Closing the Gap

An Overview of the Policy Options to Close the Competitiveness Gap and Enable an Equitable Zero-Emission Fuel Transition in Shipping

For the Getting to Zero Coalition

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Preface
This report has been written by a team of experts from UMAS and UCL for the Getting to Zero Coalition. The views expressed are those of the authors, not necessarily of the client.

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About UMAS
UMAS undertakes research using models of the shipping system, shipping big data (including satellite Automatic Identification System data), and qualitative and social science analysis of the policy and commercial structure of the shipping system. Research and consultancy is centred on understanding patterns of energy demand in shipping and how this knowledge can be applied to help shipping transition to a low-carbon future. UMAS is world-leading on two key areas; using big data to understand trends and drivers of shipping energy demand or emissions and using models to explore what-ifs for future markets and policies. For more details visit www.u-mas.co.uk

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List of Abbreviations

BMU German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit)

CAPEX Capital Expenditure

CBDRRC Common But Differentiated Responsibilities and Respective Capabilities

CC Carbon Capture and Sequestration

CfD Contract for Difference

CII Carbon Intensity Indicator

COP26 Conference of the Parties 26th session

CO_2 Carbon Dioxide

CO_2e Carbon Dioxide Equivalent

EEDI Energy Efficiency Design Index

EEXI Energy Efficiency Existing Ship Index

ETS Emissions Trading System

EU European Union

EU MRV EU Regulation for the Monitoring, Reporting and Verification of CO_2 Emissions from Maritime Transport

GHG Greenhouse Gas

Gt Gigatonne

IKI International Climate Initiative (Internationale Klimaschutzinitiative)

IMO International Maritime Organization

IMO DCS International Maritime Organization data collection system for fuel oil consumption of ships

Initial GHG Strategy Initial IMO Strategy on Reduction of GHG Emissions from Ships

LDC Least Developed Countries

LSHFO Low-Sulphur Heavy Fuel Oil

MACC Marginal Abatement Cost Curve

MBM Market-Based Measure

MEPC Marine Environment Protection Committee

MWh Megawatt-hour

NDC Nationally Determined Contribution

NMFT No More Favourable Treatment

NOx Nitrogen Oxide

R&D Research and Development

RD&D Research, Development and Deployment

SCC Social Cost of Carbon

SEEMP Ship Energy Efficiency Management Plan

SIDS Small Island Developing States

SMR Steam Methane Reformation

UNFCCC United Nations Framework Convention on Climate Change

US$ United States Dollar

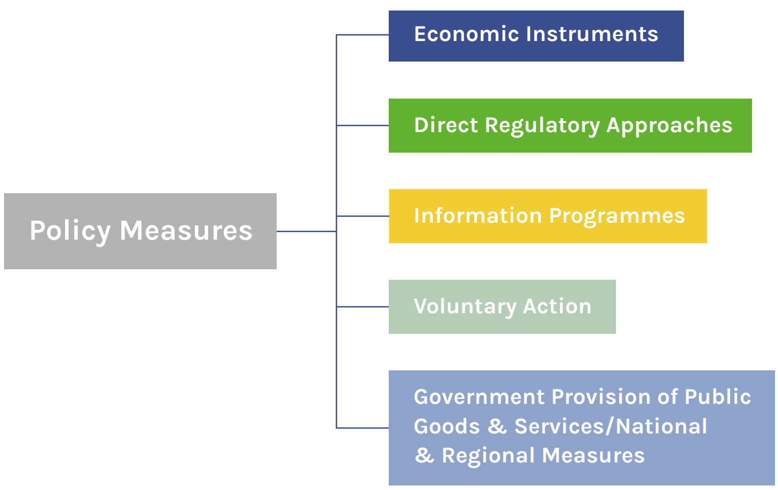
Executive Summary

Shipping is a cornerstone of global trade and, as such, the GHG emissions created by shipping are significant and rising, accounting for almost 3% of global anthropogenic emissions (Faber et al. 2020a). Recent projections suggest that by 2050, shipping emissions will increase by between 90-130% of 2008 emissions by 2050 (ibid.). However, in April 2018, the IMO adopted the Initial GHG Strategy which set the ambition to reduce total annual GHG emissions by at least 50% by 2050, while pursuing efforts towards phasing out GHG emissions this century as a matter of urgency, consistent with the Paris Agreement temperature goal. With emissions projected to rise and international targets having been set, the question becomes, how these targets can be met by shipping?

For international shipping to align with the IMO's Initial GHG Strategy, zero-emission fuels would need to become the dominant fuel source by the 2040s, gradually phasing out current fossil fuels. However, there exists a significant competitiveness gap between incumbent fossil fuels and alternative zero-emission options. This gap is the result of the existence of market barriers and failures, availability issues, a relative lack of information and regulation on safety, as well as the price difference in the fuels, which in turn is driven by R&D, infrastructure, and investment requirements. Projections suggest that across the 2030s and 2040s, zero-emission fuels will be approximately double the price of conventional fuel at best (Lloyd's Register & UMAS 2020). As a result, there is an urgent need for policy to close the competitiveness gap and ensure shipping meets its decarbonisation commitments.

There is a range of potential measures to promote decarbonisation in shipping, including economic instruments or MBMs, direct regulatory approaches, information policies, voluntary initiatives, and national and regional action. This report provides an overview of different policy measures to address maritime decarbonisation and to close the competitiveness gap while enabling an equitable transition. Fairness and equity aspects are emphasised by e.g. the Initial IMO GHG Strategy. Therefore, the viability of any IMO climate policy instrument depends to a large extent on how these aspects are considered and operationalised.

This report explains which policy options could help close the competitiveness gap and enable an equitable transition. It considers the policy options shown in the diagram below.



Overview of Economic Instruments

In many other sectors and countries, economic instruments, or market-based measures (MBMs), are widely used by regulators to internalise the costs of pollution caused by economic activities, address market inefficiencies and decrease price differences between fossil fuels and alternatives. MBMs have been on the IMO agenda since 2003[1] and although discussions of MBMs in the IMO were suspended in 2013, MEPC 76 in June 2021 adopted a structured plan to start work on mid-term measures to cut GHG emissions from ships, which include MBMs alongside other measures.

MBMs can support the decarbonisation of shipping by closing the competitiveness gap between fossil fuels and zero-emission fuels by increasing the costs of using fossil fuels through setting a price on carbon, and/or reducing the costs of zero-emission alternatives, e.g. through tax breaks, RD&D funds, subsidies, or a combination of these. Additionally, MBMs can also help to mitigate some of the market failures and barriers which are slowing decarbonisation efforts. The main MBM policy options are summarised in the table below.

1. IMO Resolution A.963(23)

	Emissions Taxes and Levies	Emissions Trading System	Subsidies
Role of the regulator	Regulator sets a fixed price tied to fossil fuel consumption or CO_2/ GHG emissions.	Regulator sets maximum emissions target or baseline and creates a market for emissions, either as a cap-and-trade or a baseline-and-credit system.	Regulator directs the use of subsidy payments.
How the MBM works	The carbon price set by the regulator increases the price of fossil fuels, stimulating the market to decrease consumption and switch to alternatives.[2]	Market reaction to a cap or baseline increases the price of fossil fuel use, stimulating the decrease of emissions and move to alternative fuels. Cap-and-trade system: A cap is set and lowered over time. Allowances under the cap are distributed or auctioned to market actors. Baseline-and-credit system: Baseline emissions levels are defined and emission credits are issued to entities with emissions below the baseline. Credits can be banked or sold to other entities exceeding baseline emission levels.	Subsidies are sums of money granted by the State or a public body used to support RD&D and lower the cost of alternative zero-emission fuels (e.g. Contracts for Difference) rather than increasing the price of fossil fuels.
Price characteristics	The price is known for the timeframe chosen by the regulator.	The price is not known and is produced by the market response to the parameters of the policy design.	N/A
Risks/ uncertainty	The exact reduction of emissions is not certain, as this is dependent on the market reaction to the price.	Price is uncertain and defined by market action, which can lead to price volatility, market uncertainty and higher risks for investors.	Being a direct form of funding, subsidies are highly dependent on the information available to and focus of the subsidy-awarding body and may not be an option for all governments or organisations.
Key to effectiveness	Appropriate price setting and reviewing on a clearly communicated schedule against predefined criteria will increase control over environmental impacts and decrease business uncertainty.	Setting an appropriate cap or baseline is key to effectiveness.	Subsides are best used as a companion to other policies and can be targeted to support either the supply or demand-side of the fuels transition.

2. There is also a feebate MBM which is a variant of taxes/levies whereby the regulator sets a pivot point (benchmark) of maximum total or relative pollution. Those above the pivot point pay fees and those below receive rebates. For more detail, see the full report.

Potential Uses of Revenue Generated by Economic Instruments

A key advantage of taxes/levies and ETS is the potential to generate significant revenues which could be used in different ways to help close the competitiveness gap and/or enable an equitable transition, for example:

- Addressing disproportionately negative impacts on States of GHG reduction measures as stipulated by the Initial IMO GHG Strategy.
- Supporting capacity development, technology transfer, and crew training in developing countries, in particular small island developing States (SIDS) and least developed countries (LDCs), to facilitate the development and uptake of zero-emission technologies and fuels, and the implementation of maritime climate policies.
- Funding climate projects in developing countries, SIDS and LDCs through existing or new climate finance mechanisms under the UNFCCC or other international organisations.
- Recycling revenues back into the maritime industry to support shipping decarbonisation by subsidising deployment of zero-emission fuels and technologies.
- Offering incentives to ships with lower emissions or carbon intensity compared to a certain benchmark.

The most fair and effective allocation of revenues across the different options will require further investigation and deliberation. The management of revenue, from collection to allocation and distribution, is a fundamental aspect to be considered and for some of the revenue usage options, existing mechanisms could be used. An aim of any system should be to avoid significant administration and transaction costs.

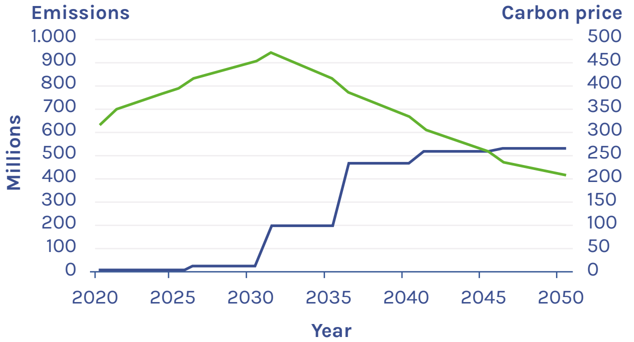
Possible Level of the Carbon Price

Recent analysis based on techno-economic models provides estimates of how the carbon price might need to be set to enable a certain absolute emissions reduction trajectory. Two scenarios are produced, achieving a 50% and 100% reduction in absolute emissions by 2050 respectively. In both scenarios, the carbon price is started in 2025, but the emissions pathway followed has emissions rising until a peak in 2030. It should be noted that all carbon price estimates have been calculated solely to create the commercial case for reducing emissions. The modelling does not include the consideration of how to ensure that emissions mitigation is equitable.

In order to achieve 50% GHG emissions reduction by 2050 compared to 2008 (-50% scenario), the carbon price level averages US$173/tonne CO_2. For a 2050 target of full decarbonisation (-100% scenario), the average carbon price would only need to be slightly higher: around US$191/tonne CO_2. In both scenarios, according to the model, the price level begins at US$11/tonne CO_2 when introduced in 2025 and is ramped up to around US$100/tonne CO_2 in the early 2030s at which point emissions start to decline. The carbon price then further increases to US$264/tonne CO_2 in the -50% scenario, and to US$360/tonne CO_2 in the -100% scenario.

The carbon price trajectories and their associated emissions trajectories are shown in the figure below.

CARBON PRICES IN THE -50% SCENARIO

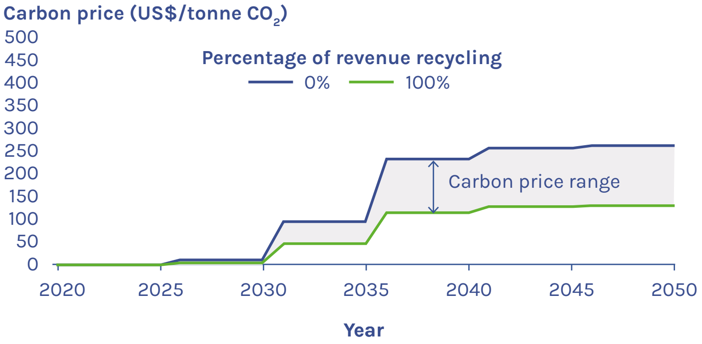


CARBON PRICES IN THE -100% SCENARIO

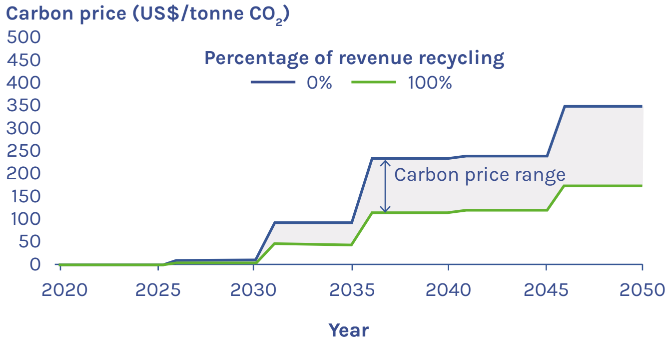
Even though the carbon prices as modelled in the two scenarios start at a very low level, they make two significant price increases over the following decade. These two price jumps may be challenging from both a political and practical business perspective; thus, it could be better to set the initial carbon price at a higher level than the model and follow a smoother increase, thereby easing potential economic shocks of sharp price increases. This could also help to ensure there is an emergence phase of the transition during the 2020s (e.g. funding RD&D to reach five percent zero-emission fuel penetration by 2030), which enables shipping-specific cost reductions prior to the more rapid uptake of new fuels scheduled for the 2030s.

Carbon prices could be lower than the model estimates if revenues generated by the MBM are 'recycled' to further support decarbonisation of shipping, for example by subsidising the deployment of zero-emission fuels and technologies. If all MBM revenue was recycled to support shipping decarbonisation, in theory, this could lower the carbon price level by up to half (but this would mean no revenue use for enabling an equitable transition and addressing disproportionately negative impacts on States). Depending on the level of revenue recycling, an MBM with global scope in the -100% scenario could be designed to have a carbon price level averaging between US$96-191/tonne CO_2 and reaching a maximum of between US$179-358/tonne CO_2 (see the figure below). In reality, the carbon price would likely be somewhere in this range, so that more revenue can be used to enable an equitable transition.

CARBON PRICES IN THE -50% SCENARIO, BASED ON % OF REVENUE RECYCLING



CARBON PRICES IN THE -100% SCENARIO, BASED ON % OF REVENUE RECYCLING



It is worth noting that the relationship between the carbon price and revenue collected depends on modelling assumptions, including global transport demand, future fuel cost assumptions and the emission reduction pathway for which only one scenario is being presented here. The collected revenue should be considered in terms of the total amount of available revenue which can be distributed over the period of decarbonisation (from 2025-2050), rather than assuming the revenue will be deployed only in the year it is collected. This scenario generally provides more subsidy/support for zero-emission fuels early in the transition when price spreads to zero-emission fuels are expected to be highest, and less towards the end of the transition when zero-emission fuels are more established and have a lower price spread. Other scenarios and spending profiles are conceivable.

Direct Regulatory Approaches

Direct regulatory approaches, such as the IMO's energy efficiency regulation (EEDI, EEXI and CII), often called command-and-control measures, could also be employed to close the competitiveness gap and include the following:

- Performance or Emission Standards: Set specific performance goals that must be achieved, but without mandating which technologies or techniques to use to achieve the goal.
- Technology Standards: Mandate which technologies or techniques must be adopted without specifying the overall outcome.
- Product Standards: Define the characteristics of potentially polluting products.

These standards can support efforts to reach the goals of the Initial IMO GHG Strategy by directly decreasing ship emissions, thus indirectly making fossil fuels more expensive. They could have a positive effect on RD&D and stimulate the uptake of alternative fuels in a similar way to carbon pricing. By mandating certain outcomes, they can also bypass some of the market barriers and failures and guide investments in a way that avoids locking in infrastructural choices and stranding of assets.

One potential shortcoming of standards is they do not generate revenues, meaning that unless they are accompanied by an appropriate revenue-raising and -use policy, they are restricted in their capacity to enable an equitable transition and address disproportionately negative impacts on States. Design elements, such as exemptions, differentiation in the standard's stringency and/or phased implementation of the standard, could be used. However, such design elements could have adverse consequences. For example, they would lower the environmental effectiveness of the standard, could (if applied on a route-level basis) create loopholes and lead to carbon leakage, but also result in exempted routes being serviced by increasingly old and inefficient ships which would leave countries serviced by those vessels behind on the technological trajectory.

Information Programmes

Information programmes, such as IMO's Data Collection System, are designed to influence behaviour through the disclosure of information. Quality and availability of information is a key factor in raising public awareness to environmental impacts and driving policy change. In isolation, information programmes are unlikely to have a significant role in closing the competitiveness gap. However, they could contribute to enabling an equitable transition: For example, information sharing between companies, countries and regions could spread best practices, diffuse technological innovation, build capacities and lower costs associated with RD&D.

National and Regional Policy Measures

While IMO mainly regulates international shipping, about 30% of GHG emissions from shipping stems from domestic shipping. Therefore, national and regional policy measures have the potential to contribute significantly to the reduction of ship emissions. Furthermore, the ambition of countries' Nationally Determined Contributions (NDC) should increase over time, so it can be expected that countries will look increasingly to sectors not previously considered in their NDCs. The IMO also recently adopted a resolution encouraging countries to develop voluntary National Action Plans to address GHG emissions from ships.

Engagement at a national and regional level could help create enabling environments for first movers, stimulate innovation and shield it from open market pressures initially before scaling it up over time. Zero-emission trade routes could be established between countries supporting each other to develop the necessary infrastructure, enabling zero-emission trading and a more collaborative and equitable transition. Countries with more capacities and resources could lead the decarbonisation of their national maritime sectors and domestic shipping through the development of dedicated policies and National Action Plans. Portions of any national or regional revenue-generating policy measures could be used to support developing countries, LDCs, and SIDS as part of the equitable transition. Many countries are already taking widespread action at a national level which can inform and potentially complement the development of global IMO-driven policies.

Voluntary Initiatives

Voluntary initiatives refer to initiatives taken by firms, non-governmental organisations, and other actors beyond regulatory requirements. However, policy-makers can play a key role in enabling the emergence of voluntary initiatives, e.g. governments can use soft policy tools like dialogue with stakeholders to encourage voluntary action. Furthermore, research suggests that voluntary initiatives are most successful when tied to future regulations. They could play an important role in reducing or removing market failures and could usefully complement other policy measures or stimulate innovation in the industry. They could also help with disseminating information, mobilising resources for less-resourced countries, and support capacity development, thereby playing a supporting role in enabling an equitable transition alongside mandatory measures. Nevertheless, voluntary initiatives are unlikely to result in significant emissions reduction and to enable the switch to zero-emission fuels. Therefore, they should be viewed as companion activities to future mandatory policy measures and should be promoted and supported, where possible, by policy-makers.

Potential Route Forward

There are multiple potential policy options for closing the competitiveness gap between fossil and zero-emission fuels and enabling an effective and equitable transition. One potential route forward is the following policy package:

1. **Adopt a global MBM** capable of generating significant revenue. This mechanism needs to create a carbon price that incentivises emissions reductions and investments into readily available GHG mitigation options in the near term, and fuel switching once alternative zero-emission fuels are widely available.
2. **Combine an MBM with an effective and fair use of revenue recycling and other revenue use options** to drive both demand and supply of zero-emission fuels whilst also supporting an equitable transition and addressing disproportionately negative impacts on States.
3. **Use a direct command-and-control measure** such as a fuel mandate in the long term to send an unequivocable signal to the market that a fuel transition will take place.
4. **Develop national and regional policy** that can ensure the transition of domestic fleets at least at the same rate or sooner than international fleets and that work in synergy with global IMO-driven policy.
5. **Promote voluntary initiatives and information programmes** to stimulate supply-side investments in RD&D and infrastructure, encourage knowledge sharing and support capacity development.

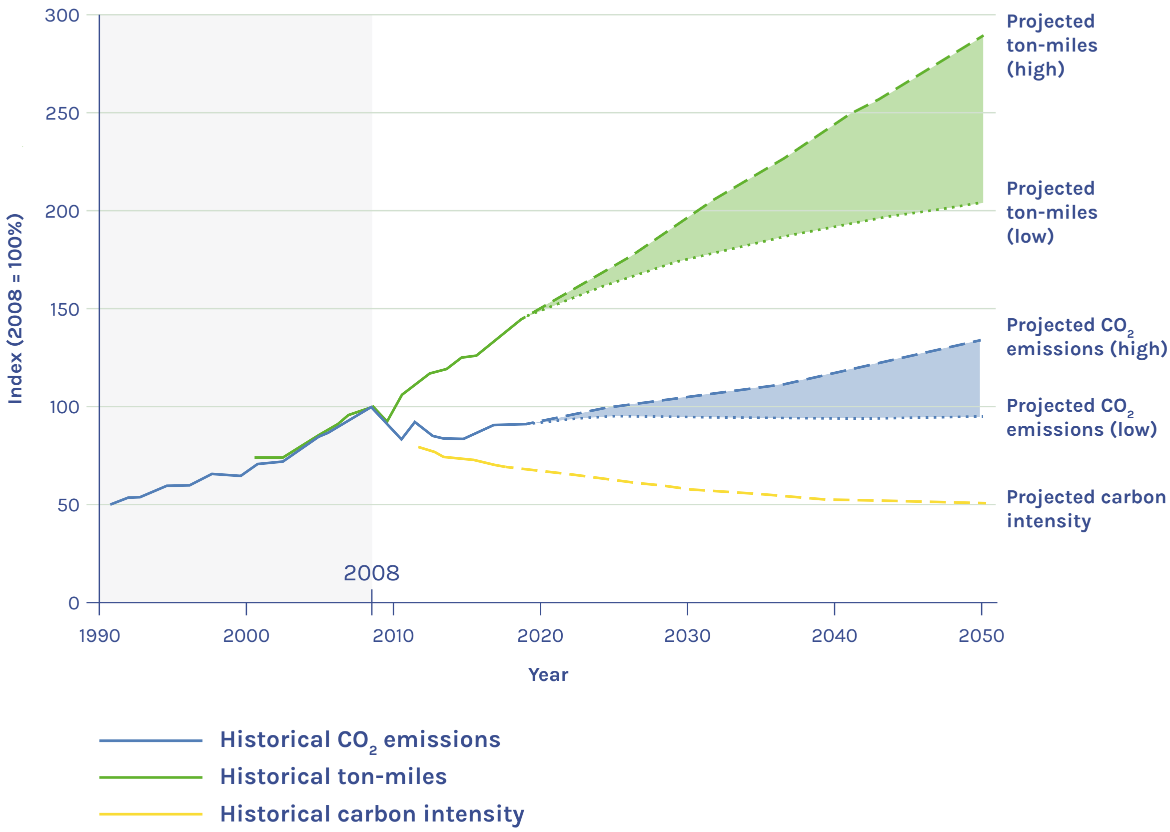
Shipping is an essential global industry which is currently on an emissions trajectory that is dramatically out of line with the Paris Agreement temperature goal. As such, there is an urgent need for the development of policies which guide and support this sector through an equitable transition towards zero emissions.

1.

Introduction and Background

Maritime transport is a major emitter of greenhouse gases (GHG); in 2018, GHG emissions from shipping (international, domestic, and fishing) amounted to an estimated 1,076 million tonnes which accounted for almost 3% of global anthropogenic emissions (Faber et al. 2020a). **Emissions are projected to increase by between 90-130% of 2008 emissions by 2050 for a range of plausible long-term economic and energy scenarios** (ibid.). This is illustrated in Figure 1 below.

Figure 1:
Historical and projected international shipping emissions and trade metrics, indexed in 2008, for 1990–2050



Source: Faber et al. (2020b)

The regulation of shipping pollution falls under the auspices of the International Maritime Organization (IMO), the United Nations' specialised agency for international shipping. **The IMO has a long history of considering policy to address GHGs, yet little has been achieved to date**. In 1997, the IMO initiated work on GHG emissions with the adoption of Resolution 8 on 'CO_2 (Carbon Dioxide) emissions from ships'. This resolution requested the IMO to undertake a study on GHG emissions from ships and to consider feasible emissions reduction strategies (IMO 2017). Since then, the IMO has discussed technical and operational measures, as well as market-based measures (MBMs) to reduce GHG emissions from international shipping and conducted three studies on GHG emissions from ships. In 2011, the IMO adopted the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP), both of which entered into force in 2013. In 2016, the IMO adopted a Data Collection System for fuel oil consumption of ships, which entered into force in 2018 (ibid.).

In April 2018, the IMO adopted the Initial IMO Strategy on Reduction of GHG Emissions from Ships (Initial GHG Strategy) at the 72nd session of the IMO's Maritime Environmental Protection Committee (MEPC). **The Initial GHG Strategy sets the ambition to reduce the carbon intensity of international shipping by at least 40% by 2030 compared to 2008 and to reduce total annual GHG emissions by at least 50% by 2050, also compared to 2008**. This is while pursuing efforts towards phasing out GHG emissions this century as a matter of urgency, consistent with the Paris Agreement temperature goal. The Initial GHG Strategy also aims to achieve further reduction of GHG emissions from international shipping before 2023 (IMO 2018). This emphasis on emissions reductions in the short term, as well as the 'at least' 50% GHG reduction language in the Initial GHG Strategy is important. That is because it means the IMO's Strategy can be much closer aligned with a 1.5°C trajectory which, as shown in IPCC (2018), will require significant global GHG reductions in the next ten years and GHG emissions to reach net zero around 2050. **Thus, while the IMO's Initial GHG Strategy is currently ambiguous in its ambitions, it can be clarified to be 1.5°C aligned**.

The Initial IMO GHG Strategy sets a timetable and structure for when to consider different policies. It includes a non-exhaustive list of candidate short-, mid- and long-term policy measures, i.e. measures that could be finalised and agreed between 2018 and 2023, between 2023 and 2030, and beyond 2030, respectively (IMO 2018). The short-term measures focus primarily on energy efficiency improvements and in June 2021, MEPC 76 adopted regulations which will apply technical efficiency standards to existing ships (Energy Efficiency Existing Ship Index, EEXI) (IMO 2021b). Ships will also need to achieve a specified annual operational Carbon Intensity Indicator (CII) (ibid.). The non-exhaustive list of candidate mid- and long-term measures included in the Initial GHG Strategy broadly focuses on the implementation of low- and zero-emission fuels and vaguely refers to new and innovative emission reduction mechanism(s) which could include market-based measures (MBMs). At MEPC 76, a workplan on mid- and long-term measures was adopted which envisages three different phases during which proposals for measures will be 1) collated and initially considered (spring 2021-spring 2022), 2) assessed and selected for further development (spring 2022-spring 2023), and 3) developed into a measure to be finalised. This means that **the consideration of policies to drive the fuel transition is starting imminently**.

Regardless of which candidate IMO policy measure is considered, **the Initial GHG Strategy requires the socio-economic impacts on States of IMO climate policy measures to be assessed and taken into account before their adoption (IMO 2018)**. It further states that "disproportionately negative impacts should be assessed and addressed, as appropriate", without however specifying how such impacts could be addressed, nor what constitutes a disproportionate impact (ibid.). These requirements were a response to concerns of developing countries, small island developing States (SIDS) and least developed countries (LDCs) that additional climate change mitigation policies in shipping could negatively impact their economies and hamper their access to goods and services. These requirements are an integral part of the Initial GHG Strategy and their importance in the context of adopting ambitious GHG reduction measures can hardly be overstated. This can be seen in the recent discussions related to the adoption of short-term energy efficiency measures in which the subject of impacts on States took centre stage.

The Initial GHG Strategy is guided by several underlying principles. On the one hand is the need to consider principles included in IMO conventions, i.e. the **principle of non-discriminatory regulation** of all ships in international trade irrespective of flag or ownership and the **principle of no more favourable treatment** (NMFT), which requires that IMO members apply the provisions included in IMO conventions to ships that are registered in countries that are not party to the relevant convention. On the other hand is the need to be cognisant of the **principle of common but differentiated responsibilities and respective capabilities (CBDRRC), in the light of different national circumstances**. CBDRRC is a principle that was first enshrined in the 1992 Rio Declaration on Environment and Development and has since been incorporated into many international environmental agreements, including the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the Paris Agreement. It combines the idea of a common responsibility of all countries to fight climate change with an acknowledgement of countries' different levels of responsibility for climate change and capabilities to address it. **The language in the Initial GHG Strategy, which lists the non-discrimination and NMFT principles side-by-side with CBDRRC, was a hard-fought political compromise that does not specify how the principles should be interpreted or operationalised** (Rojon 2020). They could be reconciled by, for example, preserving equal treatment on countries' core obligations of a regulation while providing financial, technological and capacity-development assistance to vulnerable countries.[3]

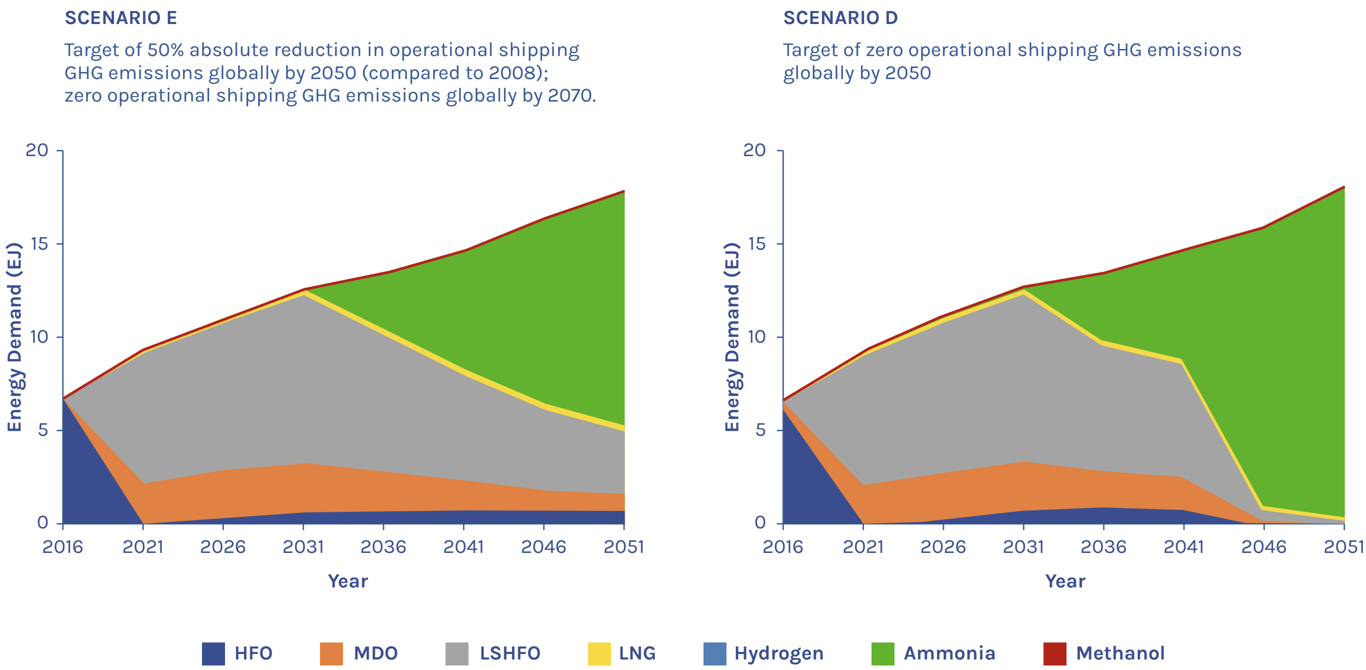
The inclusion of the need to assess and address impacts on States and to be cognisant of CBDRRC shows that the Initial GHG Strategy is as much about equity as it is about reducing emissions. Whether the IMO manages to adopt sufficiently ambitious GHG reduction measures to decarbonise shipping on a Paris-aligned trajectory will, to a large extent, depend on policy-makers' ability to operationalise these currently very ambiguous considerations and enable an equitable transition without compromising the measures' environmental effectiveness. This will need to be taken into account when assessing the viability of IMO GHG reduction measures.

3. For more information, please see Romera & van Asselt 2015.

1.1 The Need for Zero-Emission Fuels to Become Competitive

For international shipping to be in line with the ambition of the Initial GHG Strategy, the shipping industry will have to substantially increase its energy efficiency and introduce alternative zero-emission marine fuels as a significant part of the industry fuel mix. This is highlighted in Figure 2 below, which shows that both in the lowest-ambition scenario – i.e. only achieving a 50% GHG reduction by 2050 (depicted in scenario E) – and a higher ambition scenario targeting zero emissions by 2050 (depicted in scenario D), zero-emission fuels would have to become the dominant fuel source by the 2040s, gradually phasing out current fossil fuels.

Figure 2:
Projected future marine fuel demand for two decarbonisation scenarios



Source: Based on Raucci et al. (2020). Further information on the input assumptions for the scenarios can be found in chapter 4 of Smith et al. (2019).

The two scenarios show that **no matter whether a slower or faster transition to zero-emission shipping is envisaged, a rapid switch to zero-emission fuels will be needed**. However, the timing and speed of the transition will be important for the ease and costs of shipping's decarbonisation. In a sector like shipping where both ships and land-side assets will see major changes in fundamental technologies/design within a fraction of their economic lifetime, an earlier transition will allow more gradual changes, thereby reducing the risk of significant disruptions of the sector and of asset stranding.

From a market/economic perspective, one of the principal issues affecting the successful roll-out of an alternative zero-emission marine fuel is the price difference between such fuels and current conventional fossil-based fuels.[4] The size of this price difference – both in the near and long term – is shown in Table 1 below. The Table illustrates that zero-emission fuels like hydrogen and ammonia are expected to be more expensive than low-sulphur Heavy Fuel Oil (LSHFO). At best, zero-emission fuels are approximately double the price of LSHFO across the 2030s and 2040s. In the lower-bound fuel price scenario shown in Table 1 below, most of the renewable-based fuels in the 2030s and 2040s are between three and four times the price of LSHFO as is the case of ammonia and hydrogen, and rise up to nine to ten times the price of LSHFO as is the case of e-diesel.

Table 1:
Fuel price projections

		Lower bound				Upper bound			
		$/GJ				$/GJ			
Primary energy source	**Fuel**	**2020**	**2030**	**2040**	**2050**	**2020**	**2030**	**2040**	**2050**
Oil	LSHFO	8	11	11	11	8	11	11	11
Biomass	Bio-diesel	22	24	27	29	25	49	74	98
Biomass	Bio-methanol wood	23	25	27	30	24	48	72	96
Biomass	Bio-methanol waste stream	19	21	23	25	20	40	61	81
Substitution price for biofuels		9	19	26	33				
Renewable electricity	E-diesel	130	114	99	83	208	182	156	130
Renewable electricity	E-methanol	84	73	63	52	136	118	101	83
Renewable electricity	E-LNG	69	60	51	42	113	98	84	69
Renewable electricity	E-ammonia	55	47	39	30	96	82	68	55
Renewable electricity	E-hydrogen	52	44	36	28	92	79	65	52
Natural gas	NG-ammonia	28	26	24	23	46	43	40	38
Natural gas	NG-hydrogen	25	23	21	19	44	40	37	34

Source: Lloyd's Register & UMAS (2020).

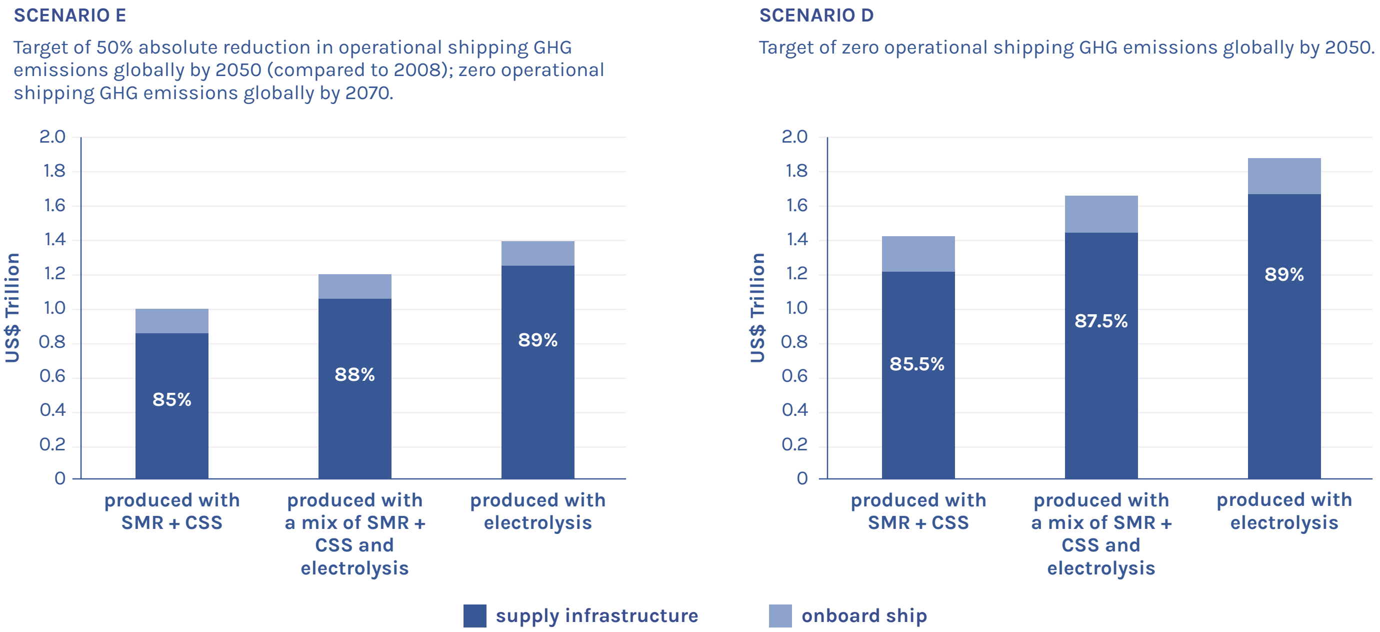
This price difference is the result of the inherently higher price of new zero-emission fuel alternatives in comparison to established fossil fuels. Being widely used and well-established, fossil fuels have limited new capital investment costs, and relatively small research and development (R&D) costs.

4. (Low-sulphur) Heavy Fuel Oils and Marine Diesel Oils.

They also have no 'chicken-and-egg'[5] issues related to bunkering infrastructure and much of the associated safety regulation is well-developed. In contrast, zero-emission fuels will require the development of new bunkering infrastructure, additional R&D, production scale-up, a drop in renewable electricity prices, development of new regulations, safety measures and ship designs, amongst other factors (Lloyd's Register & UMAS 2019).

Substantial investment is needed for the production and provision of zero-emission fuel alternatives. At an industry level, Raucci et al. (2020) and Krantz et al. (2020) estimate that **between US$1-1.4 trillion of investments will be needed from 2030 until 2050 to at least halve the shipping sector's GHG emissions until the middle of the century**. Around US$1.4-1.9 trillion (i.e. US$400-500 million more) may be required to fully decarbonise shipping in the same time frame. The investments needed depend on the production method for the hydrogen used to produce ammonia. Figure 3 below shows the total investment in infrastructure needed for three different methods of hydrogen production: 1) pure electrolysis production, 2) production based on pure steam methane reformation (SMR) with carbon capture and sequestration (CCS), and 3) a mix between the two. Figure 3 also shows that **87% of the total investments needed for zero-emission shipping are expected to be linked to land-based infrastructure** such as hydrogen production, ammonia synthesis and storage/distribution. All of these issues, in addition to existing fossil fuel policy support mechanisms in some countries, i.e. subsidies and tax breaks, put zero-emission marine fuels at a significant competitive disadvantage compared to conventional fossil fuels.

Figure 3:
Total investments needed to decarbonise shipping



Source: Krantz et al. (2020), Raucci et al. (2020)

5. Existing evidence (EEA 2017) refers to a 'chicken and egg' problem whereby no shipowner wants to invest in abatement options, such as alternative fuel technologies, until other actors, such as ports, put in place the supporting infrastructure. However, ports may not want to invest in the supporting infrastructure until the demand can be credibly demonstrated.

Studies suggest that for the price difference between conventional marine fuels and renewable energy-based zero-emission alternatives to decrease significantly, the price of renewable electricity would have to be around US$19/MWh (Lloyd's Register & UMAS 2019). Taking ammonia as an example of a zero-emission fuel, a significant scale-up of production through electrolysis would be possible at such a renewable electricity price (ibid.). The global weighted-average levelized cost of renewable electricity is currently around US$39-108/MWh (depending on the renewable energy technology) (IRENA 2021). However, renewable power generation costs have fallen sharply over the past decade and the International Energy Agency reports that in the best locations and with access to the most favourable policy support and finance, solar photovoltaics can now generate electricity at or below US$20/MWh (Evans 2020, IRENA 2021).

Storage and on-board costs also increase the price difference between conventional marine fuels and zero-emission fuels, but investment into R&D could potentially lower these costs significantly (Lloyd's Register & UMAS 2019). In addition to a difference in fuel prices based on investment and infrastructural requirements of zero-emission fuels over fossil fuels, it is possible that the act of decarbonising itself will drive the price of oil downwards and consequently increase the price difference. Indeed, as more and more sectors and nations continue on their respective decarbonisation trajectories, at some point in the medium term, it is possible that 'peak oil' demand will be reached, and supply will outstrip demand (Ait-Laoussine & Gault 2019). Equally, some economists suggest the imminence of climate policy could cause fossil fuel producers to accelerate extraction in order to benefit from higher revenues at present (Duval 2008). While the oil price is likely to change in response to decarbonisation, it is uncertain whether this would occur at the same rate or the same time as the decrease in zero-emission energy prices, so it is unclear how such a development would affect the difference in prices between fossil fuels and zero-emission fuels.

In summary, **new alternative zero-emission fuels will struggle to compete directly with fossil fuels during their initial emergence into the mainstream market**. This is driven by a number of factors from capital requirements, production costs, availability of source materials, lack of infrastructure and price difference. To capture the disparity of competition between fossil fuels and zero-emission fuels, we employ the terminology 'competitiveness gap' throughout the report. Section 1.2 now moves on to discuss specific market features of the shipping industry which have been known to impede the uptake of alternative emission-reducing technologies, and which will almost certainly contribute to the competitiveness gap between fuels.

1.2 Market Failures and Barriers

Closing the competitiveness gap between zero-emission fuels and fossil fuels is an essential step to decarbonising shipping. Simultaneously, **the market failures and barriers that exist in this industry, which slow the transition to zero-emission shipping and worsen the competitiveness gap, will need to be understood and addressed by policy-makers**.

Currently, the shipping sector has numerous options to improve energy efficiency that lower emissions and costs through the reduction of fuel consumption. These options can be categorised mainly as operational and technological measures. Research in this area demonstrates that despite shipowners considering available options as commercially ready, the implementation level remains low across different technological measures (Rehmatulla et al. 2017). Indeed, several studies across different sectors and regions have shown that cost-effective energy efficiency measures are not always implemented, despite the substantial cost savings and GHG abatement potential they could offer (Thollander & Ottosson 2008, Maruejols & Young 2011, Vernon & Meier 2012, Trianni et al. 2013, Hochman & Timilsina 2017). One explanation for the lack of uptake is the existence of market failures and market barriers.

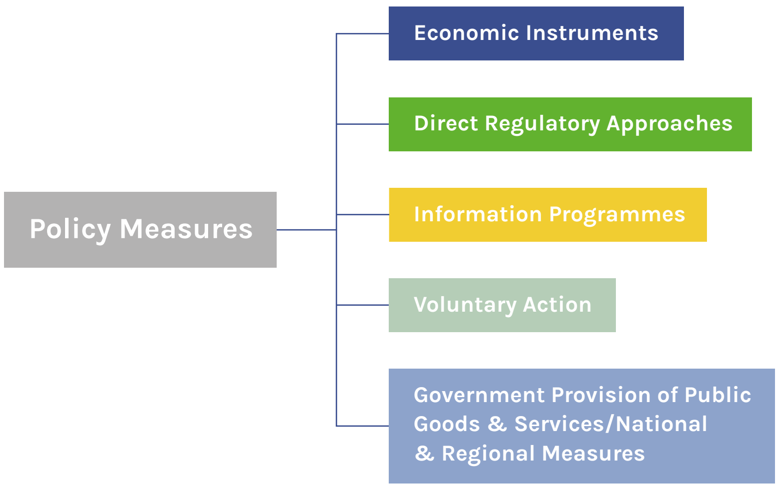
In the shipping industry, market barriers can include, but are not limited to, business and financial risks, capital costs, limited access to capital, transactional costs, and hidden costs (Fitzpatrick et al. 2019). In other words, these are largely economic obstacles faced by individual firms which can slow the uptake and implementation of energy efficiency and decarbonisation technologies (Sorrell et al. 2004). Market failures, on the other hand, occur when the market itself is not allocating resources efficiently. **Market failures particularly relevant to preventing the uptake of zero-emission transition measures occur because of split incentives, imperfect information, and asymmetric information**. Split incentives occur because of contractual or organisational arrangements, for example they can arise in a time charter, where fuel costs are borne by the charterer (in addition to the daily charter rate) and capital and operating costs are borne by the shipowner. Imperfect information refers to the lack of knowledge and certainty around abatement options and affects the choices of the shipowner. Indeed, there is a lack of independently verified information on cost savings and performance of abatement technologies and alternative fuels (Rehmatulla & Smith 2015, Fitzpatrick et al. 2019). Asymmetric information between a shipowner and the charterer refers to a situation where different levels of information are held by contracting parties (Lonsdale et al. 2019).

The consequence of both market barriers and failures is the slow and stunted uptake of zero-emission transition measures which suggests the need for specific and targeted policy intervention. This means that, as part of addressing the competitiveness gap, any future policy design in shipping should consider and address these market features, where possible.

1.3 Potential Policy Measures

There is a broad range of policy measures for climate change mitigation. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Kolstad et al. 2014), these fall into five broad categories, as illustrated by Figure 4 below:

Figure 4:
Overview of policy measures for climate change mitigation



Based on a review of the existing literature, this report aims to provide an overview of these different policy measures in the context of maritime decarbonisation. It is organised as follows: Section 2 highlights economic instruments as one of the key options for narrowing the competitiveness gap, whereas Section 3 considers the role of direct regulatory approaches in enabling the switch from fossil to zero-emission fuels. It is assumed that the measures discussed in Sections 2-3 would likely suit implementation at a global level. The potential contributions of information programmes and voluntary initiatives to decarbonise shipping are discussed in Sections 4 and 5, respectively. Section 6 then looks at what could be done at a national and regional level. For each of the Sections 2-6, the report also considers how each measure addresses the core issues of closing the competitiveness gap and enabling an equitable transition. Section 7 offers concluding remarks.

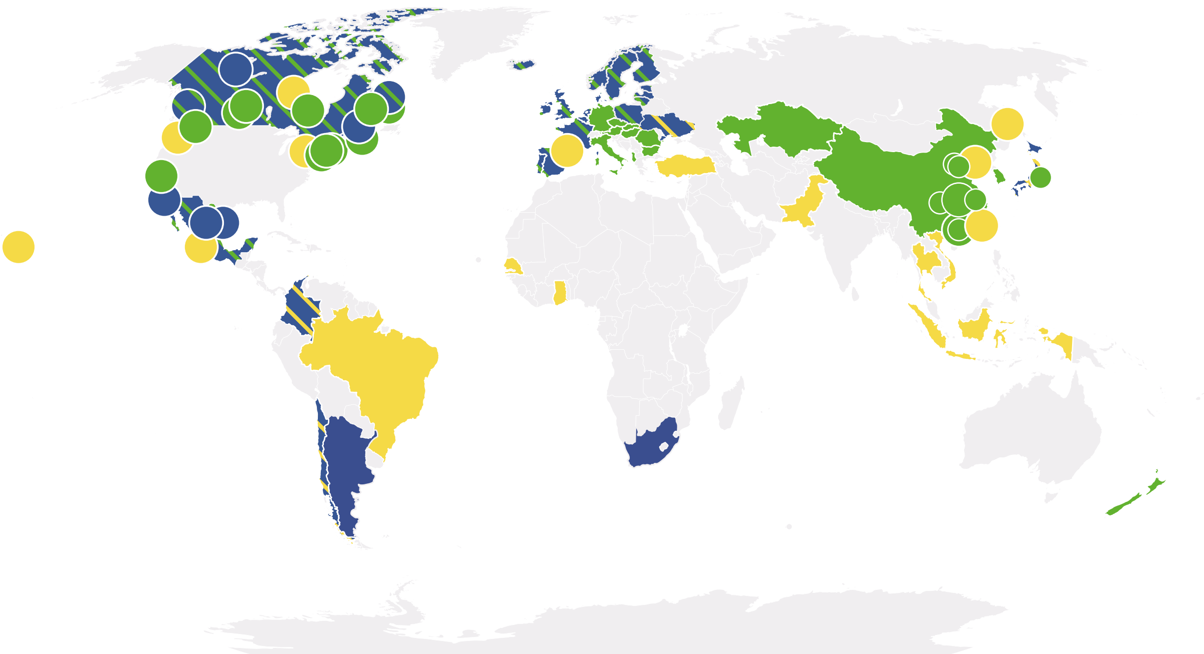
2.

Economic Instruments

Economic instruments are defined as "fiscal and other economic incentives and disincentives to incorporate environmental costs and benefits into the budgets of households and enterprises" (OECD 2019). They aim to bring about better outcomes for society by ensuring that the individuals or organisations responsible for an activity account for the costs they impose on others through their decisions (Wilson et al. 2019). In the context of decarbonising maritime transport, economic instruments are usually referred to as 'market-based measures' (MBMs).

The use of economic instruments or MBMs in relation to reducing emissions is widespread. The map in Figure 5 below illustrates the global carbon pricing landscape as of 1st April 2021. It shows the MBMs[6] which are implemented, scheduled for implementation or are under consideration by governments at a national, regional and subnational level. **As of April 2021, there were 64 carbon tax policies – 35 carbon taxation and 29 emissions trading systems – covering 45 national jurisdictions and 35 subnational jurisdictions**. The initiatives highlighted here would equate to covering 11.65 gigatonnes (Gt) of CO_2-equivalent (CO_2e), representing 21.5% of global GHG emissions (World Bank Group 2021).

Figure 5:
Summary map of regional, national and subnational carbon pricing initiatives



ETS implemented or scheduled for implementation
ETS or carbon tax under consideration
ETS implemented or scheduled, ETS or carbon tax under con...
Carbon tax implemented or scheduled for implementa
ETS and carbon tax implemented or scheduled
Carbon tax implemented or scheduled, ETS under cons

Source: World Bank Group (2021)

Several potential measures can fit into the broad category of economic instruments and discussions for shipping measures tend to centre around emissions taxes and levies, feebates, emission trading schemes and subsidies. Each of these are briefly discussed in Section 2.1 below.

6. Either a carbon tax or an emissions trading scheme.

2.1 Types of Economic Instruments

2.1.1 Emissions Taxes and Levies

Emissions taxes and levies[7] are both pricing instruments whereby a pre-defined price is put on either the amount of fossil fuel consumed or the amount of CO_2 or GHG emitted, and market actors are required to pay accordingly. Taxes and levies thus make the use of fossil fuels more expensive.

In an emissions tax or levy system, the price for GHG emissions is determined by a political decision, fixed for a specified amount of time and known to those who are subject to it, however the GHG emissions reduction outcome is unknown. This means that the achievement of certain environmental targets cannot be guaranteed. Hence, **for any emissions tax or levy to be effective, it is crucial that the price is set at a level that will drive emissions reductions to the desired environmental output** (High-Level Commission on Carbon Prices 2017; WBCSD 2018), see also Section 2.2.

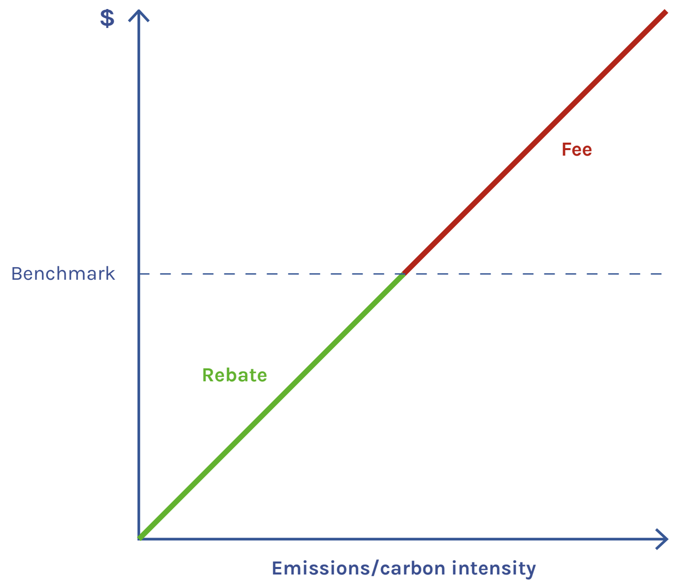
Monitoring, reviewing, and adjusting the tax/levy rate at regular intervals can increase the certainty of achieving environmental outcomes. However, this may come at the cost of reduced business certainty, for example, shipping companies will not know exactly how the tax or levy will change over time. This is an important point because **the expectation of what the carbon price will be in the future is key to establishing the business case for zero-emission investments**. Price corridors – i.e. setting a band of minimum and maximum carbon prices – could be implemented to offset some of the business uncertainty with future carbon pricing. Such a measure can help to de-risk investment decisions and thereby facilitate the transition to new fuels and energy sources.

2.1.2 Feebates

A feebate is a variant of a tax/levy. In a feebate system, an emissions or carbon intensity benchmark is set. The benchmark can be kept constant or become more stringent over time to increasingly incentivise zero-emission shipping operations. Those participants (i.e. shipowners/operators) emitting above the benchmark are charged fees, whilst those with emissions below the benchmark receive rebates generated from the fees collected (hence the word ‘feebate’, a contraction of ‘fee’ and ‘rebate’), see Figure 6 below for an illustration. Under a feebate system. vessels with high emissions/carbon intensity are penalised whilst vessels with low emissions/ carbon intensity are rewarded.

7. Despite ‘tax’ and ‘levy’ often being used interchangeably, there is a difference between the two instruments related to the revenues generated: revenue generated by a tax is not designated for a specific purpose and is paid to the administering State, whereas revenue generated by a levy is earmarked for a specific purpose (United Kingdom 2020).

Figure 6:
Illustrative feebate mechanism



A feebate mechanism offers added value by providing incentives for continuous improvement in carbon intensity, investment in zero-emission fuels and technologies and more efficient operations, thereby stimulating innovation and reducing emissions. However, similar to emissions taxes/levies, the achievement of certain environmental targets cannot be guaranteed and the viability and environmental effectiveness of feebates will, to a large extent, depend on the regulator's ability to set a benchmark[8] fee and rebate at the appropriate level. In addition, there is the possibility of greater uncertainty in achieving given targets for absolute emission reductions where the system is based on carbon intensity. Feebates may also lead to – or exacerbate an existing – two-tier market as low- or zero-emission vessels would be rewarded, whereas high-emission vessels are penalised, which could make it harder for the latter to make the necessary investments to meet the required benchmark. Essentially, some owners may find themselves paying fees whilst simultaneously trying to invest in alternative technologies/fuels which can be financially burdensome.

8. The short-term measures adopted by the IMO at MEPC 76 in June 2021 could provide the basis for setting the benchmark for a feebate mechanism: the annual operational CII for setting operational efficiency benchmarks or the EEXI for technical efficiency benchmarks. Operational energy efficiency is the consequence of a combination of both technical efficiency and how the ship is operated, so operational energy efficiency encompasses technical efficiency, whereas technical efficiency is only weakly related to operational efficiency. This means that using the CII as a policy lever can drive efficiency improvements and emissions reductions more directly than the EEXI. However, the currently more limited scope of the CII compared to the EEXI – the former applying to ships of and above 5,000 GT and the latter to those of 400 GT – will need to be taken into consideration. All measures that regulate on the basis of energy efficiency or carbon intensity do not provide certainty over the absolute level of emissions reduction that is likely to be realised (see Section 3.1.1 for more information on this point).

2.1.3 Emissions Trading System

In contrast to an emissions tax or levy, an Emissions Trading System (ETS) is a quantity instrument: an emissions target or baseline is set by the regulator, but not the carbon price to achieve it. Instead, the market creates the carbon price (referred to as allowance price). The two main types of ETS are cap-and-trade systems and baseline-and-credit systems:

- In a **cap-and-trade system**, an upper limit on emissions is fixed (cap), and emissions allowances (each one usually representing the right to emit one tonne of CO_2 or CO_2e) are auctioned (market-based price setting-approach) or distributed for free according to specific criteria ('grandfathered'). The amount of distributed emission allowances equals the amount of emissions equivalent to the cap. Regulated entities then have the option of either reducing emissions to the required level or to acquire emission units in the carbon market (UNCTAD 2018; World Bank Group 2021).

- Under a **baseline-and-credit system**, baseline emissions levels are defined for individual regulated entities and emission credits are issued to entities that have reduced their emissions below this level. These credits can be banked or sold to other entities exceeding their baseline emission levels (World Bank Group 2021; Sweden 2007). The baseline emissions level can either refer to absolute emissions or to emissions intensity (C2ES 2016).

A cap-and-trade system has a higher degree of certainty over the environmental outcome in comparison to emissions tax/levy mechanisms. The system incentivises actors to realise emissions reductions which can be achieved quickly and cheaply as they can then sell the achieved abatements to others – it thereby encourages the uptake of so-called 'low-hanging fruits'. In contrast, this system does not bring the added value of incentivizing participants to reduce their emissions beyond the targets set by the system. In comparison, a baseline-and-credit system provides participants with the incentive firstly to reduce their emissions below the baseline to avoid the need to buy permits for excess emissions, and secondly, to reduce their emissions further in order to generate sellable credits.

One of the often-mentioned drawbacks of ETS is the uncertainty over the price of carbon and potential price volatility which could make corporate planning difficult and may prove unattractive to risk-averse investors. However, this uncertainty over future carbon/allowance prices could be mitigated through the introduction of price corridors. In addition, creating a precise monitoring and enforcement system would be necessary to avoid non-compliance and cheating. Monitoring and enforcement are of course needed for any policy measure, but are particularly important for an ETS to be effective as the price-setting mechanism is sensitive to the participants' reporting.

2.1.4 Subsidies

An environmental subsidy or similar transfer is defined as 'current or capital transfer that is intended to support activities which protect the environment or reduce the use and extraction of natural resources' (UN et al. 2014, §4.138). In the context of this report, subsidies work by lowering the cost of alternative zero-emission fuels, rather than by increasing the price of conventional fossil fuels.

Regarding the decarbonisation of shipping, three types of subsidies appear well-suited to support closing the competitiveness gap:

- **Fuel subsidies: Introduced at the fuel consumption/utilisation stage and usually given in the form of a financial support mechanism to an entity** (Tyner & Taheripour 2007)**. They can be granted as a cash handout or a tax break and can take the form of direct financial support per unit of fuel, or per unit of GHG reduction**. Fuel subsidies have been criticised for potentially creating social costs (deadweight losses) and leading to higher position prices (Gardner 2007). This is because the funds provided by the subsidy could incentivise more production of goods than demanded by the market, thus leading to oversupply and potential deadweight losses. On the other hand, manufacturers could – rather than using the subsidy to lower the market price of the product – simply increase their profit margin and continue selling the product at a higher market price, thus decreasing the benefits of the subsidy for decreasing the price difference and the competitiveness gap. Such concerns would have to be addressed by creating subsidies which are adequately targeted to support alternative fuels and technologies, whilst being re-evaluated over time. If subsidies were adequately set up to address such concerns, they could play an important role in reducing the competitiveness gap. However, the question remains as to where the revenue to fund such subsidies could come from. This is discussed further in Section 2.2.1 below.

- **Production subsidies: Introduced at the production stage to financially support the higher production costs of zero-emission vessels and/or additional costs associated with the production of zero-emission bunkering infrastructure**. They can fund a certain percentage of overall capital expenditure (CAPEX). In the case of subsidising the production costs of zero-emission vessels, the subsidy could pay for a certain amount of the overall capital investment associated with the vessel production – usually, the subsidy would cover the additional capital costs for the zero-emission vessel, compared to a vessel of the same size/specifications fuelled by conventional fuels. The support for measures could also be linked to the GHG emission reduction potential they have, compared to a reference ship.

- **R&D subsidies: Introduced to support R&D into alternative fuels and technologies which could lower their prices through new technological developments and support innovation and first movers** (González et al. 2005). In the case of zero-emission fuels, such subsidies could be introduced in several technological development areas where they could lead to a long-term reduction in costs of associated supply components such as electrolysers and storage (Lloyd's Register & UMAS 2019).

In addition to the different types, subsidies can also take various forms. One example is the **Contract for Difference (CfD) Scheme** to support low-carbon electricity generation in the United Kingdom which has been instrumental in driving rapid cost reductions within offshore wind (UK BEIS 2020; KPMG 2019). **The CfD scheme offers price certainty to investors in projects with high upfront costs, by removing price volatility** where investors can enter a 'sealed bid'. The developers are paid a flat rate for the electricity, produced over an extended period, which covers the difference between the cost of investment and the market price. Clark et al. (2021) explore the application of this policy instrument to the decarbonisation of shipping, unpack design and implementation decisions and assess two CfD options in more detail: one based on fuel-only solutions and the other on the total cost of ownership covering all costs associated with building and operating a zero-emission ship.

CfD, production subsides and R&D subsidies are all examples of policy options which promote and support the production of alternative zero-emission fuels. As such, they complement demand-side policy e.g. carbon pricing or command-and-control measures. Combining both demand- and supply-side policies is viewed as a more effective mix than stimulating only one side of an energy transition (Mazzucato 2018).

It should be noted, however, that **subsidies may not be an option for all economies and need to be carefully designed to avoid creating competitive distortions and to maintain alignment with World Trade Organization and European Union (EU) State Aid rules** (see e.g. Charnovitz 2014; Pirlot 2017). Subsidies have also been criticised for picking winners and are highly dependent on the information available to the subsidy-awarding body. In cases where significant uncertainty over technology pathways exists, subsidies could be designed to support multiple options, which in turn could allow the market to determine the most suitable transition pathway for the sector. Furthermore, subsidising fuels is a well-established practice with long-standing subsidies for fossil fuels still in existence (IEA 2021a; Roberts 2016).

While subsidies alone are unlikely to decarbonise the shipping industry, they could play an important role in closing the competitiveness gap by lowering the prices of zero-emission technologies and fuels and stimulating RD&D and innovation. They could also be designed to support an equitable transition in developing countries, SIDS and LDCs.

2.2 Possible Level of the Carbon Price

In order to ensure that a carbon pricing instrument achieves its stated goals, it is important that the carbon price is set at the 'correct' level. Depending on the objective of the carbon pricing instrument, there are several different approaches to determining what the 'correct' level is:

- Using the **Social Cost of Carbon (SCC)**: If the objective is for the carbon price to reflect the costs to society of each additional tonne of CO_2 emitted, SCC values could be used to determine the carbon price. It should be noted that there are significant uncertainties related to SCC estimates which means that such estimates vary widely (Evans et al. 2017).
- Using **target-consistent carbon prices**: If a certain climate target is to be reached, it is possible to work backwards from a given emission reduction or temperature goal (e.g. Paris Agreement temperature goal, IMO's levels of ambition) and estimate what the level of carbon price would be needed to achieve this goal. This is often done using techno-economic modelling and/or marginal abatement cost curves (MACCs) which represent the relationship between the total reduction of GHG emissions and the cost efficiency for individual abatement measures (Faber et al. 2020a). While still subject to significant uncertainties, this approach is considered to be less uncertain than determining SCC values (Rogelj et al. 2018).
- **Raising a certain level of revenue**: If the aim is to raise a certain level of revenue from the carbon pricing instrument, one can calculate what the carbon price would need to be to achieve this level of revenue.
- **Replicating price levels used in other carbon pricing schemes**: In order to increase political acceptability of a carbon pricing instrument, one idea would be to replicate price levels used in existing carbon pricing schemes. However, these vary widely and despite increasing in many jurisdictions, they remain substantially lower than those needed to be consistent with the Paris Agreement (World Bank 2020).

As the objective here is to identify the carbon prices needed to achieve the levels of ambition of the IMO's Initial GHG Strategy, the most appropriate approach is to use target-consistent carbon prices.

To estimate carbon price levels needed to meet the IMO's levels of ambition, this report builds on different scenarios and techno-economic modelling conducted by Smith et al. (2019). The assumptions behind the scenarios and the modelling approach are explained in detail in Smith et al. (2019). Two scenarios are used, achieving a 50% and 100% reduction in absolute emissions by 2050 respectively.

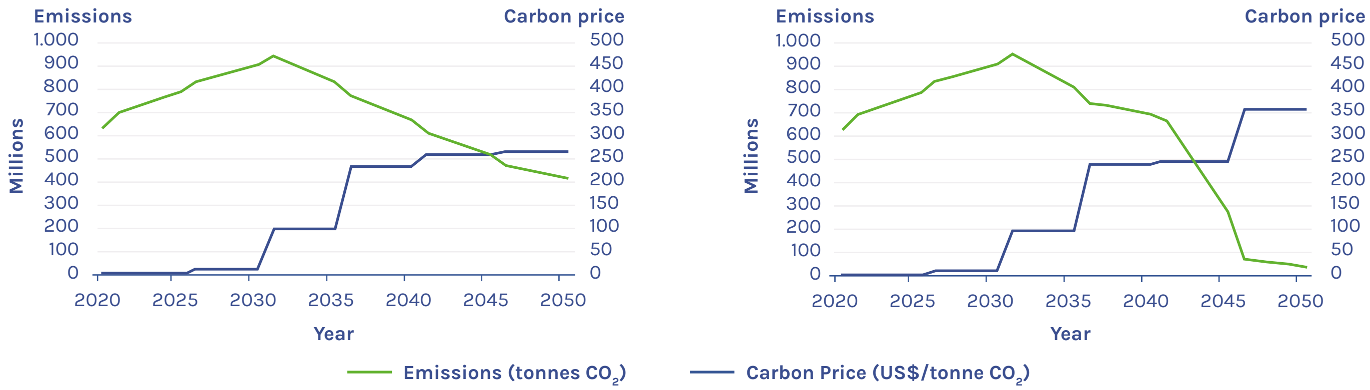
The model suggests that **in order to achieve the lowest ambition of the IMO's Initial Strategy – i.e. reduce ships' GHG emissions by 50% by 2050 compared to 2008 - an average carbon price of US\$173/tonne CO_2 would be needed. To fully decarbonise shipping by 2050, the average carbon price would only need to be slightly higher, around US\$191/tonne CO_2**. Both scenarios assume that carbon pricing begins in the mid-2020s at which point a relatively low carbon price of US\$11/tonne CO_2 is introduced. However, for the first five years, this low carbon price does not have a significant effect on emissions which rise until a peak in 2030.

The lower initial carbon price could allow for an adjustment period for the industry, and the collected revenue (i.e., if recycled) could facilitate initial diffusion of zero-emission fuels into the industry. It would be unlikely to drive major behavioural change towards zero-emission fuels apart from certain niche industry segments and could support uptake of some lower-cost energy efficiency options. **To incentivise the switch to zero-emission fuels, the carbon price would then need to ramp up to close to US$100/tonne CO_2 in the early 2030s and be around US$230-260/tonne CO_2 between 2035-2045. To reach full decarbonisation by 2050, the carbon price in the more ambitious scenario would need to increase even further to around US$360/tonne CO_2**, whereas it could largely stay the same (US$264/tonne CO_2) in the minimum ambition scenario. The carbon price trajectories and their associated emissions trajectories are shown in Figure 7 below.

Figure 7:
Carbon price trajectories and associated emissions projections for two decarbonisation scenarios

Scenario E: Target of 50% absolute reduction in operational shipping GHG emissions globally by 2050 (compared to 2008); zero operational shipping GHG emissions globally by 2070.

Scenario D: Target of zero operational shipping GHG emissions globally by 2050



Source: based on Scenarios E and D in Smith et al. (2019)

These two scenarios illustrate the range the carbon price levels would need to be in if carbon prices were the only policy measures put in place to achieve the IMO's levels of ambition and decarbonise shipping. In turn, this also means that **if lower carbon prices are implemented, additional measures will be needed to drive the same levels of decarbonisation**.

It should also be noted that even though the carbon prices as modelled in the two scenarios start at a very low level, they make two significant price increases over the following decade. **These two price jumps may be challenging from both a political and practical business perspective; thus, it could be better to set the initial carbon price at a higher level than the model suggests and follow a smoother increase, thereby easing potential economic shocks of sharp price increases**. This could also help by ensuring that there is an emergence phase of the transition during the 2020s (e.g. funding Research, Development and Deployment (RD&D) to reach 5% fuel penetration by 2030), which enables shipping-specific cost reductions prior to the more rapid uptake of new fuels scheduled for the 2030s.[9]

9. For more information, please see Osterkamp et al. 2021.

A further factor for consideration is the need to overcome market barriers (such as those mentioned in Section 1.2). **The presence of market barriers means that the carbon price required to stimulate action to reduce emissions, i.e. change market behaviours, is higher than the carbon price needed if there are no existing market barriers** (Smith et al. 2019). This is because the cost of overcoming the barriers must be met in addition to the abatement action cost and as such, a greater price signal is required (ibid). The added need to overcome market barriers has been incorporated into the pricing scenarios in this report.

Of course, modelling exercises, such as the one cited above, work on the basis of various assumptions which may not always reflect reality and hence, they can only provide indications on the carbon pricing levels needed. Therefore, **review and adjustment mechanisms would need to be built into a carbon pricing scheme**, taking into account continued technological developments of alternative technologies, global market trends and success of the scheme in achieving the required levels of emissions reduction and supporting decarbonisation up to that point.

The scenarios depicted in Figure 7 above show rising carbon price trajectories until 2050. While the literature generally agrees on the need for rising carbon prices, some research suggests that rather than continuing to climb, the carbon price may start to decline after 2050 (Daniel et al. 2019). This is attributable to the insurance value of mitigation declining, as well as cost reductions through technological development making emissions cuts cheaper (ibid.).

2.2.1 Implication of Revenue Recycling for Carbon Pricing Levels

Depending on their design, **emissions levies/taxes, feebates and ETS all have the potential to generate revenues**. There are different revenue usage options, both within the maritime sector as well as externally (see Section 2.3.2). This section will explore the implications on the level of the carbon price of 'recycling' revenue back into the shipping industry and using it, through various subsidies, to further support closing the competitiveness gap between zero-emission and fossil fuels. Such subsidies could for example be used to fund the deployment of zero-emission fuels and technology.

By combining a carbon pricing mechanism with revenue recycling in the form of subsidies, the competitiveness gap can be narrowed, or even closed, by simultaneously increasing the costs of using fossil fuels (carbon pricing) and reducing the costs of zero-emission fuels (revenue recycling).

Figure 8 below describes the carbon price which would be needed to close the competitiveness gap between fossil fuels and zero-emission fuels considering varying degrees of revenue recycling. It is based on the same scenarios as Figure 7 above, but what is considered here is the effect that different percentages of revenue recycling would have on the carbon price. The '0% carbon price' in Figure 8 below is the carbon price which would be needed if there was no revenue recycling and consequently no subsidy. On the other end of the scale is the '100% carbon price' which assumes that all the revenue collected from a carbon pricing mechanism would be recycled through subsidies to support zero-emission marine fuels. In between these two poles is a range of potential carbon prices, which become lower as the revenue recycling percentage increases (and vice versa). This is because with larger percentages of revenue recycling, larger amounts of funds can be invested into zero-emission fuels and associated infrastructure, which in turn means that a smaller proportion of these costs is being carried on to the shipowner.

The carbon price levels incorporating revenue recycling have been calculated as follows:

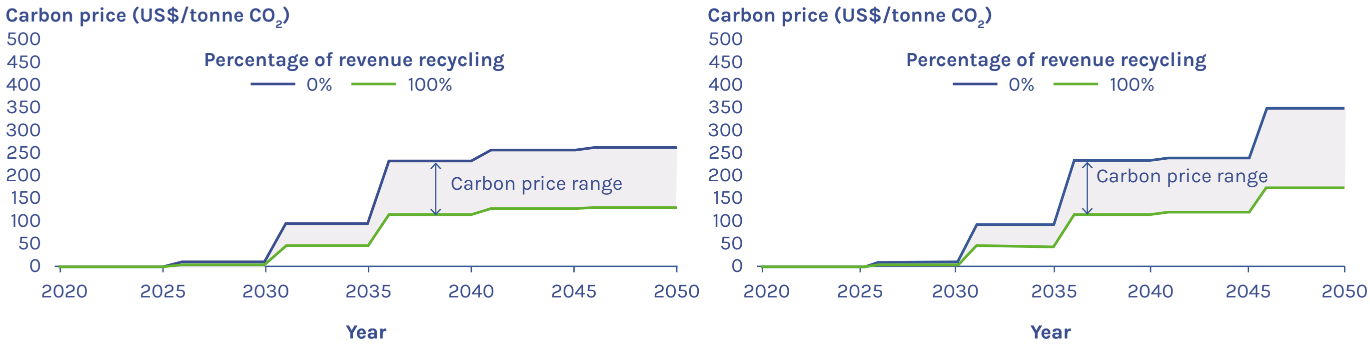
$$\textit{Carbon Price with Revenue Recycling} = \frac{\textit{Carbon Price without Revenue Recycling}}{1 + 1 * \textit{\% of Revenue Recycled}}$$

The calculation assumes no transaction costs, productivity or other additional costs.

Figure 8:
Carbon price trajectories based on % of revenue recycling for two decarbonisation scenarios

Based on Scenario E which has a target of 50% absolute reduction in operational shipping GHG emissions globally by 2050 (compared to 2008); zero operational shipping GHG emissions globally by 2070.

Based on Scenario D which has a target of zero operational shipping GHG emissions globally by 2050.



Source: Based on Scenarios D and E in Smith et al. (2019).

As shown in Figure 8 above, **if a 100% of the revenue generated by a carbon pricing mechanism was reinvested into the industry through subsidising zero-emission fuels and associated infrastructure, the carbon price necessary to close the competitiveness gap between fossil fuels and zero-emission fuels could in theory be halved**. In the scenarios shown here, this would mean that to reduce emissions by 50% by 2050 compared to 2008 emissions, the average and maximum carbon price needed would be US$87/tonne CO_2 and US$132/tonne CO_2, respectively. Zero operational shipping emissions could be achieved globally by 2050 with an average and maximum carbon price of US$96/tonne CO_2 and US$179/tonne CO_2, respectively.

It should be noted that in practice, the carbon price does not need to be lowered if revenue is recycled into the shipping industry. The point here is to demonstrate that **carbon prices could be decreased to the lowest possible level through revenue recycling, whilst still achieving**

the same environmental outcomes. A carbon price that is higher than necessary would then provide additional financial incentives for a zero-emission transition, and generate more revenues which could be used for different purposes (see Section 2.3).

It is worth noting that the relationship between the carbon price and revenue collected depends on modelling assumptions, including global transport demand, future fuel cost assumptions and the emission reduction pathway for which only one scenario is being presented here. The collected revenue should be considered in terms of the total amount of available revenue which can be distributed over the period of decarbonisation (from 2025-2050), rather than assuming the revenue will be deployed only in the year it is collected. This scenario generally provides more subsidy/support for zero-emission fuels early in the transition when price spreads to zero-emission fuels are expected to be highest, and less towards the end of the transition when zero-emission fuels are more established and have a lower price spread. Other scenarios and spending profiles are conceivable.

2.3 Potential Revenue Generation and Usage Options

Most of the carbon pricing mechanisms covered in Section 2.1 – i.e. taxes/levies, feebates, ETS - have the potential to raise revenues. This section starts by calculating the potential volumes of revenue raised from a carbon pricing scheme based on the carbon price levels discussed in Section 2.2, and then outlines different options to use these revenues.

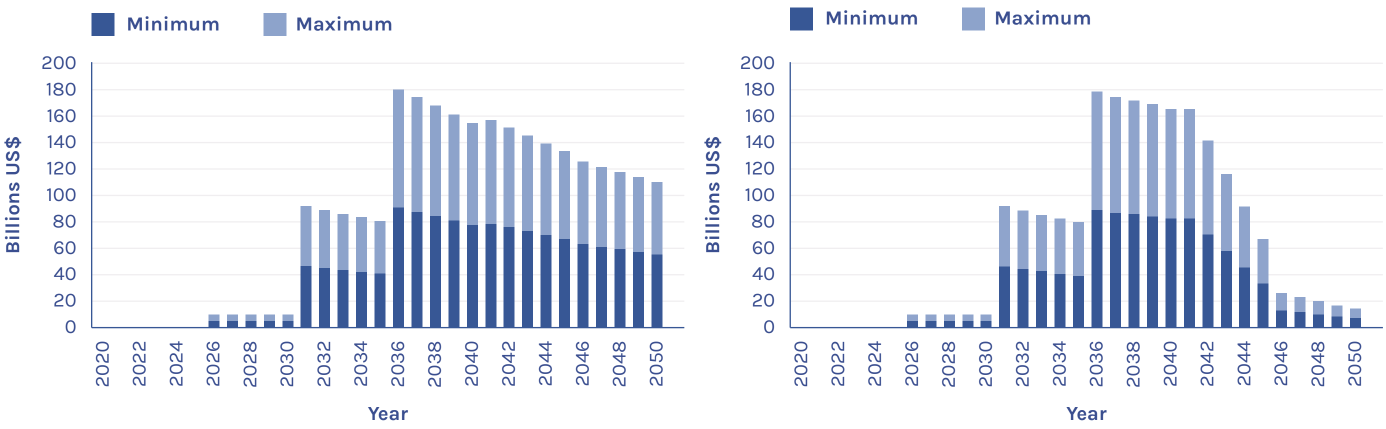
2.3.1 Potential Amount of Revenue Generated

Figure 9 below shows the range of revenues that can be collected on an annual basis using the carbon price levels identified in Section 2.2 above, taking into account no- and full-revenue recycling. These are calculated by multiplying the carbon prices for every year (the carbon prices required at 0% and 100% revenue recycling, as illustrated in Figure 8 above) with the projection of total emissions from international shipping in that same year. The light blue bars show how much revenue would be generated in a given year if no revenue was recycled back into the shipping industry and hence the carbon price was as high as calculated by the model. It represents the maximum amount of revenues that can be generated based on the given assumptions about carbon price levels and emissions trajectory. The dark blue bars, on the other hand, illustrate the amount of revenue generated if the carbon price estimated by the model was halved through recycling 100% of the revenues back into shipping and represents the minimum amount of revenues that could be generated.

Figure 9:
Future revenue range from carbon price, based on % of revenue recycling for two decarbonisation scenarios

Based on Scenario E which has a target of 50% absolute reduction in operational shipping GHG emissions globally by 2050 (compared to 2008); zero operational shipping GHG emissions globally by 2070.

Based on Scenario D which has a target of zero operational shipping GHG emissions globally by 2050



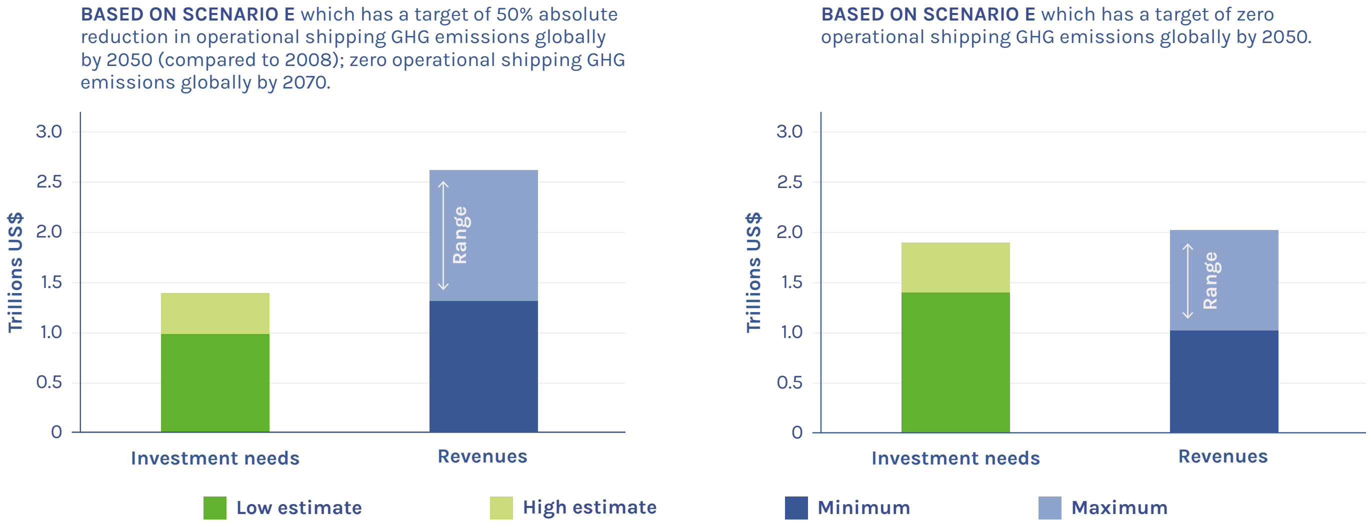
Source: Based on Scenarios D and E in Smith et al. (2019).

Figure 9 above shows that as the carbon price increases over time, the amount of revenue that can be collected increases significantly by the mid-2030s. From then on, however, revenues decrease gradually as the model anticipates that more and more shipowners will opt for zero-emission fuels, meaning that they do not need to pay carbon prices and hence less revenue is collected. Somewhat counterintuitively, a higher carbon price and a faster decarbonisation trajectory in the scenario targeting full decarbonisation by 2050 result in a lower amount of total revenue generated. That is because in this scenario, emissions reduce rapidly from the early 2040s to achieve zero emissions by 2050 and with that, the potential for generating revenues decreases as well.

The figures give the upper and lower limits for the range of revenue that can be collected from a carbon pricing mechanism based on the same scenarios already used in Section 2.2.

In the scenario targeting a 50% global reduction of operational shipping emissions by 2050, the average amount of revenue collected would range between US$53 and US$105 billion per annum depending on the level of revenue recycling, totalling between US$1.3-2.6 trillion. **In the scenario in which shipping decarbonises by 2050, the annually collected revenues would on average range between US$41 and US$81 billion, totalling between US$1.0-2.0 trillion**. This means that in the -50% GHG reduction scenario, the revenues generated could cover the US$1-1.4 trillion of investment required (see Section 1.1 for the investment requirements). In the scenario in which shipping decarbonises by 2050, the revenues collected could cover most or all of the US$1.4-1.9 trillion investment required. Figure 10 below compares the investment needs to decarbonise shipping with the potential amounts of revenues generated depending on the carbon price, the level of revenue recycling and the emissions trajectory. The minimum revenue (dark blue bar) is based on the lowest required carbon price (i.e. at 100% revenue recycling) in all years, whereas the maximum revenue (light blue bar) presumes a carbon price which could reach the 2050 decarbonisation target without any support from revenue recycling. The regulator could choose a price level that is somewhere in that range of carbon prices.

Figure 10:
Total investment needs compared to total revenues that could be generated



It should be noted that the 'investment needs' figures cover both private and public investment. This means that the revenues collected, representing public funding, would not need to cover the entire investment costs as they will only need to complement private investments. This is particularly the case as the introduction of a carbon price would help establish viable business cases for private investments.

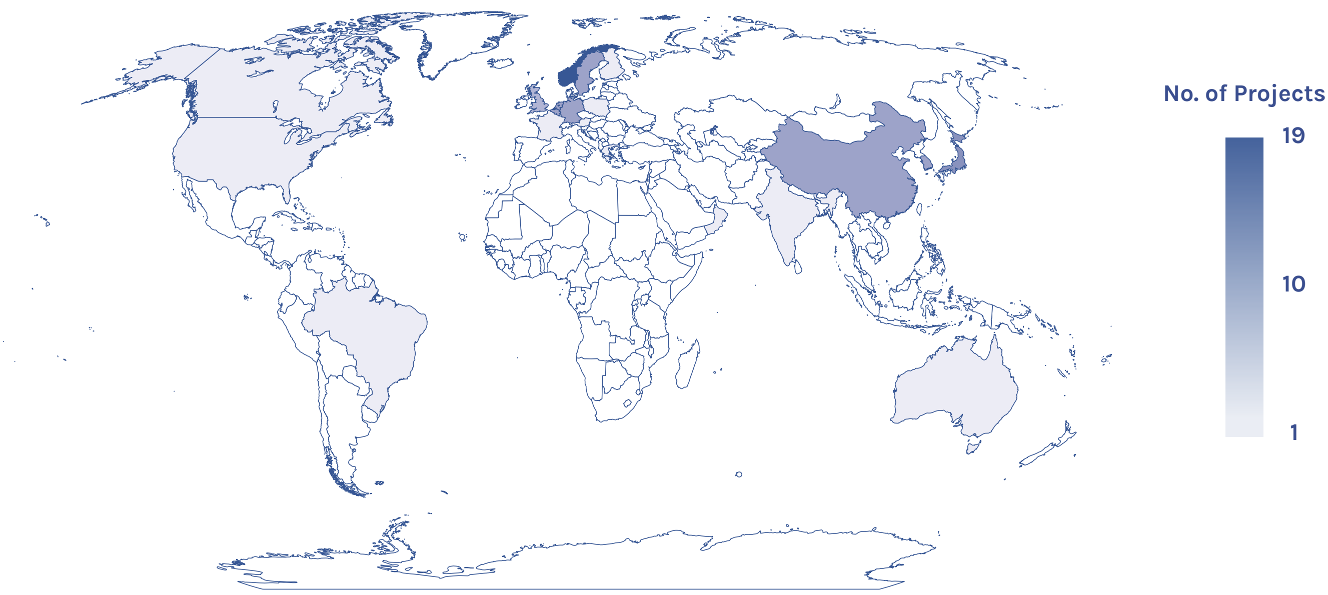
2.3.2 Options for Using Revenues generated by Economic Instruments

Considering the large amounts of revenue that could potentially be collected from a maritime carbon pricing instrument, it is important to carefully consider how such revenues could be spent. Section 2.2.1 has already outlined the potential usefulness of recycling revenues back into the maritime sector in the form of, for example, subsidising the deployment of zero-emission fuels and technology. Other usage options include, but are not limited to, the following:

- **Addressing disproportionately negative impacts on States**: If disproportionately negative impacts on certain States are expected, they could be addressed through value transfers and payments which could be financed from revenues. Such transfers and payments could be disbursed to certain States to absorb disproportionately negative impacts on imports or exports, to shipowners or shipyards to build a clean fleet, to ports and other transport infrastructure operators to improve efficiency and bring down transport costs at their respective level of the supply chain or to fuel suppliers to develop zero-emission fuels (UNCTAD 2018). Other examples for revenue usage in connection with addressing disproportionately negative impacts include investments into general transportation infrastructure, trade and transport facilitation measures of disproportionately negatively impacted countries, but also include value transfers to be used at the discretion of those countries.

- **Capacity development and technology transfer**: According to a mapping conducted by Fahnestock & Bingham (2021), there are 106 projects underway focusing on the zero-emission pathways for the maritime industry. Even though the geographical spread of the projects has increased since the first review in 2020, with more projects taking place in Asia in particular, most projects have a significant connection to Europe (ibid.), see Figure 11 for illustration. Furthermore, IEA (2021b) reports that nearly all electrolyser manufacturing is in advanced economies and China, meaning that currently countries wishing to produce zero-emission hydrogen and hydrogen-derived fuels will need to rely on this manufacturing capacity.

Figure 11:
Country heatmap of zero-emission pilots and demonstration projects in the maritime industry



Source: GMF (2021)

This points to a potential need to support developing countries, SIDS and LDCs with capacity development and technology transfer activities. In this context, Chircop et al. (2018, p. 81) caution that 'On the one hand, open or fair access could significantly accelerate dissemination of new technological solutions in the shipping industry and among regulators, while on the other hand, intellectual property rights and the global competition in the industry are factors that may militate against such initiatives'. They suggest that some of the revenues of a maritime carbon pricing measure could be directed toward maritime R&D for the public domain to make future technological developments subject to open access (Chircop et al. 2018). In addition, revenues could be used to finance capacity-development activities to support the implementation of maritime climate policies in those developing countries, SIDS and LDCs that have less capacity. In this way, revenues would both help to achieve climate change goals as well as enable an equitable transition.

- **Climate finance**: To date, finance flows are inconsistent with zero-emission and climate resilient pathways: For example, IPCC (2018) shows that **to limit warming to 1.5°C, annual investment needs in the energy system alone are around US$2.38 trillion between 2016 and 2035**. This contrasts with climate finance flows in 2017 and 2018 which averaged at US$ 574 billion per year (Macquarie et al. 2020). This points to a **significant discrepancy between the needs and the provision of climate finance**. The report of the High-Level Advisory Group on Climate Change Financing in 2010 identified that a revenue-generating maritime carbon pricing instrument could potentially mobilise significant public resources for climate action in developing countries (AGF 2010). Similarly, IPCC (2018) reports that levies on international maritime transport could raise resources for adaptation, for achieving the Sustainable Development Goals and meeting basic needs. During the previous MBM negotiations at the IMO, the use of revenues was discussed. MEPC 59 in 2009 'noted that there was a general preference for the greater part of any funds generated by a market-based measure under the auspices of the IMO, to be used for climate change purposes in developing countries through existing or new funding mechanisms under the UNFCCC or other international organizations' (IMO 2009). Around that same time, Anger et al. (2009) found in an IMO-commissioned study that large revenue transfers for climate projects in SIDS, LDCs and landlocked developing countries could prevent negative impacts of maritime carbon pricing measures and even result in positive ones, for example growth in Gross Domestic Product.

- **Crew training**: The correct handling of zero-emission technologies and fuels will require new crew training courses and initiatives (see e.g. ABS 2020, ETC 2020, Lloyd's Register & UMAS 2019, Rehmatulla et al. 2017). Carbon pricing revenues could be used for this and thereby support the industry's zero-emission transition.

- **Satisfying the need to be cognisant of the CBDRRC principle**: As outlined in Section 1, the need to be cognisant of CBDRRC, in the light of different national circumstances, is one of the guiding principles of the Initial GHG Strategy. Some of the revenue use options outlined above could satisfy the need to be cognisant of this principle.

- **Ship-level incentives**: Revenues could be distributed to vessels that have lower emissions or carbon intensity levels compared to their peers or compared to a certain benchmark. This could incentivise shipowners and operators to further invest and implement relevant technologies and operational solutions (UNCTAD 2018).

The World Bank (2021) suggests several criteria against which different revenue use options could be assessed - i.e. their alignment with the Initial IMO Strategy (specifically addressing disproportionately negative impacts and the need to be cognisant of CBDRRC), climate benefits, non-climate-related development benefits and political acceptability – and provide a brief assessment on that basis.[10]

10. This brief assessment is high-level and based on broader research that is currently being carried out by the World Bank (World Bank 2021)

It is conceivable that revenues from a maritime carbon price – should one be implemented – would be used for several purposes. In this context, it would be helpful to identify potential connections and reinforcing relationships between the different revenue use options. For example, recycling revenues into the deployment of zero-emission technologies and fuels may reduce the level of the carbon price needed for achieving the same environmental outcome, which in turn could reduce disproportionately negative impacts on States and thus the need to address these.

Similarly, channelling revenues into climate mitigation and adaptation activities in SIDS, LDCs and landlocked developing countries could not only prevent negative impacts of maritime carbon pricing measures, but also result in positive ones. **Further investigation and deliberation on this subject are needed, both in terms of the assessment criteria and the selection of revenue use options, taking into account their interactions and the need to enable an effective and equitable transition.**

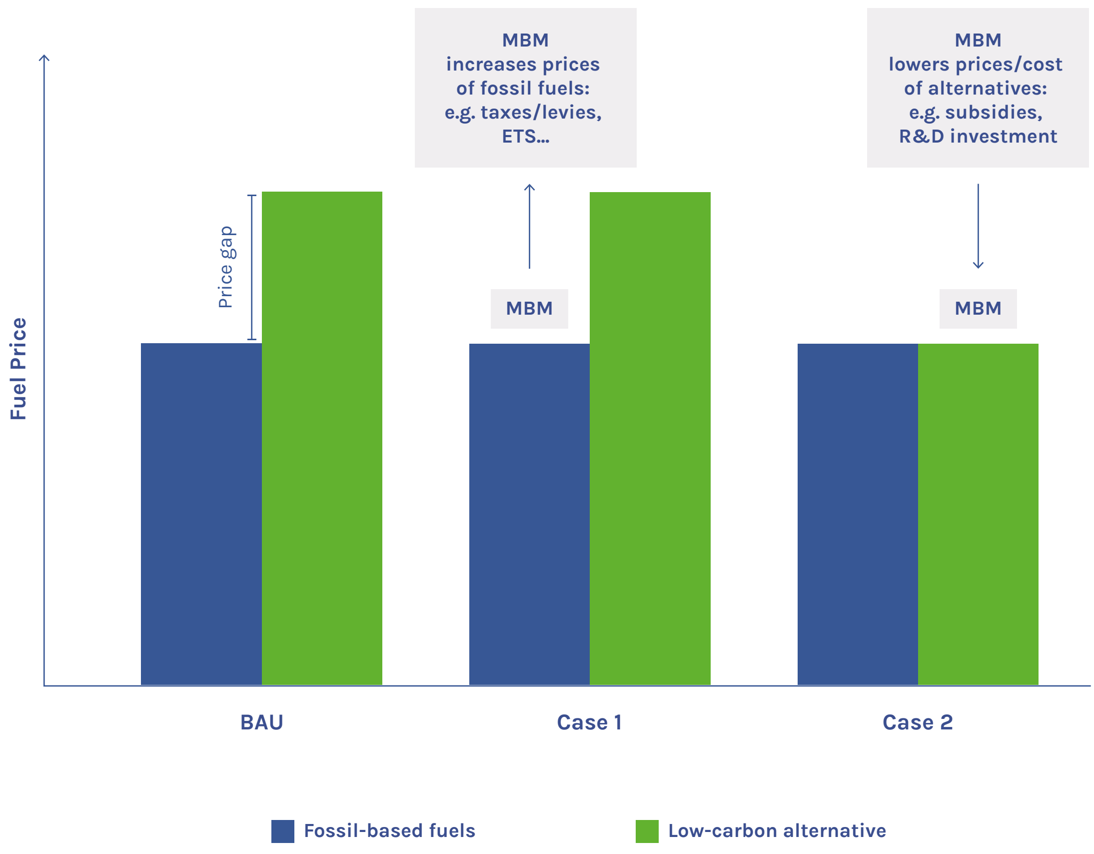
In light of the potentially large sums of revenue generated from a maritime carbon pricing instrument, another important question is how to manage revenue distribution effectively without incurring significant administration and transaction costs. For some of the revenue usage options, there are existing mechanisms which could be used. With regards to climate finance, financial mechanisms have been established under the UNFCCC and other United Nations organisations with already determined allocation and distribution criteria and mechanisms. For technical cooperation and capacity development activities related to the implementation of the Initial GHG Strategy, the IMO's voluntary multi-donor 'GHG TC-Trust Fund' could be used. Furthermore, a share of the revenues could be allocated and managed 'passively' using the feebate mechanism, potentially leaving only a small share that would need active management.

2.4 Economic Instruments, the Competitiveness Gap and an Equitable Transition

Economic instruments can contribute to closing the competitiveness gap between fossil and zero-emission fuels by mitigating the difference in the prices between these fuels. They can do so in two ways:

- By increasing the costs of using fossil fuels, e.g. through a carbon price, thereby closing the gap and increasing the competitiveness of zero-emission fuels (Case 1 in Figure 12 below); and/or
- By reducing the costs of zero-emission fuels, e.g. through tax breaks, stimulating RD&D to enable cost reduction, or subsidising in some way either the capital costs or operating costs of zero-emission alternatives (Case 2 in Figure 12 below).

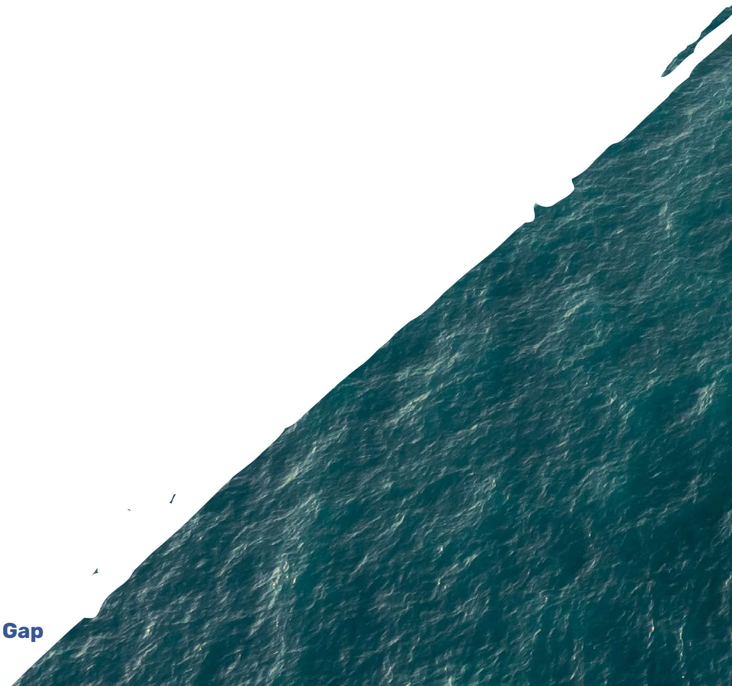
Figure 12:
Schematic outlining the principal function of an MBM



Source: Suarez De La Fuente et al. forthcoming.

Furthermore, economic instruments offer different options to address potential disproportionately negative impacts on States and to enable an equitable transition without reducing the environmental effectiveness of the measure. This is due to the fact that, depending on their design and stringency levels, they have the potential to generate a significant amount of revenues. These revenues could be used towards equity-related objectives, for example value transfers to, and investments in, disproportionately negatively impacted countries, capacity development and technology transfer activities as well as climate finance benefitting developing countries, SIDS and LDCs.

One notable shortcoming of MBMs is that they do not directly address all types of market failures, for example, while MBMs do function as a corrective mechanism for negative environmental externalities, they do not address informational issues or split incentives directly. By only addressing one market failure, the value gained by the MBM could be undermined by the costs for design and implementation. Furthermore, high monitoring costs and inefficient application of revenue generation features could significantly undercut the cost effectiveness of MBMs. Nevertheless, **MBMs can contribute to closing the competitiveness gap and depending on their design, generate useful revenues for stimulating innovation and transition, addressing disproportionately negative impacts on States and enabling an equitable transition.** Section 3 moves on to discuss direct regulatory measures.



3. Direct Regulatory Approaches

Regulatory approaches constituted the first environmental policies and remain very important in environmental and climate policies around the world (Somanathan et al. 2014). Often referred to as command-and-control measures, they prescribe the actions a firm must take or the environmental results it must achieve (Sterner & Robinson 2018). They establish a rule and/or an objective that polluters must fulfil and a penalty for failure (Somanathan et al. 2014).

Standards applicable to climate change policies can fall into several categories, mainly:

- Performance or Emission Standards
- Technology Standards
- Product Standards (Somanathan et al. 2014)

Section 3.1 briefly outlines these different standards and how they relate to maritime transport.

3.1 Types of Direct Regulatory Approaches

3.1.1 Performance Standards

Performance standards (or emissions standards) set specific performance goals that must be achieved, but without mandating which technologies or techniques to use to achieve said goals. For example, they specify the maximum allowable GHG emissions from certain activities or regulate the carbon intensity of those activities.

There are numerous examples of performance standards used by the IMO to prevent environmental pollution, some of which include:

- The **Ballast Water Management Convention** sets standards for the ballast water exchange and the ballast water treatment performance.
- **Nitrogen oxides (NO_x) Tier III standards** limits NO_x emissions at varying degrees for ships built on or after January 2016 and operating in Emission Control Areas.
- **The EEDI** is a CO_2 intensity metric which considers the total emissions of a ship (at the design stage) relative to the transport work done by the ship resulting in grams of CO_2 per tonne nautical mile.
- **The EEXI** will apply technical efficiency standards to the existing fleet.
- **The CII** will require ships to achieve a specified annual operational Carbon Intensity Indicator.

The last three examples listed above show that performance standards are already used with the aim of reducing GHG emissions from ships. However, it should be noted that **the stringency levels of these standards are currently too low to lead to significant emissions reductions and, by themselves, will not cause the sector to even meet the IMO's minimum level of ambition**.

Performance standards can provide a relatively high level of certainty about future emissions when they set absolute emission targets. However, relative targets – e.g. energy efficiency targets, fuel economy standards and carbon intensity targets – do not provide certainty over the absolute level of emissions reduction that is likely to be realised (Wilson et al. 2019). This is due to two reasons:

- **Inability to account for scale effects** – While emissions intensity could decrease, total emissions could continue to increase as a result of underlying economic conditions, e.g. increase in production, trade, growth in gross domestic product, etc. (Wilson et al. 2019).
- **Rebound effects** – Rebound effects refer to the potential that the demand for emissions-generating activity increases because of the target. This could arise if, for example, emissions are reduced through fuel efficiency measures which therefore save fuel costs. One response to this could be to increase the level of shipping activity because it now costs less. This reduces the benefits of the emissions savings that may otherwise have been achieved (Sorrell 2007). Another example can be seen in the ship-speed and efficiency relationships. If all else is equal, a ship has a commercial incentive to operate at a higher-than-average speed if it has better-than-average technical efficiency and if there is sufficient market demand (all else being equal). When a technically more efficient ship operates at an increased speed, the emissions savings achieved in practice are lower than those of the technical efficiency increase (Smith 2012).

It should be noted that these drawbacks are not unique to performance standards. Wherever a relative target is used (e.g. in economic instruments or in other standards), these effects can occur.

3.1.2 Technology Standards

Technology standards mandate which technologies or techniques must be adopted without specifying the overall outcome (Field & Field 2009). They are relatively common in legislation in many countries, partly because inspection, monitoring and verification of technological installations are relatively easy compared to verification of compliance with other environmental policies (Sterner & Robinson 2018).

An example of a technology standard in the context of policymaking at the IMO is the mandating of double hulls to reduce the risks of oil spills. Another example related to preventing oil pollution is the requirement to fit oil filtering equipment onboard ships.

With regards to decarbonising shipping, technology standards could, for example, mandate the use of wind propulsion technology, set mandatory speed limits, and phase out or ban the use of fossil fuels altogether.

3.1.3 Product Standards

Product standards define the characteristics of potentially polluting products and could include labelling of appliances in buildings, industry, and the transport sector (Kolstad et al. 2014). As polluting products, we include fossil fuels in this category.

One example of product standards being used to regulate pollution from maritime transport is the regulation of sulphur oxides and particulate matter. The principal approach taken by the IMO is to limit the maximum sulphur content of the fuel oils used. These limits were subject to staged reductions and are more stringent for ships operating within Emission Control Areas. **At the European level, the draft FuelEU Maritime Regulation envisages the introduction of a goal-based fuel GHG intensity target that increases in stringency over time** (Gozillon & Abbasov 2021), see also Section 6.

To decarbonise shipping, product standards could, for example, specify the maximum (lifecycle) carbon content of marine fuels used and set sustainability standards for marine fuels (e.g. biofuels). Blending standards could also fall into this category. However, these could cause some potentially adverse effects since many zero-emission fuels for shipping are not easily blended (e.g. hydrogen, ammonia) with distillates, thus such standards could unintentionally give precedence to options with less long-term decarbonisation potential like liquefied natural gas.

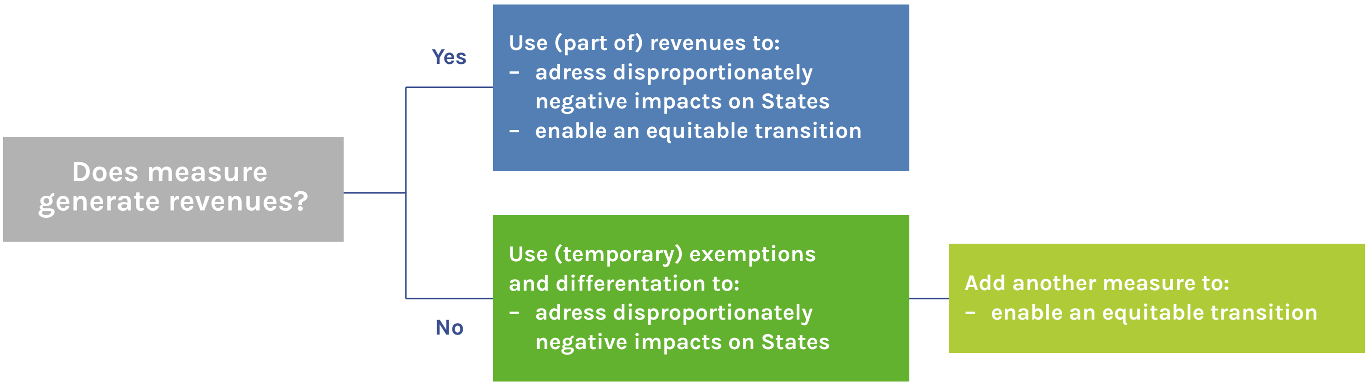
3.2 Direct Regulation, the Competitiveness Gap and an Equitable Transition

Technology, performance, and product standards can achieve the goals of the Initial GHG Strategy and decarbonise shipping by decreasing ship emissions directly and potentially internalising some of the costs associated with the operation of fossil-fuelled ships. They could have a positive effect on R&D (thereby alleviating informational problems) and stimulate the uptake of alternative fuels in a similar way to carbon pricing. By mandating certain activities or outcomes, they can also bypass split incentives between shipowners and charterers and nudge the industry forward in a way that can prevent infrastructural lock-ins and asset stranding.

Direct regulatory approaches, such as a fuel mandate, can be less cost-intensive to develop for the regulatory body because their design is relatively simple compared to MBMs. Without a revenue-generation and -recycling element, the regulator would not need to set up collection mechanisms or make distribution decisions. These are potentially some of the more contentious design elements in an MBM for shipping in light of the need to invest in shipping's decarbonisation, address disproportionately negative impacts and enable an equitable transition. This may also mean that a direct regulatory approach is simpler, which may make it more politically palatable to some than a revenue-generating MBM (Duval 2008), however, in general economic incentives are considered more cost-effective than direct regulatory interventions (Kolstad et al. 2014).

Nevertheless, one shortcoming of standards in the context of IMO climate regulation is that **because they do not generate revenues, disproportionately negative impacts on States – if identified – would need to be addressed through either the design of the measure itself or by adopting an additional measure that specifically addresses the disproportionately negative impacts on States**. Indeed, regulations that forgo revenue have implicitly higher social costs as they tend to exacerbate pre-existing (tax) distortions without providing the revenue to address these inefficiencies (Kolstad et al. 2014). Exemptions, differentiation of the standard's stringency or phased implementation are measures which could be designed into a standard to address disproportionately negative impacts on States. However, such measures could have adverse consequences. For example, if they're applied on routes servicing select countries, they remove incentives for the shipping fleet servicing those routes to transition to zero-emission technology and operations. According to the Solomon Islands and Tonga (2020, p. 2), 'this could result in a situation where States are being serviced by exempted ships that are increasingly more inefficient and older whilst others benefit from newer vessels and innovation through compliance with the measure.' They could also create loopholes and perverse incentives and risk carbon leakage. Furthermore, they would also lower the environmental effectiveness of the measure. To make up for this loss of effectiveness, higher stringency levels would either need to be applied to other shipping actors, or over time, or both. Ultimately, GHG emissions from shipping will need to reach zero, which means such measures would only buy the countries, to which they are applied, more time for the transition rather than actively supporting them in the transition. Similar to the difficulties of dealing with disproportionately negative impacts, if identified, **it is also not clear how standards could promote an equitable transition and satisfy the need to be cognisant of the CBDRRC principle**. In order to enable an equitable transition, it is likely that another (revenue-generating) measure would need to be adopted. This relationship is shown in Figure 13.

Figure 13:
Addressing disproportionately negative impacts and enabling an equitable transition with and without revenues



Ultimately, a direct regulatory approach has advantages and disadvantages compared to MBMs. The suitability and effectiveness of either approach depends on a number of factors including differing capacities between countries and the predictability or uncertainty of future policy (ibid). The following sections move on to consider alternative options for closing the competitiveness gap as part of an equitable transition.

4.

Information Programmes

Information programmes refer to "required public disclosure of environmentally related information, generally by industry to consumers" (Gupta et al. 2007, p. 750). They aim to promote better choices and lead to more support for government policy by providing information on the costs and benefits of different options, as well as through the communication of reasoned arguments and persuasion (Gupta et al. 2007; Kolstad et al. 2014; Bemelsman-Videc 2017). Examples of established information instruments include labelling programmes, rating and certification schemes and collection and disclosure of data on GHG emissions (Gupta et al. 2007).

The rationale underlying information programmes is that when firms or consumers lack the necessary information about their actions, they may act inefficiently, and in turn more efficiently if this information is readily available (Gupta et al. 2007). **Information disclosure in relation to policymaking creates socio-economic pressure to improve on the current status quo** (Blackman et al. 2004; Tietenberg 1998; Foulon et al. 2002). On an organisational level, governance-by-disclosure or information-based governance is designed to influence a firm's behaviour through the dissemination of information across parts of the value chain, e.g. in production, supply, consumption (Gupta & Mason 2014). Furthermore, there is evidence that investors care about companies' GHG emission disclosures (Griffin et al. 2012; Somanathan et al. 2014). Indeed, there has been a significant rise in focus on carbon disclosures in annual reports and ethical investing in general. This points to a need for greater information disclosure in any decarbonisation measures. **While there is only limited evidence that the provision of information results in actual emissions reductions, it has been found to improve the effectiveness of other policies** (Gupta et al. 2007).

In the context of maritime GHG emissions, there are two key examples of mandatory information requirements: **the IMO Data Collection System** (DCS) for fuel oil consumption of ships and the **EU Regulation for the monitoring, reporting and verification of CO_2 emissions from maritime transport** (EU MRV). Both the IMO DCS and the EU MRV have established processes to collect and analyse emissions data related to the shipping sector. One of the key differences between the two schemes is that data collected under the IMO DCS is confidential, whereas it is made publicly available under the EU MRV (Lonsdale et al. 2019).

Modelling conducted by Lonsdale et al. (2019) suggests that by reducing market barriers, the EU MRV could deliver a cumulative potential energy saving and a CO_2 emissions reduction of approximately 0.7% compared to the IMO DCS. That is because the EU MRV – with its robust monitoring and verification as well as information disclosure requirements – is expected to improve the current market failures around imperfect and asymmetric information, whereas the IMO DCS - due to its limited transparency and less stringent monitoring and reporting - would not address any market failures, such as split incentives or asymmetric information (ibid.). In another study, CE Delft et al. (2019) assess the impacts of different potential IMO short-term policy measures on emissions in 2030. One of the potential measures assessed would mandate ships to regularly establish a speed-fuel curve following a standardised method.

This could facilitate the communication on efficiency between shipowners and charterers and help reduce the 'split incentive' market barrier. The modelling conducted in the study finds that such a policy would reduce CO_2 emissions by up to 1% in 2030 (CE Delft et al. 2019).

4.1 Information Programmes, the Competitiveness Gap and an Equitable Transition

As discussed in Section 1.2, asymmetric information can constitute a market failure and reduce the uptake of decarbonisation measures. **Quality and availability of information is a key factor in raising public awareness to environmental impacts and driving policy change** (Somanathan et al. 2014). Information programmes, therefore, have a role in closing the competitiveness gap and supporting decarbonisation.

However, despite their important role in alleviating market failures, available evidence – both in- and outside the maritime sector – suggests that the actual impact of information policies in terms of emissions reductions is small. Therefore, **information programmes are best suited to be a complimentary instrument to enhance the effectiveness of other policy measures aimed at driving shipping's decarbonisation**.

In addition, **information programmes could contribute to enabling an equitable transition of the shipping industry**. For example, countries and/or companies – especially those with more capacities and resources – could share information, lessons learned and best practices with others. This would not only lower the costs involved in identifying suitable solutions[11], but also (partly) redistribute these costs to those with more capacity and resources. The IMO's role could be to help with this information sharing. Indeed, it already does so to a certain extent. The IMO-Norway GreenVoyage2050 Project, for example, aims to facilitate sharing of operational best practices, and the IMO Resolution MEPC.323(74) encourages voluntary cooperation between the port and shipping sector to contribute to reducing GHG emissions from ships and invites Member States and international organisations to support collaboration, capacity development and sharing of best practices through initiatives that bring together relevant stakeholders.

Furthermore, **the availability of reliable and accurate data is a prerequisite for understanding and addressing the needs of developing countries, SIDS and LDCs**. For example, the validity of the assessments of measures' impacts on States depends to a large extent on the availability, granularity and reliability of data on transport and trade costs. IMO (2021a) highlights major shortcomings in this regard, especially for SIDS and LDCs, and suggests that the MEPC consider possible ways to address these shortcomings.

11. It should be recognised that some solutions may be more or less suitable depending on countries' specific circumstances.

For the reasons outlined above, information disclosure is possibly best targeted at stimulating change through information sharing between companies, nations and collaborative networks in order to promote the diffusion of innovation and best practices and encourage more transparency and better availability of data.

In addition to the information disclosure discussed above, there are voluntary initiatives aimed at increasing transparency and fostering the exchange of information in support of reducing GHG emissions from ships. These will be discussed in Section 5 below.

5.

Voluntary Initiatives

Voluntary initiatives refer to initiatives taken by firms, non-governmental organisations, and other actors beyond regulatory requirements. However, policy-makers can play a key role in enabling the emergence of voluntary initiatives, e.g. governments can use soft policy tools like dialogue with stakeholders to encourage voluntary action. Voluntary initiatives are based on the idea that, under certain conditions, polluters can decide collectively to commit themselves to abatement instead of, or beyond the requirements of regulation (Somanathan et al. 2014). They can range from formal collaborations between industry members and non-governmental organisations, to the internal goal-setting of a single company. **The strength of voluntary initiatives lies in their flexibility; they can be created and implemented by any arrangement of organisations and shaped to meet the individual needs and aims of their members**. In general, they promote progressive action on environmental impacts, transparency, and collaboration.

On an individual level, there are certain shipowners, such as Maersk and Compagnie Maritime Belge, that have outlined decarbonisation commitments for reaching net-zero or zero emissions by 2050 (Johnson 2019, CMB 2020). Additionally, certain industry associations such as the Norwegian Shipowners Association have committed to be 'climate neutral' by 2050 (Norwegian Shipowners Association 2020). There are also many more formal voluntary arrangements that have been established. Table 2 below presents some examples of these voluntary initiatives in the maritime sector.

Table 2:
Examples of voluntary initiatives in the maritime sector

Name	Date Established	Overview
Cargo Owners Zero Emission Vessel Initiative	2020	Under this initiative, shippers/buyers make commitments to provide a specific volume of freight to zero emission vessel(s) and have set a target for exclusively buying zero-emission maritime freight by 2040. The shippers/buyers will also track their maritime emissions to check alignment with their goals.[12]
Clean Cargo	2002	The Clean Cargo Working Group is focused on improving environmental performance in marine container transport using standardized tools for measurement, evaluation, and reporting.[13]
Climate Bonds Initiative: Shipping Criteria	2020	The Climate Bonds Initiative is an international organisation working to mobilise the US$100 trillion bond market for climate change solutions by promoting investments in projects and assets necessary for a rapid transition to a low carbon and climate resilient economy. The Shipping Criteria provide a clear definition for evaluation whether a shipping project contributes to climate change mitigation.[14]
Environmental Ship Index	2011	The Environmental Ship Index identifies seagoing ships that perform better in reducing air emissions than required by the current emission standards of the IMO.[15]
Poseidon Principles	2019	The Poseidon Principles provide a framework for integrating climate considerations into lending decisions to promote international shipping's decarbonisation.[16] This initiative is aimed at financiers.
Science Based Targets Initiative	Not launched yet	The Science Based Targets Initiative aims to drive ambitious climate action in the private sector by enabling companies to set science-based emissions reduction targets. It is a partnership between the Carbon Disclosure Project, the United Nations Global Compact, the World Resources Institute and the World Wide Fund for Nature.
Sea Cargo Charter	2020	The Sea Cargo Charter provides a global framework for aligning chartering activities with responsible environmental behaviour to promote international shipping's decarbonisation.[17] This initiative is aimed at charterers.
Sustainable Shipping Initiative	2010	The Sustainable Shipping Initiative is a multi-stakeholder collective driving change through cross-sectoral collaboration to create a more sustainable maritime industry.[18]

In addition to the above, there is also the principle of internal carbon pricing which can be understood as setting a hypothetical 'shadow carbon price' by an organisation, to 'evaluate the sensitivity of investments to future potential regulatory scenarios' (CPLC 2019). In the absence of mandatory market-based carbon pricing for shipping, various organisations may, in future, take up internal carbon pricing mechanisms. Indeed, in a recent response to the Carbon Disclosure Project, Maersk stated that they anticipate using an internal carbon price within the next few years (CDP 2020).

12. Cargo Owners Zero Emission Vessel Initiative: https://www.cozev.org/
13. Clean Cargo: https://www.clean-cargo.org/
14. Climate Bonds Initiative: https://www.climatebonds.net/
15. Environmental Ship Index: https://www.environmentalshipindex.org/
16. Poseidon Principles: https://www.poseidonprinciples.org/
17. Sea Cargo Charter: https://www.seacargocharter.org/
18. Sustainable Shipping Initiative: https://www.sustainableshipping.org/

5.1 Voluntary Initiatives, the Competitiveness Gap and an Equitable Transition

As discussed in the previous section, **the main advantage of voluntary initiatives is that they can be spontaneously initiated by any actor or group of actors, across any region and for any purpose**. This means that voluntary initiatives have the potential to close the competitiveness gap if they:

- Drive investment in RD&D of zero-emission fuels
- Stimulate market demand for zero-emission fuels
- Draw attention to the fuel transition and spread information and awareness
- Increase the willingness of firms to act on their emissions, demonstrate to others and policy-makers that there is willingness to act and thereby pave the way for the adoption of stringent policy measures
- Lobby for policy to assist in closing the competitiveness gap
- Address market barriers and failures by aligning the interests of investors, shipowners and charterers
- Increase transparency and information sharing

Naturally, it is unlikely that any single initiative would be capable of carrying out every action presented above, however, it is possible that a collection of initiatives could have these effects, thereby assisting to close the competitiveness gap. Nevertheless, numerous studies have been critical of the role of voluntary/private initiatives in the past (Prakash et al. 2016, Scott et al. 2017, Poulsen et al. 2018, Gibson et al. 2019). Analysis by Price (2005) of 23 voluntary programmes across 18 countries found that **many of the programmes did not meet their target for emissions reductions and only voluntary programmes which were tied to future regulations were generally successful in meeting their goals** (Alberini & Segerson 2002; Price 2005). It has been suggested that voluntary initiatives could, perhaps, complement a mandatory target or generate information about how a mandatory target could be designed and monitored most effectively (Krarup & Ramesohl 2000). Therefore, **voluntary initiatives are perhaps best viewed as stimulators of innovation and change and complimentary to regulatory policy**.

Due to their nature, voluntary initiatives are unlikely to result in disproportionately negative impacts on States, but could instead perhaps result in advantages for first- or early-moving companies and countries, e.g. cost savings due to reduced fuel consumption, development opportunities related to investments in zero-emission fuel bunkering infrastructure. However, it is likely that countries with less capacity and resources will require support to realise these cost savings and development opportunities, and to transition to zero-emission shipping. **Voluntary initiatives could, for example, help with disseminating information, commit and/or mobilise resources for less-resourced countries, support capacity-development efforts and thereby play a supporting role in enabling an equitable transition alongside mandatory measures**.

6.

National and Regional Policy Measures

To date, the IMO has received most attention in the context of regulating GHG emissions from ships. **However, national and regional policy measures have the potential to significantly contribute to the fall in overall shipping emissions**. Two areas which such measures can target are:

- **Ship-side**: National and regional policy measures to decarbonise international and coastal shipping, inland navigation and other national shipping (e.g. fisheries) and plans to invest into RD&D for zero-emission shipping, such as propulsion mechanisms, zero-emission fuels and technologies.
- **Land-based**: Policy plans to invest in the production and supply of zero-emission marine fuels (including the associated production of renewable energy) and bunkering infrastructure.

It is expected that action at the national and regional level will become increasingly important for several reasons. **Domestic shipping emissions fall directly within national government responsibility and the Fourth IMO GHG Study found that 30% of total shipping emissions are attributable to domestic shipping** (Faber et al. 2020a). The ambition of countries' Nationally Determined Contributions (NDCs) should increase over time, so it can be expected that countries will look increasingly at sectors not previously considered in their NDCs – which is the case for most countries with regards to shipping (Löhr et al. 2017; Ocean Conservancy 2021). Furthermore, in 2020, the IMO adopted a resolution on National Action Plans. The resolution urges Member States to develop and update a voluntary National Action Plan with a view to contributing to reducing GHG emissions from international shipping (IMO 2021d). It further encourages Member States to share their plans publicly on the IMO website. At the time of writing, only India, Japan, the Marshall Islands, Norway and the United Kingdom had shared such plans (IMO 2021c).

There are also examples of countries and regions already taking action to reduce emissions from their maritime industries. The non-exhaustive list below shows the breadth of measures and actions taken:

- **Norway** has a national plan which states the ambition 'to reduce emissions from domestic shipping and fisheries by half by 2030 and promote the development of low- and zero-emission solutions for all vessel categories' (Norwegian Government 2018, p. 4). It also, for example, mentions a government proposal to allocate 25 million Norwegian Krone through a grant scheme to promote the introduction of low- and zero-emission solutions for high-speed passenger vessels (Ibid.). These measures follow a similar pattern to existing schemes, such as various forms of grants from 'Innovation Norway' and the 'Research Council of Norway', as well as funding for various low-carbon solutions through the NOx Fund (Ibid.).
- **Norway** aims to make the Fjords zero-emission zones (including air pollutants and GHG emissions) by 2026. This will require all ferries and cruise ships operating in the Fjords to produce zero emissions during operation (Lambert 2018).

- The **UK's Clean Maritime Plan** contains several commitments, including for the UK to consult on how the Renewable Transport Fuel Obligation could be used to encourage the uptake of marine low-carbon fuels, to (financially) support clean maritime innovation in the UK and establish a dedicated support service for innovators using zero-emission propulsion technologies (UK Department for Transport 2019).
- **UK as the host of the 26th Conference of the Parties (COP26)** to the UNFCCC is developing two COP26 shipping initiatives, one of which – the **Clydebank Declaration** - encourages and provides a process for governments to establish maritime 'green corridors', i.e. specific maritime routes decarbonised from end to end, including both land-side infrastructure and vessels (UK Department for Transport, n.d.).
- **Germany's National Hydrogen Strategy** makes several references to using hydrogen as a marine fuel. One of the measures set out in the strategy is to continue the funding instruments for 'Maritime.Green' (green shipping) as set out in the Maritime Research Programme. Approximately €25 million has been earmarked for the Maritime Research Programme from 2020-2024, a portion of which can be used for hydrogen-related work (German BMWI 2020).
- **The Pacific Blue Shipping Partnership** is a multi-country-driven initiative for a large-scale blended finance investment to catalyse a multi-country transition to sustainable, resilient, and low-carbon shipping for Pacific Island countries. The PBSP targets domestic shipping to zero carbon by 2050 with a 40% reduction by 2030 (MCTTT 2020).
- For the past few years, there have **been ongoing discussions within the European Union to include shipping in the EU ETS**. These are now gathering momentum; in September 2020, the European Parliament voted in favour of including GHG emissions from the maritime sector in the EU ETS (European Parliament 2020) and in July 2021, the European Commission released its latest proposal for the inclusion of shipping in the EU ETS. According to the proposal, the ETS would cover emissions from intra-EU voyages, half of the emissions from extra-EU voyages as well as emissions occurring at berth in EU ports. The obligation to surrender allowances in the maritime transport sector would be gradually phased-in over the period 2023 to 2025, with shipping companies having to surrender 100% of their verified emissions as of 2026 (European Commission 2021a).
- The revised **Renewable Energy Directive** (RED II) (European Commission 2018) requires the EU to fulfil at least 32% of its total energy needs with renewable energy by 2030, with an upwards revision clause by 2023. It also stipulates that a minimum share of at least 14% of fuel for transport purposes must come from renewable sources by 2030. Renewable fuel supplied into the maritime and aviation sectors counts towards countries' national targets for renewable fuel in transport at 1.2 times their actual volume.
- The **FuelEU Maritime initiative** aims to stimulate the uptake of sustainable maritime fuels and zero-emission technologies by introducing a goal-based fuel GHG intensity target that increases in stringency over time, requiring ship operators to reduce the carbon footprint of the energy used onboard ships calling at EU ports (European Commission 2021b; Gozillon & Abbasov 2021). Furthermore, from 2030, a ship at berth in a EU port would need to connect to on-shore power supply and use it for all energy needs while at berth (European Commission 2021b).

6.1 National and Regional Measures, the Competitiveness Gap and an Equitable Transition

It is becoming increasingly apparent that national and regional action plans and policies will play a significant role in the decarbonisation of shipping. What remains to be seen is if, and how, these plans and policies will address the competitiveness gap. Considering the diversity of the approaches listed above, it is unclear whether the cumulative effect of these will be to close the gap between fuels effectively, and on a broad scale. However, it has been suggested that these **national and regional approaches may assist in the development of the market for zero-emission fuels. In stimulating demand for these fuels on a smaller scale, the development and production of zero-emission fuels can be initially shielded from the market pressures and barriers of the wider industry before supply is scaled up over time** (Baresic 2020). In this way, these plans and measures may indirectly contribute to closing the gap through market creation and shielding, RD&D and regulatory requirements. That being said, an international measure which would directly close the competitiveness gap may have a far more significant impact on unifying decarbonisation efforts across the sector.

Countries with more capacities and resources could lead the decarbonisation of their national maritime sectors and domestic shipping through the development of dedicated policies and NAPs. This would create niches for the development of zero-emission technology and fuels, could drive cost reductions due to learning curves and thereby support the uptake of these technologies and fuels in other countries. Furthermore, **zero-emission trade routes could be established between countries in such a way that countries with more capacities and resources help countries with less capacities on the other end of the trade route develop the necessary infrastructure to enable zero-emission trading**. In the case that countries or regions put in place revenue-generating policy measures, the revenues could also be used to support the transition to zero-emission shipping in other countries. There is some historic precedent for this in the form of the International Climate Initiative (IKI), one of the most important instruments of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) for the international financing of climate change mitigation and biodiversity in developing, emerging and transition countries (IKI n.d.). While IKI is now funded from the BMU, for the first few years it was financed through the auctioning of emission allowances under the EU Emission Trading System (Climate-ADAPT 2020). These few examples show that national and regional measures could contribute to enabling an equitable transition in shipping.

7.

Concluding Remarks

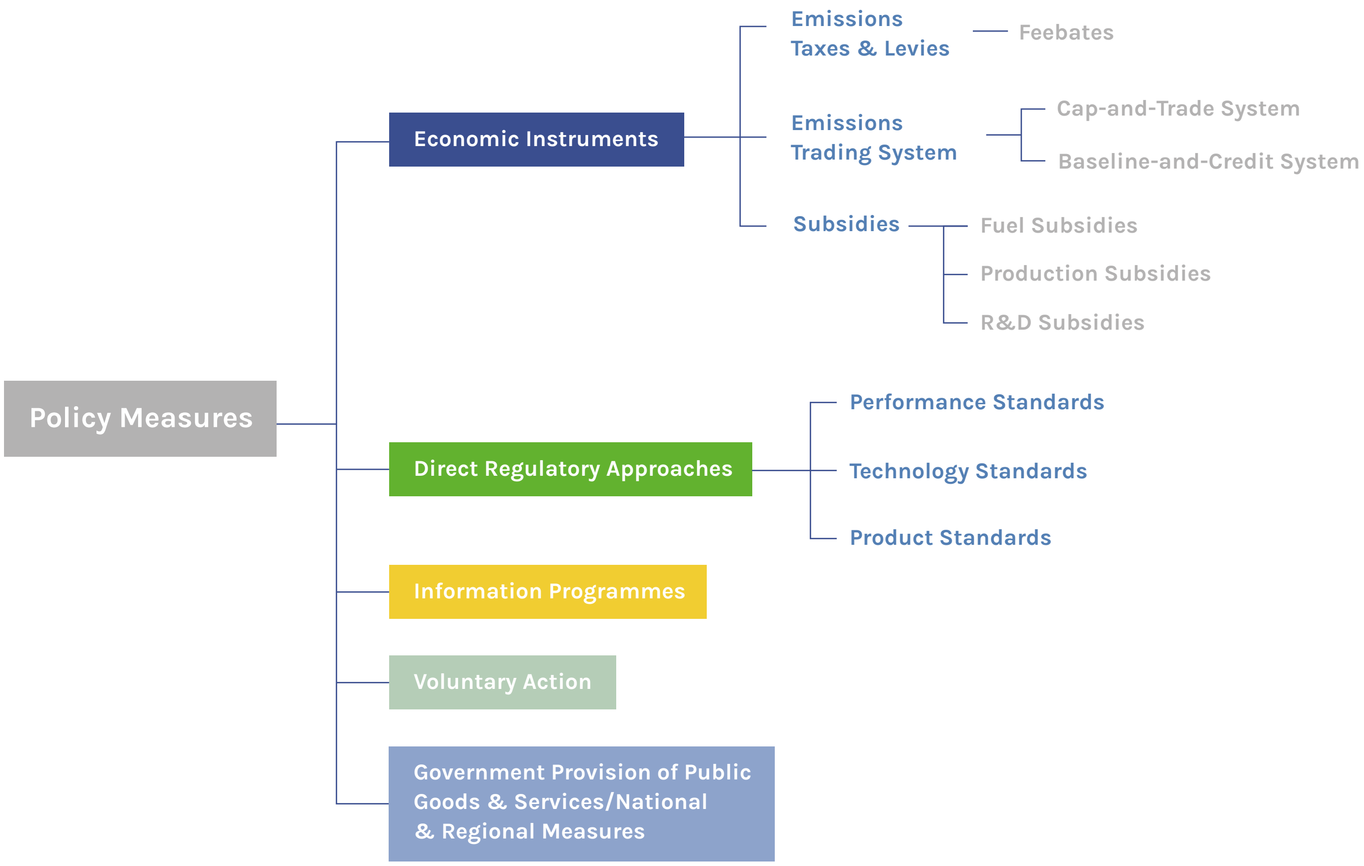
Shipping is a cornerstone of global trade and, as such, the GHG emissions created by shipping are significant and rising, accounting for almost 3% of global anthropogenic emissions (Faber et al. 2020a). Recent projections suggest that by 2050, shipping emissions will increase by between 90-130% of 2008 emissions by 2050 (ibid.). However, in April 2018, the IMO adopted the Initial GHG Strategy which set the ambition to reduce total annual GHG emissions by at least 50% by 2050, while pursuing efforts towards phasing out GHG emissions this century as a matter of urgency, consistent with the Paris Agreement temperature goal. With emissions projected to rise and international targets having been set, the question becomes, how these targets can be met by shipping?

For international shipping to align with the IMO's Initial GHG Strategy, zero-emission fuels would need to become the dominant fuel source by the 2040s, gradually phasing out current fossil fuels. However, there exists a significant competitiveness gap between incumbent fossil fuels and alternative zero-emission options. This gap is the result of the existence of market barriers and failures, availability issues, a relative lack of information and regulation on safety, as well as the price difference in the fuels, which in turn is driven by R&D, infrastructure, and investment requirements. **Projections suggest that across the 2030s and 2040s, zero-emission fuels will be approximately double the price of conventional fuel at best** (Lloyd's Register & UMAS 2020). As a result, there is an urgent need for policy to close the competitiveness gap and ensure shipping meets its decarbonisation commitments.

There is a range of potential measures to promote decarbonisation in shipping including economic instruments or MBMs, direct regulatory approaches, information policies, voluntary initiatives, and national and regional action. This report provided an overview of different policy measures to address maritime decarbonisation and to close the competitiveness gap while enabling an equitable transition. The latter is pivotal as the IMO's Initial GHG Strategy places a lot of emphasis on fairness and equity considerations, so **the viability of any IMO climate mitigation depends to a large extent on how these considerations are taken into account and operationalised**.

Figure 14 lists the different policy instruments considered in this report.

Figure 14:
Overview of climate mitigation measures considered in this report



MBMs include emissions taxes and levies, feebates, emissions trading systems and subsidies. They can promote decarbonisation and close the competitiveness gap by increasing the price of fossil fuels, e.g. a carbon price is adopted, and by reducing the cost of zero-emission fuels by providing specific funds, e.g. direct subsidies or revenue recycling.

A key element of adopting a carbon pricing instrument is the determination of a suitable carbon price in relation to the stated goals of the instrument. Based on modelling by Smith et al. (2019), the report finds that **reducing emissions by 2050 (i.e. the minimum requirement of the Initial GHG Strategy) would require an average carbon price over this period of US$173/tonne CO_2**. Indeed, to fully decarbonise shipping by 2050, the average carbon price would only need to be slightly higher: around US$191/tonne CO_2. Both these scenarios assume carbon pricing would begin in the mid-2020s at a relatively low level and then rise more sharply through the 2030s and 2040s.

A key advantage of adopting an economic measure, depending on the design and price level, is the potential to generate revenue. If revenues generated by an economic measure are 'recycled' to further support the decarbonisation of shipping, for example by subsidising the deployment of zero-emission fuels and technologies, carbon prices could be lower than the model estimates. For example, **if a 100% of the revenue generated by a carbon pricing mechanism was reinvested into the shipping industry through subsidising deployment, the carbon price required to close the**

competitiveness gap could theoretically be halved, i.e. to an average price of US$87-96/tonne CO_2.

In the scenario targeting a 50% global reduction of operational shipping emissions by 2050, the average amount of revenue collected would range between US$53-105 billion per annum or between US$1.3-2.6 trillion total, depending on the level of revenue recycling. **In the more stringent scenario of full decarbonisation by 2050, the total revenue could range between US$1-2 trillion. This means that revenue recycling alone has the potential to meet much of the investment required to decarbonise shipping, projected at between US$1-1.9 trillion depending on the decarbonisation trajectory** (Krantz et al. 2020, Raucci et al. 2020).

However, **the use of revenues to directly support shipping's decarbonisation needs to be traded off against any amounts needed to achieve an equitable transition and to satisfy the need to be cognisant of the CBDRRC principle**. In this context, a portion of revenues is likely needed for addressing disproportionately negative impacts on states, capacity development and technology transfer, climate finance and crew training.

Any revenues directed for purposes other than specifically supporting shipping's decarbonisation will result in less revenue available for shipping and a higher average carbon price requirement than US$87-96/ tonne CO_2. Higher carbon prices generally create greater impacts and therefore have a correspondingly greater need for revenue that can help to counter those impacts. Therefore, finding a balance where the net impacts (taking into consideration both the magnitude of the carbon price, and the results of revenue use to mitigate impacts and improve equity) are minimised. **Without being specific on what that balance should be, this report's evidence suggests that the carbon price needed for the transition, if implemented on its own, is between US$87-96 and US$173-191/tonne CO_2.**

Direct regulatory approaches could also be employed to close the competitiveness gap. These approaches include the setting of performance, technology and product standards, and have, thus far, been a widely used policy approach in the shipping industry. Standards can achieve the goals of the IMO's Initial GHG Strategy and decarbonise shipping by decreasing ship emissions directly, potentially internalising some of the costs associated with the operation of fossil-fuelled ships and overcoming certain market barriers. They can be less cost-intensive to develop for the regulatory body because their design is relatively simple compared to MBMs. However, because they do not generate revenues, **standards offer much fewer options than revenue-generating MBMs to address potential disproportionately negative impacts on States and enable an equitable transition**.

Information programmes and voluntary initiatives are unlikely to result in significant emissions reduction and to enable the switch to zero-emission fuels. However, **they could play an important role in reducing or removing market failures/barriers and could usefully complement other policy measures. In addition, they could contribute to enabling an equitable transition of the shipping industry** by, for example, promoting the exchange of lessons learned and best practices between countries, with developing countries, SIDS and LDCs benefitting from the experiences of countries with more capacities and resources.

National and regional measures are expected to become more important for decarbonising shipping. They could play a key role in developing niche markets for alternative zero-emission marine fuels, which can be scaled up over time. In this way, they may indirectly contribute to closing the gap through market creation and shielding, RD&D and regulatory requirements and assist global efforts to decarbonise shipping. Furthermore, **countries with more capacities and resources could lead the decarbonisation of their national maritime sectors and domestic shipping through the development of dedicated policies and NAPs and ensure developing countries, SIDS and LDCs benefit from their experiences**.

Of the measures discussed in this report, **only certain MBMs and direct regulatory approaches could close the competitiveness gap between incumbent fossil fuels and new zero-emission fuels on their own**. However, it is questionable whether the implementation of one single measure to decarbonise shipping and close the competitiveness gap is even desirable as **economists and political scientists increasingly point to the benefits, or even necessity, of a policy mix approach**. Grubb et al. (2014), for example, argue that multiple policy instruments are needed for different purposes. Standards and public engagement through the provision of information could be used to maximise energy efficiency and would also help lower the costs of energy if carbon pricing measures are introduced. Carbon pricing, in turn, would provide incentives in relation to both energy efficiency and innovation, whilst also generating revenues that could help overcome structural barriers to adequate efficiency and innovation programmes. Strategic investments in innovation and infrastructure would generate options for furthering energy efficiency and zero-emission fuels in response to associated policies (ibid.). Additionally, the diversity of market barriers and failures that need to be addressed to fully decarbonise shipping makes it unlikely that cost-effective climate mitigation can be achieved through a single policy instrument (Duval 2008).

According to Mazzucato (2018), demand-side policies, such as carbon pricing or command-and-control measures are essential for signalling to industry that 'business as usual' is no longer an option and change is needed. However, if implemented in isolation, without corresponding policies which stimulate and support supply, they 'too often become pleas for change' alone, rather than a well-rounded driver of change (ibid. 2018, p. 123). **The case of renewable energy policies illustrates the effectiveness of developing a policy mix which can support a transition from both the supply and demand sides**, and gives useful insight for the development of the market for zero-emission fuels. The gap between prices of solar/wind energy and fossil fuels has declined over the past decade to a level that allows the renewable energy sector to compete with fossil fuels even though a price difference does remain. This is considered to be a consequence of effective policy decisions (Krugman 2021). In particular, the success of sustainable renewable electricity policies in Germany, Netherlands, US and China is attributed to having effectively combined demand- and supply-side policies (Mazzucato 2018). For example, in Germany a programme to develop wind power electricity plants was supported by a feed-in-tariff, that created above-market prices, a 70% tax credit for small producers, and long investment time horizons (20 years). This de-risked and stimulated investment in supply and supported producers. Another example of an effective supply-side policy is the Contract for Difference (CfD) Scheme discussed earlier in Section 2.1.4. This has been used in the UK to support low-carbon electricity generation. It has increased certainty for investors by removing price volatility in projects which are capital intensive upfront and has been instrumental in driving rapid cost reductions (UK BEIS 2020; KPMG 2019). Based on these examples, **a transition policy mix is more likely to be effective if it combines demand-side policy (e.g. carbon pricing), with supportive supply-side policy (e.g. subsidies), in order to support the fuels transition and close the competitiveness gap**.

Further work is needed to understand and assess how different policy options both supply- and demand- facing could be combined in the shipping sector to enable not only an effective, but also an equitable transition of the shipping industry to zero-emission fuels in the required timescale. **It is imperative that any basket of policy measures aimed at closing the gap incorporates elements that enable a just, fair and equitable transition**. The reasoning for this is two-fold: first and foremost for ethical reasons - vast inequalities already exist globally, many of which are worsening in the face of climate change impacts. Decarbonisation should not become a process which further exacerbates these inequalities when, with careful development, policy for decarbonisation could be used to lessen existing inequalities. Secondly, **in light of the climate catastrophe society is currently headed towards, the decarbonisation transition must begin urgently and in earnest and will require a stringent policy package supported by strong multilateral agreement**. This in turn is only likely to be achieved if the issue of how the transition can be secured equitably is given similar prominence to the objective of mitigation.

8.

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