



The pathway to green shipping



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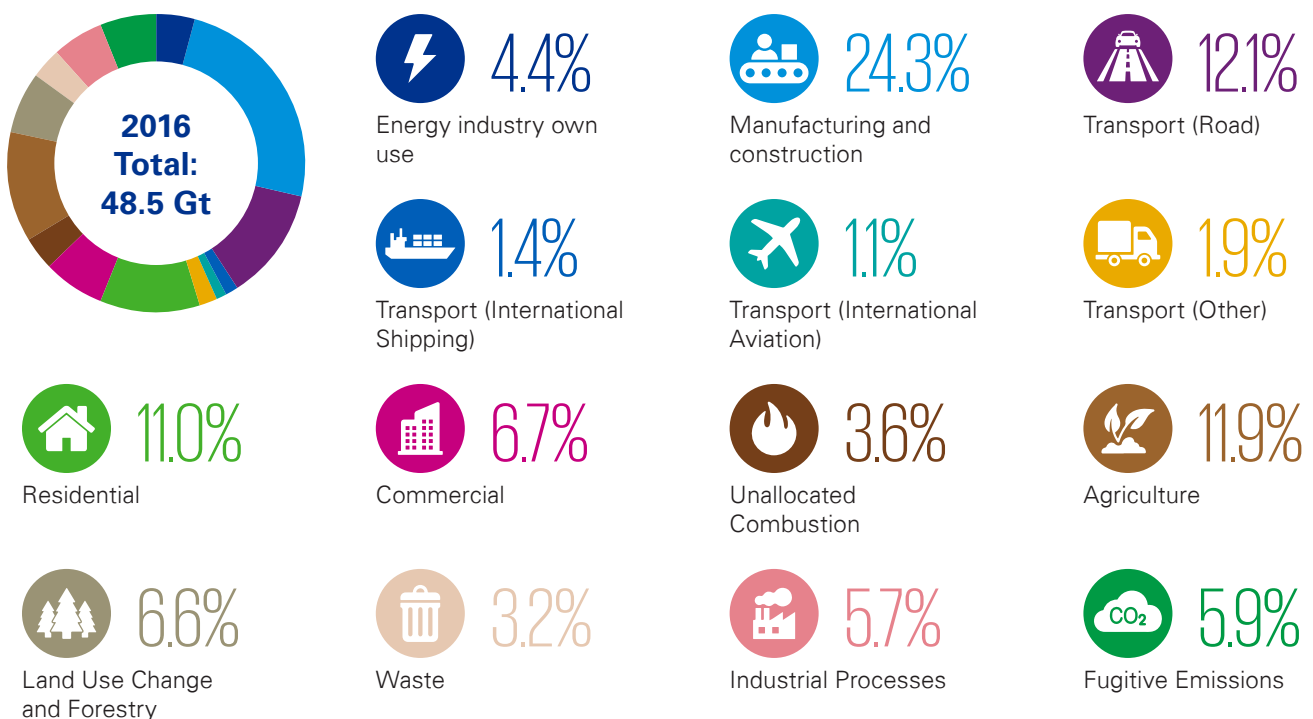
Introduction

The earth's climate has changed throughout history, without many alarming fluctuations. However, in recent times, the change has been unusual. Since the industrial revolution, the global temperature has been increasing at an alarming rate. According to studies, there has been an increase of about 0.9 degree Celsius in the planet's average surface temperature since the late 19th century. This is largely driven by man-made greenhouse gas (GHG) emissions. Carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), chlorofluorocarbons (CFCs) and water vapour (H₂O) are the major contributors to GHGs. The greenhouse effect is the process of absorbing heat radiation emitted from earth's surface by GHGs and

emitting it back to earth's surface contributing to the warming of the earth. The indication for rapid climate change can be seen by numerous examples such as global temperature rise, warming oceans, shrinking ice sheets, glacial retreat, sea level rise, ocean acidification and extreme weather events. Many countries have committed to the reduction of their GHG emissions in the Paris Agreement to avoid the catastrophic impacts of climate change. This agreement aims at keeping the rise of global warming to well below 2 degrees Celsius above pre-industrial levels and at pursuing efforts to limit the rise to 1.5 degrees.

Figure 1: Global GHG Emission by Sector

2016 global emissions of greenhouse gases (fuel combustion emissions attributed to energy consumers)



Source: <http://earthcharts.org/emissions-sources/>

There are different sources of economic activities that are causing the build-up of GHGs in the atmosphere. Around two thirds of the GHGs are due to the combustion of fuels for producing energy and resulting from transport¹. Considering only the power generation at the point of production, around 25% of Global GHG emissions are attributed to the environment.²

If these emissions are attributed to the final consumption, then 24% of emissions are from manufacturing, forestry and construction which primarily involves fuels burned on site for metallurgical, mineral transformation processes, energy and chemical. The CO₂ emission from the Chinese industrial sector is reaching almost the total emissions including all sectors — of Canada and the European Union combined.³ GHG emissions from fossil fuels burned for road, rail, air and maritime transportation account for 17% of the total emissions. Residential and commercial consumers account for around 11% and 7% of the emissions, respectively, by burning fuels for production of heat in buildings or for cooking at homes and due to onsite energy generation. The process other than energy generation accounts for 11.9% emissions from agriculture (cultivation of crops, livestock), 6.6% from land use change and forestry (deforestation), 5.7% from industrial processes, and 3.2% from waste.

⁴Emissions from the transport sector are one of the major contributors to the climate change due to extreme dependency on fossil fuels. GHG emissions from this sector have increased at a faster rate than any other energy end-use sector, leading to more than twice the emission volume since 1970. When the world is stressing on the reduction of emissions across sectors, the emissions from the transport sector are on the rise. The majority of the emissions from this sector comes from road transportation (including passenger and freight), which accounted for 80% rise in emissions during 1970–2010.⁵ There is an increase in emissions from other transport modes as well, such as aviation and maritime, except rail. The emissions from railways have significantly reduced over the past decades due to conversion of power to electricity from coal and diesel. In 2014, 53% of the global transport emissions mainly came from the high-income and middle-income developing countries.⁶



Although shipping is the most fuel-efficient mode of transport, it is the growing source of GHG emissions and consumption of fossil fuels, that contributes to climate change. In 2012, around 85% of the total CO₂ emissions from ships were contributed by international shipping (see Table 1). If international shipping were to be considered as a country, it would have been the 10th largest emitter of energy related CO₂ in 2012. As per a study, maritime transport accounts for 2–3% of the GHG emissions annually; this fraction is expected to rise to 5% by 2050 if left unregulated.⁷ This will affect the internationally agreed goal of keeping global warming below 2 degrees Celsius, which requires immediate, significant and sustained global mitigation. This might lead to a net negative emissions in the long term worldwide.

1 <https://www.iaea.org/reports/co2-emissions-from-fuel-combustion-overview>

2 <https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data>

3 <https://www.statista.com/statistics/1054826/carbon-dioxide-emissions-by-country-sector/>

4 https://www.researchgate.net/publication/335104931_Estimating_the_infrastructure_needs_and_costs_for_the_launch_of_zero-emission_trucks

5 https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter8.pdf

6 <https://www.wri.org/blog/2019/10/everything-you-need-know-about-fastest-growing-source-global-emissions-transport#:~:text=Emissions%20from%20the%20transport%20sector,emissions%20from%20burning%20fossil%20fuels.>

7 https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/marine_transport_en.pdf

IMO and international regulations in shipping

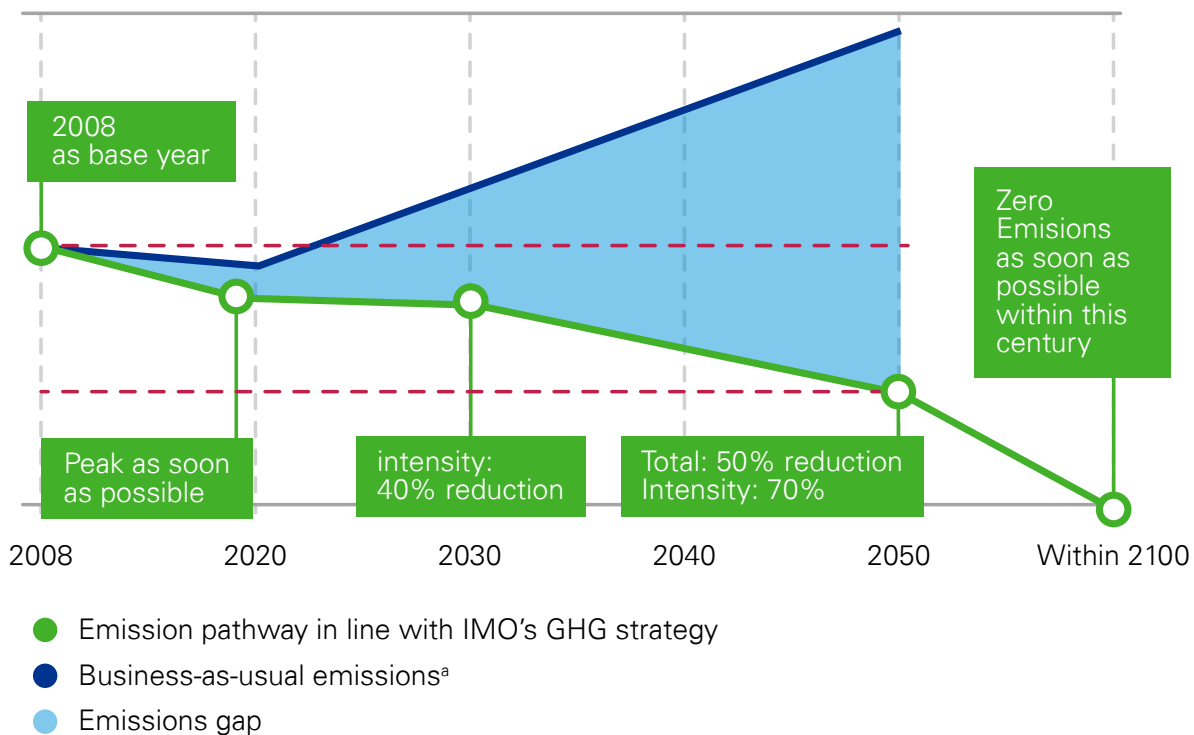
The International Maritime Organization (IMO) is a UN body formed to specialize in the creation of international treaties and other important regulations to ensure safety and sustainability in the maritime environment, e.g. to tackle climate changes from maritime transport. IMO has embarked on a vision to reduce the GHG emissions

from international shipping by 50% and carbon intensity by 70% by 2050 (compared to the 2008 emissions). Though climatology scientists realized the threats of global warming in the mid-20th century, it took a while to draw the international community to respond.

Historical background

Figure 2: GHG emission gap between IMO GHG strategy and BAU emissions

Units: GHG Emission



Source: <https://www.tandfonline.com/doi/pdf/10.1080/25725084.2019.1707938>

In 1988, the World Meteorological Organization and the United Nations Environment Programme established the Intergovernmental Panel on Climate Change (IPCC). In 1990, the First IPCC Assessment Report (FAR), which reflected the views of 400 scientists, underlined the importance of climate change as a challenge with global consequences and required international cooperation. The FAR played an important role in the creation of the United Nations Framework Convention on Climate Change (UNFCCC), the key international treaty to reduce global warming and cope with the consequences of climate change.

The United Nations Conference on Environment and Development, popularly known as the Earth Summit, was held in Rio de Janeiro in 1992. The Earth Summit served as a platform for other member states to collaborate. The Kyoto Protocol, which was adopted in December 1997, mandated that industrialized nations cut their carbon dioxide (CO₂) and GHG emissions at a time when the threat of global warming was growing rapidly and became an international law on 16 February 2005. The protocol holds provisions for reducing GHG emissions from international aviation and shipping, according to the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) respectively.

The Kyoto Protocol was adopted by the International Convention for the Prevention of Pollution from Ships

(MARPOL) to amend the MARPOL Convention (MARPOL Annex VI) in September 1997. This resolution invited the Marine Environment Protection Committee (MEPC) to limit the main air pollutants contained in ships' exhaust gas such as sulphur oxides (SO_x) and nitrogen oxides (NO_x) and prohibits deliberate emission of ozone-depleting substances. The resolution also invited IMO, in cooperation with the UNFCCC, to study CO₂ emissions from ships for the purpose of establishing the amount and relative percentage of CO₂ emissions from ships as part of the global inventory of CO₂ emissions. MARPOL Annex VI also regulates shipboard incineration, and the emission of volatile organic compounds (VOCs) from tankers.

IMO has conducted four studies on GHG emission in the year 2000, 2009, 2014 and 2020, respectively. The studies estimate multi-year annual total GHG emissions from all shipping activities (see Table 1). The Fourth IMO GHG Study (2020) provided an update on GHG emission estimates from international shipping from 2012 to 2018 and future scenarios for shipping emissions from 2018 to 2050. It also introduced the inventory of black carbon (BC) emission from vessels for the first time. Black carbon is an aggregate of small carbon spheres that are released into the atmosphere during combustion⁸, i.e. the emission of fossil fuels such as heavy fuel oil (HFO). The 2020 study added that there was almost 12% emission of black carbon from 2012 to 2020 and IMO plans to agree on the regulations of black carbon next year.

Table 1: Fourth IMP GHG study 2020⁹

Total shipping and voyage-based and vessel-based international shipping CO₂ emissions 2012-218 (million tonnes)

Year	Global anthropogenic CO ₂ Wemissions	Total shipping CO ₂	Total shipping as a percentage of global	Voyage-based international shipping Co ₂	Voyage-based international shipping Co ₂	Vessel-based International shipping CO ₂	Vessel-based International shipping as a percentage of global
2012	34,793	962	2.76%	701	2.01%	848	2.44%
2013	34,959	957	2.74%	684	1.96%	837	2.39%
2014	35,225	964	2.74%	681	1.93%	846	2.37%
2015	35,239	991	2.81%	700	1.99%	859	2.44%
2016	35,380	1,062	2.90%	727	2.05%	894	2.53%
2017	35,810	1,064	2.97%	746	2.08%	929	2.59%
2018	36,573	1,056	2.89%	740	2.02%	919	2.51%

Source: <https://safety4sea.com/wp-content/uploads/2020/08/MEPC-75-7-15-Fourth-IMO-GHG-Study-2020-Final-report-Secretariat.pdf>

⁸ https://www.iass-potsdam.de/sites/default/files/files/policy_brief_2_2017_en_black_carbon_in_europe.pdf

⁹ <https://safety4sea.com/wp-content/uploads/2020/08/MEPC-75-7-15-Fourth-IMO-GHG-Study-2020-Final-report-Secretariat.pdf>

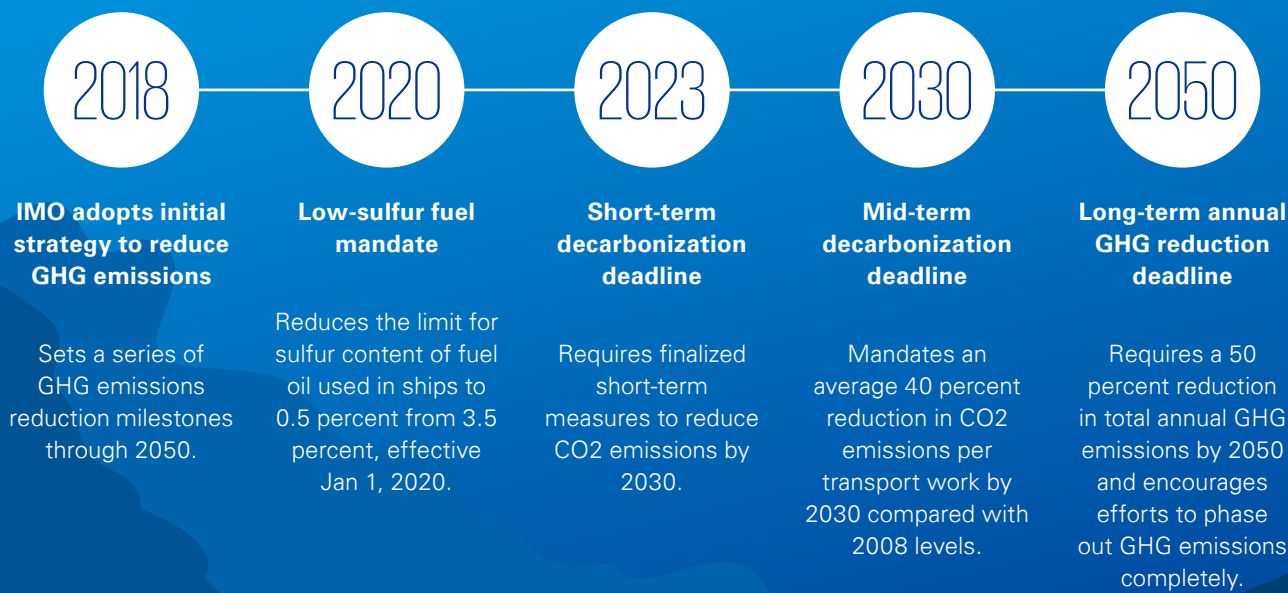
Figure 3: IMO’s GHG reduction strategy¹⁰

Sailing towards zero-emission container shipping

The International Maritime Organization (IMO) has introduced rules aimed at reducing harmful sulfur oxide (SO₂), carbon dioxide (CO₂), and other greenhouse gas (GHG) emissions from ships.



Source: IHS Markit



¹⁰ <http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Greenhouse-Gas-Studies-2014.aspx>

In April 2018 (Figure 4), the **Initial IMO Strategy on Reduction of GHG Emissions from Ships** was adopted to enhance IMO's contribution to global efforts in reducing GHG emissions from international shipping. The strategy is aimed toward starting off a vision to reduce GHG emissions from international shipping and phase them out as soon as possible during this century.

The strategy represents a framework for further action, starting with the long-term vision for international shipping, the levels of ambition to reduce GHG emissions and guiding principles. It also includes a candidate's short- and mid-term measures with possible timelines and their impacts on member states, which are the subject of ongoing negotiations. The strategy also identifies hurdles and supportive measures including capacity building, technical cooperation and research and development. In October 2020, to make progress in reaching its goals by 2030, IMO drafted new compulsory measures to carry out GHG emission strategy. The proposal requires vessels to reduce carbon intensity through technical and operational approach. A remote meeting was held to draft this amendment developed by the seventh session of the Intersessional Working Group on Reduction of GHG Emissions from Ships (ISWG-GHG 7). In addition to the mandatory requirements for vessels, the ISWG-GHG 7 addresses further steps in evaluating the possible impacts of the proposed

combined measures for states, focusing on Small Island Developing States (SIDS) and least developed countries (LDCs). The drafted amendment updated the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) for all ships by providing requirements to measure and assess the energy efficiency of all vessels and set the necessary attainment values. The new Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CII) have been introduced as a technical and an operational requirement, respectively, to reduce carbon intensity. Their aim is to address how ships are retrofitted, equipped and operated.

The introduction of these tools looks like a huge step by IMO, but is it enough? The pressure received from states and stakeholders make this step worthwhile. It may be too early to praise or criticize it as its implementation has just started. It is hoped that it will be effective and efficient and serve as a yardstick toward a green shipping environment. Its progress will be clearer during its review in 2026.

Diving into the details of the path to green shipping, the relevant milestones mentioned below should be considered and addressed to aid in reaching the aforementioned goals.



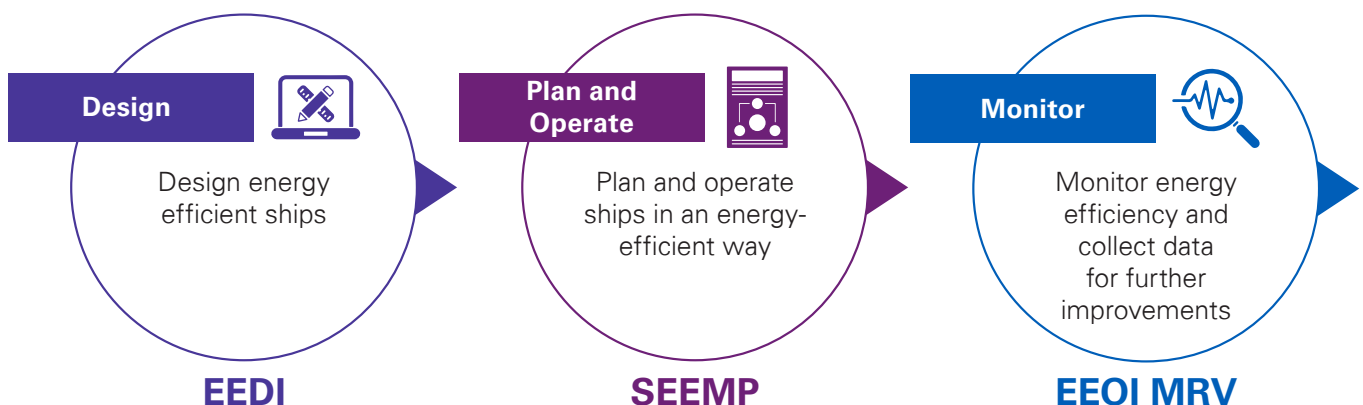
Milestone 1: IMO's first regulatory measure

To improve the energy efficiency of international shipping, IMO in July 2011 adopted mandatory measures through the Marine Environment Protection Committee (MEPC) — 62nd session, also known as MEPC 62. The resolution passed at MEPC 62 was the first-ever mandatory global energy efficiency standard and the first mandatory global GHG reduction regime for an international maritime sector. EEDI, which is a package of technical requirements applicable to the largest and most energy-intensive segments of the global merchant fleet, is applicable to all new ships and sets a minimum energy efficiency level for the work undertaken (e.g. CO₂ emissions per ton-mile) for different ship types and sizes. SEEMP is an operational measure that establishes a mechanism to improve the energy efficiency of a ship in a cost-effective manner. SEEMP also provides an approach for shipping companies to manage ships and monitor ship and fleet efficiency performance over time. These mandatory requirements entered into force on 1 January 2013. The technical design package, EEDI, has been developed for massive and the most energy-

intensive fleets following the inclusion of the additional ship types, which account for approximately 85% of the emissions from international shipping. The aim is to release 30% more energy-efficient ships in 2025 than those constructed in 2014 in a phased manner.

Energy efficiency is a considerably important topic these days. Every sector is striving toward sustainability by adopting new technologies or burning less amount of fossil fuels. The biggest source of GHGs in maritime transportation is burning of fuels to generate energy. If one uses less energy, it will not only save the cost of energy but also contribute to less pollutants in the environment. Ship energy efficiency can be attained by following a few simple steps as mentioned below; the concept needs to be adopted right from ship design through its operation and monitoring stages. IMO developed the concept of EEDI and SEEMP at MEPC 62 to improve the energy efficiency of the new and existing ships at the design and operation level.

Figure 4: Ship's Energy Efficiency Process



EEDI is the most important technical measure for new ships and mandates a minimum required level of efficiency and reduction of GHG emission. The objective of EEDI is to stimulate continued innovation and technical development of all the components (hull design, hydrodynamics, engine, propulsion and alternative fuels) influencing the fuel efficiency of a ship by reducing GHG emission from its design phase. EEDI is a nonbinding, performance-based mechanism that allows the industry a freehand in the choice of technology to use in a specific ship design. The ship designers and builders are free to use the most cost-efficient solution, as far as the required energy efficiency level is achieved to comply with the regulations. EEDI estimates grams of CO₂ released per amount of transport work performed (gram of CO₂ per ton-mile). The smaller the EEDI, the more energy efficient the ship design. It is calculated by a formula based on the technical design parameters for a given ship.

The regulation came into force on 1 January 2013. The regulation was followed by an initial two-year phase required before a new ship design will meet the reference level for their ship type. The CO₂ reduction level (grams of CO₂ per ton-mile) for the first phase was set at 10% and is upgraded every five years to keep pace with technological developments of new efficiency and reduction measures. Initial reduction rates have been established for the period until 2025 and thereafter 30% reduction is mandated for applicable ship types, compared to a reference line representing the average efficiency for ships built between 2000 and 2010. Smaller ships have different efficiency requirements for different phases.

The 74th session of the IMO Marine Environment Protection Committee (MEPC 74) approved amendments to strengthen the existing mandatory energy efficiency rules for new ships. The draft brought forward the entry of phase three to 2022 from initially planned 2025. This means that new ships built from 2022 must be significantly more energy efficient than the baseline. This is a sign of IMO continuously striving to eliminate GHGs from the shipping industry by upgrading the norms as required by the current conditions.

IMO also developed SEEMP to maintain the energy efficiency and control the GHGs of all existing shipping fleet. SEEMP aims to improve the efficiency of ships

and can be implemented in various ways such as by optimizing the speed of the vessel, making a course change to tackle rough weather, performing hull cleaning in dry dock, and installing heat recovery methods. All these methods help in increasing a ship's efficiency and optimizing its operation.

IMO adopted a mandatory Data Collection System (DCS) for fuel oil consumption for international shipping by a resolution passed at MEPC 70, requiring ships weighing 5,000 gross tons or above to start collecting and reporting data to an IMO database from 2019. SEEMP shall include a description of the methodology that will be used to collect the data and the processes to report the data to the ship's flag state. The updated version introduces a carbon intensity indicator and a carbon intensity indicator rating for vessels weighing 5,000 gross tons and above to determine their required annual operational carbon intensity indicator. This process will be performed annually through a data collection system approach for an amount of fuel consumption of vessels. It will determine the yearly reduction factor needed for a sustained improvement of a vessel's operational carbon intensity within a required level of rating.

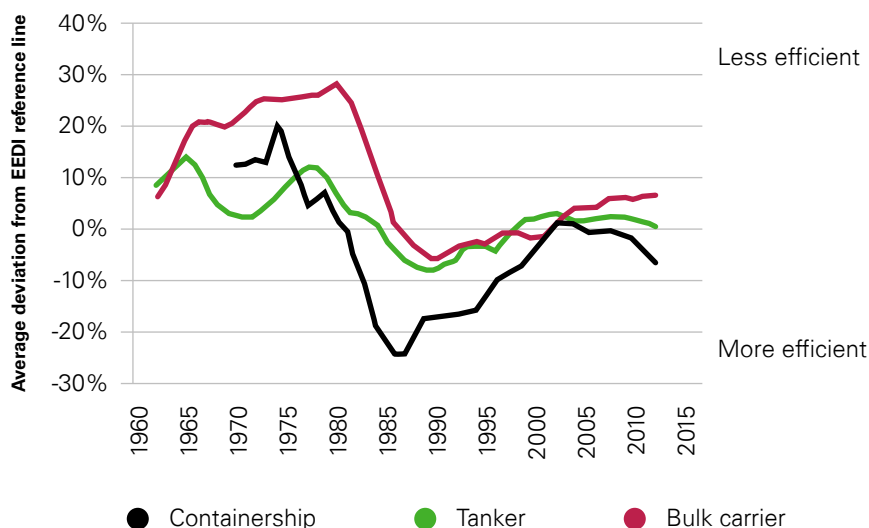
The documentation of the annual operational CII obtained is needed to be verified against the required annual operational CII. This will ensure that the operational carbon intensity rating is determined. The rating will be classified into A, B, C, D and E signifying the major superior, minor superior, moderate, minor inferior and inferior performance level, respectively, and will be recorded in the ship's SEEMP. Ships rated below C for three consecutive years will need to submit a corrective action plan to indicate how they can attain rating of C or above.

The effectiveness of the current amendments, EEXI and CII is to be reviewed at the beginning of 2026 to check if they require further development.¹¹

Energy Efficiency Operational Indicator (EEOI) is a monitoring tool that enables operators to measure the ship and fleet efficiency in operation and gauge the effect of any changes in operation, e.g. improved voyage planning, more frequent propeller cleaning, and introduction of technical measures such as waste heat recovery systems and a new propeller. EEOI index will change after each voyage due to a number of factors such as weather, temperature, and cargo carrying weight.

¹¹ <https://www.imo.org/en/MediaCentre/PressBriefings/pages/36-ISWG-GHG-7.aspx>

Figure 5: Design efficiency, all ship sizes



According to a study,¹² the energy efficiency of the new ships built post 1990 deteriorated compared to older ships. The ships built such as container ships, tankers and bulk carriers in 2013 were on an average 10% less efficient than those built in 1990. This emphasizes the need for regulations to check the efficiency of ships. However, ships built post 2013 showed a significant improvement in energy efficiency. Apart from the bulk carriers, ships in all other categories already comply with EEDI phase 3 target of 30% efficiency from baseline.

Source: <https://seas-at-risk.org/18-shipping/574-new-ships-10-less-fuel-efficient-than-those-built-in-1990-study.html>

Table 2: Performance of bulkers, containerships, tankers, gas carriers and general cargo ships

Ship Types analysis from 2013 to 2017, inclusive		Bulk carriers	Container ships	Tankers	Gas carriers	General cargo
Total number of ships in mandatory phase		1087	258	540	141	32
Distance to EEDI reference line	Mean	20%	40%	26%	25%	48%
	Median	20%	43%	27%	24%	50%
Share with EEDI 30% under reference line		<1%	71%	26%	13%	69%
Share of ships with innovative technology		0%	9%	0%	0%	0%
Average distance to EEDI reference line of top 10%		27%	58%	35%	42%	57%

Source: T&E analysis based on IMO data

¹² https://www.transportenvironment.org/sites/te/files/publications/2016_CE_Delft_Historical_Trends_in_Ship_Design_Efficiency.pdf



Out of the 1,087 bulk carriers built between 2013 and 2017, less than 1% of the vessels comply with IMO's requirements to EEDI phase 3 target. Oil tankers and gas carriers built during the aforementioned period are better than bulk carriers in attaining the phase 3 target, but the category needs a lot of improvement. The most common type of ships in the global merchant fleet are general cargo ships — 22 out of 30 ships attained phase 3 target with the top 10% performing ships being 57% more efficient than the baseline. It was discovered that 71% of all newly built container ships already comply with EEDI phase 3 target, which is the highest among all categories. The top 10% of the newly built container ships are already almost two-fold more efficient than required for phase 3 of EEDI.¹³

Since only 9% of the containerships have reported the use of innovative mechanical or electrical technologies and no other major ships built during this period have reported the use of innovative electrical and mechanical energy saving technologies, there is a considerable scope for further improvement in these categories of ships. This portrays that extraordinary compliance on certain categories is not because of EEDI regulations but due to lower cargo rates and higher fuel prices pushed for better fuel efficiency. It looks like new ships attained efficiency by building bigger container ships (economies of scale) and slow steaming (reducing the speed). Therefore, in order to motivate all the stakeholders to develop and deploy the innovative technologies in ship design and operation, IMO needs to revise and strengthen the updated energy efficiency regulations.

¹³ <https://www.transportenvironment.org/sites/te/files/publications/Statistical%20analysis%20of%20the%20energy%20efficiency%20performance%20%28EEDI%29%20of%20new%20ships.pdf>

Milestone 2: Development of alternative fuels in international shipping

The global merchant fleet consumes over 400 million tons of marine fuel annually, with projection of demand exceeding in coming years.¹⁴ The stricter regulations on the sulphur content of marine fuels, both in the emission control area and globally, have increased the demand for low-sulphur fuels; earlier, 80-85 percent of total consumptions used to be residual fuel with high sulphur content.¹⁵ More than half of the share of total running costs is typically from fuel costs and is increasingly becoming the focus for improvements in order to gain market advantage, both to achieve cost efficiency and reduce GHG emission; the implementation of energy efficiency measures needs to be supplemented by alternative marine fuels.

Alternative fuels are also known as advanced fuels that are derived from sources other than petroleum or from renewable energy. Environmental revolution has pushed shipping, like any other transport mode, to focus significantly on the potential application of different cleaner fuels and sustainable source of energy solutions.

The technological development in sustainable transport is the sign of advancement in the use of alternative fuels. There is a variety of alternative fuel types available for shipping, such as liquefied natural gas (LNG), liquefied biogas (LBG), methanol, hydrogen, hydrotreated vegetable oil (HVO), ethanol, and ammonia. To achieve IMO GHG emission reduction ambitions by mid-century, carbon neutral fuels must supply 30–40% of the total energy for international shipping.¹⁶ The industry must choose the future marine fuels by evaluating factors such as environmental impact, technical performance, availability, cost, and infrastructure.

¹⁴ https://www.joc.com/sites/default/files/u45421/Whitepapers/GeminiSeaburyWP_24pages.pdf

¹⁵ <https://transportemaritimoglobal.files.wordpress.com/2014/01/dnv-gl-alternative-fuel-2014-positionpaper.pdf>

¹⁶ <https://www.dnvgl.com/expert-story/maritime-impact/Forecasting-the-effects-of-world-fleet-decarbonization-options.html>



LNG

LNG is a colorless mixture of gases, mostly methane cooled to condense into liquid. It is sourced from natural gas, which is extracted from gas fields. LNG has been ranked high as a fossil-fuel-based alternative by the shipping industry and the choice for newbuilding since 2000. LNG is an attractive option to meet the new regulations on sulphur content in marine fuels, as sulphur levels are less than 0.004% by mass. Almost all new ships, including container ships and cruise ships, are being built to run on LNG, which emits approximately 25% less CO₂ than conventional marine fuels in providing the same amount of propulsion power. However, it has had a 150% increase in methane emission from 2012 to 2018. This is due to the increasing number of LNG-powered vessels in operation. There are currently around 175 LNG-fueled ships in operation while there are additional 141 ready LNG vessels, with another 203 on order books.¹⁷ LNG is cheaper compared to marine gas oil (MGO) and HFO. The fueling infrastructure has widely developed beyond just a handful of key bunkering ports in recent times. LNG can now be delivered to vessels at 96 ports with further 55 LNG bunkering ports under development.¹⁸ Even though the demand for LNG-powered vessels in major ports around the globe illustrates the keen interest to use LNG as a marine fuel by vessel owners and operators, it is only a good alternative for vessels in the short-run, and not in the long-run. This can be justified by the Fourth IMO GHG Study published in 2020.



Hydrogen

The cleanest marine fuel with zero carbon emission is green hydrogen, which is produced by using renewable energy. It can be produced in many ways such as by electrolysis of renewable matter and by reforming natural gas. This is why only **green hydrogen** is currently being considered, and not any other form of hydrogen. Hydrogen is the lightest of all gas molecules, thus offering the best energy-to-weight storage ratio among all fuels. While fuel cells are mostly used to convert chemical energy of hydrogen into electric energy, other applications are also under consideration such as gas turbines or internal combustion engines in standalone operations. Japan launched the world's first liquefied hydrogen carrier vessel in December 2019. However, it seems that hydrogen is still a fringe concept when it comes to maritime applications. Liquid hydrogen is costly, difficult to produce, transport and store. It is subject to the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code). The current IGF Code does not cover the storage hydrogen. Also, rules to store hydrogen are yet to be formed. The scalability of hydrogen as a marine fuel is high as it can be produced from water using electrolysis.

Japan adopted 'Basic Hydrogen Strategy' in early 2017, aiming to achieve parity with fossil fuels in the transportation sector and cover the entire supply chain from production to market applications.

In June 2020, some of the European countries came up with the hydrogen strategy as part of the COVID-19 stimulus package. Germany has come up with the National Hydrogen Strategy. The goal is to develop a hydrogen market and promote hydrogen as a solution for decarbonization. As a maritime country, Norway released its Hydrogen Strategy in which the Norwegian government proposed to grant substantial fund to finance R&D on hydrogen and set out its ambitions for the development of value chains for hydrogen-based solutions. The UK government recently released an amount of £400,000 as fund for the HydroFLEX project to experiment with hydrogen fuel cells and bring the first hydrogen train to the country.¹⁹

With proper advanced technologies, there are no principal limitations to production capacity that could restrict the amount of available H₂ to the shipping industry.

¹⁷ <https://sea-lng.org/why-lng/global-fleet/>

¹⁸ <https://sea-lng.org/why-lng/bunkering/>

¹⁹ <https://www.theguardian.com/environment/2020/jun/28/hydrogen-fuel-bubbles-up-the-agenda-as-investments-rocket>



Sails

Sails were the primary means of ship propulsion till the advent of fossil fuel engines 100 years ago. Nowadays, wind propulsion is considered a means of reducing ships' fuel consumption. The most commonly used technologies for wind-assisted ship propulsion (WASP) are the wing sail concept, the kite sail and the flettner rotor. Kites and flettner rotors are currently in use with practical experience. There are no direct fuel costs involved in operating WASP since it uses the wind energy on water for propulsion but mostly requires a small amount of secondary source of energy to operate the kites or sails initially with minimal cost. Though the availability of wind is limitless, the quality of the energy required is not constant. Hence, only selected global routes with high wind conditions are suitable for use and one needs to depend on the weather routing software for maximum benefits. The design changes in ships, unlike other transport vehicles, are slow due to which many of these technologies currently being deployed are retrofittable solutions. These wind propulsion systems installed on existing vessels save 5–20% fuel and possibly up to 30% emissions as retrofits or incorporated into optimized new builds with potentially higher savings.²⁰ WASP would not be an option for all ships sailing in different routes; it can be used on certain patches of the complete sail where wind energy is available abundantly as a secondary propulsion system.



Battery

Batteries provide abilities to store electricity critical for the use of ship propulsion. Recent technologies in batteries such as lithium-ion have made it possible for battery-powered propulsion systems to be engineered for smaller ships. The lower power density and greater weight limit the usage for many applications. Hence, for larger vessels, engine manufacturers are focused on the hybrid electric solutions. However, using batteries as a standalone solution is not possible in the current technology status; it may be combined with other renewable sources of energy such as solar and wind. Solar energy is the proven solution in shipping to meet the partial electricity requirements. However, the photovoltaic technology is not energy-dense enough to power a whole ship's requirement for propulsion. The relative unreliability of solar energy round the clock makes it ill-suited for deep sea transportation or operating in certain weather conditions.

Fuel cells are just like batteries — they produce electricity with a high frequency through an electrochemical process. They offer higher electric efficiencies with lower noise. Fuel cells need hydrogen-rich fuel such as natural gas, methanol and diesel using chemical reactors for the cells, apart from pure hydrogen. There are several manufacturers available to scale up the technology but availability of suitable fuels in large amounts will be essential if adopted widely. The use of fuel cells increases as the cost of the renewable hydrogen continues to fall over the years due to large-scale productions.

LNG, hydrogen, sails and batteries are some of the alternatives recommended by shipping experts as a better retrofit for ships. These ideas are great; however, they are a lot to enable vessel owners narrow their decisions on the best retrofit for their new built. The shipping industry needs to narrow its options down to aid in making a better decision in the path toward a greener industry.

²⁰ <https://www.offshore-energy.biz/wind-assisted-ship-propulsion-project-officially-launched/>



Milestone 3: Efficient technologies by shipping lines and ports for ship operations



There is a great potential for digitalization regarding the processes in ship operation and system integration for the efficiency and safety of vessels. Data is necessary to achieve energy-efficient decision-making and reduction in GHG emissions. Implementing smart ship technology to upgrade the core systems of the current ships will increase the data volumes (weather, navigation and sensors) and processing requirements. While maritime autonomy is a popular subject in the industry, the technology is currently in the trial stage. Autonomous shipping is a highly practical technology that helps in the navigation of vessels and improves their productivity and efficiency on the sea. It uses an on-board computer that takes decisions about the route, speed, fuel consumption, maintenance and even mooring at the harbor. Smart shipping not only covers on-board technologies but also includes the design of ports that use technologies such as artificial intelligence (AI), big data, internet of things (IoT) and blockchain to improve shipping performance. There are a lot of research and trials that have taken place for both newly built unmanned vessels and retrofit options. IMO's Maritime Safety Committee has considered including the issue of maritime autonomy in the regulatory framework for safe, secure and environmentally sound trials and operations.

Figure 6: Smart ship at a glance



Source: <https://www.smartship2020.eu/>

Milestone 4: Transparency

The success of a business depends on its customers — how well they trust the business, and whether they recommend it to others and continue to be part of it. Trust serves as a glue that binds customers and businesses together. Businesses cannot survive without trust from customers and business partners. While some parts of the shipping industry and bunkering sector are guarded with secrecy, the broader business sector is strengthening its bonds of trust by pushing for accountability, transparency and incorporating governance.

There are some shipping lines providing visibility on their website to their customers regarding the location of ships, arrival time of ships and other relevant factors that might affect ships' delay. Are such visibilities enough? Can they do better? We believe they can go beyond this limit of visibility.

Hidden surcharges in prices of shipping should be clearly addressed as shipping customers complain about container prices giving a wrong representation of the total cost when deciding on a carrier.

The shipping industry sees digitalization as a significant support system, but it should know that digitalization,

e.g. blockchain, goes hand in hand with transparency. This poses the bigger question of whether a sector with a history of secrecy is ready for digitalization at all. Is justifying secrecy all in the name of keeping trade moving really the reason for not being transparent? Transparency sounds and looks expensive; however, it is the ladder toward effective partnerships and cost-efficient downstream.

It sounds vague to justify secrecy by claiming that customers will not be able to pay for, deal with and handle data. Has the industry attempted to be transparent'?

Recently, Hapag-Lloyd introduced the smart container opportunity for customers to be able to know where their reefer containers are and if they are being tempered with. Though it sounds expensive, it was a technology customer were willing to invest in. Also, companies from the logistics ecosystem like Kobo360, Airspace, Boxxport, Freight Tiger, Waresix and Optimiz, are providing an all-round transparency for their customers. Airspace, in an interactive session, stated how transparency and speed met critical shipping requirements for clients combating the pandemic. This should make other sectors in the shipping ecosystem aware that customers are in for transparency and they should not be denied as they hold businesses together.

Transparency and data accuracy can help the shipping industry to proactively and efficiently manage disruption in its supply chain. Finding a balance to effective and financial-wise results is important to every business. Additionally, access to the right data makes results measurable and equips customers with the right decision, which in the end benefits businesses. Building a trustworthy relationship not only strengthens one side of the business but also builds trust for the entire ecosystem of the business.



Milestone 5: The power of ESG (environmental, social and governance)

In January 2004, the former UN Secretary General, Dr. Kofi Annan scripted down an invitation to more than 50 CEOs in prominent financial institutions regarding a mutual initiative under the auspices of the UN Global Compact with the International Finance Corporation (IFC) supporting it. Afterward, the story of ESG commenced. A year after this initiative came about 'Who Cares Wins', a report that had Ivo Knoepfel as the author. The report delivered the information that incorporating environmental, social and governance breeds sustainable markets, makes business sense and delivers better results for societies. Simultaneously, UNEP/Fi created a report named the 'Freshfield Report', which was also an evidence that the ESG concept is important for the evaluation of finances.

ESG investing, which is also collectively and popularly known as the 'sustainable investing', are the three relevant factors that are used when screening the ethical and sustainability effect of an investment in a company or business.²¹ The factors of this term tackle a broader range of issues that are not included in financial analysis, however, might have a financial relevance. ESG are the three standards used by investors to measure the behavior of businesses and determine their financial performance in the future. Environmental concerns such as labor practices, product safety, resource management, climate change, data security, etc. are

covered by ESG. Basically, anything that will affect the impact a business has on the environment. ESG do not necessarily apply to some specific companies, hence, these are applicable in all businesses and companies.

There are a number of ranking reports that investors use as a tool to decide on which business to invest in, however, these reports might miss most relevant businesses that might not have made it to the list. To be on a safer side, basing an investment decision on just one's conscience is not enough. The ESG rating is the best tool to help investors make smart decisions to attain a market-beating profit since companies that perform high in ESG are likely to create a longer duration of value, recognize talent and have a better financial performance. ESG-based ranking system helps sieve well-founded sustainable performers from the rest.²²

The ESG rating depends on the institution measuring it. Different institutions come with different strategies, however, the most general one in examining the vulnerability to ESG risk and management metrics is by drawing an annual report, gathering stories from the media, results from shareholders meetings, analytics on investments and data on executives. A numeric score of business' financial risk is extracted from this data. The final score is a representative of ESG performance.

²¹ <https://marketbusinessnews.com/financial-glossary/esg-definition-meaning/>

²² <https://www.alva-group.com/blog/what-are-esg-ratings/>

In the environmental section of ESG, the shipping industry's headache is the emission of GHG, ability to meet tight climate-related regulations, marine pollution, ship recycling and climate risk²³, while the social section looks at people, security of assets, diversity, equal opportunity, health and safety, labor right and forced labor in the industry.

Finally, in the governance field, tax transparency, anti-corruption and political accountability are the problems facing the shipping industry. Albeit ESG rating differs from industry to industry, the most relevant ones in the shipping industry are corruption, sanctions, human rights, risk-related transactions and trading, recycling practices, waste and emissions. While all these are relevant problems in the shipping industry, this publication focuses on the green deal.

The entire value chain of the shipping industry is facing different ranges of ESG risks. Generally, the shipping industry often does not consider ship recycling as a vital part of the shipping value chain. Unsustainable ship recycling is having a negative effect on the shipping industry because these practices have a larger risk to both the environment and the health of human at large. Even though most companies do not acknowledge the fact that it is an integral part of which all the value chains in the industry are responsible for, some are paving the way by developing and implementing policies for a smooth and successful recycling of vessels. In conducting ESG risk assessment in a shipping company, its recycling practices, policies and transparency must be closely examined to ensure that it is backed by the EU regulations on recycling or the Hong Kong Convention at the minimum.²⁴ Additionally, it must entail instructions on reporting and further details.

Funding by banks and investors are key for the shipping industry. Therefore, it is important for companies to integrate ESG into their business model because investors use this as a yardstick in selecting which business to invest in. Firms that perform higher in ESG probably have a better retention in talent, create longer-term value and have a better financial performance. A survey conducted by BNP Paribas indicated that the participants of the survey who put more than one fourth of their funds in ESG escalated from 48% in 2017 to 75% in 2019.²⁵



Lately, customers are interested in the operations of companies, their transparency, ethics and responsibilities. Companies take years to build their reputation, however, it takes minutes to defame it. The media is always on the lookout for negative information as it sells more, which makes it vital for companies to integrate ESG in their business model.

Simply put, the focal point in assessing ESG in the shipping industry will be on fleet emission and energy efficiency because banks' lending to maritime companies are already using KYC (know your client) check in tracking the processes of their clients. In instances where there are weak or no ESG regulations, the least regulation regarding that aspect, for example, sanctions and anti-money laundering are specifically explained. Failure to do so might result in serious ramifications for the sponsoring bank. Along with how relevant ESG is to the stakeholders, the question of how its integration in companies can pay off is essential. Is ESG enough to tackle the sustainability goals?

Sustainability across all sectors of businesses has recently been a talking point. Is it just a 'talk more, do less' topic or these ideas will come to light? If this is a realistic discussion, what is shipping doing to be less harmful to the environment? Are they paying for their carbon emission like other sectors? Is IMO doing enough to handle shipping's emission? Are regulators such as EU over pushing? Are civilians overacting to climate change?

Even though there are a lot of innovative ideas suggested by various institutions on how IMO can attain its 2050 carbon reduction goal, the shipping industry has not laid a specific tunnel to see the brighter light at the end of it. Some suggest research and development (R&D) as the best way to start. Others also think imposing carbon levies, using wind-powered ships, just to mention a few, are also a way forward as read earlier. These are all great ideas but some of these are long-term plans. What is the interim solution?

23 https://static1.squarespace.com/static/59f0a1d780bd5ece4761c6ae/t/5cf6688ea62fc600015b55e8/1559652530403/TheGovGroup+ESG+Ocean+report+spreads_spine.pdf

24 https://static1.squarespace.com/static/59f0a1d780bd5ece4761c6ae/t/5cf6688ea62fc600015b55e8/1559652530403/TheGovGroup+ESG+Ocean+report+spreads_spine.pdf

25 <https://assets.kpmg/content/dam/kpmg/cn/pdf/en/2020/01/integrating-esg-into-your-business.pdf>

Milestone 6: Carbon pricing

What may be the best short-term plan before the implementation of a long-term plan? One of the best possible way to an immediate solution is for IMO to initiate carbon levies. Will an emissions trading system (ETS), a carbon tax or the hybrid of these two methods be the best option? The answer to this would not be easy, but we believe IMO has enough resources to throw light on this.

ETS and carbon tax both are types of carbon pricing but the success rate of carbon tax integration into the maritime sector is high. While they both put a price on carbon, generate revenue and are cost effective, a hybrid system would be complicated. Looking at how both operate and their implementation and differences, carbon tax comes across as a suitable option for the shipping industry. Since carbon tax uses well-established channels of tax system and does not require new infrastructure such as the cap and trade do for its trading allowance, its global implementation by IMO will be easier.

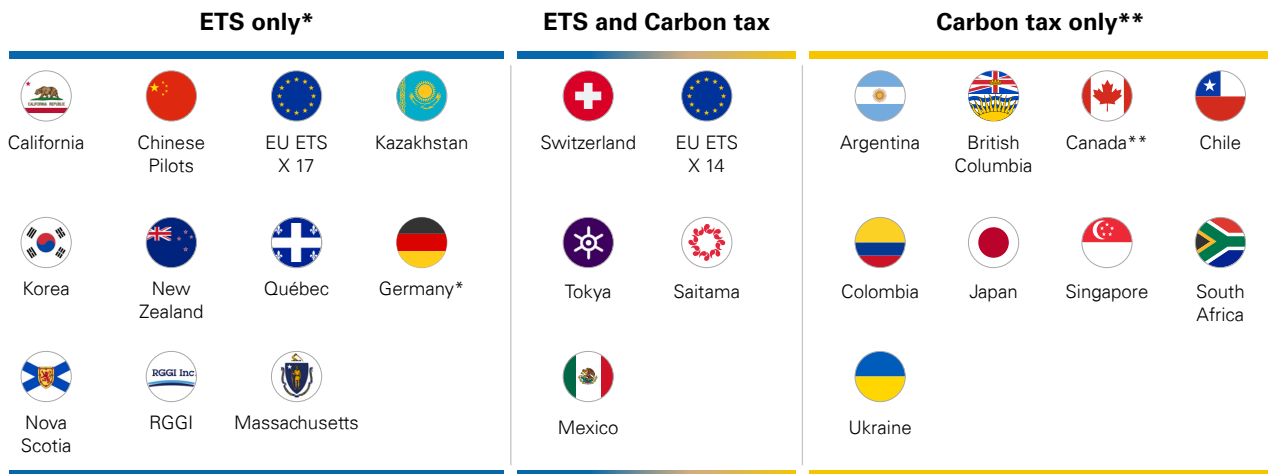
Under the cap and trade system, short-term price volatility can easily be removed due to the tax approach.²⁶ This can be a barrier for capital investment and hinder political support for climate policy and dispirit investment for research and development and new technologies to mitigate emission. It is reasonable to permit emission to vary yearly than to make it static for a longer period. With ETS, this flexibility needs to be built through borrowing of allowances or bank loan, but it happens automatically for carbon tax. Additionally, carbon tax can apply actions to automatically adjust to meet a targeted quantity. In 2011, there was an emission allowance theft case in Czech Republic and a cyberattack in the EU ETS registry system. It was reported that 475,500 allowances were stolen, which

forced the EU to halt the transfer of its carbon units. VAT fraud and re-sale of used carbon credits are other challenges that the EU ETS encountered. Of course, the Czech Republic opposed to the claim that it did not initiate the theft of allowances. It went further to explain how the Czech registry headquarters was evacuated for three hours and shifted the blame to that time period. Tax evasion will be the parallel concern with carbon tax. Comparing the two concerns, cybertheft is riskier than tax evasion and this is another reason why carbon tax is the best solution for global integration in shipping. ETS permits its users to trade allowances among themselves, which can result in extra transactional costs that the shipping industry might not be ready to incur looking at the numerous changes in the industry right now. These reasons make carbon tax a viable option for global implementation.

Figure 7 shows the locations that have implemented the two types of carbon pricing.



²⁶ https://seors.unfccc.int/applications/seors/attachments/get_attachment?code=TJQGTYI096K3J33ANM1HDWYEU51VRXNC

Figure 7: Locations that are currently using carbon pricing

* As of 2021

** Canadian Federal 'backstop' measure applied to provinces not already implementing carbon pricing. As of October 2020 this includes Alberta, Manitoba, New Brunswick, Northwest Territories, Nunavut, Ontario, Prince Edward Island, Saskatchewan, Yukon

Source: https://icapcarbonaction.com/es/?option=com_attach&task=download&id=715

1. Evolution of EU ETS

The most recent hot topic of discussion is EU's idea of introducing ETS into the shipping industry as it believes that the shipping industry is being excluded from a lot of taxes compared to other sectors (e.g. untaxed bunkers for vessels).

Carbon pricing has been existing since 2005 but is now spreading its wings across the world — among industries and countries due to states' and institutions' goal to reduce carbon emission in the near future. It is a tool that records the external costs of GHG emissions for damages, such as loss of buildings and infrastructure from flooding, diseases from heat waves and droughts, and vegetation damage, tied to their sources through a price, i.e. a price from the emission of carbon dioxide.²⁷ It comes in different types, such as ETS, carbon tax, offset mechanism, results-based climate financing (RBCF) and internal carbon pricing, with ETS and carbon tax being the most discussed. Different institutions such as DGB Financial Group are bringing out logical and feasible tools to help price carbon emission.²⁸

In 1995, an Environmental Defense Fund employee named C. Boyden Gray worked together with the Environmental Protection Agency (EPA) to come up with a bill that later became a law of the Clean Air Act of 1990 in the United States. That was the first time the cap and trade system was launched. The aim of the bill was to reduce acid rain. Later, it was reported by Smithsonian magazine that acid rain emission was reduced to 3 million tons that year. In 2005, the EU adopted this idea of the US as a strategy to reduce emission of greenhouse gases at a lower cost. Even though it was adopted, it remains a vital pillar of the EU energy policy. The EU ETS remains the largest GHG trading scheme that operates not only in the EU but also in Iceland, UK, Liechtenstein and Norway. Currently, many countries (all 27 countries in the EU, Norway, Liechtenstein, Iceland, China, UK) and companies have adopted this scheme with the aim of reducing climate change wherein carbon is the main cause.

In 1997, the third session of the UNFCCC adopted the Kyoto Protocol at the Conference of Parties in Kyoto, Japan. The objective of this convention was to make industrialized nations and economies transform and

²⁷ <https://carbonpricingdashboard.worldbank.org/what-carbon-pricing>

²⁸ https://6fefcb886e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/004/918/original/CDP_India_Second_Handbook_on_ICP.pdf?1580233115

decrease the emission of GHGs in accordance with the agreed individual targets. Kyoto Protocol simply asks industrialized nations and economies to adopt policies and actions to help mitigate climate change and report periodically. The European Commission adopted this convention in 2003 and launched it in 2005 after presenting a green paper with ideas on how to design the EU ETS. Since its launch, the EU ETS has evolved and undergone four stages.

It was all learning by doing in the first phase, which commenced in 2005 and ended in 2007. The EU decided to make ETS properly to help meet the Kyoto Protocol target. The first phase aimed at covering only carbon emission from power generators and energy-intensive industries and giving most of the allowances to businesses for free. Failure to comply with the scheme resulted in a 40 euro per ton penalty. At the end of the first phase, the EU ETS had successfully established a price for carbon, free-trade emission allowance through the EU and an infrastructure to monitor, report and verify the emission from various businesses.

The first commitment period of the Kyoto Protocol corresponded with the second phase of the EU ETS, which stated that the countries under the EU ETS had a solid emission reduction target to meet. This phase featured the bottommost cap on allowances (around 6.5% lower than the first phase), and included other states (Iceland, Liechtenstein and Norway) and the aviation sector. Additionally, another greenhouse gas (nitrous oxide) emission was introduced and the proportion of free allocation decreased to almost 90% with an increased penalty fee of 100 euro per ton. Finally, the second phase permitted businesses to purchase international credits amounting to 1.4 billion tons of CO₂ equivalent. This shows how the phases of the EU ETS kept developing.

In the third phase, the scheme underscored the single wide cap for the EU on emission applied in place of the previous system of the national cap, auctioning of the automatic method for assigning allowances and harmonized allocation of rules applied to free allowances. It also featured the inclusion of more sectors and gases, such as carbon dioxide from power and heat generation, energy-intensive sectors such as oil refineries and steel industry, nitrous oxide from the production of nitric,

adipic and glyoxylic acid and glyoxal and perfluorocarbon from the production of aluminum. Finally, the third phase set aside 300 million allowances in the New Entrants Reserve (NER) to sponsor the distribution of innovative, carbon capture and storage through the NER 300 program and renewable energy.

The new phase, which is the fourth phase, started this year (2021) and ends in 2030. This phase aims at helping industries and the power sector to solve innovation and investment problems of the low-carbon movement through various low-carbon funding strategies. Another bedrock of this phase is to strengthen the EU ETS as an investment driver by escalating the rate of its annual reduction in allowances to 2.2% as of 2021. Additionally, it seeks to reinforce the EU's mechanism established in 2015 to limit the excess of emission allowances in the carbon market in order to improve the EU ETS's resilience to future disruptions.

The EU ETS operates on a cap and trade system. It allows its users to trade emission units to reach their emission targets and is being debated on to include the maritime sector in the EU to help steer the industry toward a greener environment. The scheme is engulfed by a cap that is set on an amount of specific greenhouse gases that can be emitted. Companies and businesses get or purchase emission allowances that are traded, as needed, among themselves. Contrary to this, they can also get a finite size of foreign credits out of the emission-saving projects globally. Companies are required to turn over enough allowances to shield all the emissions they use annually; else huge fines are inflicted on them. On the brighter side, the excess allowances that are idle to a company can be stored for future needs or sold to another company. Allocation of allowances of the EU ETS is done on two bases, i.e. auctioning and allocation. The European Commission estimated that 57% of the total allowance were auctioned between 2013 and 2020.²⁹

²⁹ https://ec.europa.eu/clima/policies/ets/allowances_en

During the third phase after the trial, and second phase, where data was absent, auctioning became the default method of allocating emission allowance. Auctioning allows businesses to purchase an increasing proportion of allowances. The goal of auctioning is to ensure that transparency, harmony and non-discrimination is attained. Businesses in the EU that generate power are required to purchase all their allowances at auctions. According to the EU, auctioning is the most transparent method to allocate resources and allows polluters to be responsible. Auctioning is done on different platforms, such as the common platform, EEX platform, and the United Kingdom platform; WebICE. In the aviation sector, which was recently introduced in the EU ETS, only 15% of the total allowance allocation were auctioned.³⁰ So far, among the included sectors in the EU ETS, only the power generation sector (electricity generation/power plant companies) purchases all their allowance without any free allocation.

Besides the power generation sector, free but diminishing allocation is given to the integrated sector. As of 2020, 43% of the allowance were allocated for free. Power generation businesses located in Bulgaria, Cyprus, the Czech Republic, Estonia, Hungary, Lithuania, Poland and Romania under Article 10c of the EU ETS Directive were required to give a diminishing number of free allowances to existing power plants until 2019. In the fourth phase of the EU ETS, only Bulgaria, Hungary and Romania are required to still use the free allocation under the same article. As of 2020, the manufacturing sector received 30% of the free allocation while the aviation sector received 82% of the free allocation.³¹

1.1 A case of how the EU ETS prompted the integration of the offsetting scheme into the global aviation sector

The aviation industry accounts for a significant proportion of CO₂ emission. As of 2019, this industry produced 915 million tons of CO₂ globally. Despite its rising levels of emission, aviation was excluded from the Paris Agreement and the Kyoto Protocol. This raised questions why it was not integrated in the EU ETS. In 2012, the EU integrated ETS into the aviation industry at the end of the second phase of the scheme. This regulation applies to all flights operating in the EU. The EU ETS initiative was implemented in the aviation sector to give the ICAO, a UN body that regulates the

global aviation sector, enough time to implement the measure globally. When the proposal was initially made to integrate aviation into the EU ETS, there was an international resistance from some airline associations through their countries opposing the scheme.

In 2009, US carriers, through Airlines for America, sued the EU for its integration of ETS into the aviation sector. This was on the basis that the EU ETS in aviation was illegal under the international law. The US carriers lost the case in 2011 as the European court ruled in favor of the EU, stating that the coalition is in accordance with the international law. Following this development, the US passed a law (the Thune Bill) prohibiting US carriers from complying with the EU ETS when operating in Europe. The bill is currently valid but not yet activated. The unwillingness of some nations to agree to the EU ETS prompted other first and third world nations to also oppose it. For instance, one nation wanted to withdraw from buying aircraft from the biggest aircraft manufacturer in Europe even after making a non-refundable down payment due to EU ETS. After the European aircraft manufacturer raised its concern to the government heads in Berlin, London and Paris, the European Commission waived its independent right toward all airlines' integration into the EU ETS, which led to the proposal of 'stop the clock' on aviation ETS in November 2012. The 'stop the clock' law on the aviation ETS applies to only airlines operating in the European Economic Area (EEA) airports. In 2013, despite the resistance from other countries and airline associations, aviation ETS included all intra flights in the EU. As a result, all flights leaving and arriving in the EU are to submit a report on their emission during their operation annually. In their response, countries like China, India, Russia and Saudi Arabia prohibited its airlines from complying with it.

Four years after the EU's implementation (2016), the ICAO came to an agreement on a solution for global measurement to handle the carbon emission in international aviation starting from 2021. The measurement sets out the goal and vital design elements of a global scheme, which also serves as a plan for the execution of work on carrying-out modalities.³² The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which is based on a Global Market-based Measure (GMBM) system, aims to reduce carbon emissions by asking

³⁰ https://ec.europa.eu/clima/policies/ets/auctioning_en

³¹ https://ec.europa.eu/clima/policies/ets/allowances_en

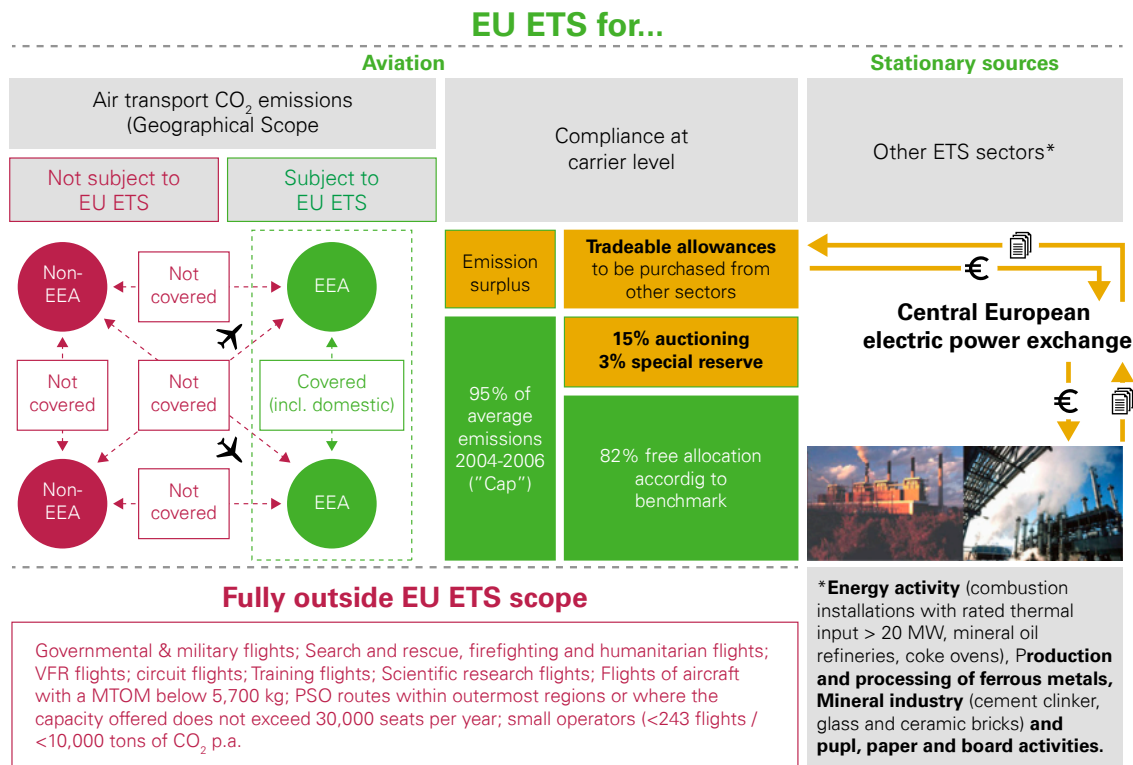
³² https://ec.europa.eu/clima/policies/transport/aviation_en#:~:text=In%20October%202016%2C%20the%20International,international%20aviation%20as%20of%202021.



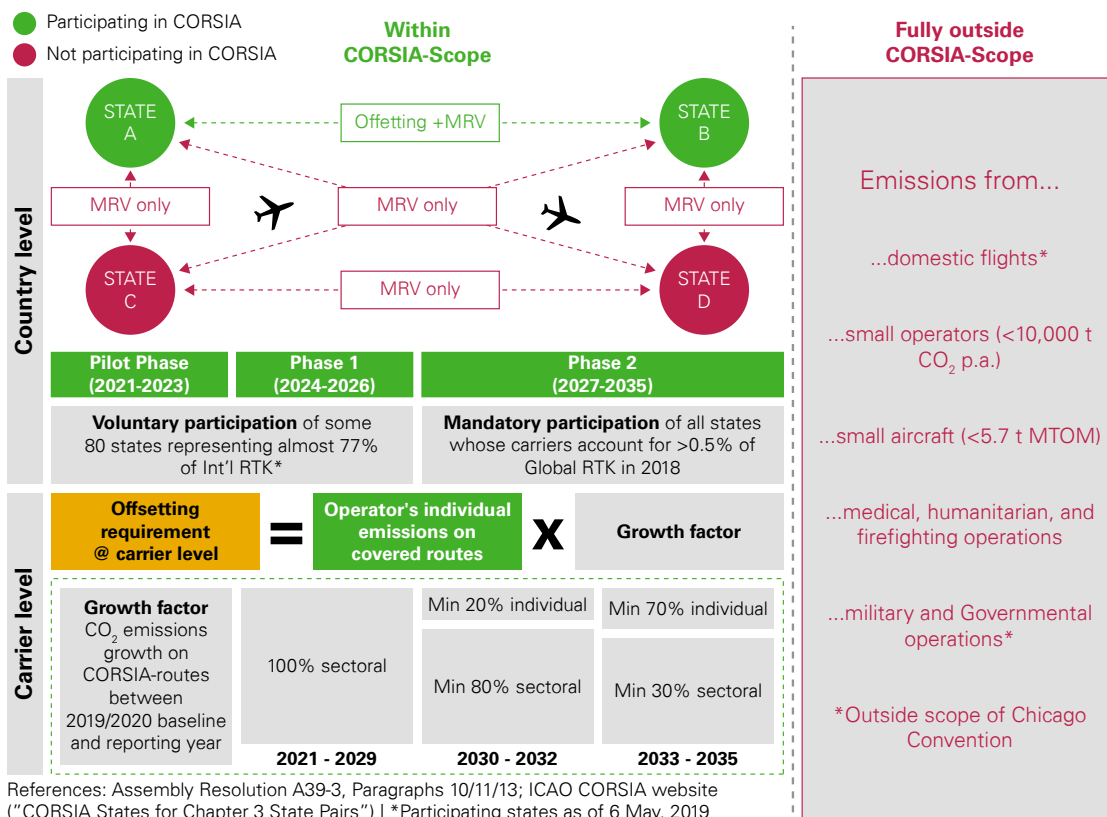
airlines to offset their emission from 2021. Airlines are required to monitor their emissions on every international route and offset the emission on routes included in the scheme — by buying permitted units of emission produced by projects that reduce emission in other sectors like renewable energy. For compliance, the airlines are required to have tradable certificates or permits allowing them the right to emit one ton of CO₂ or carbon credits. The carbon credits will likely come from programs or projects that are required to reduce emission, or from reduction mechanisms like UNFCC's Clean Development Mechanism. Though this is considered a global measure, it only applies to international airlines that fall under ICAO as they are only responsible for international air flights. As seen in Figure 9, participating countries moving from their state (State A) to another participating country (State B) are subject

to offsetting and MRV. Non-participating states (State C or D) are not subject to offsetting but they still need to be monitored, reported and verified. Domestic air flights, humanitarian aircrafts, firefighting operations, rotor craft, medical and smaller aircrafts are excluded from CORSIA. Figure 8 and 9 show the differences of how the EU ETS and CORSIA operate. The scheme contributes to the goal of the Paris Agreement and operates in three phases. The pilot phase runs from 2021 to 2023, while the phase one and two will run from 2024 to 2026 and 2027 to 2035, respectively. The pilot and phase one are voluntary for all countries; however, CORSIA will be mandatory for all international airlines from 2027. As of September 2020, 88 states (see Table 3) out of ICAO's 193 member states have agreed to voluntarily participate in the scheme; however, big states like China, India, Brazil and Russia are still resistant to it.

Figure 8: Illustrates how the EU ETS for Aviation works while Figure 9 describes how CORSIA works together with its phases



Scope of EU ETS: international and national aviation in the EEA, e.g. flights from Berlin to Paris or Berlin to Munich



Scope of CORSIA: international aviation between participating states, e.g. flights from Berlin to NYC or from Berlin to Paris

Source: <https://www.mdpi.com/2071-1050/11/20/5703/htm>

Table 3: Voluntary Participants in CORSIA Offsetting Scheme from January 2021

Afghanistan	El Salvador	Kenya	Republic of Korea
Albania	Equatorial Guinea	Latvia	Republic of Moldova
Armenia	Estonia	Lithuania	Romania
Australia	Finland	Luxembourg	Rwanda
Austria	France	Madagascar	San Marino
Azerbaijan	Gabon	Malaysia	Saudi Arabia
Belgium	Georgia	Malta	Serbia
Benin	Germany	Marshall Islands	Singapore
Bosnia and Herzegovina	Ghana	Mexico	Slovakia
Botswana	Greece	Monaco	Slovenia
Bulgaria	Guatemala	Montenegro	Spain
Burkina Faso	Guyana	Namibia	Sweden
Cameroon	Honduras	Netherlands	Switzerland
Canada	Hungary	New Zealand	Thailand
Costa Rica	Iceland	Nigeria	Turkey
Côte d'Ivoire	Indonesia	North Macedonia	Uganda
Croatia	Ireland	Norway	Ukraine
Cyprus	Israel	Papua New Guinea	United Arab Emirates
Czechia	Italy	Philippines	United Kingdom
Democratic Republic of the Congo	Jamaica	Poland	United Republic of Tanzania
Denmark	Japan	Portugal	United States
Dominican Republic	Kazakhstan	Qatar	Zambia

Source: https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA_States_for_Chapter3_State_Pairs_Jul2020.pdf (

CORSIA does not automatically replace the EU ETS in aviation but rather complements it. This means some airlines, starting January 2021 will be subject to both the EU ETS and CORSIA. Is this fair for these airlines operating in the EU?

Albeit differences in the EU ETS and CORSIA, the similarities make it look like ICAO built its scheme based on the EU ETS. This raises the question how the EU can influence IMO's decision by setting an example in including the shipping sector into the EU ETS. Is this possible? Will all states agree to it?

An assessment of the EU ETS in the aviation sector indicates that though the free allowance allocation keeps decreasing, airlines should be able to handle it. Also, since the EU has integrated ETS into its emission reduction strategy, it will be difficult to eliminate the initiative; however, international flights (not the airlines) operating in the EEA could be excluded, subjecting them to only CORSIA.

1.2 Merits and demerits of EU ETS being integrated in the shipping industry

Though a thorough proposal on how shipping emission will be included has not yet been established, the EU's proposal of including the maritime sector in ETS is a slice of a bigger pie on a global scale. However, there are other regulators, e.g. the UNFCCC, across the globe that are also adopting to address shipping emission. This is making it difficult for the shipping industry to agree to the EU's proposal on the basis that shipping is a global system and should not be skewed by regional regimes. The industry is in favor of IMO's strategy and is looking forward to its revision in 2023. IMO's revision in 2023 should be clearer to help stakeholders in the shipping industry know where they are steering their 'greener decisions' toward. The aim of the EU ETS in the maritime sector is to yield returns that will be reinvested in research innovations to help develop better alternative climate-neutral inventions for the industry. The goal sounds good but is it fair for shipping industries operating in the European community? Does it not look like if the EU is successful, these shipping lines operating in Europe will incur most of the cost in driving the industry toward a greener environment? Is this not supposed to be global regulation since shipping is a global entity?

There are always two sides to a coin, and integrating the EU ETS in shipping is no exception. In favor of this regulation is an argument that since the EU has successfully been able to set up many successful and track record implementations for issuing carbon permits and platforms for trading, it will be able to make this work. The existing implementation of EU's Monitoring,

Reporting & Verification (EU MRV) system for vessels, both in the EU and internationally, can be used and not just in the regional space as the cap set by the EU for emitters can be revised to see the achievement of the policy goal. Additionally, CO₂ emission will economically decrease and possibly trading will be permitted with different carbon markets due to the price determination of carbon by the market and will have the potential to restore the uptake of alternative fuels and other innovative technologies to aid emitters in accomplishing their needed carbon emission limits. These, among others, are some of the brighter features of EU's idea of integrating ETS into the shipping sector. However, maritime EU ETS can lead to a dispute between some first-class nations, which can potentially result in extended trade conflicts. The shipping industry argues that this application, which has already been implanted in local aviation in the EU, has not made any reduction in emission and wonders how effective it will be in the maritime sector. Moreover, it opens risk and undermines most of the regulations of IMO, which is the official body governing the maritime industry. The EU ETS in the shipping industry can lead to distortion due to increasing leakage of carbon and calls for uncertainty of carbon emission prices due to factors of demand and supply. Finally, accurate data is difficult to obtain, which will make ETS in shipping a bigger problem, at least for the start. During the first phase of the EU ETS, the prices of allowances fell to zero due to the absence of reliable data. How will the EU approach this data problem? Will it adopt a 'learning by doing' approach in the EU ETS pilot phase as well? Table 4 summarizes the merits and demerits of the EU ETS in the maritime sector.

Table 4: Summary of merits and demerits of the EU ETS in the maritime sector

Merits	Demerits
The existing implementation of EU's Monitoring, Reporting & Verification (EU MRV) system for vessels, both in the EU and internationally, can be used.	It can lead to a dispute between first and some third world nations, which can potentially result in a trade conflict.
The EU ETS has already set up many successful and track record implementations for issuing carbon permits and platforms for trading.	The shipping industry argues that this application, which has been implanted in local aviation in the EU, has not made any reduction in emission. This raises the question of how effective it will be in the maritime sector.
A cap set by the EU for emitters can be revised to see the achievement of the policy goal.	It opens risk and undermines most of the IMO regulations.
The EU ETS has the potential of restoring the uptake of alternative fuels and other innovative technologies to aid emitters in accomplishing their needed carbon emission limits.	It calls for uncertainty of carbon emission prices due to factors of demand and supply.
CO ₂ emission will economically decrease and possibly trading will be permitted with different carbon markets due to the price determination of carbon by the market.	The EU ETS in the shipping industry can lead to distortion due to increasing leakage of carbon.
	The absence of reliable emission data can lead to decrease in prices of allowances and competition disadvantages.

1.3 How can ETS in shipping be calculated?

The EU wants the maritime industry to be forceful into steering their industry towards sustainability. That is why for the exclusion of vessels weighing less than 5,000 gross tons loading and unloading at any EU member state should be monitored and reported. Monitoring, Reporting & Verification (MRV) is so far the proposed tool that will be used to measure carbon emission in the EU territory in case it succeeds in integrating ETS into the shipping sector.

Annually, shipping lines need to submit an emission report to a recognized MRV shipping verifier. The data of monitoring their vessels' carbon emissions, fuel consumptions and other activities such as distances covered by the vessels, cargos carried per voyage and time at the sea are to be collected in an emission report. The emission report will then be submitted to the European Commission and the flag state (where the vessels are registered). Thereafter, each vessel calling at any EU port would have to come along with a document of compliance issued by THETIS MRV and it may be called for inspection by the member state's authorities.

There is no global regulation yet on how to integrate carbon pricing into the shipping industry and IMO is the only organization that can help make shipping pay for its emission globally since it is the international body governing the maritime sector. In March 2018, IMO adopted a data collection system (DCS)³³, which is similar to EU's MRV system to some extent. IMO's data collection system calls for large vessel owners to participate in global shipping and report on their fuel consumption to the flag state of the vessel. A yearly outline report to the MEPC is produced upon the reporting of the data collected by the flag states. This has no correlation to the integration of carbon pricing into the shipping industry. However, since it already has this regulation in place, which is in accordance with EU's way of measuring ETS in the maritime sector, it is possible for IMO to globally impose carbon pricing on shipping.

Though the shipping industry may see this as a huge cost inflicted on it, the industry should also know that it emits a lot of CO₂, which pollutes the environment. IMO needs to move fast on imposing a levy on this industry. Whichever way it may be, the shipping industry needs to pay for its emission before regulators take matters into their own hands.

EU has a good idea and it is right in saying that the shipping industry needs to pay for its emission. How does it now plan to execute this idea? Even though reduction of CO₂ emission is highly discussed these days, are the relevant authorities not in a haste to make an implementation that will only affect a small proportion of companies that operate on a global scale? For a fair global treatment, the EU can join forces with other continents or states to push IMO into implementing a price on carbon emitted by vessels. We suggest the best way to curb this problem is if IMO can work together with governments of nations to impose a carbon tax in the shipping sector.

1.4 Implementation of a carbon tax

Although the EU ETS has been in existence since 2005 and has been successful, carbon tax has also been there since 1990 as a type of carbon pricing to help minimize the output of GHGs and carbon dioxide into the atmosphere.³⁴ In response to climate change, Finland was the first to implement carbon tax in January 1990.³⁵ Its idea relied on the carbon content of fossil fuels. In respect to the carbon tax, the government sets a tax rate and emitters who fall under it (except those exempted) are bound to pay the set amount for every ton of CO₂ they emit. When it was implemented in Finland, the wood and raw material industry was exempted while the natural gas sector had an affordable tax treatment. The price at the start of its implementation was 1.12 euro per ton CO₂, and gradually it increased as there were consistent reforms in 1997, 2007 and 2011. In 1997, the tax evolved into a combination of carbon tax and energy tax with a price charge of 18.05 euro and 66.2 euro per ton CO₂, respectively. Due to its early implementation, the Finnish government has announced that Finland will be carbon neutral by 2035, which is earlier than IMO's targeted year. Currently, countries such as Singapore, Argentina, and Japan, to mention a few, have also implemented a carbon tax with a price of \$5, \$10 and \$2.8 (JPY 289), respectively.

IMO can adopt different mechanisms to help steer shipping into a greener environment but the solutions do not rely only on IMO. It calls for the involvement of the entire value chain of the shipping industry to help reach the goal. In view of that, what are shipping lines doing to help reach this goal? What have they done in the past? What are their future plans as well toward carbon zero emission?

33 [https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/642224/EPRS_BRI\(2019\)642224_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/642224/EPRS_BRI(2019)642224_EN.pdf)

34 <https://www.investopedia.com/terms/c/carbon-dioxide-tax.asp#:~:text=The%20tax%20is%20designed%20to,the%20goal%20of%20environmental%20protection.>

35 <https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/05/FINLAND.pdf>

Milestone 6: Including sustainability into the business model of shipping companies

Let us take a dive into the implementations of some shipping lines around the globe and where they are now.

Shipping lines around the globe are strategizing toward emitting less CO₂ or permanently cutting emission. Currently, some are retrofitting their vessels with alternative technologies, testing zero-emission vessels or researching on better alternatives to contribute toward the green shipping deal. Even though there are various technologies that most organizations believe will help with decarbonization, some still believe that there needs to be more research in order to get a good view on how to attain carbon zero emission. By 2030, the goal of Maersk Line is to operate carbon-neutral vessels using fuel alternatives and other ship technology in order to attain their carbon-zero emission goal by 2050. It is also looking to heavily invest into the solution of decarbonization by improving technical and financial viability. In previous years, Maersk has invested heavily in getting energy-efficient solutions through multiple engineers. Recently, it partnered with other important industry stakeholders to set up a non-profit research center that will aid in the research of new fuel types and technologies. The center is not limited in its operations

and has been set up to work with specialized and interdisciplinary people from around the world to develop ideas on ways to achieve decarbonization, create chosen alternative decarbonization fuels and technologies. Additionally, this decarbonization centre intends to help in the creation of commercial, regulatory and financial paths to allow transformation.

Earlier in this publication, it is mentioned that vessel recycling is a part that most shipping companies refuse to integrate in their value chains, but Hapag-Lloyd has overlooked this additional cost and integrated it to attain a sustainable environment. In managing lower emission, it is taking measures that will increase the efficiency of its fleet. In doing so, it has converted some of its vessels into climate-friendly vessels by using LNG. In addition, it is currently testing biofuels that have cooking oil as an ingredient and reducing the consumption of bunkers, which it believes limit its costs. Planting trees to reduce GHGs, using less disposable paper on board and repairing instead of replacing are some of the few measures the company has taken toward building a sustainable maritime environment.



Based on its previous implementation of technological innovation, vessels operation improvement and mobilization, CMA CGM was able to reduce its carbon emission by a total of 6% in 2019.³⁶ Since 2008, it reduced carbon emission by 48% per TEU-km. CMA CGM's voluntary target is to reduce the GHG by 50% by 2030. The target set by the IMO is to reduce GHG by 40% by 2030. It pledged in 2020 to be carbon neutral by 2050. The company also launched new 23,000 (TEU) LNG-powered vessels in 2020 as a short-term, economic-friendly technology. Contributing to carbon neutrality, its goal is to include 10% alternative fuels by 2023 in its energy supplies. Together with Energy Observer, it seeks to tour around and experiment on the first hydrogen-powered ship with the aim of developing energy solutions based on solar, tidal and wind power and hydrogen.

New-build and retrofitting programs seem to be one of the vocal focus of MSC as well. Between 2015 and 2018, its new implementations resulted in a carbon emission reduction of 13% per transport work.³⁷ One of its latest largest container ships contributes to energy efficiency with a bow design shape by limiting hull resistance. To be able to adapt to future changes, in case research and development conclude on zero fuel, the vessel is equipped with a hybrid exhaust gas cleaning system.

Looking at the various shipping line goals toward carbon neutrality, retrofitting, research and development, alternative fuels and zero emission vessels are common among them.

³⁶ <https://www.cma-cgm.com/news/3143/the-cma-cgm-group-heads-towards-carbon-neutrality-by-2050>

³⁷ <https://www.msc.com/lbr/news/2019-december/msc-confirms-long-standing-commitment-to-reducing>

Summary and outlook

The adoption of alternative fuels will likely be driven by regulations from international bodies, fuel prices, technological developments, availability of alternative fuels and development of infrastructure. The pace of development for the alternative fuels, such as biofuels from waste biomass and hydrogen from water using renewable energy, must be accelerated. Maritime applications of renewable sources such as solar and wind are developing, but it is unclear whether they are a feasible solution for deep sea sailing. The energy sector is not only seeking alternative solutions to lower emissions but also meeting the rising demand for energy.

IMO's sulphur cap regulation is a major change for the global maritime industry. Many players in the industry recognize that LNG is the current fuel solution to leverage the requirements imposed by new regulations. There has been a significant development in the deep-sea new builds embracing LNG as an alternative fuel, considering that the infrastructure needed to support LNG is rapidly growing. LNG will be the best short-term alternative for larger ships with consistent routes that operate in the major trade lanes, as well as for large cruise ships.

Hydrogen is competing with LNG and other alternative fuels for shipping as a zero-emission-fuel solution. Unlike other alternative fuels, hydrogen seems to be the promising solution for the transportation industry including shipping. There is a significant push by regulators, governments and operators in signing for investment in hydrogen technologies. A number of tests and practical applications have taken place in heavy commercial vehicles and buses using fuel cells across the world; hence, scaling up the technology to shipping will be much easier, provided proper infrastructure.

Almost all the hydrogen and fuel cell technologies at present are highly dependent on public funding.

As usual, many ports are waiting for clarity from governments or specialized agencies on policies and regulations on the alternative fuel types because the cost associated with the new infrastructure is huge. Industry stakeholders are still uncertain on which fuel tanks to invest in. Since there is no regulation or standards on hydrogen by IMO, no shipping companies want to switch to hydrogen as an existing fleet. IMO needs to bring certain policies promoting hydrogen when it revises the initial GHG strategy in 2023. Hydrogen will likely play a vital role in meeting the shipping sector's targets. Countries with abundant and cheaper renewable energy are likely to produce green hydrogen, which will be transported far and wide.

The COVID-19 pandemic has a great impact on decarbonization of shipping. There has been suppression on investments for the research and development of new technologies. Shipyards are facing issues in newbuilding or conversion projects due to unavailability of labor force and disruption in supply materials. Maritime emissions have reduced due to less trade and travel, but it may be a temporary effect. The policies and stimulus measures drawn by governments and regulatory bodies to support the global economy, which is severely affected by the ongoing pandemic, should lead toward more resilient economy and future-proof suitability. Since the industry is facing a huge loss due to affected trade, governments must play an important role by incentivizing sustainable projects, accelerating the technology development of zero-carbon shipping and preparing ports and shipyards for future demand for zero emission.

Investors need to invest in shipping companies whose business practices align with sustainability goals. The effects of ESG are appreciated as it continues to grow in businesses and filters out sustainable companies. ESG should not be the sole responsibility of investors but also a responsibility of companies to know the environmental, social and economic impact of their operations in order to implement the required regulations in place. Since the maritime industry is a large capital-intensive sector, there is no difference in integrating ESG into this sector. It is mentioned earlier that the shipping industry is exposed to different ESG risks and challenges ranging from the construction stage of vessels, through its trading and finally to the recycling stage. It is the duty of the shipping industry to sustain the ocean since it covers 70% of the earth's surface and is the operator of this environment.

IMO has aided in the cover of most of the environmental issues through legislation and regulations. Even though not all the environmental issues that shipping has impacted are touched on, there is constant and annual improvement. The same argument cannot be made for the social aspect of ESG. The impact of shipping in the social aspect varies from sea to shore. Even though regulatory measures are already in place, further regulations and support are still needed. The most complicated area for ESG implementation is the governance sector. The governance structure does not promote culture transparency in the industry. It is important that shore-based protocols, procedures and policies serving corporate bodies are performed and interpreted into procedures that can be conformed to on board and at shore.

The aviation industry in the EU is already paying for its emission, which triggered the ICAO to bill global aviation since the start of 2021. It is essential and fair that the global shipping industry, which accounts for 2–3% of the global emission, also pays for its emission. Shipping will continue to contribute to climate change since it is an integral part in connecting the world through trade, unless measures are taken to eradicate or limit it. IMO is doing its best in implementing efficient and effective ways to make shipping environment-friendly; however, its strategies are not pushing enough. Therefore, the EU is taking matters into its own hands and discussing on integrating ETS into shipping. The mere proposal by the EU should push IMO to take more actions into making shipping environment-friendly, else other institutions or continents/states will do their job for them.

We believe that IMO's data collection system for vessels can be a starting point. IMO already has a policy where vessels report to it annually. Its data collection system is similar to EU's MRV system, which the EU plans to use in measuring the EU ETS in shipping if it is successful in implementing it. MRV can also be a tool for IMO to monitor emitters. Additionally, carbon levies seem to be the most immediate effective remedy for shipping emitters. They can be imposed on global shipping, which many believe is the easiest way in making shipping pay for its emission globally. Since most sectors in the shipping industry are campaigning for sustainability, embracing carbon levies will not be a stress, burden or tough task for them.

To move forward, sustainable technologies should be narrowed down to easily help the industry have a head start on how to retrofit and build sustainable vessels to meet its sustainable goals. Handling data sharing secrecy in the industry should be addressed to aid progression across the maritime ecosystem. This will turn the data rich industry (shipping) into a data smart industry due to the technological developments that will arise from data sharing. Moreover, the shipping industry needs to rethink its business models and strategies. The traditional method of working should transition to digital methods; only then will there be great and innovative ideas leading to the growth of the industry. Since some believe that the idea of alternative fuels is far-fetched, investment should be made in research and development in coming up with the best alternative among these numerous suggestions for sustainable shipping in the nearby future. Until a better alternative to decarbonization is introduced, the shipping industry should prepare itself to embrace carbon levies if they are implemented.

The succession to all these great ideas is not subjected to just one sector of the entire industry. It calls for collaboration across the entire supply chain to lead the industry into a sustainable, effective and efficient sector.

The shipping industry is heading toward a digital and sustainable transformation. Business models within the industry shall keep this into consideration. Besides, the shipping industry needs to recognize the value of its data. Respective ambitious goals can only be achieved once the industry operates in a data smart environment.

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