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Accelerating a Zero-Emission Transition in Maritime Shipping:

The Solutions Landscape and Opportunities for Philanthropy

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Accelerating a Zero-Emission Transition in Maritime Shipping: The Solutions Landscape and Opportunities for Philanthropy

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Executive Summary

Almost everything in your home—from your sofa to your toaster to your shampoo—likely traveled to you on a ship. About 90% of world trade utilizes maritime shipping, and nearly all vessels involved in moving goods around the world run on fossil fuels. The international maritime shipping sector is at a critical decarbonization inflection point, with tremendous implications for the health of our planet and future climate scenarios. Under its current trajectory, the sector could account for 10% of global greenhouse gas emissions by 2050—or the sector could instead transform itself into a zero-emission industry.

This primer is intended as an informational resource for anyone looking to better understand the current state of play in the decarbonization of international maritime shipping. Philanthropy, civil society, policymakers, and industry representatives will find an easy-to-digest guide that outlines the challenges and opportunities in this rapidly evolving sector.

The report begins with an orientation to the shipping sector's role as a driver of climate change. It then transitions into the solution sets in this space. Finally, it concludes with investable opportunities for accelerating a zero-emission transition in shipping, with a focus on philanthropy's unique role as a catalyst. While new funders are entering this space and providing greater support for shipping decarbonization, there is still significant need and a tremendous opportunity for philanthropy to support shipping decarbonization solutions to protect ocean health, mitigate the impacts of climate change, and limit air pollution that impacts vulnerable communities and ecosystem health.

Key Takeaways

Maritime shipping accounts for 3% of global greenhouse gas emissions, or roughly 1 billion tonnes per year.

Action is needed this decade to ensure shipping can align with a 1.5° Paris Agreement-aligned trajectory and fully decarbonize no later than 2050, given that maritime infrastructure and other capital investments are long lived (e.g., Large container ships have a lifespan of up to 30 years).

Maritime shipping is regulated at the global level, unlike many other global industries whose governance is fragmented. Action by the International Maritime Organization, a body of the United Nations, provides a unique opportunity for a comprehensive approach to the sector's decarbonization.

Maritime shipping is a global industry that needs global solutions to decarbonize (e.g., global regulation, fuel readiness at scale), but opportunities also exist for significant decarbonization leadership and innovation at the national, regional, and port levels.

Green maritime shipping corridors are an avenue for coordinating across stakeholder groups in specific high-potential geographies to align incentives, test-drive new technologies, target investments, and build public-private partnerships.

Ambitious global policy combined with growing customer demand for zero-emission shipping services can drive innovation, support first movers, incentivize laggards, and ensure elements of justice and equity are incorporated into the transition.

Advancing the scale, pace, and inclusivity of the maritime sector's transition to zero emissions will result in tangible climate benefits and enhance both ocean and human health more broadly.

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Decarbonizing Maritime Shipping as a Leading Ocean-Climate Solution

Emissions from the maritime shipping sector are a major contributor to climate change, air pollution in port communities, and degradation of ocean health. Representing 3% of global emissions, the maritime shipping sector emits close to 1 billion tonnes of greenhouse gases a year, equivalent to the emissions of a G7 country like Germany or Japan. As other sectors of the global economy make progress reducing their emissions, those from the maritime shipping sector are still rising. Left unchecked, these emissions are on track to increase up to 130% from 2008 levels by 2050, threatening our ability to reach the climate goals of the Paris Agreement.

Rising emissions not only impact global temperatures, but also have hyperlocal effects in port communities around the world; 14 million childhood asthma cases annually can be linked to emissions from maritime shipping, and shipping emissions have been found to contribute to approximately 60,000 deaths annually. Maritime shipping is the predominant source of human noise pollution in the ocean, degrading ocean habitats and impacting whales and other long-lived marine mammals.

In the face of overlapping climate and biodiversity crises, there is increasing societal expectation that harder-to-abate sectors like maritime shipping do their part to eliminate emissions, particularly as technological and economic pathways become clearer. Therefore, in recent years, decarbonizing maritime shipping has gained attention as a priority for public, private, and civic sector action.

Discussions on maritime shipping decarbonization have benefited from the growing recognition that ocean-based climate solutions are critical for achieving societal climate goals. A 2019 report from the High Level Panel for a Sustainable Ocean Economy lists ocean-based transport decarbonization as one of five priority ocean-based climate action areas. Decarbonizing maritime shipping represents a major opportunity for countries to reduce their national emissions while at the same time scaling zero-emission shipping solutions that can help decarbonize the global maritime sector and broader energy supply chains. It also offers companies that rely on shipping an opportunity to reduce their supply chain emissions, which are usually the biggest barrier to achieving their net-zero goals. The zero-emission fuel requirements for decarbonizing the maritime shipping sector can further incentivize the development of renewable energy. Because the maritime shipping sector has global reach paired with local, regional, and national impact, progress in this sector has potentially far-reaching benefits.

Given the long lifespan of vessels and the on-land infrastructure investments needed to facilitate shipping's

(right) Southern California industrial facilities adjacent to neighborhood recreation areas. Manhattan Beach. Photo: iStock/rarpia

transition to zero, efforts to decarbonize the sector must begin in earnest during the 2020s to align with a 1.5° Paris Agreement-aligned path. **Figure 1** shows the emissions reductions needed to meet various Paris-aligned trajectories, compared to the sector's current emissions trajectory. Achieving these reductions and ultimately completely decarbonizing shipping requires the sector to begin shifting from fossil fuel to new zero-emission means of propulsion, ranging from electrification for shorter distances to a variety of new zero-emission fuels for transoceanic voyages. Those fuels in turn must be supported by new zero-emission fuel value chains, addressing factors such as fuel storage and transportation as well as verification and quality control of emissions reductions.

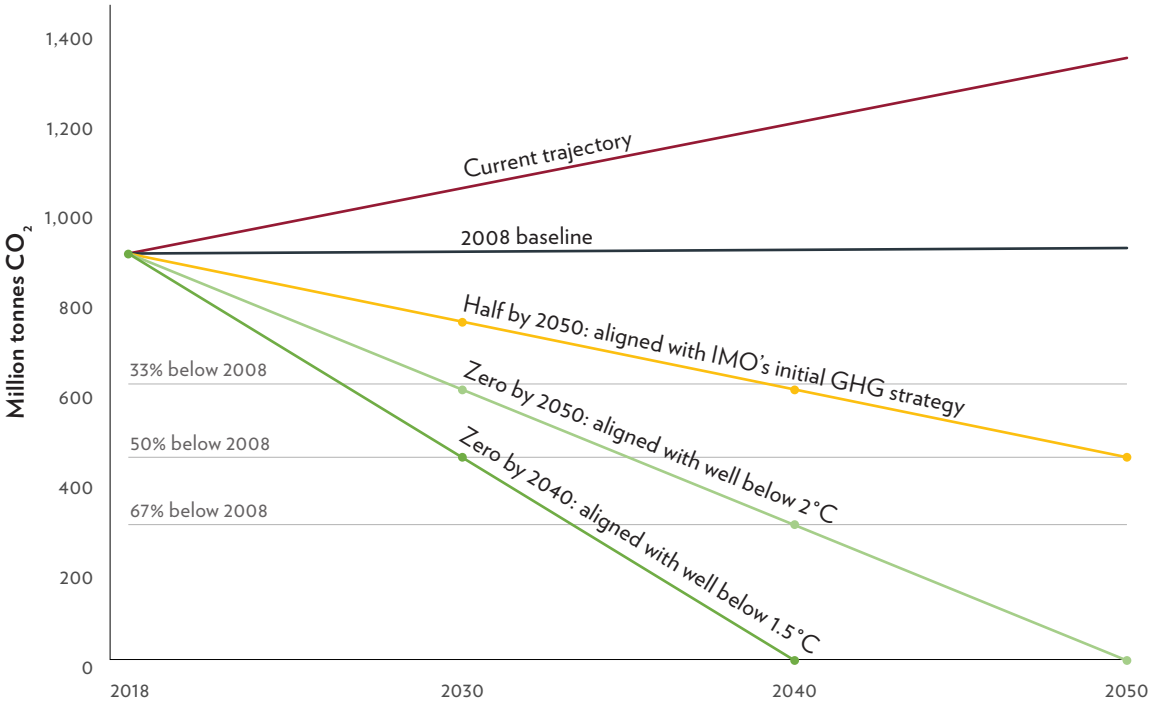

Figure 1. International shipping emissions trajectories to 2050 with interim targets for absolute emissions reductions
International shipping emissions consistent with the Paris Agreement temperature goals require emissions from the sector to fall by one-third or one-half by 2030 and to be zero by 2040 or 2050, depending on alignment with a 1.5° or 2° Celsius trajectory. Adapted from source: The International Council on Clean Transportation.

> *Decarbonizing maritime shipping also offers companies that rely on shipping an opportunity to reduce their supply chain emissions, which are usually the biggest barrier to achieving their net-zero goals.*

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Pathway to Zero-Emissions: Contribution of New Fuels and Technologies

Nearly all vessels now operating on the water (both inland and oceanic vessels) run on fossil fuels. Efficiency measures can reduce emissions intensity in the short term through technical and operational improvements, and such measures should be taken aggressively to reduce emissions now. But the maritime shipping sector cannot decarbonize if it continues to use fossil fuels to power ships. The sector will require a diverse array of solutions depending on factors such as geography and vessel type. For example, smaller vessels with set routes, such as ferries, are prime candidates for electrification as a form of propulsion, while large oceangoing cargo ships at this time cannot feasibly be powered by batteries and instead are expected to require energy-dense liquid fuels. To shift the sector onto a 1.5° Paris Agreement-aligned path will require massive development and deployment of new zero-emission fuels and associated technologies.

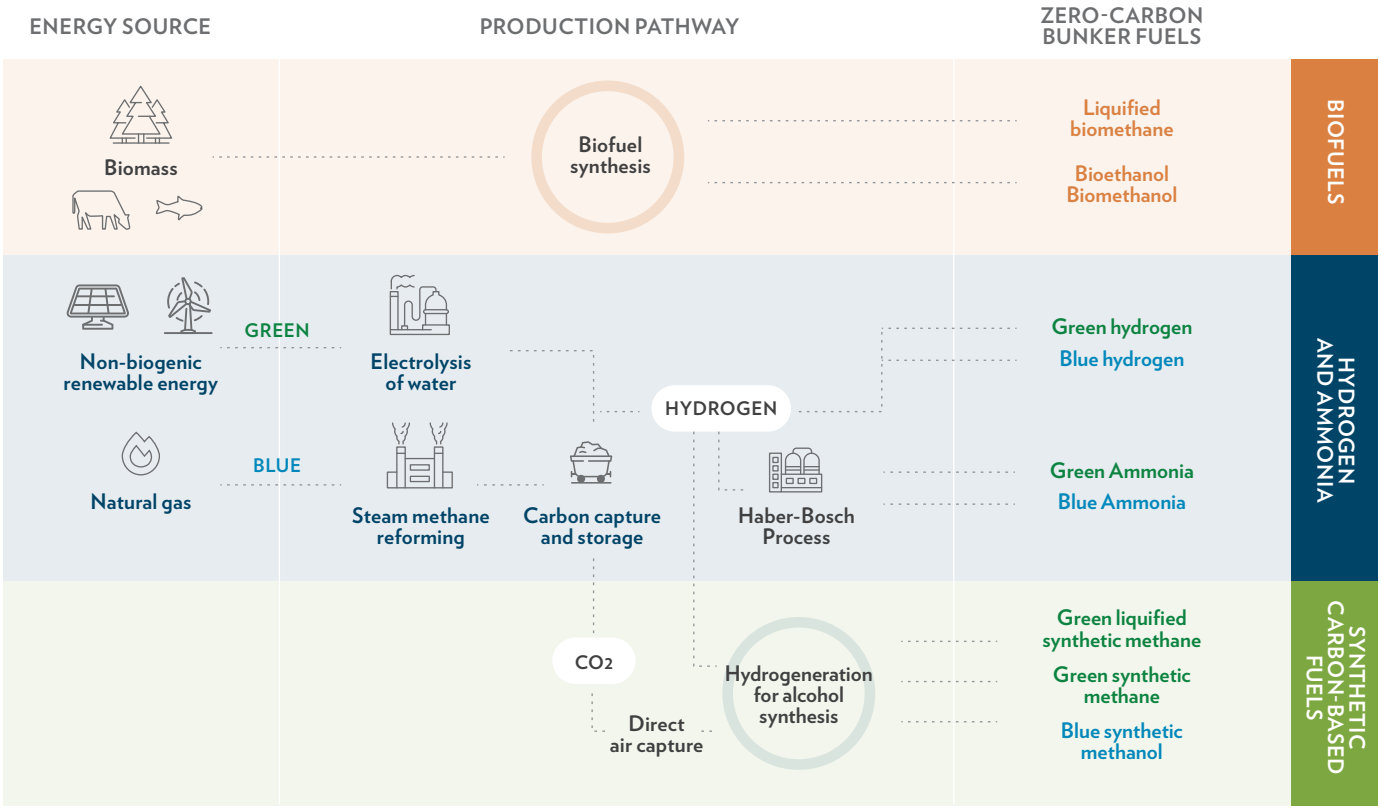
Many fuels and technologies needed to decarbonize the maritime shipping sector currently exist, and some have already been deployed in the sector. For example, electrification is being used to help decarbonize smaller vessels around the world, and ammonia—a potential zero-emission shipping fuel if produced using renewable energy and with the proper safety conditions met—is already a widely traded global commodity. The challenge, then, is effectively scaling and deploying these solutions so that they become the default choice for maritime shipping based not only on emissions, but also on cost, reliability, and safety. Building a community of first movers in the maritime sector ready to adopt these new technologies and drive the transition forward will be essential.

Several types of zero-emission fuels are under consideration for decarbonizing the maritime sector, but analysis from Lloyd's Register and University Maritime Advisory Services (UMAS) has found that hydrogen-derived fuels are the most promising mid- and long-term solutions in terms of cost, scalability, and emissions reduction potential.[1] **Figure 2** outlines the production pathway for various fuels under consideration, all of which have different emissions profiles. The lowest-emitting fuels are those produced using renewable energy.

> *Hydrogen-derived fuels are the most promising mid- and long-term solutions in terms of cost, scalability, and emissions reduction potential.*

1 Lloyd's Register and University Maritime Advisory Services, *Techno-Economic Assessment of Zero-Carbon Fuels*, 2020, https://www.lr.org/en/insights/global-marine-trends-2030/techno-economic-assessment-of-zero-carbon-fuels/.

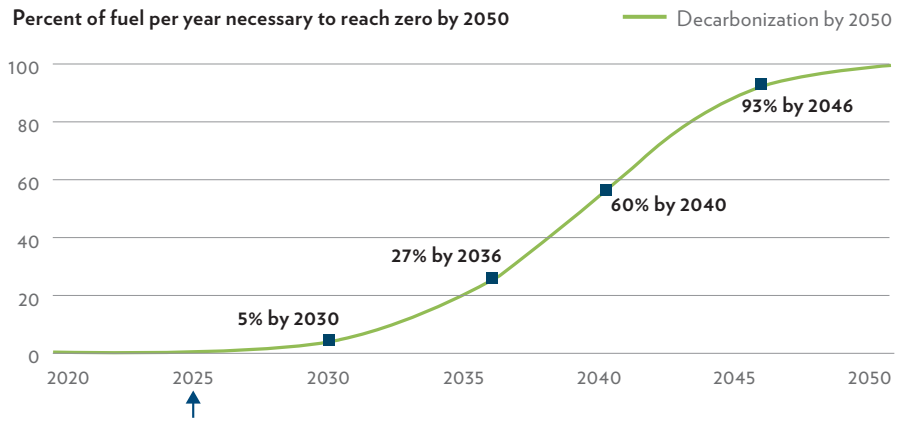
Figure 2. Energy source and production pathways for potential zero-carbon bunker fuels for maritime shipping decarbonization
Adapted from source: Dominik Englert, Andrew Losos, Carlo Raucci, and Tristan Smith, *The Potential of Zero-Carbon Bunker Fuels in Developing Countries* (World Bank, 2021).

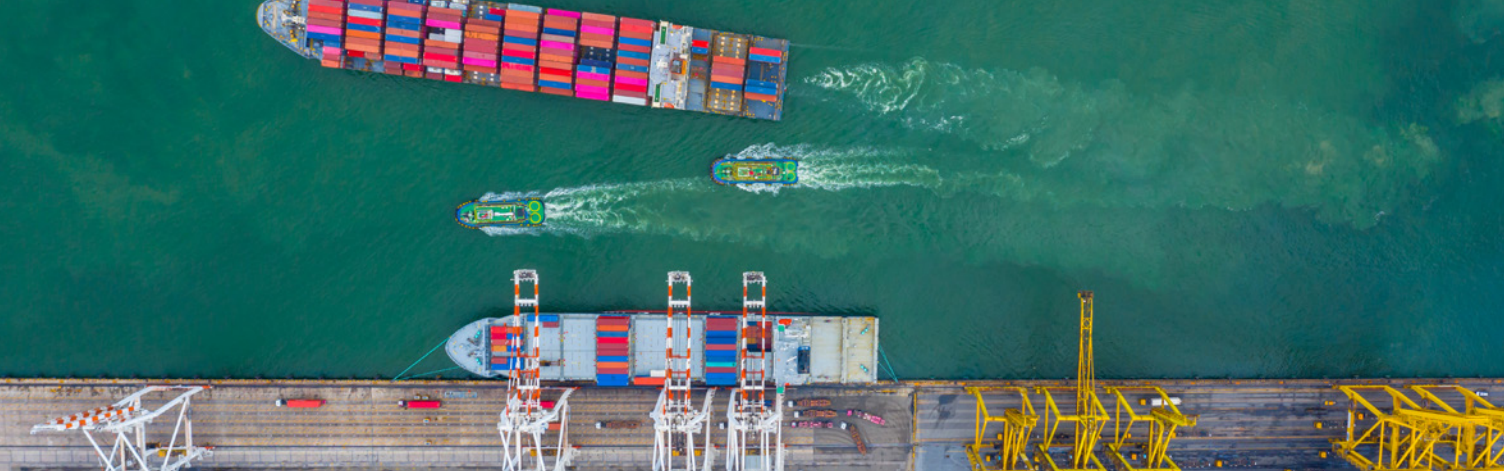


Due to the crucial role of zero-emission fuels and technologies, progress toward the sector's decarbonization has been analyzed in terms of fuel uptake throughout the sector. S-curve-based analysis in **Figure 3** shows that to enable full maritime sector decarbonization by 2050, zero-emission fuels need to make up at least 5% of the international shipping fuel mix by 2030 for all segments of shipping (e.g., bulk, tanker, container) and then grow rapidly over the next two decades to reach near 100% adoption by 2050.

To achieve this rate of uptake and the associated necessary infrastructure—both on land and water—action is needed at multiple levels, on varying time scales, across the maritime value chain, and around the world. There is no silver bullet that can enable an easy transition away from fossil fuels in the maritime sector. The sector's complexity paired with the many actions required to facilitate its decarbonization necessitates a portfolio approach that considers different timelines and also allows for concurrent action. For example, ocean carriers must improve energy efficiency in the short term while at the same time investing in long-term zero-emission solutions.

Figure 3. Zero emission fuel adoption necessary to reach maritime sector decarbonization by 2050
This graphic shows that commercial adoption of zero-emission fuels must begin in the mid-2020s to achieve Paris alignment; it also shows the necessary fuel adoption rate in various years on the way to complete decarbonization by 2050. Adapted from source: COP26 Climate Champions, UMAS, Global Maritime Forum.





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Typology of Interventions for Shipping Decarbonization

The multifaceted solutions to drive maritime shipping decarbonization can be broadly divided into five categories: (1) building a community of action, (2) increasing demand for zero-emission solutions, (3) improving policy and regulation, (4) fostering technological innovations, and (5) enabling deployment of solutions through green shipping corridors.

Building a community of action

To facilitate a 1.5° Paris Agreement-aligned transition within the maritime shipping sector, stakeholders from across the value chain must work together in new ways. Ports, vessel owner-operators, cargo owners, fuel producers, policymakers, renewable energy producers, ship builders, finance institutions, and more will need to align on pathways to ensure a transition to a zero-emission shipping that is ambitious, predictable, and economically viable across the value chain. This cross-sectoral collaboration is especially necessary during the early phases of the transition to ensure stakeholder buy-in and create a shared understanding of the goals, sectoral transition strategy, and steps required to assess progress.

Coordinating and driving this collaboration forward, however, requires targeted efforts to deeply understand the challenges and opportunities facing different parts of the value chain, build trust, and identify innovative opportunities to work together. Efforts have emerged in recent years to foster such collaboration and encourage the sector to pursue actionable pathways. These include the Getting to Zero Coalition, Cargo Owners for Zero Emission Vessels (coZEV), the Green Ports Forum, and Ports for People, which are currently working to engage both specific stakeholder groups and drive action across the value chain.

There is still a significant need, however, to expand these efforts by expanding workstreams to address a broader range of challenges and reaching the many still un-engaged members of the maritime value chain. Each of the solutions described below depends on strengthening communities of first movers across the maritime value chain that are willing and able to drive these solutions forward.

Increasing demand for zero-emission solutions

Because zero-emissions fuels and technologies are predicted to cost more than fossil fuels for decades to come, stakeholders from across the value chain must demonstrate committed demand and willingness to pay for zero-emission solutions to drive the speed and scale of this transition. Fortunately, some major stakeholders across the maritime value chain have begun demonstrating this demand. For example, major marine engine manufacturers MAN Energy Systems and Wärtsilä are developing new engine technologies and engine retrofit kits to enable use of new zero-emission fuels.

The world's second-largest shipping company, AP Moller Maersk, has placed orders for 19 vessels that are capable of running on green methanol fuel, a move quickly followed by dual-fuel vessel orders by a number of other global carriers. Producers of potential zero-emission fuels are also activating, such as Fortescue Future Industries (FFI), which announced plans in late 2020 for a capital investment of $6.2 billion that will, in part, enable the company to deploy an additional 2-3 gigawatts of renewable energy and battery storage, which FFI intends to use to produce green hydrogen and green ammonia fuels for harder-to-abate sectors such as maritime shipping.

However, the commercial success of all such efforts depends on demand from the shipping industry's customers. Their willingness in the coming years to purchase zero-emission shipping services with higher incremental cost is critical to break the chicken-and-egg dilemma currently playing out, where actors across the value chain are concerned about the risk and cost of investments in new zero-emission fuels and technologies, unsure if end customers will support new zero-emission service offerings, just as those end customers await details about the availability and cost of zero-emission alternatives before making demand commitments. Bold first movers are urgently needed to break this cycle. Such action will also positively affect policy as public sector decision-makers await signals of private sector support for measures that would accelerate the transition.

In the maritime shipping space, the key customers are referred to here as "cargo owners"—businesses that use maritime shipping services to transport their goods around the world. To address the need for a demand signal, 19 companies have signed on to the Cargo Owners for Zero Emission Vessels (coZEV) 2040 Ambition Statement, in which they state their aim to use only zero-emission ocean shipping services by 2040, sending an important signal of urgency across involved industries to accelerate decarbonization of the maritime value chain. Following successful launch of the statement, coZEV is now starting to engage cargo owners in more concrete levers for action, including supporting a consortium for procurement of zero-emission shipping to foster speed and scale called the Zero Emission Maritime Buyers Alliance (ZEMBA), tapping owners' voices to support policy improvements, and engaging in the development of ambitious green corridors.

The First Movers Coalition, a joint initiative between the World Economic Forum and several national governments (initiated by the U.S. State Department), is also working to harness the purchasing power of companies, in this case to decarbonize a number of harder-to-abate sectors, including actors across the maritime shipping value chain that have made zero-emission purchasing commitments for 2030. Growing the pool of cargo owners willing to support a zero-emission transition will depend on two important drivers for companies: consumer and shareholder pressure to influence corporate climate impact and public policy. Public advocacy campaigns such as Ports for People and affiliated efforts engage communities most impacted by maritime pollution in advocating for change. The role of policy is addressed below.

Improving policy and regulation

Maritime shipping is simultaneously a global, regional, national, and local sector, which means that relevant policy and regulations can be implemented at many different levels. Policymakers and regulators have taken advantage of this multifaceted governance approach to spur action on shipping decarbonization as it becomes politically feasible in different jurisdictions. A small but growing group of nonprofit organizations has played an essential role in facilitating that progress.

Policy to accelerate shipping decarbonization requires addressing various land- and ocean-based parts of the shipping value chain, e.g., deployment of renewable energy specifically to create zero-emission fuel for the maritime shipping sector and incentives for vessel owners to upgrade to dual-fuel capabilities. Below are summarized key aspects of the policy and regulatory landscape for maritime shipping decarbonization.

GLOBAL: INTERNATIONAL MARITIME ORGANIZATION

Maritime shipping is one of the few sectors that is regulated at a global level. The International Maritime Organization (IMO) is a specialized agency of the United Nations responsible for setting global standards for the safety, security, and environmental performance of international shipping. The global scope of the IMO presents a unique opportunity to develop consistent, comprehensive global policy solutions for decarbonization.

The IMO's global purview and the need to account for perspectives of a large and diverse set of Member States (and organizations with observer status that influence those Members) have resulted in slow action from this body on decarbonization. In 2018, the IMO agreed to an Initial IMO Strategy on Reduction of GHG Emissions from Ships (Initial GHG Strategy), which envisages a reduction in the

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carbon intensity of international shipping. Since that time, the IMO has faced heavy criticism from the public and private sectors for the low ambition of its interim climate goals and inadequacy of its decarbonization strategy, which targets a 50% reduction in greenhouse gas emissions by 2050 (compared to the 2008 baseline). This target would not align the maritime shipping sector with a 1.5° Paris Agreement-aligned path and would in fact allow emissions to continue to grow over the next decade.[2]

The IMO is currently revising its Initial GHG Strategy, and a final version is expected to be adopted in July 2023. Some of the key measures under consideration include:

- Revising the Initial GHG Strategy's levels of ambition to set a new goal of zero greenhouse gas emissions by no later than 2050, in alignment with the Paris Agreement;
- Establishing intermediary targets in 2030 and 2040 to track progress and stimulate investment decisions in the near term;
- Using a life-cycle emissions methodology to track both upstream and downstream emissions from the sector; and
- Employing a variety of market-based (e.g., levy or feebate) and technical measures (e.g., global fuel standard) to achieve targets and ensure an equitable and just transition.

Global regulation of maritime shipping emissions through the IMO is particularly important for Small Island Developing States (SIDS) and Least Developed Countries (LDCs) whose economies and livelihoods are disproportionately reliant upon inexpensive maritime shipping services. Without a global, ambitious, equity-focused policy framework, maritime decarbonization will likely progress through a patchwork of regional and national actions that will increase costs and present new barriers to trade for industry while potentially locking out SIDS and LDCs from the economic benefits of the transition.

REGIONAL: EUROPEAN UNION

The European Union's (EU) Climate Law, which entered into force in July 2021, mandates the EU to be climate neutral by 2050, including in the maritime sector. The EU's subsequent *Fit For 55* package is a set of policies intended to help the EU achieve its climate neutrality mandate and deliver on its interim ambition to reduce net greenhouse gas emissions by at least 55% compared to 1990 levels by 2030. The *Fit for 55* package was the first regional legislation to encourage the production and use of zero-emission fuels and stimulate renewable energy demand and production. Two regulations originally proposed as part of the *Fit for 55* package (and passed by the European Parliament in October 2022) take direct aim at the maritime sector:

- Fuel EU Maritime is a greenhouse gas standard for shipping fuels meant to drive the industry toward adoption of lower-emission fuels. In October 2022, the European Parliament approved a 2% green hydrogen mandate for shipping—the world's first green shipping fuel requirement.
- In December 2022, the European Council and the European Parliament agreed to add maritime shipping to the existing EU Emissions Trading System.

NATIONAL AND SUBNATIONAL: NATIONALLY DETERMINED CONTRIBUTIONS AND SPECIFIC EXAMPLES FROM THE UNITED STATES, SINGAPORE, CHINA, AND UK

Nationally determined contributions (NDCs) are individual nations' voluntary climate action plans under the Paris Agreement. Until recently, ocean-based measures had been largely absent from NDCs, but fortunately that is changing. Recent analysis from Ocean Conservancy and World Resources Institute (WRI) show an uptick in ocean-based NDCs, including NDCs addressing ocean-based transport. WRI analysis in October 2022 found that 25 nations had included ocean-based transport in their most recent NDCs, with goals focused on reducing emissions from both

2 Domagoj Baresic, Isabelle Rojon, Alison Shaw, and Nishatabbas Rehmatulla, *Closing the Gap: An Overview of the Policy Options to Close the Competitiveness Gap and Enable an Equitable Zero-Emission Fuel Transition in Shipping* (UMAS, January 2022), https://www.globalmaritimeforum.org/content/2021/12/Closing-the-Gap_Getting-to-Zero-Coalition-report.pdf.

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domestic and international shipping in some instances.[3] The IMO has also encouraged the creation and implementation of voluntary national action plans to support the achievement of international commitments through complementary national action. Seven of these national plans have been submitted thus far.[4] The growing recognition of the role that decreasing maritime shipping emissions can play in achieving our global and national climate goals is a positive sign, and could lead to additional national and international policy opportunities.

Apart from NDCs, several nations and major subnational jurisdictions around the world are in a position to have significant positive impact in advancing zero-emission maritime solutions. In fact, a 2022 study by the NGO Transport & Environment found that China, the United States, and the EU could together decarbonize 84% of the global shipping sector if they all implemented a zero-emission mandate for ships calling at their ports. Some jurisdictions are already beginning to adopt policies aimed at addressing maritime shipping decarbonization, with select examples provided below.

Implementation of the recently passed Infrastructure Investment and Jobs Act (IIJA) and Inflation Reduction Act (IRA) are positioning the United States to positively advance maritime decarbonization through investments in green hydrogen-derived fuels and related infrastructure, increased funding to reduce air pollution at ports, and grants for the Electric or Low-Emitting Ferry Program. In addition, four federal agencies—the U.S. Department of Energy, U.S. Department of Transportation, U.S. Environmental Protection Agency, and U.S. Housing and Urban Development—recently released the U.S. National Blueprint for Transportation Decarbonization. A "whole-of-government" approach to decarbonizing the transportation sector, the Blueprint calls for evaluating fuels on a life-cycle basis and advocates for zero-emission modes of transportation, including in the maritime sector. This *Blueprint* and these policies represent significant progress toward spurring U.S. domestic maritime decarbonization. As the world's largest importer, a growing producer of renewable energy, and home to some of the world's busiest ports, the United States has the opportunity to demonstrate global leadership through the green transition while simultaneously strengthening and growing the domestic blue economy.[5]

The state of California has been leading the way sub-nationally in the United States with policies like the 2007 low sulfur fuel standard and 2007 At-Berth Regulation, which was expanded in 2020. In 2022, the city councils of both Long Beach and Los Angeles passed a resolution proclaiming their support for green shipping and an aim to reach 100% zero-emission shipping by 2030. Also in 2022, the Port of Los Angeles, Port of Long Beach, Port of Shanghai, and C40 Cities announced a partnership of stakeholders from across the shipping value chain to create a first-of-its-kind transpacific green shipping corridor on one of the world's busiest container shipping routes.

3 As of November 2022, the WRI report found that following countries had included ocean-based transport in their NDCs: Albania, Bangladesh, Canada, Cape Verde, China, Colombia, Costa Rica, Dominica, European Union, Fiji, India, Maldives, Marshall Islands, Monaco, Nauru, Papua New Guinea, Qatar, Samoa, Senegal, Seychelles, Solomon Islands, Sri Lanka, Tanzania, Türkiye, and Vanuatu.

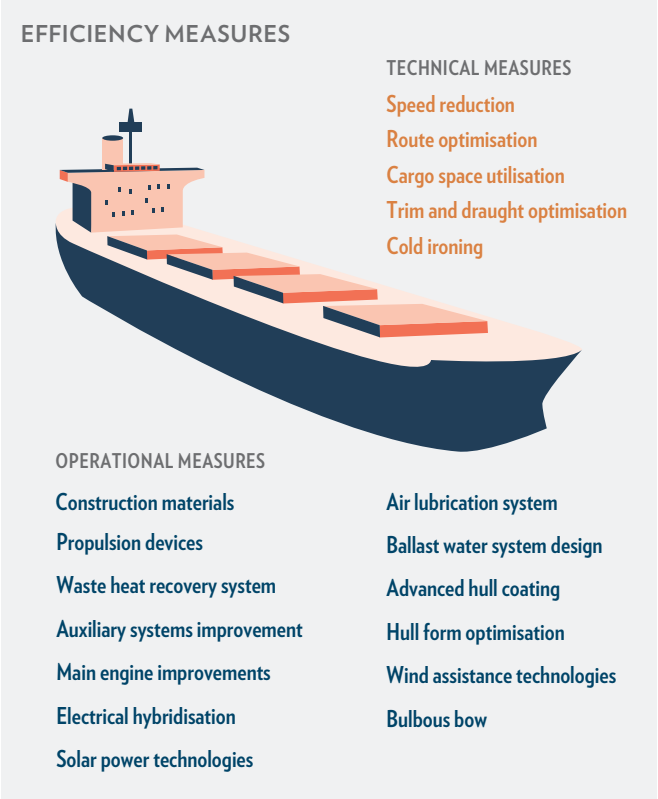
4 As of April 2022, Finland, India, Japan, the Marshall Islands, Norway, Singapore, and the UK had submitted voluntary national action plans to the IMO.

5 There are many definitions of the term "blue economy." The World Bank has defined the "blue economy" as the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem."

In March 2022, Singapore, the world's largest maritime bunkering (refueling) hub, released the Singapore Maritime Decarbonization Blueprint 2050 through the Singapore Maritime and Port Authority. It allocates $300 million to implement seven maritime decarbonization focus areas, including port terminals, research and development, future maritime fuels, and green financing.

China is home to the world's largest port complexes; is a major global exporter, ship builder, renewable energy producer (and thus potential producer of zero-emission fuels for the maritime space); and is host to a significant merchant fleet. China has formulated national and local-level legislation and policies with an eye toward reducing emissions from its maritime sector. To date, China's policies have been focused on monitoring and improving energy efficiency of ships in the maritime sector to reduce emissions and, more recently, reducing sulfur content in fuels and promoting shore power systems,[6] with one port, Tianjin Port, achieving a 100% use rate of shore power and low-sulfur fuel for its own ships. Moving forward, China has a significant opportunity to take further national action to drive decarbonization of its maritime sector and the global sector.

In 2019, the UK published a Clean Maritime Plan that outlines the UK's domestic maritime decarbonization targets and several commitments to support the sector as it moves toward the UK's vision for zero-emission shipping.



In 2021, the UK was the first country to include its share of international shipping in a national carbon budget, a legally binding restriction on the total amount of greenhouse gases the UK can emit over a five-year period. To achieve these targets, the UK has begun investing in maritime decarbonization solutions, e.g., £206 million of funding for a new office, the UK Shipping Office for Reducing Emissions (UK SHORE), which will focus on maritime decarbonization research and development and pioneering new technology. Additionally, the UK has been a driving force in supporting the creation of green maritime shipping corridors around the world through the Clydebank Declaration (further described below), which originated at COP26 in Glasgow, Scotland.

Fostering technological innovations

Like other sectors, the maritime shipping industry is undergoing a technological transformation aimed at making operations more sustainable, cost effective, and efficient. A white paper from the International Council on Clean Transportation highlights that achieving maritime emissions reduction goals will require "taking advantage of the growing number of technologies and operational strategies" within the sector. While several technological advancements and improvements are under consideration that may affect the sector's decarbonization speed and trajectory in the short and long terms, two are highlighted here.

ENERGY EFFICIENCY

Energy efficiency in the maritime sector has long been a way to reduce emissions and lower costs of operation, yet efficiency measures have not been fully deployed because of the relatively low cost of maritime fossil fuels, insufficient emissions transparency, and antiquated freight contracting systems. Fortunately, there is now an increasing focus by regulators and stakeholders on boosting efficiency to ensure that ships powered by fossil fuels use as little fuel as possible. **Figure 4** provides an overview of available efficiency measures and how much they are estimated to reduce emissions.

Figure 4. Potential emissions reductions from various technical and operational energy efficiency measures on ships
Adapted from source: UCL Energy Institute, "New Infographics from Our Shipping Team Highlight How Carbon Emissions Could Be Cut by 2050," June 25, 2019, https://www.ucl.ac.uk/bartlett/energy/news/2019/jun/new-infographics-our-shipping-team-highlight-how-carbon-emissions-could-be-cut-2050.

6 Shore power systems allow vessels to turn off their engines while in port and "plug in" to an electrical grid while at berth.

Additionally, as the sector transitions to more costly zero-emission fuels and technologies, investments in energy efficiency will be essential to reduce cost and maximize the overall emissions reduction potential of clean energy capacity globally. Thus, while increasing efficiency of fossil-fuel-powered ships cannot fully decarbonize the maritime sector, investing in these solutions carries short- and long-term benefits.

TRACKING CARBON INTENSITY

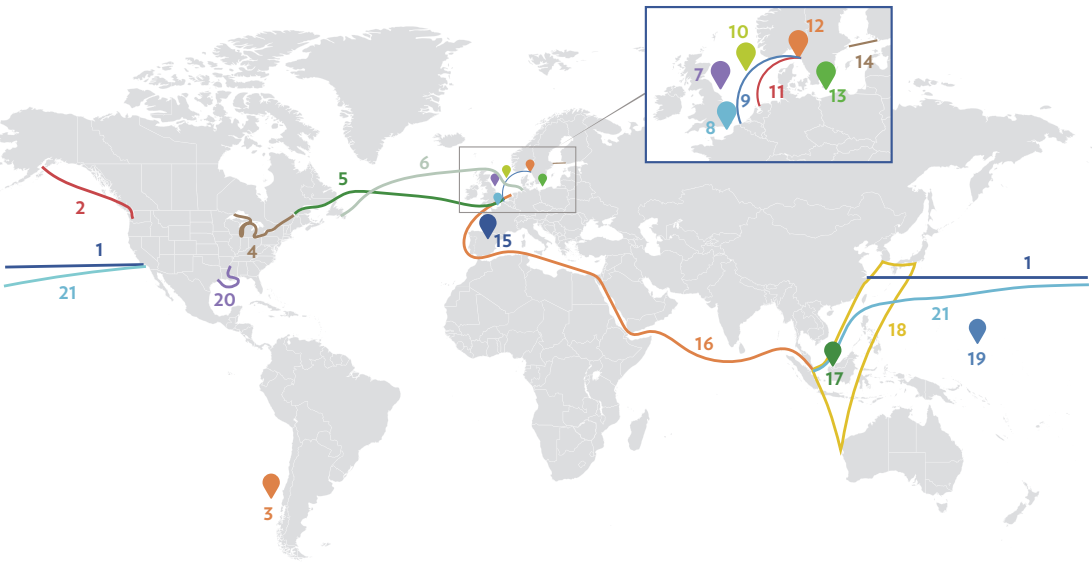
To ensure the sector achieves Paris-aligned emissions reductions, technological and process innovations are needed to better track, verify, and assure the carbon intensity of new fuels. A report by the Lloyd's Register Maritime Decarbonisation Hub and Safetytech Accelerator examines various technologies aimed at tracking the end-to-end emissions of various fuels and the authentication needs that will continue to emerge within the sector.

Enabling deployment of solutions through green shipping corridors

The concept of maritime green corridors has become central to the shipping industry's emerging efforts to decarbonize. Green corridors, defined in a recent report by the Global Maritime Forum as "specific shipping routes where the technological, economic and regulatory feasibility of zero-emission shipping is catalyzed by a combination of public and private actions," have been identified as a way to scale initial decarbonization efforts into industry-wide solutions.

As explained above, shipping's transition to zero emissions will require the coordinated development and deployment of new technologies and infrastructure inland (e.g., production of new fuels), at ports (e.g., new fueling infrastructure), and at sea (e.g., new vessels), as well as the development of new business models for sharing costs and risks, new policies at various levels to support the transition, and engagement of local stakeholders.

Green corridors simplify this complex challenge by focusing efforts on specific promising routes, for example, those with relatively limited operational complexity or those that can



1. Shanghai- LA
2. Alaska, British Columbia, Washington
3. Chilean Green Corridor Network
4. Great Lakes- St. Lawrence
5. Antwerp-Montreal
6. Halifax-Hamburg
7. Clean Tyne Corridor
8. Dover-Calais/Dunkirk
9. Gothenburg-North Sea Port
10. H2 powered North Sea Crossing
11. Gothenburg-Rotterdam
12. European Green Corridor Network
13. Nordic Regional Corridors
14. Decatrip
15. Green Corridors Spain
16. Rotterdam- Singapore
17. SILK Alliance
18. Aus-Asia Iron Ore
19. QUAD Shipping Taskforce
20. Gulf of Mexico
21. Los Angeles-Long Beach-Singapore

Indicative – ports and routing not necessarily representative

Figure 5. Green maritime corridor initiatives that have launched since the signing of the Clydebank Declaration at COP26 in November 2021
Adapted from source: Getting to Zero Coalition and Global Maritime Forum, *Annual Progress Report on Green Shipping Corridors*, 2022, https://cms.globalmaritimeforum.org/wp-content/uploads/2022/11/The-2022-Annual-Progress-Report-on-Green-Shipping-Corridors.pdf.

draw on logistical, economic, or political advantages. A 2022 article in *Bunkerspot* magazine called green corridors "zero-emission testing grounds… [to] jumpstart the energy transition within the shipping sector and align all the necessary pieces of the zero-emission shipping value chain of the future."

At COP26 in November 2021, 22 governments (the group has since expanded to 24) signed the Clydebank Declaration in support of green maritime corridors. Since then, more than 20 initiatives have been launched in both the private and public sectors, with more than 100 stakeholders engaged (see **Figure 5**).

The announced green maritime corridor initiatives cover multiple geographies and industry segments, including many of the world's most important deep-sea shipping routes, such as container shipping between Singapore and Rotterdam and bulk shipping of iron ore from Australia to Asia. The vast majority of these initiatives, however, remain at an early stage. Only a handful have advanced far enough to begin feasibility assessments or implementation planning (see **Figure 6**).

To evaluate announced corridors and assess the potential for additional routes, the Global Maritime Forum has developed a set of criteria for assessing progress, including:

- Mobilization of customer demand
- Determination of fuel pathway
- Cross-value chain collaboration
- Enabling policy and regulatory environment
- Knowledge development and exchange

While each green corridor project will progress in a slightly different manner, assessing green corridor projects against a universal rubric will help ensure an even standard of ambition and an appropriate project scope. Overall, these projects present an opportunity to align stakeholders with a common, geographically specific goal to create the building blocks needed to decarbonize the global shipping sector.

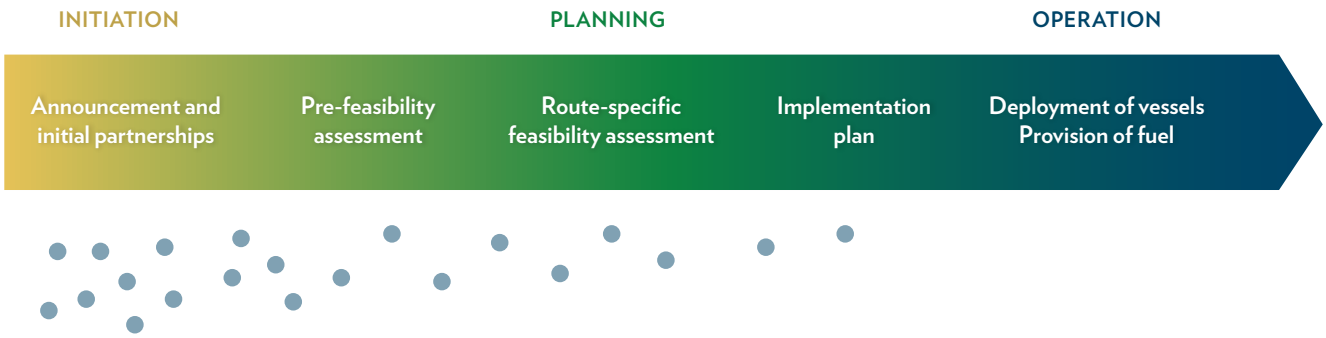


Figure 6. Development stages for green maritime corridors projects as assessed by the Global Maritime Forum
Only about one-third of announced green maritime corridor projects have progressed to the route-specific feasibility assessment phase. Adapted from source: Getting to Zero Coalition and Global Maritime Forum, *Annual Progress Report on Green Shipping Corridors, at 31.*

> *Assessing green corridor projects against a universal rubric will help ensure an even standard of ambition and an appropriate project scope.*

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Actionable Opportunities for Funders

Maritime shipping decarbonization has emerged as an exciting new opportunity for funders interested in making an impact on a range of topics, from climate change to ocean health to transportation sustainability. The cross-cutting nature of shipping decarbonization and the significant civil society effort still needed to ensure success give rise to an array of ways that funders can get involved both in the short and long terms.[7]

Thought leaders in this space view 2030 as a crucial milestone year for maritime decarbonization. As described above, at least 5% of all maritime fuels must be zero-emission fuels by 2030 to ensure the sector is on a Paris-aligned trajectory. Therefore, funding priorities in the maritime sector have been developed with this 2030 target in mind to underscore the ambitious action needed during the 2020s to get this sector on track. All of the fundable ideas identified—some short term, some longer term—need to be undertaken in the coming years to ensure complete decarbonization by 2050, at the latest.

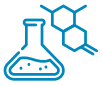
Foundational to the success of maritime decarbonization, however, is the creation of communities of action in the early phases of the transition to ensure stakeholder buy-in and create a shared understanding of the goals, sectoral transition strategy, and steps that need to be taken to assess progress. For this reason, "Building a Community of Action" is considered a cross-cutting solution category, as depicted below.

7 Because of the long-term nature of investments in the maritime and energy sectors and the scale of change required, the timelines for funding priorities discussed in this section extend beyond those in other Our Shared Seas primers.

Actionable Solutions

BUILDING A COMMUNITY OF ACTION

- Build a shared understanding of the challenge, goals, opportunities, and long-term sectoral transition strategy, and assess progress.
- Raise awareness of opportunities and co-benefits associated with the shipping sectors energy transition (e.g., for environmental justice, sustainable economic growth, reducing underwater noise and whale strikes) and explore concrete action to optimize these benefits.
- Develop cross-sectoral collaboration and engage new actors from the value chain.
- Engage with developing countries to ensure the shift is equitable and no one is left behind.
- Develop new and more specific industry commitments, including on short-term action.
- Further incorporate maritime shipping into successful multimodal initiatives to decarbonize freight.



FOSTERING TECHNOLOGICAL INNOVATIONS

- Support independent analyses of the safety and environmental risk of alternative fuel technologies, particularly ammonia, for production and use on ships, and develop solutions to minimize risks to crew and ocean and coastal ecosystems.
- Facilitate technoeconomic studies on alternative fuel technologies, including the necessary land-side infrastructure requirements, e.g., route-specific assessments of costs and benefits of zero-emission fuel options, economic opportunities for SIDS and LDCs.
- Conduct national and subnational scale studies assessing the economic opportunities/impacts of a transition to zero-emission fuels, including estimates of new jobs and tax revenues that could be generated for specific jurisdictions.

INCREASING DEMAND FOR ZERO-EMISSION SOLUTIONS

- Dramatically expand zero-emission cargo demand commitments to support the business case and drive economies of scale.
- Expand the scope and scale of existing platforms that enable cargo owner companies to commit to zero-emission shipping of their goods and take concrete action to meet those commitments.
- Expand efforts to secure concrete commitments from ship owners, carriers, fuel producers, ports, financiers, insurers, and others in the chain of supply and demand.
- Ensure that national strategies for bolstering clean hydrogen production and uptake include supporting projects that advance zero-emission maritime fuel production, including U.S. federal funding from the IIJA and IRA.
- Significantly expand efforts to develop legal mechanisms, such as model contract clauses, and financial mechanisms, including spurring private sector investment to drive the transition to zero-emission shipping.
- Analyze and disseminate information to public and private decision makers about economic opportunities at the interconnections between renewable ocean energy development, shipping decarbonization, and port development.
- Design and implement a new demand-side strategy focused on building demand in other maritime sectors (e.g., fishing, recreational boating, and offshore service vessels) for zero-emission solutions.

IMPROVING POLICY AND REGULATION

Priorities for the short term (by mid-2023):

- Expand IMO-focused advocacy to secure a global target of zero emissions by 2050 and mid-term measures aligned with 1.5°, particularly focused on engaging private-sector and community-level supporters from across the developed and developing world.
- Expand IMO-focused advocacy to secure high-ambition outcomes and to avoid the development of a global patchwork of national and regional regulation, which would leave most developing countries out of decision-making and raise the cost of the transition. This should include:
  - Ensure IMO adoption of an economic instrument that puts an incentivizing price on greenhouse gas emissions, further enabling and unlocking rapid investments in shipping decarbonization.
  - Ensure IMO adoption of a technical instrument, like a greenhouse gas fuel standard, that phases out the use of fossil fuels no later than 2050.
  - Provide capacity building, including training in diplomacy and negotiations, for high-ambition SIDS and LDCs to strengthen their voice in IMO deliberations to secure Paris-aligned measures that result in equitable outcomes.

Priorities for the medium/long-term:

- Support analyses of global opportunities and trade costs (e.g., energy production and exports, decent green jobs, costs for import- and export-dependent economies) that could stem from a high-ambition IMO GHG Strategy and enabling policy measures.
- Ensure effective implementation and review of the maritime components of the EU's *Fit for 55* package through expanded advocacy efforts and engagement of private-sector supporters.
- Help coordinate and align national governments' ambitions at the UN Framework Convention on Climate Change and IMO through targeted advocacy and convening assistance from civil society to ensure achievement of overall climate and maritime shipping decarbonization goals.
- Secure additional international and domestic measures to protect vulnerable Arctic ecosystems from the impacts of shipping and scope additional region-specific areas for high-impact campaigns.
- Organize targeted civil society efforts to ensure potential co-benefits and unanticipated consequences are accounted for in proposed policy measures, including elements related to oceanic and human health, underwater noise, equity, seafarer training, and gender issues in the maritime industry.

DEPLOYMENT OF SOLUTIONS THROUGH GREEN SHIPPING CORRIDORS

- Support effective green corridor implementation for announced corridor collaborations.
- Build on and expand nascent platforms and networks being developed by civil society for sharing lessons and best practices across green corridor projects.
- Support collaboration with international finance institutions and multilateral development banks in the development of green shipping corridor funding facilities for LDCs and SIDS to help identify and prepare investable projects.
- Organize field visits for select stakeholders, including policymakers, to port communities to explore the challenges and opportunities of decarbonizing the global maritime sector and benefits of robustly implemented green corridor efforts.

ISTOCK/CHRISTOPHER STOLTZ

Conclusion

The benefits of decarbonizing the maritime shipping sector extend beyond climate wins. A zero-emission maritime sector also will improve ocean ecosystem and human health. Gains will include reducing pollution in portside communities, minimizing underwater noise and whale strikes, producing economic benefits and job creation up and down the value chain, accelerating renewable energy development, especially in developing countries, advancing justice and equity, and ensuring seafarer safety.

The global nature of the transition and the complex value chain mean that there is no silver bullet solution for decarbonizing the maritime sector. Global action must be taken concurrently this decade on multiple levels to put the sector on a 1.5° Paris Agreement-aligned pathway. The increased attention devoted to decarbonizing this sector combined with the presence of ready-to-scale technologies, a global regulator with the ability to enact universal change, and cross-value-chain demand and supply present opportunities for funders to drive solutions on various levels, from funding for zero-emission fuel pilots to on-the-ground support for port community organization. The global trade fostered through the maritime shipping sector connects the world, and decarbonizing the sector can produce ocean-climate benefits on global, regional, national, and local scales.

> *Decarbonizing the maritime shipping sector can produce ocean-climate benefits on global, regional, national, and local scales.*

Aspen Institute is a global nonprofit organization committed to realizing a free, just, and equitable society. Founded in 1949, the Institute drives change through dialogue, leadership, and action to help solve the most important challenges facing the United States and the world. Headquartered in Washington, DC, the Institute has a campus in Aspen, Colorado, and an international network of partners. For more information, visit www.aspeninstitute.org

The Aspen Institute Energy and Environment Program's Shipping Decarbonization Initiative (SDI) is partnering with leading organizations and companies from around the world, tapping into a vast network to drive the transition to zero emission maritime shipping and decarbonize one of the most important sectors of the global economy. Aspen SDI is convening multinational cargo owners to accelerate shipping decarbonization through Cargo Owners for Zero Emission Vessels (coZEV) and the Zero Emission Maritime Buyers Alliance (ZEMBA), elevating the need for shipping decarbonization within the U.S. policy context, and advancing the establishment of zero-emission transoceanic maritime transport corridors. To learn more, visit www.cozev.org.

The Global Maritime Forum is an international not-for-profit organization dedicated to shaping the future of global seaborne trade to increase sustainable long-term economic development and human wellbeing. Visit www.globalmaritimeforum.org for more information.

Our Shared Seas provides timely data, research, and insights to support ocean conservation policy, practice, and philanthropy. This independent resource synthesizes threats to ocean health and elevates evidence-based solutions for the ocean. Learn more at www.oursharedseas.com.

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