Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

What will it take to decarbonize global shipping?

Five critical levers that make a difference

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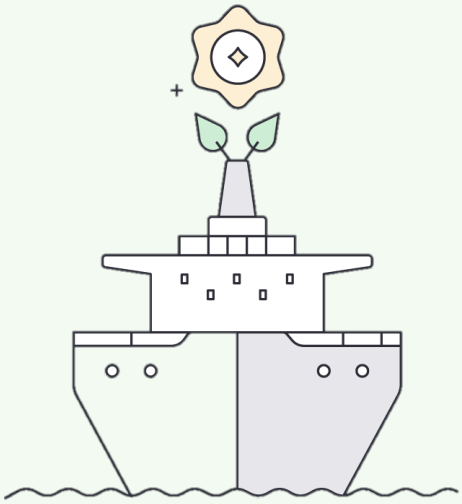

A three-part series explores maritime transportation's decarbonization journey, complementing the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping's "Industry Transition Strategy" report.

The second installment takes a look at the critical levers in five key areas to accelerate the decarbonization of the maritime industry.

The Center would like to thank McKinsey & Company, as knowledge partner to the Center, for its analytical and editorial contributions to this series of articles.

Introduction

Global shipping's determination to reach carbon zero is admirable—but what will this endeavor actually require?

In our first article, we learned that the shipping industry's current trajectory could result in emissions growing around 20 percent by 2050. Changing direction towards carbon zero will involve significant challenges, such as the high cost of clean fuels, misaligned financial incentives between ship owners and charterers, and a lack of consensus among various stakeholders.

To overcome these hurdles, it's crucial to take stock of the tools we have at our disposal. Which will make the biggest impact? How can we can wield them for maximum positive outcomes? Together with our partners, the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping has identified five critical levers that stakeholders could activate to meet existing challenges, and accelerate the pace of decarbonization in global shipping. (See infographic 1.)

While these levers apply to different facets of the shipping ecosystem, and impact various stakeholders differently, it would be a mistake to think of them in isolation. In our analysis, no one lever by itself is able to generate sufficient impact on decarbonization. To stand a fighting chance of propelling the shipping industry toward carbon zero by the middle of the century, stakeholders will need to activate all five levers in concert, sparking the reinforcing effect they have on each other.

We analyze the impact of levers in five critical areas, using the most probable and realistic outlook

1 Tech advancements on ship

2 Energy & fuel advancements

3 Policy and regulation

4 Finance-sector mobilization

5 Customer demand/pull

Note: These projections and outlooks are subject to significant uncertainty, predominately linked to the evolution of global environmental regulation and enforcement; global trade developments; and the cost and competitiveness in the development of fuel alternatives. More information on each individual lever is presented in our "deep dives".

Ship efficiency

Innovations made onboard a vessel to enhance its fuel economy have the potential to deliver a 40–50 percent reduction in energy demand in new ships. Onboard energy efficiency plays an important role both in the short-term and the long run because it is fuel agnostic. This means that if and when alternative fuels become more widely used, technologies improving fuel efficiency will unlock further reductions in carbon emissions.

When it comes to existing technologies an industry wide implementation of a best practice of technology adoption, application to optimise powering systems and fleet operations holistically can take us a long way. Substantial gains can for example be achieved by implementing air-lubrication and wind-assisted propulsion technologies on existing ships, as well as voyage optimization software to reduce fuel burn on a large scale.

In terms of new technology, there are several promising avenues to pursue, which may unlock greater efficiency. For example, giving hulls biomimetic surfaces by replicating the qualities of shark skin, or incorporating passive air-entrapment qualities to reduce friction. Researchers could take inspiration from history's seafarers, harnessing the power of wind as a primary source of propulsion, going beyond the flettner rotors and traditional sails already on the market.

Of course, digitalization and advanced data analytics could also optimize cargo flows. Many of these nascent technologies are still at the research and development stage, and safety, scale, and operational challenges may hinder their eventual impact.

By reducing fuel consumption and saving on emissions, ship efficiency is often "in the money" today, on a total-cost-of-ownership (TCO) basis. It also comes with the added advantage of having the biggest impact on decarbonization from now to 2030. More efficient fuel consumption may help bring forward the moment when alternative fuels become more economically attractive to shipping companies.

Compared to alternative fuels, most onboard efficiency innovations are cost-competitive, and typically yield good returns on investment. However, there are numerous technologies that are not getting the attention they deserve. Without continued investment, and increased penetration of new technologies, energy savings will be limited.

Activating this lever would require the industry to agree to extend the payoff times on such investments, by adjusting commercial structures and incentive dynamics. We estimate that if these new technologies were to become commercially available and widely adopted, better ship efficiency could lead to a ten percent reduction in carbon-dioxide emissions every year to 2050. Furthermore, activating other levers—such as government coordination and leadership—could further reinforce and boost this impact.

Alternative fuels

Technological advances could also open up more sustainable and environmentally friendly fuel options. There are two primary categories of alternative fuels: biofuels and electrofuels, each of which comes with a specific set of challenges that hinder their widespread adoption.

Biofuels are sources of energy derived from biomass such as trees, crops, municipal waste, and animal manure. With heat and pressure applied, these materials are refined to extract carbon and hydrogen. Examples of biofuels are bio-methanol and bio-methane. These chemical processes have been around for decades, and innovation is unlikely to improve efficiency by the orders of magnitude necessary to make significant impact on carbon reductions.

Another limiting factor pushing up the price of biofuels is that gathering the feedstocks needed to create them is expensive. Raw materials are dispersed: vast networks of collection facilities are required to coordinate the transportation of feedstocks from both urban and rural areas, where farms and forests spread out over large swathes of land.

The other category of alternative fuels, electrofuels, depends on wind and solar energy to create green hydrogen, which then can be transformed into various e-fuels to power ships. Unlike the processes used to manufacture biofuels, the electrolysis technology used to harness solar and wind power is less mature, which means that much of its potential is untapped. A significant learning curve lies ahead as deployment scales up. In addition, the levelized cost of solar and wind power

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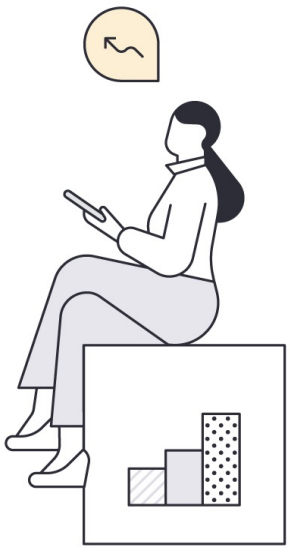

continues its steady march downwards as those technologies mature. Both these effects point to electrolysis becoming increasingly cost-competitive.

One potential fuel that could make a difference is e-ammonia, which isn't yet commercially available in the maritime industry. However, production technology is already known and optimized given the century-long production of fertilizers. The challenge of using e-ammonia as a marine fuel is two-fold: technical (shortage in its main ingredient - green hydrogen, toxicity/handling and refrigerated/pressurized storage), and commercial (engines, bunkering infrastructure, and safety procedures). If these hurdles are overcome, however, e-ammonia would enjoy a long-term cost advantage.

In the meantime, e-methanol offers a number of advantages. It has more manageable handling requirements, and unlike e-ammonia engines, projected to enter the market in 2024, e-methanol engines are already commercially available.

Unlike onboard technological innovations, alternative fuels are currently not cost-competitive, although the cost of utility-scale wind and solar energy has fallen by between 5 and 15 percent annually over the past five years. If no further action is taken, prices may continue declining at a gentler rate, with levelized cost of electricity reaching about half of today's by 2050.

It's crucial that further improvements in the development and deployment of alternative fuels accelerate at a pace faster than the growth in demand for shipping fuel. Our modeling suggests that, despite the industry's best efforts, the big price gap between fossil and alternative fuels won't narrow sufficiently in time, to the point where the entire industry is incentivized to switch their energy source. Thus, despite clean, renewable sources of energy being a critically important component of global shipping's decarbonization efforts, we'll need additional support from other levers to fully realize the industry's carbon-zero ambitions.

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Technology alone won't set global shipping on a path to carbon zero

What has emerged from our analysis is that technology and innovation, as they apply to onboard ship infrastructure and energy sources, may be inadequate levers in themselves to set global shipping's course toward carbon zero. Shipping is a conservative industry, where technologies need to be trialed and proven to work in multiple contexts before they are adopted at scale. Furthermore, the average ship lasts over 20 years, making renewal of the fleet a slow-moving process.

Thus, getting the shipping industry to carbon zero is not just in the hands of shipping companies. The sector needs to work together with other offtake markets to scale up both R&D investment in green solutions, and the widespread adoption of new technologies. This is why the remaining three levers—policy and regulation, low-cost financing, and customer willingness to pay for decarbonized shipping services—play an indispensable role in accelerating the advancement and widespread adoption of these solutions.

Policy and regulation

Not all policy and regulations are effective or achieve their purpose. Some may be too restrictive, while others may be too weak or improperly enforced. But that does not mean that all regulation is harmful. In fact, we see regulation as an essential tool in achieving the international goal, and collective public good, of mitigating climate change.

As mentioned in the first article, ship owners are often not incentivized to outfit their vessels with the latest green technology, as they are often unable to share the financial burden with ship operators and charterers, who will likely opt for a cheaper lease. Governmental intervention could correct this misalignment.

The IMO is already coordinating this international effort by establishing consensus among member states on a number of fronts: carbon pricing schemes, and clear regulations for energy-efficiency measures adopted by shipping players.

As of now, no clear pricing agreement exists, even though discussions on the issue will shortly take place at the IMO. A current reference is the EU ETS carbon-trading price, which, in the first half of 2021, was around $50 per ton of carbon dioxide.

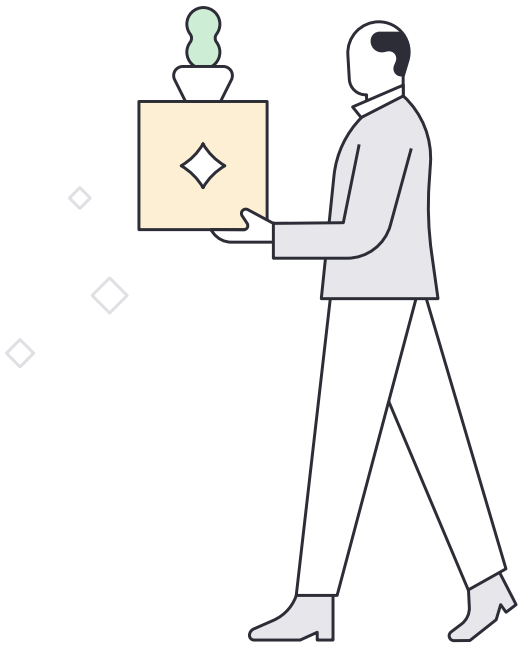
With a carbon pricing of $50/tCO$_2$, large cost gaps will continue to exist between fossil fuels and the more expensive, alternative fuels with low emissions intensity. However, it is sufficient to close the gap between cheaper alternatives such as bio-oils, which may trigger wider adoption of this fuel type. Our NavigaTE model estimates that a $50/tCO$_2$ levy on its own could lead to emissions reductions of around five percent more than what we would expect to see by 2050. This is obviously far from enough, and higher levies may be needed to reach Paris climate targets.

That said, it's encouraging to see some players showing leadership in this area by proactively discussing the carbon cost and implementing policies. Trafigura is proposing reinvesting $250 to $350 per ton of carbon dioxide equivalent into green technology R&D, while Maersk has suggested a tax of $150 per ton of carbon dioxide. Meanwhile, Norway has announced plans to impose national shipping quotas.

The second role regulation could play is in setting stricter standards governing the improvement of designs of new and existing ships, and lowering the carbon intensity of operations. Instead of focusing on alternative fuels, the priority is placed on reducing the energy demand of fleets.

In 2020, the IMO introduced the second phase of the Energy Efficiency Design Index (EEDI) for new ships, with the third phase coming into effect in 2025. By 2023, the Energy Efficiency Design Index for existing ships (EEXI) will make it mandatory for vessels already in operation to comply with phase-two regulations. Finally, all vessels will also have to adhere to the Carbon Intensity Indicator (CII) by 2023, which should yield a one percent improvement yearly from 2019 to 2022, and two percent annual improvements from 2022 to 2026. These requirements are valid until 2026.

Activating this lever could require all new vessels designed and built after 2030 to further improve energy efficiency by ten percent, and extend the current standards for carbon intensity during operations through till 2030. Tightening regulations to ensure that vessels are more energy efficient would have a critical impact on emissions reduction.



Low-cost financing

Green finance has been a flourishing sector since the Paris Agreement, standing at the crossroads of financial, socio-economic and environmental challenges. It uses financial instruments to accelerate the transition to a low-carbon economy, focusing on environmental issues, and providing a growing range of green and sustainable instruments.

The global maritime industry's transition to carbon zero is a costly endeavor, and one in which many shipping-industry players struggle to raise the necessary capital to participate. Just as impact and sustainable investing becomes increasingly mainstream, and more investors prioritize incorporating ESG (environmental, social and corporate governance) elements into their portfolios, opportunities are also opening up in the maritime sector.

Global financial commitment is needed to ensure that financing the ecological transition is genuinely effective. The financial sector now has a unique opportunity to accelerate and steer global shipping's journey toward carbon zero, by providing cheaper financing that rewards sustainability-focused endeavors.[1] Furthermore, MSCI research confirms that companies that are high ESG performers enjoy lower costs of capital, regardless of industry. This could incentivize the industry to pursue and adopt more environmental practices.

Our analysis suggests that because fuel consumption represents around 20 to 30 percent of a vessel's annual cost, there's a limit to how much cheaper financing will impact carbon emissions. Nonetheless, combined with the other levers, it'll help bring the industry a step closer to its decarbonization goals.

Customer willingness to pay for decarbonized shipping

After governmental regulation and accessible financing narrow much of the cost gap, shipping companies may find that customers are willing to pay a premium for zero-carbon shipping.

Sustainability and environmental issues have risen to the top of the world's social consciousness. Across the globe, 67 percent of people consider climate change and the loss of biodiversity the top challenge over the next decade. Not only do more than half believe their individual habits matter in tackling climate change, but they are willing to change their purchasing habits to reduce their carbon footprint.

[1] A good example of such commitment is the Poseidon Principles – a global framework for assessing and dis closing the climate alignment of financial institutions' shipping portfolios. Currently 27 financial institutions are Signatories, representing nearly 50 percent of the global $400-billion ship-finance portfolio.

On the surface, what this seems to indicate is that customers are willing to pay more for sustainable shipping, which relieves some of the cost burden on shipping companies. Research suggests that the closer the customer is to the supply chain, the more willing they are to pay a premium for sustainable practices. This means shipping companies are likely to be able to charge more for (some) container freights than for dry bulk and tankers. We also see an increase in corporate willingness to pay for sustainable practices (especially around scope-3 emissions), as brands seek to burnish their green credentials.

However, reality is more complex; research reveals that surprisingly few consumers actually walk the talk. We analyzed the percentage of consumers reporting positive sustainability attitudes who actually follow through with their wallets. In 2020, only around ten percent of maritime consumers acted on their willingness to pay a low premium. There's also the risk of companies greenwashing their practices, which may give rise to consumer skepticism around paying more for carbon-zero shipping. This gap between what is said and done will likely limit the impact of changing customer expectations.

Even given the industry's best efforts, the reduction potential of this lever in the global maritime industry may be less than what we hope for. While customers may be willing to spend a little more for sustainable shipping, the industry should not rely on them as a major source of decarbonization funding.

Despite the many roadblocks on the road to carbon zero, the global shipping industry is not without the tools it needs to clear them. As this article has laid out, we have five critical levers, all of which must be pulled to catalyze the transition. If we activate them all together, they reinforce each other. However, this means decarbonization decisions and actions must be made today, following a clear abatement roadmap.

This roadmap must combine actionable quick wins with long-term goals, enabling a continuous transition toward net-zero emissions that keeps all stakeholders on board. Our final article explores what these steps are, and what shipping players can do to effect the necessary change.

About

Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

The Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping is a not-for-profit, independent research- and development center working across the energy- and shipping sectors to explores viable decarbonization pathways for the maritime industry.

With partners from leading organizations across the world, we accelerate the development and implementation of new energy solutions and technologies.

The Center was established in 2020 with a start-up donation from the A.P. Moller Foundation.