3

DECARBONIZING SHIPPING

The shipping sector is at the centre stage of the debate on sustainability. Like other economic sectors, shipping generates greenhouse gas (GHG) emissions and must reduce its carbon footprint. International shipping, which carries over 80 per cent of the world merchandise trade by volume, is responsible for nearly 3 per cent of all global GHG emissions.

Although shipping contributes relatively small shares of GHG emissions per unit of transport work, without further action, emissions from the sector would continue to increase. For shipping to succeed in decarbonizing and help prevent dangerous levels of global warming, the sector must reach consensus regarding the regulatory framework and GHG mitigation measures of the future as soon as possible. International shipping is governed by rules and regulations negotiated and agreed at the International Maritime Organization (IMO), and work is currently under way at IMO to develop global rules on shipping decarbonization that apply to commercial shipping. At the same time, regional regulations are influencing the global process, as illustrated by the regulations adopted at the European Union level and applying to all ships calling at European ports.

Decarbonizing shipping will require a shift in technology and operations and an uptake of alternative low and zero GHG fuels. The transition entails a potential increase in maritime logistics costs, shipping rates and voyage times. Investments required to adjust ship designs, engines, operations, generate alternative low and zero carbon fuels at scale and implement green onboard technologies all have a price tag. This will drive up costs for shipowners, industry and, ultimately trade and the final consumer.

Implementing differentiated rules, whether by country of the flag or ownership, trade route, type of commodity, fleet profile, or any other basis, presents a considerable challenge. Shipping is inherently global: ships call at ports of different countries, cross various national and international waters, and operate in a context where a vessel's ownership, flag of registration, crew, insurance, management and classification are associated with a range of countries. Thus, it would be difficult to make developing countries or the least developed countries and small island developing States exempt from the application of the decarbonization rules to avoid the associated costs. Exemptions would likely lead to distortions and potential carbon "leakage" and could cause some countries to lag behind in progress on achieving the Sustainable Development Goals, while undermining an inclusive transition in shipping.

Compliance with new IMO rules should be uniformly enforced to reflect common responsibilities. However, mitigating measures for transition costs will be required to ensure that the most vulnerable economies are not unduly burdened. IMO member States are currently negotiating economic measures that could generate funds which could partly be channelled to support developing countries, including to alleviate the rise in maritime logistics costs and support a level playing field in maritime transport and trade. However, delaying decarbonization action in shipping would also be costly. First, there are the costs of climate change and its impacts. Second, starting the decarbonization process later will result in the need for steeper emissions reductions in an even shorter period. Thirdly, delayed action will lead to higher shipping rates and costs, as it adds uncertainty to investment decisions.

Scaling up investment in new ships (design, engines, onboard technologies, crew skills), energy supply and bunkering infrastructure (i.e., alternative fuels availability and supply through dedicated and adequate production, bunkering facilities, and storage) is crucial. Minimizing uncertainty about future regulations and reducing a lack of clarity about carbon prices and fuels is needed to spur action and investment by shipowners and other stakeholders across the maritime transport and energy production value chain.

The global shipping sector has a large potential to usher in a synchronized technology change and energy shift, guided by just and equitable transition objectives. If the international community can advance with a predictable regulatory framework and agree on clear, cost-effective technical and economic measures, the sector will minimize uncertainty and reduce transition costs.

A. RIDING UNCERTAINTY AND CHARTING THE COURSE TO LOW CARBON SHIPPING

1. Momentum for decarbonizing grows as regulatory and commercial pressure mounts

Shipping is at the forefront of the sustainability and climate change debate and must reduce its carbon footprint as soon as possible. Trends show that the sector continues to grapple with how to meet the greenhouse gas (GHG) emission targets as set out in the 2018 Initial Strategy on Reduction of GHG Emissions from Ships adopted at the International Maritime Organization (IMO) (IMO, 2018), as well as the most recent revised strategy (IMO, 2023a, Annex 15). International shipping is responsible for 2.8 per cent of all global GHG emissions. Without further action, carbon dioxide (CO_2) emissions from the sector are projected to increase from about 90 per cent of 2008 emissions in 2018 to 90–130 per cent of 2008 emissions by 2050 (IMO, 2020).

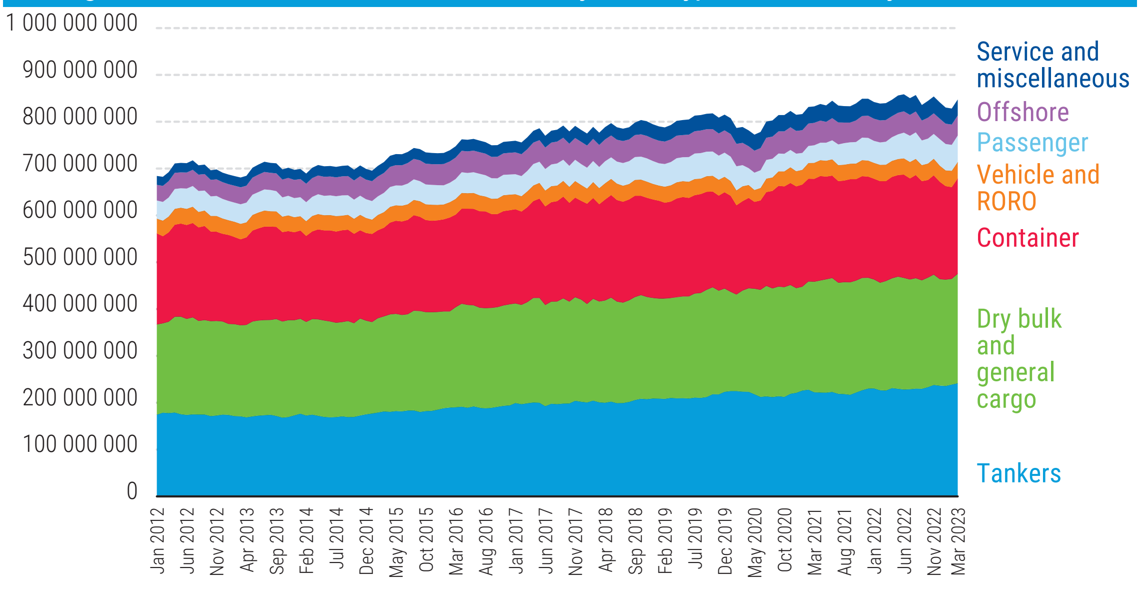
For shipping not to erode its own benefits, particularly as demand for shipping has grown faster than fuel efficiency improvements over the years, mainstreaming shipping decarbonization objectives is an urgent priority. This goal needs to be addressed to achieve the ambitions of the Paris Agreement (UNFCCC, 2015),[1] which include 'pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels', by 2100 (Art. 2(1)(a)). However, this threshold is likely to be reached by 2040, or earlier, if emissions are not slashed in the next few years, giving rise to rapidly growing risks of increasingly extreme heatwaves, droughts, and flooding that could have devastating consequences (IPCC, 2022a, 2022b). By the end of the century, global warming of 2.7°C is considered "very likely" in the IPCC's intermediate emissions scenario and could range from 3.3°C–5.7°C in the very high GHG emissions scenario (IPCC, 2023). Implementing existing policies and pledges will only reduce this to a 2.4–2.6°C temperature rise by 2100 (UNEP, 2022). Accelerated mitigation action in shipping is a matter of increasing urgency, as is effective action on climate impact adaptation, including for ports (UNCTAD, 2023).

To better align with GHG emission reduction targets, the shipping industry requires a portfolio of measures. Relevant intervention measures will affect operations (e.g., route optimization, vessel speed, and maintenance), fleet design, propulsion, engine, and fuels as well as infrastructure for alternative fuel bunkering supply.

2. Emissions vary by engine and ship type, age, and service

GHG emissions vary with shipping activity levels, trade flows, ship type, size, age, and operational practices. As shown in figure 3.1, total CO_2 emissions have evolved over the last ten years and continued to grow, even though the emissions per ton-mile have decreased. Carbon intensity by vessel type varies, with emissions from container shipping being higher per ton-mile than those from dry and liquid bulk shipping. However, overall shipping emissions per transport work improved over the last decade (figure 3.2).

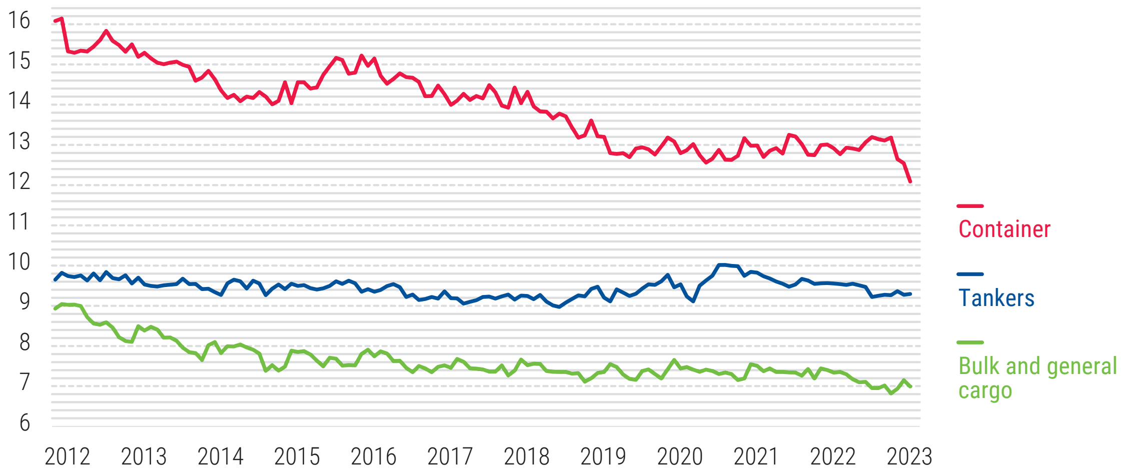
Figure 3.1 Total carbon dioxide emissions by vessel types, tons, January 2012—March 2023



Source: UNCTAD, based on data provided by Marine Benchmark, July 2023.

Note: RORO means roll-on/roll-off vehicle carrier.

Figure 3.2 World fleet, three main vessel types, monthly carbon dioxide emissions per ton-mile, January 2012—March 2023
(Gram/ton*nautical mile)



Source: UNCTAD, based on data provided by Marine Benchmark, July 2023.

Figure 3.3 and figure 3.4 depict trends in ships' carbon emissions by flag of registration and country of ownership. The countries of the flag are responsible for enforcing IMO regulations on reducing GHG emissions, while owners are generally responsible for making commercial and investment decisions pertaining to the ships, including when to order new capacity and the type of engines and fuels to be used by ships ordered.

In 2022, ships flying the flags of Panama, Liberia and the Marshall Islands, the world leading flags of registration by tonnage and number of vessels, accounted for over one-third of CO_2 emissions, similar but not identical to their share in tonnage registered under their respective flag (see chapter 2). Registries provide their flags to different ships, including both highly and less efficient vessels, which can impact the registry's overall emission profile.

As regards ownership, vessels controlled by owners in China, Japan and Greece account for the largest share of CO_2 emissions. As owners invest in different vessel types, the countries ranking in terms of tonnage owned diverge from their ranking in terms of carbon emissions.

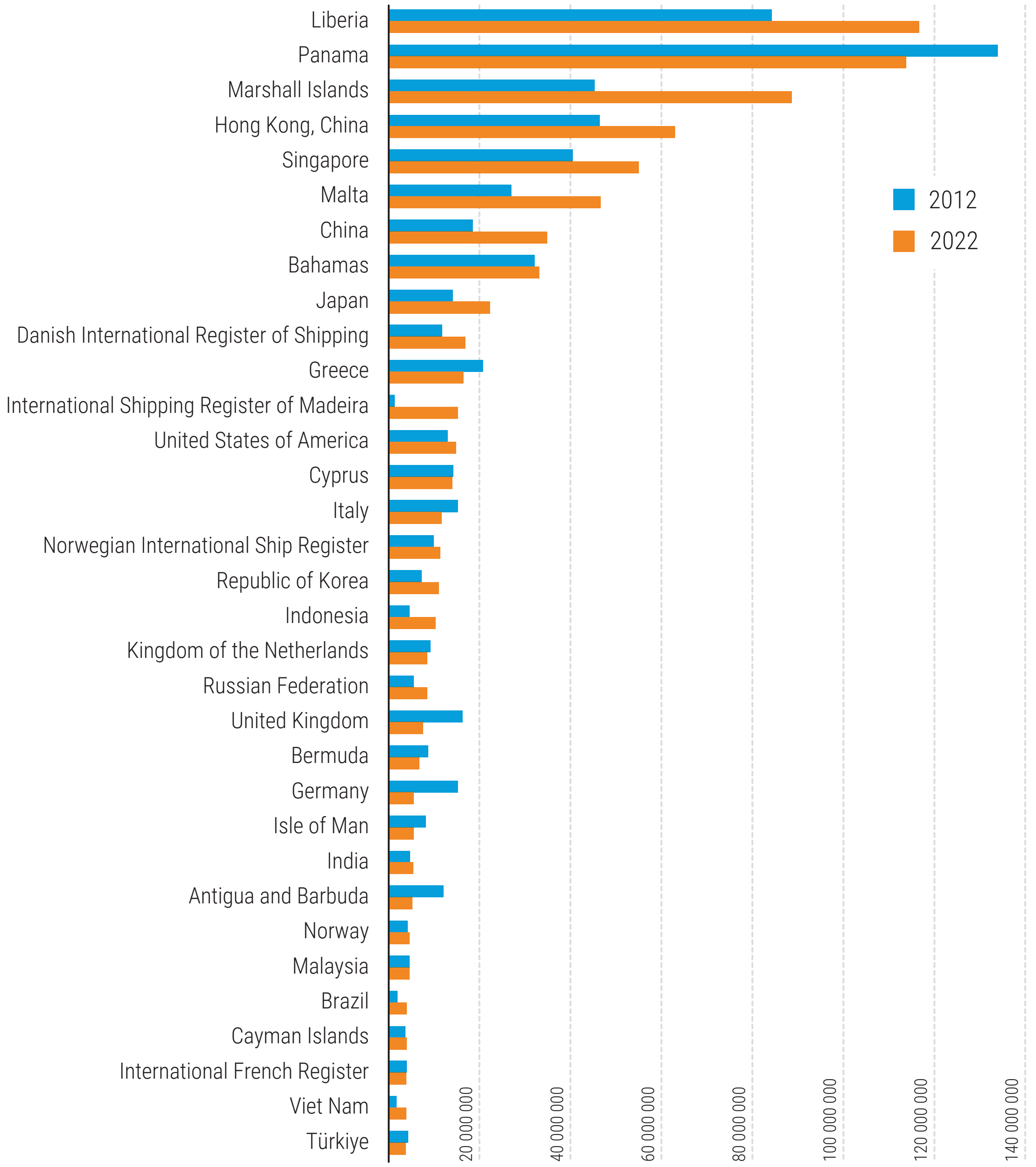
Shipowner investments in the future fleet, fuels and onboard green technologies play an important role in shaping the global shipping fleet's emission profile and its ability to meet IMO GHG emission targets. Enforcement of globally applicable IMO rules by both flag States and port States will be important for ensuring compliance and achieving effective decarbonization. At the same time, national and regional measures can contribute significantly to GHG emission reduction from shipping. For example, the European Union is enforcing regional measures, such as the inclusion of shipping into the European Union Emissions Trading System (ETS), irrespective of flag of registration or ownership.

In addition to the flag States and shipowners, stakeholders from several other countries may also determine the GHG emission performance of the fleet. As an example, decisions of shipbuilders pertaining to ship design and onboard technology to be fitted on vessels and the requirements by lending institutions for ships to comply with environmental sustainability standards and decarbonization objectives can contribute to shaping the carbon footprint of the global fleet.

3. Measures from the International Maritime Organization aim to reduce greenhouse gas emissions and improve energy efficiency

Regulatory requirements play a critical role in decarbonizing and improving the energy efficiency of the shipping sector. Following the adoption of a number of short-term measures since 2011, ongoing work at IMO is focusing on medium and long-term measures and related comprehensive impact assessments on States. A Revised Strategy with strengthened levels of ambition were adopted at the 80th session of the Marine Environment Protection Committee (MEPC 80), held by the IMO in July 2023 (IMO, 2023a, Annex 15).

Figure 3.3 Carbon dioxide emissions by main flags of registration, tons, 2012 and 2022



Source: UNCTAD based on data provided by Marine Benchmark, June 2023.

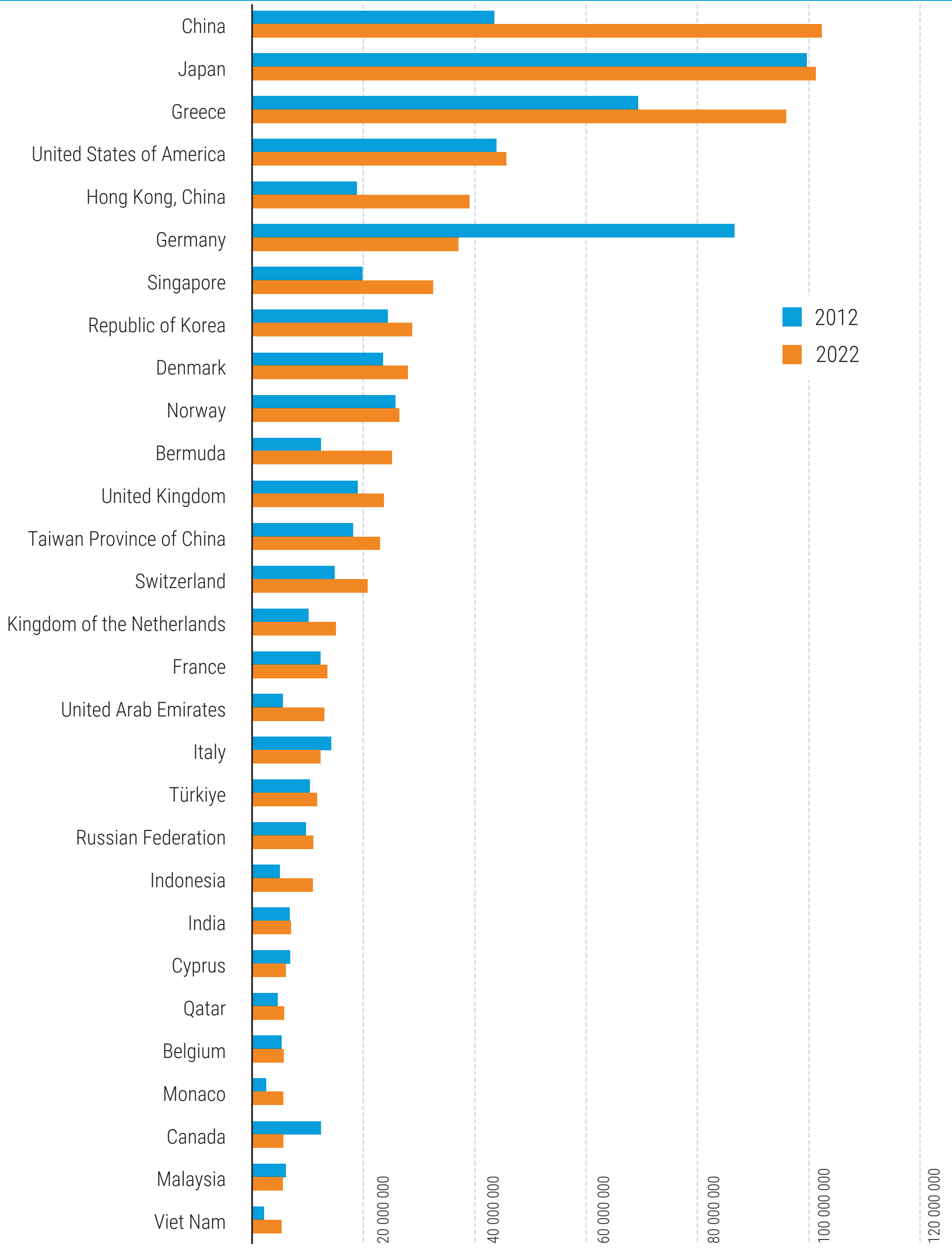
Note: Carbon dioxide emissions from vessels' mains and auxiliary engines calculated based on AIS data (Automated Identification System) on bunker fuel consumption.

Short-term decarbonization measures, adopted by way of revisions to chapter 4 of the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI (IMO, 2021a), include the Energy Efficiency Design Index for Existing Ships (EEXI) and the Carbon Intensity Index (CII) rating scheme. These need to be implemented from 2023 onwards. These complement earlier rules, namely the Energy Efficiency Design Index (EEDI) (Regulations 22 and 24) focusing on newbuild ships only, and Ship Energy Efficiency Management Plan (SEEMP) (Regulation 26) (UNCTAD, 2021, chapter 6). The short-term measures are set to be reviewed by 2026 (IMO, 2023b).

a) Energy Efficiency Existing Ship Index – Regulations 23 and 25

The EEXI is a technical measure in force since 1 November 2022 and applies to all existing ships of 400 gross tons (GT) or above. EEXI is a "sister" measure to EEDI and concerns design parameters of the vessels and measures their structural efficiency in terms of energy efficiency level per capacity mile (for related industry guidance, see IMO, 2023c).

Figure 3.4 Carbon dioxide emissions by main economies of ownership, tons, 2012 and 2022



Source: UNCTAD based on data provided by Marine Benchmark, June 2023.

Note: Carbon dioxide emissions from vessels' mains and auxiliary engines calculated based on AIS data (Automated Identification System) on bunker fuel consumption.

Compliance with EEXI can be enforced by issuing and verifying the International Energy Efficiency Certificate (IEEC) and can be initially met through technical improvements such as fitting engine power limiters or shaft power limitation systems (Lloyd's Register, 2022). Results suggest that the EEXI as proposed would make only a small contribution to the climate goals of IMO and would reduce CO_2 from the 2030 fleet by 0.7 — 1.3 per cent from a baseline without the EEXI (ICCT, 2020).

b) Carbon Intensity Indicator – Regulation 28

The CII is an operational measure that also applies to existing ships. Since 1 January 2023, ships of 5,000 GT and above have to calculate their Attained CII, which links the CO_2 emissions to the cargo carrying capacity over distance travelled, and rates the vessel on a scale of A to E. The CII is calculated according to the Annual Efficiency Ratio (AER), which is the ratio of CO_2 produced in a year, divided by the product of dead weight tons multiplied by miles sailed in a year.

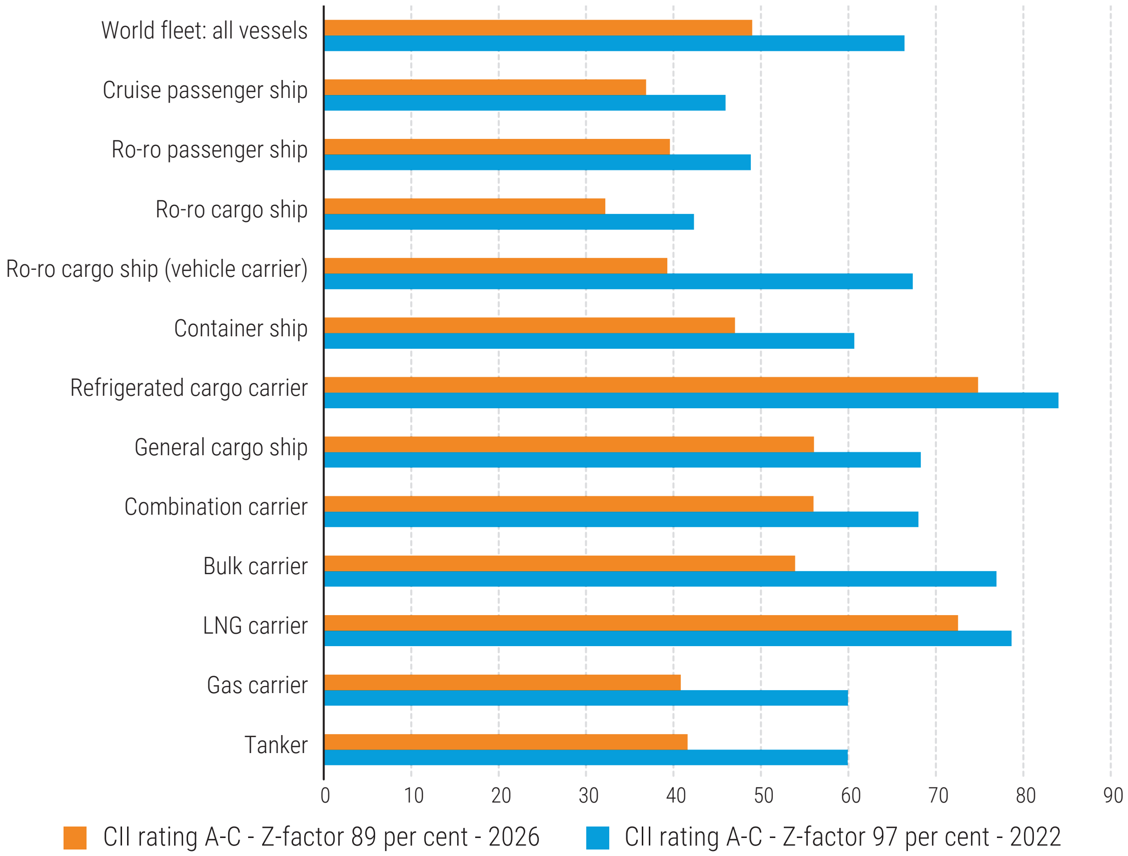
CII ratings will be recorded in a ship's SEEMP. If the ship is rated as D or E for three consecutive years, its SEEMP will need to be reviewed and include corrective actions to improve the rating. The annual carbon intensity reduction factor was equivalent to business-as-usual until entry into force; then 2 per cent from 2023 to 2026; and to be further strengthened for the period 2027 to 2030. IMO will review the effectiveness of the implementation of the CII and EEXI requirements by 1 January 2026 at the latest and develop and adopt further amendments as required.

Compliance should be ensured by both flag States and port States, which respectively issue and verify the existence of a statement of compliance in relation to fuel oil consumption reporting and operational carbon intensity rating, while the IMO provides implementation guidelines.

A good CII score will require ships to operate efficiently by leveraging route optimization, fuel efficiency, and speed. Figure 3.5 presents the performance of the world fleet against the 2022 CII ratings and how performance could deteriorate in 2026 if no action is taken to ensure compliance. In 2022, two thirds of the world fleet performed within the A to C rating. However, by 2026, this share will drop to 49 per cent if further measures are not taken to improve operations and reduce carbon intensity.

The regulation for CII uses a reference line of CO_2 emissions per capacity mile with the year 2019 as the base. Each year after 2019 has a lower permissible CO_2. The factor for multiplying the 2019 year values is called the Z-factor. The Z-factor is 0.99 for 2020, 0.98 for 2021, 0.97 for 2022, 0.95 for 2023, 0.93 for 2024, 0.91 for 2025 and 0.89 for 2026. The Z-factors are regulated under MEPC.328 (76) (IMO, 2021).

Figure 3.5 Percentage of vessels with Carbon Intensity Indicator ratings, A, B or C – with z—factor for 2022 and 2026



Source: UNCTAD based on data provided by Marine Benchmark, June 2023.

Note: Carbon dioxide emissions from vessels' mains and auxiliary engines calculated based on AIS data (Automated Identification System) on bunker fuel consumption.

Concerns have been raised regarding CII as it favours lengthy journeys and incentivizes activities that may lead to higher CO_2 emissions (StormGeo, 2023). Some ships maybe be penalized with low CII grades, not due to technical deficiencies but rather due to trading patterns, such as brief voyages or frequent waiting times that are needed to fulfil charter requirements.

Even a new, modern and efficient vessel may receive lower CII ratings than an older one, when engaged in short voyages or long waiting times. CII's perceived shortcoming lies in its use of dead weight or gross ton capacity as a proxy for cargo weight, making it impossible to distinguish or reward ships operating more efficiently on a cargo ton-mile basis. It has also been argued that the CII overlooks logistical and geopolitical limitations of sourcing compliant or low carbon fuel and the poor performance consequences of unforeseen bad weather (Safety4Sea, 2022).

Responding to these concerns regarding CII calculation, several correction factors have been under consideration, and related IMO guidelines (Resolution MEPC.355(78)) (IMO, 2022b, Annex 17) have been adopted. These would enhance the methodology for CII calculation and adjust CII scores for certain vessels in certain circumstances.

Since the CII is based directly on fuel consumption, its value and related correction factors mainly relate to fuel type, vessel efficiency, and operational parameters such as vessel speed, cargo, weather conditions and the general condition of the vessel (e.g., biofouling). For example, a clean biofouling-free hull can be around 10–15 per cent more fuel efficient than a fouled hull, but this is often overlooked, as it is challenging to monitor (Wartsila, 2022). Shipowners and charterers can influence the CII by maintaining vessels in good condition and optimizing operations.

Responsibility for compliance with CII primarily falls on the shipowners, unless that responsibility is contractually shared with charterers. To this end, the Baltic and International Maritime Council (BIMCO) recently issued the *CII Operations Clause for Time Charter Parties 2022* (BIMCO, 2022), which contractually assigns some of the responsibility for CII to charterers and requires both shipowners and charterers to work together in good faith to ensure the agreed CII score is met. In that sense, the CII mechanism is already leading to enhanced dialogue and transparency between shipowners and charterers regarding how best to manage energy efficiency onboard ships.

Both CII and EEXI requirements impact vessel speed, ship values and earnings, liquidity, capacity and the supply and demand balance. As EEXI is based on design parameters of the ship, most ships should already be compliant if they are relatively new Eco ships. Ships would also be compliant if they were fitted with engine power limitation or an energy saving technology, with no knock-on impact on current operating speeds. Less efficient older ships will need engine power limitation or be retrofitted with energy saving technology to comply. For old ships, this may not be cost-effective and could lead to more scrapping (Clarksons Research, 2023).

c) Complementary recent regulatory actions at IMO relevant for greenhouse gas emissions

These include the following decisions taken at MEPC 79 in December 2022 (IMO, 2022a), and MEPC 80 in July 2023 (IMO, 2023a):

- Adoption by MEPC 79 of revised resolutions on voluntary cooperation with ports and on national action plans (amendments (to resolution MEPC.323(74)) and resolution MEPC.327(75)), which include references to shipping routes to support decarbonization.
- Approval by MEPC 79 of the revised procedure for assessing impacts on States of candidate measures (MEPC.1/Circ.885/Rev.1), which takes into account the experience of the comprehensive impact assessment of short-term GHG reduction measures. This includes a new appendix largely following the methodology used for the comprehensive impact assessment of the short-term measures.
- Adoption by MEPC 79 of amendments to appendix IX of MARPOL Annex VI on the information that has to be submitted to the IMO Ship Fuel Oil Consumption Database in relation to the implementation of the short-term GHG reduction measure. This includes the attained values of the EEXI, CII and rating, and approval by MEPC 80 of an additional set of draft amendments to include data on transport work and an enhanced level of granularity and accessibility in the IMO Ship Fuel Oil Consumption Database.
- Approval by MEPC 80 of a plan for the review of the short-term GHG reduction measures.

Adoption by MEPC 80 of Guidelines on life cycle GHG intensity of marine fuels (LCA guidelines) allowing for a well-to-wake calculation,[2] including well-to-tank and tank-to-wake emission factors, of total GHG emissions related to the production and use of marine fuels and establishment of a Correspondence Group on the further development of the IMO LCA framework.

Approval by MEPC 80 of an MEPC circular on interim guidance on the use of biofuels under regulations 26, 27 and 28 of MARPOL Annex VI (Data Collection System (DCS) and CII), expected to incentivize the use of sustainable biofuels in the short-term as a compliance option for CII.

MEPC 80 also discussed proposals on onboard CO_2 capture and forwarded them to the Intersessional Working Group on Reduction of GHG Emissions (ISWG-GHG 16), set to meet in March 2024) for further consideration.

In addition to MEPC intensifying work around reducing GHG emissions from ships, in its work programme, the Maritime Safety Committee of IMO included a continuous output on "Development of a safety regulatory framework to support the reduction of GHG emissions from ships using new technologies and alternative fuels".

d) Adoption of the 2023 greenhouse gas reduction strategy by the International Maritime Organization

The Initial Strategy on the reduction of GHG emissions from ships (IMO, 2018) aimed in particular to reduce the carbon intensity of international shipping by at least 40 per cent by 2030, and total GHG emissions by at least 50 per cent by 2050, compared to 2008 levels.

To achieve these targets, the strategy outlined a range of candidate measures, including operational improvements, technological innovation, and alternative fuels. In December 2022, MEPC 79 reaffirmed its commitment to adopt a Revised Strategy in all its elements, including with a strengthened 'level of ambition', by MEPC 80. To this end, work continued during the Intersessional Working Group on Reduction of GHG Emissions from Ships (ISWG-GHG) 14 and 15, (March and June 2023) to finalize the draft Revised Strategy in that time frame (IMO, 2022a). Given the growing urgency of reducing global GHG emissions, the revised 2023 IMO GHG Strategy adopted in July 2023 (IMO, 2023a, Annex 15) establishes new, more ambitious targets.

A large number of documents on the Revised Strategy were submitted for consideration by the ISWG-GHG and MEPC in 2023.[3] They broadly related to: 1. Vision; 2. Levels of ambition and guiding principles; 3. List of candidate mid- and long-term further measures with possible timelines and their impacts on States; 4. Barriers and supportive actions, capacity-building and technical cooperation, Research and Development; 5. Follow-up actions and periodic review of the Strategy.

Some of the key elements of these documents are summarized below.

Proposals on the levels of ambition suggested levels for 2030, 2040 and 2050 with different numbers of absolute reduction of emissions. These could be grouped as proposals relating to the phase out date and the 2050 level of ambition; early action by 2030; additional milestones, in particular 2040; the further improvement of the energy efficiency of ships; and the structure and introductory text of the section on levels of ambition (for more information and a summary of proposals see, IMO, 2023a, 2023e).

Outside of IMO, including at the United Nations Framework Convention on Climate Change Conference of the Parties (UNFCCC COP), the European Union, the Group of 7, and at national levels, most of the discussions and focus have been on the "zero by 2050 target". Against this background, there seemed to be consensus at IMO as well that anything below this ambition would not contribute to meeting the Paris Agreement temperature goal (see e.g. TradeWinds, 2023a).

As regards governing principles in the revised 2023 Strategy, it had been suggested that they should include, in addition to those already in the Initial Strategy, widely used legal principles such as: the polluter pays principle, the principles of equity and of greatest possible ambition enshrined in the UNFCCC Paris Agreement, and the recognition of the human right to a clean, healthy, and sustainable environment. However, during the Intersessional Working Group meetings, there was no sufficient support for their inclusion. Most member States agreed that the existing guiding principles in the Initial Strategy, such as the principle of non-discrimination and the principle of no more favourable treatment, enshrined in MARPOL and other IMO conventions should be retained with minimum adjustments. Also, the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances, enshrined in the UNFCCC, its Kyoto Protocol and the Paris Agreement, should be retained with minimum adjustments.

MEPC 80 adopted by acclamation on 7 July 2023 resolution MEPC.377(80) on the 2023 IMO Strategy on reduction of GHG emissions from ships (IMO, 2023f).The 2023 IMO GHG Strategy includes an enhanced common ambition to reach net-zero GHG emissions from international shipping close to 2050, a commitment to ensure an uptake of alternative zero and near-zero GHG fuels by 2030, as well as indicative checkpoints for 2030 and 2040:

(a) To reduce the total annual GHG emissions from international shipping by at least 20 per cent, striving for 30 per cent, by 2030, compared to 2008;

(b) To reduce the total annual GHG emissions from international shipping by at least 70 per cent, striving for 80 per cent, by 2040, compared to 2008.

The Vision has been revised to include a reference to promoting a just and equitable transition for international shipping.

The 2023 GHG Strategy states that a basket of candidate measures that deliver on the reduction targets should be developed and finalized. These should also comprise both a technical element, namely a goal-based marine fuel standard regulating the phased reduction of the marine fuel's GHG intensity; and an economic element, on the basis of a maritime GHG emissions pricing mechanism. The candidate economic elements will be assessed observing specific criteria to be considered in the comprehensive impact assessment, with a view to facilitating the finalization of the basket of measures.

Developing the basket of candidate mid-term GHG reduction measures should take into account the well-to-wake GHG emissions of marine fuels as addressed in the LCA guidelines developed by IMO. The overall objective is to reduce GHG emissions within the boundaries of the energy system of international shipping and prevent a shift of emissions to other sectors.

Finally, the 2023 Strategy sets out a clear timeline towards adopting the basket of measures in autumn 2025 and adopting a new updated IMO GHG Strategy on reducing GHG emissions from ships in 2028.

e) Development of a basket of mid-term measures

Further to adopting the 2023 IMO GHG Strategy, in July 2023, MEPC 80 further discussed a set of candidate mid-term GHG reduction measures which are key to enabling the Strategy, and moved from Phase 2 to Phase 3 of a structured work plan to finalize these measures.

A large number of submissions to MEPC and the Intersessional Working Group on GHG emissions related to various candidate measures to be developed as part of a basket of measures consisting of both technical (e.g., a GHG fuel intensity standard and/or enhancement of IMO carbon intensity measures) and economic (e.g., a levy, a reward, feebate or flat rate contribution) elements.

The 2023 GHG Strategy provides that the impacts on States of a measure/combination of measures should be assessed and taken into account before adopting the measure(s) in accordance with the revised procedure for assessing impacts on States of candidate measures (IMO, 2022a). Particular attention should be paid to the needs of developing countries, notably the least developed countries (LDCs) and the small island developing States (SIDS).

The 2023 GHG Strategy recognizes that LDCs and SIDS have special needs with regard to capacity-building and technical cooperation. An appendix provides an overview of relevant IMO initiatives supporting the reduction of GHG emissions from ships.

The 2023 IMO GHG Strategy revokes the Initial IMO GHG Strategy of 2018, and will be kept under review with a view to adopting another revised IMO GHG Strategy in 2028.

4. Other measures to reduce greenhouse gas emissions in shipping

In parallel to the IMO work, some regional developments are also directly relevant for reducing shipping emissions, energy efficiency, market-based mechanisms, and energy taxation in the shipping sector, including in trade outside the European Union. More specifically:

Under Regulation 2015/757 (European Union, 2015) on the monitoring, reporting and verification of CO_2 emissions from maritime transport (MRV Regulation), shipowners and operators of ships above 5,000 GT and making commercial voyages to, from, or within European Union ports are required to submit a verified emissions report to the European Commission. A recent amendment to the regulation (European Union, 2023a) adopted in April 2023, provides that emissions from shipping will be included within the scope of the European Union ETS for the first time to ensure that maritime transport activities contribute their fair share to the increased climate objectives of the European Union as well as the objectives of the Paris Agreement (para. 8).

Amendments to the ETS adopted in April 2023 (European Union, 2023b), increase the overall ambition of emissions reductions by 2030 in the sectors covered by ETS to 62 per cent compared to 2005 levels (para. 39). Moreover, 100 per cent of emissions from the European Union's internal shipping and at European Union ports, and 50 per cent of emissions from ships engaged in voyages between European Union and non-European Union ports will be covered by the European Union ETS (pg. 97, art. 3ga). While there is no explicit reference to developing countries, "this approach has been noted as a practical way to solve the issue of common but differentiated responsibilities and respective capabilities, which has been a longstanding challenge in the UNFCCC context" (para.20). Obligations for shipping companies to surrender allowances will be introduced gradually, starting with 40 per cent for verified emissions from 2024, 70 per cent from 2025 and 100 per cent from 2026. Most large vessels above 5,000 GT will be included within the scope of the ETS from the start, while offshore vessels between 400 and 5,000 GT will be included in the MRV regulation first, and only later in the ETS (pg. 23, para. 30). Non-CO_2 emissions (methane and N_2O) will be included in the MRV regulation from 2024 and in ETS from 2026 (pg. 17) (see also Verifavia, 2023).

A number of other related regulatory proposals are under active consideration. These include an update of the Energy Taxation Directive 2003/96/EC, which restructures the framework of the European Union for taxation of energy products and electricity (European Commission, 2021), and a regulation on the Fuel European Union Maritime Initiative known as the FuelEU) which was adopted in July 2023[4] (European Union 2023c, Riviera 2023). The latter establishes requirements to gradually reduce GHG emissions across a ship's life cycle. It also requires, from 2030 onwards, that passenger and container ships connect to an onshore electricity supply for stays longer than two hours. According to the regulation, ships should hold a valid FuelEU document of compliance, and if they fail to do so, may be banned from European Union waters until the obligations are fulfilled.

The recent amendments may have significant implications for European trade, including trade with developing countries. They may also prompt other countries to adopt similar measures, supporting global efforts to reduce emissions from shipping and a shift towards cleaner technology and industry practices.

Voluntary initiatives to develop standards for ships and fuels are undertaken by industry, including in partnership with other stakeholders. These include the Poseidon Principles initiative for responsible ship finance which involves 30 banks and seeks to align ship finance portfolios with climate action and sustainability; the Sea Cargo Charter scheme for cargo owners; and the Poseidon Principles for marine insurance adopted in 2021. Table 3.1 features selected voluntary initiatives of private or public-private partnerships (OECD, 2023).

Table 3.1 Selected voluntary initiatives for decarbonizing shipping

Initiative	Members	Purpose
Getting to Zero Coalition	200 organizations, including entities from the maritime, energy, infrastructure, and finance sectors	Decarbonize maritime shipping and develop and deploy commercially viable deep sea zero emission vessels by 2030 and full decarbonization by 2050
Mission Innovation	Co-led by Denmark, Norway, United States, Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, Global Maritime Forum	Demonstrate commercially viable zero-emission ships by 2030 and promote zero-emission fuelled vessels
Poseidon Principles	30 banks jointly representing approximately $200 billion in shipping finance	Voluntary principles by global shipping banks to promote shipping decarbonization, a framework for disclosing the climate alignment of lending portfolios to the shipping industry
	36 charterers and operators	A framework for aligning chartering activities with responsible environmental behaviour and disclosing the climate alignment of global ship chartering activities
Clean Energy Marine Hubs	International Chamber of Shipping, International Association of Ports and Harbours and the Clean Energy Ministerial	A public-private platform across the energy-maritime value chains to promote green fuels and support the global energy transition. Includes the governments of Canada, Norway, Panama, Uruguay, and the United Arab Emirates
GreenVoyage2050	Led by IMO and funded by Norway. Aims at selected developing countries	Cooperation between SIDS and the LDCs and maritime-related international associations and the industry
Zero-Emission Waterborne Transport	Horizon Europe, European maritime companies	Provide and demonstrate zero-emission solutions for ships before 2030

Source: OECD (2023).

B. POTENTIAL IMPLICATIONS OF DECARBONIZATION ON STATES

1. Assessing possible impacts on States

Reducing GHG from shipping will require investments in technologies and alternative fuels. Accordingly, IMO short- and medium-term GHG reduction measures will lead to investments in new technologies and ships that use alternative fuels. This may lead to increased maritime logistics costs and affect trade and economic output.

To clarify the potential impact of short-term IMO GHG reduction measures on States, in 2021, UNCTAD conducted a Comprehensive Impact Assessment of the proposed IMO short-term GHG reduction measures, namely the EEXI and CII.

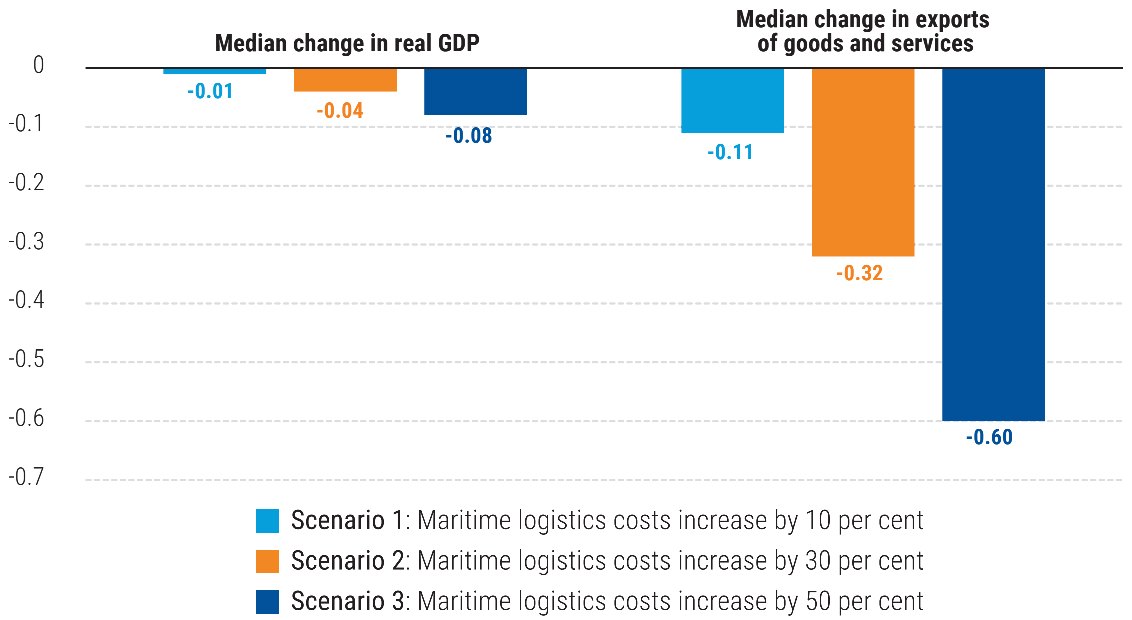
UNCTAD assessed the potential impact of a technical approach embedded in the EEXI, setting out scenarios for 2030 with or without the measure, across three levels of emission reduction ambition. The three scenarios included the EEXI-only scenario, high-GHG reduction scenario and low-GHG reduction scenario, each compared to the baseline 2030 scenario (current regulations). The aim was to quantify the changes in maritime logistics costs, including shipping and time costs (UNCTAD, 2021b). IMO subsequently adopted the low EEXI scenario which came into force in November 2022. In its assessment, UNCTAD concluded that the agreed measure would lead to a reduction of 2.8 per cent in average speed and an increase of 1.5 per cent over average maritime shipping costs in 2030.

While significant, these changes are relatively small when compared to typical variations in freight rates. They will also have a very small impact on global gross domestic product (GDP) and be far smaller than the disruption caused by the pandemic or climate change, or the costs of not acting in the face of climate change. However, IMO measures – short and medium term – will have a greater impact on some countries than others, notably on SIDS or LDCs, which may need support to mitigate the increased costs and alleviate the consequent fallout on their incomes and trade flows (UNCTAD, 2021b).

In 2023, UNCTAD carried out the “Expert Preliminary Review of the Technical and Economic Elements, and their Possible Combinations, of the Proposals for Candidate Mid-term Measures” (for a preliminary assessment of six proposals see IMO, 2023g; for the final report see IMO, 2023h).

To explore the potential impact of an increase in maritime logistics costs, UNCTAD modelled the outcome of a hypothetical increase in maritime logistics costs on global trade and GDP. Simulations assumed three levels of maritime logistics cost increases of 10 per cent, 20 per cent and 50 per cent, respectively. At a global level, the 50 per cent scenario implies changes in trade flows of minus 0.6 per cent (median per country). This translates into an impact on real GDP of minus 0.08 per cent (figure 3.6). Based on International Monetary Fund data (2023) for the global GDP of $104 trillion in 2022, a reduction of 0.08 per cent would be equivalent to a reduction of global GDP of about $80 billion.

Figure 3.6 Assessing the impacts of increased maritime logistics costs, percentage change



Source: IMO (2023h).

Although the changes may seem relatively small on a global scale, countries heavily reliant on specific trade sectors could experience more significant impacts due to the potential for larger increases in maritime logistics costs.

The mechanism driving the result is that higher shipping costs and fuel charges translate into higher trade costs. This in turn drives a larger divergence between consumer and producer prices which is to the disadvantage of consumers, including firms that use imported intermediates. The trade numbers depicted in figure 3.6 account for total goods and services trade and incorporate the shift of some economic activity towards services because of the increased trade costs in goods.

These simulations provide indicative values for the potential impact of shipping decarbonization measures on trade and global output. For a complete picture, the impact of the measures on maritime logistics costs must be estimated.

2. Monitoring shipping costs and fuel charges amid the rise in alternative fuels

Fuel costs account for a significant portion of the overall ship operating costs. Transitioning to cleaner fuels may be more expensive and add to these costs. Depending on factors such as vessel size, efficiency and the distance travelled, fuel costs can account for up to two thirds of the overall expenses making it by far the largest component of the carrier's variable cost base. Consequently, the shift towards cleaner fuels will generate additional costs and will make fuel an ever more critical component in the cost structure of shipping operations.

When comparing bunker fuels to their low and zero GHG fuel alternatives, the price differential can be significant. Data from Clarksons Research shows that in December 2022, very low sulphur fuel oil was priced at approximately $635 per metric ton and the average cost of heavy fuel bunker oil (380 centistoke in Rotterdam, Kingdom of the Netherlands) hovered around $515. Meanwhile, under an assumption of green hydrogen at $2.5 per kilogram, the cost of ammonia would amount to $1,239 per ton (fuel oil equivalent), and methanol would reach approximately $1,400 per ton (*Financial Times*, 2023).

Comparing prices for alternative fuels is not straightforward. Energy content of the fuels per ton varies significantly. Prices may be referred per gross calorific value. There are also different standards regarding units (energy vs quantity) and currencies across markets. Argus Media publishes alternative marine fuels prices based on energy equivalents, including marine gas oil equivalent, very low sulphur fuel oil and British thermal units. These allow for fair price comparisons based on energy density (DNV, 2023).

Alternatively, fuelled vessels are also more capital intensive. For example, the cost of building a new liquified natural gas-powered-powered ship is estimated at around 10–20 per cent higher than a conventional ship (OECD, 2023). Similarly, additional expenditure involved in vessel dual fuel capability, which enables a ship to operate on both methanol and conventional low sulphur fuel, is in the range of 10–15 per cent of the total price, estimated at around $175 million (Frangoul, 2021). Similar values have been suggested with an ammonia dual-fuel vessel. Many of the existing, conventionally fuelled fleet could be retrofitted to ammonia or methanol dual-fuel use, with a similar total expenditure to a dual-fuel newbuild (Mærsk Mc-Kinney Møller Center, 2022).

It is important to understand and monitor the evolution of freight rates and associated costs, namely fuel surcharges, in the context of the energy transition. The precise formulas used to calculate the various surcharges applied in shipping, including fuel surcharges, are generally an issue of concern for shippers. Shippers argue that more clarity is required, and that evidence of cost-recovery as opposed to revenue generation is necessary for greater transparency and visibility.

With the energy transition in shipping is expected to accelerate in the coming years, the way in which alternative fuels will be priced and charged to carriers and, consequently, shippers and trade, will require attention. All relevant stakeholders should collaborate to devise suitable pricing mechanisms and avoid different and unfair practices and imbalances. Transparent, fair, and sustainable pricing will be key.

It will be important to understand how freight rates and the cost of new, low- or zero-carbon bunker fuels will be established and incorporated into the final costs. For example, a mechanism or framework could be developed to help define the basis used to determine the shipping rates and surcharges levels. This would help standardize the calculation of these rates and charges, enhance transparency and promote greater collaboration in shipping and trade.

Monitoring alternative fuel prices would also provide valuable data for assessing the economic implications of decarbonization efforts. This information can guide decision-making processes, inform regulatory efforts, and boost sustainable shipping practices.

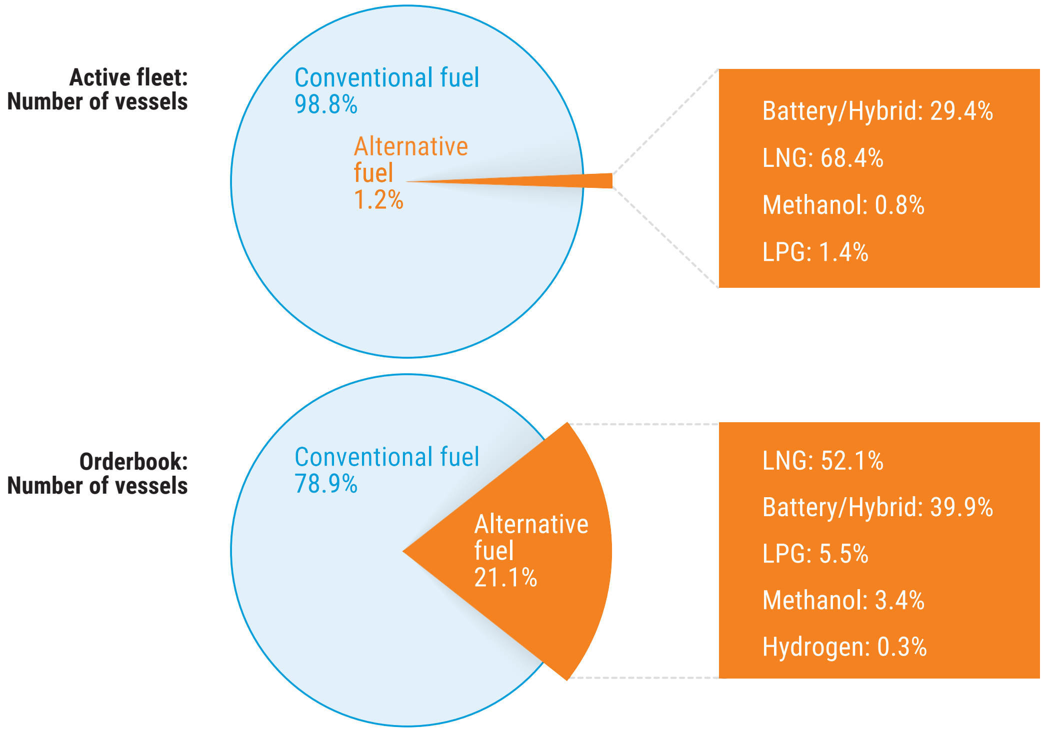
C. FUEL TRANSITION PATHWAYS

1. The fuel transition in shipping is still in its infancy, but progress is under way

While logistics, digitalization, hydrodynamics, machinery and “after treatment/carbon capture and storage” measures have a potential to curb GHG emissions from shipping by up to 30 per cent on average, the largest potential for deeper GHG emission cuts lies in a fuel switch to low- or zero-carbon fuels (DNV, 2022a). Shipping needs to replace fossil fuels with alternatives that do not emit GHGs across their entire life cycle (well-to-wake). At present, there is no readily available, one-size-fits-all solution. The pathway to decarbonization shows that zero emission fuels will need to make up 5 per cent of the international shipping fuel mix by 2030 (Osterkamp, Smith, Søgaard, 2021). The 2023 IMO GHG Strategy also includes a commitment to ensure an uptake of alternative zero and near-zero GHG fuels by 2030. The Strategy provides that uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources should represent at least 5 per cent, striving for 10 per cent of the energy used by international shipping by 2030.

The transition to alternative fuels is still in its infancy. A total of 98.8 per cent of the global fleet in terms of number of vessels use conventional fuels. Only 1.2 per cent are using alternative fuels, mainly liquified natural gas (LNG), and to a lesser extent, battery/hybrid, liquified petroleum gas (LPG), and methanol (figure 3.7).

Figure 3.7 Alternative fuel uptake, world active fleet and orderbook, number of vessels, 2022



Source: UNCTAD based on DNV (2022a).

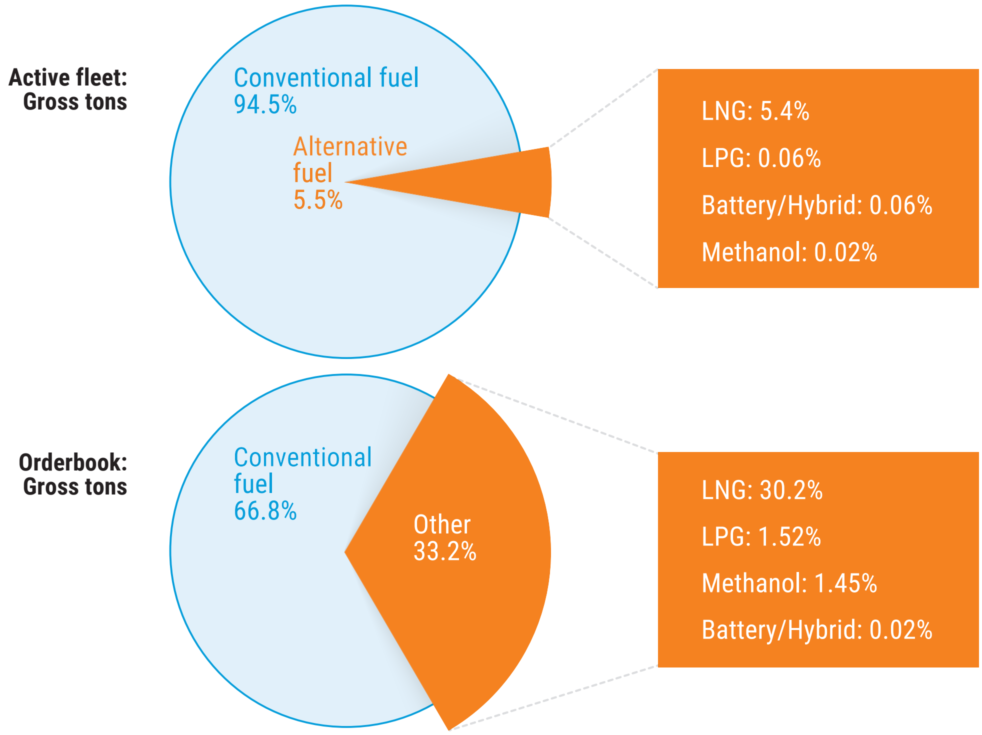
Technological readiness, scalability, and regulatory certainty are required to firm up demand for alternative fuels and vessels. Testing and demonstration, which allows for a solid proof of concept is important given the average age of the existing vessel fleet and the long lifespan of ships (25 to 30 years). In this context, the design of new vessels and engines needs to occur now to enable the deployment of zero-carbon vessels fuelled by alternative fuels. These vessels will still be in operation in 2050 (IRENA, 2021).

Shipowners need to decide whether to order more capacity and renew the fleet now while lacking clarity about the best alternative fuels and technologies or wait until the alternative fuel pathway and regulations are clearer. Fleet renewal needs, concerns over shipbuilding yard capacity and higher building prices are posing challenges for shipowners and complicate their investment decisions. The mid-term measure will come into force no earlier than 2027. Starting from that year, a portion of the fleet will be able to use these fuels and green technology options.

Depending on whether operators will seek to delay the delivery or cancel some new builds and whether speeds will fall due to IMO EEXI and CII requirements, effective supply remains uncertain. Compliance with these requirements will likely result in lower sailing speeds and alter the effective ship capacity supply. Meanwhile, trends in ship recycling can also affect effective supply. If, by 2027 all container ships aged 25+ are scrapped, annual fleet container capacity would expand by 4.6 per cent over the 2023–2027 period instead of 5.6 per cent if no scrapping is carried out. If, by 2027 all container vessels aged over 20 years old are scrapped, the fleet will expand at an annual 1.5 per cent over the same period (MDST, 2023). In this context, ambitious energy transition and decarbonization targets could cause a container capacity crunch. The supply will grow at a slower rate than both the long-term annual growth in container demand – 4.8 per cent for nearly three decades – and the annual growth of 2.5 per cent over the 2023–2027 period projected by UNCTAD (see chapter 1).

Despite the conundrum faced by shipowners, progress is under way as 21 per cent of vessels currently on order are designed to run on alternative fuels, notably LNG, LPG, battery/hybrid and methanol. In terms of active tonnage (figure 3.8), nearly 6 per cent of the active fleet is operating on alternative fuels, mainly LNG, while one-third of the tonnage on order is designed to run on alternative fuels (DNV, 2023a). It should be noted that while LNG may have a lower carbon footprint than heavy fuel oils, it remains a fossil fuel and faces problems such as methane slip and 'well-to-tank' emissions. As for batteries, these are more suited for use by vessels operating on shorter distances.

Figure 3.8 Alternative fuel uptake, world active fleet and orderbook in gross tons, 2022



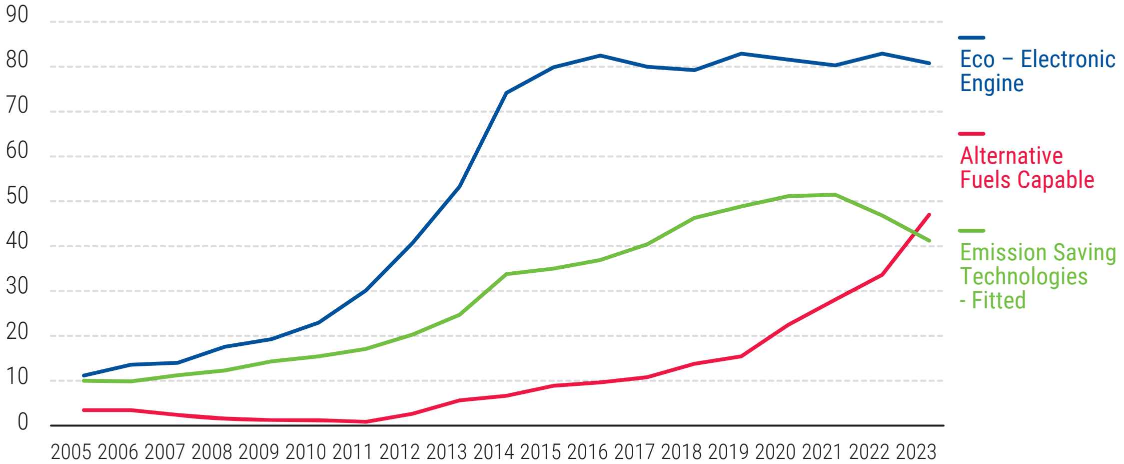
Source: UNCTAD based on DNV (2022a).

Alternative fuel capacity on order increased in recent years, particularly since the COVID-19 pandemic (figure 3.9). At the same time, vessels fitted with energy saving technologies and Eco ships with electronic engines also gained traction in recent years.

Alternative fuels, depending on the feedstock used and the specific production pathways involved, are often identified using colour codes. "Grey/black" and "brown" fuels are generated from fossil fuels. "Blue" fuels are sourced from fossil fuels, but carbon emitted during their production is captured and stored using carbon capture and storage from either direct air capture or point source. "Green" refers to fuels produced with electrolysis powered by renewable energy. Green fuels also include fuels produced from biomass sources. Table 3.2 offers an overview of alternative fuels by category and production pathways.

The alternative energy fuels most suited for international shipping are primarily advanced biofuels and e-fuels (i.e., synthetic fuels), namely methanol and ammonia. Each alternative energy fuel varies in terms of benefits and challenges. The choice of fuel depends on factors such as the supply chain, engine technology, environmental impacts and production costs (IRENA, 2021).

Figure 3.9 Trends in alternative fuels capable and energy saving technology fitted fleet, percentage of the orderbook and gross tons, 2005—2023



Source: UNCTAD calculations, based on data from Clarksons Research, June 2023.
Note: "Eco vessels" mean vessels with an electronic injection main engine.

Table 3.2 Overview of alternative fuels and their production pathways

Production pathway	Input/feedstock	Fuel produced
Electrolysis	Water and electricity	Hydrogen (electrolytic)
Natural gas extraction	Gas energy	Methane (natural gas)
Biogas production	Farm waste	Biogas
Biogas upgrading	Biogas	Methane (bio), CO_2
Steam methane reforming	Methane and water	Syngas
Synagas pressure swing absorption	Syngas	Hydrogen (blue or bio) and CO_2
Nitrogen separation (PSA or cryo)	Air	Nitrogen and oxygen (and other traces)
Haber Bosch process	Nitrogen, hydrogen and heat energy	Ammonia
Carbon capture (industrial)	Fuel gas	CO_2
Carbon capture (air)	Air and electricity	CO_2
Sabatier process	CO_2 and hydrogen	Methane (synthetic) and oxygen
Methane liquefaction	Methane (natural gas, bio) and electricity	LCH_4 (liquid methane)
Hydrogen liquefaction	Hydrogen and electricity	LH_2 (liquid hydrogen)
Ammonia liquefaction	Ammonia and electricity	LNH_3 (ammonia)
Liquid bio-fuels	Wastes, oils and crops	Hydrotreated vegetable oil, fatty acid methyl esters, etc.
Methanol synthesis	CO_2 and hydrogen	Methanol (synthetic)
Fischer- Tropsch	Hydrogen and CO_2	Blue crude, e-diesel
Hydrogen ICE (hydrogen internal combustion engine)	Hydrogen	Water (+ nitorgine oxides)
Hydrogen fuel cell	Hydrogen	Water
Methane ICE	Methane (+diesel)	CO_2+ NOx + CH_4 (methane)
Methanol ICE	Methanol (+diesel)	CO_2+ NOx
Ammonia ICE	Ammonia + diesel	CO_2+ NOx + NH_4 (ammonium) + N_2O (nitrous oxide)
Diesel ICE	Diesel	CO_2+ NOx

Source: UNCTAD, based on Ricardo and DNV (2022).

Ammonia is more attractive as it has zero carbon content when produced from renewable sources. It does not require capturing CO_2 emissions, which can increase the final cost of e-methanol (IRENA, 2021). Methanol is gaining attention while hydrogen, sail power, biofuels and other technologies are being explored, including batteries. Electric and hybrid propulsion systems relying on batteries or a combination of batteries and diesel or gas engines are also evolving, especially among small and coastal tonnage. Technology readiness levels of methanol fuel technologies are higher than for ammonia and hydrogen, while onboard fuel technologies for ammonia and hydrogen are not readily available. Although green ammonia is expected to have the lowest total cost of operation whilst achieving zero or near zero GHG emissions on a well-to-wake basis, safety and availability issues remain important barriers that need to be overcome before it can be used at scale.

Advanced biofuels are a viable short-term option for the shipping industry because current rules allow for fuel blends of up to 20 per cent without a change in engines. As methanol engines are a proven technology, new ships can easily rely entirely on biofuels. Renewable methanol such as bio-methanol and renewable e-methanol require little to no engine modification and can provide significant GHG emission reductions in comparison to conventional fuels. Renewable e-methanol is of particular interest in the shipping sector. While the production cost ranges for advanced biofuels are similar to the various alternatives, the sustainability of the biomass feedstocks used is a critical factor. The current focus is therefore on the use of waste fats, oils, and greases to produce biofuels that do not impact food security, and land availability. Other production options using other feedstocks are possible but not yet mature. The shipping sector will face competition for suitable feedstocks and fuels from other sectors, including road transport and aviation.

The current vessel orderbook suggests that, for now, LNG dual fuel remains the most popular choice, although methanol-capable ordering is becoming increasingly attractive. There have also been orders for LPG, ethane, and hydrogen capable vessels, while some ships ordered are set to be equipped with battery or battery-hybrid propulsion. Some owners are pursuing fuel optionality which allows for more flexibility, by ordering ships with LNG, methanol, or ammonia with the 'ready' notation or label attached (Clarksons Research, 2023). This ensures that ships ordered are propelled by an oil-based marine fuel but also fitted with the space to enable future fitting of a technology that enables the use of alternative fuels such as LNG, methanol or, later, ammonia.

LNG and LPG can offer a reduction in carbon intensity of 15–25 per cent (DNV, 2022b), although these numbers are lower if considering a well-to-wake GHG basis (Englert et al, 2021). LNG technology is well-developed, and bunkering infrastructure is currently expanding. LPG is also emerging as a fuel for ships with LPG infrastructure being well developed.

Alternative fuels must comply with the requirements of the International Convention for the Safety of Life at Sea (SOLAS) and MARPOL, including the International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code). There is also interest in using onboard carbon capture and storage with conventional fossil fuels. More pilot projects are needed to enhance the readiness of this technology.

Deploying alternative fuels on a large scale calls for a revamping of fuel production and distribution value chains. This involves stakeholders from within the shipping industry as well as the port, energy, and finance sectors, among others. It also requires policy and regulations to move rapidly to stimulate demand for these fuels; this will encourage industry to invest in required ships and fuels.

One estimate suggests that achieving full decarbonization by 2050 requires the fuel infrastructure to deliver around 270 million tons of the heavy fuel oil equivalent of alternative fuels (DNV, 2022a). Switching to alternative fuels requires investments in the fuel infrastructure that will outpace onboard vessel investments. As the development of alternative low- or zero-carbon fuels is mainly in the hands of out-of-sector stakeholders (fuel producers and suppliers, engine manufacturers, shipyards etc.), collaboration across the wide-ranging stakeholders from inside and outside the shipping sector is crucial.

Decarbonizing shipping requires major investments: just halving shipping emissions by 2050 may require $1.4 trillion in investment ((Krantz R, Søgaard K, Smith T, 2020). Existing estimates indicate that additional investments of $8 billion to $28 billion are required annually by ships to decarbonize by 2050. About $28 billion to $90 billion are needed annually onshore to scale up production, fuel distribution, and bunkering infrastructure to supply the totality of carbon-neutral fuels by 2050. The more expensive energy sources and onshore investments could increase annual fuel costs by over $100 billion to $150 billion when fully decarbonized or incur a 70 per cent to 100 per cent increase from today (DNV, 2022a).

There is a need to progressively but rapidly replace fossil fuels with renewable fuels. The energy transition must move beyond the current infancy stage and the search for alternative fuel must move beyond the exploration and testing phase in favour of large-scale deployment, availability and adequate supply of alternative and safe fuels.

The timescales and targets of the revised IMO GHG strategy imply that the majority of the sector's energy transition must happen by 2040. Additionally, it is critically important to ensure that the requisite regulatory technological and safety maturity and readiness levels are in place. Furthermore, as ports and terminals face the same uncertainty and dilemma as shipowners regarding future fuels and regulatory requirements, efforts should aim to speed up the transition and enable timely investment in port cargo handling equipment, infrastructure/storage facilities and replace or construct new terminals.

2. Clarifying the transition pathway key to addressing barriers to alternative fuels and technologies

Some of the key factors currently hindering a rapid shipping energy transition and decarbonization include alternative fuel availability and costs, fuel technology maturation levels, technical feasibility, safety, bunkering infrastructure requirements and onboard storage, not to mention implications for ship and engine design and crew skills and capabilities.

Shipping cannot decarbonize on its own. It requires action across the entire ecosystem, involving shipping and the energy sector. This collaboration should include carriers, port and terminal operators, manufacturers, shippers, investors, energy producers and distributors to drive the necessary change. Ports are positioning themselves to take a more active role in enabling the energy transition and decarbonization in the maritime supply chain (box 3.1). They are increasingly aligning their activities with global policy processes on sustainable development and climate action (box 3.2).

Box 3.1 Port of Antwerp-Bruges aims to become a green energy hub and climate neutral by 2050

The Port of Antwerp-Bruges, Belgium aims to become climate neutral by 2050. This requires a switch to green energy strategically focused on:

1. Production and supply, by drawing on renewable energy sources, including imports, and local hydrogen production. This is for energy and feedstock purposes.

2. Provision of infrastructure for fuel distribution by adding to the extensive facilities already available to support alternative fuels.

3. Consumption in port (bunkering) and transport to end users in the hinterland such as local chemical plants.

Hydrogen, ammonia, and methanol are already being traded today. The chemical industry uses these products in large quantities when refining or producing chemicals. The market for green hydrogen and derivatives is growing rapidly for use as feedstock, in heat production and heavy transport.

As the second largest bunkering port in Europe, the bunker market in the Port of Antwerp-Bruges is still mainly based on conventional shipping fuels. Alternative fuels for shipping are already offered on a small scale, in addition to conventional fuels. The Port of Antwerp-Bruges is strengthening its position as a bunkering port on a global scale by actively promoting the use of alternative fuels. The strategic objective is to become a multifuel port by building a framework that enables safe bunkering and use of alternative fuels on a large scale and to establish alternative fuels within the local bunker market. Alternative fuels include methanol, ammonia, hydrogen gas, LNG, and electrical energy.

Given its specific properties in comparison with fuel oil, much attention has been paid to LNG and its use as a fuel by government authorities, classification companies, shipping operators and ports over the last decade. The International Association of Ports and Harbors has developed an audit tool that can be used by ports to award permits to bunkering companies in accordance with the highest industry standards, as well as a bunker checklist that many ports around the world have incorporated into their port regulations. This tool is being extended to zero carbon fuels. Following detailed risk analyses, it was determined where and under what conditions LNG may be bunkered in the port of Antwerp-Bruges. The result is the LNG Bunkering Map. Considering this development, the port has established basic principles that can also be applied to other alternative fuels.

Source: Input received from the Port of Antwerp-Bruges, June 2023.

Box 3.2 The Port of Las Palmas shows commitment to environmental sustainability

The Port of Las Palmas, Spain, situated in the Canary Islands archipelago, holds a crucial position in the maritime routes connecting Europe, West Africa, and Latin America. The port has aligned its operations with the Sustainable Development Goals and its sustainability strategies are in line with the goals of Spain and the European Union, as defined within the Strategic Framework of State Ports.

The Port Authority of Las Palmas (the governing body of the ports of Las Palmas, Salinetas, Arinaga, Puerto del Rosario, and Arrecife) has established four key environmental commitments:

1. Implement control and prevention systems related to quality of port waters, atmospheric pollution, noise pollution, exotic species, waste generated by ships, sanitation networks and early detection of the presence of hydrocarbons in port waters.

2. React to and contain crises by establishing Internal Maritime Plans along with actions for combating pollution, promoting regular interisland traffic, traceability of MARPOL waste discharges, and initiatives that reduce the carbon footprint of Port Authority facilities.

3. Promote research into sustainability by facilitating alliances with organizations and scientific institutions such as the Spanish Seaweed Bank, the University of Las Palmas de Gran Canaria, the University of Oviedo, the Clean Landscape Association, State Ports and the Cabildo de Gran Canaria, resulting in projects such as the floating garden of algae, which absorbs CO_2.

4. Promote environmental industry projects, such as the ones hosted by the Port of Arinaga, or the ones focusing on delimiting maritime areas off its coasts for the exploitation of offshore wind energy or approving maritime space management plans.

In addition, the Port of Las Palmas is facilitating new infrastructure projects, such as the Prolongación Dique de la Esfinge which focuses on technical parameters that can forecast increases in sea level and its effect on port operations.

Source: Input received from the Port of Las Palmas, June 2023.

The role of ports is recognized in the Clydebank Declaration of the Conference of the Parties 26 (COP26), which pledges to establish green shipping corridors, i.e., routes that leverage collaboration across multiple stakeholders operating between two or more ports. The aim is to offer bunkering options for vessels running on low or zero carbon fuels, test various solutions and support first movers in their efforts. Ports should not only offer bunkering options for low/zero carbon vessels, but also run on zero-emissions equipment themselves to ensure truly green corridors. Since the signing of the Clydebank Declaration, 21 green shipping corridor initiatives have emerged (Global Maritime Forum, 2022). More than 110 stakeholders from across the value chain are engaged in these initiatives, with a high level of public–private collaboration.

Translating the green corridor concept into concrete action requires assessing the feasibility of such corridors. These corridors can help to reduce the costs of zero-emission fuels, enable the mobilization of demand, and lower risks to incentivize stakeholder investment (McKinsey, 2022). Experiences with green shipping corridors will vary by region and will entail both challenges and opportunities (box 3.3).

Most initiatives are still at an early stage and corridors currently considered are in the feasibility study phase (Global Maritime Forum, 2022). Going forward, it will be important to clarify whether the corridor projects will morph into a lasting solution once the demonstration phase is completed (Hubatova, 2022). It will also be important to revisit the concept and ensure more inclusiveness in terms of vessel types, shipping routes and geographic distribution.

Box 3.3 Promoting low- and zero-emissions shipping in Asia and the Pacific

A recent study by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) on the Implementation Strategy of the Green Shipping Corridor in Asia and the Pacific provides an overview of green shipping corridor initiatives worldwide. The study highlights that one of the main challenges in successfully implementing these corridors includes helping shipping companies to build zero-emission ships and run their fleets competitively, as well as ensuring that sufficient green energy and fuels can be produced and deployed along the shipping routes.

The study also identifies key success factors, which span government leadership, infrastructure, governance, legal system and involving stakeholders along the supply chain. Particularly important is the incentivization of the green corridors though funding from major stakeholders and monetary and non-monetary incentives. Innovative financing schemes are especially needed, as these

Box 3.3 Promoting low- and zero-emissions shipping in Asia and the Pacific *(cont.)*

corridors come with much higher operating and capital costs than conventional shipping. Finally, on the operational side, the economies of scale and density that prevail across longer corridors with more frequent shipping services and involving larger vessels allow for better decarbonization performance.

Stakeholders participating in green shipping corridors in Asia and the Pacific face various challenges, notably, lack of awareness and insufficient infrastructure for green shipping such as green energy bunkering facilities or green energy plants. The study underscores the links between green shipping corridors and digitalization. It demonstrates how digitalization could further promote shipping decarbonization, enable seamless cargo, and ship traffic along the green shipping corridors.

Source: ESCAP (2023).

3. Digitalization can enable decarbonization

All available options to reach net-zero GHG emissions should be pursued. Exploiting the full potential of digital tools for energy-saving in shipping should also be pursued. Energy-efficient technologies can deliver up to 15 per cent of the GHG emission savings required by 2050 (DNV, 2022a). Thus, in tandem with the fuel switch, technology should be leveraged for greater energy efficiency gains.

Digitalization and decarbonization are both transformative forces in shipping. In many ways, digitalization enables decarbonization. Combined, digitalization and technology can help unlock energy-efficiency potential and support the collaboration needed to accelerate the transition. Various digital tools can be used to provide digital-enabled optimization and reduce emissions in shipping.

Applying technologies such as blockchain, machine learning, artificial intelligence, Internet of things, and performance optimization platforms (e.g., monitoring, routing, speed, predictive maintenance, crew training), and “digital twin” applications can all help accelerate decarbonization. In a digital ecosystem, vessels can integrate applications and data models and leverage digital tools to unlock the power of advanced predictive analysis, including for operations and maintenance. The digital twin combines all available information and models of a ship throughout its life cycle. It allows a range of useful operations to be performed and simulated, such as system design, assurance and verification services, simulator-based testing, virtual system integration and to generate predictions (Smogeli, 2017).

Ships can use speed optimization and weather-routing services to plan routes around weather forecasts. An AI-enabled fuel model, incorporating a ship’s digital twin, enables ships to accurately predict fuel consumption. Technology can be used to measure the efficiency of elements such as the hull, the propeller, the boiler, and the auxiliary engine, leading to improved performance (Stone, 2023).

When applied in a port environment, the digital twin can reduce GHG emissions and support efficiency, productivity, energy saving. Port call optimization (see chapter 4) can help support energy efficiency and fuel saving by enabling better access to data and improved synchronization of ship arrival in ports (McLeman, 2023). Other technologies such as exhaust gas savers, propeller efficiency equipment, bow enhancement, hull fins and air lubrication systems are also becoming popular, as they enable energy efficiency gains.

Despite the potential for technological advances and innovation to help maritime transport curb emissions, it should be emphasized that leveraging technology should also adopt a full life cycle perspective and prevent carbon leakage. The recent boom in the use of AI has raised concerns over the emission impact of the servers that power AI. One estimate suggests that AI language models and data centres are estimated to account for 1 per cent of global carbon emissions (Biggs, 2023). Another estimate expects that by 2040, server farms may account for 14 per cent of global carbon emissions (Auslender and Ashkenazi, 2023).

4. Successful shipping decarbonization and energy transition requires a level playing field

For shipping to succeed in decarbonizing and help prevent dangerous levels of global warming, the sector needs to act swiftly. The sector must also reach consensus regarding the regulatory framework and measures of the future as soon as possible.

The shipping industry requires a clear, uniform, and predictable operating landscape with minimum regulatory uncertainty. Delaying the adoption of IMO mid-term or long-term measures aimed at managing shipping GHG emissions will jeopardize decarbonization targets. It could also result in different tiers of overlapping regulations at multinational, national and regional levels and regional tiers of compliance such as specific green corridors or exemptions. Additionally, it may pave the way to regional pockets of unsustainable and substandard shipping.

If a GHG mitigation policy (e.g., fuel standards or an economic measure) is implemented regionally or is designed with many shipping and trade route exemptions, there is a high risk of carbon leakage and excessive tax base erosion. Ships could alter their route to evade the system and/or refuel outside its jurisdiction. One study has suggested that in the case of the European Union ETS, transshipment hubs could relocate from the European Union to non-European Union ports to avoid paying into ETS (Lagouvardou and Psaraftis, 2022).

Delaying action will also generate more costs and undermine the legal certainty required to incentivize prompt action and investment in low or zero carbon ships, fuels, and bunkering infrastructure. While many estimates underscore the magnitude of damages and losses that may result from unchecked global warming, Oxford Economics (2022) finds that 2.2°C of warming by 2050 has the potential to reduce global GDP levels by up to 20 per cent.

Given the globalized nature of international shipping, fragmented solutions that favour exemptions and differentiated rules can lead to sub-optimal outcomes. A universal regulatory framework for decarbonization that applies to all ships irrespective of their flags, country of ownership and region of activity is critical to ensure a level-playing field and avoid a two-speed decarbonization shipping landscape. For developing countries, a multilateral solution adopted under the auspices of IMO, which considers the special needs for assistance of the most vulnerable economies such as SIDS and LDCs, will provide a workable outcome and avoid fragmented regional and unilateral approaches. Fragmentation increases uncertainty, undermines the level playing field and distorts markets while jeopardizing the achievement of climate targets due to, among other factors, lack of incentives, carbon leakages, compliance evasion, etc.

The flag of registration of most ships differs from the nationality of their owners, and international trade typically involves two or more countries. In principle, ships that trade internationally must comply with the same rules when it comes to reducing GHG emissions. That said, there is a need to recognize the importance of the common but differentiated responsibilities and respective capabilities principle, to reflect the special requirements of the most vulnerable economies and consider the impact of climate change mitigation measures on these States. Economic elements such as a levy or a contribution that has to be paid when fuel emits GHGs can incentivize investment and action by making alternative fuels more competitive. This can be done by narrowing the cost differential with conventional heavy fuels, as well as through the targeted use of the revenues arising from these levies and contributions.

The proposed midterm measures of IMO are expected to generate funds that could support the maritime sector's decarbonization efforts. Some of the funds generated by these measures could assist developing countries impacted by potential increases in maritime logistics costs. They could also help them enhance the resilience of their critical port infrastructure to the impacts of climate change and seize the business opportunities arising from the energy transition and decarbonization in shipping. Some of the funds generated could be invested in developing countries, including SIDS and LDCs, to mitigate transition costs or reduce trade costs, thanks to trade and transport facilitation intervention measures in ports and hinterland connections. As complying with the new IMO requirements entails administrative costs, funds generated could also help bridge these costs.

Proceeds from the economic measures could also be leveraged to tap into emerging business opportunities arising from alternative fuel production, storage, bunkering and distribution. Ultimately, the potential economic measures can help achieve the twin objective of decarbonizing shipping while ensuring a just and equitable energy transition.

D. OUTLOOK AND POLICY RECOMMENDATIONS

1. Outlook

Important progress made at the MEPC 80 held in July 2023 at IMO, has helped clarify the pace of the fuel transition. Still, the future low and zero carbon fuel mix is yet to be decided and rapid progress at IMO regarding the particular targets and regulations needed to reach decarbonization goals, is essential.

Soon, energy production and associated fuel bunkering systems will need to change considerably to offer the fuels of the future. The uncertainty surrounding the adoption of green technologies and alternative fuels, as well as the regulatory framework, is increasing the risk of stranded assets. However, as the deployment experience of key candidate fuels improves throughout this decade, this uncertainty should gradually resolve into clarity. However, the real danger in striving for decarbonization targets at the lowest possible cost, is for shipowners to adopt a "wait and see" policy. This means they will delay investment in fleet renewal, alternative fuels, and green technologies for ships. As the shift to low-carbon fuels and technologies requires significant investments onboard and onshore, delaying the timing and scale of investments, both in newbuildings and the energy supply chain, can lead to ship capacity bottlenecks, supply chain disruptions and increased costs for shipping and trade.

Fuel costs account for a significant part of vessel operating expenses, and the transition to alternative low or zero GHG fuels is likely to generate additional costs. Added expenses will likely be passed on to shippers and consumers via increased freight rates and surcharges. It will be important to improve understanding of how freight rates and the cost of new, low or zero GHG bunker fuels will be established and incorporated into the final ship operating costs and shipping rates.

Ships call at ports in many countries, cross different national and international waters, and operate in an international environment. As such, decarbonizing international maritime transport will require a global perspective. Given the resources required to implement IMO regulations whilst avoiding disproportionate increases in costs, including maritime logistics costs for the most vulnerable economies, it will be necessary to provide technical and financial assistance to these countries. An economic measure agreed under the auspices of IMO could generate funding for such assistance.

2. Policy recommendations

To accelerate the energy transition in shipping and achieve the GHG emission targets of IMO, robust collaboration is required among all stakeholders. These include Governments, policy makers, shipping and ports, as well as energy suppliers and lending institutions, among others. Some key priority actions, including the following:

Facilitate the fuel transition and enable a level playing field

- Develop regulations and set clear targets for the use of zero and near-zero GHG fuels in the shipping industry. Encourage carriers to adopt the associated energy sources, vessels, operational practices, and technologies.
- Support research, development and deployment initiatives promoting innovative and sustainable technologies for shipping, including fuel-efficient engines, alternative and renewable energy, and emission reduction technologies. Stimulate the supply of zero and low carbon fuels for international shipping.
- Prepare for shipping fleets that simultaneously run on more than one fuel type and promote optionality through dual-fuel and tri-fuel designs.
- Gather the low hanging fruit by leveraging technologies in shipping that improve operational efficiency, fuel saving and energy efficiency and promote digital solutions that accelerate shipping decarbonization.
- Build partnerships between Governments, academia, and industry stakeholders to foster knowledge sharing and collaboration; scale up efforts to implement sustainable and resilient shipping.
- Promote sustainable facilities at ports, clean energy marine hubs and green shipping corridors that are more geographically, vessel and commodity inclusive.
- Ensure stakeholders in seaports collaborate widely across the port ecosystem with fuel suppliers to ensure a sufficient supply of alternative low and zero GHG fuels and infrastructure for distribution.

- Assess the readiness of the alternative fuels and vessel designs, the sustainability and scalability of potential solutions and their regulatory and safety maturity levels.
- Governments, academia, and public- and private-sector organizations should analyse the upstream footprint of alternative fuel production for shipping, including the GHG life cycle of the different fuels, as well as their full potential and production limits (e.g., biofuels).
- Ensure that international rules enable a level playing field and promote measures to lower the cost or price gap between alternative and conventional marine fuels.
- Create certainty regarding the volume of low and zero carbon fuels and energy that will be needed at different points in time, through technical measures such as a fuel standard.
- Consider economic measures such as a levy that acts as a price for carbon to support the energy transition and incentivise investment in alternative fuels and green technologies for ships.

Monitor impacts of the energy transition and decarbonization in shipping on costs, trade, and economic output

- Monitor alternative fuel prices to help generate data for assessing the economic implications of decarbonization efforts. This information can guide decision-making processes, inform regulatory efforts, and boost sustainable, fair, and transparent shipping practices.
- Establish an advisory mechanism to guide the setting of freight rates and fuel surcharges. Communicate and monitor trends in freight costs and fuel surcharges. The advisory mechanism should bring together shipping, trade and relevant stakeholders in the maritime supply chain, including government and regulatory bodies. It could, for example, set guidelines on how to determine low and zero carbon fuel prices, freight rates and surcharges. This will help ensure transparency, an inclusive operational environment and enable a smooth decarbonization process. International organizations such as UNCTAD and IMO could provide support in this regard.

Align the regulatory framework in shipping with internationally agreed goals

- Targets for usage of low and zero carbon fuels in the shipping industry are needed to ensure progress on global climate mitigation objectives set out in the Paris Agreement.
- A strong regulatory framework for shipping to reduce GHG emissions and protect the environment should align with the 2030 Agenda for Sustainable Development.
- The regulatory framework should also ensure an equitable transition. In this regard, economic measures such as a carbon levy can help make alternative fuels competitive vis-à-vis GHG-generating traditional fuels and alleviate the transition costs in many developing countries. Support fleet renewal and avoid a capacity crunch in shipping.
- National and international regulations should minimize uncertainty, which prevents shipowners' timely investment in a new and modern fleet that runs on low or zero carbon fuels and which delays the introduction of onboard and onshore energy saving and green technologies.
- Monitor trends in ship finance for both fleet renewal and green investment and scale up ship financing and investment levels.
- Monitor trends in shipbuilding capacity to ensure a timely energy transition for shipping decarbonization.
- Ensure that crews are adequately trained in the use of alternative fuels and related shipboard systems.

Support developing countries particularly small island developing States and the least developed countries during the transition

- Continue to assess the impacts of the decarbonization of international shipping on the most vulnerable economies, who already pay higher shipping costs and depend heavily on maritime transport for their trade, consumption needs and economic development.
- Provide technical and financial support to countries where maritime logistics costs increase due to shipping decarbonization. Support could include investing in port infrastructure and services, implementing trade facilitation measures, and taking up ship and port technologies and digital tools, as well as providing capacity-building for national maritime, port and competition authorities.

- Provide support to developing countries grappling with higher maritime logistics costs. The economic component of the proposed IMO midterm measures such as levies on bunker fuels or carbon could generate funds to scale up decarbonization efforts. These funds could partly be channelled to support investment for SIDS and LDCs in ports, including investment in enhancing the resilience of their critical port infrastructure to the impacts of climate change and seizing business opportunities relating to the energy transition. Support to developing countries could also aim to promote trade and transport reforms, as well as transport and digital connectivity.

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END NOTES

1 195 out of the 198 Parties to the United Nations Framework Convention on Climate Change (UNFCCC) 1992 adhere to the 2015 Paris Agreement which has been in force internationally since 4 November 2016. With international shipping emissions deeply integrated into countries' economies, a recent legal analysis concludes that emissions from international shipping should be included in government climate targets under the Paris Agreement (Transport and Environment, 2021).

2 "Well-to-wake" refers to the entire process of fuel production, delivery and use on board ships, and all emissions produced therein. An important related argument is that using alternative fuels in shipping will only bring climate benefits if they are produced sustainably. Any regulation of international shipping which encourages the sector to switch fuels must examine the full life cycle of the fuels to control the impact (TradeWinds, 2023b).

3 See in particular, ISWG-GHG 14/2 -14/2/12, ISWG-GHG 15/2 -15/2/11, ISWG-GHG 15/INF.2, ISWG-SP 1/2/1, MEPC 80/7/8 and 80/7/11. For a mapping of the various proposals on the draft Revised GHG Strategy, submitted to ISWG-GHG 14, see IMO, 2023d.

4 According to a European Union press release, "the new regulation will be published in the official journal of the European Union after the summer and will enter into force the twentieth day after this publication. The new rules will apply from 1 January 2025, apart from articles 8 and 9 which will apply from 31 August 2024" (see European Council, 2023).