



Integrating shipping into nationally determined contributions (NDCs): A guidance tool for decarbonization

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1. Introduction

When world leaders agreed at the 2015 UN Climate Change Conference in Paris to progressively reduce greenhouse gas emissions with a view to reaching net zero by midcentury, they expected most of this action to be driven by countries, based on their own priorities and national contexts, implemented through short-to-medium-term commitments in mandatory nationally determined contributions (NDCs), and guided by voluntary long-term low-emission development strategies (LT-LEDS).

The Paris Agreement does not explicitly mention shipping, but the sector is widely recognized to be a major source of carbon emissions, air and water pollution, and other adverse effects. In 2023, tank-to-wake emissions from global shipping reached an estimated 911–1,205 million tonnes of carbon dioxide equivalent (Mt CO₂e).¹ The lower number amounts to about 1.7 percent of global greenhouse gas (GHG) emissions in 2023—more than Canada’s emissions, and just below Japan’s.² It also represents a 12-percent increase since 2016.³

The vast majority of those emissions, about 86 percent, were from international shipping,⁴ which is not directly covered by the Paris Agreement, but rather is the responsibility of the International Maritime Organization (IMO), a specialized UN agency charged with ensuring the safety and security of shipping and preventing marine and atmospheric pollution by ships.

Yet most Parties to the Paris Agreement—176 of 193—are also IMO Member States,⁵ so even if indirectly, they will ultimately be responsible for any efforts to decarbonize shipping through the IMO. Moreover, 10 percent of the sector’s GHG emissions in 2023 came from domestic shipping and another 4

1 Note that the spelling “tonne” is used to clearly indicate metric tons.

Mao, X., Z. Meng, B. Comer, and T. Decker. 2025. “Greenhouse Gas Emissions and Air Pollution from Global Shipping, 2016–2023.” Washington, DC: International Council on Clean Transportation. <https://theicct.org/publication/greenhouse-gas-emissions-and-air-pollution-from-global-shipping-2016-2023-apr25/>.

Along with CO₂, ships emit several short-lived climate pollutants—methane, nitrous oxide, black carbon—that have more powerful warming effects than CO₂ but remain in the atmosphere for a much shorter time. To convert emissions of those pollutants to CO₂e, analysts multiply them by a global warming potential (GWP) factor, typically looking at a 100-year or 20-year time frame.

Excluding black carbon emissions, the ICCT analysis puts 2023 emissions from shipping at 911 Mt CO₂e with a 100-year GWP, and 925 Mt CO₂e using a 20-year GWP. Including black carbon increases total emissions to 989 or 1,205 Mt CO₂e, depending on the GWP used.

2 The widely used reference source ClimateWatch estimates Canada’s 2023 GHG emissions (including from the land sector) at 876.71Mt CO₂e, and Japan’s at 1035.83 Mt CO₂e. See https://www.climatewatchdata.org/ghg-emissions?end_year=2023&start_year=1990.

3 Mao, Meng, Comer, and Decker, 2025, “Greenhouse Gas Emissions and Air Pollution from Global Shipping, 2016–2023.”

4 Mao, Meng, Comer, and Decker, 2025.

5 A total of 194 Parties, including 193 countries and the European Union, have ratified the Paris Agreement; see <https://unfccc.int/process/the-paris-agreement/status-of-ratification>. For a list of IMO Member States, see <https://www.imo.org/en/ourwork/ero/pages/memberstates.aspx>.

percent from fishing, both of which are covered by national GHG inventories.⁶ Ports, which are not included in the shipping emissions estimate, are also covered.

This means that, to fully decarbonize their economies, countries need to proactively address shipping and ports in their climate policies, plans, and commitments. It is also strategic to do so, as demand for zero- and near-zero-carbon technologies and fuels—and ports that support them—will only grow as shipping decarbonization progresses worldwide.

Several Parties have already stepped up. An analysis of the 66 new or updated NDCs submitted by coastal or island nations by November 2025 found that 28 included mitigation actions targeting ocean transportation.⁷ The European Union's NDC notes that it has included maritime shipping in its Emissions Trading System (EU ETS) since 2024 and has created a complementary initiative, FuelEU Maritime, to gradually reduce the GHG intensity of the energy of ships calling at EU ports.⁸ The NDC analysis also highlighted plans by Brazil, Canada, Japan, Singapore, and the United Arab Emirates (UAE) to develop green maritime fuels, including through enhanced production, safety pilots, and incentives.⁹

The Marshall Islands' NDC gives particular prominence to shipping decarbonization. It notes that through the Pacific Blue Shipping Partnership, it has already set out to reduce domestic shipping emissions by 40 percent from 2010 levels by 2030 and fully decarbonize the sector by 2050.¹⁰ It highlights the country's active engagement in the IMO, in particular its efforts to use a levy on international shipping emissions to mobilize more climate finance. And it notes that the country is "actively working on zero and low-emission technologies" for shipping: from a high-tech pilot supported by Germany, to an initiative to decarbonize transport within atoll lagoons.

A foreword from the Marshallese President highlights the benefits of these actions: "Our efforts to tackle sea transport emissions have put RMI at the cutting edge of low-carbon shipping, developing a new vessel that combines wind-assisted propulsion, fuel efficient engines and solar power, and also given us an opportunity to draw on our indigenous construction skills, in creating traditional wind-powered canoes with new technologies for inter-island transport."

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- 6 Mao, Meng, Comer, and Decker, 2025, "Greenhouse Gas Emissions and Air Pollution from Global Shipping, 2016–2023."
 - 7 Khan, M., J. Baines, M. Lecerf, et al. 2025. "The State of Ocean-Based Climate Action in 2025 Nationally Determined Contributions: A Preliminary Update." Washington, DC: World Resources Institute. doi:10.46830/wriwp.25.00004.
 - 8 See paragraphs 35, 36, and 86 in: European Union. 2025. "The Nationally Determined Contribution of the European Union and Its Member States." Submission by the Danish Presidency of the Council of the European Union and the European Commission on Behalf of the European Union and its Member States. Brussels. <https://unfccc.int/sites/default/files/2025-11/DK-2025-11-05%20EU%20NDC.pdf>.
 - 9 Khan, Baines, Lecerf, et al., 2025, "The State of Ocean-Based Climate Action in 2025 Nationally Determined Contributions: A Preliminary Update."
 - 10 RMI. 2025. "The Republic of the Marshall Islands Nationally Determined Contribution 2031–35." Majuro. <https://unfccc.int/sites/default/files/2025-02/Republic%20of%20the%20Marshall%20Islands%20NDC%203.0.pdf>.

Yet on a global scale, countries are still pursuing only a fraction of available opportunities to advance shipping and port decarbonization. The 2025 NDC analysis found that ocean-based climate actions in general remain underused, especially when it comes to mitigation; indeed, only 12.1 percent of the ocean-based climate actions included in the NDCs involved sectors with significant mitigation potential, such as shipping.¹¹

This guidance tool, produced by Ocean Conservancy with support from the NDC Partnership, is designed to help countries to better understand and pursue these opportunities:

For the dozens of countries that have yet to submit a new or updated NDC, it provides practical guidance on how to integrate the decarbonization of domestic shipping and/or ports, including relevant targets and measures.

For countries that already submitted NDCs, but did not explicitly include ocean transport, it highlights ways in which action on domestic shipping, ports, and/or zero- and near-zero-carbon shipping fuels can accelerate progress towards economy-wide or sectoral emission reduction targets. It also shows how such action and supporting policies can lay a strong foundation for integrating ocean transport in the next NDC.

For countries that did include ocean transport in their NDC, it provides insights on how to create an enabling environment, how to strengthen accountability, and how to mobilize resources to support decarbonization efforts, including conditional pledges.

For all countries, regardless of the status or approach of their NDC, it provides insights on how to integrate shipping and/or port decarbonization in long-term low-emission development strategies (LT-LEDS) and other key policies, strategies, and plans that complement NDCs and will be crucial to achieving net zero emissions by midcentury.

The rest of this section provides a brief overview of shipping emissions, why there is an urgent need to rapidly reduce those emissions, pathways to decarbonization and key efforts made to date, and the main reasons why most NDCs do not yet meaningfully address shipping. Section 2, the core of this guidance, provides a brief overview of pathways to decarbonization, then looks at options for integrating targets and actions on shipping in NDCs and in supporting policies, strategies, and plans, including how to create an enabling environment, how to mobilize resources, and how to ensure robust monitoring, reporting, and verification (MRV). Section 3 aims to help build the case for action by reviewing the many social, economic, and environmental co-benefits of decarbonizing shipping and ports. Multiple practical examples are presented in the text, and Annex 1 provides additional examples and supporting analysis. Annex 2 provides more details on MRV data requirements, which could have implications for how countries choose to formulate their commitments on shipping.

¹¹ Khan, Baines, Lecerf, et al., 2025, "The State of Ocean-Based Climate Action in 2025 Nationally Determined Contributions: A Preliminary Update."

1.2 The Climate Impacts of Shipping

Maritime shipping is central to the global economy. Ships carry more than 80 percent of goods traded worldwide by volume,¹² connecting production, consumption, food systems, energy supply chains, and industrial activity across regions. Shipping is thus more than a mode of transport; it is a strategic sector for developed and developing countries alike.

Yet shipping is also a major source of GHG emissions, because the vast majority of vessels are powered by fossil fuels—in particular, heavy fuel oil (HFO) or, since the IMO's 2020 global sulfur limit, very-low-sulfur fuel oil (VLSFO). The analysis cited in the introduction, by the International Council on Clean Transportation (ICCT), found that since 2020, VLSFO has been the dominant fuel, used by a large majority of container ships, bulk carriers, oil tankers, chemical tankers, and general cargo ships.¹³ However, shipping companies and governments are increasingly adopting liquefied natural gas (LNG), liquefied petroleum gas (LPG), and, to a lesser extent, methanol as less-polluting alternatives. Between 2016 and 2023, the number of LNG-fueled ships more than doubled and the use of LNG as a marine fuel grew by more than 80 percent.

Burning bunker fuels produces not just carbon dioxide (CO₂) emissions, but also black carbon and other particulate matter (PM), nitrogen oxides (NO_x), sulfur oxides (SO_x), methane (CH₄, from “slip” or leakage on gas-fueled ships), carbon monoxide, and non-methane volatile organic compounds (NMVOCs); some refrigerants also seep into the atmosphere.¹⁴ Several of these pollutants are also harmful to human health and contribute to ocean acidification.¹⁵ Notably, as LNG use has increased, methane emissions from shipping have risen sharply: from 88,000 tonnes in 2016 to 247,000 tonnes in 2023, according to the ICCT analysis.¹⁶

Operational efficiency gains have reduced the shipping sector's fuel use and carbon intensity, but GHG emissions have continued to rise in absolute terms, as increased global shipping activity has kept growing, while efficiency gains slowed.¹⁷ The IMO's latest analysis found that the sector's total GHG

12 UNCTAD. 2025. “Shipping Data: UNCTAD Releases New Seaborne Trade Statistics.” UN Trade & Development news story. April 23. <https://unctad.org/news/shipping-data-unctad-releases-new-sea-borne-trade-statistics>.

13 Mao, Meng, Comer, and Decker, 2025, “Greenhouse Gas Emissions and Air Pollution from Global Shipping, 2016–2023.” HFO still predominates among cruise ships, and liquefied natural gas (LNG) carriers mainly use LNG.

14 IMO. 2020. “Fourth Greenhouse Gas Study 2020.” International Maritime Organization. <https://www.imo.org/en/ourwork/environment/pages/fourth-imo-greenhouse-gas-study-2020.aspx>.

See also: Llabrés Pohl, I. 2023. “The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health.” Consultancy report for Seas at Risk. Brussels. <https://seas-at-risk.org/publications/the-state-of-shipping-oceans-report/>.

15 Llabrés Pohl, 2023, “The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health.”

16 Mao, Meng, Comer, and Decker, 2025, “Greenhouse Gas Emissions and Air Pollution from Global Shipping, 2016–2023.”

17 IMO, 2020, “Fourth Greenhouse Gas Study 2020.”

emissions had risen by about 9.6 percent from 2012 to 2018. As noted in the introduction, the ICCT analysis found that from 2016 to 2023, global CO₂e emissions from shipping had grown by 12 percent.¹⁸ This represents a compound annual growth rate of about 1.4 percent. The COVID-19 pandemic briefly disrupted growth: emissions declined by 3.2 percent from 2019 to 2020, but they then grew by 3.2 percent between 2020 and 2021.

Geopolitical disruptions can drive up emissions as well. One analysis found that in 2024, emissions from container ships rose by 14 percent year over year, to 240.6 Mt CO₂e, largely due to ships having to travel around the Cape of Good Hope because of conflict in the Red Sea.¹⁹ A recent study by the Organisation for Economic Co-operation and Development (OECD) found significant year-to-year variations in the influence of different factors on CO₂ emissions from 2019 to 2024, but it concluded that rapid post-pandemic GDP growth and even faster-growing demand for marine transport were the main drivers of emissions growth.²⁰

Shipping is difficult to decarbonize for several reasons. Ships have long operational lifespans: vessels designed and built today may remain in service for decades. Moreover, replacing bunker fuels with zero- or near-zero-emission fuels is a key aspect of the transition, and that requires securing not only ample supplies of those fuels, but also vessels capable of using them. Port and bunkering infrastructure, in turn, must be able to supply the fuels and service the vessels. Decarbonization thus requires not just a change in vessel technology, but coordinated action spanning fuels, vessels, ports, safety standards, finance, and regulation. Making this happen requires clear demand signals from cargo owners and governments.²¹

That said, real progress is already being made. In June 2025, an IMO press release cited data from the World Shipping Council showing that at least 200 ocean liners (container ships) already in operation could run on zero or near-zero emission fuels (ZNZ fuels), adding that close to 80 percent of all new orders for container ships and vehicle carriers would have the same hybrid

18 Mao, Meng, Comer, and Decker, 2025, "Greenhouse Gas Emissions and Air Pollution from Global Shipping, 2016–2023."

19 Stausboll, E. 2025. "Record-Breaking Carbon Emissions in Ocean Container Shipping: Here's What Shippers Need to Know." Xeneta. Ocean (blog), April 16. <https://www.xeneta.com/blog/record-breaking-carbon-emissions-in-ocean-container-shipping-heres-what-shippers-need-to-know>.

20 Queljoe, M.D., P. Herrero, S. Sakata, et al. 2025. "Analysing Recent Trends and Drivers of Maritime Transport CO₂ Emissions: Insights from a Decomposition Analysis for the OECD and the World." OECD Statistics Working Papers, 2025/03. Paris: Organisation for Economic Co-operation and Development. doi:10.1787/6bb2bd69-en.

21 IMO. 2025. "Shipping Gears up for Massive Investments in Decarbonization." International Maritime Organization press release. May 9. <https://www.imo.org/en/mediacentre/pages/whatsnew-2269.aspx>.

Ocean Conservancy. 2025. "Green Shipping Corridors: A Pathway to Zero-Emission Shipping." Washington, DC. <http://oceanconservancy.org/work/climate/deep-dive/green-shipping-corridors/>.

For some additional perspectives highlighting the complexity of decarbonizing shipping, see the overviews from the Global Shipping Council: <https://www.worldshipping.org/decarbonisation-by-2050> and RMI: <https://rmi.org/maritime-decarbonization/>.

capability.²² The council's president noted that the industry had already invested an "unprecedented" US\$150 billion in decarbonization.

As of March 2026, the World Shipping Council's website shows, 440 dual-fuel ships had been delivered and another 764 were on order; by 2030, at least 1,000 dual-fuel ships are expected to be in operation.²³ Several countries and major ports are investing in sustainable maritime transport, including decarbonization of domestic shipping and of ports, cleaner fuels, and "green shipping corridors,"²⁴ all discussed further below and in Section 2.

1.3 Pathways to Decarbonization

In its 2020 GHG study, the IMO estimated that, on a business-as-usual trajectory, shipping emissions could reach 130 percent of their 2008 levels by 2050.²⁵ Studies by the ICCT and OECD show that, despite efforts made in recent years, GHG emissions continue on an upward trajectory.²⁶ So what will it take to decarbonize the sector?

The climate impact of shipping depends on several linked factors, including the energy sources used and their lifecycle emissions, shipboard technologies, engine types, vessel operations, and the availability of ports and infrastructure able to support cleaner shipping systems. Decarbonizing shipping thus requires a combination of technical, operational, fuel and energy-related, and infrastructure investments and policy measures. Action on any one of those pathways alone will not suffice; progress is needed on all fronts.

Energy efficiency is an essential starting point. New ship designs, retrofits, and operational improvements can reduce fuel consumption, emissions, and the overall cost of the maritime energy transition. Indeed, the IMO's 2020 GHG study found that from 2008 to 2018, the carbon intensity of international shipping had declined by 21–29 percent per voyage, depending on the metric used, though the performance of individual vessels varied significantly from year to year.²⁷ However, the study also found that more than half the improvements had occurred before 2012, and annual gains had slowed to just 1–2 percent since 2015.

22 IMO, 2025, "Shipping Gears up for Massive Investments in Decarbonization."

23 See <https://www.worldshipping.org/decarbonisation-by-2050>.

24 Baines, J., O. Ashford, S. Gander, et al. 2025. "Modernizing Ports Is a Major Untapped Opportunity for a Healthier Planet." World Resources Institute. Insights (blog), October 30. <https://www.wri.org/insights/modernizing-ports-major-untapped-opportunity-healthier-planet>; Ocean Conservancy, 2025, "Green Shipping Corridors: A Pathway to Zero-Emission Shipping."

25 IMO, 2020, "Fourth Greenhouse Gas Study 2020."

26 Mao, Meng, Comer, and Decker, 2025, "Greenhouse Gas Emissions and Air Pollution from Global Shipping, 2016–2023"; Queljoe, Herrero, Sakata, et al., 2025, "Analysing Recent Trends and Drivers of Maritime Transport CO₂ Emissions: Insights from a Decomposition Analysis for the OECD and the World."

27 IMO, 2020, "Fourth Greenhouse Gas Study 2020."

Measures to further improve energy efficiency include improved biofouling management,²⁸ more efficient engines, optimized propellers, hull designs and retrofits that reduce drag, improved weather routing, optimized trim, draft and ballast, reduced onboard power demand, use of shore power while in port, and better maintenance of hulls and propellers. **Speed reduction** is also a highly effective operational measure that can promptly reduce energy demand and GHG emissions. A 2019 study found that the effects would vary across ship types, but, on average, a 10 percent reduction in vessel speed would reduce CO₂ emissions by about 13 percent, with similar reductions in NO_x and SO_x emissions.²⁹ A 20 percent speed reduction could curb emissions by about 24 percent. The study also found that slower speeds would significantly reduce both underwater radiated noise and the likelihood of lethal whale strikes.

Fuel switching has been central to decarbonization efforts through the IMO, and it remains crucial. Even if all vessels, including current fleets and future additions, are maximally efficient, they will still need an energy source, which can no longer be fossil fuels. As discussed further below, the IMO has made zero- or near-zero-GHG emission technologies, fuels, and energy sources central to its decarbonization strategy.³⁰ Along with maximizing the use of on-board wind renewables (see below), ships will need to replace bunker fuels with cleaner options.

The fuels currently under consideration include green hydrogen, ammonia, and methanol, among others.³¹ None is interchangeable with conventional bunker fuels, but, as noted in section 1.2, a growing share of new ships can run on zero or near-zero emission fuels (ZNZ fuels) as well as fossil fuels.³² Meeting demand for ZNZ fuels is thus a key way for countries to advance shipping decarbonization. By setting fuel transition targets—for domestic shipping at the very least, but potentially also for ships arriving at and departing from their ports, as the EU has done—countries can actively drive up demand. Crucially, such targets should be accompanied by policies on fuel production, supply chains, bunkering infrastructure, and safety standards. The investment needs are likely to be substantial, and each fuel has different implications for cost, safety, infrastructure, lifecycle emissions, storage, and vessel design.

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- 28 Biofouling is the accumulation of aquatic organisms—microbes, algae, plants, barnacles, etc.—on a ship's hull and other submerged surfaces, which causes major hydrodynamic drag, increasing fuel consumption, operating costs and GHG emissions. For an overview from the IMO, see: <https://www.imo.org/en/ourwork/environment/pages/biofouling.aspx>.
- 29 GL Reynolds. 2019. "The Multi-Issue Mitigation Potential of Reducing Ship Speeds." Report commissioned by Seas at Risk and Transport and Environment. <https://seas-at-risk.org/wp-content/uploads/2021/03/2019.6.11.-Mitigation-ship-speeds.pdf>.
- 30 IMO. 2023. "2023 IMO Strategy on Reduction of GHG Emissions from Ships." MEPC 80/17/Add.1, Annex 15. International Maritime Organization. <https://www.imo.org/en/ourwork/environment/pages/2023-imo-strategy-on-reduction-of-ghg-emissions-from-ships.aspx>.
- 31 Note that in order to be zero- or near-zero-emission fuels, these alternative fuels would need to be produced with 100 percent clean energy—not, say, electricity from coal- or gas-fired power plants—and could not be derived from fossil fuels.
- 32 IMO, 2025, "Shipping Gears up for Massive Investments in Decarbonization."

Wind-assisted propulsion can also contribute to the mitigation pathway. Modern wind technologies can significantly reduce the fuel use of most vessels. This means that by installing wind propulsion technologies on routes whenever possible, and incorporating wind propulsion into the design of new builds, the industry can reduce its energy demand—and its dependence on fuel supply chains. These measures thus complement both efficiency improvements and fuel-switching measures. The first wind-assisted ships are already in operation, and initiatives are exploring both wind-assisted propulsion and fully wind-powered cargo shipping.³³

On-board **solar photovoltaic** (PV) systems are emerging as a promising complementary technology, although their application remains limited due to the large surface area required.³⁴ PV systems can be retrofitted to existing vessels with minimal structural or electrical modifications, they can supply auxiliary power either independently or through the ship's electrical grid, reducing fuel consumption and associated emissions while offering additional benefits such as low maintenance requirements, long service life and operation without fuel use, exhaust emissions or noise. The integration of PV systems has been successfully tested across a range of vessel types, including naval vessels, cruise ships, Ro-Ro vessels and cargo ships. They have been found to be particularly suited to cargo ships, where large deck areas facilitate installation, and to offer fuel savings of up to 7 percent in Ro-Ro vessels.

As research advances, hybrid configurations combining solar power with other low-carbon technologies are expected to further improve. In fact, the Marshall Islands' NDC describes how, with German support, the country obtained a prototype hybrid vessel, the *Juren Ae*, to serve inter-island transport needs.³⁵ Launched in 2024, the ship combines wind-assisted propulsion, fuel-efficient engines, and solar power.

Electrification is another key decarbonization pathway, particularly for shipping across shorter distances, harbor craft such as ferries and port service vessels, and domestic routes for which range and infrastructure requirements are more manageable. As countries develop and implement their NDCs, targeting these segments can provide practical early opportunities to deploy zero-emission vessels. It is important to stress that electrification will only lead to zero-emission shipping if the electricity itself comes from clean sources. The most promising opportunities are likely to arise in places where renewable electricity supply and charging infrastructure can be integrated into port modernization and/or decarbonization projects.

Green shipping corridors—maritime routes that support the deployment of vessels using ZNZ fuels and/or other low-emission technologies—can focus investment, fuel supply, vessel deployment, port readiness, policy

33 For an example of a company pursuing these technologies, see <https://propelwind.com>.

34 Piazza, M.C.D., M. Pucci, G. Rodono', et al. 2025. "Shipboard Photovoltaics Integration for Retrofitting Cargo Ships: A Case Study." In *Technology and Science for the Ships of the Future*, edited by V. Crupi and V. Bucci. SAGE Publications. doi:10.3233/PMST250023.

35 RMI, 2025, "The Republic of the Marshall Islands Nationally Determined Contribution 2031-35." See also <https://www.giz.de/en/projects/transitioning-low-carbon-sea-transport>.

coordination, and stakeholder cooperation along specific routes, making the transition more manageable than attempting immediate sector-wide transformation. Multiple definitions of the concept have been put forward; Ocean Conservancy has highlighted the importance of such corridors seeking to achieve zero GHG emissions across the corridor value chain in support of equitable sector-wide decarbonization no later than 2040.³⁶ Establishing a green shipping corridor requires engaging with a range of public, private, and community interests, adopting supporting policies, and securing financing from both public and private sources. Ocean Conservancy has stressed the need to pursue green shipping corridors with equity in mind, including remote ports and historically underserved routes, and making real commitments to knowledge-sharing, capacity-building, and technology transfer.

1.3.1 Avoiding fossil fuel lock-in

Because ships typically operate for several decades, investment decisions made today will shape the sector's emissions profile well into the future. It is thus crucial to ensure that new vessels are highly efficient and designed to work with zero- and near-zero emission fuels. Investments in port upgrades and fuel infrastructure—which national governments are well positioned to steer—should also support decarbonization, rather than locking in assets that depend on fossil fuels.

This may seem obvious when the fossil fuel in question is heavy fuel oil (HFO) or its somewhat less-polluting successor, very-low-sulfur fuel oil (VLSFO). However, as discussed in section 1.2, another fossil fuel—liquefied natural gas (LNG)—is rapidly gaining market share.³⁷ Between 2016 and 2023, the number of LNG-fueled ships more than doubled, and LNG consumption as a marine fuel grew by more than 80 percent. Both in the shipping sector and among many policymakers, LNG is often promoted as a transitional option on the path towards net zero.

The oil and gas company Shell, for example, produced a report touting the “methane pathway” as a “compliant, scalable, and commercially viable route to net zero.”³⁸ The Port of Shanghai, as part of its “green transformation of international shipping fuels,” aims to create LNG bunkering capacity of 1 million cubic meters by 2030, along with 1 million metric tons of bunkering capacity for methanol and ammonia.³⁹ Some in the industry are already

36 Ocean Conservancy, 2025, “Green Shipping Corridors: A Pathway to Zero-Emission Shipping.”

37 Mao, Meng, Comer, and Decker, 2025, “Greenhouse Gas Emissions and Air Pollution from Global Shipping, 2016–2023.” HFO still predominates among cruise ships, and liquefied natural gas (LNG) carriers mainly use LNG.

38 See <https://www.shell.com/business-customers/marine/decarbonising.html>.

39 Shanghai International Services. 2024. “Shanghai Promotes Green Transformation of International Shipping fuels_Policy Insights.” Policy Insights, December 20. <https://english.shanghai.gov.cn/en-PolicyInsights/20241220/702ed96255724b7f86af9197cb3051f0.html>.

looking for strategies to keep their LNG-fueled ships viable by switching to bio-methane and other options.⁴⁰

However, methane is a powerful greenhouse gas, with nearly 30 times the global warming potential of CO₂ over 100 years, and about 80 times over 20 years.⁴¹ Methane slip on ships and leakage across the LNG supply chain can thus sharply increase lifecycle CO₂-equivalent emissions, potentially surpassing conventional fuel oil.⁴² This makes LNG unsuitable as a low-carbon fuel. Yet using it even just in the near term requires investing in vessels and storage and delivery infrastructure that can create an economic “lock-in” of LNG use. It is thus important for countries to avoid promoting or supporting a shift to LNG as a decarbonization pathway, and instead focus on genuinely zero- or near-zero-emission options and fuels.

1.4 The IMO Net-Zero Framework

A great deal of the progress towards the decarbonization of shipping has been driven by international cooperation and engagement with the shipping sector through the IMO. The UN agency has produced four studies of GHG emissions, most recently in 2020,⁴³ and developed the 2023 IMO Strategy on Reduction of GHG Emissions from Ships, which commits to reaching net zero GHG emissions from international shipping by 2050.⁴⁴

The strategy sets interim targets of a 20–30 percent emission reduction (from a 2008 baseline) by 2030 and a 70–80 percent reduction by 2040. It also calls for zero- and near-zero emission fuels and energy (ZNZs) to make up 5–10 percent of shipping energy use by 2030. In addition, it calls for a “just and equitable” transition to ensure no countries are disproportionately affected by the maritime energy transition or excluded from its potential benefits, particularly small island developing states (SIDS) and least developed countries (LDCs).

Expert analyses have raised questions about the viability of the IMO strategy. For example, a 2025 modeling study by the ICCT found that mid-term measures developed by the IMO could improve operational efficiency enough to reduce cumulative GHG emissions by about 10 percent between 2020 and

40 Sekkesæter, Ø. 2026. “Low-GHG Methane’s Role in Keeping LNG-Capable Ships Compliant.” DNV Industry Insights, June 17. <https://www.dnv.com/expert-story/maritime-impact/low-ghg-methanes-role-in-keeping-lng-capable-ships-compliant/>.

41 Forster, P., T. Storelvmo, K. Armour, et al. 2021. “The Earth’s Energy Budget, Climate Feedbacks and Climate Sensitivity.” In *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by V. Masson-Delmotte, P. Zhai, A. Pirani, et al., 923–1054. Cambridge, UK, and New York: Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg1/>.

42 Lladrés Pohl, 2023, “The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health.”

43 IMO, 2020, “Fourth Greenhouse Gas Study 2020.”

44 IMO, 2023, “2023 IMO Strategy on Reduction of GHG Emissions from Ships.”

2050.⁴⁵ The rest of the emissions gap would need to be closed by replacing fossil fuels with net-zero GHG fuels or energy, the study found, “which can only be achieved by advanced technologies that have not yet been fully commercialized.”

Moreover, the ICCT analysis noted, decarbonization will only succeed if the fuel standard set by the IMO (discussed below) and the guidance to implement it accurately account for the life-cycle emissions of marine fuels and prevent the use of food- and feed-based biofuels.⁴⁶ It will also require “unprecedented” levels of investment in the “nascent and pre-commercial technologies necessary to produce genuinely zero-carbon fuels.” If the IMO standards are not strict enough, the ICCT study argued, national and regional authorities will need to close the gap through their own, stricter measures.

Implementing the IMO strategy requires a formal agreement, and in April 2025, at the 83rd session of the Marine Environment Protection Council (MEPC 83), the IMO achieved a historic regulatory breakthrough: the approval of a draft Net-Zero Framework (NZF).⁴⁷ It includes several binding policy measures to support implementation of the IMO strategy, most notably a global fuel standard to progressively reduce the GHG intensity of fuels, and a GHG pricing mechanism to incentivize emissions reductions, generate revenues for the maritime energy transition, and help ensure a just and equitable transition.

The original plan was to have Member States approve the NZF at an extraordinary session of the MEPC in October 2025, then approve detailed implementation guidelines in the spring of 2026; the framework would have entered into force in 2027, 16 months after its adoption.⁴⁸ However, due to concerns from some Member States, the vote had to be postponed.⁴⁹ The MEPC session was adjourned for a year, to October 2026. In the meantime, the 2023 IMO strategy, with its net-zero objective, remains in force, and the NZF continues to frame the industry’s planning horizon.

If/when the NFZ is ultimately adopted, it will be the first binding regulation in the world to combine mandatory GHG fuel intensity limits with a global

45 Cho, H.J., G. Alvarez, and B. Comer. 2025. “Vision 2050: Fuel Standards to Align International Shipping with the Paris Agreement.” Washington, DC: International Council on Clean Transportation. <https://theicct.org/publication/vision-2050-fuel-standards-to-align-international-shipping-with-the-paris-agreement-mar25/>.

46 Cho, Alvarez, and Comer, 2025.

47 IMO. 2025. “IMO Approves Net-Zero Regulations for Global Shipping.” International Maritime Organization press release. April 11. <https://www.imo.org/en/mediacentre/pressbriefings/pages/imo-approves-net-zero-regulations.aspx>.

See also the IMO’s “frequently asked questions” factsheet: <https://www.imo.org/en/mediacentre/hottopics/pages/faqs-the-imo-net-zero-framework.aspx>.

48 IMO, 2025.

49 Sengupta, S. 2025. “U.S. Pressures Countries to Delay Fees to Clean Up Ship Pollution.” The New York Times, October 17, sec. Climate. <https://www.nytimes.com/2025/10/17/climate/shipping-pollution-fee-international-maritime-organization.html>.

emissions pricing mechanism across an entire industry sector.⁵⁰ The framework builds on the 2023 strategy's indicative checkpoints of a 20–30 percent reduction in emissions from 2008 levels by 2030, a 70–80 percent reduction by 2040, and net zero by or around 2050. The NZF initially would apply to ships over 5,000 gross tonnes, which produce 85 percent of the sector's CO₂ emissions.

In each successive year, all covered vessels would have to meet well-to-wake GHG fuel intensity (GFI) reduction targets, a higher “direct compliance” emission reduction target and a lower “base” target. To incentivize ambitious emission reductions, ships that exceed the GFI compliance target would receive surplus units (SUs) that they can “bank” for future compliance or sell to ships that fail to meet the base target. Non-compliant ships would face a two-tiered compliance penalty mechanism and have to acquire “remedial units” (RUs) at \$100/tonne CO₂e for emissions above the direct compliance target but below the base target. Ships with emissions above the base target would be required to pay \$380/tonne CO₂e or purchase SUs from overperforming ships. Revenues from RUs would be paid into an IMO Net-Zero Fund. These revenues are projected at US\$11–13 billion per year and would be used to accelerate clean fuel transitions through rewards or other incentives for the use of zero- and near-zero fuels and energy and support a just and equitable transition, particularly for SIDS and LDCs.

These measures are essential for decarbonizing international shipping. However, they do not cover every dimension of the sector's transition, including domestic shipping and the national systems needed to support fuel, port, infrastructure, and investment changes.

This is why national-level action, including through NDCs, is key. Many of the enabling conditions needed to decarbonize shipping sit within national (or, in the case of the European Union, regional) policy frameworks, including port infrastructure, domestic fuel production, bunkering systems, public procurement, national transport strategies, investment planning, and measures addressing domestic shipping emissions. NDCs and other national policies, strategies, and plans can accelerate progress and provide strong signals to the market about policy direction. They can identify investment priorities, clarify institutional responsibilities, and align transport, energy, industrial, port, and climate strategies.

50 European Commission. 2025. “Landmark Agreement towards Achieving Net-Zero Emissions from Global Shipping by 2050.” Directorate-General for Mobility and Transport news article. April 11. https://transport.ec.europa.eu/news-events/news/landmark-agreement-towards-achieving-net-zero-emissions-global-shipping-2050-2025-04-11_en.

1.5 Why Don't More NDCs Already Include Shipping?

International shipping is often excluded from, or only indirectly reflected in, NDCs because, as noted in the introduction, the sector's emissions are addressed through the IMO, not as part of countries' own emissions inventories and mitigation strategies. As discussed in detail in Section 2, this should not stop countries from including relevant measures in their NDCs—nor should it affect efforts to decarbonize domestic shipping and ports. Still, there are some real challenges.

The sector is transboundary, capital-intensive, technically complex, and governed through a combination of international, regional, national, and local frameworks. At the same time, shipping decarbonization can help countries reduce emissions, strengthen port and trade resilience, improve air quality, develop new fuel/energy and industrial value chains, and align national policy with emerging international shipping decarbonization pathways.

A central challenge is the split between the governance of international shipping through the IMO, national climate governance under the Paris Agreement, and implementation. This can create uncertainty over how shipping should be reflected in national climate commitments, particularly where emissions are generated across international routes, by foreign-flagged vessels, or through trade activities linked to several jurisdictions.

This governance complexity has contributed to shipping decarbonization being treated inconsistently in NDCs. Some countries include domestic maritime transport, ports, or fuel infrastructure, while others refer more generally to transport, logistics, or blue economy measures without specifying whether they are working to reduce shipping emissions. This lack of clarity weakens accountability and makes it more difficult to assess whether commitments are sufficient, measurable, and implementable.

A second challenge relates to data, accounting, and attribution. Shipping emissions are difficult to allocate because vessels operate across borders, may be owned, flagged, fueled, operated, and serviced in different countries, and may serve both domestic and international trade. This makes it difficult for countries to define the scope of shipping-related NDC commitments and to determine whether they should cover domestic shipping, international shipping, port operations, fishing vessels, fuel supply chains, or some combination of these.

Although the Paris Agreement envisions the full decarbonization of economies, reporting on international shipping and aviation remains at the discretion of individual countries and, when reported, must be documented separately. In practice, countries generally do not report these emissions or explicitly cover them in their NDCs. Indeed, unclear accounting and governance arrangements have been identified as a barrier to decarbonization.⁵¹

Lastly, as noted above, countries that seek to decarbonize shipping face considerable financial and technological barriers. Zero- and near-zero-

51 Llabrés Pohl, 2023, "The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health."

emission fuels, new vessel designs, port infrastructure, bunkering systems, safety protocols, and workforce skills all require significant investment.⁵² Clean fuels can be significantly more expensive than conventional fuels, so carbon pricing, subsidies, and other economic instruments will be key. By one estimate, decarbonizing shipping by 2050 will require US\$1.4–1.9 trillion in investment between 2030 and 2050, mainly for new fuel production and distribution infrastructure.⁵³

These barriers are especially relevant for developing countries, especially SIDS and LDCs. At the same time, by using NDCs as strategic planning tools, countries can clearly identify investment priorities, which may help them mobilize climate finance, and align key sectoral policies and plans with their ambitions. This can help move shipping decarbonization from isolated pilot projects toward scalable national and regional implementation pathways.

52 Ocean Conservancy, 2025, "Green Shipping Corridors: A Pathway to Zero-Emission Shipping."

53 Llabrés Pohl, 2023, "The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health."



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2. Integrating Shipping and Ports in NDCs, LT-LEDS, and Beyond

Section 1 explained why it is so crucial to decarbonize shipping and ports—and why national-level action has a key role to play as a complement to efforts through the IMO. This section focuses on how countries can integrate shipping and ports into their NDCs and related strategies, policies, and plans, outlining how to formulate targets, create enabling conditions, and mobilize finance.

2.1 How to Use this Guidance

Given the centrality of NDCs in national climate policies and plans, this guidance provides detailed advice for countries still formulating new or updated NDCs. However, as noted in the introduction, the guidance is also meant to be useful to governments in implementing their latest NDCs, developing long-term low-emission development strategies (LT-LEDS), and throughout the national climate and development planning and implementation cycle:

Countries preparing or updating an NDC: Identify the best options for integrating shipping and ports, and decide whether to do so through an economy-wide target, a dedicated transport or maritime target, or a combination of sectoral targets and enabling measures. The guidance can also support decisions on the scope of the commitment, including whether it covers domestic shipping, fishing vessels, ports, harbor craft, fuel supply systems, or nationally controlled measures that contribute to international shipping decarbonization. It further provides options for defining quantified and time-bound targets, distinguishing between unconditional and conditional actions, identifying implementation measures and financial needs, and establishing arrangements for monitoring progress.

Countries developing or revising an LT-LEDS: LT-LEDS provide an important opportunity to take a longer view of the climate transition and think strategically about how shipping may evolve in the coming decades, and what role the country can/should play. While NDCs focus on nearer-term commitments, an LT-LEDS can plan a series of measures over several decades, including fleet renewal, the retirement or retrofitting of fossil-fuel-dependent vessels, the development of zero- and near-zero-emission fuel supply, port and bunkering infrastructure, grid requirements, workforce development, and industrial investment. Countries can therefore use this section to connect near-term measures with longer-term objectives for 2040, 2050, or another nationally defined horizon, while avoiding infrastructure and vessel investments that could lock in emissions.

Raising ambition and strengthening implementation of existing NDCs: Many countries already have an NDC in force but may have included shipping only indirectly, under a broad transport target, or not at all. These countries can use the guidance to pursue shipping- and port-related opportunities aligned with their NDC and accelerate progress. For example, they can create a

roadmap for decarbonizing shipping to advance their targets for transport. They can introduce policies on vessel efficiency, public procurement, port electrification, fuel standards, carbon pricing or green shipping corridors; they can identify relevant financial or technical-assistance needs and opportunities. All this can strengthen implementation and generate the institutional experience, data and evidence needed to formulate a stronger commitment in the next NDC cycle.

Updating sectoral policies, strategies, and investment plans: The guidance is also relevant to finance and line ministries, maritime authorities, port authorities, regulators, and other institutions working at the sectoral level. It can inform national maritime transport strategies, domestic shipping plans, port master plans, alternative-fuel and energy strategies, industrial-development policies, public-procurement frameworks, workforce and training programs, climate-finance strategies, and monitoring systems. Applying the guidance through these sectoral processes can help align transport, energy, industry, finance, trade, labor, and climate policies, even where the NDC itself is not being revised.

This section is designed to be flexible, so users can find the entry points that best suit their national context and their specific needs. Section 2.2 focuses on technical considerations in formulating an NDC, which are also relevant to LT-LEDS, and provides examples of measures adopted in NDCs to date. Section 2.3 focuses on policies and measures that may be crucial to the success of NDC commitments—and that can also build a foundation for future commitments. Section 2.4 presents concrete examples for how to design effective and accountable measures to address shipping and port decarbonization. Section 2.5 focuses on how to finance these measures. Section 2.6 focuses on monitoring, reporting, and evaluation, highlighting what it takes to track progress and ensure accountability.

2.2 Key Considerations in Formulating NDCs

Countries have a great deal of flexibility in how they formulate NDCs. They can choose to focus entirely on climate change mitigation, or also include adaptation, as many do. On the mitigation side, they can choose to set **economy-wide targets**, specify **sectoral targets** (e.g., for the energy sector, transport, or land use-related emissions), or take a **hybrid approach** (e.g., pledging to reduce overall emissions by 5 percent and also to reduce electricity-related emissions by 20 percent by replacing coal with solar power).

Developing countries can also distinguish between **unconditional** targets, which countries commit to achieving using their own resources, and **conditional** targets. The latter are contingent upon receiving external support, such as international climate finance, technology transfer, and/or capacity-building. Conditional targets offer a way to significantly raise ambition and invite bilateral and multilateral partners to provide the necessary support to pursue them. Under the Paris Agreement, developed countries

are expected to provide that support, though in practice, international climate finance from public sources is now on the decline.⁵⁴

2.2.1 Economy-wide vs. sectoral commitments

Economy-wide targets reflect a commitment to addressing climate change across all aspects of a country's economy, which is ultimately essential to reaching net zero GHG emissions. At the same time, they are inherently less specific, and targets may be achieved or missed for reasons unrelated to climate ambition. (For example, massive forest fires can drive up emissions, while the COVID-19 pandemic brought down emissions by shutting down economic activity.) Hybrid approaches can enable governments to target high-emitting sectors while also pursuing a broader range of emission reductions.

In theory, the decarbonization of shipping and ports can be integrated into an NDC taking any of these approaches. The more common approach to date has been to include shipping only indirectly through an economy-wide GHG reduction target, without disaggregating or tracking the sector's emissions separately. This is the easiest option, but it has a significant limitation: It provides no sector-specific accountability, no price signal for ship owners or fuel suppliers, and no basis for designing maritime-specific climate finance.

Several legal analyses have concluded that this indirect route does not fully satisfy the Paris Agreement's implicit expectation of "economy-wide" coverage, particularly where shipping is a material component of a country's emissions profile.⁵⁵ The third NDC cycle ahead of COP30 in 2025 offered the clearest opportunity yet for port states and flag states to move from passive references to shipping toward explicit, measurable shipping-related commitments, but, as noted in section 1.5, they generally did not.

Still—and this is important for countries that already submitted their NDCs—countries can still move forward with shipping and port decarbonization even if their NDC lacks specific targets for the sector. For example, Singapore's latest NDC sets only an economy-wide target: to reduce GHG emissions to 45–50 Mt CO₂e by 2035.⁵⁶ However, the country's Maritime Decarbonisation Blueprint, adopted in 2022, charts out a plan towards net zero GHG emissions and explicitly connects it to Singapore's NDC and its national

54 Abraham, S., P. de A. Fernandes, J. Connolly, et al. 2026. "Global Landscape of Climate Finance 2026." Climate Policy Initiative. <https://glcf.climatepolicyinitiative.org>.

The report finds that, after increasing by 33 percent in 2022 and 20 percent in 2023, international public climate finance fell by 6 percent in 2024. More recent data indicate that official development assistance (ODA), a key mechanism through which climate finance flows, fell by 8.5 percent in 2024 and 23.3 percent in 2025, the largest single-year drop on record, and is projected to drop by another 6.9 percent in 2026. See: Thwaites, J. 2026. "Midway Through a Tumultuous 2026, Where Do We Stand on International Public Climate Finance?" Natural Resources Defense Council blog. July 27. <https://www.nrdc.org/midway-through-tumultuous-2026-where-do-we-stand-international-public-climate-finance>.

55 Opportunity Green, Seas At Risk, and Transport and Environment. (2025, June 9). Ocean protection means including shipping in countries' Paris climate targets [Press release]. <https://www.transportenvironment.org/articles/ocean-protection-means-including-shipping-in-countries-paris-climate-targets>

56 Government of Singapore. 2025. "Singapore's Second Nationally Determined Contribution (NDC) and Accompanying Information." <https://unfccc.int/sites/default/files/2025-02/Singapore%20Second%20Nationally%20Determined%20Contribution.pdf>.

agenda on sustainable development and climate action, the Singapore Green Plan 2030.⁵⁷ The Blueprint notes that Singapore is the world's second-busiest port in terms of container throughput and a major bunkering hub, and it lays out a seven-prong agenda, covering port terminals, domestic harbor craft, clean fuels and supporting infrastructure, the Singapore Registry of Ships, international action through the IMO and other platforms, research and development, and carbon accounting and green finance.

The most direct and legally robust approach is to explicitly incorporate specific targets for shipping in the NDC, as part of the section on the transport or maritime sector. Under this model, a country sets a quantified emissions reduction target for shipping, names the policy instruments through which it will achieve that target, and reports progress against it through the United Nations Framework Convention on Climate Change (UNFCCC) transparency framework.

Sectoral inclusion is most practical for countries with large domestic fleets or significant port activity, where national policy levers over vessels, fuels, and infrastructure are strong, and where the emissions in question are clearly attributable to activities under national jurisdiction.

Countries taking a sectoral approach may still look more broadly than shipping—for instance, including it under the transport or energy sector. For example, Fiji's NDC 3.0 takes a sectoral NDC approach and includes a conditional target for domestic shipping under its broader energy sector target.⁵⁸ Fiji has committed unconditionally to reducing GHG emissions from the energy sector by 12 percent from business-as-usual levels, rising to 36 percent with international support. About 6 percentage points of that conditional reduction would come from reducing emissions from domestic maritime transport by 40 percent.

The analysis of 66 NDCs from coastal and island nations discussed in Section 1,⁵⁹ as well as a more in-depth review conducted for this guidance, showed that shipping is generally not yet treated as a distinct mitigation sector with quantified targets, timelines, or dedicated implementation measures—though often it is addressed on the adaptation side of NDCs. Instead, shipping is more often included under broader transport, infrastructure, port, fuel, or energy measures. While that may be sufficient in many cases, especially for smaller countries, and/or where separate policy documents provide that level of detail (as in Singapore), there are good reasons to be more specific. Good practices in the NDCs reviewed for this guidance include sector-specific targets, dedicated implementation roadmaps, regulatory and market-based instruments, green shipping corridors, and links to international finance.

57 MPA Singapore. 2022. "Maritime Singapore Decarbonisation Blueprint: Working Towards 2050." Maritime and Port Authority of Singapore. <https://www.mpa.gov.sg/maritime-singapore/sustainability/maritime-singapore-decarbonisation-blueprint>.

58 Government of Fiji. 2025. "Fiji's Third Nationally Determined Contribution 2025-2035." Suva: Department of Climate Change, Ministry of Environment and Climate Change,. <https://unfccc.int/documents/497488>.

59 Khan, Baines, Lecerf, et al., 2025, "The State of Ocean-Based Climate Action in 2025 Nationally Determined Contributions: A Preliminary Update."

Another reason to focus specifically on the maritime or shipping sector in an NDC (and/or an LT-LEDS) is that, as discussed in Section 3, marine ecosystems and coastal communities face multiple interconnected challenges, and many of the solutions are also interconnected. The analysis of 66 NDCs found that 10 included adaptation measures related to ocean-based transport, with seven specifically referring to climate-proofing ports and other critical infrastructure.⁶⁰ This reflects the high exposure of ports and coastal transport infrastructure to sea-level rise, flooding, storms, and wider climate-related disruption. With 28 NDCs listing mitigation measures targeting ocean transport, and 39 and 53, respectively, listing mitigation and adaptation measures related to coastal and marine conservation, it is clear that there is significant interest in ocean-based climate action in these countries.

Another reason to take a sectoral approach is that it can help countries to mobilize climate finance and attract private investment by sending a clear signal to markets. As noted earlier, by one estimate, decarbonizing shipping by 2050 could require US\$1.4–1.9 trillion in investment between 2030 and 2050, mainly for new fuel production and distribution infrastructure.⁶¹ For countries developing NDCs and/or LT-LEDS, the key message is that if decarbonization of the sector is to succeed, it must be supported by clear financing and implementation mechanisms.

2.2.2 Domestic vs. international shipping

A critical source of complexity in NDC design is the distinction between domestic and international shipping. Domestic shipping, covering vessels operating entirely within a single country's jurisdiction, is already captured in national GHG inventories and can be covered by NDC targets using standard accounting methods. International shipping, however, produces emissions on the high seas that are not attributable to any single state under the UNFCCC's current accounting conventions, and are therefore excluded from virtually all existing NDCs.

As noted in Section 1, the vast majority of countries that have ratified the Paris Agreement are also IMO Member States,⁶² so ultimately, governments will still have to step up to decarbonize both domestic and international shipping—not just the former. Nonetheless, it is unlikely that most countries will have the resources or motivation to start quantifying their emissions from international shipping. A practical solution may be to make specific GHG emission reduction commitments for domestic shipping and ports, while supporting the decarbonization of international shipping through fuel transition targets and electrification, for instance. Developed countries with strong bilateral relationships can also accelerate progress through green

60 Khan, Baines, Lecerf, et al., 2025.

61 Llabrés Pohl, 2023, "The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health."

62 A total of 194 Parties, including 193 countries and the European Union, have ratified the Paris Agreement; see <https://unfccc.int/process/the-paris-agreement/status-of-ratification>. For a list of IMO Member States, see <https://www.imo.org/en/ourwork/ero/pages/memberstates.aspx>.

shipping corridors, climate finance for port upgrades, clean fuel pilots, and other actions.

2.2.3 Specific and time-bound targets

A key strength of the commitments required under the Paris Agreement is that they must be specific and time-bound. Every NDC has a specific time frame, and within that time frame, countries commit to a specific set of GHG emission reductions (and other actions). To send a clear market signal, encourage prompt action, and ensure accountability, commitments about shipping should be specific and time-bound as well.

Fuel transition targets

The European Union offers a useful example. The EU's FuelEU Maritime regulation, which entered into force in 2025, is framed as one of several "complementary policy instruments" alongside the EU's commitment to reach climate neutrality by 2050.⁶³ It applies to half the energy used by a ship arriving at or departing from an EU Member State port from an external jurisdiction and to all energy used by ships traveling from one EU Member State to another, as well as energy use at EU ports. It sets progressively tightening GHG intensity mandates, starting from a reference value of the average GHG intensity of energy used on board ships as of 2020: from a 2 percent reduction from 2025, to an 80 percent reduction by 2050.

To more rapidly scale up e-fuels, Renewable Fuels of Non-Biological Origin (RFNBOs, including e-ammonia, e-methanol and e-hydrogen) benefit from a 2x multiplier until 2033, with a 2 percent RFNBO subtarget triggered from 2034 if uptake remains below 1 percent by 2031. The European Commission has estimated that 86–88 percent of EU maritime fuel must be renewable or low-carbon by 2050 for the sector to align with EU climate-neutrality goals.⁶⁴ Since 2024, the EU Emissions Trading System has also included shipping, making it the first major carbon market to price maritime emissions directly.⁶⁵

When developing national shipping emissions targets, countries can start from existing international and regional trajectories and adapt the level of ambition, baseline, scope, and target year to national circumstances. For example, the 2023 IMO GHG strategy called for reducing emissions by at least 20 percent (striving for 30 percent) by 2030 and at least 70 percent (striving for 80 percent) by 2040, both relative to 2008 levels, with net-zero

63 European Union. 2023. "Regulation (EU) 2023/1805 of the European Parliament and of the Council of 13 September 2023 on the Use of Renewable and Low-Carbon Fuels in Maritime Transport, and Amending Directive 2009/16/EC (Text with EEA Relevance)." PE/26/2023/INIT. Brussels. <https://eur-lex.europa.eu/eli/reg/2023/1805/oj/eng>.

64 See also the overview from Bureau Veritas: <https://marine-offshore.bureauveritas.com/sustainability/fit-for-55/fueleu-maritime>.

65 Li, W. and Z. Hu. 2024. "Pathways in the Governance of Shipping Decarbonization from Perspective of Balancing the Conflicting Interests." *Frontiers in Marine Science* 11 (November): 1479528. doi:10.3389/fmars.2024.1479528.

"by or around 2050."⁶⁶ Fiji's NDC 3.0 sets a (conditional) target for domestic maritime transport of 40 percent below business-as-usual levels by 2035.⁶⁷

Beyond its NDC, Fiji is further raising ambition through the Pacific Blue Shipping Partnership (PBSP),⁶⁸ a group of seven states that has committed to aligning sea transport with a shared GHG emission reduction trajectory: 40 percent by 2030, 80 percent by 2040, and net zero by 2050. The partnership's near-term deliverable involves retrofitting and replacing over 11,000 vessels across the seven member countries, with international technical and financial support. Fiji is also a signatory to the Clydebank Declaration for Green Shipping Corridors, launched at COP26 in Glasgow in 2021, which commits to establish at least six green shipping corridors by 2025; more than 50 initiatives are now under development globally.⁶⁹

Fuel transition targets can take several different forms and still be specific and time-bound. Countries may specify the share of maritime transport energy supplied by zero- and near-zero-emission fuels (and/or clean electricity), or a required reduction in the lifecycle GHG intensity of maritime energy use, for instance. Less ambitious, but still valuable targets may focus on establishing a certain level of ZNZ fuel production and/or bunkering capacity.

Vanuatu's NDC 3.0, for example, has only one dedicated target for shipping: to continue to engage with the PBSP towards a carbon-free maritime transport sector by 2050, and to "establish a policy and regulatory framework for the reduction of GHG in the maritime transport sector and transition all major ports to Green Ports with high resilience."⁷⁰ However, broader targets for the energy and transport sectors are also likely to advance that objective: to more than double renewable energy capacity, for instance; to increase the blending of diesel with biodiesel, including coconut-based biofuel, to over 20 percent by 2035; and to improve energy efficiency in both land and marine transport by 10 percent.

If a country lacks the data, fuel supply, or technological readiness to establish a quantified maritime fuel-share or lifecycle GHG-intensity target, it can instead set measurable targets for the deployment of vessels using electric or renewable-energy propulsion. For example, Samoa's NDC 3.0 calls for 20 percent of all vessels to be electrified or powered by onboard solar photovoltaic systems by 2035 and also includes the provision of shore-side electricity for vessels at berth.⁷¹ This provides an alternative way of defining and tracking progress toward the maritime energy transition until more developed fuel use targets can be established.

66 IMO, 2023, "2023 IMO Strategy on Reduction of GHG Emissions from Ships."

67 Government of Fiji, 2025, "Fiji's Third Nationally Determined Contribution 2025-2035."

68 See <https://mcstrmi.org/projects/pacific-blue-shipping-partnership/>.

69 See <https://www.gov.uk/government/publications/cop-26-clydebank-declaration-for-green-shipping-corridors>.

70 Government of Vanuatu. 2025. "Vanuatu's Nationally Determined Contribution 3.0 2025-2035." <https://unfccc.int/sites/default/files/2025-09/Vanuatu%20NDC%203.0.pdf>.

71 Government of Samoa. 2026. "Samoa's Third Nationally Determined Contribution." Ministry of Natural Resources and Environment. https://unfccc.int/sites/default/files/2026-01/Samoa%20NDC3.0_FINAL.pdf.

Infrastructure and port decarbonization targets

Countries can complement vessel and fuel targets with measurable infrastructure and deployment milestones. These may include deadlines for equipping priority ports with onshore power or alternative-fuel infrastructure, minimum coverage requirements for eligible port calls, and targets for developing green shipping corridors.

As discussed further in section 3.3.1, some ports are already making major upgrades to support decarbonization. For instance, the Port of Barcelona plans to electrify docks with power from renewable sources, aiming to halve emissions by 2030 and be a carbon-neutral port by 2050.⁷² Namibia's Walvis Bay Port already has a green hydrogen production plant that is providing fuel for vehicles, container cranes, and small ships.⁷³

Given the scale and complexity of the investments required to decarbonize ports, funding from national governments—and, in developing countries, international climate finance—will be key. That was the rationale of the nearly US\$3 billion Clean Ports Program in the United States, which funded clean port equipment and infrastructure as well as climate and air quality planning.⁷⁴

Understanding that decarbonizing vessels alone is insufficient without parallel investment in port infrastructure, bunkering capacity, and electrification, the EU Alternative Fuels Infrastructure Regulation (AFIR) requires core and comprehensive Trans-European Transport Network (TEN-T) maritime ports to install onshore power supply (OPS) by 31 December 2029, targeting that at least 90 percent of port calls by container and passenger ships at TEN-T ports be supplied with shore-side electricity by 2030.⁷⁵ FuelEU Maritime makes OPS connection mandatory for container and passenger ships above 5,000 GT at TEN-T ports from 1 January 2030, extending to all OPS-equipped EU ports from 1 January 2035. A 2020 survey by the European Sea Ports Organisation (ESPO) found that 58 percent of EU ports already offered OPS capability, though out of this total, only 46 percent provided high-voltage electricity suitable for seagoing vessels.⁷⁶ However, 40 percent of ports planned to offer OPS in the coming two years.

72 See <https://www.portdebarcelona.cat/en/sustainability/environmental-sustainability/energy-transition/electrical-supply-ships>.

73 GCN. 2026. "Namibia Opens One of Africa's First Port-Based Facilities Combining Green Hydrogen Production and Export." January 8. <https://gcn.com/namibia-opens-facilities-combining-green-hydrogen/16839/>.

74 See <https://www.epa.gov/ports-initiative/clean-ports-program-awards> [accessed July 15, 2026].

75 See https://transport.ec.europa.eu/transport-themes/clean-transport/alternative-fuels-sustainable-mobility-europe/alternative-fuels-infrastructure_en. For more context, see:

Osipova, L. and C. Carraro. 2023. "Shore Power Needs and CO2 Emissions Reductions of Ships in European Union Ports: Meeting the Ambitions of the FuelEU Maritime and AFIR." ICCT Working Paper 2023-24. Washington, DC: International Council on Clean Transportation. <https://theicct.org/publication/shore-power-eu-oct23/>.

76 ESPO. 2020. "ESPO Publishes the 2020 Environmental Report for the European Port Sector." European Sea Ports Organisation press release. November 10. <https://www.espo.be/news/espo-publishes-the-2020-environmental-report-for-t>.

2.3 Sectoral Policies, Regulations, and Other Key Measures

Supportive policies and measures are essential to achieving countries' shipping and port decarbonization objectives. These policies should create a conducive environment for investment and implementation, while addressing regulatory, financial, and technical barriers across domestic fleets, ports, and fuel systems.

Key policies and measures that can facilitate the integration of shipping decarbonization targets into NDCs, and accelerate implementation, include regulatory frameworks, market-based measures, infrastructure and planning measures, and international cooperation mechanisms. Below we address each in turn.

2.3.1 Regulatory frameworks

Clear and enforceable regulations for vessels operating in national waters are critical. These include zero- or low-emission requirements in public service contracts, emission standards for harbor craft, and permitting frameworks for port and fuel infrastructure. Public procurement can act as a regulatory instrument where direct standards are limited. For example, Norway requires zero-emission solutions in domestic ferry tenders, creating binding requirements for vessels operating exclusively on national routes.⁷⁷

2.3.2 Market-based measures

Financial incentives: Targeted financial support is essential to overcome the high upfront costs of retrofitting domestic fleets and upgrading port infrastructure. Grants, concessional finance, and results-based funding can accelerate deployment. For instance, China has broadened the scope of its financing policy for the scrapping and renewal of coastal and inland river ships, in support of deploying vessels that run on low-carbon fuels, with a planned allocation of up to US\$21 billion in subsidies for the transition over the 2024–2028 period.⁷⁸

Fiscal measures: Fiscal instruments can directly influence fuel use and operational decisions in domestic maritime transport. These include carbon pricing on domestic marine fuels, differentiated port fees, and removal of fossil fuel subsidies. For example, the European Union applies carbon pricing to emissions from voyages between ports under Member State jurisdiction, demonstrating how pricing mechanisms can be applied to domestic or intra-jurisdictional maritime activity.

77 Government of Norway. 2021. "Norway's Climate Action Plan for 2021–2030." Meld. St. 13 (2020–2021) Report to the Storting. Ministry of Climate and Environment. <https://www.regjeringen.no/en/documents/meld.-st.-13-20202021/id2827405/>.

78 Meng, Z. 2024. "New Central Subsidies for Scrapping and Renewing Coastal and Inland River Ships in China." Washington, DC: International Council on Clean Transportation. <https://theicct.org/publication/subsidies-for-scrapping-and-renewing-existing-fleet-in-china-nov24/>.

Domestic vessel efficiency and retrofit requirements: Policies targeting the existing domestic fleet are critical for near-term mitigation. These include mandatory efficiency improvements, retrofit programs (e.g. electrification or hybridization), and performance-based standards embedded in procurement. For example, Finland grants discretionary government transfers for shipbuilding that reduce GHG emissions from ships,⁷⁹ and procurement requirements in Norway have resulted in large-scale deployment of electric ferries on domestic routes.⁸⁰

2.3.3 Infrastructure and planning measures

Green port and harbor infrastructure: Port and harbor operations are fully under national jurisdiction, and they are often concentrated sources of GHG emissions. National and sectoral policies and strategies should support shore power, electrification of cargo handling equipment, and infrastructure for low-emission fuels. For example, Norway funds shore-side and maritime infrastructure projects that reduce emissions from vessels at berth and in port.⁸¹ In alignment with its Maritime Singapore Decarbonisation Blueprint, Singapore is progressively electrifying all diesel-based container handling equipment and vehicles at its port container terminals, aiming to reduce at emissions from port operations by at least 60 percent by 2030 (from 2005 levels) and reach net zero emissions by 2050.⁸²

Fuel transition for domestic shipping: Policies should enable the uptake of low- and zero-carbon fuels used within national maritime boundaries, including support for production, distribution, and bunkering infrastructure. For instance, Fiji includes fuel switching and alternative energy pathways in its national strategy for decarbonizing domestic shipping.⁸³

Port services and harbor craft decarbonization: Auxiliary vessels and services operating within ports, such as tugboats, pilot vessels, and service craft, are typically high-emitting and fully domestic. Policies and investments targeting their electrification or fuel switching can deliver rapid emissions reductions. For example, the Port of Auckland in New Zealand commissioned Sparky, the world's first full-size, fully electric ship-handling harbor tugboat, built in Vietnam by a Dutch shipbuilder.⁸⁴ Its operation is expected to avoid 465 tonnes of CO₂ emissions annually, while matching the pulling power of the port's strongest diesel tugs. Norway supports low-emission maritime

79 Government of Finland. 2021. "Government Resolution to Reduce Emissions from Maritime and Inland Waterway Transport – Focus on Effective Global Action." Ministry of Transport and Communications press release. May 6. <https://lvm.fi/en/-/government-resolution-to-reduce-emissions-from-maritime-and-inland-waterway-transport-focus-on-effective-global-action-1294472>.

80 Government of Norway, 2021, "Norway's Climate Action Plan for 2021–2030."

81 See <https://enova.no/bedrift/sjotransport>.

82 MPA Singapore, 2022, "Maritime Singapore Decarbonisation Blueprint: Working Towards 2050."

83 Government of Fiji. 2018. "Fiji Low Emission Development Strategy 2018–2050." Suva: Ministry of Economy. https://unfccc.int/sites/default/files/resource/Fiji_Low%20Emission%20Development%20%20Strategy%202018%20-%202050.pdf.

84 Port of Auckland. 2022. "Sparky Wins International Tug and Salvage Tug of the Year." Press release. September 30. <https://www.poal.co.nz/news-media/sparky-wins-international-tug-and-salvage-tug-of-the-year>.

technologies through multiple dedicated funding schemes administered by Enova SF, including programs for zero-emission vessels, hydrogen and ammonia fuels, and port charging infrastructure.⁸⁵

Inland waterways and domestic logistics: Where applicable, inland shipping should be explicitly included in national mitigation strategies. Policies can promote modal shift, improve efficiency, and reduce emissions across domestic logistics systems. For example, Germany and the Netherlands include inland waterway transport within their national low-emission transport frameworks.

Environmental safeguards: Environmental protection measures are necessary to ensure that decarbonization does not create unintended impacts on marine ecosystems. These include environmental impact assessments for port infrastructure and controls on pollution from domestic shipping. For example, Chile integrates marine environmental protection in its national maritime strategy governing activities within its jurisdiction.⁸⁶

Long-term planning and coordination: National strategies should explicitly include domestic maritime transport and ports, with clear targets, timelines, and implementation pathways. Coordination across transport, energy, and maritime authorities is essential. For example, Fiji integrated domestic shipping into its LT-LEDS, including longer-term quantified emission reduction targets.⁸⁷

Innovation and pilot projects: Pilot projects and demonstration programs are critical to validate technologies in domestic operating conditions, particularly for ferries and short-sea shipping. Public support can de-risk early deployment. For example, Norway has demonstrated electric ferry solutions on domestic routes prior to scaling them through procurement.⁸⁸ The Marshall Islands received German support to obtain a prototype hybrid vessel, the Juren Ae, to serve inter-island transport needs, launched in 2024.⁸⁹

2.3.4 International cooperation mechanisms

International and regional cooperation mechanisms are increasingly important to accelerate the decarbonization of shipping through coordinated action across ports, vessel operators, fuel suppliers, and governments. Green shipping corridors can serve as practical demonstration platforms for low-emission vessels, fuels, and supporting infrastructure, while reducing investment risks through partnerships and shared governance. These mechanisms are particularly relevant where domestic routes connect multiple

⁸⁵ See <https://www.enova.no/bedrift/sjotransport>.

⁸⁶ AMN. 2022. "Estrategia General de La Administración Marítima de Chile 2021-2025." Santiago. <https://pron-tus.directemar.cl/directemar/site/docs/20230517/20230517092504/estrategia.pdf>.

⁸⁷ Government of Fiji, 2018, "Fiji Low Emission Development Strategy 2018-2050."

⁸⁸ Government of Norway, 2021, "Norway's Climate Action Plan for 2021-2030."

⁸⁹ RMI, 2025, "The Republic of the Marshall Islands Nationally Determined Contribution 2031-35." See also <https://www.giz.de/en/projects/transitioning-low-carbon-sea-transport>.

national ports or where port infrastructure and fuel supply chains require cross-border coordination. For example, the Clydebank Declaration, launched at COP26 and signed by countries including Fiji, the Marshall Islands, Chile, Japan, and Norway, explicitly supports the establishment of green shipping corridors, including specific domestic maritime routes within national jurisdictions.⁹⁰

2.4 Designing Effective Shipping and Port Decarbonization Measures

The preceding sections have covered a great deal of ground. Table 1 provides an overview of potential targets for shipping and/or port decarbonization that could be included in an NDC, LT-LEDS, or supporting national and sectoral policy and strategic processes. It shows how countries can link actions to outputs, outcomes, and longer-term impacts in support of climate goals, ocean protection, and sustainable national development. It is important to note that the list is not exhaustive; it is meant to illustrate options and good practice for setting specific targets.

Table 1
Examples of Potential NDC Targets and Actions for Shipping and Port Decarbonization

Category	Action	Output	Outcome	Impact
Emissions and monitoring, reporting, and verification (MRV)	Establish a national MRV system for shipping-related emissions, covering domestic shipping, port operations, and other relevant maritime activities where feasible	Regular shipping emissions data collected and reported, disaggregated by source where possible	Improved understanding of the sector's emissions profile and stronger basis for target-setting	Greater accountability for shipping-related NDC commitments and improved transparency under the ETF/BTR process
Fuel transition	Set a target for zero- and near-zero-emission fuels in domestic shipping or maritime fuel supply	Fuel transition roadmap, bunkering plans, pilot projects, and safety protocols developed	Increased availability and uptake of zero- and near-zero-emission maritime fuels	Reduced lifecycle GHG emissions from maritime transport and stronger alignment with global shipping decarbonization pathways

⁹⁰ See <https://www.gov.uk/government/publications/cop-26-clydebank-declaration-for-green-shipping-corridors>.

Category	Action	Output	Outcome	Impact
Fleet renewal and efficiency	Introduce efficiency standards or zero-emission procurement rules for public ferries, port service vessels, or other domestic fleets	New vessel contracts include zero-emission, hybrid, wind-assisted, or zero-emission-ready requirements	Early market demand created for clean vessel technologies and reduced emissions from priority fleet segments	Accelerated fleet transition and reduced risk of fossil-fuel lock-in
Port infrastructure	Develop shore power, charging infrastructure, and zero-emission bunkering capacity in priority ports	Ports equipped with low- or zero-emission energy supply and supporting infrastructure	Reduced emissions from vessels at berth and improved readiness for zero-emission shipping	Cleaner port operations, improved air quality, and stronger enabling conditions for maritime decarbonization
Green shipping corridors	Commit to developing one or more green shipping corridors with partner ports, countries, or private-sector actors	Corridor feasibility studies, governance arrangements, fuel supply plans, and vessel deployment pathways completed	Coordinated route-based deployment of zero-emission fuels, vessels, and infrastructure	Demonstration of scalable shipping decarbonization models and increased international cooperation
Policy and regulation	Adopt maritime decarbonization policies, fuel standards, port emission regulations, carbon-pricing instruments, or public procurement rules.	Legal and regulatory framework established to support shipping decarbonization	Stronger investment certainty and clearer incentives for private-sector action	Increased implementation credibility of shipping-related NDC commitments
Finance	Establish dedicated financing instruments for port upgrades, vessel retrofits, clean fuel infrastructure, or corridor development.	Public finance, concessional finance, blended finance, or private investment mobilized	Improved financial viability of zero-emission shipping investments	Faster deployment of clean maritime technologies and stronger alignment between NDC ambition and implementation capacity

Category	Action	Output	Outcome	Impact
Capacity and workforce transition	Develop training and reskilling programs for seafarers, port workers, maritime regulators, and technical institutions	Training programs delivered and institutional capacity strengthened	Workforce and institutions better prepared to support shipping decarbonization.	More equitable and feasible transition, particularly for SIDS, LDCs, and developing maritime economies
Environmental safeguards	Integrate air pollution, underwater noise, ship-strike risk, scrubber discharge, and biodiversity indicators into shipping-related measures	Environmental monitoring systems and safeguards established for shipping projects, ports, and corridors	Reduced non-GHG impacts of shipping and improved environmental performance	Climate mitigation delivered alongside ocean protection, biodiversity, and public health benefits

Table 2 delves deeper into three concrete examples, showing the individual components of each action and some of the indicators that might be used to track progress and outcomes.

Table 2

A Detailed Look at Three Illustrative Actions to Decarbonize Shipping and Ports

Action 1: Implement shore-side electrification systems at ports	OUTPUT	OUTCOME	IMPACT
Examples: • Install shore power systems for ferries, cargo vessels, or cruise ships. • Electrify berths at commercial ports.	Shore-side electrification systems installed and operational at ports	Reduced fuel consumption and GHG emissions from vessels while at berth	Contribution to reduced emissions and improved air quality in port areas
Steps 1. Assess port electricity demand and vessel connectivity needs. 2. Identify priority ports and berths for electrification. 3. Conduct feasibility studies and environmental impact assessments (EIAs). 4. Upgrade electrical and grid infrastructure, where needed. 5. Install shore-side electricity systems and connection equipment. 6. Develop operational procedures and technical standards. 7. Monitor electricity use and emissions reductions.	Indicators • Number of ports equipped with shore-side electrification systems • Number of berths connected to shore power systems • Number of vessels using shore-side electrification systems	Indicators • Reduction in fuel consumption from vessels at berth • Reduction in GHG emissions associated with fuel consumption from vessels at berth	Indicators • Reduction in GHG emissions in alignment with mitigation targets under the NDC • Improved air quality and public health outcomes in port communities

Action 2: Implement zero- and near-zero-emission maritime fuels uptake and supporting fuel infrastructure Examples: • Develop green ammonia or methanol bunkering facilities at ports • Introduce sustainable biofuels for domestic ferry fleets	OUTPUT Increased availability and use of zero- and near-zero-emission maritime fuels	OUTCOME Reduced GHG emissions from fuel use in domestic maritime transport through the substitution of conventional fossil fuels for zero- and near-zero -emission fuels	IMPACT Contribution to the long-term reduction of GHG emissions and air pollutants through the transition from conventional fossil fuels to zero- and near-zero -emission energy sources in domestic maritime transport
Steps 1. Assess existing fuel use and identify zero- and near-zero -emission fuel and energy options. 2. Evaluate infrastructure and safety requirements for fuel storage and bunkering. 3. Conduct feasibility studies and environmental impact assessments (EIAs). 4. Design and develop fuel supply and distribution infrastructure. 5. Support vessel transition to compatible fuel systems through regulation. 6. Train personnel on fuel handling and safety procedures. 7. Monitor fuel use and related emissions reductions.	Indicators • Number of ports supplying zero- and near-zero -emission maritime fuels • Volume of zero- and near-zero-emission maritime fuels supplied for domestic maritime transport, where data are available • Number of vessels operating on zero- and near-zero-emission fuels in domestic maritime transport • Share of domestic maritime transport fuel demand met through zero- and near-zero-emission fuels • Number of zero- and near-zero-emission fuel storage or bunkering facilities established	Indicators • Reduction in consumption of conventional fossil fuels in domestic maritime transport operations, where data are available • Share of fuel consumption in domestic maritime transport derived from zero- and near-zero -emission fuels. • Reduction in sulfur oxide (SOx), nitrogen oxide (NOx), or particulate matter emissions associated with fuel use in domestic maritime transport	Indicators • Long-term reduction in GHG emissions associated with domestic maritime transport • Long-term reduction in SOx, NOx, or particulate matter emissions from domestic maritime transport • Increase in share of low-emission energy sources in domestic maritime transport over time • Reduced long-term domestic dependence on conventional fossil fuels

Action 3: Implement digital systems and operational measures to improve domestic shipping efficiency	OUTPUT	OUTCOME	IMPACT
Examples: • Implement a port call optimization system allowing vessels to adjust speeds and arrival times to reduce waiting time at ports. • Deploy a digital vessel traffic management system to optimize vessel movements in domestic shipping routes. • Introduce electronic cargo and logistics coordination systems reducing congestion and idle vessel time at ports. • Install digital fuel monitoring systems on domestic ferry fleets to optimize fuel consumption and operational performance.	Digital and operational efficiency systems introduced and operational in domestic maritime transport and port operations	Reduced fuel consumption and GHG emissions through improved operational efficiency in domestic maritime transport and port operations	Contribution to the long-term reduction of GHG emissions and operational inefficiencies in domestic maritime transport and related port operations

Steps 1. Assess operational inefficiencies contributing to unnecessary fuel consumption and emissions in domestic maritime transport and port operations. 2. Identify priority digital systems and operational measures suitable for national circumstances and institutional capacities. 3. Conduct technical and operational assessments for proposed digital solutions. 4. Develop data-sharing and coordination arrangements among ports, shipping operators, and relevant authorities. 5. Install and operationalize digital systems and supporting infrastructure. 6. Train relevant personnel on system operation, data management, and monitoring procedures. 7. Monitor operational improvements, fuel savings, and emissions reductions associated with implemented measures.	• Number of ports implementing digital systems designed to reduce vessel waiting times and associated fuel consumption • Number of vessels using digital voyage optimization or fuel monitoring systems aimed at improving fuel efficiency • Number of domestic shipping routes covered by digital traffic management or voyage optimization systems supporting emissions reduction objectives • Percentage reduction in average vessel waiting time at participating ports • Percentage reduction in operational inefficiencies associated with vessel routing, scheduling, or port congestion	• Reduction in fuel consumption associated with vessel operations using digital optimization systems • Reduction in GHG emissions associated with operational improvements in domestic maritime transport • Reduction in vessel idle time and unnecessary voyage deviations • Improvements in voyage efficiency resulting from optimized routing, scheduling, or port coordination systems • Reduction in fuel consumption associated with port congestion and vessel waiting times	• Long-term reduction in GHG emissions associated with operational inefficiencies in domestic maritime transport • Sustained reduction in fuel consumption associated with domestic maritime transport operations • Long-term improvements in operational efficiency across domestic maritime transport systems • Increased integration of digital operational efficiency systems supporting low-emission maritime transport • Contribution of operational efficiency measures toward national emission reduction targets under the NDC
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2.5 Financing Shipping and Port Decarbonization

Securing adequate financial resources is critical for the successful implementation of shipping decarbonization projects. The Getting to Zero Coalition has estimated that cumulative investment of US\$1.4–1.9 trillion is required between 2030 and 2050 to fully decarbonize international shipping, of which roughly 87 percent must flow to land-based infrastructure—fuel production facilities, bunkering terminals, and port electrification—and 13 percent to vessels.⁹¹

Countries that include their ambitions for green shipping in their NDCs can also state their corresponding financial needs. This means that financial constraints should not prevent countries from setting ambitious green shipping targets in their NDCs. Instead, these targets can be flagged as conditional on the availability of financial resources. By clearly stating financial needs and potential funding sources, countries can highlight the support required to achieve their offshore green shipping. This approach ensures that financial mechanisms are an integral part of the NDC, facilitating the successful implementation of green shipping projects. For example, Vanuatu's NDC 3.0 estimates that increasing transport energy efficiency by 10 percent will require US\$30 million of investment, and following through on its engagement with the Pacific Blue Shipping Partnership will require US\$1.75 million.⁹²

Various complementary financial mechanisms can be employed to mobilize the necessary investments and de-risk first-mover deployment:

IMO Net-Zero Fund: The IMO Net-Zero Framework that Member States are to resume considering in October 2026 (see section 1.4) introduces the first global, sector-wide carbon pricing instrument. If it is formally adopted, ships above 5,000 Gt that fail to meet annual GHG fuel-intensity targets must purchase Remedial Units from an IMO Net-Zero Fund starting in 2029, with revenues redistributed in ways that support the maritime energy transition, including rewarding zero/near-zero (ZNZ) fuel and energy uptake, supporting fleet modernization in developing countries, and assisting climate-vulnerable developing states in a just transition, among other uses.⁹³

EU ETS revenues and Innovation Fund: The extension of the EU Emissions Trading System to maritime transport in January 2024 channels all maritime auction revenues to the EU Innovation Fund, with 20 million

91 Krantz, R., K. Sogaard, and T. Smith. 2020. "The Scale of Investment Needed to Decarbonize International Shipping." Getting to Zero Coalition Insight Series. Global Maritime Forum, Friends of Ocean Action, and World Economic Forum. <https://globalmaritimeforum.org/news/the-scale-of-investment-needed-to-decarbonize-international-shipping/>.

92 Government of Vanuatu, 2025, "Vanuatu's Nationally Determined Contribution 3.0 2025-2035."

93 See the IMO's FAQ: <https://www.imo.org/en/MediaCentre/HotTopics/Pages/FAQs-the-IMO-Net-Zero-Framework.aspx>.

See also: King & Spalding. 2025. "IMO's Net-Zero Framework and the Global Carbon Price on Shipping." Client Alert. May 22. <https://www.kslaw.com/news-and-insights/imos-net-zero-framework-and-the-global-carbon-price-on-shipping>.

allowances (about €1.5 billion by 2030) specifically earmarked for shipping decarbonization. As of early 2026, the Innovation Fund had already awarded €1.03 billion to 21 maritime projects, including hydrogen-based fuel production and zero-emission vessel pilots.⁹⁴

Multilateral development bank (MDB) financing: The World Bank, European Investment Bank (EIB), Asian Development Bank (ADB), and African Development Bank (AfDB) provide concessional loans, sovereign guarantees, and technical assistance for port electrification, green corridor development, and green-fuel production infrastructure, with particular emphasis on LDCs and SIDS at risk of being stranded by, or excluded from, the transition. The EIB's Green Shipping Programme Loan, for example, finances new-builds and emissions-reducing retrofits delivered through European shipyards.⁹⁵

Blue and green bonds: Issued under the International Capital Market Association's (ICMA) Blue Bond and Green Bond Principles, these debt instruments channel institutional capital toward marine sustainability projects, including zero-emission vessels and port decarbonization. The Asian Development Bank has issued US\$425 million in blue bonds alongside US\$13 billion in green bonds since 2015, with proceeds eligible for green ports and shipping projects; the EU Taxonomy for Sustainable Activities now formally classifies maritime transport and port-operation vessels as eligible green investments.⁹⁶

Blended finance and sustainability-linked instruments: Public-private blended finance combines concessional capital from MDBs and donors with commercial bank debt to de-risk early-mover projects, while sustainability-linked loans (SLLs) tie interest rates to vessel-level key performance indicators such as the Annual Efficiency Ratio (AER), incentivizing operators through pricing rather than penalty. The Poseidon Principles, now with 36 signatory financial institutions representing approximately three-quarters of the global ship finance portfolio, align bank lending decisions with IMO decarbonization trajectories.⁹⁷ Dedicated private debt vehicles such as the €420 million Green Shipping Fund (PROW Capital) provide tailored financing for retrofits and zero-emission new-builds.

94 European Commission. 2026. "2025 Report from the European Commission on Greenhouse Gas Emissions from Maritime Transport." COM(2026) 173 final. Brussels. <https://data.consilium.europa.eu/doc/document/ST-8722-2026-INIT/en/pdf>.

95 See <https://www.eib.org/en/projects/pipelines/all/20150742>.

96 See <https://www.adb.org/publications/adb-green-blue-bonds>.

97 See <https://globalmaritimeforum.org/report/poseidon-principles-annual-disclosure-report-2025/>.

2.6 Monitoring, Reporting and Verification

Effective monitoring and evaluation are critical for tracking the progress of shipping targets set within NDCs. Establishing suitable indicators and identifying the necessary data requirements and methodologies are essential components of this process. This section details key indicators for tracking shipping targets and provides guidance on the necessary data and methodologies. The indicators should be adapted to the scope of the commitment, available data, and national circumstances. Where possible, countries should disaggregate data between domestic shipping, international shipping, fishing vessels, port operations, and other maritime activities to improve transparency and implementation tracking.

2.6.1 Metrics and indicators

Table 3 presents 10 illustrative examples of potential indicators that could be used in monitoring, reporting, and verification (MRV) of shipping-related NDC commitments. Such indicators should be used together rather than in isolation. Emissions and emissions-intensity indicators show whether the sector is reducing its climate impact, while fuel, vessel, port, finance, and policy indicators help assess whether the enabling conditions for decarbonization are being put in place. Socioeconomic and environmental indicators are also important to ensure that shipping decarbonization supports workers and delivers wider benefits for ocean health and coastal communities.

Table 3

Selected Illustrative MRV Indicators for Shipping-Related NDC Commitments

Indicator	What it tracks	Unit
1. Total shipping-related GHG emissions	Annual emissions from shipping-related activities covered by the NDC, disaggregated where possible by domestic shipping, international shipping, fishing vessels, port operations, or other relevant maritime sources.	tCO ₂ e/year
2. Shipping emissions and energy intensity	Emissions and energy use per unit of maritime activity. Emissions intensity tracks climate performance, while energy intensity provides a clearer measure of operational and technical efficiency independent of fuel switching.	gCO ₂ e/tonne-km, passenger-km, vessel-km, or port call MJ/tonne-km, passenger-km, vessel-km, or port call

Indicator	What it tracks	Unit
3. Share of zero- and near-zero-emission fuels in maritime energy use	The proportion of shipping energy demand met by eligible zero- or near-zero-emission fuels and energy sources, such as green hydrogen, ammonia, methanol, electricity, or other zero or near-zero-lifecycle-emission options.	% of maritime energy use
4. Number or share of zero-emission and zero-emission-ready vessels	Deployment of electric, hybrid, wind-assisted, zero-emission, or zero-emission-ready vessels, including public ferries, domestic fleets, port service vessels, or other priority vessel categories.	Number of vessels / % of fleet
5. Number or share of vessels implementing energy-efficiency and operational measures	Uptake of measures such as speed reduction, hull and propeller improvements, biofouling management, weather routing, shore power use, and onboard energy-efficiency improvements.	Number of vessels / % of fleet
6. Number of ports equipped with zero-emission shipping infrastructure	Availability of infrastructure such as shore power, charging systems, zero-emission bunkering, renewable electricity supply, safety systems, and port emission-reduction measures.	Number of ports / % of priority ports
7. Number and status of green shipping corridors under development or operation	Route-based implementation of shipping decarbonization, including participating ports, vessels, fuel types, partners, financing status, and expected or achieved emissions reductions.	Number of corridors; status: planned / financed / piloted / operational
8. Number of shipping-related policies, regulations, or financial instruments adopted and implemented	Enabling environment for implementation, including maritime decarbonization strategies, fuel standards, port regulations, procurement rules, carbon pricing, incentives, financing instruments, and MRV systems.	Number / status of instruments
9. Number of workers trained or reskilled for zero-emission shipping and port operations	Just transition and workforce-readiness outcomes for seafarers, port workers, maritime regulators, technical institutions, and other affected groups.	Number of workers trained / institutions supported
10. Measured reductions in non-GHG environmental impacts from shipping	Wider environmental co-benefits, including reductions in air pollutants, underwater noise, ship-strike risk, scrubber discharge, oil pollution risk, or impacts on marine biodiversity.	Pollutant emissions, noise levels, incidents, discharge volumes, biodiversity indicators

These indicators should be used together rather than in isolation. Emissions and emissions-intensity indicators show whether the sector is reducing its climate impact, while fuel, vessel, port, finance, and policy indicators help

assess whether the enabling conditions for decarbonization are being put in place. Socioeconomic and environmental indicators are also important to ensure that shipping decarbonization supports a just transition for workers and delivers wider benefits for ocean health and coastal communities.

Moreover, while the indicators above help countries track progress, they should be linked to a clear implementation logic. Shipping-related NDC commitments are more credible when countries can show how a proposed action will lead to concrete outputs, expected outcomes, and longer-term impacts, as illustrated in Tables 1 and 2 earlier in this section.

Annex 2 provides an overview of reporting requirements under the Paris Agreement, including details on data requirements, methodology, and integration with the Enhanced Transparency Framework.

This mixed picture makes the current moment particularly important. Progress at the IMO level remains significant but uncertain, and national action remains essential. As countries prepare future NDC cycles and strengthen implementation of their current ones, shipping represents a clear opportunity to move from general recognition toward more concrete, measurable, and policy-relevant commitments.



3. The Benefits of Decarbonizing Shipping

Section 2 examined how to integrate shipping into NDCs, LT-LEDs, and other national strategies and plans, showing that it is highly feasible, and countries have many options they can pursue. Still, some will ask why countries should make this extra effort. This section briefly examines the broader environmental, economic, and social benefits of action, aiming to help policymakers and other actors to build the case for enhanced ambition.

3.1 Environmental Protection

The environmental impacts of the shipping sector go well beyond GHG emissions. They also include water pollution, underwater noise, collisions with marine animals, the transport of invasive species, and other effects that greatly harm marine ecosystems.⁹⁸ Ships create significant air pollution as well, with impacts on ecosystems as well as the health of coastal communities. Decarbonization measures cannot erase all the environmental impacts of shipping, but they could significantly reduce many of them—a major co-benefit.

3.1.1 Marine ecosystem impacts of shipping

Oil spills from ships pollute the water with toxic chemicals that kill a wide range of marine organisms by poisoning them, blocking their respiratory systems, coating them with a viscous substance that impairs movement, and, if they survive, disrupting reproduction and causing deformities and cancer, among other impacts.⁹⁹ Coastal ecosystems are also deeply affected. The persistence of oil in cold water makes the impacts of Arctic and sub-Arctic spills especially long-lasting. While the impacts of conventional heavy fuel oil (HFO) are well understood, those of very-low-sulfur fuel oil (VLSFO) are still emerging;¹⁰⁰ the first large-scale oil spill involving VLSFO only occurred in July 2020—the MV Wakashio disaster off the coast of Mauritius. The oil contains large quantities of polycyclic aromatic hydrocarbons (PAHs), which are highly toxic and carcinogenic, and the physical properties of VLSFO may make spills more difficult to clean up.

98 For more in-depth overviews in the literature, see, e.g.: Walker, T.R., O. Adebambo, M.C. Del Aguila Feijoo, et al. 2019. "Environmental Effects of Marine Transportation." In *World Seas: An Environmental Evaluation* (Second Edition), edited by C. Sheppard, 505–30. Academic Press. doi:10.1016/B978-0-12-805052-1.00030-9.

Jägerbrand, A.K., A. Brutemark, J. Barthel Svedén, and I.-M. Gren. 2019. "A Review on the Environmental Impacts of Shipping on Aquatic and Nearshore Ecosystems." *Science of The Total Environment* 695 (December): 133637. doi:10.1016/j.scitotenv.2019.133637.

99 Chen, J., W. Zhang, Z. Wan, et al. 2019. "Oil Spills from Global Tankers: Status Review and Future Governance." *Journal of Cleaner Production* 227 (August): 20–32. doi:10.1016/j.jclepro.2019.04.020.

See also Llabrés Pohl, 2023, "The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health"; Walker, Adebambo, Del Aguila Feijoo, et al., 2019, "Environmental Effects of Marine Transportation."

100 Llabrés Pohl, 2023, "The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health."

Notably, although large-scale, catastrophic events draw most of the attention, decades-long efforts to improve safety, including mandatory double hulls and traffic separation schemes, have reduced such events by about 90 percent since the 1970s.¹⁰¹ The vast majority of oil that pollutes ocean waters comes from **operational discharges** of oil-contaminated ballast water, residues from washing and cleaning equipment and tanks, and more. Although most of these discharges are illegal, they are known to occur frequently.¹⁰²

Exhaust-gas scrubbers used on some ships to remove SO_x often use seawater to remove sulfur, and this water is then discharged back into the ocean, polluting marine environments.¹⁰³ The scrubbers, installed to meet the IMO's 2020 sulfur regulations, release acidic water laden with sulfur compounds, heavy metals, and PAHs. **Antifouling** biocides (discussed further below), such as copper compounds, accumulate in near-shore sediments, impairing the reproductive success of bivalves and disrupting reef ecosystems.¹⁰⁴ **Sewage**, grey water, and food waste from vessels further degrade water quality in busy straits and port approaches. The combined chemical load reduces ecosystem resilience and compounds the effects of ocean acidification driven by CO₂, further reducing the resilience of marine ecosystems.¹⁰⁵

Biofouling is the accumulation of aquatic organisms—microbes, algae, plants, barnacles, etc.—on a ship's hull and other submerged surfaces, which causes major hydrodynamic drag, increasing fuel consumption, operating costs and GHG emissions.¹⁰⁶ From a climate mitigation perspective, reducing biofouling is thus a key way to improve the efficiency of ships.

From an ecological perspective, both biofouling and antifouling pose significant threats. The organisms that build up on the exterior of ships are transported across large distances and deposited in new environments where, in some cases, they can become invasive species, outcompeting native species and proliferating widely. Ships also take in and release billions of tonnes of ballast water every year, in which they unintentionally transport large quantities of microbes, invertebrates, eggs, larvae, cysts, and other species as well.¹⁰⁷ International conventions through IMO have addressed both ballast water and biofouling management, but the impacts persist. Moreover, antifouling efforts cause their own problems. Not only are

101 Llabrés Pohl, 2023.

102 See also Walker, Adebambo, Del Aguila Feijoo, et al., 2019, "Environmental Effects of Marine Transportation."

103 See the Pacific Northwest National Laboratory's overview on maritime decarbonization: <https://www.pnnl.gov/explainer-articles/maritime-decarbonization>.

104 Llabrés Pohl, 2023, "The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health."

105 Hatje, V. and R. Rayfuse. 2025. "Understanding and Beating Marine Pollution under Ocean Decade Vision 2030 Challenge 1." Edited by L. Pendleton. ICES Journal of Marine Science 82 (2): fsaf009. doi:10.1093/ices-jms/fsaf009.

106 For an overview from the IMO, see <https://www.imo.org/en/ourwork/environment/pages/biofouling.aspx>.

107 Jägerbrand, Brutemark, Barthel Svedén, and Gren, 2019, "A Review on the Environmental Impacts of Shipping on Aquatic and Nearshore Ecosystems"; Walker, Adebambo, Del Aguila Feijoo, et al., 2019, "Environmental Effects of Marine Transportation."



the coatings put on ship hulls toxic, as noted above,¹⁰⁸ but, without proper precautions, cleaning ships can release both exotic and invasive species, and coating particles into the water. In 2023, the IMO released detailed biofouling management guidance to try to address this issue,¹⁰⁹ though there are no easy solutions.¹¹⁰ By more actively engaging with the shipping sector, including through their NDCs, countries may be able to accelerate progress to protect marine and coastal ecosystems.

Noise pollution is another major impact from shipping that decarbonization efforts could help to address. Marine mammals depend almost entirely on acoustics to navigate, hunt, communicate, and reproduce, and loud noise from ships disrupt all this. From the 1960s to the early 2000s, the growth in commercial shipping contributed to a 32-fold increase in low-frequency noise in some parts of the ocean.¹¹¹ A 2016 study projected another near-doubling of ship noise by 2030.¹¹² Site-specific studies have confirmed these impacts: a study off San Nicolas Island, California, in 2003–2004, for instance, found ambient noise levels were 12–15 dB higher than in 1964–1966.¹¹³ Long-range sound propagation at low frequencies can also carry noise pollution to areas well beyond established shipping lanes; researchers coined the term “the soundscape of the Anthropocene” to denote the massive impact of human activities on ocean noise.¹¹⁴ For species such as whales, which communicate through sound across long distances, the impacts can be devastating.

A study published in 2025, for instance, documented how shipping noise affected orca population health: births were lower and deaths higher in noisier years, with female orcas more than 25 percent less likely to give birth following noisy years.¹¹⁵ The Southern Resident Killer Whale population declined from a peak of 98 individuals in 1995 to 74 as of July 2025. About

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- 108 Llabrés Pohl, 2023, “The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health.”
- 109 IMO. 2023. “2023 Guidelines for the Control and Management of Ships’ Biofouling to Minimize the Transfer of Invasive Aquatic Species.” Resolution MEPC.378(80). International Maritime Organization. <https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.378%2880%29.pdf>.
- 110 Nurhalimi, N.I., S.A. Adim, N. Md Noor, and A. Abas. 2025. “Marine Biofouling and Antifouling: A Decade of Systematic Review on the Environmental Risks to Coastal Water Systems.” *Biofouling* 41 (10): 965–80. doi:10.1080/08927014.2025.2559319.
- See also: Li, L., H. Hong, J. Cao, and Y. Yang. 2023. “Progress in Marine Antifouling Coatings: Current Status and Prospects.” *Coatings* 13 (11): 1893. doi:10.3390/coatings13111893.
- 111 Malakoff, D. 2010. “A Push for Quieter Ships.” *Science* 328 (5985): 1502–3. doi:10.1126/science.328.5985.1502.
- 112 Kaplan, M.B. and S. Solomon. 2016. “A Coming Boom in Commercial Shipping? The Potential for Rapid Growth of Noise from Commercial Ships by 2030.” *Marine Policy* 73 (November): 119–21. doi:10.1016/j.marpol.2016.07.024.
- 113 McDonald, M.A., J.A. Hildebrand, and S.M. Wiggins. 2006. “Increases in Deep Ocean Ambient Noise in the Northeast Pacific West of San Nicolas Island, California.” *The Journal of the Acoustical Society of America* 120 (2): 711–18. doi:10.1121/1.2216565.
- 114 Duarte, C.M., L. Chapuis, S.P. Collin, et al. 2021. “The Soundscape of the Anthropocene Ocean.” *Science* 371 (6529): eaba4658. doi:10.1126/science.aba4658.
- 115 Dwyer, K. 2025. “Saving Killer Whales Without Sinking Trade.” Property and Environment Research Center blog. September 25. <https://www.perc.org/2025/09/25/saving-killer-whales-without-sinking-trade/>.

10,000 large commercial vessel transits occur every year in the Salish Sea they inhabit. A modeling analysis found the population could be up to 30 percent larger today had vessel noise remained at pre-1998 levels. Beluga whales detect icebreaking ships up to 85 kilometers (km) away and show panic responses at 35–50 km.¹¹⁶

The IMO has created voluntary guidelines for reducing ship noise, first issued in 2014 and updated in 2023, and most recently launched a detailed Underwater Radiated Noise Action Plan.¹¹⁷ A three-year “experience building phase” is underway during which countries are to share lessons and develop best practices. In the medium term, shifting to electric and hydrogen fuel cell propulsion would eliminate combustion noise entirely and reduce propulsion-related underwater sound to near-zero.

Ship strikes, meanwhile, are a leading cause of mortality for large whales worldwide.¹¹⁸ Nutrient-rich coastal waters that concentrate whale populations also host the world’s busiest shipping lanes, making collision risk structurally unavoidable at current speeds and densities. As noted earlier, speed reductions—a key operational measure to reduce fuel use and GHG emissions—can significantly reduce the likelihood of lethal injuries and may also reduce the risk of ship strikes. Drawing on research on the North Atlantic right whale, a 2019 analysis found that the probability of lethal injury dropped to 50 percent when vessel speeds are reduced by 10 percent, and to 22 percent when speeds are reduced by 20 percent from typical levels.¹¹⁹

The U.S. Coast Guard launched a dedicated Cetacean Desk whale-alert program in 2024, using real-time hydrophone data and automatic identification system (AIS) ship tracking to reduce collision risk. Voluntary slowdowns in Puget Sound, reducing vessel speeds to 11 to 14.5 knots, yielded measurable reductions in both acoustic impact and collision incidence.¹²⁰ AI-driven route optimization tools being co-developed with zero-emission propulsion technologies will enable ships to be routed away from cetacean aggregation zones in real time. However, these technologies are still not mature, and their actual benefits remain to be seen.¹²¹

All these pressures compound: A whale weakened by acoustic stress and food deprivation, for instance, is less able to avoid a vessel or recover from a strike. Cumulatively, shipping is driving a **steady attrition of marine biodiversity**. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment found that more than

116 See <https://www.arcticwwf.org/threats/underwater-noise/>.

117 Robinet, F. 2025. “The Battle to Quiet the Sea: Can the Shipping Industry Turn down the Volume?” UN News, June 10. <https://news.un.org/en/story/2025/06/1164196>.

118 Llabrés Pohl, 2023, “The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health.”

119 GL Reynolds, 2019, “The Multi-Issue Mitigation Potential of Reducing Ship Speeds.”

120 See the Quiet Sound website: <https://quietsound.org>.

121 Spandonidis, C., V. Iliopoulos, and I. Athanasopoulos. 2026. “Toward Greener Shipping: A Systematic Review of AI-Driven Solutions for Environmental Performance in Maritime Operations.” *Renewable and Sustainable Energy Reviews* 235 (July): 116966. doi:10.1016/j.rser.2026.116966.

40 percent of the ocean was “strongly affected by multiple drivers” as of 2008, and 66 percent was “experiencing increasing cumulative impacts” as of 2014, while only 3 percent of the ocean was described as free from human pressure.¹²² A 2025 spatial analysis of the Indo-Pacific Convergence Zone, one of the world’s richest marine biodiversity hotspots, identified shipping intensity as a primary driver of habitat degradation, with only 6 percent of the region currently under any protection.¹²³

Ultimately, the single greatest benefit of shipping decarbonization for ocean ecosystems will be the end of the CO₂ emissions that warm ocean waters and directly drive ocean acidification—the process dissolving the calcium carbonate shells and skeletons of corals, mollusks, and plankton. By contributing its full share to global GHG emission reductions, the shipping sector will support the stabilization of ocean pH at levels that permit calcification. At the same time, countries have committed under the Kunming-Montreal Global Biodiversity Framework to place at least 30 percent of marine and coastal areas under effective conservation and management by 2030.¹²⁴ This means there is an opportunity to not only reduce shipping-generated stressors on marine ecosystems, but actively support the recovery and long-term protection of those ecosystems.

3.1.2 Air pollution and coastal health impacts

The combustion of bunker fuels releases a toxic mix of sulfur oxides (SO_x), nitrogen oxides (NO_x), black carbon and other particulate matter (PM), and volatile organic compounds (VOCs), each of which has distinct impacts both on ecosystems and on the health of people living and working in coastal communities, especially near major ports. Some pollutants also contribute to soil and ocean acidification.¹²⁵

Sulfur oxides

When sulfur dioxide (SO₂) from fuel combustion is oxidized in the atmosphere, it forms sulfate aerosols and sulfuric acid, contributing to acid rain that damages crops, forests, and aquatic ecosystems, and directly acidifies coastal waters.¹²⁶ SO_x and NO_x both also contribute to the formation of secondary fine particles (PM_{2.5}) and ground-level ozone. Before the IMO 2020 global sulfur cap took effect, reducing allowable fuel sulfur content from 3.5 to 0.5 percent, a study projected that air pollution from ocean-going vessels would cause over 403,000 premature deaths in 2020, as well

122 IPBES. 2019. Global Assessment Report on Biodiversity and Ecosystem Services: Summary for Policymakers (version summary for policy makers). Edited by S. Díaz, J. Settele, E.S. Brondízio, et al. Bonn: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. doi:10.5281/ZENODO.3553579.

123 Zhao, L., T. Li, B. Cong, et al. 2025. “Marine Biodiversity Conservation Planning in the Indo-Pacific Convergence Zone Based on Ecological Spatial Analysis.” *Biology* 14 (6): 700. doi:10.3390/biology14060700.

124 See <https://www.cbd.int/gbf/targets/3>.

125 Llabrés Pohl, 2023, “The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health.”

126 Llabrés Pohl, 2023.

as 14 million cases of childhood asthma.¹²⁷ The study found the sulfur cap would reduce mortality by about 34 percent, to about 266,000 per year, and childhood asthma by about 54 percent, to 6.4 million.

While the sulfur cap has indeed delivered measurable improvements in designated Emission Control Areas (ECAs), enforcement outside ECAs remains inconsistent. Progress is possible; for example, the Mediterranean Sea carries 24 percent of the global merchant fleet and more than 17 percent of worldwide cruise traffic, making it one of the most polluted maritime corridors on Earth. The Med SOx Emission Control Area entered into force on 1 May 2025, requiring ships to use fuel with a sulfur content of 0.10 percent, one-fifth of what is permitted outside the ECA.¹²⁸

However, as noted above, both the use of exhaust gas scrubbers to comply with the cap and the switch to VLSFO have created new environmental concerns.¹²⁹ Research also shows that the reduction in sulfur aerosols from ship exhausts has ended a cloud-brightening effect that was slowing North Atlantic warming.¹³⁰ All this underscores the need to couple pollution controls with deep decarbonization.

Nitrogen oxides

NOx is another major byproduct of fossil fuel combustion. Although the IMO adopted a NOx Technical Code in 2008,¹³¹ both the 2020 IMO GHG study and the more recent ICCT study found that NOx emissions had still increased in 2012–2017 and 2016–2023, respectively, though by less than overall fuel consumption.¹³² The ICCT study noted that the IMO's most stringent Tier III NOx limit, which could cut emissions by more than 75 percent, only applies in NOx emission control areas. As of 2023, there were only two such areas globally, and only 1 percent of global fuel consumption was used by ships that needed to comply with the Tier III limit.

NOx drives the formation of tropospheric ozone and secondary particulate matter (nitrate aerosols), both of which exacerbate respiratory and

127 Sofiev, M., J.J. Winebrake, L. Johansson, et al. 2018. "Cleaner Fuels for Ships Provide Public Health Benefits with Climate Tradeoffs." *Nature Communications* 9 (1): 406. doi:10.1038/s41467-017-02774-9.

128 UNEP. 2022. "Tackling Air Pollution from Ships: Three Facts about the Freshly Adopted Med SOx ECA." United Nations Environment Program, Mediterranean Action Plan. December 16. <https://www.unep.org/unep-map/news/story/tackling-air-pollution-ships-3-facts-about-freshly-adopted-med-sox-eca>.

129 Llabrés Pohl, 2023, "The State of Shipping and Oceans: Understanding the Impact of Global Shipping on Climate, the Ocean and Human Health."

For more recent analysis of this issue, see: Decker, T., Z. Meng, and B. Comer. 2025. "Health and Air Pollution Benefits of a Global 0.1% Fuel Sulfur Limit on Marine Fuels." Washington, DC: International Council on Clean Transportation. <https://theicct.org/publication/health-and-air-pollution-benefits-of-a-global-fuel-sulfur-limit-on-marine-fuels-jul25/>.

130 Gettelman, A., M.W. Christensen, M.S. Diamond, et al. 2024. "Has Reducing Ship Emissions Brought Forward Global Warming?" *Geophysical Research Letters* 51 (15): e2024GL109077. doi:10.1029/2024GL109077.

131 IMO. 2008. "Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines." Resolution MEPC.177(58). International Maritime Organization. [https://www.wcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.177\(58\).pdf](https://www.wcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.177(58).pdf).

132 IMO, 2020, "Fourth Greenhouse Gas Study 2020"; Mao, Meng, Comer, and Decker, 2025, "Greenhouse Gas Emissions and Air Pollution from Global Shipping, 2016–2023."

cardiovascular disease. In coastal cities, ship-derived NO_x contributes 11–19 percent of total aerosol concentrations.¹³³ A 2018 study projected that, without further controls, NO_x emissions from shipping would exceed NO_x from all EU land-based sources combined by 2030.¹³⁴

Black carbon and other particulate matter

One of the greatest threats to human health from shipping comes from particulate matter in the air—some of which is visible as soot, but much of which is not. Along with black carbon, these particles carry toxic heavy metals, PAHs, and other pollutants carbon and are linked to premature death from cardiovascular and pulmonary disease. About 70 percent of ship activity occurs within 400 km of coastlines,¹³⁵ disproportionately exposing port communities to air pollutants, including fine and ultrafine particles (PM_{2.5} and PM_{0.1}). Given the large share of people who live near seaports, this is a significant health threat.

Black carbon is the second most important climate forcer from shipping after CO₂, a potent short-lived climate pollutant that accelerates ice melt in the Arctic and other ice- and snow-covered areas.¹³⁶ The ICCT study found that in 2023, black carbon made up 8–23 percent of the shipping sector's CO₂-equivalent emissions, depending on whether a 100-year or 20-year global warming potential was applied.¹³⁷

ECAs play a key role in reducing coastal air pollution, including particulate matter. For example, the Norwegian Sea ECA, which was adopted at MEPC 81 and entered into force in March 2026, putting the entirety of Norwegian waters under environmental protection, is projected to reduce PM₁₀ and PM_{2.5} emissions from ships by about 50 percent by 2030 compared with 2020 levels.¹³⁸

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- 133 Shi, Z., S. Endres, A. Rutgersson, et al. 2023. "Perspectives on Shipping Emissions and Their Impacts on the Surface Ocean and Lower Atmosphere: An Environmental-Social-Economic Dimension." *Elementa: Science of the Anthropocene* 11 (1): 00052. doi:10.1525/elementa.2023.00052.
- 134 Cofala, J., M. Amann, J. Borken-Kleefeld, et al. 2018. "The Potential for Cost-Effective Air Emission Reductions from International Shipping through Designation of Further Emission Control Areas in EU Waters with Focus on the Mediterranean Sea." International Institute for Applied Systems Analysis, Ecometrics Research and Consulting, and Norwegian Meteorological Institute.
- 135 Shi, Endres, Rutgersson, et al., 2023, "Perspectives on Shipping Emissions and Their Impacts on the Surface Ocean and Lower Atmosphere: An Environmental-Social-Economic Dimension."
- 136 Chen, Y. and K. Cheng. 2025. "Decarbonizing Arctic Shipping: Governance Pathways and Future Directions." *Frontiers in Marine Science* 12 (February): 1489091. doi:10.3389/fmars.2025.1489091.
- 137 Mao, Meng, Comer, and Decker, 2025, "Greenhouse Gas Emissions and Air Pollution from Global Shipping, 2016–2023."
- 138 IMO. 2023. "Proposal to Designate the Norwegian Sea as an Emission Control Area for Nitrogen Oxide and Sulphur Oxides Submitted by Norway." MEPC 81/11/1. International Maritime Organization. <https://cleanarctic.org/wp-content/uploads/2024/03/MEPC-81-11-1-Proposal-to-designate-the-Norwegian-Sea-as-an-Emission-Control-Area-for-Nitrogen-Oxide-.pdf>.

3.2 Economic and Social Benefits

3.2.1 Economic growth, job creation, and development benefits

The transition to zero-emission shipping is one of the greatest green industrial development opportunities of the coming decades. A 2024 analysis by the engineering consultancy Arup, commissioned by the Global Maritime Forum, projects that the maritime sector's shift to e-fuels could support up to 4 million green jobs across the energy supply chain by 2050—double the current global merchant seafarer workforce of roughly 2 million.¹³⁹ Those jobs would be in three interconnected fields: renewable energy generation (wind and solar), green hydrogen production, and e-fuel synthesis and bunkering infrastructure.

The scale of capital expenditure underpinning this opportunity is correspondingly large: The Global Maritime Forum analysis estimates that up to £3.2 trillion, or about US\$4 trillion in investment may be needed to build out the renewable capacity, electrolysis facilities, and fuel production plants required to supply zero-emission shipping by 2050.¹⁴⁰ Critically, an estimated 87 percent of the infrastructure required for shipping decarbonization is land-based, meaning there is potential for significant benefits to coastal communities.

Significant investment is expected to need to flow to the Global South, where there is large renewable energy generation potential, creating optimal conditions for producing clean fuels such as green hydrogen. The Africa Green Hydrogen Alliance (AGHA), launched by six countries and since joined by five more, aims to seize that opportunity to drive economic growth.¹⁴¹ Analysis for the alliance has found that delivering on green hydrogen demand (from shipping, heavy industry, and other buyers) could add US\$66–126 billion to the GDP of AGHA member countries by 2050, or 6–12 percent of their current GDP, and create 2–4 million jobs.

Port decarbonization and upgrades are already driving large-scale investment. In the United States, for instance, the Environmental Protection Agency nearly US\$3 billion in grants to 53 projects in 26 states and territories through the Clean Ports Program, to fund clean port equipment and infrastructure as well as climate and air quality planning.¹⁴² The Port of Barcelona's "Nexigen" plan calls for investing more than €200 million to electrify docks with power from renewable sources, so ships use clean

139 Global Maritime Forum. 2024. "Decarbonisation of Shipping Could Create up to Four Million Green Jobs." Press release. May 9. <https://globalmaritimeforum.org/press/decarbonisation-of-shipping-could-create-up-to-four-million-green-jobs/>.

140 Global Maritime Forum, 2024.

141 See <https://gh2.org/agma>.

142 See <https://www.epa.gov/ports-initiative/clean-ports-program-awards> [accessed July 15, 2026].

energy while berthed instead of generators. The goal is to halve emissions by 2030 and to be a carbon-neutral port by 2050.¹⁴³

Namibia has shown that developing countries can be pioneers in greening ports as well. A green hydrogen production plant at the Walvis Bay Port, with a production capacity of 5 MW by the end of December 2025, is providing fuel for cargo-carrying heavy trucks, container cranes, and small ships at the port.¹⁴⁴

For developing economies, the IMO Net-Zero Framework revenue mechanism will include targeted disbursements for technology transfer and alternative fuel supply chain development, creating a direct fiscal instrument for ensuring that the maritime transition generates industrial capacity in the economies most exposed to both climate change and the disruption of fossil fuel trade flows. However, the actual amount of financing available—estimated by one study at US\$11–12 billion per year in the first three years,¹⁴⁵ may not be enough to support the transformative changes needed. (The same researchers also found that, with LNG in wide use, many ships might not need to move away from fossil fuels until about 2036, and ammonia—not necessarily from clean sources—might then be the lowest-cost fuel, limiting demand for true ZNZ fuels for a few years still.)

As this discussion suggests, the decarbonization of shipping and ports is likely to entail profound shifts for workers and communities, with considerable uncertainties. A 2025 Ocean Panel analysis identified multiple emerging job opportunities, including for decarbonization experts, environmental compliance officers, alternative fuel engineers, port automation engineers, data analysts and AI specialists, cybersecurity experts, multimodal logistics experts, port infrastructure developers, and maritime instructors.¹⁴⁶ These are all high-skill jobs that may not be options for most current workers in the sector, but the analysis did also note a broader need for workers trained to operate the new technologies. At the same time, large numbers of jobs linked to fossil fuel technologies and fuels are likely to disappear.

A key point is that the transition will require significant reskilling and upskilling across the maritime sector. Seafarers, port workers, and technical personnel will need to learn to use alternative fuels and emerging maritime technologies. This will require updated training frameworks, safety procedures, competencies, and certification standards for maritime

143 See <https://www.portbarcelona.cat/en/sustainability/environmental-sustainability/energy-transition/electrical-supply-ships>.

144 GCN, 2026, "Namibia Opens One of Africa's First Port-Based Facilities Combining Green Hydrogen Production and Export."

145 Smith, T., A. Frosch, M. Fricaudet, et al. 2025. "An Overview of the Discussions from IMO's 83rd Marine Environment Protection Committee." London: Shipping and Oceans Research Group, University College London. <https://www.shippingandoceans.com/post/phase-out-of-fossil-fuels-in-shipping-begins-in-earnest>.

146 Ben Hassen, L., C.S. Colgan, M.J. Spalding, et al. 2025. "The Future of the Workforce in a Sustainable Ocean Economy." High Level Panel for a Sustainable Ocean Economy (Ocean Panel) Blue Paper. Washington, DC: World Resources Institute. <https://doi.org/10.69902/64d6259f>.

personnel and training institutions.¹⁴⁷ As with other aspects of the clean energy transition, governments will need to be proactive to ensure that the job opportunities and other economic benefits of shipping decarbonization are distributed equitably among affected workers and communities.

The public health implications of shipping and port decarbonization, meanwhile, are important to highlight. As noted above, shipping and port activities are major sources of SO_x, NO_x, and particulate matter, pollutants associated with respiratory and cardiovascular disease, and premature deaths in port cities and coastal regions.¹⁴⁸ Measures such as shore-side electrification, cleaner maritime fuels, electrification of port equipment, and operational efficiency improvements can substantially reduce these emissions, improve local air quality, and reduce the health burden of shipping-related air pollution on workers and nearby communities in heavily trafficked port and coastal areas.

In 2028, the world's largest ECA will come into force in the North-East Atlantic Ocean, covering the exclusive economic zones of France, Ireland, Portugal, Spain, the UK, Iceland, Greenland and the Faroe Islands.¹⁴⁹ Ships operating in these waters must use low-sulfur fuels, while those built from 1 January 2027 onwards must comply with stricter nitrogen oxide (NO_x) engine emission standards. The ECA is expected to cut PM_{2.5} emissions by 64 percent and black carbon emissions by 36 percent, prevent more than 4,000 premature deaths between 2030 and 2050, and save up to €29 billion in health costs by 2050.

3.2.2 Energy security and trade resilience

Global shipping today is, at its core, a fossil fuel industry, given that the overwhelming majority of oceanic freight is powered by heavy fuel oil. This means that the sector is structurally exposed to oil price volatility and geopolitical disruptions of fossil fuel supply chains. Crises in recent years have provided stark reminders of the vulnerabilities that this creates, which a transition away from fossil fuels would remove.

For example, geopolitical tensions in the Red Sea in 2024–2025 forced ships that would normally use the Suez Canal—through which about 12 percent of global trade flows—to reroute around the Cape of Good Hope, at significant additional cost. Tonnage through the canal fell by 70 percent by May 2025 relative to 2023 levels, and container freight rates reached more than double

147 Maritime Just Transition Task Force. 2024. "Considerations of Training Aspects for Seafarers on Ships Powered by Ammonia, Methanol and Hydrogen." United Nations Global Compact, International Chamber of Shipping, International Transport Workers' Federation, International Maritime Organization, World Maritime University and Lloyds Register. https://www.ics-shipping.org/wp-content/uploads/2024/11/MJTTF-Report_Training-Aspects-for-Seafarers_Single-Spread_20241122.pdf.

148 Viana, M., P. Hammingh, A. Colette, et al. 2014. "Impact of Maritime Transport Emissions on Coastal Air Quality in Europe." *Atmospheric Environment* 90 (June): 96–105. doi:10.1016/j.atmosenv.2014.03.046.

149 Osipova, L., P.F. Rodrigues, S. Ünal, et al. 2024. "Environmental and Health Benefits of a Designated North Atlantic Emission Control Area." ICCT Working Paper. Washington, DC: International Council on Clean Transportation. <https://theicct.org/publication/environmental-and-health-benefits-of-a-designated-north-atlantic-emission-control-area-nov24/>.

their late-2023 level.¹⁵⁰ Most recently, the Strait of Hormuz, through which 11 percent of global trade and a third of all seaborne oil flow, was effectively closed in late February 2026 due to the U.S. war on Iran, creating the most significant disruptions to maritime energy trade in recent history.¹⁵¹ According to OECD and UN tracking data, the resulting long-distance vessel rerouting drastically increased global GHG emissions from shipping.

Electrifying and transitioning to green fuels produced with widely distributed renewable resources—such as solar in North Africa, wind in northern Europe and Patagonia, and geothermal in Iceland—will enhance the shipping sector's energy security. Instead of relying on a handful of oil-exporting regions and a small number of vulnerable sea lanes, the energy supply will come from geographically diverse (and often domestic) sources. This will significantly protect economies from the shocks created by regional conflicts and other geopolitical disruptions. Countries and port authorities investing in green hydrogen and e-fuel bunkering infrastructure gain strategic energy autonomy and insulate their fleets from oil price shocks.¹⁵²

Green shipping corridors—designated routes between port pairs committed to operating on zero-emission fuels—take this resilience logic one step further. At the UN Climate Change Conference in November 2024 (COP29), more than 50 organizations across the shipping value chain signed a Call to Action to accelerate zero-emission fuel adoption.¹⁵³

The Zero Emission Maritime Buyers Alliance (ZEMBA) completed its first collective tender in 2025 for a Singapore-to-Rotterdam corridor, achieving a reduction of more than 90 percent in lifecycle GHG emissions compared with a conventional fossil-fuel-powered service.¹⁵⁴ The UNCTAD Review of Maritime Transport 2025 calls explicitly for diversification of shipping routes, investment in sustainable and resilient port infrastructure, and decarbonization pathways that are both ambitious and achievable, underscoring that in today's volatile trade environment, the energy transition is not merely compatible with trade security but is, in fact, a prerequisite for it.¹⁵⁵

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154 See <https://greenshippingchallenge.org/announcements-at-cop29/>.

155 UNCTAD, 2025, "Review of Maritime Transport 2025: Staying the Course in Turbulent Waters."

3.3 Closing Reflections

The current state of shipping in NDCs is one of gradual progress, but still limited ambition and uneven specificity. The sector is increasingly recognized as relevant to national climate action, and a number of countries are beginning to include measures related to fuel and energy transition, infrastructure, port development, efficiency, and regulatory support. Ocean-based transport mitigation is now present in a meaningful number of updated coastal and island NDCs, and examples of stronger ambition are beginning to emerge.

At the same time, major gaps remain. Shipping is still rarely treated as a clearly defined mitigation sector within NDCs. Commitments are often framed in broad or indirect terms, and there is still limited clarity in many cases whether countries are targeting domestic shipping, international shipping, fishing fleets, port operations, or some combination of these. This weakens accountability and makes it harder to assess ambition and implementation readiness. It also suggests that, despite growing recognition of the issue, shipping has not yet been systematically integrated into the core architecture of national climate commitments.

This mixed picture makes the current moment particularly important. Progress at the IMO level remains significant but uncertain, and national action remains essential. As countries prepare future NDC cycles and strengthen implementation of their current ones, shipping represents a clear opportunity to move from general recognition toward more concrete, measurable, and policy-relevant commitments.



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Annex 1. Good Practices, Gaps, and Lessons Learned from NDCs

The 2025 analysis of coastal and island countries' NDCs shows a mixed picture.¹⁵⁶ On the one hand, shipping is appearing more frequently in climate discussions and is increasingly recognized as a legitimate area for national action. On the other hand, mitigation commitments remain sparse relative to the scale of the challenge.

Across the NDCs assessed, ocean sectors with the greatest potential to reduce emissions, including maritime transport, remain only lightly represented. Marine conservation and maritime transport were the most prioritized ocean-related mitigation areas, with 39 and 28 countries making commitments. Still, coverage of shipping is limited relative to the sector's importance. Moreover, in many NDCs, shipping is not yet addressed as a distinct mitigation sector with its own quantified targets. More often, it appears through specific measures or policy directions embedded within broader transport, infrastructure, or energy strategies.

A1.1 Main Areas of Action Emerging in NDCs

Building on the 2025 study, a deeper analysis for this report examined selected NDCs to identify common themes. It found that references to shipping tend to cluster around four broad areas:

Fuel transition: This is one of the clearest emerging themes in shipping-related mitigation with increasing attention to near-zero and zero-emission fuels such as hydrogen, ammonia, and methanol, while your other source also highlights growing efforts to develop alternative fuels as part of broader decarbonization strategies.

Infrastructure and ports: This includes both mitigation-oriented action, such as the development of cleaner bunkering and shore-side systems, and adaptation-oriented efforts to climate-proof critical infrastructure. Ports are increasingly recognized as an important entry point for action because they connect shipping decarbonization to local air quality, urban emissions, industrial development, and public health. Ports remain an underused resource in climate action, despite their central role in trade and their location in or near major cities. This is especially relevant given that 42 of the world's 50 largest ports are located around cities, where port activity has direct implications for both local economies and environmental quality.

Operational and technical efficiency: Ships can reduce emissions not only by changing fuels, but also through technical upgrades and operational measures. Improvements in efficiency, including reduced ship speeds, can lower emissions while also producing co-benefits such as less underwater noise and lower risks of ship strikes on whales. This is a useful reminder that

¹⁵⁶ Khan, Baines, Lecerf, et al., 2025, "The State of Ocean-Based Climate Action in 2025 Nationally Determined Contributions: A Preliminary Update."

shipping decarbonization is not only about future fuel systems; there are also nearer-term measures available.

Regulatory and cooperative approaches: Literature points to the role of green shipping corridors and carbon-pricing frameworks such as the European Union's Emissions Trading System in supporting sectoral decarbonization while highlighting the importance of trade-, tax-, and investment-related measures (particularly in EU).

A1.2 Selected Country Insights

This section profiles six countries spanning major maritime nations, pioneering small island developing states (SIDS), an emerging developing-country coalition, and a major developing-country archipelago, that have made more substantive efforts to integrate shipping into their NDCs or their NDC-aligned national climate strategies. For each, we describe how shipping is addressed and identify elements that represent good or best practice.

Republic of the Marshall Islands

The Marshall Islands stands out globally as one of the very few states to explicitly include quantified, sector-specific targets for domestic maritime shipping within the text of its NDC.¹⁵⁷ Inter-atoll maritime transport is not merely referenced in passing—it is recognized as a key emissions source and a defined decarbonization priority given the country's complete dependence on sea connectivity across its 29 atolls.

RMI's NDC commits to a 40 percent reduction in domestic shipping emissions by 2030 compared to baseline levels, with a pathway toward full decarbonization of the domestic fleet by 2050. This commitment is supported by a Domestic Maritime Transport Roadmap approved by the Presidential Cabinet, which charts concrete technology, procurement, and crew training pathways to achieve these targets. A new Pacific Island Supply Vessel, a hybrid-propulsion, low-emission vessel designed with international partners, represents a tangible early deliverable.

Best practices identified include:

- **Sector-specificity:** Shipping is named as a distinct, quantified mitigation sector in the NDC text, not subsumed into a generic transport category.
- **Existential framing:** RMI situates shipping decarbonization within its broader survival narrative as a climate-vulnerable SIDS, lending political force and coherence to the commitment.
- **Implementation roadmap:** The Cabinet-approved roadmap provides a credible implementation backbone, translating the NDC target into actionable fleet, technology, and training milestones.
- **International leverage:** RMI has used its NDC commitment to attract bilateral technical cooperation funding (Germany/GIZ), demonstrating how ambitious NDC framing can catalyze external finance for developing states.
- **IMO-NDC coherence:** RMI aligns its domestic NDC goal with its prominent advocacy at the International Maritime Organization for a 1.5°C-aligned global shipping strategy, creating mutual reinforcement between national and multilateral ambition.

157 RMI, 2025, "The Republic of the Marshall Islands Nationally Determined Contribution 2031-35."

Norway

Norway's NDC targets at least a 55 percent economy-wide GHG reduction by 2030 against 1990 levels and a 70–75 percent reduction by 2035.¹⁵⁸ It covers all domestic sectors, including shipping. While the NDC pledge itself is an aggregate target, Norway's domestic shipping decarbonization is one of the most elaborated components of Norwegian climate policy, sitting at the intersection of the NDC and specific sectoral legislation.

Norway has established a politically anchored goal of a 50 percent reduction in domestic shipping and fishing vessel emissions by 2030 relative to 2005 levels, though it is not explicitly stated in the NDC. To operationalize this, the government has introduced a cascade of mandatory zero-emission procurement rules: zero-emission requirements for new public ferry contracts from 2024, zero-emission vessels for public high-speed passenger services from 2025, low- and zero-emission requirements for aquaculture service vessels from 2024, and low-emission requirements for offshore support vessels from 2025 scaling to zero-emission by 2029. A formal climate partnership with the Norwegian maritime sector has been established to support industry in managing this transition.

Best practices identified include:

- **Regulatory cascade:** Rather than a single blanket measure, Norway has designed a sequenced set of procurement mandates tailored to specific vessel segments (ferries, high-speed, aquaculture, offshore), reflecting the sector's technical heterogeneity.
- **Carbon tax integration:** Norway's rapidly escalating carbon tax (to US\$220/tonne by 2030) provides a persistent economy-wide price signal that reinforces sector-specific shipping mandates.
- **Public procurement as lever:** Using state purchasing power to mandate zero-emission vessels in public contracts is a highly replicable best practice, as it creates early market demand, reduces technology risk premiums, and accelerates commercialization of new vessel types.
- **Climate partnership model:** Formalizing a government-industry climate partnership for shipping creates a structured dialogue mechanism that helps co-design realistic transition pathways and builds confidence for industry investment.
- **EU ETS alignment:** Norway's participation in the EU Emissions Trading System, now extended to maritime, integrates shipping emissions pricing into a broader carbon market, providing additional financial incentive for decarbonization.

¹⁵⁸ Government of Norway. 2025. "Norway's Nationally Determined Contribution for 2035." Oslo. <https://unfccc.int/sites/default/files/2025-06/Norways%20NDC%20for%202035..pdf>.

Singapore

Singapore's NDC sets an economy-wide absolute GHG emissions limitation target, peaking at 65 Mt CO₂e around 2030 and declining to 45 Mt CO₂e by 2035, to reach net zero by 2050.¹⁵⁹ Shipping itself does not appear as an isolated sector with a standalone quantified target in the NDC text, but Singapore's approach is notable for the institutional depth and strategic ambition with which it addresses maritime decarbonization in parallel with its NDC commitments.

In March 2022, Singapore's Maritime and Port Authority (MPA) released the Singapore Maritime Decarbonization Blueprint 2050,¹⁶⁰ backed by over SGD 300 million in committed investment. The Blueprint identifies seven strategic pillars: green port infrastructure, green and digital shipping corridors, green financing, green shipping manpower and skills, green fuels and technology, international partnerships, and enabling policy. Singapore is positioning itself as the world's leading bunkering hub for zero-emission fuels, particularly green ammonia, methanol, and hydrogen, and has launched the Green and Digital Shipping Corridor with Rotterdam, one of the longest such corridors globally.

Best practices identified include:

- **Strategic alignment of NDC and sectoral blueprint:** Singapore explicitly links its Maritime Decarbonization Blueprint to its NDC implementation, providing a sector-specific delivery vehicle for an economy-wide climate target.
- **Hub-and-corridor strategy:** By targeting its role as the world's pre-eminent bunkering hub for zero-emission fuels, Singapore addresses international shipping at a systemic level, influencing emissions far beyond domestic jurisdiction.
- **Green corridor diplomacy:** The Singapore–Rotterdam Corridor demonstrates how bilateral governmental action can lock in supply chains, attract private investment, and create replicable models for zero-emission trade routes.
- **Committed public financing:** The SGD 300M+ MPA investment signals durable government commitment to shipping decarbonization, providing the long-horizon certainty that private actors require to invest in new vessel and fuel technologies.
- **Seven-pillar comprehensiveness:** The Blueprint integrates technology, finance, workforce, policy, and international partnership dimensions, recognizing that shipping decarbonization requires simultaneous action across the whole enabling system, not just vessel technology.

159 Government of Singapore, 2025, "Singapore's Second Nationally Determined Contribution (NDC) and Accompanying Information."

160 MPA Singapore, 2022, "Maritime Singapore Decarbonisation Blueprint: Working Towards 2050."

Fiji

Fiji has been expanding NDC coverage to include maritime transport among developing country SIDS. When revising its NDC, Fiji explicitly committed to moving beyond an energy-sector-only framing to include maritime transport, domestic aviation, land transport, agriculture, waste, and forestry, a whole-of-economy approach that is rare among small island states.¹⁶¹ This expansion of scope to include domestic maritime transport represents a significant normative step, as it establishes the sectoral accounting base from which reduction ambitions can be built.

Beyond its own NDC, Fiji has anchored a regional coalition, the Pacific Blue Shipping Partnership, with six other Pacific Island states (Kiribati, Marshall Islands, Solomon Islands, Tonga, Tuvalu, and Vanuatu).¹⁶² The PBSP has committed to aligning sea transport with a shared GHG emission reduction trajectory: 40 percent by 2030, 80 percent by 2040, and net zero by 2050. The partnership's near-term deliverable involves retrofitting and replacing over 11,000 vessels across the seven member countries, with international technical and financial support. Fiji is also a signatory to the Clydebank Declaration for Green Shipping Corridors.¹⁶³

Best practices identified include:

- **NDC scope expansion:** Fiji's explicit decision to extend NDC coverage to domestic maritime transport, rather than treating it as an excluded sector, establishes the accountability framework needed for future target-setting.
- **Coalition leverage:** The Pacific Blue Shipping Partnership demonstrates how individually small and resource-constrained states can aggregate their ambition and influence to attract finance and technical support at a scale none could access alone.
- **Cascading ambition trajectory:** The 40/80/100 percent phased trajectory (2030/2040/2050) provides a clear, long-horizon pathway for shipping decarbonization, allowing industry and investors to plan accordingly.
- **Developing-country equity framing:** By foregrounding SIDS' dependence on shipping for essential connectivity, and their limited fiscal space, Fiji and its partners have successfully framed maritime shipping decarbonization as a climate justice issue, unlocking international finance and technical assistance flows.
- **Replicability:** The coalition model is directly replicable by other groups of developing coastal and island states (in the Caribbean, Indian Ocean, or East African islands) seeking to address shipping collectively.

¹⁶¹ Government of Fiji, 2025, "Fiji's Third Nationally Determined Contribution 2025-2035."

¹⁶² See <https://mcstrmi.org/projects/pacific-blue-shipping-partnership/>.

¹⁶³ See <https://www.gov.uk/government/publications/cop-26-clydebank-declaration-for-green-shipping-corridors>.

Denmark

As an EU Member State, Denmark fulfills its NDC obligations through the EU's collective commitment, currently a 55 percent GHG reduction by 2030 versus 1990 (the "Fit for 55" target).¹⁶⁴ Within this framework, the EU has introduced a comprehensive maritime package: the extension of the EU Emissions Trading System (ETS) to shipping from 2024; the FuelEU Maritime Regulation (in force from January 2025) mandating progressive GHG intensity reductions from ships calling at EU ports; and the Alternative Fuel Infrastructure Regulation (AFIR) requiring shore power availability at major ports from 2030. Denmark's emissions, including those from domestic shipping, are accounted within this aggregate EU NDC.

Denmark's distinctive contribution lies in the unusually tight alignment between its national government, the Danish Shipping Association, and its world-leading maritime companies (principally A.P. Moller-Maersk). In January 2022, Danish Shipping released a strategy targeting climate neutrality for the Danish fleet by 2050,¹⁶⁵ with at least 5 percent of the operating fleet running on zero-emission fuels by 2030 and all new ship orders from 2030 being net-zero capable. Denmark has also taken a leading role in supporting green shipping corridor development globally, including funding pre-feasibility studies in developing nations, and has championed an IMO carbon levy as a global market-based measure.

Best practices identified include:

- **EU ETS as an NDC delivery mechanism:** Denmark demonstrates how regional carbon pricing mechanisms, when aligned with NDC targets, can function as primary delivery instruments for shipping decarbonization, providing both a price signal and an accounting framework.
- **Industry strategy coherence:** The tight alignment between the national government's NDC position and the Danish Shipping Association's voluntary industry strategy creates a powerful signal of policy direction that reduces investment uncertainty across the value chain.
- **Fleet new-order mandate:** The commitment that all new Danish ship orders from 2030 must be net-zero capable is a particularly high-impact best practice: it shapes the 20–30 year asset pipeline, which is crucial given vessels' long operational lifespans.
- **Developing-country support:** Denmark's commitment to funding green shipping corridor feasibility studies in lower-income nations (Namibia, Pacific SIDS, Panama) demonstrates how major maritime nations can use development finance to extend decarbonization ambition beyond their own borders.
- **IMO carbon levy advocacy:** Championing a global IMO carbon levy within the NDC context bridges the gap between national commitments and international shipping's inherently global governance structure, a critical gap in the current Paris Agreement architecture.

¹⁶⁴ European Union, 2025, "The Nationally Determined Contribution of the European Union and Its Member States."

¹⁶⁵ See <https://test-cd.danishshipping.dk/en/about/danish-shipping/strategy/>.

A1.3 Cross-Cutting Best Practices

Drawing across the six country cases, the following cross-cutting best practices emerge for integrating maritime shipping meaningfully into NDCs:

Best practice element	Description and country illustration
Sector-specific quantified targets	NDCs should include explicit, measurable shipping reduction targets with defined baselines and timelines, not just generic transport targets. (RMI: 40% by 2030; PBSP coalition: 40/80/100% trajectory)
Enabling legislation and mandates	Political targets require legal teeth. Mandatory zero-emission procurement rules, fuel regulations, and ETS inclusion are essential to translate NDC commitments into binding obligations. (Norway, EU/Denmark)
Dedicated implementation roadmaps	NDC shipping commitments should be supported by sector-specific roadmaps outlining concrete technology, investment, infrastructure, and skills pathways. (RMI: Cabinet-approved Roadmap; Singapore: MPA Blueprint 2050)
Coalition and corridor approaches	Green shipping corridor partnerships and regional coalitions multiply ambition, attract finance, and create replicable models. (Fiji/PBSP; Denmark/Singapore corridor diplomacy)
Financial commitment signals	Sustained public investment in shipping decarbonization, whether through dedicated funds, R&D support, or development finance, de-risks private action. (Singapore SGD 300M+; Norway carbon tax; Denmark corridor studies)
IMO-NDC coherence	Countries should ensure that their NDC commitments actively support and reinforce the international shipping GHG strategy at IMO, and vice versa. (RMI, Denmark/Norway IMO advocacy)
Just transition provisions	SIDS and developing countries must be supported through capacity building, finance, and technology transfer as shipping decarbonization proceeds, ensuring connectivity is not sacrificed for climate targets. (Fiji/PBSP; RMI/Germany partnership)
Linking decarbonization to economic opportunity	Major developing countries with large renewable energy potential should frame maritime decarbonization as a green industrial opportunity, attracting finance and investment rather than treating it solely as a compliance cost.

Annex 2. Reporting Requirements for the Paris Agreement

To effectively track and report progress on shipping-related NDC commitments, countries need robust data collection, management, and reporting systems. Under the Paris Agreement's Enhanced Transparency Framework, Parties are required to submit Biennial Transparency Reports, the first of which was due by 31 December 2024 (a follow-up is due at the end of this year). BTRs describe national GHG inventories and provide other information necessary to track progress in implementing and achieving NDCs.¹⁶⁶

For shipping, this means that countries should not only monitor emissions reductions, but also track the policies, investments, infrastructure, fuel transition, and implementation measures that support those reductions. Where shipping is included in an NDC, countries should define the scope of the commitment clearly, identify the indicators used to track progress, and ensure that data systems are consistent with national inventory and reporting arrangements.

A2.1 Data Requirements

Collecting comprehensive and reliable data is essential for monitoring shipping-related NDC commitments. The specific data required will depend on the scope of the country's target or measure, but key categories include the following.

Type 1: Shipping-related GHG emissions

Countries should collect data on GHG emissions from shipping-related activities covered by the NDC. Where feasible, this should be disaggregated by domestic shipping, international shipping, fishing vessels, port operations, and other relevant maritime activities. Data should also distinguish between absolute emissions and emissions intensity, since efficiency improvements may reduce emissions per unit of activity even where total maritime activity continues to grow.

Type 2: Maritime activity data

Shipping emissions cannot be interpreted without activity data. Relevant data may include vessel movements, voyage distances, tonne-kilometers, passenger-kilometers, vessel-kilometers, port calls, port waiting time, cargo throughput, fuel consumption, vessel type, and operational profiles. These data help countries understand whether emissions changes are driven by efficiency improvements, fuel switching, changes in trade volume, route changes, or other factors.

¹⁶⁶ See <https://unfccc.int/biennial-transparency-reports> and https://unfccc.int/sites/default/files/resource/v2_ETReferencemanual.pdf.

Type 3: Fuel use and fuel transition

Countries should track maritime fuel consumption by fuel type and, where possible, lifecycle emissions. This includes conventional marine fuels; liquefied natural gas; biofuels; electricity; and green hydrogen, ammonia, methanol, and other zero- or near-zero-emission fuels. Data should also cover production, import, storage, and bunkering capacity where these are part of the NDC commitment.

Type 4: Vessel technology and fleet composition

Data on fleet composition and vessel technology are needed to assess whether the sector is moving toward zero-emission readiness. Relevant data may include the number and share of vessels that are electric, hybrid, wind-assisted, zero-emission, or zero-emission-ready; vessel age; vessel class; engine type; retrofit status; and adoption of efficiency technologies.

Type 5: Port and infrastructure readiness

Where NDC commitments include ports, bunkering, electrification, or green corridors, countries should collect data on port infrastructure and operational readiness. This may include shore power availability, charging infrastructure, zero-emission fuel bunkering capacity, renewable electricity supply, safety systems, port emission-reduction measures, and climate-resilient port upgrades.

Type 6: Policy, finance, and implementation progress

Countries should track whether enabling policies and measures are being implemented. This may include maritime decarbonization strategies, fuel standards, port regulations, public procurement rules, carbon pricing or levy mechanisms, financial incentives, concessional finance, blended finance, green corridor agreements, and institutional arrangements for implementation.

Type 7: Socio-economic and just transition impacts

Shipping decarbonization can affect workers, port communities, island and coastal communities, trade costs, and maritime connectivity. Countries should collect data on workers trained or reskilled, jobs created, stakeholder engagement, support to affected communities, impacts on shipping-dependent regions, and measures to support SIDS, LDCs, and developing maritime economies.

Type 8: Environmental and ocean co-benefits

Shipping-related NDC commitments may also deliver environmental benefits beyond GHG mitigation. Countries should collect data, where relevant, on air pollutant emissions, underwater noise, ship-strike risk, oil pollution risk, scrubber discharge, invasive species risk, and marine biodiversity impacts. These indicators can help ensure that shipping decarbonization contributes to ocean protection and public health, rather than shifting environmental burdens.

A2.2 Methodologies

Effective methodologies for data collection, management, and reporting are needed to ensure that shipping-related NDC information is reliable, consistent, and usable for decision-making. The following approaches can support countries in developing shipping MRV systems:

Regular reporting by responsible institutions

Countries should establish regular reporting processes for shipping-related indicators. Relevant institutions may include maritime administrations, transport ministries, environment ministries, port authorities, energy regulators, customs agencies, national statistical offices, and fuel suppliers. Clear institutional responsibilities are important because shipping data are often spread across multiple agencies and private actors. Under the ETF, Parties are also expected to report information on institutional arrangements used to track progress in implementing and achieving their NDCs.

Integration with national GHG inventories and NDC tracking systems

Shipping-related data should be aligned with national greenhouse gas inventory systems and NDC tracking arrangements wherever possible. This is particularly important when countries include domestic shipping, port emissions, or fuel-related measures in their NDCs. For international shipping, countries should clearly state the accounting boundary used and avoid double counting, while still reporting relevant policies and measures where these support emissions reductions.

Use of administrative, operational, and digital data

Countries can draw on administrative and operational data from port authorities, vessel registries, automatic identification systems, fuel sales, customs records, energy suppliers, and project developers. Digital systems can help integrate these data sources and support more regular tracking of vessel movements, fuel use, port activity, and infrastructure deployment.

Stakeholder reporting and surveys

Surveys, questionnaires, and structured reporting templates can be used to gather qualitative and quantitative information from shipowners, port operators, fuel suppliers, cargo owners, training institutions, financial institutions, and local communities. This is particularly useful for tracking policy implementation, investment barriers, workforce readiness, private-sector participation, and just transition outcomes.

Third-party verification and independent review

Independent verification can strengthen the credibility of shipping-related data, especially where information is provided by project developers, port operators, fuel suppliers, or private-sector actors. Third-party review may be used for emissions data, lifecycle fuel claims, green corridor performance, environmental safeguards, and finance reporting.

Geographic Information Systems (GIS) and spatial analysis

GIS and spatial analysis can support planning and monitoring for ports, green corridors, maritime routes, coastal exposure, and environmental impacts. These tools can help identify priority ports, assess climate risks to maritime infrastructure, map vessel traffic patterns, and evaluate overlaps with sensitive marine ecosystems.

Case studies and learning systems

Countries should document implementation experience from pilot projects, green corridors, port upgrades, electrification initiatives, and fuel-transition programs. Case studies can help identify what works, where implementation barriers arise, and how successful approaches can be scaled or replicated in future NDC cycles.

A2.3 Integration with the Enhanced Transparency Framework

To ensure effective tracking and reporting of climate-compatible shipping targets within the framework of NDCs, it is essential to integrate the Enhanced Transparency Framework (ETF) requirements. The ETF, established under the Paris Agreement, mandates countries to provide clear, consistent, and transparent information on their climate actions and support through Biennial Transparency Reports (BTR).

An NDC under Article 4 is communicated by Parties every five years and is not subject to review under the ETF. However, there is a crucial relationship between the NDC and the ETF. Parties need to provide a description of their NDC in their BTR against which progress made will be tracked. The information required in the BTR is similar but not identical to the information necessary for transparency, clarity, and understanding in the NDC.

While the adequacy and appropriateness of the NDC and the chosen indicators to track progress are not subject to review under the ETF, the information reported to track progress made in implementing and achieving the NDC, including the description of the NDC and information provided for each selected indicator, is subject to technical expert review under the Modalities, Procedures and Guidelines (MPGs). Progress made in implementing and achieving the NDC is transparently summarized in the "structured summary" of the BTR and is subject to review by a technical expert review team.

To support reporting under the Enhanced Transparency Framework (ETF), it is essential that national data collection and reporting mechanisms related to green shipping enable the transparent tracking of progress made in implementing and achieving NDC commitments. Depending on the extent to which green shipping measures are included in the NDC, Parties may report information related to greenhouse gas (GHG) emissions reductions from maritime transport, as well as other information relevant to tracking progress in implementing green shipping measures. Where relevant, this may include information related to fuel consumption, vessel energy efficiency, the uptake of low- and zero-emission fuels and technologies, shore-side electrification, and port decarbonization measures. Consistency in methodologies, data sources, assumptions, and indicators over time supports the transparency, consistency, and reliability of information reported in successive BTRs.

In preparing their BTRs, Parties may benefit from detailed guidance on how to report progress related to green shipping targets, measures, and indicators included in their NDCs. This may include templates and tools for compiling data, estimating emissions reductions,

documenting methodologies and assumptions, and reporting information necessary to track progress made in implementing and achieving NDC commitments. National planning processes should encourage Parties to clearly consider their NDCs and related targets, how they will domestically track implementation and achievement of the NDC, and how they will ensure the availability of information on indicators over time for reporting in subsequent BTRs. Consistency in these approaches supports the transparency and reliability of information reported under the ETF.