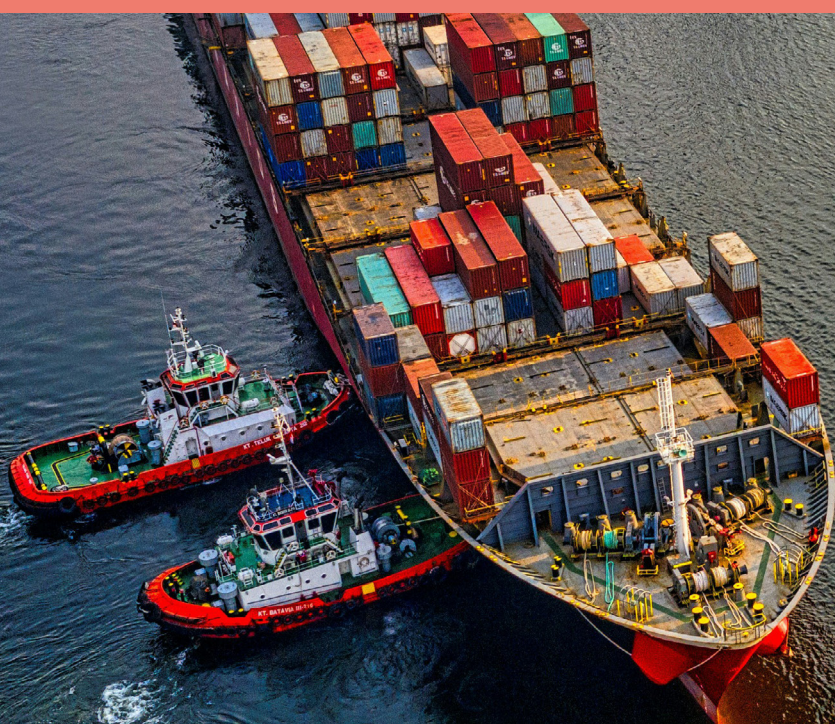
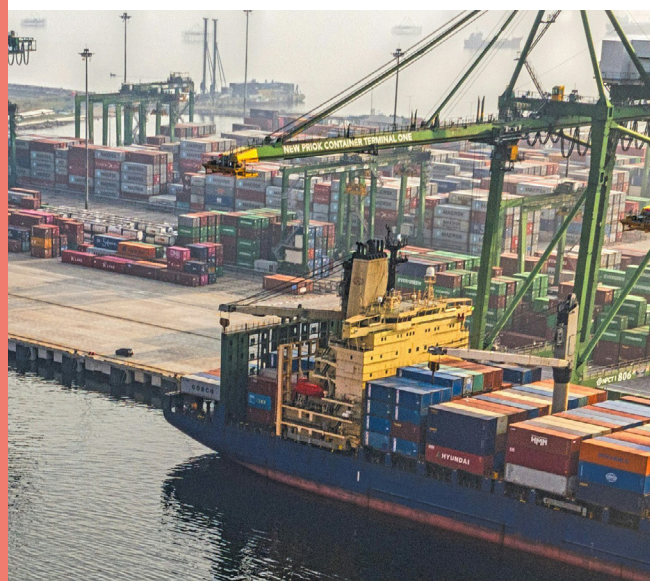




Shipping

Trade, Climate, and Net Zero Pathways: Scenarios and Implications for Developing Countries and Climate- Resilient Development

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About TESS

The Forum on Trade, Environment, & the SDGs (TESS) works to support a global trading system that effectively addresses global environmental crises and advances the sustainable development goals. To foster inclusive international cooperation and action on trade and sustainability, our activities seek to catalyse inclusive, evidence-based, and solutions-oriented dialogue and policymaking, connect the dots between policy communities, provide thought leadership on priorities and policy options, and inspire governments and stakeholders to take meaningful action. TESS is housed at the Geneva Graduate Institute.

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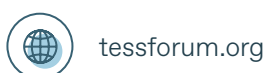
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About This Series of Sectoral Briefing Notes

This briefing note is part of a series of sectoral notes commissioned by TESS intended to inform a final report on *Trade and climate scenarios on the road to 2050: Implications for developing countries and climate-resilient development*.

The series and the report aim to provide an overview of current and anticipated transformations in trade on the road to 2050 in the context of the unfolding climate crisis and the international community's climate action agenda and to discuss potential scenarios and implications for developing countries.

A wider objective of the series is to contribute to a better understanding of emerging trade and trade policy trends and dynamics and their implications within the various sectors, with a focus on supporting developing countries in identifying and advancing their climate change trade-related interests and priorities in international discussions.

The sectors covered in the series include agriculture, border carbon adjustments, carbon markets, critical minerals, digital trade, fisheries, energy, heavy industries, renewable energy, textiles, tourism, and transport, each authored by experts in these respective fields.

Abbreviations

| | |
|--------|---|
| GDP | Gross Domestic Product |
| GHG | Greenhouse Gas |
| IMO | International Maritime Organization |
| LDC | Least Developed Country |
| IRENA | International Renewable Energy Agency |
| MEPC | Marine Environment Protection Committee |
| SIDS | Small Island Developing States |
| SZEF | Scalable Zero-Emission Fuels |
| UN | United Nations |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNCTAD | UN Trade and Development |
| VLSFO | Very Low Sulphur Fuel Oil |
| WTO | World Trade Organization |

1. Shipping and the Trade, Climate, and Sustainable Development Nexus

Shipping plays a key role in our globally interconnected economy, transporting close to 90% of internationally traded goods (Harrison et al., 2024). The sector accounts for about 3% of global greenhouse gas (GHG) emissions, which, if it were a country, would place it as the world's sixth largest emitter between Germany and Japan (Bullock et al., 2020).

Developing economies account for the majority of global seaborne trade, albeit with significant geographical variance. In 2021, Asian developing countries alone discharged 50% and loaded 35% of the world's total cargo (UNCTAD, 2023a). Singapore, the United States, the United Arab Emirates, the Netherlands, Russia, the Republic of Korea, and China account for the biggest portions of international shipping bunkering (IRENA, 2021). Container shipping is responsible for over a quarter of international shipping's energy consumption and bulk carriers for just under a quarter. The remaining 50% comes from oil, liquefied natural gas, and chemical tankers, among others (IRENA, 2021).

Maritime trade volume is expected to grow at a slow pace (UNCTAD, 2023b), and although shipping still relies on an ageing fleet that uses highly polluting fossil fuels, it remains the most carbon-efficient method of transporting goods over long distances (Harrison et al., 2024). The legacy of the Covid-19 pandemic and disruptions to trade and supply chains resulting from geopolitical tensions raise many challenges, with major uncertainties for shipping on its path to decarbonize (IRENA, 2021). Efforts have been made to reduce the sulphur content in marine fuels (IMO, 2020). While such efforts give rise to other issues in the near future (Carbon Brief, 2023), they indicate the potential for

regulation to reduce harmful GHGs. However, much more is needed to shift and define the sector's pathway to net zero across GHGs as a whole.

The global regulator for shipping, the International Maritime Organization (IMO), set clear targets for the sector's full decarbonization by 2050 in its 2023 GHG reduction strategy (IMO, 2023a). Concrete measures—both economic and technical—for delivering on this strategy are expected to be approved in April 2025. They are likely to shape the shipping industry for decades and influence global trade patterns, with implications for all nations, particularly developing countries, least developed countries (LDCs), and small island developing states (SIDS).

Full decarbonization of the sector by 2050 will require huge investments and is expected to lead to higher maritime logistics costs, raising concerns for vulnerable, shipping-reliant nations like SIDS. Notably, UNCTAD (2023b) has outlined how developing countries, LDCs, and SIDS may experience higher domestic inflationary pressures due to limited capacities to mitigate the pass-through effects of energy transition costs in shipping and the associated increase in maritime logistics costs.

Although the interplay between trade and climate change mitigation efforts has gathered some attention in recent years, crucial elements of the trade, climate, and shipping interface have remained largely unexplored. This briefing note examines some of these interactions, with a specific focus on the regulation of shipping's GHG emissions following the revised IMO (2023a) reduction strategy, including implications and considerations for developing countries.

2. Climate Action and Impact Scenarios in Industry Sectors: The Road to 2050

Global Policy Framework

Unlike many economic sectors, international shipping is not included in the Paris Agreement adopted under the United Nations Framework Convention on Climate Change (UNFCCC). Shipping's decarbonization trajectory is set by its global regulatory body, the IMO, which is a specialized UN agency.

In 2023, IMO members agreed on a new GHG strategy that set an end date for fossil fuel consumption by targeting net-zero GHG emissions "by or around, i.e. close to, 2050," with indicative emission reduction targets for 2030 and 2040 (IMO, 2023). A key additional target for 2030, endorsed in 2021 by the Getting to Zero Coalition and since adopted by the IMO, is the breakthrough target of 5% uptake of zero and near-zero emission fuels, with a stretch goal of 10%.¹ This target underscores the importance of early action and is a critical indicator of the sector's progress towards meeting global climate goals. While the ambitions set out in the IMO's strategy are not fully aligned with the Paris Agreement's goals, it calls on members to pursue efforts towards these goals.²

The IMO's revised GHG reduction strategy initiated the development of a so-called "basket of mid-term measures" that includes two categories: technical measures (or direct regulatory approach) and economic measures. Technical measures such as a global fuel standard mandate progressive reductions in fuel or energy GHG intensity over time, supporting the energy transition by setting clear requirements and a more predictable emissions reduction pathway.

Economic measures aim to financially incentivize member states, shipping companies, and other stakeholders to align with the IMO's overarching goals,

which include safety, security, and sustainability. Such measures could include market-based instruments, financial support mechanisms, or funding for research and development.

Economic measures can create two different types of incentives for the energy transition:

- When acting on GHG prices, they can increase the cost of higher GHG intensity fuels and thus increase the competitiveness of more expensive lower GHG intensity fuels.
- When acting on GHG prices in combination with revenue disbursement mechanisms, they can also function as a fuel/energy subsidy to stimulate the early uptake of scalable zero-emission fuels (SZEf).

Several policy measures and combinations thereof are currently under discussion at the IMO. Proposals include a global GHG levy, which imposes a fixed cost on emissions; a fuel intensity target with a funding and reward mechanism that incentivizes greener practices; and feebate systems, which penalize high-emission ships while rewarding those with low emissions.

The global nature of the shipping industry underpins the need for a fully global transition towards zero-emission goals, a level playing field, and the adoption of measures that facilitate a just and equitable transition, as stipulated in the IMO's 2023 GHG reduction strategy. To support such a transition, the strategy underscores the importance of financial assistance, technology transfer, and capacity building for developing countries, particularly LDCs and SIDS.

However, achieving equity in the transition poses several challenges. Many LDCs and SIDS rely heavily on

1. The target was identified by the UN High Level Climate Champions and the Global Maritime Forum. The Getting to Zero Coalition is an alliance of more than 200 organizations in the maritime, energy, infrastructure, and finance sectors (Global Maritime Forum, n.d.).

2. The Paris Agreement seeks to strengthen the global response to the threat of climate change by keeping global temperature rise to well below 2°C above pre-industrial levels by 2100 and to pursue efforts to limit temperature rise to 1.5°C.

maritime trade and lack the financial capacity to meet stricter regulatory requirements or invest in advanced technologies. Without adequate support, these nations could face disproportionate economic burdens, such as increased shipping costs that affect their imports and exports. Additionally, access to new low-carbon technologies and fuels often remains limited in developing regions. Ensuring inclusive decision-making processes and providing targeted financial mechanisms, such as reinvesting revenues from levies into developing country infrastructure and training programmes, will be essential to addressing these disparities and enabling a fair, inclusive, and just transition.

The potential impacts of different measures on countries and the global fleet are currently being assessed. A combination of measures is expected to enter into force in 2027 at the earliest. This means that the strategy alone will have a limited effect on unlocking private sector investments before the second half of this decade. Investment decisions must therefore be made before then (Global Maritime Forum, 2023b).

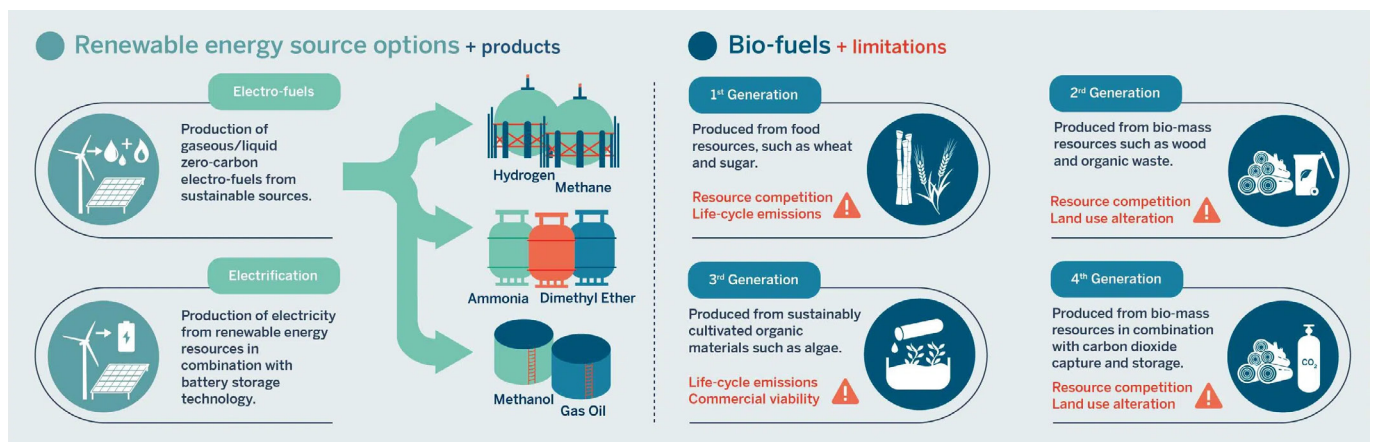
Technology and Fuel Deployment

A wide range of technologies can help reduce GHG emissions from shipping. Short-sea or domestic ships can

be suitable for electrification in certain circumstances, while fuels that support a low-carbon transition include electrofuels (e-fuels), such as hydrogen, methanol, and ammonia, and biofuels (see Figure 1). Variations in production methods among these fuels result in differing carbon intensities and other environmental impacts. For example, blue hydrogen is produced from fossil fuels (like natural gas), but carbon capture and storage technologies limit the carbon intensity of the process, whereas green hydrogen is produced using renewables and does not emit any carbon. Other technologies include wind-assisted propulsion, which can reduce fuel needs, as well as batteries and nuclear power. Improving the energy efficiency of vessels and digitalizing key processes also contribute to fuel reductions.

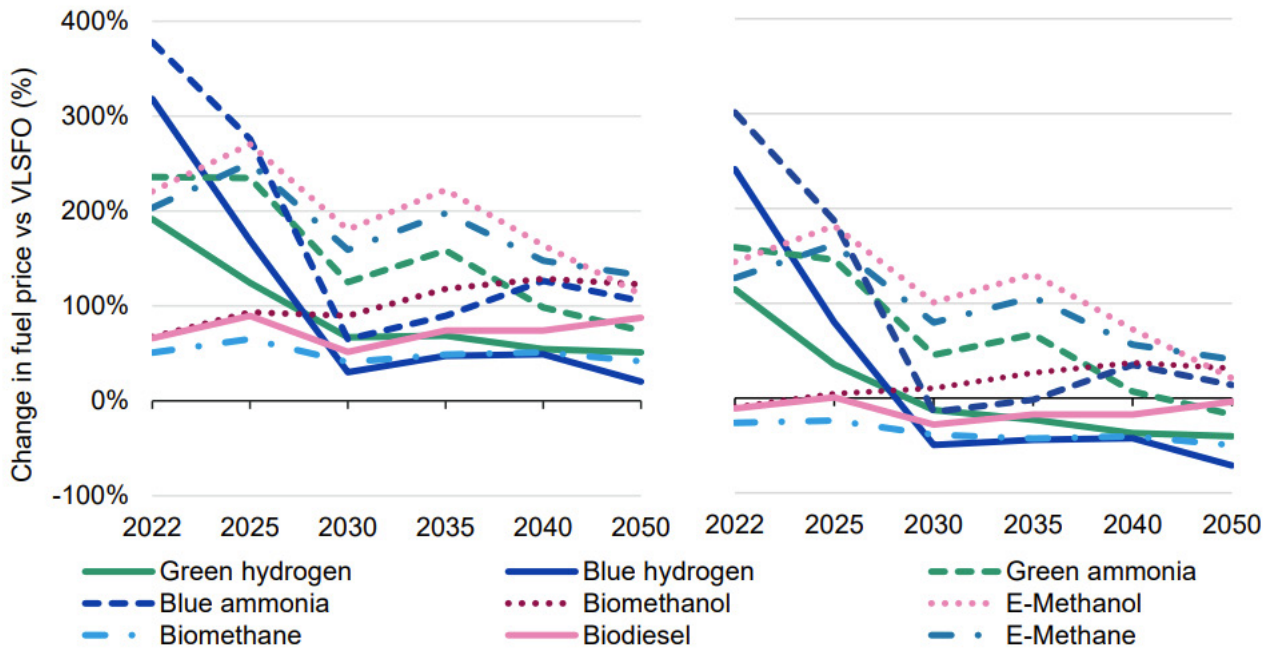
The uptake of SZEF—i.e. fuels able to meet rapid demand driven by decarbonization targets between 2030 and 2050—is at the heart of the challenge. The fuels most likely to be scalable are those that rely primarily on electricity as an input, or the so-called e-fuels like e-methanol and e-ammonia. However, there is a sizable cost gap between SZEF and fossil fuels. Figure 2 shows fuel cost forecasts relative to very low sulphur fuel oil (VLSFO) for a range of fuels.

Figure 1. Zero-Carbon Fuels for Shipping



Source: UMAS (n.d.).

Figure 2. Forecast of Fuel Costs Relative to Very Low Sulphur Oil



Note: Forecast of fuel costs relative to VLSFO after accounting for the impact of additional energy efficiency measures, without a €100/t carbon price (left), and with a €100/t carbon price (right).

Source: IMO (2023b).

Although Figure 2 indicates the anticipated reduction in fuel costs, comparing scenarios with and without a carbon price, it is important to underline that the costs of SZEF remain uncertain. There are expectations that biofuel prices will go up as demand exceeds sustainable supply and e-fuel prices will come down—but both will remain more expensive than fuel oil in the long term.

In the short term, ensuring that supply and demand can be matched (i.e. solving the “chicken and egg” problem) so that fuel production projects can reach a final investment decision is crucial to reaching the IMO 2030 SZEF targets, with lead-in times of 5–7 years. However, scaling the fuel is not only a challenge in terms of volume but also in ensuring its broad uptake across geographies and availability across sectors. Technological inclusivity—a concept coined by the IMO—is pertinent here. In the context of discussions on securing a just and equitable transition, the transfer of technologies to developing countries and regions is as important as ensuring that these countries have access to affordable zero-emission technologies—for example,

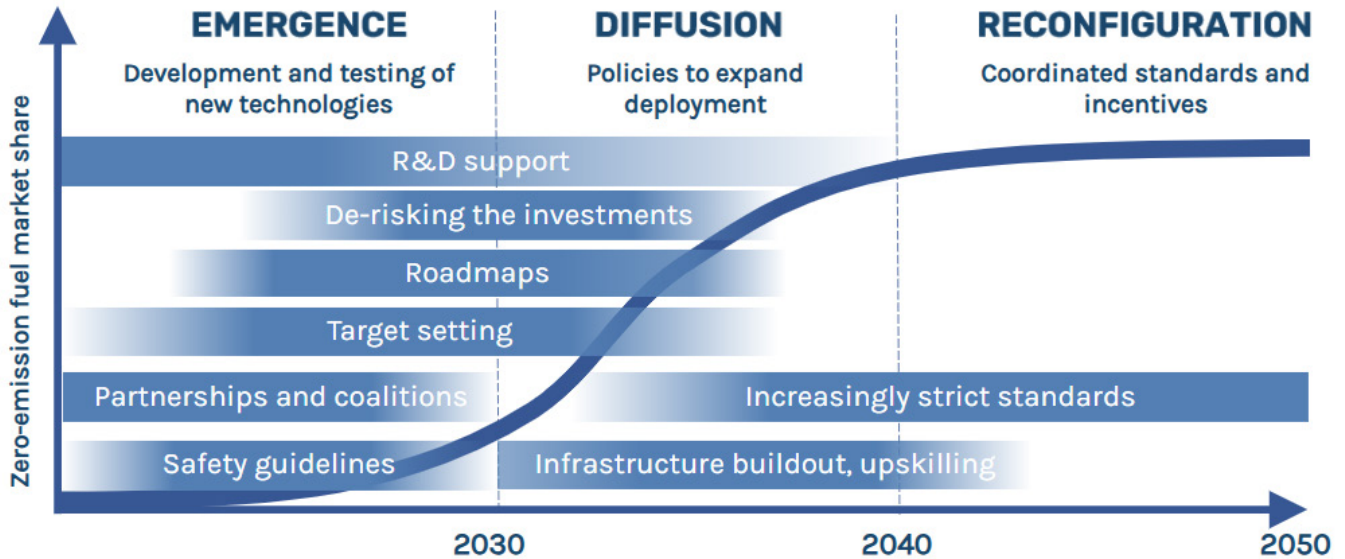
vessels capable of running on SZEF or the ability to produce and bunker such fuels.

Progress So Far

The IMO strategy provides the industry with a clear pathway for shipping decarbonization by pointing to the need to invest at scale in zero-emission fuels and technologies. However, reaching net zero cannot be driven by the IMO strategy alone. To deliver on a just and equitable energy transition, the strategy needs to be backed by ambitious national and regional policies as well as industry initiatives to support investments in zero-emission shipping.

Figure 3 illustrates the non-linear nature of technological transitions in which the speed of adoption follows an S-curve rather than a straight line. Shipping is currently in the middle of the emergence stage along the S-curve, with policy needs specific to this stage that must also shift over time.

Figure 3. Technological Transitions and the S-Curve



Source: Global Maritime Forum (2023c).

In the emergence stage, research and development policies that are guided by the transition targets and other signals of long-run intent are key. Towards the end of the emergence phase, when the first generation of promising technologies has crystallized, policy needs gradually shift towards facilitating market introduction. At this stage, successful policies contribute to matching supply and demand by bridging the cost gap and de-risking the initial commercial roll-out. The diffusion stage requires policies that support the build-out of infrastructure, followed by the reconfiguration stage which should see the universal implementation of green technologies.

An increasing number of industry-led alliances have been established around low-carbon objectives, such as the Getting to Zero Coalition and the First Movers Coalition,³ which enable, encourage, and support their members in the emergence phase. These alliances commit to decarbonization trajectories consistent with IMO targets and offer space for collaboration on key challenges.

Green corridors are also proving suitable for the emergence phase. These specific trade routes where zero-emission solutions are demonstrated and supported by public and private action cut through some of the complexities in coordinating shipping decarbonization efforts. Green corridors allow policymakers to create an enabling ecosystem with targeted regulatory measures, financial incentives, and safety regulations. For developing countries, participating in green corridor initiatives offers the opportunity to connect to significant demand sources for zero-emission fuels while collaborating on key barriers to scaled production in response to this demand, such as low-cost financing, bankability, and standards. The Global Maritime Forum leads or supports the delivery of a number of green corridors and monitors overall progress on these specific routes annually (Global Maritime Forum, 2023a). Notably, the South Africa-Europe Iron Ore Green Corridor is exploring the opportunity of a decarbonized iron ore route, investigating synergies between the greening of this corridor and the production and export of green hydrogen and ammonia from southern Africa to Europe for use in steelmaking, among other industries.

3. The First Movers Coalition is a global coalition of companies leveraging their purchasing power to advance emerging climate technologies to decarbonize the world's heavy emitting sectors, including shipping (World Economic Forum, n.d.).

Increasing work to develop aggregation mechanisms can also help solve the persistent “chicken and egg” problem in the uptake of SZEf. By aggregating demand or supply, concerns over matchmaking can be offset and risks shared. Aggregation can be carried out on the supply side (e.g. fuel producers) and/or the demand side (e.g. liners, cargo owners) and with third parties such as governments (Global Maritime Forum, 2024a). For developing countries, supply and demand matchmaking schemes (e.g. between the Global North and South) supported by capital from multilateral development banks could incentivize the development of strong investment rationales for fuel production. Another potential opportunity for developing countries is to mobilize cargo owners’ willingness to pay to cover all or part of the cost gap for SZEf. The Zero Emission Maritime Buyers Alliance is making important steps in this space, recently announcing the results of its first auction process (Zero Emission Maritime Buyers Alliance, n.d.). In the future, directing such schemes or their equivalent to developing countries could help address the cost gap.

Finally, recent actions on the part of governments and the European Union, including the adoption of the FuelEU Maritime initiative and the launch of the Clydebank Declaration for green shipping corridors, challenge the long-standing assumption that international shipping lies outside of the jurisdictions of individual countries (Global Maritime Forum, 2023c). Meaningful government support is essential, with policy pathways for each country determined by a combination of domestic strengths, ambitions, and current and envisioned position in the global shipping ecosystem. Such government support needs to happen at a much larger scale across a wider set of geographies, including through the initiation of and participation in first-mover initiatives, unblocking regulatory hurdles, incentivizing the uptake of alternative fuels, and providing financial assistance, not least in developing countries.⁴

3. Trade-Related Trends and Dynamics in Shipping

Recent Trends

With the value of global maritime trade estimated at \$14 trillion in 2019, maritime transport, in particular container shipping, underpins the global economy (International Chamber of Shipping, 2021). Trade impacts the volume, value, composition, patterns, and trends of international shipping.

Beyond the challenges associated with decarbonizing the sector, international shipping faces multiple disruptions, including heightened trade and geopolitical tensions. The Covid-19 pandemic, the war in Ukraine, and tensions in the Horn of Africa have had significant impacts on global shipping over recent years, leading to disrupted supply chains and rising trade costs and consumer prices. The global energy and cost-of-living crises will impact global shipping for years to come.

Additionally, national responses to these dynamics have seen the proliferation of trade protectionism and inward-looking policies, with economic implications for developed and developing economies (International Chamber of Shipping, 2022).

The World Trade Organization (WTO) plays a key role in the governance of shipping trade. An important issue in relation to the decarbonization of international shipping will be the response, in the WTO context, to the implementation of IMO mid-term GHG reduction measures, including possible carbon pricing instruments. In previous rounds of negotiations, some IMO member states have argued that existing WTO law could limit the ability of the IMO to implement carbon pricing for shipping—or at least some forms of pricing. In practice, this will depend on the legal instruments and procedures employed by the IMO to adopt a GHG

4. An example of effective government support is the H2Global initiative, which combines some of the elements described above as a cost-effective method for closing the cost gap (H2Global Stiftung, n.d.).

pricing instrument. Existing analysis would indicate, however, that there are probably limited grounds to challenge an IMO GHG pricing instrument under WTO law—especially if the GHG price is implemented as a direct payment from vessels to an international fund (Dominioni, 2024).

Climate Action, Trade, and Implications for Developing Countries

The cost of zero- or near-zero-carbon fuels for international shipping is significantly higher than conventional fuels like heavy fuel oil. The additional requirement of retrofitting or building new vessels capable of running on these fuels, as well as developing the infrastructure for bunkering and transporting them, further raises the cost of the transition. With shipping generally operating with low profit margins, liner companies are unlikely to absorb increased costs unless their clients (e.g. cargo owners) are willing to pay more or pass the extra costs on to consumers. IMO regulations, along with national or regional policy measures, will make fossil fuels more expensive over time. It is estimated that approximately \$3.2 trillion of investment, supported by effective regulation and subsidy schemes, is needed to achieve the low-carbon transition in the near term (Global Maritime Forum, 2024b).

There is significant debate at the IMO about the implications of such measures and how to make the transition just and equitable. Core principles include addressing the disproportionate negative impacts of policy measures, allowing equal access to the required infrastructure and technologies, reducing GHG emissions to minimize further impacts of climate change on vulnerable states, supporting wider climate adaptation and climate mitigation efforts, and unlocking global opportunities for fuel production.

The 2023 IMO GHG reduction strategy requires a comprehensive impact assessment to evaluate the

potential effects of the proposed measures on the global fleet and individual states before they are adopted. Assessing the impact on states is especially crucial for developing countries, particularly LDCs and SIDS. The comprehensive impact assessment has examined the economic, social, and environmental impacts of the proposed basket of mid-term measures, including a marine fuel standard and a GHG emissions pricing mechanism. The results of this assessment, presented at the 82nd session of the Marine Environment Protection Committee in September 2024, will continue to inform decision-making before the measures are finalized and adopted in 2025.⁵

The assessment of the impacts on states conducted by UNCTAD explored the simulated impacts on imports, exports, gross domestic product (GDP), and consumer prices resulting from the increase in shipping time and maritime transport costs at three points of time: 2030, 2040, and 2050 (IMO, 2024). These projections are based on hypothetical policy measures and consider the potential allocation of generated revenues.⁶

As a result of the policy measures to discourage the use of fossil fuels, maritime logistics costs are expected to increase over time. It is probable that a global fuel standard would affect lower income countries the most. Research indicates that that these impacts will likely differ across geographies and over time in the transition (Transport & Environment, 2022). Notably, a levy is expected to entail higher costs earlier in the transition but decrease towards 2050 compared to scenarios without a levy. However, revenue disbursement, if combined with a high levy, has the potential to economically support developing countries, LDCs, and SIDS. Alongside a levy that provides for revenue disbursement, clear support for early adoption and scaling of SZEf is essential. As discussed below, demand for new fuel production in developing countries with renewables capacity may also create economic and trade opportunities for these countries.

5. The Marine Environment Protection Committee addresses environmental issues under the IMO's remit.

6. The projections have been disputed by several member states.

4. Opportunities and Challenges for Developing Countries

Trade-Related Opportunities

There are several trade opportunities for developing countries in the low-carbon transition, in particular the production of low-cost hydrogen and its derivatives. Indeed, geographies with significant potential in solar energy or other renewables could produce low-cost hydrogen and derivative hydrogen fuels (e.g. e-methanol and green ammonia) that shipping will rely on for its decarbonization. In addition to using these fuels to power maritime transport at ports in developing countries, exporting the fuels could provide a significant economic opportunity, with demand for e-fuels projected to exceed 500 million tonnes by 2040 (Global Maritime Forum, 2024b). Green ammonia trade, in particular, is likely to be more diversified in its production locations due to its specific characteristics that enable long-distance transport from low-cost production regions to key bunkering hubs (Zero-Emission Shipping Mission, 2024).

However, there are concerns that substantial public funding for hydrogen-related investments in Europe and North America could place projects in emerging markets and developing economies at a disadvantage, with the disparity in renewable energy financing between developed and developing countries having increased significantly over recent years (IRENA, 2023). Geographical location will be an important factor in the ability to exploit the potential to become a major fuel supplier, with countries closer to key markets likely to have a competitive advantage.

Carbon pricing can help level the playing field between fossil fuels and zero-carbon bunker fuels while generating revenues that can be used to support the creation of a global zero-carbon energy supply infrastructure for shipping. Elements in the different combinations of policy measures being considered—

e.g. revenue disbursement and flexibility mechanisms— could also help ensure a just and equitable transition by addressing some developing country concerns (Global Maritime Forum, 2024d). According to the World Bank (2021), targeted investments towards developing countries that are well positioned to produce zero carbon bunker fuels could help allay some existing controversies in the policy debate around common but differentiated responsibilities and respective capabilities, a guiding principle of both the UNFCCC and the IMO GHG reduction strategy.

If a revenue distribution mechanism is agreed upon by the IMO, developing countries may be able to access financial support to develop their hydrogen potential alongside projects implemented through country programmes with official development assistance or through multilateral development banks. The hydrogen economy could contribute significantly to the economies of developing countries and regions. For example, it is estimated that the hydrogen industry in South Africa could generate 1.9–3.7 million jobs and contribute \$60 billion to GDP by 2050 (Business Tech Africa, 2023). Globally, the decarbonization of the global maritime industry could support the creation of up to four million jobs by 2050 (Global Maritime Forum, 2024b).⁷

Key Challenges

Establishing significant export volumes of green hydrogen-derived fuels will come with some challenges. Attracting finance and investment requires bankable projects, which remains a key barrier to the deployment of renewable energy (ESMAP, 2023). Responding to this challenge requires coordinated support from governments and multilateral development banks, targeting country risks and establishing effective regulatory environments. An important issue here is

7. Among a number of projects being announced, a green hydrogen production project in Namibia is expected to see N\$70 billion (\$4 billion) in investment over the next five years (The Brief, 2024).

the need for subsidization and other market-based measures to be compatible with WTO disciplines.

Harnessing the potential for employment creation in the transition to zero-emission fuels in shipping will also require retraining and upskilling across renewable energy generation, as well as hydrogen and e-fuel production (Global Maritime Forum, 2024c). Knowledge and technology transfer will also be crucial to ensuring the development of suitable safety protocols for the handling and use of e-fuels in shipping.

Cooperation for the Net-Zero Transition

One of the key opportunities for developing countries to engage and cooperate on the low-carbon transition is through the IMO negotiations on the development of mid-term measures. As discussed, the comprehensive impact assessment sought to understand how different groups of countries may be impacted, positively or negatively, by the measures being proposed in their various combinations. An additional assessment on the implications for food security is ongoing within the IMO. As noted, some options are more advantageous than others when it comes to the impacts on trade of developing countries, LDCs, and SIDS. Participating in this process, while exploring the opportunities that the low-carbon transition brings in other aspects (e.g. fuel production potential) will enable the co-creation of improved solutions.

International cooperation on shipping decarbonization, including through knowledge exchange platforms, coordinated innovation efforts such as the Zero Emission Shipping Mission,⁸ or green corridor initiatives, can improve knowledge exchange and share the risks associated with the low-carbon transition as well as maximize the opportunities.

By testing and deploying fuels, vessels, and infrastructure in a coordinated manner, corridors between developed and emerging and developing economies and regions could provide a framework for supporting investment in zero-emission shipping in developing countries, serving as an additional channel for climate finance. This could take the form of bilateral funding for shared corridor assets and/or commercial arrangements designed to leverage the greater creditworthiness and access to capital of companies in developed economies (Global Maritime Forum, 2023a). The South Pacific and South Atlantic regions have witnessed an increase in activity in this regard, with new initiatives emerging in South America and Africa, although the numbers remain low. Notably, the World Bank is completing a feasibility study on the potential for green ammonia production in the Saldanha Bay region of South Africa, which is also under exploration for an iron ore green shipping corridor (Salgmann et al., 2024; Global Maritime Forum, n.d.).

5. Priorities for Policy Engagement and Future Analysis

Trade and shipping are intricately linked. With multiple possible pathways to net zero, significant financial and technical challenges in the use of SZEF, and major regulatory decisions lying ahead, the shipping sector faces serious challenges on its path to reaching net zero by 2050. Upcoming decisions at the IMO will have important implications for shipping's low-carbon transition and therefore international trade.

Securing this transition is essential, with the cost of inaction far outweighing the necessary investments. Managing the implications of projected shifts in trade and ensuring that this transition is just and equitable are critical policy challenges. These issues will require consideration of the impacts of measures on different countries and regions as well as the development of policy frameworks that address the opportunities and needs of developing economies.

8. The Zero Emission Shipping Mission is a global initiative of 23 countries and the European Commission (on behalf of the European Union) whose goal is to demonstrate commercially viable zero-emission ships by 2030 (Mission Innovation, n.d.).

9. Scope 3 emissions are the result of activities from assets not owned or controlled by the reporting organization, but that the organization indirectly affects in its value chain (EPA, n.d.).

Achieving these opportunities will require developing port infrastructure that is both climate-resilient and fitted for the transition, notably in LDCs and SIDS, while exploring strategies such as the production of hydrogen or e-fuels that could bring economic and trade benefits. Adequate retraining and reskilling, including that of the more than two million global seafarers, will also be an integral part of a successful transition. Efforts are needed now to define a clear pathway to zero-carbon shipping that helps meet global climate targets and ensure climate resilience for growth and sustainable development.

Building on the analysis in this briefing note, there are three key policy engagement opportunities to seize for developing countries:

1. Engage productively in IMO discussions to ensure a just and equitable transition that achieves decarbonization objectives.
2. Explore hydrogen production potential in anticipation of maritime decarbonization efforts from 2030 when demand for zero-emissions fuels is expected to grow rapidly.
3. Cooperate with a diverse range of stakeholders in the value chain to maximize technology transfer and knowledge exchange, including through participation in relevant initiatives like green corridors.

Finally, it is important to note that decarbonized shipping positively impacts the transition of other economic sectors and can help achieve the climate and sustainable development goals of many countries. The growing focus on Scope 3 emissions is notably driven by corporate decarbonization targets and is heavily reliant on the shipping industry's ability to reduce emissions from transport.⁹ Low-carbon shipping can help decarbonize hard-to-abate industries such as steel or cement by unlocking fuel production and zero-emissions infrastructure and offering early offtake of hydrogen-derived fuels.

Looking ahead, further research is needed on the interplay between trade and shipping regulatory frameworks in achieving net-zero pathways, including on the opportunities and challenges of carbon pricing, carbon border adjustment measures, and green fuels development as well as on ensuring a transition that is just and equitable. This could help inform the development and implementation of effective and sustainable decarbonization policies in the maritime sector and offer insights into broader climate change governance.

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