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LEGAL ASPECTS OF DECARBONISATION IN SHIPPING

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TABLE OF ABRIVIATIONS

AFID Alternative Fuels Infrastructure Directive

AFIR Alternative Fuels Infrastructure Regulation

CBDR Common But Differentiated Responsibilities

CBAM Carbon Border Adjustment Mechanism

CCS Carbon Capture and storage

CE Circular Economy

CII Carbon Intensity Indicator

CO Carbon monoxide

CO2 Carbon dioxide

EEA European Economic Area

EEDI Energy Efficiency Design Index

EEOI Energy Efficiency Operating Index

EEXI Energy Efficiency Existing Ship Index

ETS(s) Emissions Trading System(s)/Scheme(s)

EU European Union

FEMREG Fuel Eu Maritime Regulation

GHGs Greenhouse Gases

HFO Heavy fuel oil

ICCT International Council of Clean Transportation

IMO International Shipping Organization

IMRB International Maritime Research and Development Board

IMRB International Maritime Research And Development Board

LNG Liquefied Natural Gas

MDO Marine Diesel Oil

MGO Marine Gas Oil

MARPOL International Convention for the Prevention of Pollution from Ships

MEPC Marine Environment Protection Committee

MBM Market Based Measures

MSR Market Stability Reserve

MTCC Global Maritime Technologies Cooperation

NGO(s) Non Governmental Organization(s)

NPFs National Policy Frameworks

NOx Nitrogen Oxides

OPS Onshore Power Supply

PM Particulate Matter

RED Renewable Energy Directive

SEEMP Ship Energy Efficiency Management Plan

SOLAS International Convention for the Safety of Life at Sea

SOx Sulfur Oxides

TtW Tank-to-Wake

TEN-T network Trans-European Networks

UN United Nations

UNFCCC United Nations Framework Conference on Climate Change

VOC Volatile Organic Compounds

WtT Well-to-Tank

WtW Well-to-Wake

ABSTRACT

The aim of this Masters' dissertation is focused on the study of the legislative framework that governs the concept of decarbonisation in shipping, both at the european and international level. Through their legislative work, the European Union and the International Maritime Organization emerge as pillars for achieving decarbonisation, with the ultimate goal of combating climate change and achieving climate neutrality.

More specifically, at the international level, the International Maritime Organization plays a vital role. Through global initiatives such as the Global Maritime Technologies Cooperation Global Network, IMO works with regional partners to develop, implement and enforce marine environmental goals helping to ensure that no one is left behind in the green maritime transition. Such initiatives are the so-called Market Based Measures, the establishment of indicators such as Carbon Intensity Index, Energy Efficiency Design Index, Ship Energy Efficiency Management Plan, but also the drafting of legislative texts such as the International Convention for the Prevention of Pollution from Ships of 1973.

At the European level, the European Union's strategy for achieving climate neutrality by 2050 and implementing the commitments made under the Paris Agreement is summarized in the European Green Deal and the Fit For 55 package of measures, with the aim of reducing net greenhouse gas emissions by at least 55% by 2030 and the alignment of European Union's legislation with the 2030 goal. Afterwards, an extensive analysis is carried out regarding the three main pieces of legislation (Directives, Regulations) of the European Union that focus on achieving the above target in the shipping industry. Given the nature of the legislation of the International Maritime Organization and the European Union, the transfer of this legislative work to the Greek legal system is described in detail hereafter.

To summarize, this dissertation will be based on the bibliographical method review based on collecting primary and secondary material, which has been gathered from Greek and foreign language bibliography, legislative texts and articles published on the internet.

Key words: Decarbonisation, shipping, International Maritime Organization, European Green Deal, Market Based Measures

ΠΕΡΙΛΗΨΗ

Με την παρούσα διπλωματική εργασία επιχειρήθηκε η μελέτη του νομοθετικού πλαισίου που διέπει την απανθρακοποίηση στη ναυτιλία, τόσο σε ευρωπαϊκό όσο και σε διεθνές επίπεδο. Μέσα από το νομοθετικό τους έργο η Ευρωπαϊκή Ένωση και ο Διεθνής Οργανισμός Ναυτιλίας αναδεικνύονται σε πυλώνες για την επίτευξη της απανθρακοποίησης, με απώτατο στόχο την καταπολέμηση της κλιματικής αλλαγής και την κατάκτηση της κλιματικής ουδετερότητας.

Πιο συγκεκριμένα, σε διεθνές επίπεδο πρωταγωνιστικό ρόλο παίζει ο Διεθνής Οργανισμός Ναυτιλίας. Μέσω παγκόσμιων πρωτοβουλιών, όπως το Παγκόσμιο Δίκτυο MTCC, ο IMO συνεργάζεται με περιφερειακούς εταίρους για την ανάπτυξη, την εκτέλεση και την επιβολή θαλάσσιων περιβαλλοντικών στόχων βοηθώντας να διασφαλιστεί ότι κανείς δεν θα μείνει πίσω στην πράσινη θαλάσσια μετάβαση. Τέτοιες πρωτοβουλίες αποτελούν τα λεγόμενα Market Based Measures, η θέσπιση δεικτών όπως ο Δείκτης Έντασης Άνθρακα, ο Δείκτης Σχεδιασμού Ενεργειακής Απόδοσης, το Σχέδιο Διαχείρισης Ενεργειακής Απόδοσης Πλοίου αλλά και η εκπόνηση νομοθετικών κειμένων όπως η Διεθνής η Σύμβαση για την Πρόληψη της Ρύπανσης από Πλοία του 1973.

Σε ευρωπαϊκό επίπεδο, η στρατηγική της Ευρωπαϊκής Ένωσης για την επίτευξη της κλιματικής ουδετερότητας έως το 2050 και την υλοποίηση των δεσμεύσεων που αναλήφθηκαν στο πλαίσιο της Συμφωνίας του Παρισιού συνοψίζεται στην Ευρωπαϊκή Πράσινη Συμφωνία και την δέσμη μέτρων Fit For 55, με στόχο την μείωση των καθαρών εκπομπών αερίων του θερμοκηπίου κατά τουλάχιστον 55 % έως το 2030 και την ευθυγράμμιση της νομοθεσίας της Ευρωπαϊκής Ένωσης με τον στόχο του 2030. Εν συνεχεία πραγματοποιείται μία εκτενής ανάλυση των τριών βασικών νομοθετημάτων (Οδηγιών, Κανονισμών) της Ευρωπαϊκής Ένωσης που επικεντρώνονται στην επίτευξη του ως άνω στόχου στην ναυτιλία. Περαιτέρω και δεδομένης της φύσης των νομοθετημάτων του Διεθνούς Οργανισμού Ναυτιλίας και της Ευρωπαϊκής Ένωσης, περιγράφεται αναλυτικά η μεταφορά του νομοθετικού αυτού έργου στην ελληνική έννομη τάξη.

Συνοψίζοντας, η παρούσα διατριβή θα βασίζεται στη μέθοδο βιβλιογραφικής ανασκόπησης βασιζόμενη στη συλλογή πρωτογενούς και δευτερογενούς υλικού, το οποίο έχει συγκεντρωθεί από ελληνική και ξενόγλωσση βιβλιογραφία, νομοθετικά κείμενα καθώς και άρθρα δημοσιευμένα στο διαδίκτυο.

Λέξεις κλειδιά: Απανθρακοποίηση, ναυτιλία, Διεθνής Ναυτιλιακός Οργανισμός, Ευρωπαϊκή Πράσινη Συμφωνία, Market Based Measures

1. INTRODUCTION TO DECARBONISATION IN SHIPPING

1.1 CLIMATE CHANGE AND THE SHIPPING INDUSTRY

The shipping industry must "*go beyond operational and energy efficiency and deploy zero-emission fuels and propulsion technologies*" in order to meet the Intergovernmental Panel on Climate Change's (IPCC) 1.5 °C global temperature rise target. As a result, the maritime industry must make sure that zero-emission vessels are fully operational on deep-sea trade routes on a commercial scale by 2030 and this because vessels lifetime is expected to last for 20 to 30 years (Mallouppas, et al., 2021).

More particularly, the growing awareness of environmental issues and climate change has focused attention and scrutiny on shipping emissions. Pollutants released by shipping can lead to a number of problems as following:

- Carbon dioxide (CO2), which is the most critical greenhouse gas (GHG) discharged by vessels and constitutes the main aim for global warming;
- Sulfur oxides (SOx) and nitrogen oxides (NOx), which contribute to the creation of acid rain and are highly unwelcome, due to the fact that they affect the human health and the environment;
- Carbon monoxide (CO), volatile organic compounds (VOC) and particulate matter (PM) due to their effects in human health (Serra et al., 2020).

1.2 IMPORTANCE OF DECARBONISATION IN THE SHIPPING INDUSTRY

Approximately 80–90% of all trade takes place via shipping, making in that way the shipping industry essential to international trade and, by extension, the global economy (Balcombe et al., 2019). In this respect, significant technological improvements in the shipping industry are expected as a result of stringent environmental restrictions regarding NOx, SOx, and CO2 emissions, and this because of the wide range of the sector, which is considered to be approximately 3% of all worldwide GHG emissions (Energy Transitions Commission, 2020). The sector might be decarbonized by using alternative fuels and/or technologies such carbon capture and storage (CCS), hydrogen, biofuels, and nuclear power, although each has large resource, economic, and social acceptability challenges (Balcombe et al., 2019). On the one hand propeller design, hull cleaning, and other efficiency enhancements are just a few examples of how fuel usage can be reduced but on the other hand in order to attain decarbonisation of the shipping industry, a number of issues/problems must be addressed. Consequently, several industry sectors must take a multifaceted response and there is "no single route" (Balcombe et al., 2019).

Energy Transitions Commission has underlined that within the next three decades, there will probably be an increase in the demand for shipping (Energy Transitions Commission, 2020). In 2020 Shell and Deloitte conducted a survey regarding the current market trends. In the analysis of this survey decarbonisation was deemed significant or top priority for their firms by over 90% of the shipping sector respondents to their poll. To be more specific, according to 80% of respondents decarbonisation has been increasingly important during the last 18 months (Shell, Deloitte, 2020) As a result, this indicates that the market and industry are thinking about decarbonisation as a component of their long-term business plans, in keeping with the IMO's goal of reducing shipping's carbon dioxide emissions by at least 50% by the year 2050 when compared to a baseline set in 2008 (IMO, 2018).

As Lister et al. have underlined since 2015, although the maritime sector contributes less than 3% of global greenhouse gas emissions, decarbonisation will require financial motivation and policies at the international and european levels. Generally speaking, there are two primary categories of maritime emission reduction measures: the operational ones (lower speeds, waste heat recovery, etc.) and the technological ones (ship size, ship–port interface, etc.). The use of alternative fuels (biofuels, hydrogen, ammonia), ship electrification, and wind assistance are recognized as additional distinct pathways to achieve decarbonisation by the International Transport Forum. However, it could be objected that these methods also come under the category of technical measures (ITF, 2018).

Decarbonisation of shipping intends to lower shipping emissions so that the sector can support international efforts to keep the rise in the world's average temperature well below two degrees Celsius above pre-industrial levels and to pursue efforts to keep the increase within 1.5 degrees Celsius of pre-industrial levels (Paris Agreement, 2015). Shipping faces an enormous decarbonisation challenge, which greatly increases its role in the worldwide decarbonisation effort.

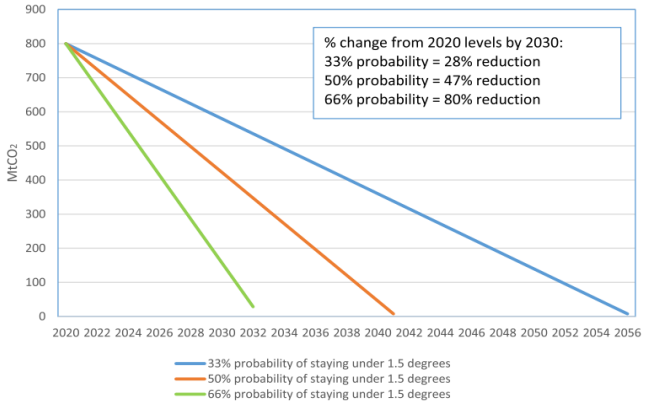

Figure 1. International shipping trajectories compatible with Paris 1.5C target

This difficulty is made worse by the global environmental, political, economic, and geostrategic policy and regulatory landscape, which is frequently out of sync and contradictory. It is also impeded by various infrastructure and technological limits. In order to properly address this situation we can say that it is crucial national and international policies with compatible objectives to be adopted and to ensure that sufficient activity and facilitating required transitions are made possible by these strategies. Nevertheless, it is important to note that many policies and regulatory frameworks at the regional and global levels that would normally facilitate these efforts are currently missing. Many reasons, such as intricate constitutional provisions, can be given for this lack. As a result, a lot of experts and stakeholders have been calling for a better distribution of these diverse mandates and difficulties that concern the shipping sector. Encouraging the maritime industry's decarbonisation endeavors requires tackling these challenges with a comprehensive strategy. Development of infrastructure, the introduction of efficient laws and regulations, and technology breakthroughs should all be part of this strategy. By doing this, the shipping sector is able to seek for ecologically beneficial and sustainable practices while navigating a complicated web of obstacles.

Additionally, the shipping sector must actively participate in cooperative initiatives with a range of partners, such as governmental bodies, non-governmental organizations, and international organizations. These partnerships will be crucial in encouraging the worldwide coordination and cooperation required for the effective execution of decarbonisation initiatives. All of these organizations can collaborate to create a unified and all-encompassing regulatory structure that tackles the particular difficulties that the shipping sector faces.

Finally, it should be noted that shipping plays a critical role in the worldwide decarbonisation process and in order to balance mandates and problems and eventually create a more environmentally friendly and sustainable shipping industry, collaboration at both the international and national levels is necessary.

The two main multilateral international agreements on climate change, the Kyoto Protocol and the Paris Agreement, originally did not include shipping, despite this alarming fact. The notion that an industry's emissions should not be exclusively attributed to the greenhouse gas emissions produced inside each country's national territory led to the exclusion of shipping from these agreements. Moreover, the United Nations Framework Convention on Climate Change (1992) addressed greenhouse gas emissions (GHG) from industrial sources worldwide, but it did not include the maritime sector. Although the shipping industry only contributed approximately 3% of worldwide greenhouse gas emissions, it was still a major source of pollution when compared to short-haul or domestic airlines. Rather, it was realized that foreign ships passing through the territorial waters of a

certain nation could potentially have an impact on the emissions of an industry. As a result of this acknowledgment, special consideration and distinct restrictions were extended to international shipping and the reason is that there are a lot of enforceable international conventions and rules for maritime climate change. These accords recognize the distinct obstacles that the shipping sector presents and endeavor to institute efficacious strategies to alleviate its ecological footprint.

In this regard and in order to guarantee that the shipping sector makes a fair contribution to mitigating climate change, an extraordinary treatment is necessary. Given that an industry's emissions are not limited to the borders of a single country but can also be impacted by worldwide activities, it is imperative to create an all-encompassing framework that holds all stakeholders responsible for their share of greenhouse gas emissions[1]. Thus, incorporating rules and policies particular to global shipping is a big step toward tackling climate change all at once. The next chapters will provide a detailed explanation of these rules and regulations as well as an investigation into the rationale behind the shipping industry's special treatment in relation to global maritime climate change. For the reasons above, it is impossible to overestimate the significance of these regulations since they could lead to a radical change in the maritime industry's trajectory toward a more sustainable and environmentally friendly future. Governments and international organizations can force shipping corporations to adopt ecologically friendly methods and encourage them to do so by applying the required incentives and requirements. This would result in a considerable decrease of the GHG emissions from the shipping industry. In addition to promoting the use of greener energy sources and encouraging innovation in sustainable shipping technologies, these regulations will help mitigate the effects of climate change. In the end, the effective execution of these laws will bring about a new phase of environmentally conscious shipping, guaranteeing a cleaner Earth for coming generations[2].

1.3 DEFINITIONS OF DECARBONISATION OF MARITIME TRANSPORT

In the article “Consolidating Port Decarbonisation Implementation: Concept, Pathways, Barriers, Solutions, and Opportunities” of Anas Alamoush et al, 2023, an analysis of the concept of decarbonisation in shipping and ports is provided as follows:

> “ *Decarbonisation is defined in this study as achievement of net zero CO2 emission by 2050 by using mitigation measures and/or through the balance of surplus emissions by removal (e.g., carbon sinks and sequestration). “Mitigation measures” indicates the switch from fossil fuels such as coal, natural gas, or oil to carbon free renewable energy technologies and energy sources such as low carbon fuels.*

[1] To read more about the theory of externalities https://www.iisd.org/savi/faq/what-is-an-externality/
[2] To read more about sustainable development https://sdgs.un.org/goals

Maritime transport decarbonisation can be defined as the process of eliminating ships' CO2 and other GHG emissions through mitigation measures or balance of surplus emissions by removal leading eventually to net zero CO2 emission by 2050.

Port Decarbonisation is defined as the utilization of mitigation measures (technical and operational emission reduction measures) to reduce, neutralise, and offset CO2 emissions from various port emission sources (port operation, ships, and land transport), while surplus CO2 emissions are offset by sinks or sequestration; that is to say that the industry aims to reach net zero emissions by 2050 in line with Article 2 of Paris Agreement".

2. GLOBAL REGULATORY AND INSTITUTIONAL FRAMEWORK FOR SHIPPING DECARBONISATION

2.1 KYOTO PROTOCOL

The Kyoto Protocol era's international legal framework for shipping emissions reductions and climate change provides more opportunities for collaboration (UN, 1998). When the Kyoto Protocol came into effect in 2005, developed nations criticized it for drawing a sharp line between developed and developing nations' obligations to reduce emissions, which led to subpar emissions reduction procedures in the shipping industry. Based on this, the IMO upgraded the research on reducing emissions from international shipping from a technical and methodological level to a political and legal level, with the goal of leading the development of the international shipping industry's low-carbon future through changes to emission reduction policies (Huirong Liu et al., 2017).

The International Maritime Organization (IMO) is an organization of the United Nations (UN), with the purpose of promoting "safe, secure, environmentally sound, efficient and sustainable shipping through cooperation" (IMO, 2017). According to the Kyoto Protocol and the Paris Agreement, the IMO is the organization in charge of regulating emissions in the maritime sector. In the past, the IMO has introduced international conventions and legislation to govern marine operations in order to address their influence on the environment and the Marine Environmental Protection Committee (MEPC) is the relevant committee of the IMO addressing environmental issues under IMO's remit. This includes the control and prevention of ship-source pollution covered by the MARPOL treaty, including oil, chemicals carried in bulk, sewage, garbage and emissions from ships, including air pollutants and greenhouse gas emissions. Other matters covered include ballast water management, anti-fouling systems, ship recycling, pollution preparedness and response, and identification of special areas and particularly sensitive sea areas.

With the aim of lowering GHG emissions from shipping by at least 50% by 2050 in comparison to the baseline of 2008, the IMO established its Initial Strategy in April 2018 (IMO, 2018). Along with short-, medium-, and long-term measures based on required ship efficiency, the Strategy also outlines support for developing nations, an authorized procedure for evaluating candidate measures' effects on nations, and additional enhancements to the current energy efficiency framework. While the Strategy does not entirely adhere to the Common But Differentiated Responsibilities principle CBDR, a principle enshrined as a basic principle in Article 3(1) of the 1992 United Nations Framework Convention on Climate Change (UNFCCC), and does not offer compensatory mechanisms, it does outline mechanisms to increase capacity for emissions reduction, technology transfer, research collaboration, and other safety measures to address the obstacles developing nations face when implementing future strategies for emissions reduction (Huirong Liu et al., 2023).
The following are the Initial Strategy's main goals:

- to cut the carbon footprint of international shipping by 40% by 2030 as compared to 2008 levels.
- to raise the percentage of reduction to 70% by 2050.
- to achieve a minimum 50% reduction in greenhouse gas emissions from international shipping by 2050, when compared to 2008 levels.
- to attain carbon neutrality by the year 2100, or as soon as feasible throughout this century.

The ever increasing need for reduction of the international shipping emissions and the international legal framework of climate change are interrelated, and the origin of the linkage between the above mentioned can be pin pointed to the UN Framework Convention on Climate Change (UNFCCC) (Huirong Liu et al, 2017). The Convention creates the internationally acknowledged concept of common but differentiated responsibilities, or CBDR principle. This concept has since grown to be the cornerstone of the legal framework pertaining to emissions from international shipping. On these matters, the UNFCCC established a top-down emissions reduction approach that was mandated and further explained the CBDR principle.

The IMO's position as the regulatory authority in charge of lowering emissions from international shipping is made clear in Article 2.2 of the document. Resolution A.963(23) (IMO, 2003) was adopted by the IMO in 2003. It makes clear that the IMO will work with the Conference of the Parties to the UNFCCC to reduce emissions in shipping. This underlines the beginning of a new era in which the IMO will lead the way in reducing emissions from shipping in accordance with the international legal framework for climate change, particularly the CBDR principle (Huirong Liu et al, 2017).

2.2 MARPOL

The primary measure enforced by the International Maritime Organization (IMO) is the International Convention for the Prevention of Pollution from Ships (MARPOL), which was adopted in 1973 (Convention), while Protocol was adopted in 1978, Protocol - Annex VI adopted in 1997, and entered into force on 2 October 1983 (Appendices 1 and 11) with the goal of anticipating and reducing pollution from ships resulting from both accidental and operational sources (Frynas, 2012). MARPOL Convention 73/78 was adopted on 2 November 1973 at the IMO. The 1978 Protocol was adopted in response to a series of tanker accidents in 1976-1977. As the Convention MARPOL 1973 had not yet come into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined act entered into force on October 2, 1983. In 1997, a protocol was adopted to amend the convention and a new Annex V1 was added which entered into force on 19 May 2005. MARPOL has been updated with amendments over the years. The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and pollution from normal operations - and currently includes six technical annexes. Special areas with strict controls on operational discharges are included in most Annexes (Boyle, 1985).

In particular:

i. Annex I: Oil Pollution Prevention Regulations, which entered into force on 2 October 1983 and covers the prevention of oil pollution from operational measures as well as accidental discharges; the 1992 amendments to Annex 1 made it compulsory for new oil tankers to have double hulls and introduced a phase-in scheme for existing tankers to fit double hulls, the which was then revised the 2001 and 2003 (Frynas, 2012).
ii. Annex II: Regulation for the Control of Pollution by Noxious Liquid Substances in Bulk, which entered into force on 2 October 1983, were included in the list attached to the Convention. The disposal of their remains is only allowed in reception facilities until certain concentrations and conditions are observed (which vary according to the class of substances). In any case, it is not allowed to dispose of residues containing harmful substances in distance of 12 miles from the nearest ground (Griffin,1994).
iii. Annex III: Prevention of pollution by harmful substances carried by sea in packaged form , which entered into force on 1st of July 1992. It contains general requirements for issuing detailed standards on packaging, marking, labeling, documentation, stacking, quantity limitations, those identified as marine pollutants in the International Maritime Organization 1) Appendix exceptions and notifications (Griffin,1994). For the purposes of this Annex, "harmful substances" are those

substances in the International Maritime Dangerous Goods Code (IMDG Code) or meeting the criteria of the appendix to Annex III (Boyle,1985).

iv. Annex IV: Prevention of pollution from sewage from ship, which entered into force on 27th of September 2003. It contains requirements for the control of marine pollution from sewage. The discharge of sewage into the sea is prohibited, unless the ship has an approved treatment plant or where the ship discharges crushed and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land. Sewage that is not crushed or decontaminated must be discharged more than 12 nautical miles from the nearest land.

v. Annex V: Prevention of Pollution by Garbage from Ships, which entered into force on 31st of December 1988) of Annex I prohibiting the disposal of any form of plastic at sea). It deals with different types of waste and specifies the distances from land and how they can be disposed of. Its most important feature is the complete ban of the disposal of any form of plastic at sea (Curtis, 1985).

vi. Annex VI: Prevention of air pollution from ships, which entered into force on 19th of May 2005. It sets limits on emissions of sulfur oxides and nitrogen oxides from the exhaust gases of ships and prohibits intentional emissions of ozone-depleting substances; designated emission control areas set more stringent standards for SOX, NOx and particulates. A chapter approved in 2011 covers mandatory technical and operational energy measures performance with the aim of reducing greenhouse gas emissions from ships. Furthermore, Annex VI defines Emission Control Areas (ECAs) where stricter emission regulations are implemented and sets global emission limitations for SOx, NOx, and PM. The goal of Annex VI was to gradually lower the sulfur content of marine fuel oils below 0.5% by weight by 2020. Additionally, only ships built after January 2016 are subject to gradually stricter NOx regulations. The Baltic Sea, North Sea, North American, and United States Caribbean Sea are among the SO2 Emission Control Areas (SECAs) that the IMO established. Since 2015, the sulfur limit in these areas has been set at 0.01. Moreover, the North Sea and the Baltic Sea are designated as ECAs for NOX by MARPOL Annex VI revisions made in January 2019. These changes have come into effect since January 1, 2021 (Griffin, 1994).

In the last 3 years Annex VI has been constantly amended and more specifically:

- With resolution MEPC.362(79), adopted on 16 December 2022, concerning the regional reception facilities within Arctic waters, information to be included in the bunker delivery note (BDN) and information to be submitted to the IMO Ship Fuel Oil Consumption Database, Regulation 17 was amended with the replacement of paragraph 2 by the following

"*2 The following States may satisfy the requirements in paragraph 1 of this regulation through regional arrangements when, because of those States' unique circumstances, such arrangements are the only practical means to satisfy these requirements: .1 small island developing States; and .2 States the coastline of which borders on Arctic waters, provided that regional arrangements shall cover only ports within Arctic waters of those States. Parties participating in a regional arrangement shall develop a Regional Reception Facilities Plan, taking into account the guidelines developed by the Organization. * The Government of each Party participating in the arrangement shall consult with the Organization, for circulation to the Parties of the present Convention, on: .1 how the Regional Reception Facilities Plan takes into account the guidelines developed by the Organization; * .2 particulars of the identified Regional Ships Waste Reception Centres taking into account the guidelines developed by the Organization; * and .3 particulars of those ports with only limited facilities.*". The abovementioned amendment came into force in 1st of May, 2024.

- With resolution MEPC.361(79), adopted on 16 December 2022, concerning the Mediterranean Sea Emission Control Area for Sulphur Oxides and Particulate Matter, Regulations 13.6 and 14 were amended, with the addition of the following paragraphs *"4 In respect of the application of regulation 14.4, the Mediterranean Sea Emission Control Area for Sulphur Oxides and Particulate Matter includes all waters bounded by the coasts of Europe, Africa and Asia, and is described by the following coordinates: .1 the western entrance to the Straits of Gibraltar, defined as a line joining the extremities of Cape Trafalgar, Spain (36°11'.00 N, 6°02'.00 W) and Cape Spartel, Morocco (35°48'.00 N, 5°55'.00 W); .2 the Strait of Canakkale, defined as a line joining Mehmetcik Burnu (40°03'N, 26°11'E) and Kumkale Burnu (40°01'.00 N, 26°12'.00 E); and .3 the northern entrance to the Suez Canal excluding the area enclosed by geodesic lines connecting points 1-4 with the following coordinates:*

Point	*Latitude*	*Longitude*
1	*31˚29'.00*	*N 32°16'.00 E*
2	*31˚29'.00*	*N 32°28'.48 E*
3	*31˚14'.00*	*N 32°32'.62 E*
4	*31˚14'.00 N*	*32°16'.00 E ".*

The abovementioned amendment came into force in the 1st of May, 2024.

- With resolution MEPC.385(81) adopted on 22 March 2024, concerning the Low-flashpoint fuels and other fuel oil related issues, marine diesel engine replacing steam system, accessibility of data and inclusion of data on transport work and enhanced granularity in the IMO Ship Fuel Consumption Database (IMO DCS), Regulations 2,13,14, 18 and 27 were amended, with the most important of those being the amendment of Regulation 27 with the addition of the following paragraphs:
  New paragraphs 14 and 15 are added after existing paragraph 13, as follows:

"14 *On an ad hoc basis, the Secretary-General of the Organization may share data with analytical consultancies and research entities, under strict confidentiality rules. 15 The Secretary-General of the Organization, on the request of a company, shall grant access to the fuel oil consumption reports of the company's owned ship(s) in a non-anonymized form to the general public*."

The abovementioned amendments will come into force on 1st of August 2025.

2.3 IMO AND THE ADAPTATION OF ITS LEGISLATIVE WORK

2.3.1 CONVENTIONS

2.3.1.1 ADOPTING A CONVENTION

There are six primary IMO entities that deal with convention adoption and implementation. The committees engaged include the Maritime Safety Committee, the Marine Environment Protection Committee, the Legal Committee, and the Facilitation Committee. The Assembly and Council are the key organizations. Member States discuss developments in the maritime industry and other connected industries in these bodies, and any one of them may bring up the need for a new convention or changes to an existing one.

2.3.1.2 ENTRY INTO FORCE

The adoption of a convention marks the conclusion of only the first stage of a long process. Before the convention comes into force - that is, before it becomes binding upon Governments which have ratified it - it has to be accepted formally by individual Governments.

2.3.1.3 SIGNATURE, RATIFICATION, ACCEPTANCE, APPROVAL AND ACCESSION

A state can indicate its agreement to be bound by a treaty through a variety of processes, some of which are denoted by the phrases signature, ratification, acceptance, approval, and accession.

2.3.1.4 SIGNATURE

Consent may be expressed by signature where:

- the treaty provides that signature shall have that effect

- it is otherwise established that the negotiating States were agreed that signature should have that effect
- the intention of the State to give that effect to signature appears from the full powers of its representatives or was expressed during the negotiations.

A State may also sign a treaty "subject to ratification, acceptance or approval". In such a situation, signature does not signify the consent of a State to be bound by the treaty, although it does oblige the State to refrain from acts which would defeat the object and purpose of the treaty until such time as it has made its intention clear not to become a party to the treaty.

2.3.1.5 SIGNATURE SUBJECT TO RATIFICATION, ACCEPTANCE OR APPROVAL

A provision found in the majority of multilateral treaties states that a State may sign the document, subject to ratification, to indicate its agreement to be bound by it. In this case, the State will need to deposit an instrument of ratification with the treaty depositary in order for a signature to be binding on it. This option to indicate agreement to be bound by signature, subject to ratification, acceptance, or approval, was first introduced in a time before instantaneous international communications. It was a way to make sure that when it came to making a specific treaty, a State delegate did not go beyond what was required of them or their authority. Although they are less formal and technical, the terms "acceptance" and "approval" have essentially the same meaning as ratification and may even be favored by certain States that may be having constitutional issues with the phrase.

These days, a lot of States select this option, particularly when it comes to multinational treaties, because it gives them the chance to make sure that the required laws are passed and other constitutional requirements are met before making treaty obligations. The conditions for expressing assent by signature, subject to approval or rejection, have a striking resemblance to the rules of ratification. Article 14.2 of the Vienna Convention on the Law of Treaties, which states that "a State's consent to be bound by a treaty is expressed by acceptance or approval under conditions similar to those which apply to ratification," supports this.

2.3.1.6 ACCESSION

The majority of multilateral accords have a deadline for signatures. The process by which a State joins a treaty that it did not sign while it was still open for signature is known as accession. In theory, the deposit of an instrument of accession with the depositary is a prerequisite for accession for the State in question. According to Article 15 of the Vienna Convention on the Law of Treaties, consent by accession may be granted where the treaty expressly permits it or where it can be

demonstrated that the negotiating States agreed—either initially or later—that consent by accession may take place.

2.3.1.7 IMPLEMENTATION OF THE CONVENTION

After the convention has been ratified by the required member states, it would enter into force after a pre-defined time. This time is used for the implementation of the convention. The member states which have ratified the convention need to include the convention in their country's legal system. Therefore, when the convention enters into force, the countries which have ratified the convention would have the provisions of the conventions included in the country's laws.

2.3.1.8 AMENDING A CONVENTION

In early conventions, such as the International Convention for the Safety of Life at Sea (SOLAS), amendments came into force only after a percentage of Contracting States, usually two thirds, had accepted them. This normally meant that more acceptances were required to amend a convention than were originally required to bring it into force in the first place, especially where the number of States which are Parties to a convention is very large. This percentage requirement in practice led to long delays in bringing amendments into force.

Figure 2. Classical amendment procedures

To remedy the situation a new amendment procedure was devised in IMO. This procedure has been used in the case of conventions such as the International Convention for the Prevention of Pollution from Ships, which incorporates a procedure involving the "tacit acceptance" of amendments by States. Thus, instead of requiring that an amendment shall enter into force after being accepted by, for example, two thirds of the Parties, the "tacit acceptance" procedure provides that an amendment shall enter into force at a particular time unless before that date, objections to the amendment are received from a specified number of Parties.

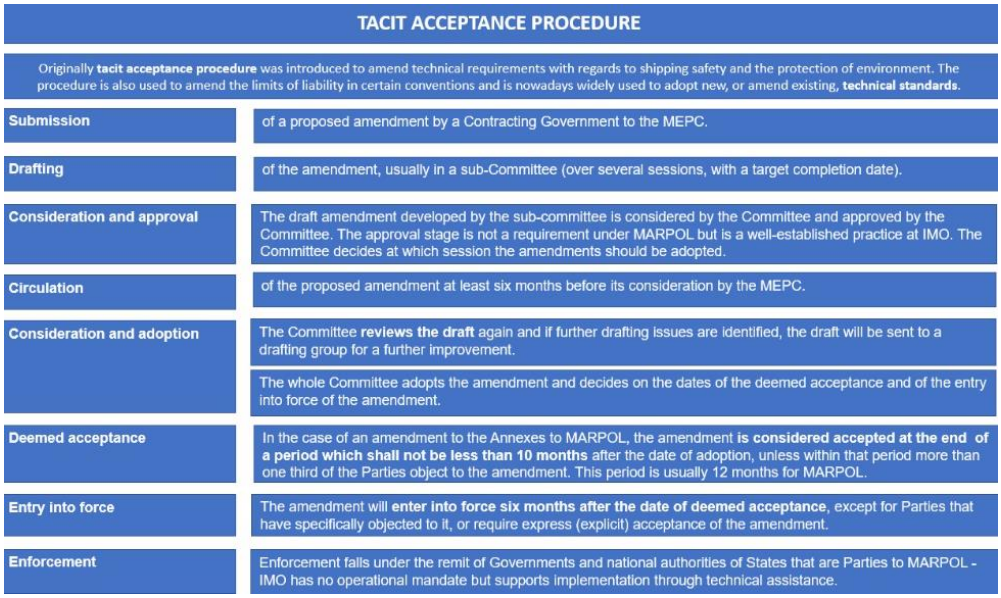

Figure 3. Tacip acceptance procedure

2.3.2 TRANSPOSITION INTO GREEK LEGAL ORDER

2.3.2.1 CONVENTIONS

2.3.2.1.1 RATIFICATION

Of course from a legal point of view, the contract of the treaty corresponds more closely to the narrow meaning of the term. Here, however, it is necessary to examine the entire cycle of actions that lead to the realization of the contractual relationship.

The conclusion of the treaty is completed primarily through ratification. Therefore, becomes legally binding. However, depending on the will of the contracting states, the object of the treaty, and the provisions of the constitutional law of the individual states, the treaty can also be concluded by signature, acceptance, or approval. These options are provided for in the Vienna Convention (1969) on Treaties (Articles 11 and 12) (Roukounas, 2015).

In Greece the ratification requires a “typical” law for the consent of the Hellenic Parliament. The treaty is attached to a draft law with the proposal of the competent Ministry as well as of the Ministry of Foreign Affairs and with a Report of the General Accounting Office on the corresponding expenses and appropriations. It is then forwarded to the Secretariat of the Council of Ministers and from there to the Central Legislative Committee for an opinion. It is then sent to Parliament and further to the parliamentary committee on Foreign Affairs and Defence. The Committee either discusses in principle and decides on the referral to the Plenary of the Parliament, or discusses and votes on the relevant bill.

2.3.1.2.2 PUBLICITY FORMALITIES

The last condition is the compliance with the rules of publicity and therefore, in order for them to be published in the Government Gazette. For example MARPOL was adopted in Greek legal system through the Law 1269/1982 (A' 89).

2.3.2.2 REGULATIONS

The Regulations of the IMO do not have direct effect in the internal legal system unless national "reception" measures are interposed, the type of which depends on the content of the regulations, as the case may be, sanctioning law, if their regulations fall under the provisions of art. 36 § 2 of the 1975 Constitution, presidential decree or ministerial decision. However, in any other case, the issuance of "reception" measures for the acceptance of the Regulations is usually provided for in the common legislative provisions of the sanctioning international convention or the statute of the international organization law[3].

3. GLOBAL MEASURES TO IMPROVE THE ENERGY EFFICIENCY OF SHIPS

3.1 MARKET-BASED MEASURES (MBM)

3.1.1 INTRODUCTION TO MBM

According to IMO, since the shipping industry is expected to grow, operational and technical measures are thought to be insufficient to reduce GHG emissions sufficiently. As a result, there is a general consensus that market-based measures (MBMs), when included in a comprehensive package of measures, will aid in the achievement of the IMO's targets (IMO, 2019). The Marine Environment Protection Committee (MEPC) addressed MBM, which are expected to endure for a medium amount of time (Hirdaris et al., 2012). However, similar to CO2 emission reduction efforts, disagreements among stakeholders have impeded the discussions (Hirdaris et al., 2012). Since MEPC 65 in 2013, the MBM discussions that started at MEPC 56 in 2006 have not made any advance (Tanaka et al., 2019).

Market-based measures, also known as market-based instruments, are more adaptable policies that utilize pricing or additional economic variables to provide polluters with financial incentives to lower their emissions. MBMs implement the "polluter pays principle," which requires the polluters to make up for any negative external environmental cost resulting from their emissions. Emission

[3] Decisions, recommendations and instructions of the IMO will be accepted with ministerial decision. See and practical elaborations of the Council of State 2141/1983, 1163/1980, 486/ 1983, 596/1977, in ToS 1978, p. 410. On this subject, see and C. Economides, Les amendements à la Convention relative à l'Organisation Maritime Consultative Intergouvernementale et leur introduction dans l'ordre juridique hellénique, RHDI 1968, and by the same, Nature juridique des actes leedroneets intergouvernementale et leur 1970, p. 225 et seq.

Trading Systems (ETS), various offsetting mechanisms, subsidies, and environmental levies are a few examples. In other words, MBMs allow the stakeholders determine how to respond and reduce the cost of their emissions by enforcing indirect market-based restrictions. Their response can take many forms, both logistical and technical, such as reducing speed or purchasing more energy-efficient appliances or alternative fuels.

It is worth mentioning that MBMs have the ability to motivate both immediate, logistics-driven actions—like reducing speed—and long-term, non-viable ones—like investing in energy-saving devices or alternative fuels. Any discussion at the IMO should identify the primary goal for deployment in order to evaluate the efficaciousness of MBMs. Restrictive measures on environmental damage are supposed to be maintained but lowered by applying the "polluter pays" principle. MBMs have the potential to initially drive the necessary adjustments for reducing emissions; but, a fully decarbonized future is only possible if MBMs are appropriately engineered to facilitate the switch to alternative fuels and energy systems.

As a result of their market orientation, MBMs can help bring about equity in the sector by providing incentives to environmentally conscious operators. Nevertheless, if the efficiency target is falsely standardized, the ultimate objective may be overlooked. Either way, pluralistic solutions and a well-crafted, easily-enforced MBM are required for full decarbonisation of shipping in order to support the necessary modifications (Lagouvardou et al., 2020).

The IMO Secretary General created an Expert Group in 2010 following a request for member state participation. The group's assignment was to assess up to ten (10) distinct MBM proposals that had been submitted by different IMO member states as well as other organizations.

MBM proposals submitted to the IMO were the following:

1. International Fund for Green House Gas emissions from ships (GHG Fund) (Cyprus, Denmark, the Marshall Islands, Nigeria and IPTA
   (MEPC 60/4/8)): Sets a worldwide shipping reduction goal that is either set by the IMO or the UNFCCC. By acquiring authorized emission reduction credits, emissions over the goal line would be primarily offset. An amount equal to one tone of bunker fuel purchased by each ship would be used to fund the offsetting operations.
2. Leveraged Incentive Scheme (LIS) (Japan (MEPC 60/4/37)): Contributions to the GHG Fund are gathered on a maritime bunker. Ships that reach or surpass predetermined efficiency benchmarks and are designated as "good performance ships" receive a portion of this money back.

3. Port State Levy (Jamaica (MEPC 60/4/40)): Imposes a consistent emissions fee on all ships that call at their designated ports, determined by the quantity of fuel each ship used to get there (not by the bunker suppliers).
4. Ship Efficiency and Credit Trading (SECT) (United Sates (MEPC 60/4/12)): Imposes obligatory energy efficiency regulations on all ships. Establishing an efficiency-credit trading program would be one way to adhere to the criteria. Over time, these requirements would get increasingly strict.
5. Vessel Efficiency System (VES) (World Shipping Council (MEPC 60/4/39)): Sets strict efficiency requirements for both new and old ships. Every vessel would be assessed in relation to the need to increase its efficiency by X% over the base efficiency (baseline) for that particular class and size of vessel. Over time, the standards would become more stringent and be layered. For ships that are already in service and cannot be upgraded to meet the necessary standards, there will be a charge per tone of fuel used.
6. Global Emission Trading System (ETS) for international shipping (Norway (MEPC 61/4/22)): Caps the net emissions from international shipping at a sector-wide level. Through a worldwide auction mechanism, a certain number of allowances (Ship Emission Units) equal to the cap would be issued into the market annually. Then, the units might be exchanged.
7. Global Emissions Trading System (ETS) for international shipping (United Kingdom (MEPC 60/4/26)): Two key areas separate it from the Norwegian ETS proposal: the way in which emissions permits are distributed (national auctioning as opposed to international auctioning) and the way in which the emissions ceiling is established (a long-term dropping trajectory).
8. Emissions Trading System (ETS) for International Shipping (France (MEPC 60/4/41)): Provides more information about the design of auctions under a shipping ETS. The plan and the Norwegian ETS proposal are identical in every other way.
9. Market-Based Instruments: a penalty on trade and development (Bahamas (MEPC 60/4/10)): insists that any fees should be proportionate to the amount that international shipping contributes to the world's CO2 emissions.
10. Rebate Mechanism (RM) for a market-based instrument for international shipping (IUCN (MEPC 60/4/55)): Provide developing nations with compensation for the monetary consequences of an MBM. It is applicable to any maritime MBM that brings in money.

Although the Report evaluated the several options based on predetermined criteria, it did not offer a preference or advice regarding the course of action to take in order to reduce greenhouse gas emissions.

The following member states subsequently changed their ideas, as listed below:

1. The Bahamas initially offered a revised version of their "do nothing" plan before withdrawing in it entirely.

2. The WSC's VES and Japan's LIS concepts were combined to create the Efficiency Incentive Scheme (EIS). The WSC and Japan suggested that, in light of the EEDI, particular efficiency benchmarks be set for both new and old ships in the global fleet (Lagouvardou et al., 2020). Discussions about MBMs at the IMO were put on hold in 2013 and shifted to the MRV/DCS topic.

According to the article of Lagouvardou et al. in 2020, MBMs have two major goals and are based on tax levies and/or economic indicators:

i. financial incentives for the marine industry to invest in fuel-efficient ships and technologies to run ships more energy-efficiently in order to cut down on fuel usage.
ii. counteracting rising emissions from the maritime sector in other areas.

The abovementioned can be achieved through the enforcement of emissions price-control or quantity-control mechanisms. Both measures enforce the “polluter pays” principle and can assist internalize the external costs of shipping emissions (Kosmas et al., 2017).

Price-control strategies address bunker levy programs like the GHG Fund and the carbon tax. A portion of the fixed levy that ship owners and operators pay, which is determined by their fuel usage, may be used to fund upcoming CO2 reduction initiatives. Though theoretically efficient from an economic and environmental standpoint, these kinds of initiatives nevertheless carry a danger of contributing to the transition from maritime to higher-carbon modes of transportation, especially with regards to short sea shipping (where the demand for shipping services is elastic and alternative transport modes are available) and the likelihood of carbon emanation (Balcombe et al., 2019). In addition, this type of tax can be smoothly avoided by taking fuel onboard from countries where it is not implemented (Gu et al., 2019). To bypass competitive deformation, they must be implemented all over the world rather than regionally, thus, necessitate the interference of independent extraneous bodies (Psaraftis et al., 2020).

3.1.2 INTERNATIONAL MARITIME RESEARCH AND DEVELOPMENT BOARD (IMRB)

The shipping sector has proposed accelerating the development of low-carbon and zero-carbon emission technology in order to meet the massive emissions reduction targets set by the Paris

Agreement and the IMO's Initial Strategy. The outcome was the creation of the International Maritime Research and Development Board (IMRB). A required payment per ton of fuel oil purchased powers the IMRB, and over the program's lifetime, this payment will raise around $5 billion. Although this program has not been considered or an overall agreement has not been reached by the IMO, it is expected to produce market-based measures (Wärtsilä; DNV GL, 2020).

3.1.3 BUNKER LEVY

Bunker fuel levies are simple to put into place and offer pricing certainty as shipping companies may respond proactively to expected increases in fuel prices. Gu et al. support this approach in their study, arguing that it is the only one that allows participants to choose an economical method of lowering their emissions without the help of the government (Gu et al., 2019).

Due to the fact that contributions are gathered as the ship uses gasoline, an international fund system appears to have the capacity to address issues brought on by market volatility.

According to Psaraftis and Lagouvardou, money raised by a carbon tax might be utilized to fund technological adoption and research and development. The Norwegian NO-fund is an investment RM (rebate mechanism) designed to encourage the adoption of abatement technologies. It has been implemented with great success. The industries won't have enough motivation to invest in innovative, ecologically friendly technology, nevertheless, if the levy is low. Paying the charge alone will yield a higher return than taking on the risk of their investment. Consequently, the size of the tax and the entities responsible for handling the levy collector's administrative duties are crucial aspects of the plan that require additional examination ((Psaraftis et al., 2020).

Psaraftis and Lagouvardou's study tackled several obstacles associated with enacting a bunker charge in the shipping industry. The authors conclude that, in order to prevent competition distortion, all ships should be subject to the levy, maybe with the exception of very tiny ships (below 400 GRT) and this brings us to the question of which vessels will be subject to the levy (Psaraftis et al., 2020).

A benchmark on EEDI, on the speed reached, and on any technological advancements that are incorporated on the vessel's equipment and thereby improve their efficiency, as well as criteria like the ship type, size, age, flag, and size should all be included in any specialization, differentiation, or rebate schemes. Additionally, all the scholars concur that the levy needs to depend on the fuel type. When comparing fuels with different carbon footprints, such as fossil fuels, fuels with lower carbon footprints ought to be taxed less heavily. A modest tax of USD 0.5–5 per ton of CO2 would primarily generate funds for research and development and have no effect.

Higher taxes—above USD 75 per ton of CO2 equivalent—would yield more significant outcomes and increase the affordability of alternative fuel sources. The consequences of a moderate tax rate, say USD 5-75/ton of CO2, would have reasonable effects. Furthermore, the report proposes a tax phase-in schedule that has already started since 2023 and increases steadily until 2050 (Psaraftis et al., 2020).

3.1.4 GLOBAL MARITIME EMISSIONS TRADING SYSTEM (ETS)

Emissions quantity-control strategies, such as emission trading schemes (ETS) or cap-and-trade programs, issue a certain number of annual allowances that permit companies to emit a specific amount of CO2. Companies may trade any unused emissions allowances or face up taxes if their emissions exceed the limits on their licenses after the overall emissions cap is established. The cap needs to be adjusted carefully. When allowances are scarce on the market, a too cautious cap could cause prices to soar, while an overly generous cap could defeat the purpose of the ETS.

There are two types of effects that ETS are projected to have: short-term and long-term emission reductions (Gu et al., 2019). In the long run a reduction in CO2 emissions can be achieved by shipping businesses investing more in technological innovation thanks to a successful ETS and at the same time save money. In the near future, shipping corporations might slow down their ships to cut down on fuel usage, which would lower associated emissions and allowances. While most people take the short-term emission reduction benefit of the ETS for granted, some researchers have shown that this isn't always the case. Depending on other variables like the cost of bunkers and charter rates, the ETS implementation may potentially result in an increase in CO2 emissions (Serra et al., 2020).

Thus yet, no MBM has been enforced globally, and it doesn't seem likely that it will happen very soon (Wan et al., 2018). Nonetheless, the long-term development of MBMs seems to be anticipated under the IMO's strategy (Shi, 2016).

As far as incentives are concerned, they can come in a variety of forms, such as the offering of subsidies, low-interest loans for eco-friendly initiatives, and advantageous tax structures. Ports have also lately begun to take steps to follow a more ecologically conscious route and to lessen the quantity of marine in-port emissions from ships (Acciaro et al., 2014). Port initiatives could include the promotion of successful voluntary programs to enhance the quality of the air around port areas or reductions in port fees for ships meeting specific environmental requirements (Serra et al., 2020).

3.1.5 COMPARISON OF CARBON TAXES AND ETS

According to Parry et al., in the absence of political restrictions, carbon prices make sense from a practical standpoint.

They readily expand on current gasoline tax collection, they can offer certainty over future emissions prices—which is necessary to encourage investments in emissions-saving measures—and they automatically generate income to fund ministries. Carbon taxes are consistent with the mitigation tools (such as feebates) that will be required for the transportation and building sectors, as well as possibly border adjustments. Carbon tax revenues can fund substantial support for low-income populations, with the majority of proceeds going toward reducing other onerous taxes or increasing profitable investments. Additionally, carbon taxes can be expanded to include a wider range of emissions sources, building on the business tax regimes that are currently in place (Parry et al., 2022).

On the other hand, although ETS has certain drawbacks, they could nonetheless be appealing in their own right. The growing number of Emissions Trading Schemes (ETSs) in Europe and Asia attests to the fact that ETSs are a more natural instrument in situations where mitigation policy is the responsibility of environment ministries and free allowance allocation to build political support seems to be a key decision factor for many countries. ETSs also help achieve emissions targets with greater certainty as it gives the possibility to shipping companies to choose either to invest on new technologies in order to improve their energy efficiency or simply buy allowances and the benefit for the first one is that shipping companies will increase at the same time their competitiveness (Christodoulou et al. 2024).

However, significant price volatility has not been prevented by price stability measures in existing ETSs; also, the monies that have been raised have mostly been allocated, and ETSs are impractical in many nations (such as those with limited capacity). According to A. Christodoulou this happens as in order for the ETSs to be implemented, in the first place require new administrative infrastructure and administrative processes in order for the emissions cap to be established and the allocation of allowances and therefore for the verification an monitoring of the use of the allowances in contrast with the bunker levy which can be implemented on the basis of previous energy levies (Christodoulou et al. 2024). Also legal barriers to border adjustments may be higher for export rebates, for example, than for carbon taxes, and ETSs are not always consistent with strengthening mitigation tools (Parry et al., 2022).

There is no automatic mechanism in place to prioritize cost-effective projects in the offsetting sector, so incorporating broader emissions sectors under an ETS through offsetting provisions may result in a rise in emissions overall. Reiterating the Paris Agreement with a formal international carbon price floor is more effective at scaling up global mitigation and could address concerns about international equity, and better accommodate alternative approaches at the national level. However, linking ETSs

into a global carbon market could improve the cost-effectiveness of mitigation across countries (Parry et al., 2022).

Design issue	Instrument	
	Carbon tax	ETS
Administration	Administration is more straightforward (for example, as extension of fuel taxes)	May not be practical for capacity constrained countries
Uncertainty: price	Price certainty can promote clean technology innovation and adoption	Price volatility can be problematic; price floors, and cap adjustments can limit price volatility
Uncertainty: emissions	Emissions uncertain but tax rate can be periodically adjusted	Certainty over emissions levels
Revenue: efficiency	Revenue usually accrues to finance ministry for general purposes (for example, cutting other taxes, general investment)	Free permit allocation may help with acceptability but lowers revenue; tendency for auctioned revenues to be earmarked
Revenue: distribution	Revenues can be recycled to make overall policy distribution neutral or progressive	Free allowance allocation or earmarking may limit opportunity for desirable distributional outcomes
Political economy	Can be politically challenging to implement new taxes; use of revenues and communications critical	Can be more politically acceptable than taxes, especially under free allocation
Competitiveness	Border carbon adjustment more robust than other measures (for example, threshold exemptions, output-based rebates)	Free allowances effective at modest abatement level; border adjustments (especially export rebate) subject to greater legal uncertainty
Price level and emissions alignment	Need to be estimated and adjusted periodically to align with emissions goals	Alignment of prices with targets is automatic if emissions caps consistent with mitigation goals
Compatibility with other instruments	Compatible with overlapping instruments (emissions decrease more with more policies)	Overlapping instruments reduce emissions price without affecting emissions though caps can be set or adjusted accordingly
Pricing broader GHGs	Amenable to tax or proxy taxes building off business tax regimes; feebate variants are sometimes appropriate (for example, forestry,	Less amenable to ETS; incorporating other sectors through offsets may increase emissions and is not cost effective
Global coordination regimes	Most natural instrument for international carbon price floor	Can comply with international price floor; mutually advantageous trades from linking ETSs but does not meet global emissions requirements

Figure 4. Summary comparison of Carbon Taxes and ETS, Source. IMF staff[4]

3.2 TECHNICAL MEASURES - INDEXES

The MEPC presented a number of significant technical and operational publications at its 59th session (IMO, 2009), including the Ship Energy Efficiency Management Plan (SEEMP), the Energy Efficiency Operating Index (EEOI), and the Energy Efficiency Design Index (EEDI). The first required energy efficiency index for shipping was implemented in 2011 and is a modification to MARPOL Annex VI, that covers all trade ships in the maritime domain weighing 400 tons or more (IMO, 2011). Additionally, since the Kyoto Protocol, this is the first legally binding limitation on greenhouse gas emissions (Huirong Liu et al., 2023).

3.2.1 SHIP ENERGY EFFICIENCY MANAGEMENT PLAN (SEEMP)

The Ship Energy Efficiency Management Plan (SEEMP) is an operational improvement strategy that increases fuel economy for both new and old ships. Ship operators must set up an efficient ship energy efficiency management system in accordance with the SEEMP in order to continuously enhance the fleet's overall operational structure and further reduce energy consumption. This process consists of five steps: thorough planning, implementation, monitoring, self-assessment, and improvement. All vessels 400 GT and up engaged in international voyages are covered by it (Huirong Liu et al., 2023).

[4] Note: Green indicates an advantage of the instrument; orange indicates neither an advantage nor disadvantage; red indicates a disadvantage of the instrument.

The quite frequent cleaning of hull or propeller, the improved vessel speed, or simply having a variety of ways to reach a location (which involves staying out of bad weather) are among the enhancements provided by SEEMP. One important point to note is that SEEMP is ship-specific since it considers specific aspects like cargo, routes, dry docking schedules, and larger corporate or fleet level strategies (Bradley et al., 2020).

3.2.2 ENERGY EFFICIENCY OPERATIONAL INDEX (EEOI)

The IMO has proposed the Energy Efficiency Operational Indicator (EEOI), a voluntary index designed to gauge the efficiency of current vessels and aims to collect all relevant data for the ship's energy usage and, therefore, the consumption of fuel onboard (Olympia Nisiforou et al., 2022). The mass of CO2 emitted per unit of transportation work, or "capacity mile," is the definition of the EEOI. The index considers all fuel used by main and auxiliary engines, including boilers and incinerators, at sea and at ports during the reference period, along with the associated CO2 emissions (Pariotis et al., 2016).

3.2.3 ENERGY EFFICIENCY DESIGN INDEX (EEDI)

In 2011, MARPOL was expanded to include the Energy Efficiency Design Index (EEDI). A "*monitoring tool which ship owners and operators can consult to gauge the potential impact of any management changes they make and thus weigh up the options from a more informed position*", the EEDI is applicable to new ships. Therefore energy efficiency decreases as the EEDI index rises. The first international rule to set CO2 emissions standards is the EEDI. The International Council of Clean Transportation (ICCT) projects that by the years 2040–2050, not all vessels (globally) will be completely compliant with the EEDI requirements, subject to the adoption year.

The (EEDI) calculates a ship's CO2 emissions per ton of capacity and each mile of transit (for transportation purposes). Since CO2 emissions are directly correlated with fuel usage and, by extension, ship energy consumption, the EEDI serves as a gauge of energy efficiency. The EEDI, which has to do with the hardware used in ship design, seeks to gradually improve the efficiency of newly built vessels by including cutting-edge, technically complex, and consequently energy-efficient technology. The EEDI is a non-prescriptive system that gives industry autonomy over technology selection (Olympia Nisiforou et al., 2022).

Furthermore, in June 2021, during the 76th session of the Marine Environment Protection Committee (MEPC 76), the IMO amended Annex VI of the MARPOL convention and the establishment of the Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII) as well as the implementation of new energy efficiency requirements are among the revisions. These measures,

were the result of the ISWG-GHG 7 meeting, which effectively created new measures from various groupings of countries within the two following categories:

1. Technical: For existing ships EEXI, taking EEDI and applying to existing ships (Wärtsilä; DNV GL,2020)
2. Operational: Addition of a mandatory Carbon Intensity Index with a rating scheme from A to E (Wärtsilä; DNV GL,2020). The measure is applied to all existing ships with a certain size threshold.

In general we could say that despite being the primary measures that the Initial IMO Strategy focused on for the short-term reduction of GHG emissions, several crucial viewpoints about its formulation and efficacy have been identified in the literature (Lindstad et al., 2019). In particular, there have been reports of shortcomings in the EEDI formulation that could provide concerns in terms of less safe and inefficient design in the pursuit of EEDI compliance (Krüger, 2011).

3.2.4 ENERGY EFFICIENCY EXISTING SHIP INDEX (EEXI)

The Energy Efficiency Existing Ship Index (EEXI), a recent metric for existing vessels, was adopted when the IMO approved revisions to MARPOL Annex VI in November 2020. The EEXI "*will be applicable for all vessels above 400 GT falling under MARPOL Annex VI*" and has been already set into effect by 2023. Since the "required EEXI is almost in agreement with requirements" for new build ships, the EEXI is essentially seen as an extension of the EEDI.

The EEXI "*determines the standardized CO2 emissions related to installed engine power, transport capacity, and ship speed*" in addition to describing the CO2 emissions per cargo ton and mile. Stated differently, the EEXI sets a restriction on the quantity of CO2 released for each transport supply unit. Keep in mind that the EEXI is not an operational index; rather, it is a technical (or design) index. As a result, neither onboard measurements nor measured values from prior years are needed. Essentially, the EEXI is limited to the ship's design.

Unless the vessel is a vessel constructed in accordance with EEDI Phase 2 or Phase 3 standards, a technical file that gives a technical calculation of the obtained EEXI of a specific vessel must show that it is lower than the required EEXI value (DNV, 2020).

3.2.5 CARBON INTENSITY INDEX (CII)

A recent metric known as the Carbon Intensity Indicator (CII) is designed to help the IMO's goal of "*reducing CO2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008*".The IMO approved a

CII rating system in June 2021 that will assess a ship's operational efficiency in terms of energy used in order to transfer people and cargo (Olympia Nisiforou et al., 2022).

According to a rating system that ranges from A to E, "*the CII determines the annual reduction factor needed to ensure continuous improvement of the ship's operational carbon intensity within a specific rating level*". Unlike EEXI, the CII is a temporary operational measure. Within the ship's SEEMP, the CII performance will be documented (Wärtsilä, DNV GL, 2020).

3.3 OPERATIONAL MEASURES

3.3.1 ROUTE PLANNING AND VOYAGE OPTIMIZATION

With the use of modern technologies, it is possible to choose the most energy-efficient navigation routes by accurately forecasting meteorological and sea conditions. By simply avoiding routes where the ship could not operate as efficiently due to poor weather, voyage optimization is a particularly cost-effective method for shipping corporations to cut expenses and their carbon impact. Since long routes have the most potential, deep-sea shipping has more interest in route planning than short-sea shipping.

3.3.2 ONSHORE POWER SUPPLY

When compared to rail and road traffic, the shipping industry is thought to have comparatively low emissions; yet, port locations produce the most pollutants (Merk, 2014). This is due to the fact that as a ship is maneuvering, docking, undocking, loading, and unloading it releases a lot of pollutants. Furthermore, on-board power generators must be maintained in operation when a ship is docked in order to operate cargo handling, control, pumping, and air conditioning systems. Therefore, operations involving parked ships account for as much as 70% of all emissions from seaports in affluent nations (Sifakis et al., 2021).

The onshore power supply, also referred to as shore-to-ship power supply, shore-side electricity, or cold ironing, is the process of providing berthed ships with power from a shore-side source so they can turn off their on-board power generators and lower noise and pollution emissions from ships.

The benefits of OPS are many and cover environmental and economic aspects: for example, Stolz et al. estimated that implementation of OPS could cut up to 5 $MtCO_2$ in the 714 major ports in the European economic area and in the United Kingdom (Stolz et al., 2021). Moreover, it was determined that the external costs per abated ton of pollutants with OPS are less than the external costs of emissions from ships that idle while moored at the dock (PTR, 2022). Furthermore, it was demonstrated that external expenses resulting from particulate emissions account for 61% of the total

expenditures related to ship emissions (with reference to the Port of Piraeus) (Chatzinikolaou et al., 2015).

3.3.3 SPEED MANAGEMENT

It is commonly known that there is a nonlinear relationship between fuel usage and sailing speed. The bunker fuel consumption is related to the third power of the vessel's sailing speed, meaning that even a slight decrease in speed results in a large decrease in fuel consumption (Alvarez et al., 2010).

It is possible to reduce speed using both operational and technological methods. The first is about building ships with fewer installed horsepower, while the second is about using slow steaming.
In particular, "slow steaming" is the practice when large ships travel at a slower speed to use less fuel, this is referred to as a means of addressing growing fuel expenses, the major shipping corporations adopted this strategy extensively during the worldwide economic downturn of 2007 (Cariou et al., 2011).While slow steaming is helpful in lowering CO2 emissions (Kim et al., 2014), it is not always helpful in lowering operating expenses unless an ideal voyage speed and a strategic range of voyage speed are utilized (Woo et al., 2014).

To conclude, although slow steaming can have unfavorable side effects, it can also help reduce the shipping overcapacity, which is currently the standard practice. It may lead to a move toward alternative land-based transportation options, particularly for short-sea trade, which would raise GHG emissions (Kim et al., 2014).

3.3.4 MANAGEMENT AND LOGISTIC MEASURES

Intermodal transportation is made possible by port logistics between the three main port areas (quayside, yard side, and landside;) as well as between port regions and the interior. Currently, logistics dominate the shaping of port key attributes that satisfy the intended trade-offs between: (i) operation performance and attractiveness (i.e., based on productivity, automation level, and connectiveness with distribution networks); (ii) compliance with EN16001 or ISO50001 (i.e., energy management, RES-based energy production, energy efficiency improvement); (iii) compliance with ISO14001 (i.e., air and water systems management); (iv) economic competitiveness; and (v) safety and security (Pivetta, et al., 2024).

3.4 ALTERNATIVE FUELS AND ENERGY SOURCES

3.4.1 SWICH TO ALTERNATIVE FUEL OPTIONS

The shipping industry utilizes fewer refined and/or processed fuels than other industries like road transportation and aviation. Heavy fuel oil (HFO) is the main fuel used in the shipping industry to

run marine diesel engines. When burning, heavy fuel oil (HFO) emits dangerous SOx emissions due to its high viscosity and high sulfur content. Other fuels with lower viscosity and sulfur concentration are used in the shipping industry; these fuels include marine diesel oil (MDO) and marine gas oil (MGO), with the former being used for smaller boats (Hsieh et al., 2017).

When utilized for ship propulsion, alternative fuels may reduce or have no net emissions (ITF, 2018). The usage of alternative fuels is currently becoming more popular, such as hydrogen and LNG (EAFO, 2019). Though they are still utilized in shipping on an experimental basis, some alternative fuels—which are covered in more detail in this section—can also be utilized as "drop-in" fuels (like biodiesel) (EAFO, 2019). Hereinafter follows a short analysis of the most popular alternative fuel options.

3.4.2 HYDROGEN

Although burning hydrogen releases no CO2, PM, or SOx, its low volumetric energy density and limited supply necessitate extensive system design and infrastructure improvements (Andrews et al., 2014). However, if the flame temperature exceeds 1700 K and air is the oxidant, NOx emissions may be produced at considerable amounts. Fossil fuels are the primary source of hydrogen production; specifically, 2% of coal and 6% of CH4 are utilized to produce hydrogen (IEA, 2020).

Heavy fuel oil (HFO) and other conventional diesel fuels that are currently utilized in the transportation sector can be blended with hydrogen to provide a fuel for fuel cells (ITF, 2018). It's widely agreed upon that hydrogen needs more development before it can be regarded as a competitive substitute for conventional fossil fuels. The research commissioned by the European Maritime Safety Agency (EMSA) provides an overview of various fuel cell technologies with potential use in shipping (DNV GL, 2017). As noted in the paper, fuel cell technology is still a relatively small industry globally and faces a number of obstacles before it can be considered a practical and sustainable alternative for energy solutions in the future (Serra et al., 2020). Nonetheless, hydrogen can be burned at low levels of blending as a "drop-in" fuel in marine diesel engines (Mofor, et al., 2015).

3.4.3 AMMONIA(NH3)

Several studies address ammonia as a viable shipping fuel, despite the fact that no marine engine on the market today is able to burn it (Brohi, 2014). Prior to the release of NH3 engines on the market, a number of technological obstacles must be overcome in order to use ammonia as a marine fuel.

It is already widely acknowledged by classification societies and researchers alike that reducing shipping emissions by half by 2050 will require a steady transition away from fossil fuels (Baresic, et

al., 2018). According to DNV GL's projections, by 2050, the energy used in shipping will primarily come from electricity and biofuels, with gas fuels providing 32% of the energy and oil-based fuels providing 47% (Rehmatulla, 2016).

Through the use of a catalyst and high temperatures, the Haber-Bosch process mixes nitrogen and hydrogen to generate ammonia for commercial use. Green ammonia has a comparative advantage over HFO production when it comes to production because it may be created through the use of renewable energy sources like solar, wind, or hydropower. Comparing green ammonia production to traditional ammonia, which depends on fossil fuels like natural gas for 90% of its production, is still more expensive. A number of international projects are underway to create green ammonia (ITF, 2018).

3.4.4 METHANOL

Although methanol is still being introduced to the market, several extensive experiments have already been carried out (DNV GL, 2019). Methanol offers cheaper investment costs and easier handling, therefore it might have potential (DNV GL, 2020). Due to its low carbon content and sulfur-free nature, methanol is an attractive fuel (SOTACARBO, 2020). Considering that it is liquid at normal temperature, it is simpler to distribute and store than LNG. It has various benefits, including the ability to reduce NOx and PM emissions, is sulfur-free, and can be utilized in accordance with SECA rules. It is primarily useful in dual-fuel engines. Methanol is already available in large quantities, but it is not anticipated that it will soon play a significant role as an alternative fuel in the maritime industry due to the limited availability of related global infrastructure and bunkering facilities (DNV GL, 2019). There is a massive expansion phase currently underway in the global methanol market. Methane may be converted into methanol, which may one day be used as a naval fuel. Methanol has the potential to reduce CO2 emissions by about 25% when compared to HFO. Furthermore, methanol can reduce SOx, NOx, and PM by 99%, 60%, and 95%, respectively; but, it can also be manufactured using renewable energy sources, including CO2 capture, industrial waste, municipal waste, or biomass, which can greatly minimize the greenhouse gas effect (ITF, 2018).

3.4.5 LIQUEFIED NATURAL GAS (LNG)

Since liquefied natural gas (LNG) requires 600 times less space for storage and transportation than gaseous natural gas, natural gas is liquefied by cooling it to -162 °C (Andersson et al., 2015). At the moment, although LNG has been heavily critisized for methane slip during the combustion process LNG is the cleanest fuel that can be used for transportation that can be generated in significant quantities, meet SOx and NOx regulations, and reduce CO2 emissions by 20–30% (Shell, 2020).

LNG, in particular, lowers pollution from NOx and PM by a large margin when compared to traditional marine fuels, and it reduces SOx emissions by over 90% (Sphera, 2019). LNG is also a cost-effective fuel thus LNG is readily available globally and has a favorable economic profile, making it a viable fuel option for transportation in the upcoming decades. The quantity of ships that use LNG as fuel is increasing quickly (Lowell et al., 2013).

LNG offers significant benefits for ships that operate the majority of their sailing time within ECAs and seems to be a viable choice for meeting the IMO's sulfur cap (Baresic et al., 2018). But given that it is unable to fulfill the IMO's mandate for GHG reductions, its use as a marine fuel suggests that it will only be temporary. In this sense, there are potentially disastrous financial risks for those who have recently made significant investments in assets for the use of LNG as a marine fuel (Baresic et al., 2018).

Moreover, the lack of availability of bunkering facilities at ports urges the ship-owners to be unwilling to invest in LNG vessels as LNG refueling opportunities are not easy to obtain, if we take under consideration that bunker suppliers are unlikely to invest in bunkering sites, until there is a substantial demand for LNG as a marine fuel (Baresic et al., 2018).

3.4.6 BIOFUELS (BIODIESEL, LIQUEFIED BIOGAS, ETC.)

The organic waste from plants and animals is converted into biofuels (ITF, 2018). Their fast biodegradability is a plus, and they may help lower greenhouse gas emissions. At the time, plant-based sugars and oils, like those from palm, soybean, and rapeseed, are the primary sources of biofuels (Hsieh et al., 2017). Biofuels are adaptable fuel substitutes since they don't necessitate major technological changes to be employed as drop-in fuels in current installations or combined with conventional fuels.

According to Mofor’s, Nuttall’s and Newell’s article in 2015, first, second, and third generation biofuels are defined as follows by the European Biofuels Technology Platform as following:

First Generation: "Directly extracted sugar, lipid, or starch from a plant serves as the biofuel's source of carbon." The crop is said to compete with food, either directly or indirectly. Second Generation: "Cellulose, hemicellulose, lignin, or pectin are the sources of the biofuel carbon." For instance, these could be wastes or residues from forestry, agriculture, or purpose-grown feedstocks that aren't meant for human consumption (such energy grasses or short rotation coppice). Third Generation: "Aquatic autotrophic organisms, such as algae, provide the carbon for the biofuel." The feedstock is created using light, carbon dioxide, and nutrients, so "extending" the carbon supply that may be utilized to manufacture biofuels (Mofor et al., 2015).

While a number of demonstration projects have tested the technological viability of different biofuels, securing the required production volume is the primary obstacle to their widespread deployment (IEA, 2017). Regarding their ability to reduce greenhouse gas emissions, there are also some doubters. Due to the destruction of forests necessary for their production, a number of studies claim that biofuels may not be completely carbon neutral during cultivation and may even cause air pollution (Balcombe et al., 2019).

3.4.7 ELECTRIFICATION, BATTERIES, FUEL CELLS AND HYDROGEN WITH FUEL CELLS

Since electrification lowers emissions in port areas and enhances energy management on board, it has become increasingly popular in the maritime shipping industry (Dai et al., 2019). Opportunities for electrification have taken advantage of in order to provide energy for cold ironing (berthing ships) as well as for charging batteries for hybrid or fully electric ships (Zis, 2019). Battery hybrid ships employ batteries to increase energy efficiency rather than bunkering electricity from shore, as opposed to full-electric ships, which rely on batteries supplied from the onshore grid while at dock.

Between a fully electric system and a conventional system, batteries can be used to achieve various degrees of hybridization. Hybrid systems are thought to have a great deal of energy efficiency potential and work well for a variety of ship types. Similar to other alternative energy sources, the electric option's commercial and technological suitability for deep-sea and short-sea shipping will differ greatly (DNV GL, 2019). Fuel cells are more efficient than typical reciprocating engines because they can convert fuel to electricity with a fuel to electricity conversion efficiency of up to 60%, compared to 40% for conventional engines. They can also produce electricity effectively using the chemical energy of hydrogen or another fuel (Mahapatra et al., 2014).

The most promising solution for fueling fuel cells on board is hydrogen. However, using it as fuel presents a number of difficulties with regard to not just its manufacturing, transportation, storage, and associated expenses, but also significant safety issues (Saito 2018).

4. EUROPEAN LEGAL FRAMEWORK FOR DECARBONISATION IN SHIPPING

4.1 THE EUROPEAN GREEN DEAL: CONTEXT AND AMBITIONS

4.1.1 HISTORICAL DEVELOPMENT AND POLICY CONTEXT

The European Green Deal, as proposed by the European Commission in December 2019, has proved to be an ambitious plan elaborated to make the EU climate-neutral by 2050. This extremely ambitious initiative strives not just to reduce greenhouse gas emissions but also to foster economic growth with the help of green technologies, sustainable industry, and transport (Siddi, 2020). The

way to a modern, resource-efficient economy has been established. The historical development of the Green Deal also goes far back, essentially from the point where the EU began working on environmental issues and climate change and brought out an integrated policy throughout the sectors of the economy (European Commission, 2014).

Before the Green Deal, the EU had already firmly established itself as a leader in global environmental governance through such initiatives as the 20/20/20 targets set in 2007: 20% reduction in greenhouse gas emissions, 20% increase in the efficiency of energy in the EU, and 20% of the EU's energy needs met with renewables by 2020. The follow-up, 2030 Climate & Energy Framework as well as the Energy Union strategy, went ahead to ideate this goal by being more ambitious on the emission-cutting targets and further ramping up on renewable energy. This has been a reflection of the trend in the nature of EU policy action for the environment to increasingly embed sustainability within its economic and social policy (European Commission, 2014).

Therefore, the policy context of the Green Deal lies in the increasing awareness of the need to urgently address and fight climate change and its impacts, well emphasized in different scientific reports and requested by civil society, pressing the EU to take environmental measures that are simultaneously comprehensive and binding. Indeed, the Green Deal seeks a transformation in several fields: energy, agriculture, biodiversity, and transport, which is concrete in decoupling value creation from resource consumption and transforming challenges provoked by climate and the environment into opportunities. It also comes from international commitments within the Paris Agreement, where, with the others, the EU was committed to reducing greenhouse gas emissions by 2030 by a significant quantity (European Commission, 2019).

In transitioning towards a greener economy, Green Deal is to redefine policies starting from clean energy, sustainable industry, building and renovating, eliminating pollution, sustainable mobility, biodiversity, from farm to fork (agriculture) to climate action, among others (European Commission, 2020). It goes without saying that it is going to move it from being haphazard to generally integrated environmental policymaking that will allow sustainability to be a part of every single thing in economic development. It is an initiative intended to be aimed not only at meeting the climate goals, but also at fostering sustainable and economic recovery after the pandemic period and thereby setting an example in terms of global environmental issues for the rest of the world: leading by example (European Commission, 2020).

In addition, with the Green Deal, the EU can position itself as a world leader. With strongly policy-based international leadership and very high-level environmental ambition, the EU leads other

nations and regions to follow such a path and offers a benchmark in international environmental and climate diplomacy. The Green Deal also expects economic benefits by putting Europe in the vanguard of the next wave of global industrial innovation, focused on sustainability—a major dimension of the future of global markets in balance with nature (European Commission, 2021).

In conclusion, the European Green Deal is a seminal policy initiative, building on the enduring commitments of the European Union to environmental stewardship and climate action. The Green Deal seeks to transform the EU economy by covering a wide number of sectors and building on successes in past policy areas. Its implementation throughout the EU will be key to the success of the initiative, and how businesses, member states, and even the citizens of the EU adapt and accept that things are progressively moving towards a sustainable future (European Commission, 2020a).

4.1.2 KEY OBJECTIVES AND TARGETS OF THE GREEN DEAL

The European Green Deal is one of the cornerstones of the EU policy agenda, explicitly designed to address the pressing challenges posed by climate change and environmentally related degradation. It provides an ambitious roadmap for making the EU a just and prosperous society with a modern resource-efficient and competitive economy by 2050, where there are no net emissions of greenhouse gases. It is the transformative agenda that centers on fighting climate change while protecting and preserving human health and natural habitats through decoupling economic development from resource use.

At the heart of the ambition of the Green Deal also lies the commitment to reach a climate-neutral status by 2050—an extremely ambitious target, which means a net reduction of greenhouse gases to zero in the middle of the current century. The 2019 European Commission communication initially outlined this goal, requiring participation from all sectors. To operationalize this, the EU has adopted a comprehensive plan involving the revision of policies in the areas of energy, buildings, transport, industry, agriculture, and biodiversity (European Commission, 2014).

Among the interim targets, the most important is to reduce the level of greenhouse gases by at least 55% in 2030 compared to 1990. The EU updated this goal in 2020 from the previous 40%, ensuring it will keep the EU on track to meet its target by 2050. Meeting this target should set the standard for the rest of the world, putting the EU at the forefront of international climate action and challenging the rest of the world to pursue an equally ambitious journey (European Commission, 2014).

Besides climate neutrality, the Green Deal also focuses on economic growth through green technology, sustainable industry, and biodiversity restoration. It includes a zero-pollution ambition for a toxic-free environment, which is very relevant to protecting EU citizens' health and reducing

environmental degradation that undermines economic activity sustainability. It is also expected that on this basis, the Green Deal will make sure that air, water, and soil are clean and free of pollutants, a goal very central to broader health and environmental strategies pursued by the EU (European Commission, 2019).

The Green Deal also sets targets on energy efficiency and renewable energy, core elements of any transition to a green economy. Indeed, below these general targets, there are detailed measures to expand offshore wind capacity for the EU and double EU solar energy production by 2030 (European Commission, 2021).

The EU strategy underpins these targets by focusing on building renovations to enhance their energy efficiency, thereby significantly reducing the EU's overall carbon footprint.

The European Green Deal also contains a strategic plan that aims at integrating environmental concerns in agriculture and biodiversity. For instance, the 'Farm to Fork' strategy aims to make the food systems equitable, healthy, and environmentally sustainable. This includes reducing pesticide use and risk targets by 50%, reducing nutrient losses by at least 50%, maintaining soil fertility, and reaching at least 25% of the agricultural land under organic farming by 2030 (European Commission, 2020c).

The broad ambitions of the goals and targets laid out by the Green Deal—a testament to the EU's ambitious leadership in global environmental governance—will further integrate environmental sustainability into economic and social policy. This will be stimulating innovation and investments in green technologies, job creation, and competitiveness across the EU. In sum, the Green Deal is not just about environmental goals; it's a strategic economic policy to ensure long-term sustainable growth within the EU and worldwide (European Commission, 2020c).

4.1.3 CONTRIBUTIONS OF LEGISLATIVE MEASURES TO THE GREEN DEAL GOALS

The legislative measures at the heart of the European Green Deal are crucial for its success, shaping the framework within which the EU is aiming to reach climate neutrality by 2050. A close interlink between legislation and policy outcomes shows that these measures guide both the public and private sectors in reaching their goals on sustainability. While this strong legal framework is one of the key drivers for the adoption of green technologies and practices, achieving the stated goals of the Green Deal remains under its canopy of accountability and governance. Initial legislative initiatives would involve the revision and strengthening of existing environmental and climate laws (European Commission, 2021). This is important because existing legal instruments need to be put on a par with more ambitious targets set by the Green Deal.

The first steps included the proposal for a European Climate Law, with the ambition to make the target of climate neutrality at 2050 legally binding—an irreversible process for the Union. The latter serves as a legal instrument, binding member states to a shared understanding regarding the national policies they must execute to align with the EU's integrated objectives and establish a unified strategy across national policies (Council of the European Union, 2022).

Aside from general legislation like the European Climate Law, separate legislative measures target specific industrial sectors and are directly integrated in the Green Deal's broad objectives. For example, the revision of the EU ETS will impose a tighter cap on GHG emitted by the major industrial sectors; it will increase the cost of emitting carbon and thereby encourage businesses to switch over to greener technologies. The Renewable Energy Directive and the Energy Efficiency Directive, on the other hand, provide binding annual targets for the uptake of renewable energy and energy-saving measures that each member state is to achieve (European Commission, 2021).

All of these sectoral directives and regulations contribute to the translation of the ambition contained in the Green Deal into action. For example, the Mobility Strategy outlines a pathway for the reduction of emissions from transport—one of the most polluting sectors—by means of specific legislation that promotes the use of electric vehicles, sustainable public transport solutions, and infrastructure development for alternative fuels. It is these laws that guide as much as they bind member states and industries for the institution of new norms, hence making systemic and enforceable this transition towards a green economy (European Commission, 2020).

Other than that, the Green Deal legislative framework has mechanisms that pertain to monitoring, reporting, and compliance, which are major features necessary for its successful implementation. For instance, the Governance Regulation on the Energy Union requires the member states to draft national energy and climate plans that illustrate how they would achieve the energy and climate targets in 2021-2030. The plans must be reviewed by the Commission, which then can propose further measures necessary to reach the goals collectively. Mechanisms placed for such concerns ensure transparency and accountability, hence giving a real-time view of where progress is taking place and where attention is still required (European Commission, 2021).

It finally concerns legislation's role within the Green Deal, which surpasses the concept of mere compliance and enters into views concerning a culture of innovation and sustainable development. Financial regulation today—for example, through the Taxonomy Regulation—directs investments to sustainable activities. As defined in this regulation, environmentally sustainable economic activities

encourage investment by the private sector in green technologies and support the wide-ranging goals of the Green Deal (European Parliament, 2020).

As the above-mentioned legislation moves forward, the EU also fortifies its environmental policy and economic growth while reaffirming its leadership at an international level with respect to climate action. The Green Deal legislative measures aim to transform compliance concepts from merely technical to transformative, bringing about a shift in societies and economies towards a sustainable future (Siddi, 2020).

4.1.4 POSSIBLE OBSTACLES AND SOLUTIONS IN THE SHIFT TO A CIRCULAR ECONOMY

To reach climate neutrality by the year 2050, the European Union has just put out a strategy with the aim to achieve net zero greenhouse gas emissions for EU countries as a whole, mainly by cutting emissions, investing in green technologies and protecting the natural environment. According to the Council of the European Union's "European Green Deal," this goal can only be achieved by a socially and economically balanced, equitable, and cost-effective transformation of Europe. The European Commission has developed legislative schemes and policies to encourage societal movements through green projects and to eliminate obstacles to their implementation, starting from 2020. These initiatives are based on the European Green Deal, which outlines crucial strategies for the EU's climate policy. The EU Green Deal stresses the importance of a comprehensive strategy whereby all EU policies and actions support the Green Deal's goals. According to the Council of the European Union's "European Green Deal," the programs address a wide range of interconnected policy domains, such as sustainable finance, agriculture, climate, energy, transportation, the environment, and the environment (European Commission, 2020c).

Still, Europe's greatest challenge and opportunity is to achieve climate neutrality by 2050. A shift to a model of regenerative growth, conservation of natural resources within ecologically sustainable limits, and advocacy for circular material usage are all necessary to achieve this goal (ibid). The shift towards a clean and circular economy, which is seen as a strategy to achieve sustainability, is one of the most crucial steps. The plan lays out a series of interconnected steps to create a solid and consistent product policy framework that will lead to the creation of environmentally friendly goods, services, and business models, as well as a change in consumer habits that eliminates waste altogether.

Lawmakers in Europe have elevated the urgency and gravity of the need to reduce emissions of greenhouse gases and achieve carbon neutrality by the year 2050. Considering the gravity of the climate crisis, the European Union has shown its political commitment to the cause by outlining a

number of objectives pertaining to renewable energy, energy efficiency, and the complete eradication of greenhouse gas emissions. The Commission has put forward sustainability principles to govern the longevity, upgradability, and reparability of products. These principles include, among other things, reducing or eliminating the use of harmful chemicals in products and making them more energy and resource efficient; increasing the amount of recycled materials in products without compromising their performance or safety; outlawing the disposal of unsold long-lasting goods; harnessing the power of digital product information, using tools like digital passports, tagging, and watermarks; and recognizing and rewarding products according to their level of sustainability (European Commission, 2020b).

Waste management, recycling, and reusing have mainly concentrated on the final step of the linear model of industrial production—consumption—while extracting, combining, and processing inputs have been the primary focus of sustainability efforts. One important normative principle in Circular Economy (CE) theory is that social equality, economic growth, and environmental preservation are all legitimate goals of CE that should be addressed appropriately in practice. In addition to reducing its amount, the CE model recommends reusing and recycling materials whenever possible.

The move towards a circular economy may represent a sea change in our production processes, employment patterns, consumer habits, and overall way of life. Business models and industrial organizations must prioritize sustainability and green growth. The core tenet of CE is the reutilization rather than the disposal of limited resources like minerals, metals, etc. (European Commission, 2020a).

Changes and improvements to industrial and technological processes are necessary for the aforementioned activity. The production process necessitates cutting-edge technology that supersedes all prior methods. Investment in new technology, the establishment of new production capacity, the broader use of know-how, and the development of new socio-economic activities are all necessary for the development and evolution of economic structures. To achieve this goal, it is necessary to think about the widening income and economic gaps in the nations of Southeast Europe. An further obstacle is the absence of a well-defined strategy for addressing climate change, deindustrialization, and inequality, as well as a blueprint for the development of a sustainable, undivergenced economy in Europe (European Commission, 2021).

The quantity and quality of jobs, wages, and capabilities are all susceptible to changes in the systems of production, services, and technology. So, CE policies should make sure that businesses reap the monetary, human, and capacity benefits of sustainability while also reducing industry disparities

(Siddi, 2020). Additionally, there is cause for concern over the interplay between EU national and local policies, which have the potential to significantly impact the way we tackle climate change. The issue at hand pertains to the development of strategies that take into account the variations in capital, production, and capacities among the many areas and countries that make up the European Union (European Commission, 2020c).

Additionally, between 2021 and 2027, the Just Transition Mechanism is aiming to spend 100 billion euros in public and private finances, with Member States contributing 7.5 billion euros. On the other hand, there is a significant income gap and a lack of equality in the ability to raise capital for environmentally friendly investments and technology across the European Union's member states, so this sum of money is not nearly enough to ensure that society is actively responding to climate change (European Commission, 2020a).

The European Green Deal Agenda requires a comprehensive EU industrial policy, which is acknowledged by the EU Commission itself. Unfortunately, there has been little progress in implementing industrial strategy, and it is unclear whether or not the EU requirements will be taken into account when it comes to governmental institutions' lack of support for businesses that incorporate environmentally friendly practices. Businesses have responded to the Green Deal's lack of clarity on how to alter the price network—which includes the price of carbon dioxide—by using environmentally harmful measures. In the past, rapid industrialization and infrastructure that relies heavily on natural resources have propelled the conventional view of development. The physical infrastructure of worldwide production, consumption, and trade is heavily reliant on fossil fuels and tailored toward once-through manufacturing processes; this model is largely followed by developing nations' burgeoning economies. There has to be a development approach that does not use as many resources, but there aren't any concrete examples to follow (European Commission, 2021).

Financial, structural, operational, attitude, and technological hurdles are the primary ones that prevent CE from being implemented. The observed obstacles are comparable to those for sustainability issue integration in general, but they show much more serious problems when the business viewpoint needs to be included, elevating sustainability issues to a crucial strategic level.

Here, the effectiveness and persistence of the stakeholders' commitment to implement the strategy is crucial to the success of the EU Green Deal. Developing aggressive government initiatives to assist the best possible transition in each nation is required to narrow the difference within the 27 EU Member States, according to a comparison analysis on the CE transition (European Commission, 2021).

A robust economic foundation, policy-making openness from governments, a territory-wide entrepreneurial spirit that can grasp the economic possibilities presented by the shift, and an open and receptive populace that can perceive the change as a chance to improve their social context and overall well-being are all necessary for a smooth transition (ibid). The increasing volume of waste and resource trafficking, as well as the multi-national nature of many product supply chains, makes it clear that current efforts to solve the CE through national laws alone will not be sufficient. It will be necessary for critical technologies to adapt to local needs and extend across boundaries.

Prioritizing circularity and reaching consensus on shared principles and standards is critical for global value chains. The international community must prioritize CE if policymakers are to play a pivotal role in this process; they must also encourage dialogue among all stakeholders, including those who allocate political and financial resources to CE on a global scale (European Parliament, 2020).

4.2 OVERVIEW OF THE FIT FOR 55 PACKAGE

4.2.1 INTRODUCTION TO THE FIT FOR 55 LEGISLATIVE FRAMEWORK

The "Fit for 55" package forms one of the fundamental building blocks in the ambitious legislative agenda of the European Union, interlinked legislative proposals toward addressing climate change, geared at cutting net greenhouse gas emissions by at least 55% by 2030 from the 1990 levels (Council of the European Union, 2021). This target, about setting the EU on a realistic track to climate neutrality by 2050, comprises a wide area of energy, transport, and housing; thus, requiring key revisions and updates of existing legislation but also introducing new initiatives (European Commission, 2021).

The Commission presented the Fit for 55 package legislative framework in December 2019, aiming to align EU climate, energy, land use, transport, and tax policies with the newly raised target of 2030. It is bold to expand the ambition to meet EU commitments under the Paris Agreement, as the previous goal was a mere 40% reduction. This package proposes amendments across a suite of directives and regulations to create one truly integrated approach to the reduction of emissions. Reforming the EU ETS is a key part of the Fit for 55 package. It includes more sectors and subsectors and a plan to lower the number of allowances given out more quickly. This will make it more expensive to emit, which will make reductions more strongly desired. Concomitantly, CBAM helps to avoid carbon leakage by putting a carbon price on the imports of certain goods coming from outside the EU; in fact, it also allows for greener production internationally (European Commission, 2021).

The package also seeks to increase renewable energy through new changes to the Renewable Energy Directive-RED that ramp up the target of renewable energy generated from sources in relation to the share of the overall energy mix in the EU. The result is the decarbonisation of Europe's power sector and innovation in greener technologies. In addition, the EU has revised the EED to set more ambitious annual targets for reducing energy consumption, and member states are collaborating to implement more binding energy-saving policies (European Union, 2021).

Along with the main EU emitters, the other priority sector under Fit for 55 will be transportation. The package is also supposed to include proposals to make emissions reductions in road transport easier by setting higher standards for new vehicle emissions, incentives for the market uptake of electric vehicles, and the large-scale deployment of alternative fuel infrastructure through the general EU mobility strategy. This includes major improvements, such as the rules for CO2 emissions from cars and vans that will underpin a rapid transition to electric mobility (European Commission, 2020).

In addition, Fit for 55 legislative measures will consider social equity and biodiversity protection, making the transition smoother due to socio-economic impacts on vulnerable households, small businesses, and energy-intensive industries. This may also include financial support through the Social Climate Fund proposed within the package in support of effective measures by such groups to adapt to the green transition equitably and inclusively.

In general, the Fit for 55 package means a far-reaching approach to tackling climate change and allowing the EU more substantive laws on how to achieve the ambitious targets for 2030 while opening ways to achieve climate neutrality by 2050. The integration of economic, environmental, and social issues for a sustainable and inclusive future is a significant advancement in EU climate policy (European Commission, 2021).

4.2.2 KEY COMPONENTS AND LEGISLATIVE MEASURES

The "Fit for 55" package was prepared as a main element of the European Green Deal of the European Union and encompasses various legislative measures that provide for assurance whereby the EU cuts greenhouse gas emissions by at least 55% by 2030 compared to levels in 1990 under. These policies, all connected, will be the backbone in fastening the EU's roadmap with respect to achieving its 2050 climate neutrality. It includes revisions of existing legislation, along with new legal proposals in several sectors such as energy, transport, and industry (European Commission, 2020a).

One of the key components of this package is the revision of the EU ETS, which forms the backbone of EU policy to fight climate change and is an important tool for cost-efficiently cutting industrial

greenhouse gas emissions. The proposed modification extends the system to new sectors, such as maritime, and further reduces the general cap on emissions, resulting in a faster pace of emission reduction. The ETS reform will also include, according to the European Commission (2021a), a supply adjustment mechanism that will help to maintain price stability so that emission reduction can be viable economically.

Another key legislative policy package under Fit for 55 includes the CBAM. These measures prevent carbon leakage by placing a carbon price on some products imported from outside the EU—to ensure that ambitious climate action in Europe does not displace emissions to other countries. The CBAM is designed to complement the ETS in a way that European businesses that pursue decarbonisation are not found at a disadvantage compared to their peers trading outside the EU (European Union, 2021).

The package introduces significant changes in the renewal energy sector, specifically the Renewable Energy Directive (RED) and the Energy Efficiency Directive (EED). The EU has significantly enhanced its target to derive 40% of its energy from renewable sources by 2030. At the same time, the new EED sets binding annual energy consumption reduction targets at the EU level. These are key drivers of energy efficiency in the wider economy. These directives help move toward a transition toward a sustainable energy system that is crucial in reducing reliance on fossil fuels and dealing with climate change (European Commission, 2020b).

The EU has proposed amendments to its standards on CO2 emissions for cars and vans, considering transport as one of the high-emitting sectors. The legislative action will reduce the limits set on new car emissions, thereby encouraging zero-emission vehicles within the next decade. In addition, the ReFuelEU Aviation and FuelEU Maritime plans will increase the use of sustainable fuels in aviation and maritime, showing the EU's comprehensive approach to reducing emissions across all modes of transport.

The Fit for 55 package offers a Social Climate Fund that would serve to abate the socio-economic impacts brought about by the green transition. In this regard, it targets financial support for households, small businesses, and communities most affected by the transition, with the express aim of ensuring that this shift toward the green economy is socially fair and just (European Commission, 2020c).

These mutually intertwined legislative measures form the so-called Fit for 55 package, which reinforces one another and helps the EU to reach ambitious climate targets effectively. The integration of these policies under one umbrella reflects the comprehensive approach towards climate

action by the EU, where environmental sustainability is pursued along with economic and social relevance (Siddi, 2020).

4.2.3 THE INTERRELATION BETWEEN DIFFERENT LEGISLATIVE ACTS

The "Fit for 55" package is proof that the European Union adopts a strategic and all-in-one approach to the introduction of legislation, especially on matters dealing with climate action. The European Union will stitch together this suite of legislative measures to ensure coherence of policy in cross-cutting sectors, which will mutually reinforce each other and increase capacity towards its ambitious target of reducing GHG emissions by 55% by 2030 compared to the 1990 level. Understanding the interrelations between these legislative acts will shed light on the comprehensive approach of the EU to systemic change toward a sustainable future (European Commission, 2020a).

Underpinning this set of interrelationships is, of course, the interaction between EU ETS and CBAM. The ETS does this by setting a cap on emissions and allowing the trading of emission allowances to provide for an efficient market for carbon pricing within the EU to correctly incentivize companies in the reduction of emissions. The CBAM complements this by imposing a carbon price on certain product imports to prevent carbon leakage, a phenomenon where firms shift their production to countries with more lenient emission constraints. The two instruments, when put together, therefore hold potential for promoting reductions within the EU and incentives for greener production elsewhere (European Union, 2021).

Energy legislation under the Fit for 55, including the revised Renewable Energy Directive and the Energy Efficiency Directive, is another example of the interlinkage. The RED has an ambitious target to increase the share of energy from renewable sources, which would directly contribute to the decarbonisation targets of the ETS by providing more clean fuel sources to replace and decrease the demand for emission allowances. Similarly, the EED targets binding energy savings, contributing directly to an overall reduction of energy demand in the EU and hence complementing efforts to reduce emissions under the ETS (Council of the European Union, 2022).

Transport-related directives in Fit for 55, in particular for CO2 Emissions Standards for Cars and Vans and ReFuelEU Aviation, will be interconnected with the general purposes of ETS and CBAM mentioned above: increasingly stringent emission standards expedite the transition to low-emission and zero-emission vehicles, and in turn aid reduced demand for carbon allowances in ETS, illustrating the intended general reduction targets (PwC, 2021). The proposal for ReFuelEU Aviation and FuelEU Maritime will contribute to the adoption of sustainable aviation and maritime fuels, respectively, as a means to decarbonize hard-to-abate sectors. These measures are particularly

important in terms of their contribution to the overarching goals outlined in the Green Deal (European Commission, 2020b).

Nonetheless, the Social Climate Fund, under the Fit for 55 package, deals with the social dimensions of these transitions. The Social Climate Fund provides financial support to households, small businesses, and communities, who are the most vulnerable to cost increases resulting from carbon pricing and energy transition. The Fund will help cushion the economic and social impacts of rigorous environmental legislation and provide greater public support while assuring a fair transition in the EU (European Commission, 2020c).

The sum of these separate legislative measures demonstrates the EU's integration commitment; every single act of action is not alone but also supports and galvanizes the impacts of the other acts. This is systemic integration, which is crucial for the success of the European Green Deal in ensuring a sustainable economic transition. It is not piecemeal but comprehensive, addressing environmental, economic, and social challenges in a coordinated manner (Council of the European Union, 2022).

4.3 DETAILED ANALYSIS OF SPECIFIC LEGISLATIVE ACTS

4.3.1 EU EMISSIONS TRADING SYSTEM EU ETS DIRECTIVE

4.3.1.1 PURPOSE AND MECHANISM

The EU ETS, set up in 2005, is the cornerstone of the European Union policy to combat climate change and a pivotal tool for cost-effective reductions of industrial greenhouse gas emissions. It is the world's first major carbon market and remains by far the largest. It underpins the EU's strategy to lower carbon emissions by promoting reductions that cost the least (IRENA, 2019).

The principal aim of the EU ETS is the determination of the market price of greenhouse gas emissions as well as ensuring that such emissions are reduced at a minimal cost to the economy. It covers about 11,000 power stations and industrial plants in 31 countries and airlines operating between these countries also, accounting for some 45% of the EU's greenhouse gas emissions. By setting a price on carbon, thus internalizing the cost of emitting carbon into the environment, the EU ETS provided an additional financial incentive for investing in technologies reducing emissions and improving energy efficiency.

EU-ETS operates on "Cap and Trade" principles. A limit is imposed on the overall amount of certain greenhouse gas emissions emitted by the installations falling under the ambit of the system. Over a period of time, this limit is reduced so as to make the total level of emissions go down. There is a limit within which companies are either given emission allowances or purchase those, and such

allowances can be transferred amongst each other according to one's need. Each allowance grants the holder the right to emit one metric ton of CO2 or the equivalent of another greenhouse gas. At the end of every year, each company must surrender sufficient number of allowances to cover all its emissions; otherwise, heavy fines are imposed. To enhance the effectiveness of the ETS, a gradual reduction in the cap on emissions allowances necessitates an increase in the price of allowances, thereby encouraging companies to reduce their emissions more economically. The commitment to ensure at least a 55% reduction in all GHG emissions by 2030 compared to 1990 levels under the European Green Deal includes a 2.2% annual cap cut starting in 2021 (European Parliament, 2020).

The EU ETS, over the years, has undergone a raft of reforms to improve efficiency and be more effective in driving emission reductions. The major reforms include the Market Stability Reserve (MSR), which would start in 2019, devised to resolve the accumulated surplus of allowances, partly due to a lower-than-projected economic activity in the post-financial crisis, reducing demand for allowances. It automatically adjusts supply under MSR to ensure that allowances put into the market would keep a stable carbon price to ensure cost-effective emission reductions (European Commission, 2021).

Furthermore, the EU ETS is not only a tool for reducing emissions, but also a significant source of financing for climate and energy projects across the Union. Member states apply the auctioning revenues from allowances under the ETS system to fund sustainable development projects, and the European Parliament mandates at least 50% of these revenues to climate and energy-related projects by 2021.

Besides, EU-ETS is the cardinal instrument in the legislative armamentarium that the EU has to tackle climate change. The EU ETS operationalizes the polluter pays principle by providing a profit motive for companies to reduce their carbon emissions. As this system evolves, it is expected to play an increasingly critical role both in meeting the ambitious greenhouse gas emission reduction goals of the EU and in demonstrating a scalable model for market-based environmental regulation (European Union, 2021).

4.3.1.2 AMENDMENTS AND UPDATES IN THE CONTEXT OF FIT FOR 55

The ambitious Fit for 55 package of the European Union includes the major amendments and updates necessary for the EU ETS, enhancing its capacity to meet higher greenhouse gas reduction targets. It will be essential for the alignment of the EU ETS with the more comprehensive aims of the European Green Deal target: a reduction of net greenhouse gas emissions by at least 55% by 2030 compared to the level in 1990 (Council of the European Union, 2021).

Among the major amendments to the EU ETS under the Fit for 55 package, there has been an expansion of its scope. The system, so far mainly applied to power plants, manufacturing industry, and intra-EU flights, now covers emissions from maritime transport and refines its aviation emissions coverage. This expansion not only broadens the impact of the EU ETS but also ensures a more comprehensive approach to carbon pricing across more sectors of the economy, critical for achieving deeper emissions reductions (European Commission, 2020a).Furthermore, the Fit for 55 amendments introduce an accelerated reduction of the cap on the level of emissions allowances. Starting from 2024, the cap will reduce by 4.2% annually, leading to a more rapid decline in the total amount of allowances. That represents a significant increase compared with the annual cut of 2.2% adopted so far and helps explain the current pace at which EU climate policy is developing (European Union, 2021). By reducing allowance availability, the EU ETS forces the cost of carbon emissions upwards, creating a stronger economic incentive for investing in cleaner technological options and enabling industries to lower their carbon footprint.

The reform also made the MSR stronger (Council of the European Union, 2019). The MSR is an important part of the EU ETS because it deals with extra allowances that could make the market less efficient and stop price signals that encourage low-carbon investments. The parameters of the MSR were tuned to make it more responsive and resilient, enabling it to manage the supply-demand balance of this market more effectively, thereby enhancing the resilience of the system and assuring more stable and predictable pricing of carbon.

Other key developments include adding a social element to the EU ETS to mitigate many socioeconomic impacts blamed on the low-carbon transition. A new Social Climate Fund was proposed that would help households, small businesses, and communities manage costs associated with the energy transition. This would be financed through auctioning part of the EU ETS allowances, thus creating a direct link between emissions trading and financial support for the most affected by the climate policies (European Commission, 2020a).

Other changes under the EU ETS introduce the provision for a new CBAM. By imposing a carbon cost on imports of specific goods from outside the EU, the mechanism aims to level the playing field, matching the cost that would have resulted from production under the EU's carbon pricing rules. Conversely, CBAM aims to collaborate with the EU ETS, preventing carbon leakage and encouraging global trading partners to adopt comparable carbon reduction strategies (Council of the European Union, 2021).

These changes and updates to the EU ETS represent an important evolution of the system toward aligning it with the amplified ambitions contained in the European Green Deal. The EU ETS will, for the first time, be in a position to play a fundamental role in the EU's efforts toward its 2030 climate targets by expanding the scope of the system, increasing the rate of reduction of allowances, providing an enhanced Market Stability Reserve, adding mechanisms to address associated social impacts, and linking with international carbon pricing (European Commission, 2020b).

4.3.1.3 THE EU ETS IN THE MARINE SECTOR

As we have already mentioned above, the European Parliament on 18 April 2023, voted in favour of the legislative amendments published on 8 February 2023 to the EU Emissions Trading Directive (the "Amendment") to include the maritime sector in the EU's Emissions Trading Scheme ("EU ETS"). The Amendment covers ships above 5000 GT and transporting cargo or passengers for commercial purposes ("Maritime Transport") since 1st of January 2024, while ships between 400 and 5000 GT fall outside of the EU ETS. According to DNV, Offshore ship and general cargo ships between 400 and 5000 GT will also be required to report emissions and may be included in the EU ETS at a later stage. However, the Commission will consider whether to include the exempt ships by the end of 2024 in accordance with the inclusion of these ships under the EU MRV starting in 2024.

As fas as the emissions are concerned, the EU ETS has been expanded to include the following: (i) 100% of emissions from maritime voyages within the EU; (ii) 100% of emissions from ships berthed in EU ports; and (iii) 50% of emissions from voyages that begin or end at EU ports but have a destination outside the EU. Additionally, the Amendment states that the Commission would examine whether to collect "more than" 50% of international emissions from ships after 2028 if the IMO fails to establish a global market-based mechanism ("MBM") similar to the EU ETS or in the form of a global carbon levy.

Additionally, the definition of "port of call" is amended by the Amendment to exclude a stop at a neighboring container transshipment port that is less than 300 nautical miles from a port inside the EU. This prevents ships from making a port call at a nearby non-EU port and from forfeiting a significant portion of their allowances for the brief journey from the nearby port to the EU. By the end of 2023, the Commission is anticipated to publish a list of these neighboring ports through implementing legislation; the list will be updated every two years. The emissions covered from 2024 will be carbon dioxide from Maritime Transport, nonetheless from the 1st of January 2026, emissions under the EU ETS will be extended to cover methane and nitrous oxide.

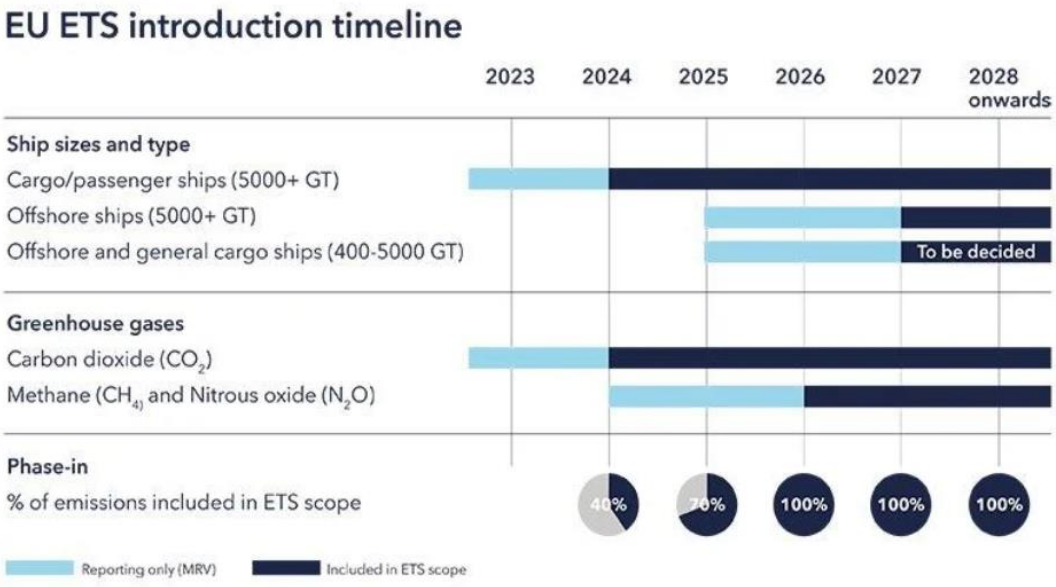

Figure 5. EU ETS Introduction timeline

According to the diagram above, a shipping company will be required to surrender allowances by 30 September of each year incrementally as follows:

(i) 40% of emissions in 2025, for its 2024 verified emissions;

(ii) 70% of emissions in 2026, for its 2025 verified emissions; and

(iii) 100% of emissions in 2027 (and thereafter), for its 2026 verified emissions (and each year thereafter).

As fas as the term "shipping company" is concerned, as defined in the abovementioned Amendment, it covers widely the shipowner or any other organization or person, such as the manager or bareboat charterer of a ship, that has assumed (contractually) the responsibility for the operation of the ship from the shipowner and that, on assuming such responsibility, has agreed to take over all the duties and responsibilities imposed by the International Management Code for the Safe Operation of Ships and for Pollution Prevention. This is usually the entity responsible for the choice of fuel, route and speed of the ship – i.e. the factors affecting the emissions of the ship – however arrangements may vary depending on what has been agreed in the ship management services agreements and/or the charter parties applicable to the ship. In this respect, shipping companies will be required to surrender their EU ETS allowances for the first time on 30 September 2025.

To conclude, what is worth to say is that in the Commission's latest package of infringement decisions, save for Denmark, all Member States failed to transpose the amended EU ETS directive fully into national law by the 31 December 2023 deadline. This means that ETS costs provisions and local enforcement mechanisms for any breaches of ETS have not yet been implemented by Member

States, leaving significant gaps in compliance which will need to be filled. In this respect, the Commission has started infringement proceedings against those Member States.

4.3.2 FUEL EU MARITIME REGULATION EU 2023/1805 (FEMREG)

4.3.2.1 OBJECTIVES AND REGULATORY FRAMEWORK

The main legislation under the ambitious European Union Fit for 55 package to reduce GHG emissions in the maritime sector is the adoption of the Fuel EU Maritime Regulation, which is planned to enter into force from the 1st of January 2025 except for Articles 8 and 9 on monitoring plans which have been already applied since 31st of August 2024, with the "shipping companies" (defined in similar terms as EU ETS) being required to submit their Fuel EU Monitoring Plans by **31st August 2024**.This Regulation aims to support the European Green Deal's objectives by ensuring that maritime transport effectively contributes to the EU's target of reducing net greenhouse gas emissions by at least 55% until 2030, compared to 1990 levels. The main purpose of the Fuel EU Maritime Regulation is to reduce energy-related greenhouse gas emissions from maritime transport. This move tackles the very pressing issue of the need to decarbonize a sector that has been traditionally very difficult to regulate because of its international nature, yet with a significant contribution to global emissions. Maritime transport is responsible for a significant share of anthropogenic sulfur oxide and carbon dioxide emissions globally. Therefore, it naturally becomes a crucial focus of climate action (European Commission, 2021).

The Fuel EU Maritime Regulation has established a regulatory framework that necessitates progressive reductions in the carbon intensity of fuels used by ships calling at European ports. The Fuel EU Maritime Regulation establishes precise targets and timelines, mandating a minimum 6% reduction in the GHG intensity of maritime fuels by 2025, with an increase to 80% by 2050, relative to 2020 levels. These are among the most ambitious targets globally, reflecting the EU's commitment to leading global efforts for maritime decarbonisation (Council of the European Union, 2022).

The Regulation also introduces additional zero-emission requirements for containerships and passenger ships above 5,000 gross tonnage (gt) at berth, mandating from 1st January 2030 the use of on-shore power supply (OPS) or alternative zero-emission technologies under the jurisdiction of a Member State, with a view to mitigating air pollution emissions in ports, which are often close to densely populated areas. The aim is to ensure the smooth operation of maritime transport, create regulatory certainty for the uptake of sustainable technologies and renewable and low-carbon fuels, and prevent distortions in the internal market. This will help the Union achieve its goal of becoming

climate neutral by 2050 and to increase consistently the use of renewable and low-carbon fuels and substitute sources of energy in maritime transport across the Union.

Beginning from 2025, ships operating in the EU, or European Economic Area (EEA) must cover their energy needs by fuels of GHG intensity (measured in gCO_{2e}/MJ) below a threshold value. The GHG intensity will be measured on a Well-to-Wake (WtW) basis, where Well-to-Tank (WtT) phase covers the generated emissions from the extraction, cultivation, production and transportation of the fuel whereas Tank-to-Wake (TtW) covers the emissions generated during the combustion of the fuel.

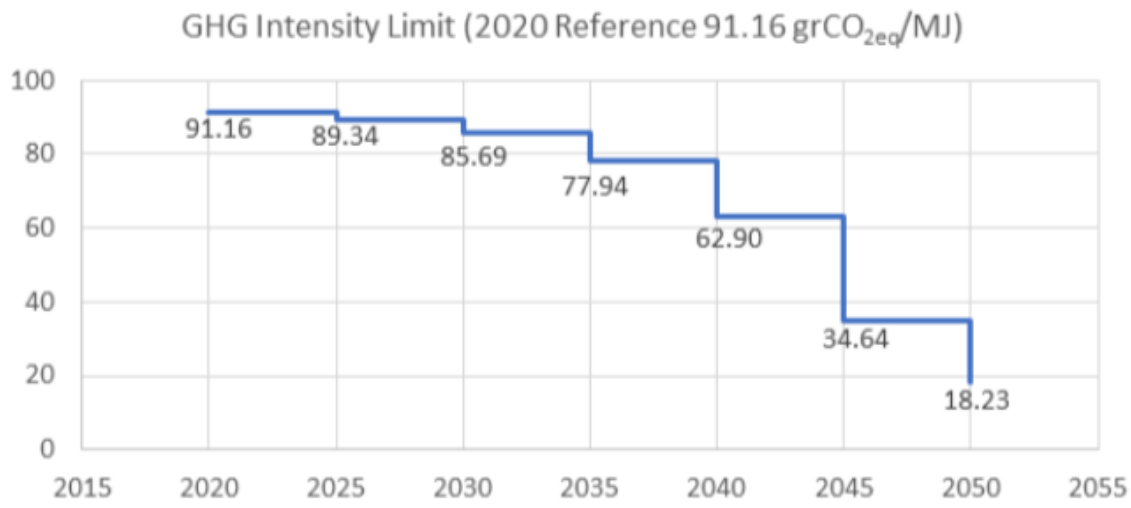

Figure 6. GHG Intensity limit

According to ABS, the GHG intensity threshold will be subject to a five-year percentage reduction with respect to a reference value, which is based on the average energy used onboard in 2020, reported in the EU Monitoring Reporting and Verification (MRV) data of that year, calculated equal to 91.16 gCO_{2e}/MJ.

It meets these objectives by introducing mechanisms that provide the right economic incentives for alternative, low-carbon fuels. Certainly, it creates a staged road map as to how maritime will gradually integrate sustainable biofuels, synthetic fuels, and liquefied natural gas into its operations. The framework encourages innovation and investment in new technologies and fuel types that are so crucial for the long-term viability of maritime transport. The same requirements are enforced by means of certification and penalties for non-compliance against ship operators in order to be able to meet the stipulated standards of fuel (Council of the European Union, 2021).

To be more specific, according to article 19 of said regulation, ships that do not meet the limits on the yearly average GHG intensity of the energy used on board should be subject to a penalty that has

dissuasive effect, is proportionate to the extent of the non-compliance and removes any economic advantage of non-compliance, thus preserving a level playing field in the sector (the 'FuelEU penalty'). The FuelEU penalty should be based on the amount and cost of renewable and low-carbon fuels that the ships should have used to meet the requirements of this Regulation.

Furthermore, in accordance with article 20, a FuelEU penalty should be imposed also for each non-compliant port call. That FuelEU penalty should be proportionate to the cost of using the electricity at sufficient level, should have a dissuasive effect as regards the use of more polluting energy sources and should be expressed in a fixed amount in EUR, multiplied by the established total electrical power demand of the ship at berth and by the total number of hours, rounded up to the nearest whole hour, spent at berth in non-compliance with OPS requirements. Due to lack of accurate figures on the cost of providing OPS in the Union, this rate should be based on the average electricity price in the Union for non-household consumers multiplied by a factor of two to account for other charges related to the provision of the service, including, inter alia, connection costs and investment recovery elements.

This regulation also meets the IMO's larger international provisions, such as the global sulfur cap by IMO 2020 in ship fuel oil. The Fuel EU Maritime Regulation goes even further by focusing not just on sulfur reduction but on comprehensive greenhouse gas emissions reductions and, thus, thirdly, situating the EU positively in maritime environmental governance. The Fuel EU Maritime Regulation also interacts with other elements of the Fit for 55 package, including the EU Emissions Trading System (EU ETS). Large ships will be covered by the EU ETS in 2023 and, equally, provide an economic incentive for ship operators to reduce their GHG emissions by using cleaner fuels as set out under the Fuel EU Maritime Regulation (IMO, 2020).

The EU Fuel Regulation introduces a sound regulatory framework that requires significant cuts in carbon intensity for maritime fuels. With ambitious targets and stringent mechanisms to ensure compliance, the EU is pursuing not just a reduction in the environmental impact of its maritime sector, but also the induction of development and diffusion of innovative technologies for maritime fuels. This regulation is a crucial step toward achieving the EU's overarching climate goals and demonstrates the EU's leadership in addressing maritime emissions on a global scale (European Commission, 2021).

4.3.2.2 IMPLICATIONS FOR THE MARITIME SECTOR

The Fuel EU Maritime Regulation constitutes one aspect of the more intensive climate strategy pursued by the European Union under the Fit for 55 package. It has a strongly profound impact on

the revolution in operational practices, fuel consumption, and overall strategic planning within the maritime sector. This is a regulation that has more to do with initiating a greener approach to maritime operations than it does with reducing GHG emissions (European Commission, 2020a).

The immediate implication of the Fuel EU Maritime Regulation is to move towards the adoption of other alternative, low-carbon-intensity fuels. This regulation requires fuels used by ships to decrease in greenhouse gas intensity, complicating and forcing the industry to gradually move away from heavy conventional fuel oils into other alternative options that include LNG, biofuels, methanol, and finally hydrogen- and ammonia-based fuels. These changes are foreseen to bring about major transformations in fuel supply chains and demand infrastructures across global maritime routes. This transition requires considerable investment in novel technologies and infrastructure. All EU harbors must have alternative fuels refueling points and other relevant facilities that can handle new fuel types. Moreover, the cost to ship owners for retrofitting ships already in business or buying new ones that can run on these cleaner fuels is extremely high. This transition is aided by the EU through various funding mechanisms intended to ease the financial impact of such a switch (Storm, 2020).

Economically, the rule takes hold of the cost structures in the maritime industry. The cost of early capital outlay for new technologies and the increased prices for alternative fuels may raise operationally. However, we anticipate that the efficiencies gained in newer technologies and the stabilization of alternative fuel markets will mitigate these costs over time. Adding the marine sector to the EU ETS means that shipping companies will now have to buy an allowance for their emissions, adding another layer to operational costs that will either keep freight rates up or alter global trading patterns in their own right (European Union, 2021).

In fact, the compliance and enforcement mechanisms under the Fuel EU Maritime Regulation even introduce new administrative and operational requirements: shipping companies would have to be very cautious in monitoring and reporting on fuel consumption and emissions in order to comply with new regulations. An increased regulatory burden necessitates enhanced data management systems and, possibly, the need to employ additional staff to manage compliance tasks in order to make all their operations subject to new legal requirements.

Beyond that, the environmental impact of such regulations is significant. In reducing the carbon intensity of maritime fuels, the EU has the ambitious goal of actually drastically reducing the overall carbon footprint of the shipping industry to help in the global fight against climate change. This shift in policy also joins other related international environmental imperatives, such as the strategy to have

the International Maritime Organization reach net zero ship-produced greenhouse gas emissions by 2050 compared with 2008 levels (IMO, 2020).

The regulation also acts as an incentive for the broader rethink of sustainability practices within the maritime industry. There is strategic encouragement for companies to find energy-efficient designs and operational practices, such as better hull designs, route optimization, or slow steaming, which reduces fuel consumption and resulting emissions. This alignment with sustainability will not only help in terms of compliance with the new regulation but also enhance the corporate responsibility profiles of shipping companies, making their credentials more attractive to environmentally conscious investors and customers (Storm, 2020).

The Fuel EU Maritime Regulation is complex in that it has a variety of implications for the maritime sector, ranging from economic and operational to strategic. On the other hand, the regulation brings complicated compliance and especially initial costs; however, at the same time, new opportunities have opened through modernization of fleet and practice, further assisting the global fight against climate change (Schlacke et al., 2019).

4.3.3 ALTERNATIVE FUELS INFRASTRUCTURE REGULATION EU 2023/1804 (AFIR)

4.3.3.1 PREVIOUS FORM OF THE REGULATION AS A DIRECTIVE

The Alternative Fuels Infrastructure Directive 2014/94/EU, formed an integral part of European Union policy to stimulate the market for sustainable transport fuels and the basis for supporting wider EU climate objectives under the European Green Deal. AFID, which was updated and made wider as part of the Fit for 55 package, would help get the infrastructure needed for alternative fuels like electricity, hydrogen, and natural gas up and running faster (Trippel, 2020).

Essentially, the Directive aimed to establish a dense network of fueling points and charging stations across the EU where alternative fuels could become widely available and easily accessible for all modes of transport. This ambition was in line with the EU's objective of drastically reducing greenhouse gas emissions caused by transport, which account for almost a quarter of the EU's total emissions and therefore are one of the most important sectors for achieving climate neutrality by 2050 (European Commission, 2020a).

4.3.3.2 THE REPEAL OF AFID DIRECTIVE AND ITS REPLACEMENT BY (EU) 2023/1804 REGULATION

On 14 July 2021, the European Commission presented the 'fit for 55' package of proposals to help reduce net greenhouse gas emissions by at least 55% by 2030, compared with 1990 levels. A proposal to amend and make a regulation out of the 2014 Directive on Alternative Fuels Infrastructure was included in the package. The Commission proposed to repeal the AFID and replace it with a regulation, suggesting that this change was needed to ensure swift and coherent development of the EU infrastructure network. While the 2014 Directive required Member States to develop national policy frameworks to ensure sufficient coverage of recharging and refuelling infrastructure for electrically chargeable vehicles, CNG- and LNG-powered vehicles, and natural gas supply in ports, the proposal set a number of mandatory national targets for the deployment of alternative fuels infrastructure for road vehicles, vessels and stationary aircraftin the EU. The Commission suggested binding targets in the draft regulation for hydrogen refueling stations, electric charging stations for stationary aircraft at airports, and on-shore power supplies for ships at ports (European Union, 2023).

Interinstitutional negotiations started in November 2022 and a provisional agreement was reached on 28 March 2023. Parliament adopted the new rules in plenary on 11 July. The Council adopted them on 25 July. The final act was signed on 13 September and published in the Official Journal of the EU on 22 September 2023. The Regulation has come into force since the 13th of April 2024.

Furthermore, in order to facilitate the adoption of low-carbon and renewable fuels, EEA member states must submit their national policy frameworks (NPFs) by 2025 together with their national targets for infrastructure rollout. In general, the idea is to make sure that a lack of delivery infrastructure doesn't impede the adoption of the alternative fuels required for decarbonisation. n this way, it supports ship owners and operators in their compliance with FuelEU Maritime.

According to the Article 1 of said Regulation, the latter establishes mandatory national targets leading to the deployment of sufficient alternative fuels infrastructure in the Union for road vehicles, trains, vessels and stationary aircraft. It also lays down common technical specifications and requirements on user information, data provision and payment requirements for alternative fuels infrastructure. It also establishes rules for the national policy frameworks referred to in Article 14 to be adopted by the Member States, including rules for the deployment of alternative fuels infrastructure in areas where no mandatory Union-wide targets are set and for reporting on the deployment of such infrastructure.

Last but not least, it establishes a reporting mechanism to encourage cooperation and ensures robust tracking of progress. The reporting mechanism shall take the form of a structured, transparent and iterative process taking place between the Commission and Member States for the purpose of finalizing the national policy frameworks, taking into account existing local and regional strategies for the deployment of alternative fuels infrastructure, and their subsequent implementation and corresponding Commission action to support the coherent and more rapid deployment of alternative fuels infrastructure in the Member States.

More specifically, according to the European Council (2023), targets set by the Regulation and which have to be met in 2025 or 2030, are in particular:

- from 2025 onwards, fast recharging stations of at least 150kW for cars and vans need to be installed every 60 km along the EU's main transport corridors, the so-called 'trans-European transport (TEN-T) network',
- recharging stations for heavy-duty vehicles with a minimum output of 350kW need to be deployed every 60 km along the TEN-T core network, and every 100 km on the larger TEN-T comprehensive network from 2025 onwards, with complete network coverage by 2030,
- hydrogen refuelling stations serving both cars and lorries must be deployed from 2030 onwards in all urban nodes and every 200 km along the TEN-T core network,
- maritime ports welcoming a minimum number of large passenger vessels, or container vessels, must provide shore-side electricity for such vessels by 2030,
- airports must provide electricity to stationary aircraft at all gates by 2025, and at all remote stands by 2030,
- users of electric or hydrogen-fuelled vehicles must be able to pay easily at recharging or refuelling points with payment cards or contactless devices and without a need for a subscription and in full price transparency,
- operators of recharging or refuelling points must provide consumers full information through electronic means on the availability, waiting time or price at different stations,

4.3.3.3 AFIR AND THE MARINE SECTOR

Along with a variety of transport types AFIR covers also some marine specific points such as inland waterways and ships and applies to major EEA ports, both coastal and inland and covers the core ports under the established TEN-T network (Trans-European Networks).

Onshore power supply (OPS) facilities will now be required, and AFIR will offer the technical requirements needed to standardize this. In addition, it will present guidelines and technical details

about the supply of hydrogen, methanol, and ammonia as well as the electricity needed to recharge batteries. The application will concern all ships over 5000GT entering EU ports and the provision will take place so that passenger ships, including ro-ro passenger, high speed passenger craft and cruise ships and container ships will be able to use shoreside electricity can be used by the following ships while at berth.

In this respect, member states are required to take some necessary measures to ensure that by 1st of January 2030 in marine ports there is sufficient OPS to meet demand for at least 90% of the average annual number of port calls in the last three years for container and passenger ships and appropriate LNG refuelling points in TEN-T core ports exist as well. LNG provision can be based on actual market needs rather than a prescriptive provision, which arguably implies an acknowledgement of LNG as a transitional fuel rather than a long-term solution. Furthermore, as far as inland waterway ports are concerned, member states by 1st of January 2025, there is at least one OPS installation in all TEN-T core ports and at least one OPS installation in all TEN-T comprehensive ports.

Simply stated, the Alternative Fuels Infrastructure Regulation is a catalyst for sweeping transportation and energy infrastructure changes in the EU, driving both the adoption of cleaner vehicles and fuels in support of strategic EU goals on energy and environment policy toward a more integrated, sustainable, and economically robust mobility and energy ecosystem.

4.3.4 TRANSPOSITION INTO GREEK LEGAL ORDER

One of the most important tasks of the European Union's government is to transpose EU legislation into national law, ensuring the effective integration of directives and regulations into the legal systems of all member states, including Greece. This is a very crucial process that helps to ensure the uniformity and effectiveness of EU policies across all member states in the pursuit of collective goals.

While regulations are directly applicable, directives, in contrast, do not take direct effect, and for the objectives set out in a directive to be reached, member states are obliged to adopt specific national legislation. In other words, the procedure is completed by the adoption of the directive at the EU level, following which the member states are set a deadline for implementing the necessary national legislation. Of course, this transposition procedure is very important in the sense that it allows member states like Greece to fit the provisions of the directive into the context of their specific legal system and administrative structures (Hellenic Republic, 2021).

The typical start of a transposition process by the Greek government includes an analysis of the directive's requirements and an assessment of the national legal framework as to what needs to

change or even new legislation to be introduced. This usually contains consultations with the major stakeholders, among which are also industry bodies, NGOs, and other entities, with the purpose of making sure that the transposed law will be practical and effective within the Greek context. These consultations help understand what the implications of the directive are and how to design legislation that comfortably agrees with the EU requirements, taking into consideration the national interest (European Commission, 2020a).

After this, the competent ministries prepare the legislative proposals for the directive's transposition. The competent ministries subject these to legal scrutiny and successive revisions to ensure their compatibility with both EU law and the Greek constitution. Finalized draft laws go to the Hellenic Parliament, which debates them and eventually votes them into law. This legislative process is critical as it ensures democratic oversight and public transparency in the transposition of EU directives (Greek Ministry of Justice, 2021).

Besides the legislative measures, transposition may involve administrative changes. This also encompasses the establishment of a new institution or change in any existing institution in order to give effect to the new laws. For instance, the transposition of environmental directives usually requires strengthening the capacity of the environmental agency or creating new bodies that will monitor compliance with environmental standards. The practical application of the directives on the ground requires another administrative aspect of transposition to achieve their intended effects. (Schlacke et al., 2019).

Economic constraints, bureaucratic futility, or even political instability often plague Greece's inconsistent elucidation of effectiveness in the transposition of EU law. Delaying this may result in the Commission's infringement procedure, which may lead to fines or penalties. Conversely, Greece closely watches the process of transposition through mechanisms of avoidance, often coordinating better across various governmental departments and levels of administration in pursuit of timely and correct implementation of EU directives (European Commission, 2020b).

The whole process of transposing EU law into Greek is complex, with multifaceted facets involving legal, administrative, and sometimes political considerations. This process also ensures that national laws align with the policies and objectives set by the EU, while also accommodating local conditions and requirements. Thus, this process points out not only the problems of policy implementation across diverse legal systems but also the collaborative nature of governance within the European Union.

CONCLUSIONS

To achieve the goals of the Paris Agreement and prevent serious anthropogenic intervention to the global climate, climate policies must reduce greenhouse gas emissions in a sustainable way over the future decades. This requires sustained political support in today's democracies. If the consumer costs of carbon pricing are low, and the policy is perceived as delivering cost benefits to end users rather than just higher prices overall, public support for climate action will be easier to be sustained.

In this respect, the IMO and the European Union, through their regulatory and institutional frameworks, are playing an active role in efforts to reduce greenhouse gas emissions.

The European Union's desire to lead the shipping industry in its decarbonisation is reflected in the European Green Deal, which is essentially a combination of carefully considered decarbonisation pathways. The global shipping industry is complicated and diverse, making it a challenge to successfully steer it in new directions that take into account different ship types, operating styles and market-specific strategic logics. In this context, benchmarks might indicate likely places along future carbon trajectories.

Several obstacles, such as the withdrawal of certain governments from current or future IMO rules and conventions, will need to be overcome in order to fully implement the IMO framework for decarbonising shipping. Another barrier that is likely to prevent international shipping from achieving zero carbon emissions is financial and technical constraints.

International cooperation should be a key objective of all national and international decarbonisation policies affecting the maritime industry. Policies should adhere to an established regulatory framework, ideally through IMO regulations. At present, however, creating zones and using the Paris Agreement to push the boundaries to encourage the shipping sector and leading states would be the most efficient way to achieve decarbonisation within the current framework. In an ideal world, international cooperation would determine the future of such a global framework, as evidenced by the stark differences between the initial COP26 outcomes and the promises made. It is not only feasible, but essential for the survival of our planet, to decarbonise shipping with as little negative environmental impacts as possible.

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