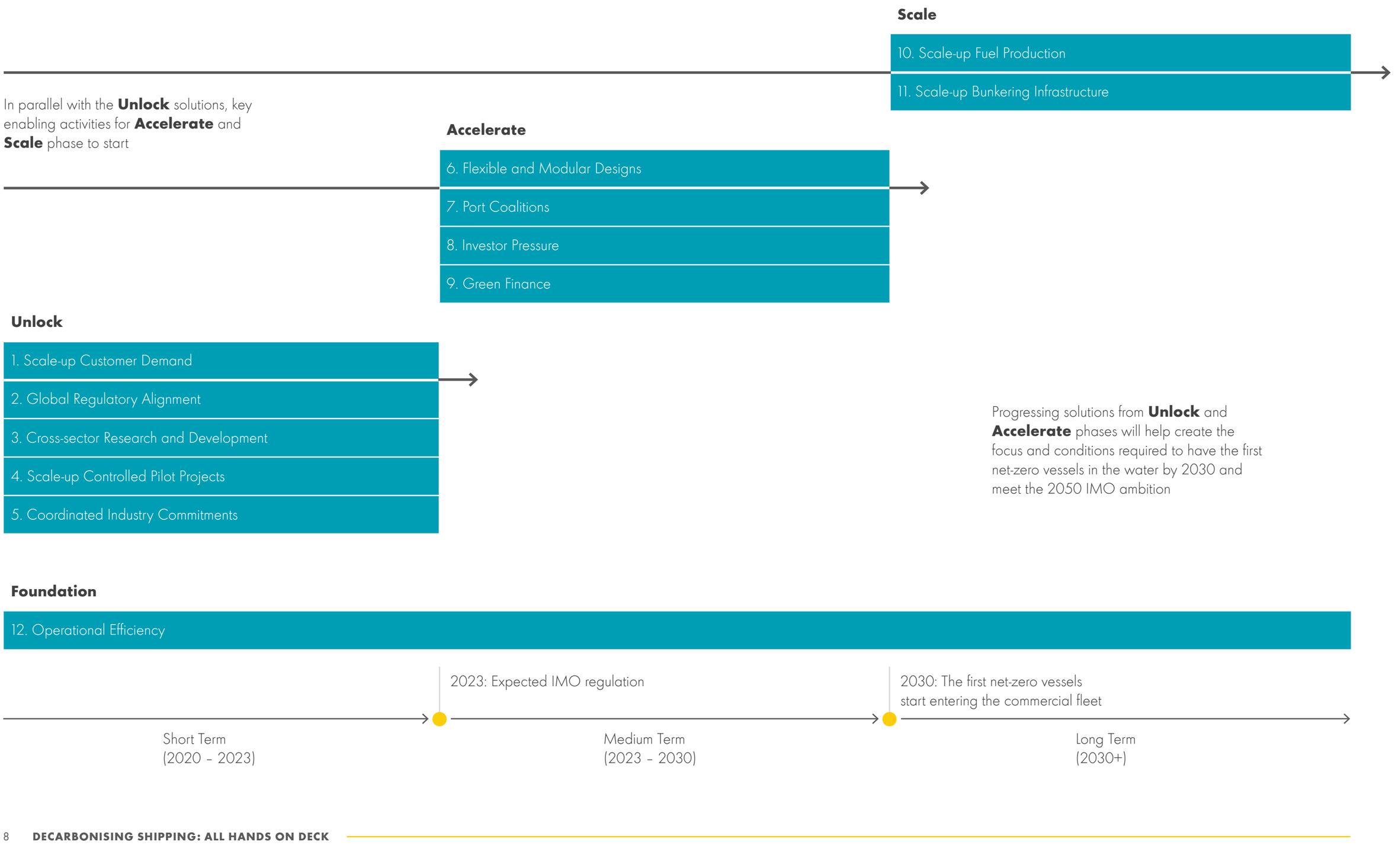
These five solutions make up the first phase of the decarbonisation roadmap (see Exhibit 02). The industry will then need to *"accelerate"* progress by further de-risking early investments through flexible ship design, new port coalitions, greater investor pressure and new financing schemes that encourage low-carbon shipping. Next, the reduced risk and expanded incentives resulting from previous phases will help attract the investment needed to *"scale"* green fuel production and bunkering infrastructure. Finally, operational efficiency must remain the *"foundation"* of all these phases and is crucial to reducing emissions of both existing and future vessels. Energy efficient technologies, such as hull streamlining, air lubrication, wind technology, weather routing, port optimisation, and high quality fuels and lubricants are some of the measures the industry can implement immediately and throughout the decarbonisation journey.

"We can build rockets that come back from the moon but not make ships green? No way. We can do it"

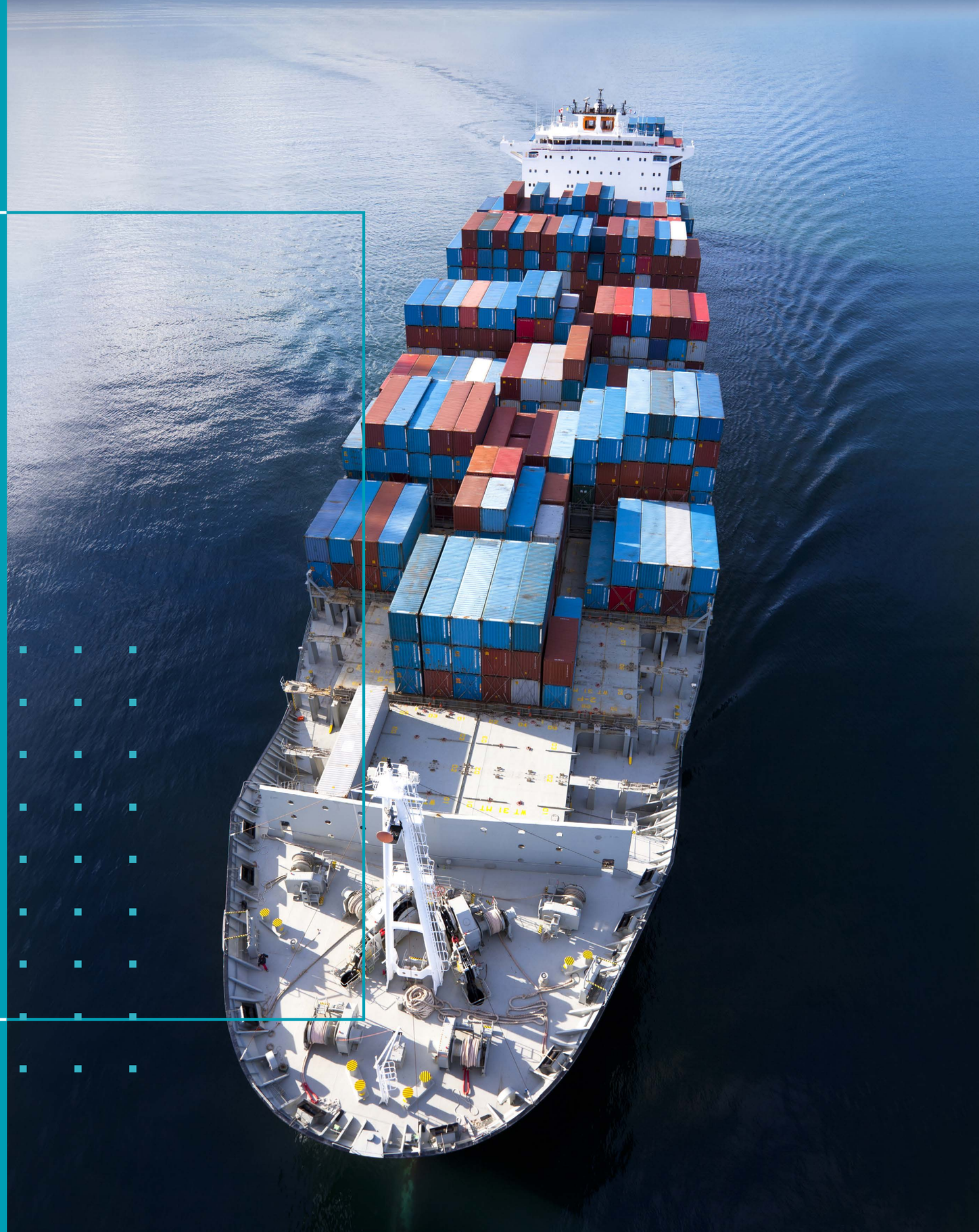
Shipping Owner & Operator CEO

The Roadmap

The opportunity for the industry to break the deadlock is clear, and there is little time to lose if it is to meet the IMO 2050 ambition. The solutions outlined in this report offer a roadmap to build on progress already happening within the sector and to drive further change. Momentum is building, and there is a sense of optimism that it can be done. Those who take the lead are in a better position to influence the outcomes, but every operator and stakeholder in the industry has a role to play. As one CEO said, it's *"all hands on deck."*


Scale
10. Scale-up Fuel Production
11. Scale-up Bunkering Infrastructure
In parallel with the **Unlock** solutions, key enabling activities for **Accelerate** and **Scale** phase to start
Accelerate
6. Flexible and Modular Designs
7. Port Coalitions
8. Investor Pressure
9. Green Finance
Unlock
1. Scale-up Customer Demand
2. Global Regulatory Alignment
3. Cross-sector Research and Development
4. Scale-up Controlled Pilot Projects
5. Coordinated Industry Commitments
Progressing solutions from **Unlock** and **Accelerate** phases will help create the focus and conditions required to have the first net-zero vessels in the water by 2030 and meet the 2050 IMO ambition
Foundation
12. Operational Efficiency
2023: Expected IMO regulation
2030: The first net-zero vessels start entering the commercial fleet
Short Term (2020 – 2023)
Medium Term (2023 – 2030)
Long Term (2030+)

Where We Are Today



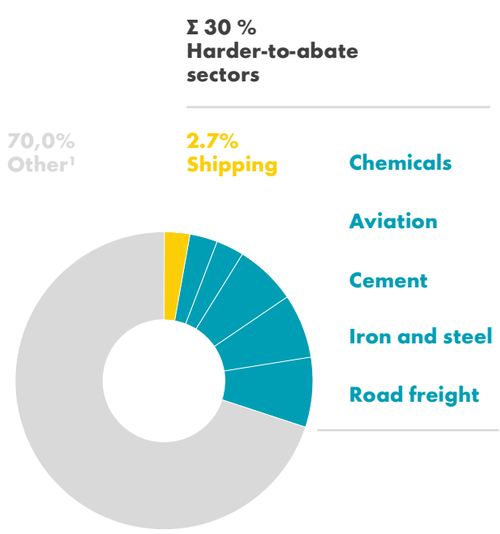
THE DRIVE TO DECARBONISE

The 2015 Paris Agreement defined a bold ambition to limit global warming to well below 2°C and pursue efforts to limit it to 1.5°C. In response, many countries, industries and individual organisations have set targets to limit their carbon emissions and started developing plans on how to reach them.

There is no shortage of positive signs, but the international community can do more to address climate change. As the United Nations Environment Program notes, "on current unconditional pledges, the world is heading for a 3.2°C temperature rise."[10] It is clear that a more focused, industry-specific and action-oriented approach is required to facilitate and accelerate decarbonisation efforts.

The challenge is particularly pronounced in six harder-to-abate sectors that, according to the International Energy Agency, currently account for around 30% of global CO_2 emissions (see Exhibit 03). These industries share common characteristics, such as long asset lifespans, high energy dependency, and complexity of electrification. Decarbonisation of these industries will, therefore, be slower, more investment-intensive and a more technically demanding endeavour compared to other industries. As other industries decarbonise more rapidly, pressure and focus on harder-to-abate industries is expected to increase.

03 **Global CO_2 Emissions by Sector[1]**

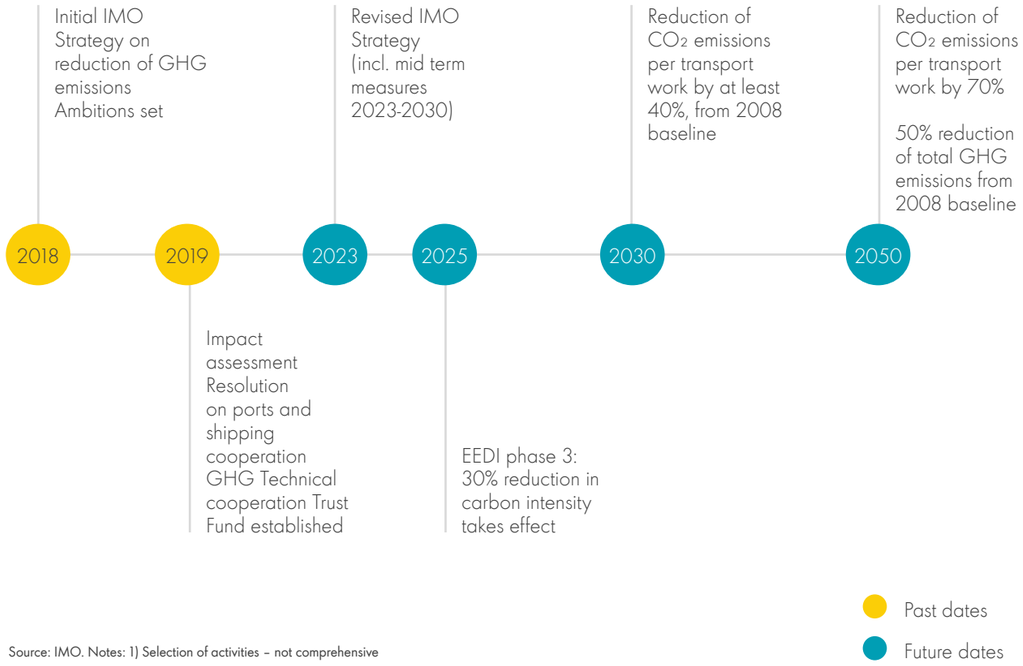


Source: IEA Energy Technology Perspectives 2017; IEA 2014 baseline value assumptions; Deloitte analysis. Notes: 1) Other includes feedstock, buildings, light transport

Where we are: The shipping industry has set an ambition to halve international shipping GHG emissions by 2050.

In 2018, the IMO announced the initial strategy to reduce GHG emissions (see Exhibit 04). The strategy outlines an ambition to at least halve international shipping GHG emissions by 2050, while reducing CO_2 emissions intensity by at least 40% by 2030, and pursuing efforts towards 70% by 2050, relative to a 2008 baseline.[11] While this is not binding, the IMO is expected to follow up with more specific measures by 2023. The IMO is the first regulatory body to adopt a global ambition for an entire industry, which is of critical importance given the role of shipping in the global economy.

04 **IMO Timetable to Reduce GHG Emissions[1]**



Source: IMO. Notes: 1) Selection of activities – not comprehensive

GHG EMISSIONS IN SHIPPING

Where we are: Shipping is critical to the global economy and accounts for around 2.7% of global emissions.

In the words of one interviewee, shipping is the *"backbone of the global economy,"* allowing the world to trade more goods over greater distances than any other mode of transport. It has historically grown in lockstep with economic activity. For instance, between 2000 and 2018, global GDP increased by approximately 65% while international shipping volumes increased by 93% over the same period (see Exhibit 05).[12]

The industry currently accounts for around 2.7% of global CO_2 emissions, but emissions are geographically concentrated across East-West trade routes and a relatively small set of vessel types.[13] Bulk carriers, oil tankers and container ships account for around 85% of all shipping activity (see Exhibit 07),[14] while around 45% of international maritime trade passes through the 20 largest global ports.[15]

Interviewees believe this concentration of emissions from specific uses and on specific routes creates an opportunity. An operator from Asia-Pacific region said, *"it allows us to focus our efforts on a small number of vessels and ports for the greatest impact."*

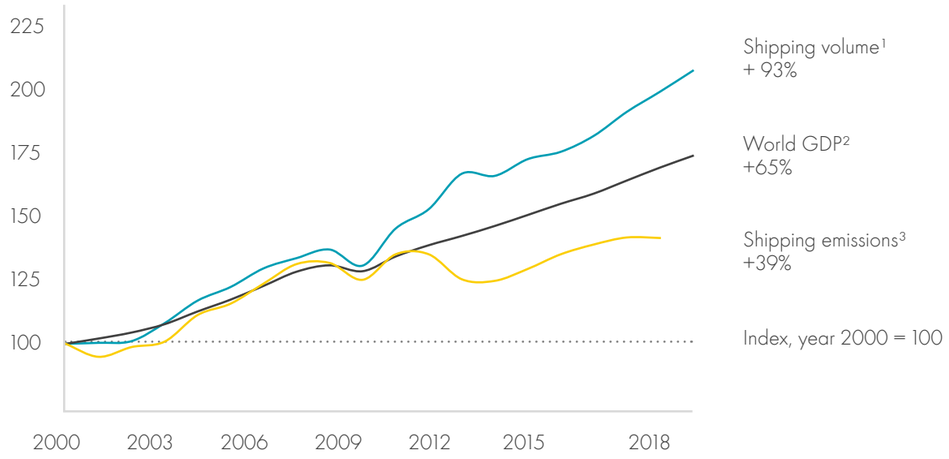
Where we are: Shipping is the most efficient means of transport and continues to make efficiency improvements as volume grows.

Due to the colossal size of ships and the continual drive for efficiency, shipping is by far the least emissions-intensive mode of transport (see Exhibit 06). A large vessel emits 1% of the CO_2 per ton-km that is emitted by a plane and 14% of the CO_2 emitted by the next most efficient transport alternative – a cargo train.[16]

The shipping industry continues to improve its efficiency. Over the last two decades, shipping volumes have increased by 101% while emissions only grew by 40% over the same time frame. This is due to increased scale, technical innovation and far-reaching operational improvements.

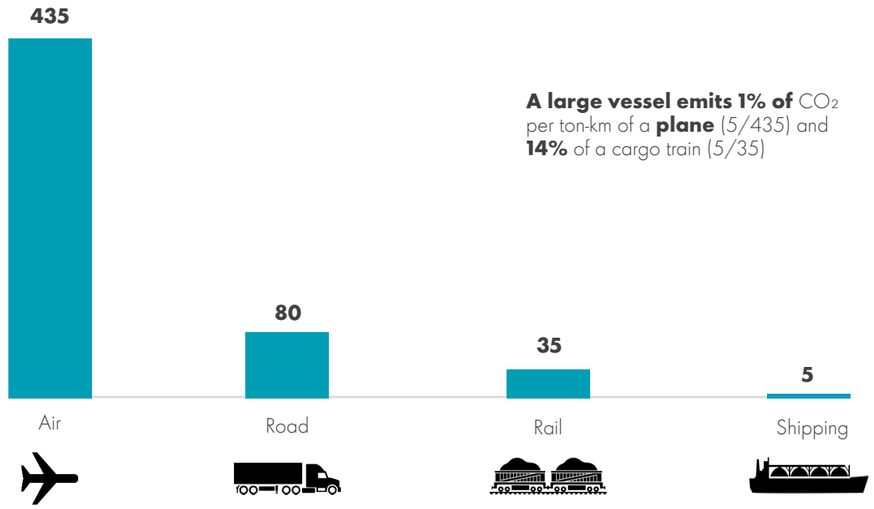
For instance, today's largest container vessels can carry around 22,000 containers, compared with a maximum of around 1,000 containers in the early 1970s. Ship sizes have doubled over the past decade alone, reducing their carbon intensity and also reducing the average shipping cost per container by roughly a third.[17]

05 **Shipping Volume, Emissions and GDP Growth**



Source: UNCTAD; World Bank; IEA; Deloitte analysis
Notes: 1) Shipping volume indicates ton-miles (how many tons of cargo were shipped over how many miles);
2) World GDP in constant 2010 $, to eliminate effect of inflation; 3) International shipping shown, accounting for over 80% of global shipping

06 **Emissions by Mode of Transport**
g CO_2/ton-km[1, 2, 3]



Source: IMO GHG study 2009. Notes: 1) Energy-efficient transport is much dependent on the load factor, vehicle efficiency and cargo type; heavier cargo and larger vehicles will improve the cargo/vehicle weight ratio, resulting in better CO_2/ton-km values; 2) Air = Boeing 747, Road = Truck > 40 ton, Rail = 3-4 hp / short-ton, Shipping = Average of very large container vessel (3 gCO_2/ton-km), oil tanker (6), bulk carrier (8); 3) Estimations assuming current energy mix

07 Global Shipping Fleet[1]

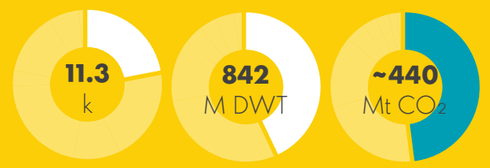
Σ~51.7k vessels **Σ~1,962 DWT[2]** **Σ~930 $MtCO_2$**

Source: UNCTAD; IMO; IEA; Deloitte analysis

Notes:
1) Ships of >1,000 gross tons, representing 99% of global tonnage;
2) DWT = Dead Weight Tonnage, an indicator of capacity;
3) General cargo includes multipurpose transport and other unclassified vessels;
4) Large ferries included. There is another ~8k+ of ferries < 1,000 gross tons

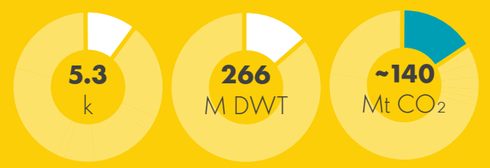
~85%
of total emissions

Bulk Carriers

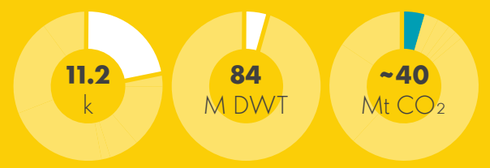


Oil Tankers

Container Ships



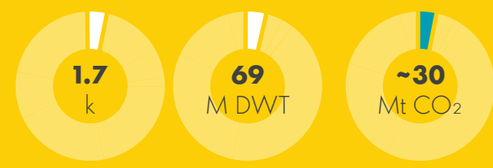
General Cargo[3]



Offshore Vessels

Cruise Ships / Ferries[4]

Gas Carriers



Chemical Tankers

The industry has also become more efficient through operational and technical improvements. Between 1976 and 2008, the carbon efficiency per weight-distance of some vessels improved by 75%.[18] Interviewees believe an additional 10 to 20% reduction in emissions can be achieved with technical innovations and digitalisation opportunities such as just-in-time arrivals, to cut the time that ships spend waiting outside ports.

Efficiency improvements are a central way to meet the IMO's 2030 ambition, but the industry will require a more fundamental shift in fuel as shipping volumes continue to grow.

Where we are: The growth in shipping volumes will increase pressure to accelerate decarbonisation.

Interviewees say that several trends in demand will influence shipping volumes and emissions in the coming years (see Exhibit 08). For instance, automation and 3D printing could improve production efficiency and reduce the benefits of having factories in distant, lower-cost locations. This could lead to a reduction in subcontractor layers and bring production closer to end markets, resulting in lower demand for shipping services. Shifting consumer preferences and trade protectionism may also have a similar negative impact on shipping volumes.

The impact of the COVID-19 pandemic significantly reduced shipping volumes. By April 2020, up to 60% of China's shipping capacity in Asia-Europe routes was idle.[19] While the impact has been acute, interviewees believe it will be a relatively short-term disruption and the industry will show signs of recovery by 2021.[20]

While these demand-side factors may individually decrease demand for shipping, interview participants do not believe they will fully offset growth in demand. Trade volumes and, in turn, shipping emissions are expected to continue to grow, increasing the importance of addressing barriers to decarbonisation.

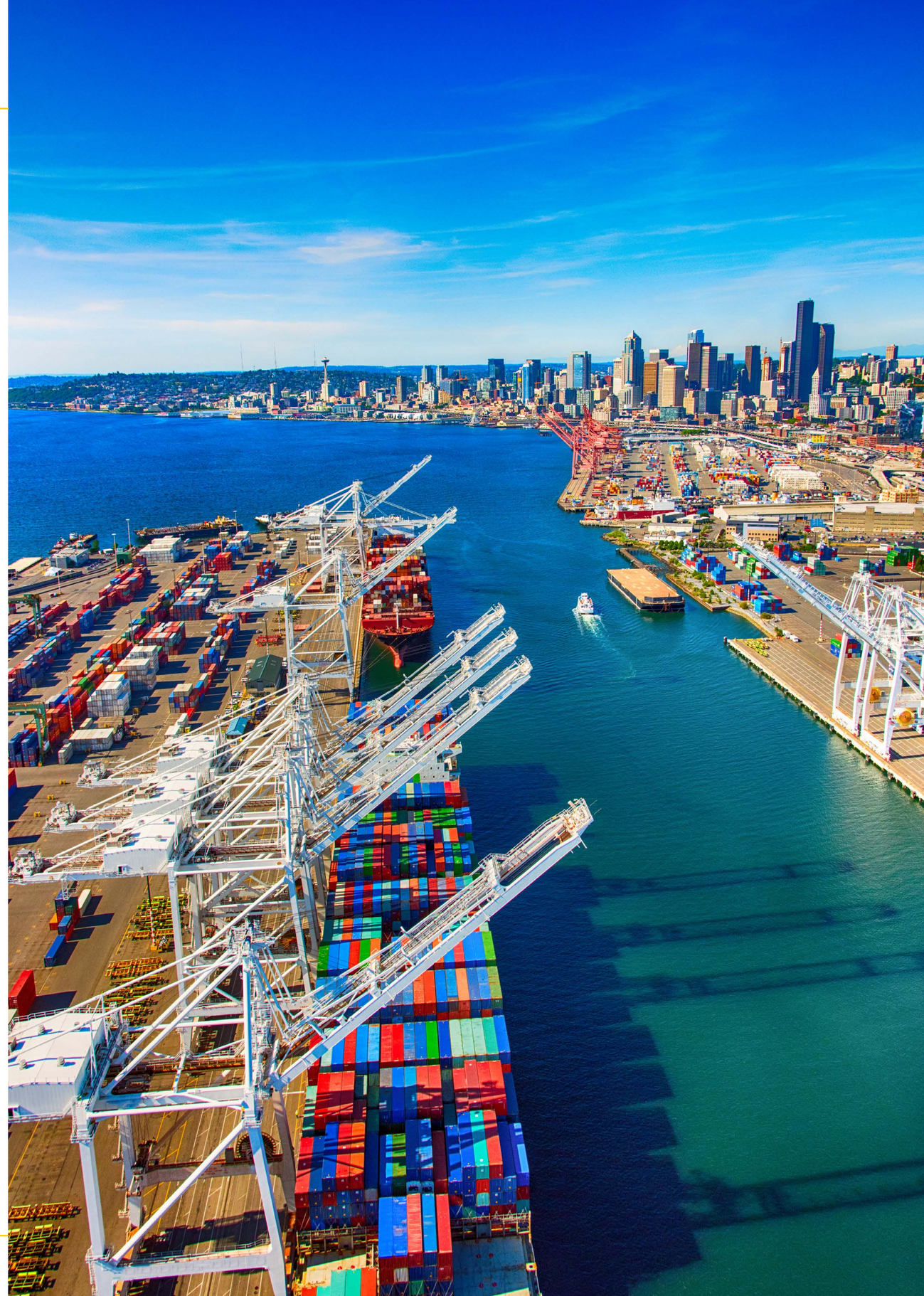
08 **Trends in Shipping Demand**

Trend	Impact on global shipping demand
Global economic growth (particularly from developing regions)	↗
More agile supply chains and nearshoring, enabled for example through production automation and 3D printing	↘
Trade protectionism and trade barriers	↘
Shifting consumer behaviour, for example circular economy, more conscious purchasing	↘
Short term: Trade growth post-COVID 19	↘
NET IMPACT	↗

Note: Trends identified are not exhaustive nor conclusive

Colour indicates estimated magnitude of impact

LOW — HIGH



The Deadlock: Barriers to Decarbonisation

DECARBONISATION READINESS FACTORS

A systematic approach to assess the industry's readiness to decarbonise was developed in collaboration with industry leaders by focusing on three core questions. Then, based on a wide range of responses, we converged on six decarbonisation readiness factors for the sector. We further refined these in workshops with industry leaders from across the globe. These factors are described in detail below.

Why should the sector change? i.e. what might trigger industry stakeholders to act:

1. **Market and Customer Demand**: Pressure and incentives from society, customers, financiers and investors which create motivation for ship owners and operators to change.

2. **Regulatory Incentives**: Instruments applied by global regulators and regional and local authorities. These can include incentives such as tax cuts and disincentives like fines and carbon levies.

Can the sector change? i.e. is decarbonisation feasible in a foreseeable future:

3. **Technology Alignment**: Technical and commercial feasibility of alternative fuels and other lower emission technology alongside clarity on how to further develop these.

4. **Clarity on Roles and Decision-Making**: The ease in making decisions, clarity on the roles and responsibilities of key groups in the industry, and whether their priorities are aligned.

How fast can the sector change? i.e. what effort is required to implement change at scale:

5. **Ease of Asset Replacement**: What it takes to replace or upgrade the ships. This depends on ship cost, complexity and lifespan, and the rate at which alternative technologies are developed.

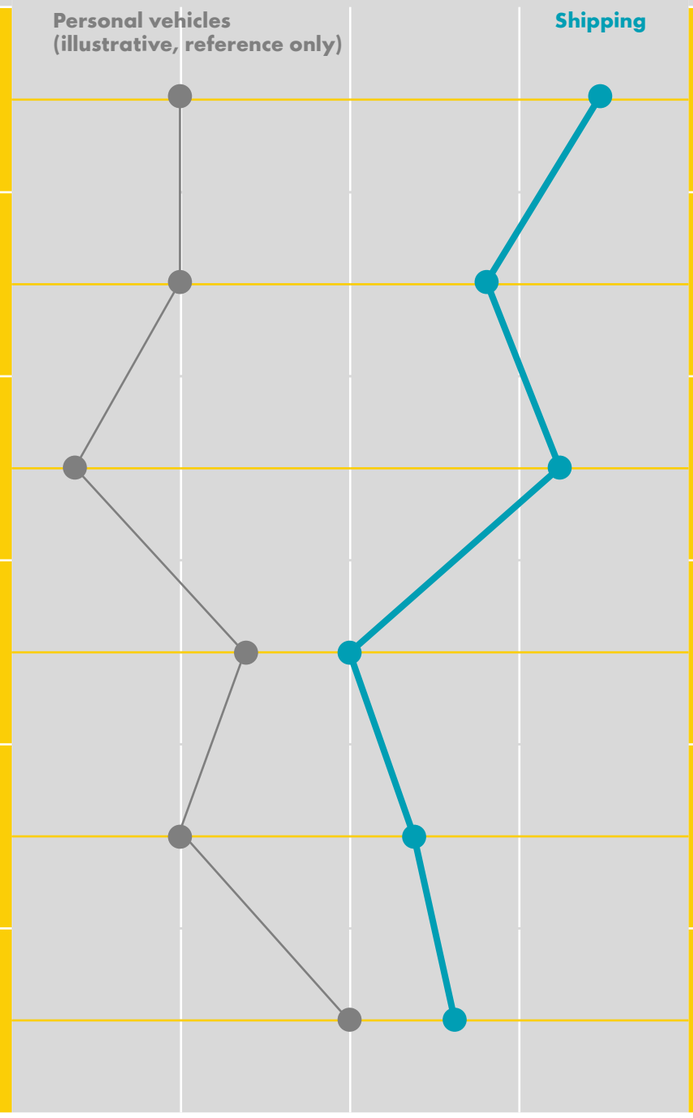
6. **Ease of Infrastructure Replacement**: What it takes to set up green production of new fuels at scale, deliver them to ports and prepare for bunkering. The more production capacity needed and the more dispersed the infrastructure, the greater the challenge.

Based on responses from industry executives, the shipping sector scores on the low side in terms of its readiness to decarbonise, especially when compared with some other transport sectors (see Exhibit 09).

The following sections focus on these six factors in greater detail.

09 **Decarbonisation Readiness Assessment**

Readiness questions	**Readiness factors**	**Participants' view on criticality of barriers**			
Why should the sector change?	1. Market and Customer Demand	~85%	Minor barrier 0%	Major barrier 100%	
	2. Regulatory Incentives	~70%	Minor barrier 0%	Major barrier 100%	
Can the sector change?	3. Technology Alignment	~80%	Minor barrier 0%	Major barrier 100%	
	4. Clarity on Roles and Decision-Making	~50%	Minor barrier 0%	Major barrier 100%	
How fast can the sector change?	5. Ease of Asset Replacement	~60%	Minor barrier 0%	Major barrier 100%	
	6. Ease of Infrastructure Replacement	~65%	Minor barrier 0%	Major barrier 100%	



MARKET AND CUSTOMER DEMAND

Most interviewees indicate that incentives from customers and the broader financial market are critical to free up investments in decarbonisation (see Exhibit 10). Such incentives are currently limited.

Industry Perspective: Customers and charterers are not willing to pay or co-fund lower emission solutions.

Shipping plays an instrumental but invisible role in most consumers' lives. *"Limited awareness means limited willingness to change the buying behaviour, especially when green products cost more,"* as mentioned by an executive from a transport and logistics company.

Lower emission shipping will result in additional cost, especially during the early transition period. Interviewees indicated that charterers and other shipping customers currently have limited appetite for additional costs, citing competitiveness concerns and the fact that shipping often represents a small proportion of their total emissions and cost.

"Shipping faces less scrutiny from end consumers than aviation and road freight where visibility is high"

Shipping Operator

Interviewees see initial signs of more sustainable practices in shipping procurement criteria set by companies that are under high regulatory or consumer pressure, such as the automotive, food, luxury retail and some large commodities sectors. However, there is currently insufficient demand to unlock investments at scale.

Industry Perspective: Investors have no incentives to invest in companies with lower emission solutions.

Returns to shareholders of shipping companies have been low over the last decade; therefore, major operators have been reluctant to make major investments that may further erode margins.

There are examples of shareholder activism leading to sustainability commitments, such as scope 3 emissions targets, but *"returns still take precedence over all other factors,"* said an executive from a ship management company. Consequently, executive teams at ship-owning companies remain reluctant to make investments in lower emission technologies, which their shareholders may regard as imprudent.

Industry Perspective: Financiers do not have the risk appetite to fund unproven technologies.

Shipping companies rely heavily on loans, which make up approximately 70% of capital in the sector.[21] According to most interviewees, loans have dried up in recent years as pressure has mounted on industry profitability. Smaller ship owners consider it particularly challenging to obtain funding for new ships, let alone for more sustainable alternatives because financiers currently regard them as financially and operationally riskier.

Recent initiatives in green finance, such as the Poseidon Principles, are important signals of progress.[22] However, interviewees see them as more relevant and accessible to large owners, who already have good access to lower-cost financing.

Industry Perspective: Lack of transparency regarding emissions hinders decision-making.

To enable decarbonisation activity, there must be better transparency of emissions across the sector. Without transparency, it will be impossible for customers, investors and financiers to identify top performers and to verify commitments.

Such data is not available today, as emissions reporting is only conducted for regulatory purposes and remains largely confidential. In addition, interviewees noted that consistent collection and comparison of data would be challenging given the lack of accepted calculation standards.

Exhibit 10

INTERVIEW INSIGHTS

85%

Study participants perceive a **lack of market and customer demand** to be a major barrier to decarbonisation

Calls for more transparency are intensifying, with some customers and charterers requiring emissions profiles and performance data for the ships that they use. As transparency grows, it will become easier for first mover operators to differentiate themselves by demonstrating the impact of their investments on emissions.

REGULATORY INCENTIVES

The IMO's 2050 ambition has created a common goal for the industry. However, most interviewees believe more clarity is needed regarding binding regulations, which will be instrumental to unlock progress (see Exhibit 11).

Exhibit 11

INTERVIEW INSIGHTS

70%

Study participants perceive a **lack of regulatory incentives** to be a major barrier to decarbonisation

Industry Perspective: Lack of binding regulation regarding carbon emissions limits progress.

Interviewees indicate that historically there is limited evidence of the shipping industry implementing major changes without new regulations. The IMO 2020 regulations provide a case in point. Interviewees indicated that despite advance notice, many companies were unprepared for the changes and had to make last-minute investments to comply.

In general terms, interviewees hold two views on the role of regulation. A slight majority believe that nothing can be done until regulation becomes clearer. A sizeable minority indicate that the industry should take proactive steps ahead of regulation. In the words of the CEO of one tanker operator, the lack of regulation is used *"as an excuse to do nothing, even though there are no regret activities that can be taken today."*

Industry Perspective: Enacting global regulation is a slow and complex process with many interests to align.

"IMO 2020 took over 15 years, and that was simpler than decarbonisation"

Shipping Operator

The IMO has 174 member-states, and most interviewees believe that developing and adopting new global regulation will be very time consuming. Interviewees wait with caution for more guidance on binding targets, expected in 2023.[23]

However, most believe the long wait for global regulations will be worth it if it creates a level playing field across the globe. A chairman of an Asia-based global operator noted, *"it is either a level playing field across the globe, or speed. You cannot have both. The power of the IMO is its member nations working together, but that takes time."*

Industry Perspective: The industry is worried that misalignment of global and local regulation may lead to an uneven playing field.

Interviewees acknowledge that if global regulation takes too long, there is a risk global or regional bodies move first, creating an uneven regulatory landscape and unnecessary complexity.

For the most part, interviewees believe this could cause competitiveness issues and increase the cost of compliance. As an example, many interviewees flagged a possibility that the European Union could define emission regulations before the IMO, creating an uneven playing field. Companies with Europe-based operations could then end up carrying a larger proportion of the early decarbonisation costs than their competitors from other parts of the world.

TECHNOLOGY ALIGNMENT

The shipping fuel landscape has not evolved a great deal since the transition from coal in the 1950s. 80% of interviewees indicated that technology alignment is needed if the industry is to meet the IMO's 2050 ambition, especially regarding which new fuels will be used where (see Exhibit 12). Yet the pathway to powering net-zero vessels remains uncertain.

Industry Perspective: Alternative fuels that support the 2050 ambition have technical limitations, are unproven and/or perceived as unsafe.

Liquefied Natural Gas (LNG)

LNG is 20 to 25% less carbon intensive than Heavy Fuel Oil (HFO), and emits less nitrogen oxides (NOx) and sulphur oxides (SOx).

The prevailing view among interviewees is that LNG will have a role to play as a transition fuel in the next decade. As an executive at a global bulk ship owner and operator said; *"It took many years for LNG to become viable, it is the only alternative we have today, and it will get us under the 2030 IMO target."*

These interviewees pointed out that LNG adoption is increasing, and some ship owners are in the process of taking on LNG-powered ships to reduce emissions.

Others were more reserved about the role of LNG, pointing out that it will be insufficient to meet the 2050 ambition, carries the risk of methane emissions in the supply chain and that it may distract the industry from investments in zero-emission fuels.

Hydrogen and Ammonia

Interviewees consider hydrogen and ammonia to be the most promising long-term fuel alternatives for shipping, although neither of them is viable today.

Hydrogen and ammonia have significantly lower energy density than HFO, requiring either new technology, more frequent refuelling stops, or compromised cargo space to store fuel. In addition, interviewees highlighted that hydrogen requires ultra-low cryogenic conditions to maintain its liquid state under atmospheric pressure, creating potential for additional costs. The storage challenge could be offset by adopting energy-efficient technology and moving from internal combustion engines to fuel cells. This potentially makes the ships more efficient, while saving space on ships. However, most interviewees believe that fuel cell technology is immature. It will likely take at least 5-10 years before it becomes a viable alternative. If fuel cell technology was developed before hydrogen or ammonia are available at scale, transition fuels like LNG could potentially be used, and switched to a new fuel when it emerges.

"Hydrogen economy is the ultimate solution, but still many years away"

Ship Manager

Ammonia and hydrogen have different characteristics. Hydrogen requires more storage volume than ammonia for the same range, while both hydrogen and ammonia require more storage volume than HFO and LNG. Given that energy density plays a more important role on ships than on land, one executive from a global shipping technology company noted, *"if on land hydrogen becomes the big thing, ammonia could be a good option for shipping, as it is a good way of carrying hydrogen."* Ammonia is also already used in fertilizers. As such, there is some existing infrastructure that could be used, and *"the shipping industry has had experience handling it for over 30 years."* However, some interviewees are concerned about ammonia's high ignition energy and toxicity, with one Asia-based bulk ship operator saying that *"we have been trying for the last 20 years to stop transporting ammonia by ships as it is toxic and difficult to handle."*

Current production of ammonia and hydrogen represents a small fraction of what the shipping industry would require. A common concern is the high cost to produce hydrogen and ammonia in a low-carbon or carbon-neutral way. However, in a scenario of abundant renewable power and as technology costs decline, the cost of producing these fuels sustainably will decrease. As one interviewee put it, *"the scale of investments we see in green hydrogen globally means it will become cost effective much faster than we think."* Conversely, there is little evidence that other industries consider ammonia as a future fuel. For that reason, if shipping was to select ammonia as its dominant fuel, it is likely that the infrastructure costs would be borne entirely by this sector.

Other alternative fuels

Biofuels are made from biomass. Synthetic fuels are produced using a combination of hydrogen and carbon monoxide. These fuels are relatively easy to adopt because they can largely use existing infrastructure and existing engines. But given the large volume of fuel needed for the industry and the land and biomass required to produce it, interviewees raised concerns about the availability of biofuels in enough quantities.

Exhibit 12

INTERVIEW INSIGHTS

80%

Study participants perceive a **lack of technology alignment** to be a major barrier to decarbonisation

More scepticism was expressed regarding the use of batteries. As one executive from a cruise company put it, *"electrifying small ships is great, but most emissions come from deep-sea shipping, and there are no viable options to address that with batteries."*

> *"If we don't get our act together, we will still be talking about ten different fuels when the deadline flies by"*
>
> *Shipping Operator*

Finally, some US-based operators suggested that, *"nuclear is really the only solution that exists today that could be implemented relatively quickly."* To strengthen that point, one Europe-based operator suggested that, *"if climate change accelerates, the negative connotations of nuclear will be secondary to global warming."*

Exhibit 13 provides a summary of interviewees' assessment of key alternative fuels.

Industry Perspective: Too many future fuels are being considered, and there is a lack of clarity on how the preferred fuel(s) will be chosen to allow for scale.

Many interviewees expressed concerns that the range of fuel options being considered is still too broad. This results in effort and investment being spread too thin and challenges efforts to coalesce around a viable solution in time to meet targets.

Interviewees indicated that many onshore sectors are also undergoing transitions in energy source and that decisions made on land will have major consequences for which fuel will be viable in shipping. One executive from a global bulk ship operator indicated that, *"most of these technologies will have to find their way into land-based sectors first, before being adopted in shipping. It is easier to develop these on land".*

Industry Perspective: HFO is hard to match in terms of commercial attractiveness and existing scale.

HFO, shipping's primary energy carrier today, is cheap, energy-dense and has well-established supply chains. As a by-product of the refining process, it is used by few other industries which creates more certainty around cost and supply. As one executive from an Asia-based tanker operator put it, *"shipping uses the lowest quality fuel from refineries, which means it's cheap and no one else wants it."* As a result, new fuels will likely cost more and will require the industry to compete for supply with other industries.

Without a stronger commercial or regulatory incentive, operators are sceptical about their ability to find a fuel that is a viable alternative to HFO. They indicate that many stakeholders will need to play a part to develop and commercialise new technology. If a viable alternative is not found, various forms of carbon offsets will be required to reduce net emissions to levels that support the sector's ambition.

13 **Industry Perspective on Alternative Fuels**

Fuel	Part of future mix? (% participants)	Engine type	View on technology maturity	View on applicability to shipping	Advantages	Disadvantages
Green Hydrogen	65%	Combustion	Medium	Medium	Cross-sector applications – possibly faster R&D	Cost Low energy density Cryogenic storage conditions
		Electric (fuel cell)	Low	High	Less space for engine and better specs than combustion	
Green Ammonia	55%	Combustion	Medium	High	Relatively high energy density Port experience in handling	Cost Toxicity
		Electric (fuel cell)	Low	High	Less space for engine and better specs than combustion	
Biofuels	10%	Combustion	High	Low	Easy to implement in current engines	Limited feedstock, unlikely to be available to shipping
Methanol	10%	Combustion	Rarely mentioned	Rarely mentioned	Rarely mentioned	Rarely mentioned
Batteries	< 5%	Electric	High	Low	Mature technology	Extremely low energy density – size and weight of batteries
Nuclear	< 5%	Heat	Medium	Low	Mature technology	Very high investment, social aversion

CLARITY ON ROLES AND DECISION-MAKING

Decarbonisation is a complex process and requires decision-making with a high degree of global alignment. Interviewees noted concerns regarding the industry's ability to clarify roles and decision-making power of key stakeholders, which could negatively impact the effective allocation of resources in the sector (see Exhibit 14).

Industry Perspective: The global fleet is owned by many small companies, and multiple stakeholders are involved in ship operations, which complicates decision-making regarding new technologies.

Ownership of the global shipping fleet is fragmented, with the top 10 ship owners making up less than 20% of total capacity. The remaining 80% of the fleet is owned by thousands of smaller ship owners, often with only a few ships each (see Exhibit 15). There are exceptions – particularly in container shipping where 10 companies control most of the global fleet – but interviewees noted that this fragmentation of ownership makes it difficult to get consensus within the industry.

"It is very difficult to get any consensus in shipping"

Ship owner

Different forms of company ownership add extra complexity. State-owned enterprises, large publicly listed corporations, large private companies and numerous small, often family-run, businesses all play important roles in the industry. Varying forms of ownership mean differing approaches to decarbonisation. As one executive from a chemical ship operator put it, *"state-owned entities are under the most social pressure, public companies face a mix of social and commercial pressure, and private companies seem to be the most commercially-focused."*

Shipping is equally complex when you look across its entire value chain. There are often several parties – such as brokers, freight forwarders, ship managers and operators – between the asset owner and charterer or customer. This makes it unclear where the ultimate responsibility for decarbonisation sits. As one charterer noted, *"there are three companies between me and the owner of one of my ships. So, who is responsible for the emissions, and who will make the investment?"*

Industry Perspective: Contracting models are inflexible, hindering investments that support lower-carbon emissions.

Interviewees indicate that optimising ship operations, such as speed management or just-in-time port arrivals, is one of the largest potential areas of emissions reduction in the short term.

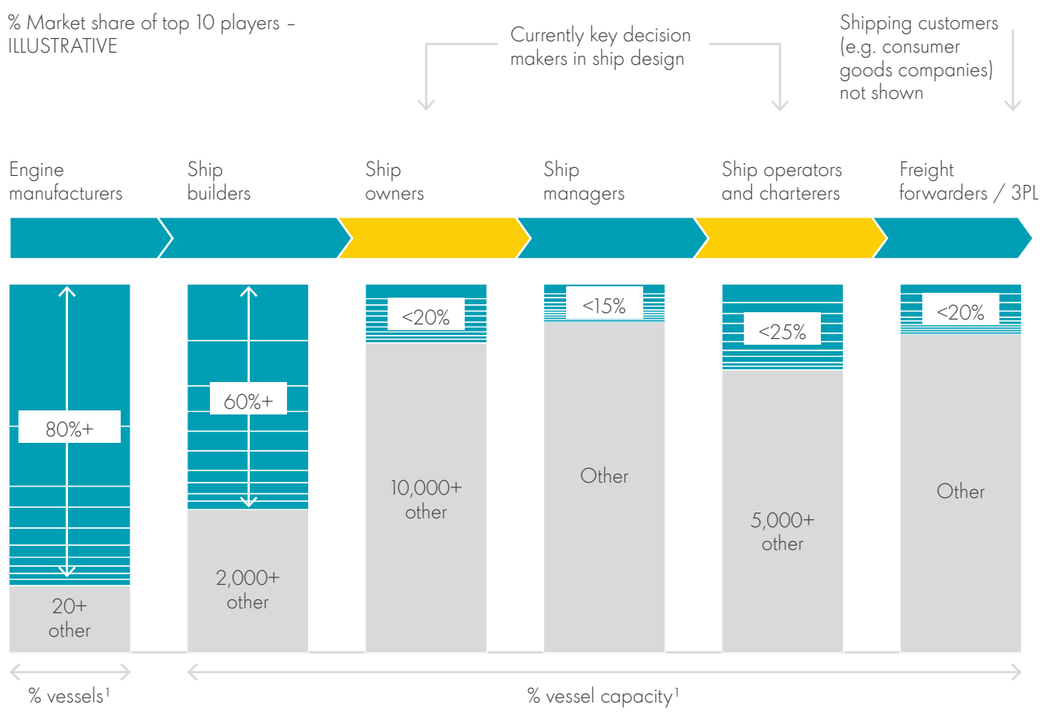
Exhibit 14

INTERVIEW INSIGHTS

50%

Study participants perceive a **lack of clarity on roles and decision-making** to be a major barrier to decarbonisation

15 **Shipping Value Chain**



Source: Clarksons Research; Company reports; UNCTAD; Deloitte analysis. Notes: 1) Based on # of main engines for diesel engine builders, TEU for Freight Forwarders/3PL and Dead Weight Tonnage for all other segments

However, decisions about speed and port arrival times are often dictated by charter party agreements, which many interviewees say are inflexible and, therefore, disincentivise improvements.

"We could get a 10% CO_2 reduction and fuel-cost savings by optimising arrival times like airlines. But contracts mean we would not get the benefits"

Shipping Operator

Charterers are often equally unable to invest in new on-board solutions to improve vessel efficiency. Asset owners are typically responsible for new investment decisions but rarely reap the benefits of resulting efficiency.

EASE OF ASSET REPLACEMENT

Today's ships are huge feats of engineering, requiring major capital and several years to build. They are also costly to modify. Interviewees highlighted the risks of investing in new ships and the time it will take to replace the fleet as key challenges (see Exhibit 16).

Industry Perspective: Ship owners are reluctant to invest in net-zero vessels due to risks resulting from lack of clarity regarding future fuels and regulation.

Interviewees highlighted that the lack of clarity regarding regulation and future fuels has exacerbated conservatism in the industry and generated a reluctance to invest in new ships to *"avoid the risk of getting locked into a wrong technology,"* said an executive from a global shipping financier.

"There is a risk that new fuels or regulation will make new ships obsolete"

Shipbuilder

Additionally, some interviewees noted that the industry is starting to recognise that current ship designs are inflexible. Designers and technology providers are focusing on improving flexibility to allow easier switching between fuels or lower cost of retrofits. For example, a few interviewees mentioned LNG-powered propulsion installations, which can be made ammonia-ready with a relatively small investment.

Industry Perspective: Ship lifespans are long, requiring significant time to replace existing fleets.

Given the average lifespan of a ship, interviewees acknowledge that transitioning the global fleet will take 20 to 30 years, even if a viable zero-carbon fuel was available today. Considering the IMO's 2030 and 2050 ambitions, this creates significant pressure to identify viable fuel alternatives as soon as possible.

Most interviewees indicate that the industry will need to make greater progress in operational efficiencies, retrofitting and ship decommissioning to transition the fleet in time. However, many believe that retrofits are costly, and, as margins are under pressure, they need to *"sweat the assets,"* in the words of the CEO of a large tanker operator.

Some shipping leaders are more optimistic, pointing out that the industry has successfully transitioned fleets in the past. For example, after the introduction of new design regulations for tankers in 1992, the entire fleet was changed from single to double-hull design in under 25 years.

"Our timer doesn't start until we get our fuel, and the clock is already ticking"

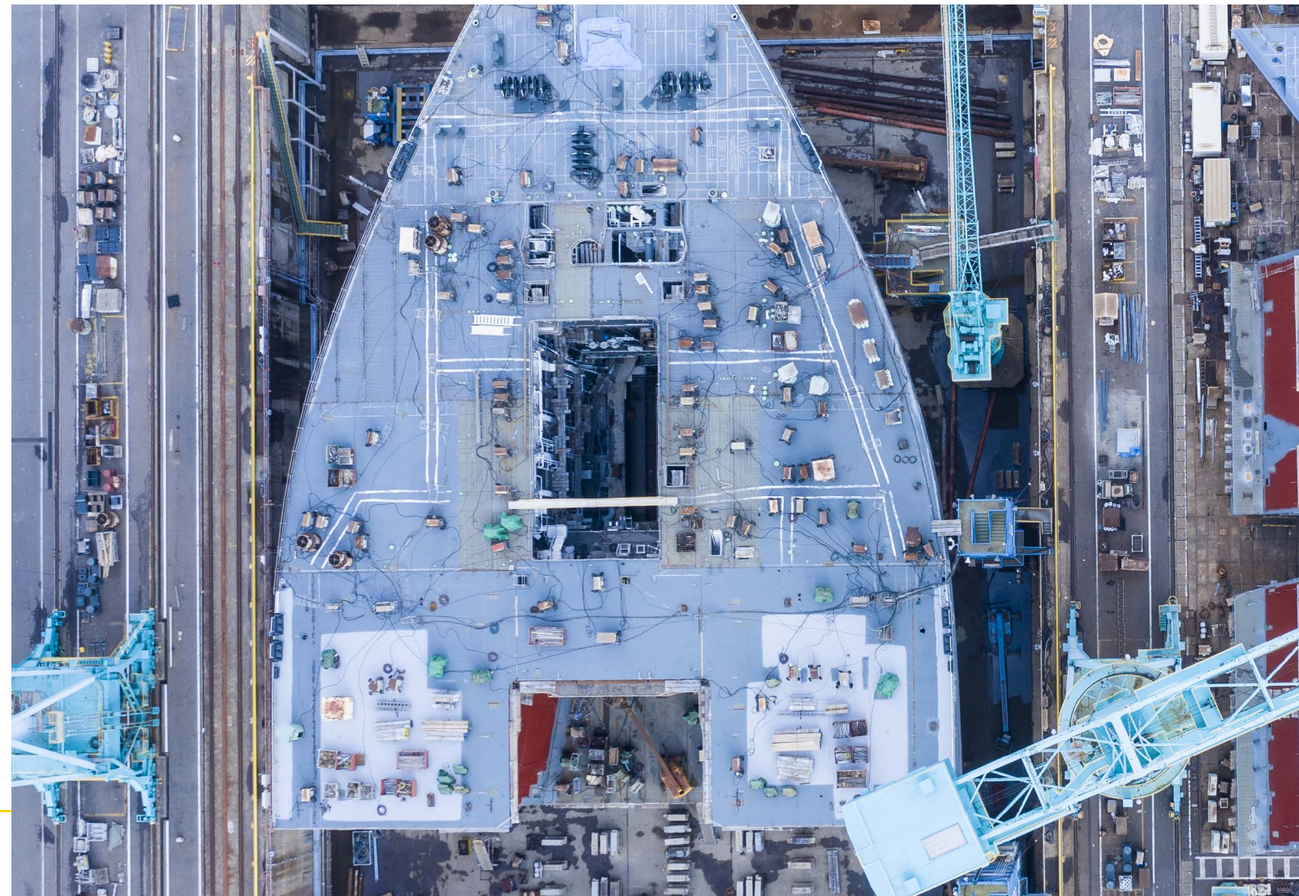
Ship owner

Exhibit 16

INTERVIEW INSIGHTS

60%

Study participants perceive **complexity of asset replacement** to be a major barrier to decarbonisation



EASE OF INFRASTRUCTURE REPLACEMENT

The shipping industry consumes 3.3 pWh (~12EJ) of energy annually.[24] Transitioning the world's fleet to a new source of energy will, therefore, take a huge effort to build out the necessary fuel production and bunkering infrastructure. Most interviewees consider this a major barrier to decarbonisation (see Exhibit 17).

Exhibit 17

INTERVIEW INSIGHTS

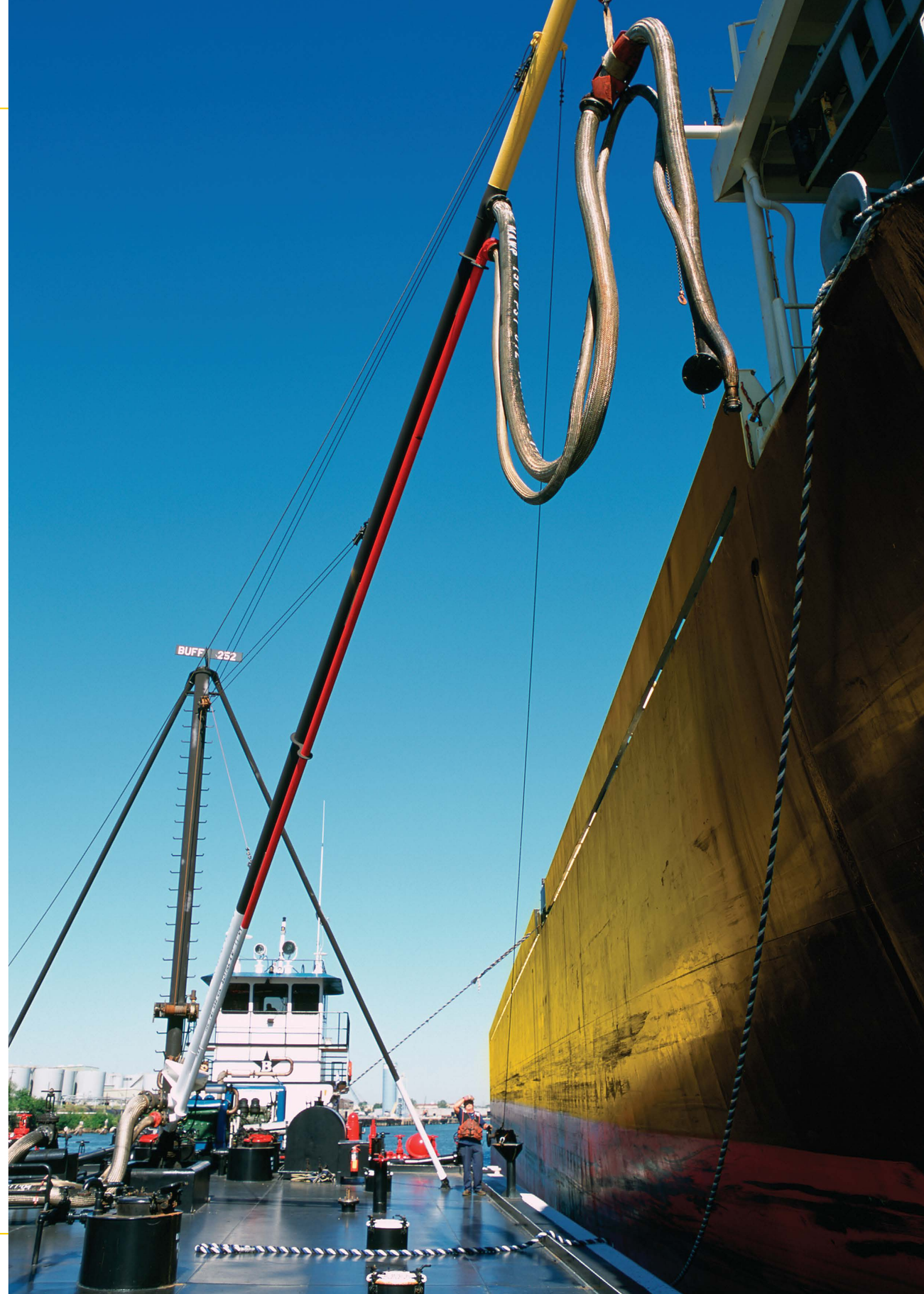
65%

Study participants perceive **complexity of infrastructure replacement** to be a major barrier to decarbonisation

Industry Perspective: Infrastructure to produce zero-emission fuels will require significant investment, time to scale up and will depend on decisions in other sectors.

There is currently very limited infrastructure for the sustainable production of alternative fuels being explored by the industry. Several interviewees cited a recent study by the University Maritime Advisory Services, which estimates that 87% of the $1.65 trillion cost to decarbonise shipping by 2050 will need to be dedicated to creating supply and bunkering infrastructure.[25]

While bunkering infrastructure will be specific to shipping, fuel production is a broader global challenge involving many sectors of the global economy. As such, interviewees recognise the need to collaborate with onshore sectors and energy companies to secure reliable fuel supply.



Industry Perspective: Bunkering providers and ship operators are waiting on each other to make the initial investments in net-zero ships and infrastructure.

Given the uncertainty over fuels, neither ports nor ship owners are willing to make investments in new technologies.

The biggest challenge in the shift to a new fuel is in tramp trade, where ships do not operate according to a predetermined schedule. Ships operating in this way require a near-ubiquitous supply of fuel. Conversely, developing infrastructure in a few key ports could have a disproportionate impact due to the needs of large container lines and regular bulk routes. For instance, 20 ports handle around 45% of global container trade[26]. In the words of one classification society, *"building infrastructure in the top five ports would already help a lot."*

However, port decisions on adopting new fuels and building out the infrastructure will take time. *"With LNG, it took some ports ten years to go through the authorities, and that was when they knew they wanted LNG,"* said an executive at a large European operator.

Given the uncertainties, developing the bunkering infrastructure will be one of the most time-consuming steps in shipping decarbonisation.

"Why would I build a ship that runs on a new fuel until I know I can fuel it. And no new bunkering will be built until there is a market"

Ship operator

The main barriers to shipping decarbonisation are summarised in Exhibit 18. The changing paradigm and solutions to address the barriers and meet the IMO's 2050 ambition are explored in the next section.

18 **Decarbonisation Readiness Summary**

	Readiness factors	Main barriers			
Why should the sector change?	1. Market and Customer Demand	Customers and charterers are **not willing to pay or co-fund** lower emission solutions	**Investors** have no incentives to **invest in companies** with lower emission solutions	**Financiers** do not have the **risk appetite** to fund unproven technologies	**Lack of transparency** around emissions hinders decision-making
	2. Regulatory Incentives	Lack of **binding regulation** around carbon emissions limits progress	Enacting global regulation is a **slow, and complex process** with many interests to align	The industry is worried that misalignment of global and local regulation may lead to an **uneven playing field**	
Can the sector change?	3. Technology Alignment	Alternative fuels that support 2050 ambition have **technical limitations, are unproven and / or perceived as unsafe**	**Too many future** fuels are being considered, and there is **lack of clarity on how the preferred fuel(s) will be chosen** to allow for scale	HFO is hard to match in terms of **commercial attractiveness** and **existing scale**	
	4. Clarity on Roles and Decision-Making	The global fleet is **owned by many small companies** and **multiple stakeholders** are involved in ship operations, **complicating decision-making** around new technologies	**Contracting models are inflexible** hindering investments that support lower carbon emissions		
How fast can the sector change?	5. Ease of Asset Replacement	Ship owners are **reluctant to invest in net-zero vessels** due to risks resulting from **lack of clarity around future fuels and regulation**	**Ship lifespans are long**, requiring **significant time to replace** existing fleets		
	6. Ease of Infrastructure Replacement	Infrastructure to **produce zero emission fuels** will require **significant investment, time to scale up** and will depend on **decisions in other sectors**	**Bunkering** providers and ship operators are **waiting on each other to make the initial investments** in net-zero ships and infrastructure		

Severity
- Major
- Moderate
- Minor

A New Paradigm: Solutions for Decarbonising

SIGNALS OF CHANGE

The IMO's 2050 ambition and growing global commitments to decarbonise have created a new paradigm that opens new opportunities and potential solutions.

Around the world, business and political leaders are responding to the decarbonisation challenge, with a growing number of commitments and emissions targets to combat climate change (see Exhibit 19). New industry alliances are also being created, such as The Net-Zero Asset Owner Alliance, an alliance of over 80 CEOs and climate leaders. Meanwhile, the growing investment in green energy projects, such as Germany's recently announced €50 billion green recovery programme, reflects a concerted move to lower the cost and create a more abundant supply of sustainable fuels.[27]

Almost all interviewees indicated that decarbonisation is important or among the top three priorities for their organisations (see Exhibit 20). Additionally, almost 80% indicated that it has become more important in the last 18 months following IMO 2020 sulphur regulations, which brought the discussion about emissions to the fore. European companies are a driving force while those in Asia-Pacific and Americas are not far behind (Exhibit 21).

Consumer sentiment and the expectations being placed on brands is another important driver of change. As one technology provider pointed out, *"consumer pressure is increasing."* For instance, some global consumer goods have started to carbon-label their products and the prevailing view among interviewees is that the pressure will further increase in the coming years. As one executive put it, *"everyone who orders a vessel already has to think about what engine, what fuel will make sense."*

Exhibit 20

INTERVIEW INSIGHTS

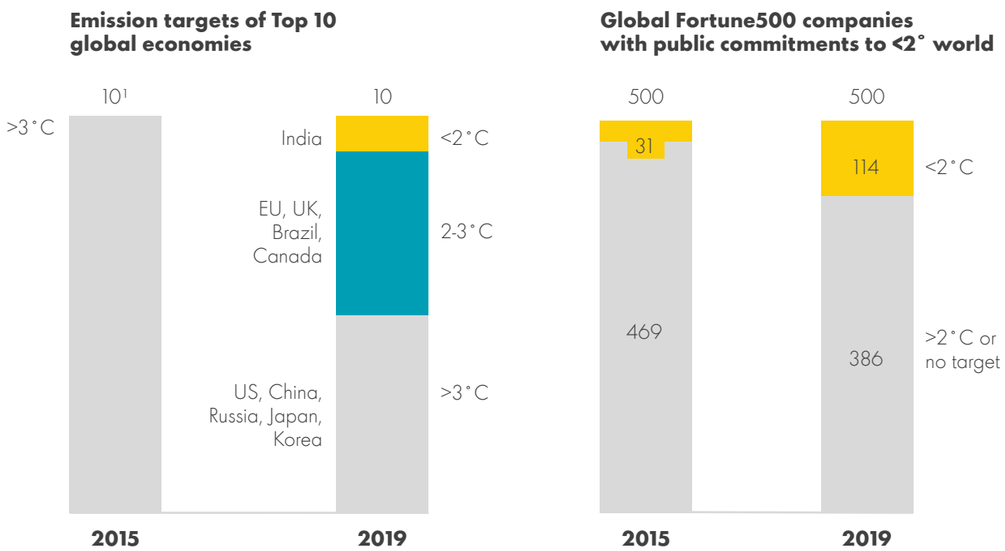
95%

of study participants perceive **decarbonisation as important or a top 3 priority** on the industry agenda

80% of participants indicated the importance has somewhat or significantly increased in the last **18 months**

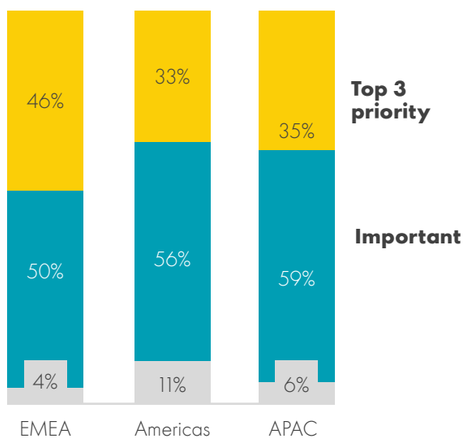
The COVID-19 crisis has further accelerated the debate around sustainability and resilience of key sectors of the world economy. Decarbonisation is front-and-centre in this debate and *"will come right back up to the top of the shipping agenda when COVID-19 crisis is over,"* says one large operator.

19 **Climate Targets and Commitments**



Source: Climate Action Tracker; Natural Capital Partners; Deloitte analysis Notes: 1) Before 2015 targets were often not reported in relation to global temperature – targets inferred based on absolute emission reduction targets by country

21 **Decarbonisation Across Geographies**



Sentiment is most positive in EMEA, largely driven by regulatory and societal pressure

PRINCIPLES

To address the barriers to decarbonisation, the shipping industry will need a novel approach. Most interviewees recognise that the scale of the challenge requires the industry to adopt an **ecosystem perspective**, with different organisations contributing to different pieces of the puzzle. Large, public and state-owned companies will have a key role to play because, in the words of one technology provider, *"if they change, the rest will follow."* Having large fleets, major emission footprints, strong balance sheets and shareholder representation, these companies will find it easier to make bold moves and *"not just focus on the short-term economics, but to make bets that move the industry forward,"* in the words of an Asia-Pacific based container executive.

The industry cannot sit and wait. *"We don't have time to go through iterative technology development. 2030 is tomorrow, 2050 is one ship lifetime away,"* says an executive at a classification society. Therefore, a **think big, start small, scale fast** attitude is needed, with uncertainty tackled through small actions that generate momentum. As these initiatives prove beneficial, early adopters will attract early followers and initial investment. Scaling up needs to follow in specific segments with the biggest impact.

To create momentum, a coalition of organisations with common interests and a longer-term perspective is needed to move progress forward. The solutions must therefore focus on **behaviours and triggers**, factoring in what motivates individuals and what will make them act with long-term benefits in mind. For instance, interviewees noted that sustainability credentials of goods and services increasingly play a role in the buying behaviour of consumers and investment choices of financial institutions. In this way, the potential incentives for operators of branded fleets carving out a greener reputation are much stronger than those that use general cargo ships. As one operator states, *"the solution will come from the operators with their name on the ships."*

Shipping decarbonisation is a challenge with few precedents in terms of size and complexity. Interviewees cited the transition from horse-drawn carriages to automobiles as an example that highlights these three principles at work (see Exhibit 22).

22 **From horse-drawn carriages to automobiles**

In the 1860s, horse-drawn carriages dominated city streets. 'They were dirty but they worked'	Less than 40 years later, motorised automobiles were the common sight What can we learn from this transition?		
	Ecosystem perspective	**Think big, start small, scale fast**	**Behaviours and triggers**
▪ In 1800s industrialisation and urbanisation exploded ▪ Horse carriages and trains led to major congestion and hygiene concerns ▪ However, horses seemed like the only viable means of transport: – Did well on unpaved roads – No need for special fuels – Slow thus 'safe' in the cities – Did not require expensive manufacturing	▪ Middle class emerges – horse-related concerns become top of mind ▪ Cities develop paved streets and parkways ▪ General stores introduce petrol for light and stationary ▪ Bicycle producers lead innovations in steel-making and manufacturing ▪ Regulators introduce traffic rules, registration, licensing	▪ Gas engines are added to carriages and bicycles – first automobiles ▪ Automobile use for racing and touring the countryside ▪ Automobiles for doctors, salesman, farmers, taxis ▪ Ford makes a big bet on Model T, which moves automobiles into mainstream	▪ Middle class lives increasingly in the suburbs, commuting to cities ▪ Mass use of bicycles in the parkways creates the concept of mobility as freedom ▪ Middle class, bicycle clubs and real estate industry lobby for building of paved streets, boulevards and parkways

Source:F. W. Geels 'The Dynamics of Transitions in Socio-technical Systems', Deloitte analysis

SOLUTIONS

Interviewees identified a range of options to overcome the barriers to decarbonisation, but ultimately converged on a group of 12 solutions that were refined in workshops. Some are aligned with existing industry initiatives, while others are new (see Exhibit 23).

1. **Scale-up Customer Demand:** create scale in demand for low or zero-emission shipping through charterers' and customers' commitments that include long-term contracts and green procurement criteria.

2. **Global Regulatory Alignment:** create a level playing field globally and reduce uncertainty regarding regulations and timeframes.

3. **Cross-sector Research and Development:** intensify partnerships to develop zero or low-emission fuels through joint R&D across shipping, other harder-to-abate sectors and the energy industry.

4. **Scale-up Controlled Pilot Projects:** increase R&D effectiveness by running end-to-end green pilot projects involving customers, charterers, operators, owners and ports on specific routes and vessel types.

5. **Coordinated Industry Commitments:** increase the reach of existing initiatives – such as the Getting to Zero Coalition, the Clean Cargo Working Group and others – by consolidating objectives and strengthening the coordination of various concurrent workstreams.

6. **Flexible and Modular Designs:** reduce the risk of choosing an emerging low or zero-emission fuel and lower the future cost of retrofitting the fleet by creating flexible or modular propulsion systems and ship designs.

7. **Port Coalitions:** reward operators of green vessels by working with the world's largest ports to implement preferential treatment schemes.

8. **Investor Pressure:** encourage the management of shipping companies to set decarbonisation targets and make related investments through activist shareholding.

9. **Green Finance:** lower the cost of capital and improve terms for ship-owners who make decarbonisation investments through dedicated green financing products.

10. **Scale-up Fuel Production:** secure production and distribution of new fuels to ports by establishing strategic partnerships with energy companies.

11. **Scale-up Bunkering Infrastructure:** secure bunkering infrastructure of new fuels by establishing strategic partnerships with energy and bunkering companies in the largest ports.

12. **Operational Efficiency:** reduce emissions of existing fleets through operational improvements including fuel and lubricant quality, energy management, digitalisation and smart navigation strategies such as just-in-time and speed optimisation.

To streamline these solutions into manageable sets of actions, this report groups and sequences these solutions into the following phases:

- **Unlock:** five solutions that incentivise decarbonisation and accelerate technology development and testing.
- **Accelerate:** four solutions that build on the initial momentum, generate early investment and further develop incentives.
- **Scale:** two solutions that focus on the production and distribution of low-emission fuels.
- **Foundation:** one solution focused on vessel efficiency throughout the transition process because the existing fleet must not be overlooked.

23 **Barriers Mapped to Solutions**

	Readiness factors	Main barriers			Solutions		
Why should the sector change?	1. Market and Customer Demand	Customers and charterers are not willing to pay or co-fund lower emission solutions	Investors have no incentives to invest in companies with lower emission solutions	Financiers do not have the risk appetite to fund unproven technologies	Lack of transparency around emissions hinders decision-making	Scale-up Customer Demand	Green Finance	Investor Pressure
	2. Regulatory Incentives	Lack of binding regulation around carbon emissions limits progress	Enacting global regulation is a slow, and complex process with many interests to align	The industry is worried that misalignment of global and local regulation may lead to an uneven playing field		Global Regulatory Alignment	Port Coalitions	
Can the sector change?	3. Technology Alignment	Alternative fuels that support 2050 ambition have technical limitations, are unproven and / or perceived as unsafe	Too many future fuels are being considered, and there is lack of clarity on how the preferred fuel(s) will be chosen to allow for scale	HFO is hard to match in terms of commercial attractiveness and existing scale		Cross-sector Research and Development	Scale-up Controlled Pilot Projects	
	4. Clarity on Roles and Decision-Making	The global fleet is owned by many small companies and multiple stakeholders are involved in ship operations, complicating decision-making around new technologies	Contracting models are inflexible hindering investments that support lower carbon emissions			Coordinated Industry Commitments		
How fast can the sector change?	5. Ease of Asset Replacement	Ship owners are reluctant to invest in net-zero vessels due to risks resulting from lack of clarity around future fuels and regulation	Ship lifespans are long, requiring significant time to replace existing fleets			Flexible and Modular Designs	Operational Efficiency	
	6. Ease of Infrastructure Replacement	Infrastructure to produce zero emission fuels will require significant investment, time to scale up and will depend on decisions in other sectors	Bunkering providers and ship operators are waiting on each other to make the initial investments in net-zero ships and infrastructure			Scale-up Fuel Production	Scale-up Bunkering Infrastructure	

Severity

- Major
- Moderate
- Minor

UNLOCK

1. Scale-up Customer Demand

Charterers and customers have the biggest influence over how the shipping industry manages its emissions. Fundamentally, as a container operator stated, *"shipping is price-driven, the one with the lowest price will gain share."* However, customers have the leverage to interrupt this status quo by embedding sustainability in their purchasing criteria.

"Social pressure is growing and will be a major driver of this change"

Shipping customer

Increasing social pressure means that consumers, employees and shareholders increasingly favour companies which are committed to lower emission supply chains and have lower carbon credentials. Influential companies with a shared vision will be well positioned to make commitments and generate the scale that is required. Participating customers could implement initiatives to support *"green ship operators"* through long-term contracts, committing to volume on selected routes and incorporating emissions targets in tender criteria. Several companies already voluntarily disclose their scope 3 emissions and share these with their suppliers (see Exhibit 24). The industry believes that there is an opportunity for them to work together to create the necessary scale to drive change.

Shipping customers from some sectors are more likely to act than others. *"Sectors that are either under their own regulatory pressure, like automotive, or where there is high visibility with consumers and importance of branding, like FMCG or apparel, will be key,"* says one large freight forwarder.

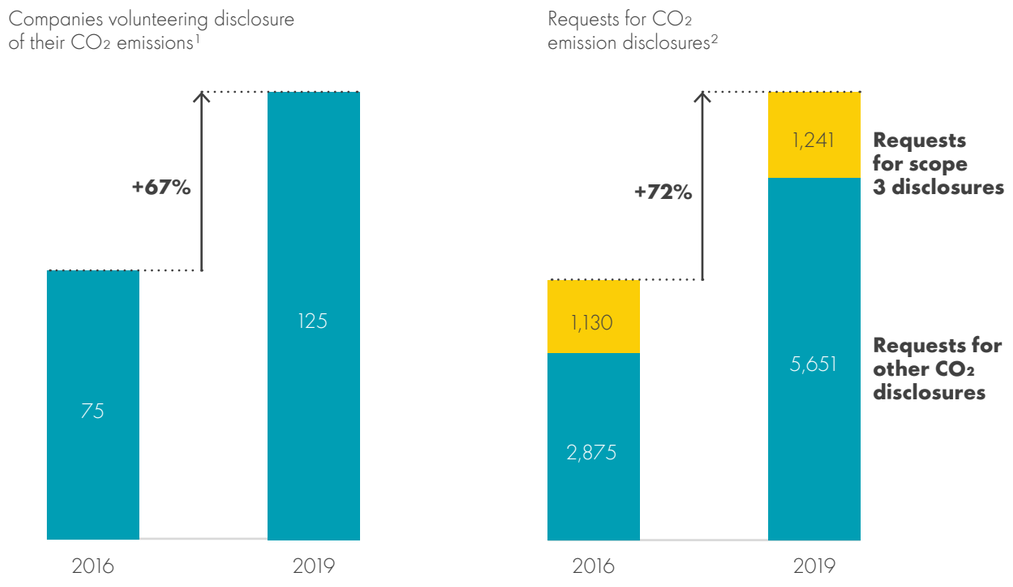
Ship owners and operators need to play a role by investing in lowering fleet emissions and in emissions transparency. They will need to share emissions data more openly or improve monitoring technologies to help customers make informed decisions and verify performance.

The benefits of this solution are twofold. First, a customer coalition can make ship operators more confident that green investments will pay off. Second, green marketed products may generate higher margins through green credits, creating an additional source of funding for the transition to low-emission fuels.

"We are talking about pennies or less on a unit basis for a consumer business to decarbonise"

Ship owner

24 **Supply Chain Emission Transparency**



Source: Carbon Disclosure Project. Notes: 1) CDP – Carbon Disclosure Project: a global system that member organisations use to verify supply chain emissions; 2) Company requests to suppliers asking for emission disclosure

2. Global Regulatory Alignment

Global, regional and local regulators need to reduce regulatory uncertainty and clarify time-bound objectives for the future. This must happen so that customers, ship-owners and ship operators can make confident investments towards lower-emission solutions.

"Shipowners don't care what it costs, as long as it costs the same for everybody"

Shipping scholar

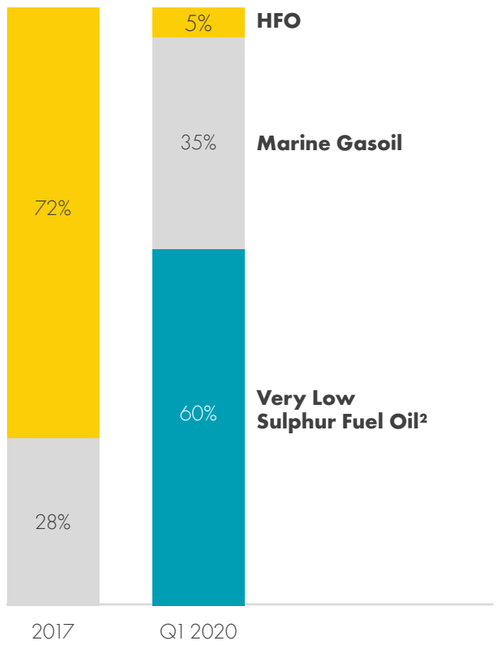
Given that the largest proportion of shipping emissions are from international deep-sea routes, global regulation will have the most significant impact. Importantly, this will create a more level playing field for companies that operate across multiple regulatory regimes.

New IMO guidelines due in 2023 need to provide some clarity. The alignment of national and regional regulation (particularly in China, the US and Europe) with IMO guidelines and with each other will then be required. Where appropriate, regulators need to consult widely with major ship owners and operators to understand how to make the transition practical and achievable for them.

In addition, interviewees highlighted short-term regulatory incentives as an opportunity to cover the costs of investments while maintaining a level playing field.

Two examples illustrate that with global regulatory alignment and clarity, the industry can successfully make a major transition. In the 1990s and 2000s the industry transitioned the global tanker fleet from single-hull to double-hull designs (see Exhibit 26), while just in the last few years, the IMO 2020 regulation enabled a global transition away from high-sulphur fuel oil (see Exhibit 25).

25 **IMO 2020 Fuel Transition**
Marine fuels used (based on US demand)[1]



- 'IMO 2020' shows targeted regulation can shift the industry towards a common goal
- Low sulfur regulations were implemented successfully by IMO without significant disruption to maritime transport and only few cases of compliant fuels unavailability to date

Source: IMO; Argus Media; SeaTradeMarine; Deloitte analysis. Notes: 1) US ports do not publish bunker sales data by type of fuel and EIA marine fuel sales data lags two years behind, therefore the fuel demand split is based on information from sellers 2) Very Low Sulphur Oil <0.5% m/m

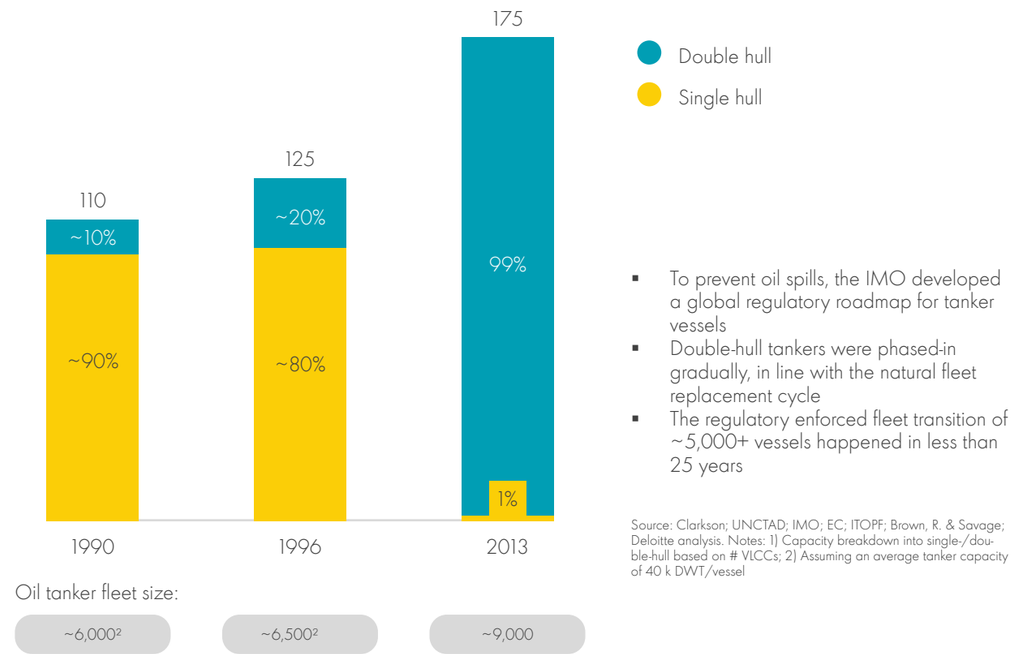
3. Cross-sector Research and Development

Whichever future fuel gains prominence, the industry must inevitably invest in R&D to transition the global fleet.

This requires energy companies, engine manufacturers, ship-owners and representatives of onshore sectors to come together to define technical requirements and priorities for fuel R&D and coordinate how to move forward. The mechanism can be a joint R&D fund or through direct investment. Partnerships could include those onshore industries that have geographic proximity to ports, such as those focused on fuel infrastructure or supply, or industries which face similar technical challenges and would benefit from working together.

Fuel availability will be a key factor for technology selection. As the CEO of a tanker operator asks, *"is it only suitable for shipping or is there competition from other sectors?"* For example, biofuels currently have limited supply due to competing demand. By working together with other sectors, the industry can increase clarity around which fuels are truly viable in the future.

26 **The Transition to Double-hull Fleets**
Very Large Crude Carrier fleet by type of hull (M DWT)[1]



- To prevent oil spills, the IMO developed a global regulatory roadmap for tanker vessels
- Double-hull tankers were phased-in gradually, in line with the natural fleet replacement cycle
- The regulatory enforced fleet transition of ~5,000+ vessels happened in less than 25 years

Source: Clarkson; UNCTAD; IMO; EC; ITOPF; Brown, R. & Savage; Deloitte analysis. Notes: 1) Capacity breakdown into single-/double-hull based on # VLCCs; 2) Assuming an average tanker capacity of 40 k DWT/vessel

"Shipping fuel will probably come from land, and we need to be jointly coordinating with these other sectors"

Shipping industry organisation

A coalition-based, cross-sector approach will create a much larger pool of capital and expertise and increase the likelihood that production and transportation infrastructure will be available once any future fuel is commercially viable. This should lead to more effective capital allocation and shorter timeframes.

4. Scale-up Controlled Pilot Projects

It is critical that the industry launch pilot projects focused on new fuels and other emission-reducing technologies along selected shipping routes, and that this happen in collaboration with their customers. Organisations can identify routes and types of cargo that are suited to specific types of fuel, like the way that ferries in northern Europe have increasingly adopted LNG or battery-powered vessels. Several interviewees considered pilot projects as the best way to learn about technologies and safety concerns. The pilots need to happen in different parts of the world to accelerate decarbonisation of the industry.

Operators that follow a predetermined schedule, such as container ships, are likely candidates for pilot projects. From a geographical standpoint, shorter and busier routes are more economical, allowing for a smaller dedicated fleet and fewer bunkering points to serve a disproportionate share of cargo (see example in Exhibit 27).

The solution will require engaging technology providers to develop new engines and operational improvements, and energy companies and ports to ensure fuel availability on the pilot routes. Governments will also play a key role in providing a source of funding for early-stage pilots.

5. Coordinated Industry Commitments

This solution aims to increase the reach and impact of existing decarbonisation initiatives and coalitions. In turn, this will accelerate other solutions such as R&D and pilot projects, and provide a transparent view on the roles and responsibilities of key players in the industry to reach the emissions ambition.

These industry groups and others represent positive first steps to address the decarbonisation challenge, though some interviewees believe that greater action is needed.

The high number of stakeholders involved in decarbonisation requires an orchestrating body to keep track of progress, ensure clear roles and responsibilities and consolidate or coordinate duplicate activities. A major industry player is unlikely to fulfil this role due to conflicting interests. A body with a specific mandate, formed with dues from the industry, could orchestrate the transition of shipping from ideas to action and break the deadlock in the process.

This solution requires the relevant parties to find win-win schemes and focus efforts on practical change.

"There are a lot of initiatives, but what's needed is coordination between them. To some extent they compete with each other and there's an opportunity to work together and take advantage of each other"

Shipping scholar

Exhibit 27

Green Corridor Project

The Green Corridor Project, initiated in 2016, was a joint industry project established to deliver a cost-efficient and environmentally-friendly solution for transporting iron ore and coal across the "Green Corridor" trade route between Australia and China that meets the IMO's 0.5% global cap on sulphur. The project was a collaboration between shippers serving the Australia-China trade route namely BHP, Fortescue Metals and Rio Tinto, ship owners MOL and U-Ming, along with LNG supplier Woodside, ship designer SDARI, and classification society DNV GL. The first phase of the project successfully delivered designs for a 210,000 DWT dual-fuel LNG 'Newcastlemax' bulk carrier. LNG supplier Shell and ship owner China Merchants, joined for the second phase of the project, which focused on upscaling the same design principles for a 260,000 DWT (VLOC) iron-ore carrier, concluding in late 2018.

Source: DNV GL; Marine Insight
Image credits: dnvgl.com

ACCELERATE

6. Flexible and Modular Designs

Ship owners, engine manufacturers and ship builders need to work together to develop modular or flexible propulsion systems that can either operate on multiple potential future fuels or be replaced cost-effectively. Although initially more expensive, these systems would reduce the risk and cost of any future fuel transition. *"It's important that you can modify your ship to use new fuels. That's what dual-fuel is doing while we wait for new technology,"* says a CEO of a ship operator.

Financiers will play an important role by enabling investments and minimising exposure to excessive retrofitting costs as emissions standards change. An assurance role by classification societies can make such decisions easier for risk-averse financiers. Lifecycle contracts could also help to de-risk future investments in lower-carbon technologies – especially if the cost of an engine is combined with the cost of future retrofitting, so the risk is shared between engine manufacturers and ship owners.

7. Port Coalitions

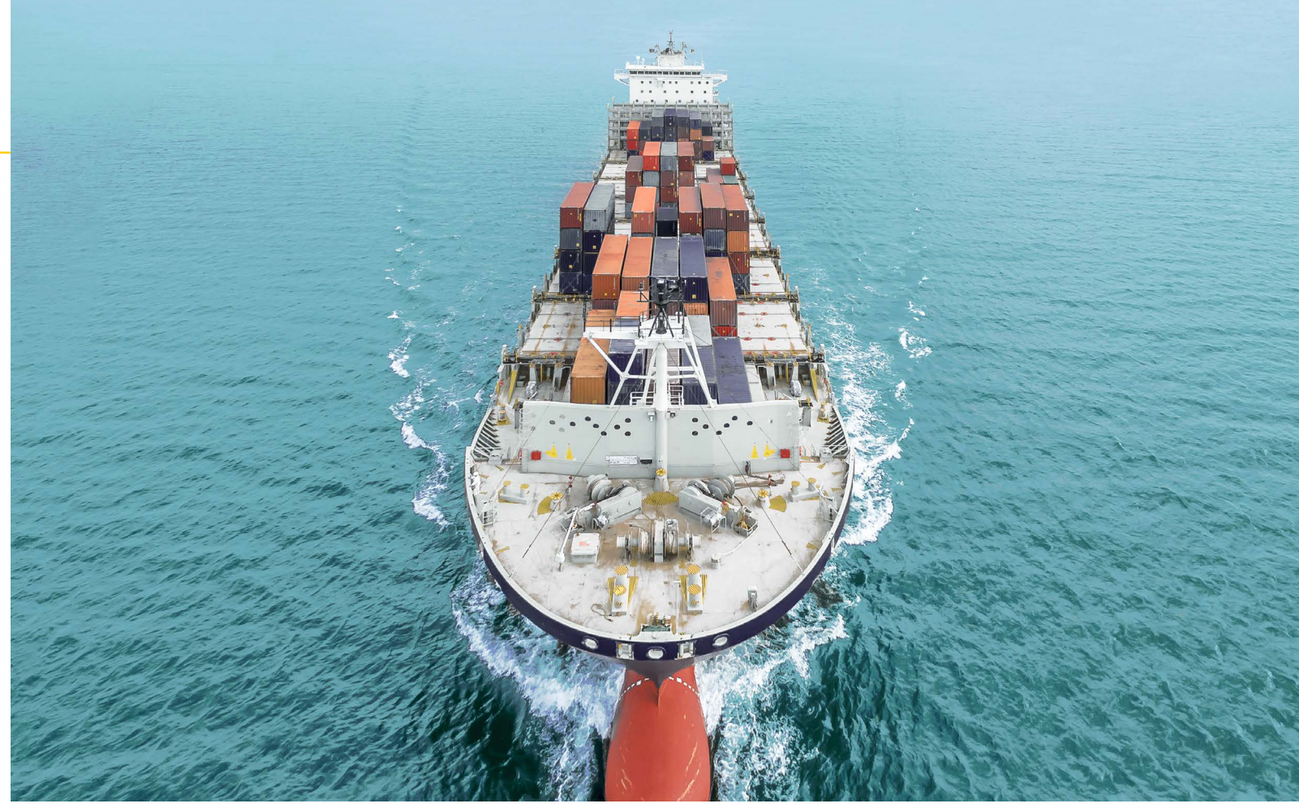
Given the concentration of global shipping volumes in a small number of ports (see Exhibit 28), interviewees believe port authorities have a key role to play in decarbonisation. If the largest ports align around a common goal, they can act as a *"forcing function,"* enabling regulation and incentivising green investments. To build scale, the largest ports in Asia, Europe and the US need to define common emission targets and measures. These ports can then design incentives and preferential treatment schemes for operators that invest in lowering emissions through measures such as reducing port charges or prioritising slot allocation.

Local and regional governments will need to help the participating ports address concerns of competitive disadvantage against peers in the region. By providing support, local and regional governments can help create a level playing field that is fair and procompetitive, while incentivising first movers from the operator side.

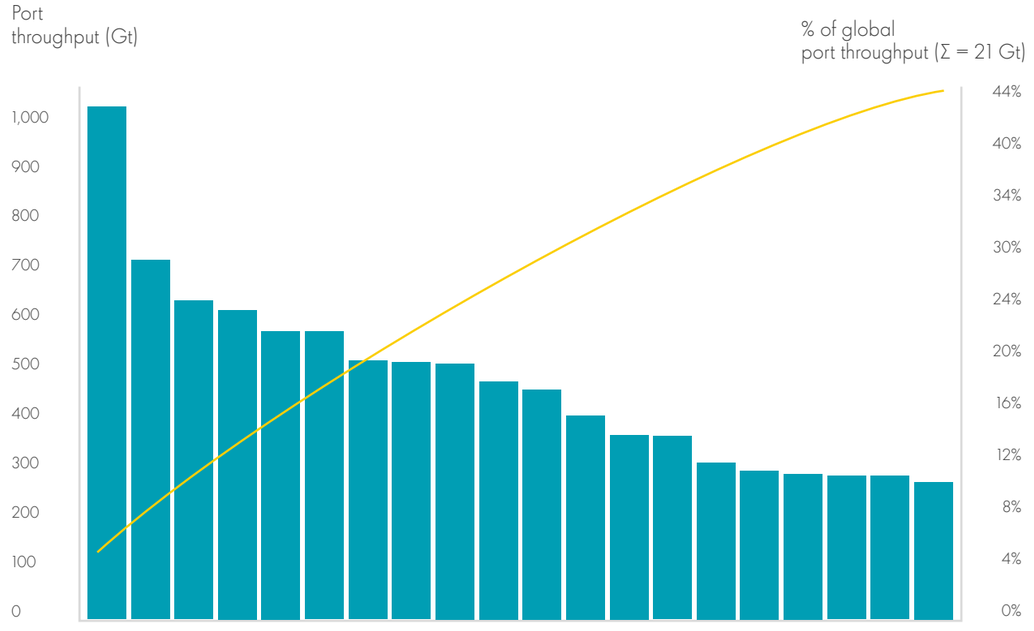
Large ports are better positioned to implement this solution, as they wield greater influence and face fewer competitive risks than smaller ones. According to one technology provider, industry stakeholders recognise that, *"if, the largest ports in Europe, Asia and US came together and said that from this and that day they won't allow HFO vessels, the operators would make the change."*

8. Investor Pressure

This solution is aimed at 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. The commitments can then be incorporated into management incentives and supervisory board guidance.



28 **Throughput of the Largest Global Ports**
20 ports handle 45% of global shipping throughput



Source: Deloitte analysis based, on UNCTAD (2019), Review of Maritime Traffic; Shanghai International Shipping Institute (2019), Global Port Development 2018, April

Publicly listed and state-owned companies account for most large ship owners and operators globally (see Exhibit 29). These companies are more visible than private ones and their investors are more likely to encourage sustainable investments.

Private companies are less prone to act as a unified group. However, interviewees noted examples of private companies with strong sustainability credentials, which are less constrained in decision-making and, thus, have more license to invest in decarbonisation.

All in all, investor pressure can have a significant impact by removing the issue of *"management hiding behind the business case"* and by creating incentives for venture-capital investments in green shipping technologies. The first signs are there said the CEO of one US-based tanker operator, *"until two years ago, I had never been asked a sustainability question by my investors. Now for every two or three investor meetings, it will be brought up at least once."*

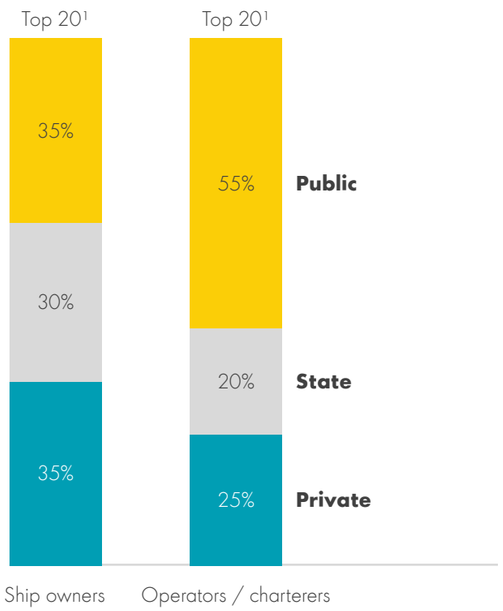
9. Green Finance

By defining and committing to sustainability targets for loan portfolios, large financiers can fund decarbonisation and send a signal that greener shipping is good business. As indicated by one European operator, *"investment is key to change – financiers are increasingly demanding green portfolios because their investors require it."*

Participating organisations will need to agree to joint standards of what constitutes green shipping and to develop dedicated financial products accordingly. Financiers can offer more capital for decarbonisation purposes or restrict capital for alternatives, both potentially with different risk-return profiles. To de-risk new technologies, new assurance schemes will need to be developed in collaboration with classification societies.

This solution applies to financing new ships and interviewees note signs of progress through initiatives like the Poseidon Principles. Additionally, several interviewees mentioned that once the principles are established to build new ships, financiers should expand their scope to provide capital in areas where it is less accessible, such as retrofitting, the second-hand market and recycling. *"There should be a bonus for scrapping unfriendly ships to hit two birds with one stone - improve economics and sustainability,"* noted one large customer.

29 **Top Ship Owners & Operators by Ownership**



Source: Clarksons; Company websites; Deloitte analysis Notes: 1) Based on DWT

SCALE

10. Scale-up Fuel Production

Once a future fuel reaches technical maturity, enough volumes need to be available for shipping. Energy companies will need to invest at scale in green fuel production, as well as in distribution networks. Whichever fuel is chosen, extensive investment in renewable power generation will likely be required to scale up production.

A cross-sector collaboration will be necessary to make the investments viable. As one ship manager said, *"if shipping can piggy-back on existing, onshore production infrastructure – this will be key."*

The industry will also need support from regulators to define technical standards for production facilities and to improve fuel price stability. Incentive schemes, such as universal carbon tax would dramatically increase the likelihood that sufficient production capacity is built.

11. Scale-up Bunkering Infrastructure

Bunkering infrastructure is a key final step in the transition to zero-emission fuels. Achieving this will require the coordinated efforts of energy companies, ports, financiers and ship owners. Interviewees discussed the need to establish long-term fuel contracts and targeted bunkering investments. They also mentioned the importance of driving safety standards and regulation for green fuels and of generating demand commitments for bunkering infrastructure.

Fuel and bunkering availability will require a long time and will be a capital intensive endeavour. Resulting infrastructure will be fundamental to achieving deep decarbonisation of the sector. However, success will be largely determined by actions taken elsewhere – in creating demand, establishing regulatory incentives and developing and piloting propulsion system technology.

FOUNDATION

12. Operational Efficiency

Given the 20 to 30-year lifespan of ships, those in operation today will still make up most of the fleet in 2030. Therefore, the industry will need to implement operational improvements to reduce emissions while the global fleet is undergoing a shift to zero-emission fuels. As one container operator states, *"the challenge is not in the new fleet, it's about what we have in the water already."*

> *"Hundreds of things can be optimised both on ships and off board"*
>
> *Shipping operator*

The industry needs to focus on accelerating the adoption of efficiency improvements across all segments of the shipping sector.

The next years are critical because, *"to get to the 2030 ambition we need technologies on the ship, as well as things like just-in-time operations, weather routing, improved reliability, voyage optimisation,"* noted the CEO of a classification society. Many in the industry are already implementing energy efficient technologies across a range of categories:

- **Design:** hull streamlining and propulsion design
- **Fuels:** higher-grade fuel oil
- **Lubrication:** air lubrication and high quality engine lubricants that enable more efficient performance
- **Navigation:** speed optimisation, weather routing and just-in-time arrivals
- **Utilisation**: partnerships and digitalisation solutions that help pool demand
- **Others:** wind technology, weather routing and port optimisation

These measures can result in less fuel being used, leading to lower emissions, while offering a cost saving advantage. The key is to establish a business case that generates extra investment, both on an individual basis and through engaging customers and regulators. The business case can improve through a change in the way chartering contracts are structured, such as extending contract duration and increasing benefit sharing schemes. To enable the solution, energy companies will need to make improvements to fuel and lubricant quality, while ports have a critical role in developing shore power, connectivity, emissions reporting and analytics infrastructure. Operators with their own vessels and those that operate their own terminals are best positioned to implement operational efficiencies at scale, leading the way for others to follow.

The Roadmap: Accelerating Decarbonisation

MOTIVATION AND IMMEDIATE FOCUS

As this research indicates, decarbonisation requires efforts by a broad and diverse group of stakeholders. Not only are the traditional ship owners, operators and regulators needed, but in many cases the customers, ports, financiers and others also need to play important roles. Organisations that show leadership in the early phases of the transition will position themselves to reap the benefits down the line. Technical readiness, faster and cheaper compliance, and consumer trust will be of significant value when lower-emission shipping inevitably gains traction.

In terms of specific roles, the focus for customers of shipping is to scale demand for low-emission shipping by working together with other companies that have made sustainability commitments. That demand will support early investments and pilots. In addition, shipping customers will need to redefine their contracts to ensure all stakeholders are incentivised to seek operational efficiency from the fleet.

Ship owners and operators need to collaborate with engine manufacturers, energy companies and onshore sectors to define the R&D roadmap. They also need to work closely with customers to pilot and test new technologies and fuels. Adopting flexible and modular designs in their new ships will be key to minimize misplaced investments and provide optionality as fuel R&D and other efforts continue. Also, operational efficiency must remain a top priority.

The main focus of the IMO and other regulators must be to establish a level playing field through global regulation that can be adopted at local and regional levels. That requires an ongoing dialogue between regulators and must be done in consultation with all segments of the industry. A broad set of perspectives and opportunities should be considered to achieve the 2030 and 2050 ambitions.

Engine manufacturers, ship builders and other technology providers need to play a leading role in R&D efforts. Together, they should co-invest and develop new designs that provide the flexibility needed for the transition. They should also proactively support and enable pilots required to mature new technologies and fuels options.

Energy providers must redefine how they support the development of new technologies and fuels. They need to offer their experience and knowledge of global markets and geographies to help build the supply chains needed for new technologies and fuel. Energy companies need to be part of R&D efforts and play a leading role in scaling up fuels and establishing the infrastructure.

Ports can be the forcing function of the ecosystem by creating a global coalition that supports, enables and incentivises green shipping.

Finally, investors and financiers need to lead activities that embed sustainable targets in business plans and balance sheets. They have an important role to play to ensure companies set decarbonisation objectives and adhere to them.

Exhibit 30 shows the key leading and supporting roles for the different solutions providing the clarity needed for stakeholders in the ecosystem.

30 **Who Will Play What Role in Shipping Decarbonisation**

	Key stakeholders	Charterers, customers of shipping	Ship owners, ship operators	Regulators, standards, industry groups	Engine manufacturers, ship builders, tech. providers	Energy companies	Port authorities and operators	Financiers and investors	Onshore sectors
Unlock	1. Scale-up Customer Demand	Lead	Support					Support	
	2. Global Regulatory Alignment		Support	Lead					
	3. Cross-sector Research and Development		Lead		Lead	Lead			Support
	4. Scale-up Controlled Pilot Projects	Support	Lead		Support	Support	Support		
	5. Coordinated Industry Commitments	Lead	Lead	Support	Support	Support	Support	Support	Support
Accelerate	6. Flexible and Modular Designs	Support	Lead	Support	Lead			Support	
	7. Port Coalitions			Support			Lead		
	8. Investor Pressure	Support	Support					Lead	
	9. Green Finance		Support	Support				Lead	
Scale	10. Scale-up Fuel Production			Support		Lead			
	11. Scale-up Bunkering Infrastructure					Lead			
Foundation	12. Operational Efficiency		Lead		Support	Support	Support		

Lead role
Support role

LET'S GET MOVING

As an engine manufacturer puts it *"we don't have much time to study things or wait for someone to find the solution for us."* There is a realisation that the industry needs to build on the ongoing initiatives and scale-up the change quickly.

To achieve the objective of having the first net-zero ships entering the global fleet around 2030, the industry needs to realise progress on all of the solutions in the next 10 years (see Exhibit 31). Tangible results across the solutions from the Unlock phase will be needed in the next two to three years to set the industry on the right path.

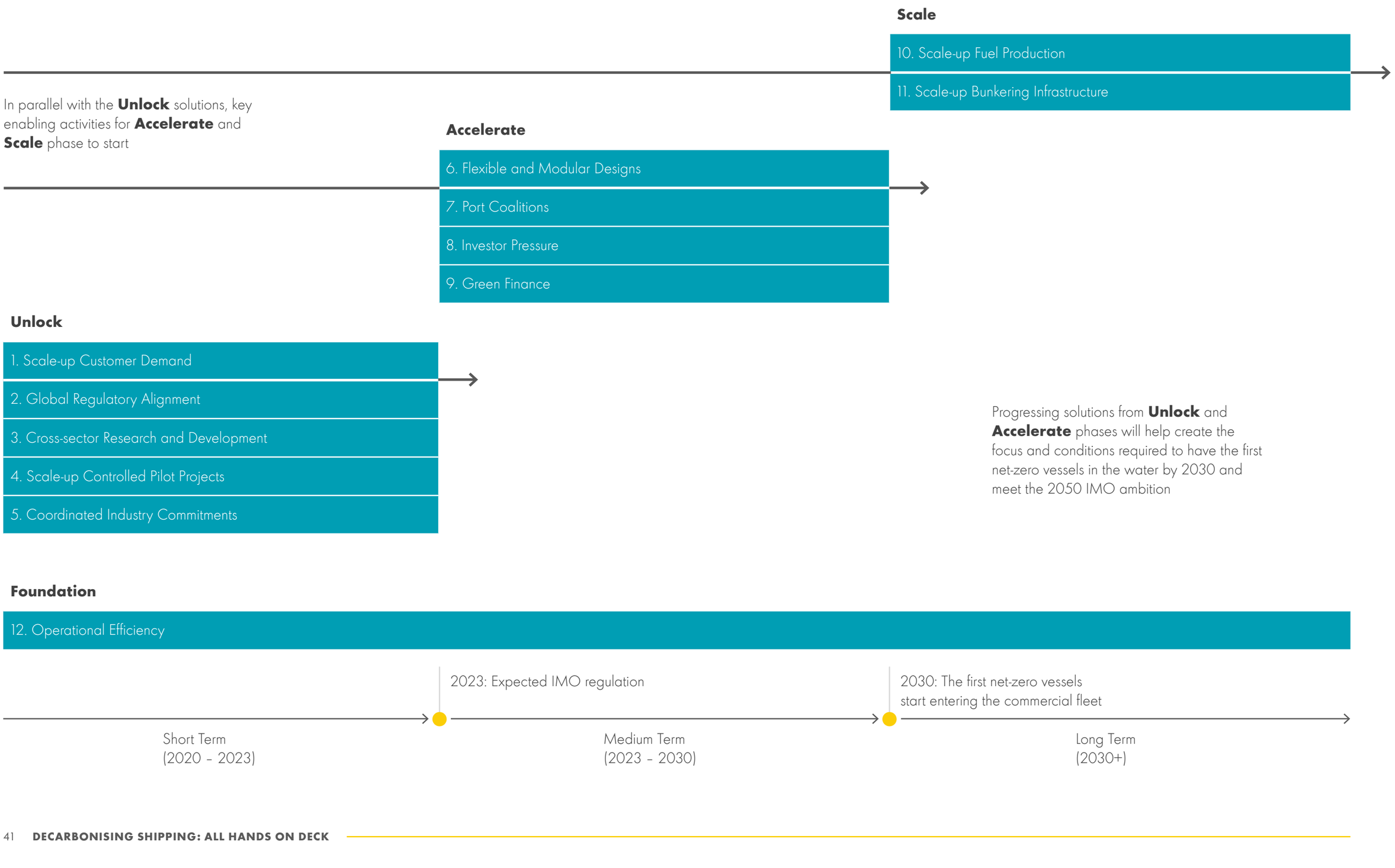
"We can build rockets that come back from the moon but not make ships green? No way. We can do it!"

Ship operator

Shipping leaders believe that this is doable, but it requires immediate engagement and mobilisation. The existing coalitions need to be the starting place. It is now critical to build on the momentum and work together today to drive real, practical change for the future.

Exhibit 32, at the end of the report, provides a summar of the solutions detailing the activities, enablers, dependencies and roles and responsibilities of key stakeholders creating the blueprint to decarbonise the shipping sector. It is time to get moving, it is "all hands on deck".

31 **Roadmap to 2030**



LEAD AND SUPPORT ROLES

32 **Summary of Solutions (1/3)**

Group	Solution theme	Key activities	Enablers	Dependent on	Lead roles	Support roles
Unlock Short-term: pre-2023	1. Scale-up Customer Demand	▪ Establish a coalition of large customers and charterers with shared commitments to create scale in demand for zero emission ships. Expand the coalition ▪ Offer long term contracts or secure demand for shipowners to invest ▪ Request owners and operators to share emissions data ▪ Implement consumer-facing activities to promote sustainable supply chains	▪ Long term contracts ▪ Value chain transparency ▪ Green certificates enabling customers to claim benefits ▪ Technology pilots as proof of concept for customer demand	8,3	▪ Major customers and charterers to drive scale in demand	▪ Ship owners and operators ▪ Investors to apply pressure on shipping lines
	2. Global Regulatory Alignment	▪ Align deep-sea shipping emission regulation between IMO and major regional and national bodies. Use IMO's upcoming 2023 guidelines as a basis for alignment ▪ Consult key industry players, including owners and operators, customers and engine manufacturers to define appropriate targets, timelines and guidance ▪ Define a transition timeline, with enforcement and reporting mechanisms	▪ Support from national governments and regulatory bodies in EU, China and US ▪ Emission reporting ▪ Value chain transparency ▪ Public commitments	-	▪ International regulators (i.e. IMO) ▪ Regional and national regulators (e.g. EU, China, US)	▪ Ship owners to provide domain expertise
	3. Cross-sector Research and Development	▪ Establish a coalition between energy companies, engine manufacturers, ship owners and notable representatives of other on-shore hard-to-abate sectors to define technical requirements and priorities for fuel R&D ▪ Create a joint R&D fund to coordinate and govern execution	▪ Fuel roadmap ▪ Public commitments from owners/ operators ▪ Open technical standards ▪ Committed energy companies with scale and expertise ▪ Government grants		▪ Large ship owners ▪ Key engine manufacturers ▪ Major energy companies	▪ Representatives from on-shore hard-to-abate sectors (e.g. steel, cement)
	4. Scale-up Controlled Pilot Projects	▪ Launch pilots of new fuels and emission-reducing technologies on selected shipping routes in collaboration with their customers ▪ Scale by combining smaller initiatives that establish infrastructure for large scale pilots ▪ Share pilot requirements and results (e.g. routes and types of cargo suited to specific types of fuel)	▪ Long term contracts ▪ Products with insignificant shipping cost additions from customers' perspective ▪ Energy companies with scale and expertise ▪ Government grants	1, 3, 5	▪ Ship owner / operators	▪ Customers / charterers as partners to drive pilots across the value chain ▪ Energy companies ▪ Engine manufacturers ▪ Ports
	5. Coordinated Industry Commitments	▪ Create or build on existing forums to coordinate ongoing industry decarbonisation initiatives and accelerate new initiatives in this report ▪ Establish a roadmap to accelerate R&D and pilots ▪ Provide visibility into decarbonisation activities happing across the ecosystem ▪ Coordinated tracking of progress against commitments	▪ Existing platforms such as Getting to Zero coalition ▪ IMO 2023 may be a catalyst for industry-wide collaboration	1, 2	▪ Customers / charters, and ship owners / operators to drive initiative	▪ Participation of all major industry groups in order to drive alignment and scaled commitments ▪ Engagement with all shipping stakeholder groups

32 **Summary of Solutions (2/3)**

Group	Solution theme	Key activities	Enablers	Dependent on	Lead roles	Support roles
Accelerate Medium-term: 2023-2026	6. Flexible and Modular Designs	▪ Strengthen partnerships between ship owners, engine manufacturers, and shipbuilders to accelerate development of flexible technology such as dual fuel engines, modular components and related vessel designs ▪ Define new contractual schemes (e.g. flexible/lifecycle contracts) that combine cost of engines with potential future retrofitting to more evenly spread the risk between engine manufacturer and ship owner	▪ New modular designs ▪ Scale in customer demand ▪ Long-term contracts	3	▪ Ship owners / operators ▪ Engine manufacturers to drive technology innovation ▪ Shipbuilders	▪ Financiers to support by providing access to funding ▪ Investors to provide source of pressure on owners to adapt ▪ Standards bodies
	7. Port Coalitions	▪ Establish a coalition of leading Asian, European, and American ports to define targets and measures around deep-sea shipping emissions ▪ Design incentives and preferential treatment schemes based on win-win principles for operators that invest in lowering emissions ▪ Align timelines and incentives with local and regional legislation	▪ Government support ▪ Large ports with green commitments ▪ Scale and consistency across participating organisations ▪ Ports that are close to urban areas and have higher resident pressure	2	▪ Key international ports across Asia, Europe and US	▪ Support provided by regional authorities (e.g. EU) to convene regional ports ▪ Coordination with ship owners / operators ▪ Fuel suppliers
	8. Investor Pressure	▪ Establish a coalition of leading institutional investors to come together and make public commitments to green investment portfolios ▪ Incorporate green metrics into management incentive schemes, as well as by general guidance on investor expectations	▪ Funds with green targets ▪ Consumer and NGO pressure on pension- and sovereign wealth funds ▪ Global regulatory alignment	2	▪ Large institutional investors with stakes in shipping companies (e.g. pension funds, sovereign wealth)	▪ Ship owners / operators respond to investors ▪ Energy companies and on-shore sectors provide support
	9. Green Finance	▪ Define and commit to sustainability targets for asset and trade loan portfolios (e.g. Poseidon Principles) ▪ Agree on joint standards on what constitutes green shipping investments (e.g. LNG, operational improvements) and develop dedicated green shipping financial products ▪ Expand scope of green investments from newbuilds to retrofitting and vessel recycling considerations	▪ Owners/ operators with strong balance sheets making first investments –offering proof of concept for future financing of similar technology ▪ Long-term vessel contracts with clear cash-flows ▪ Regulatory targets and roadmap	2,8	▪ Leading shipping financiers to scale availability of green finance and expand range of signatories	▪ Ship owners and operators to partner with key financiers ▪ Regulators to support with schemes that reward banks with green portfolios ▪ Investors to apply activist pressure

32 **Summary of Solutions (3/3)**

Group	Solution theme	Key activities	Enablers	Dependent on	Lead roles	Support roles
Scale Medium to long-term: 2026+	10. Scale-up Fuel Production	▪ Launch a cross- sector collaboration focused on scaling production and distribution infrastructures for green fuels, starting with key locations and specific routes ▪ Establish production and distribution infrastructure for green fuels ▪ Regulate during transition period to stabilise market volatilities and encourage switching (e.g. through pricing)	▪ Standards for new fuels ▪ Cross-sector research and development ▪ Carbon tax ▪ Investments in renewable power generation ▪ Energy companies with scale and expertise	3	▪ Energy companies (green energy providers)	▪ Regulators (international, regional and national) to enable market stability for new fuels
	11. Scale-up Bunkering Infrastructure	▪ Coordinate effort between energy companies (entering into long-term fuel contracts, making targeted bunkering investments), ports (creating safety standards and regulation for green fuels), financiers and ship owners (making demand commitments for specific green fuels in specific ports)	▪ Fuel availability	9, 10	▪ Energy companies (green energy providers) to scale supply	▪ Ports ▪ Financiers ▪ Ship owners
Foundation 2020+	12. Operational Efficiency	▪ Formalise incentives for fleet operational efficiencies (e.g. regulations on speed, emission reporting) ▪ Develop new hardware for more efficient vessels (hull designs and coatings, propulsion systems, etc.) ▪ Develop new technologies and systems for more efficient navigation (routing optimisation, JIT, etc.) ▪ Share non-competitive best practices and knowledge on efficiency measures ▪ Establish contracts with clauses to encourage operators to take efficiency measures	▪ Long-term contracts ▪ Flexible contracts to enable shared benefits ▪ Global regulatory alignment ▪ R&D ▪ Technology pilots		▪ Ship owners / operators integrate solutions	▪ Technology providers such as shipbuilders to deliver design innovation ▪ Universities and research centres to stimulate innovation ▪ Ports (e.g. for provision of shore-power, optimised arrivals, emissions tracking analytics) ▪ Energy companies to improve quality of lubricants and fuels

CREDITS

We wish to thank all those who were involved in the development of this research. We appreciate your time, energy and enthusiasm, particularly during the period of disruption caused by the COVID-19 global pandemic.

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