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Analytical review of countermeasures for the effective implementation of marine greenhouse gas regulations by the member states of IMO

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ANALYTICAL REVIEW OF COUNTERMEASURES FOR THE EFFECTIVE IMPLEMENTATION OF MARINE GREENHOUSE GAS REGULATIONS BY THE MEMBER STATES OF IMO

By

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACT

Title of Dissertation: **Analytical Review of Countermeasures for the Effective Implementation of Marine Greenhouse Gas Regulations by the Member States of IMO**

Degree: **Master of Science**

After the entry into force of the Paris Agreement, the control of greenhouse gas emissions from ships became one of the most important items on the IMO's agenda. To this end, the IMO has formulated a series of technical standards and management instruments in the MARPOL Amendment. For example, the Energy Efficiency Design Index (EEDD) for new ships, Ship Energy Efficiency Management Plan (SEEMP) for existing ships. However, Member States have varying degrees of obstacles to the implementation of the above standards. Therefore, this paper focuses on the recommendations for Member States to effectively implement the relevant regulations on shipping greenhouse gases under the IMO framework.

Prior to the discussion of the implementation mechanism of the Convention, a comprehensive review of the relevant legal framework for shipping greenhouse gases is made by the dissertation, and the importance of applying the IMO mandatory audit scheme to strengthen the management of shipping greenhouse gases in Member States is proposed by the paper.

Marine GHG management requires strategic planning at the national level, which not only relies on regulatory measures, but also must establish relevant safeguards and incentive mechanisms to encourage all sectors of the shipping supply chain to participate in the reduction of ship emissions and promote decarbonization of the shipping industry.

Despite the differences among Member States, there is a need for self-assessment of their ability to deliver on shipping greenhouse gases. In this paper,by comparing with IALA guidelines, the effectiveness of the guidelines is evaluated to analyze the impact of the implementation of relevant assessment tools on the implementation of the Convention by Member States. Based on this, an assessment tool is developed for the reference of Member States.

KEYWORDS: GHG；Emissions reduction； IMO audit scheme.

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LIST OF ABBREVIATIONS

AER	Annual Efficiency Ratio
CBDR	Common but Differentiated Responsibility
CII	Carbon Intensity Indicator
DIST	CO_2 Emissions per distance travelled
DCS	Data Collection System
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
EEXI	Energy Efficiency Existing Ship Index
EU	European Union
ETS	Emissions Trading System
FSC	Flag State Control
GHG	Green House Gas
III Code	MO Instruments Implementation Code
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
ISM Code	International Safety Management Code
SIDS	Small Island Developing States
MBM	Market-Base Measure
MEPC	Marine Environment Protection Committee
MoU	Memorandum of Understanding on Port State Control
MRV	Monitoring,Reporting and Verification

MARPOL	International Convention for the Prevention of Pollution From. Ships, 1973 as modified by the Protocol of 1978
PSC	Port State Control
SEEMP	Ship Energy Efficiency Management Plan
SDGs	Sustainable Development Goals
SIDSs	Small Island Developing States
TIME	CO_2 Emissions per hour underway
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER 1

INTRODUCTION

1.1 The Trend of Constant Increase in Greenhouse Gases

In 2015, at the 21st Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change, representatives of 196 State parties including developing countries agreed to keep the increase in global average temperature to well below 2°C above pre-industrial levels; and to pursue efforts to limit the increase to 1.5°C. (Paris Agreement).

The meeting directly sent a message to the international community: for the sustainable development of the earth, it is urgent for all public and private sectors of the society to reduce carbon emissions. According to the United Nations Sustainable Development Report, Global carbon emissions need to fall by a staggering 45 per cent by 2030 from the 2010 levels and continue at a steep decline to achieve net zero emissions by 2050 (UNDP,2019). As the essential part of economic globalization, the international shipping industry has played an important role in promoting industrial upgrading and improving the quality of life of people, especially people in developing countries. At the same time, due to the large-scale and lower cost of sea transport, the shipping industry has always been regarded by the international community as the most energy-efficient mode of transport, International shipping contributing only approximately 2.4% of global CO_2 emissions (IMO, 2020). As the proportion of greenhouse gases produced by ships is very small, but as the COVID-19 pandemic is gradually controlled by countries around the world. The huge increase in demand for imports and exports has brought about a lot of orders to the industry. Taking liner shipping as an example, the demand for imports of various countries has rebounded, while shipping alliances have controlled freight rates and made huge profits (Figure 1). In the long run, it will inevitably lead to an increase in greenhouse gas emissions. Shipping is expected to become one of the fastest growing sectors in terms of

greenhouse emissions, along with the aviation sector (Gilbert et al., 2010). Many developing countries have launched a process to formulate and implement national adaptation plans (NAPs) to reduce their vulnerability to climate change and to integrate climate change adaptation into national development planning. (UNDP, 2019)

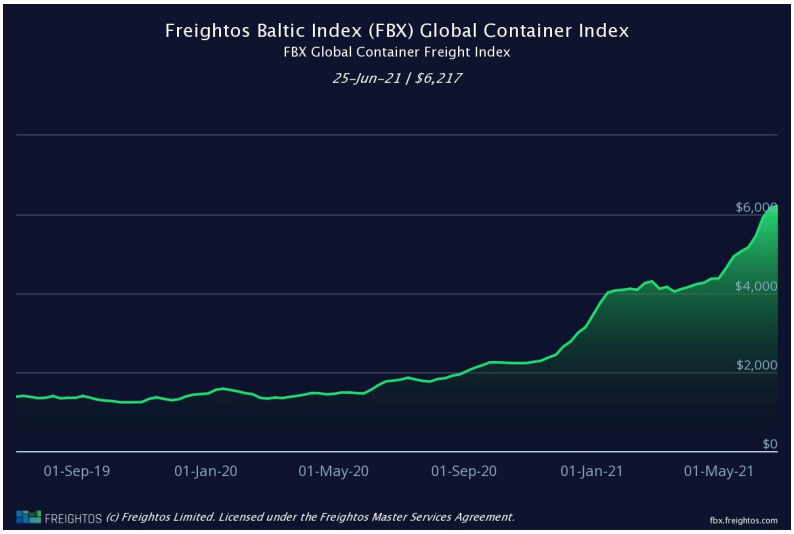

Figure 1 – Freightos Baltic Index(FBX)

Source: Freightos (Tradeos, Ltd).

The conventions and regulations developed by IMO provide reference for Member States to improve domestic legislation. At its 62nd Session Meeting (July 2011) of the Marine Environment Protection Committee (MEPC), when the IMO had adopted the proposed amendments adding to MARPOL Annex Chapter VI making the requirements on EEDI, for new ships, and the SEEMP for all ships. Notably, MEPC70 has approved the plan to develop a roadmap for the comprehensive IMO strategy for reduction of GHG emissions from ships, with a view to forming a preliminary strategic framework and serving as an important reference for Member States. IMO (MEPC72) 2018 has adopted the initial IMO strategy on reduction of GHG emissions from ships, and IMO MEPC73 2018 arranged subsequent programs following the Initial IMO Strategy（Joung, T.H. Kang, S.G., & Lee, J.K, 2020).

As the initial IMO GHG strategy was established and the follow-up schedule was agreed upon, it is inevitable for the domestic shipping and shipbuilding industries to undergo some changes such as strengthening of regulations (EEDI/SEEMP),

introduction of Market-Based Measures (MBM), and the use of alternative fuel vessel (Joung, T.H. Kang, S.G., & Lee, J.K, 2020).

In order to evaluate the implementation capacity of Member States and help them improve the effectiveness of implementing the Convention, IMO proposed a mandatory audit scheme. Under the influence of COVID-19, the mandatory audit of IMO based on III Code has to be postponed, but this does not prevent Member States from carrying out self-assessment.

Therefore, this paper mainly focuses on the implementation mechanism and mandatory audit scheme of IMO Member States in the context of marine greenhouse gas management, points out current problems and challenges in marine greenhouse gas management, and hopefully provides a feasible scheme for Member States to effectively implement relevant regulations on marine greenhouse gases.

1.2 Objectives of research

This paper focuses on the control of greenhouse gas emissions from ships and discusses the situations and limitations for Member States to implement the relevant conventions.

First of all, this paper introduces the global greenhouse gas emission reduction targets, current situation of marine greenhouse gas emissions management and actions of IMO and UN agencies on marine greenhouse gas emissions.

Secondly, this paper will introduce the existing legal framework of IMO on marine greenhouse gases, and analyze the relevant technical standards as well as the trend of the shipping industry.

Thirdly, the main content of this paper is to analyze the difficulties and challenges facing Member States in managing marine GHG in terms of technology, operation and market-based mechanism under the IMO implementation scheme. To proposed possible suggestions on how to tackle these difficulties, the following chapters explain the background and importance of IMO mandatory audit scheme, and analyse the case of relevant IALA guidelines. In order to make this paper more persuasive and

logical, China's experience will be referred to in the analysis of Member States' compliance with marine greenhouse gas regulations. In addition, the article also believes that there may be various restrictions and problems while adopting the countermeasures of mandatory audit of IMO. The measures need to be evaluated by Member States in time in the implementation process.

1.3 Key problems to be solved and methodology

This paper mainly discusses the role of Member States in managing greenhouse gas emissions from ships. At present, the limitations are mainly focused on the policies and regulations, the lack of regulatory guarantee system and the effective implementation of IMO mandatory audit. Therefore, the key issues studied in this paper are as follows:

1. The trend of greenhouse gas regulations in the international marine community and the impact of IMO on the implementation of the Convention by Member States;
2. Whether the implementation of greenhouse gas regulations by ships is effectively regulated and what role the Member States play in it.
3. The limitations of the Member States in the management of marine greenhouse gases, and how the IMO uses the audit scheme to improve the consistency of Member States' compliance.
4. In the future of carbon neutralization, how will Member States better manage ships to meet the requirements of the Convention.
5. The expected benefits and risks of implementing the new mandatory audit and evaluation mechanism.

In order to solve these problems, it is necessary to consult a large number of literatures and review and analyze them, including the conventions, rules, standards and documents on marine greenhouse gases issued by IMO and other industry organizations, and refer to the academic papers, books and related records published by other scholars through periodicals, conferences and other channels in recent years. In addition, a large number of IMO mandatory audit data and reports provide a

sufficient data basis for solving the main problems of the article.

With regard to how Member States can better manage their ships, under the IMO mandatory audit scheme, the audit guidelines of other sectors of the shipping industry can be used as an effective reference for Member States, and analyze the experience and practices of relevant countries in managing marine greenhouse gases to determine whether they are of further promotional significance.

Therefore, the purpose of this paper is to make recommendations to ensure that Member States effectively implement the regulations of ship greenhouse gas emission reduction requirements by considering the improved methods of legal framework and audit and assessment mechanisms.

1.4 Structure of the dissertation

In order to ensure the quality of the paper and achieve the research goal, this paper is divided into five chapters.

In the first chapter, the article mainly introduces the relevant background, research objectives and research methods of marine greenhouse gases, which establishes the research direction.

The second chapter mainly describes the IMO and related organizations on the management of marine greenhouse gases, and expounds on the current situation of carbon emissions of ocean-going ships in all application scenarios in the life cycle. This paper focuses on the technical standards of the ship Energy Efficiency Code in MARPOL amendment, and it is also the technical framework developed by IMO to promote the reduction of carbon emissions from ships, including EEDI, EEXI, CII, etc., and their impact on the implementation of the Convention.

The third chapter mainly analyzes the international conventions on greenhouse gas emissions control and the relevant measures implemented by Member States in the region, then, analyze the problems hindering greenhouse gas emission control and point out the challenges encountered in the future.

In the forth chapter, case study from VTS guidelines and data analysis to enhance

GHG frameworks will be discussed. Based on the analysis and comparison of the IALA audit guidelines and the historical data of the IMO mandatory audit, the paper analyzes the measures taken by Member States to strengthen the management of Marine greenhouse gases, and considers the establishment of self-assessment mechanism among Member States and other policy guarantee measures.

The fifth chapter first summarizes the main content of the paper, especially the need for IMO to strengthen the IMO mandatory audit scheme related to greenhouse gases, as well as the limitations of Member States to implement the relevant international conventions under the existing legal framework and technical standards. Secondly, in order to meet the needs of Member States to enhance their implementation capacity, suggestions are provided for Member States to strengthen the management of marine greenhouse gases, and corresponding tools are developed for reference and use by Member States.

Chapter 2

MANAGEMENT STATUS OF MARINE GREENHOUSE GASES BY IMO AND UN AGENCIES

2.1 Introductory remarks

Global warming will not only cause frequent extreme weather, but also cause glacier melting, at the same time, the sea level rises, threatening the sustainable development of human society. The problem of climate warming caused by the continued increase in global greenhouse gases is recognized as a common challenge for all mankind. The Intergovernmental Panel on Climate Change (IPCC), UN and IMO have set goals to slow the trend of global warming. However, these measures should also take into account the impact on SIDS. This is so because concerns have been raised that such States may be put in a comparative disadvantage whenever a specific GHG reduction measure is implemented, or may suffer adverse economic impacts by the measure. (Psaraftis, N. H., Zis, T. 2020)

On the one hand, due to the improvement of shipbuilding technology and the development of port infrastructure, ships are becoming more large-scaled, and the efficiency of energy use is higher than that of the aviation industry. A container ship only releases 10 grams of CO2 per tonne-kilometre as compared to 470 grams of CO2 released by air freight. (Maersk,2010)

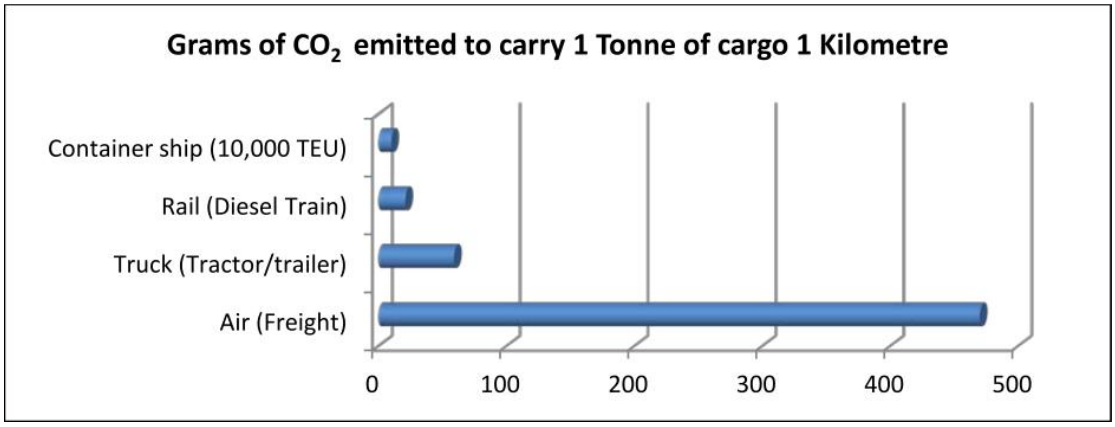

Figure 2 Comparison of CO2 efficiency of different transportation modes

Source：Maersk, 2010

On the other hand, traditionally, the shipping industry's efforts to reduce the environmental impact of international shipping do not focus on dealing with climate change, but mainly on pollutants produced by ships, such as oil pollution, garbage pollution, air pollution and so on. According to Gilbert and Bows (2012), this is due to the fact that more obvious local pollutants such as nitrogen oxides and sulphur oxides dominate environmental risks; the omission of shipping from national inventories under the Kyoto Protocol.IMO has made a specific convention for the management of ship ballast water(BWM Convention), which provides requirements and standards for ballast water treatment equipment, etc.

Shipping is expected to become one of the fastest growing sectors in terms of greenhouse emissions, along with the aviation sector (Gilbert et al., 2010). In particular, the problem of greenhouse gases caused by ships sailing in the port area has attracted the attention of many scholars and studied, Ships are the single largest source of port-related pollution, causing emissions approximately ten times greater than those from the ports' own operations. (Habibi and Rehmatulla, 2009). Therefore, as the maker of international shipping rules, IMO begins to take into account the challenge of the shipping industry to deal with climate change. On the basis of the MARPOL amendment, IMO formulated a preliminary strategy for greenhouse gas emission reduction, and identified three main ways of technical, operational, and market-based emission reduction. First of all, this chapter will discuss the legal framework related to greenhouse gases. After that, it will analyze the emission reduction situation and limitations of the shipping industry. Finally, it analyzes the positioning and role of Member States in promoting marine greenhouse gas emission reduction, especially the need for developing countries to participate will be emphasized.

2.2 Current status of seaborne greenhouse gas emissions

While IMO formulates policies, it also needs to evaluate the current situation of

shipping development. In terms of marine greenhouse gas management, IMO has been carrying out marine greenhouse gas research since 2000, and the latest fourth greenhouse gas research was completed in August 2020. The study aims to provide assessments of greenhouse gas emissions from the maritime industry and forecasts for future emissions during that period.

The fourth greenhouse gas study of IMO mainly includes two parts: "emission inventory" and "emission projections"（IMO,2020）, which will be analyzed below:

1.The share of seaborne greenhouse gas emissions and global emissions shows an overall upward trend (fluctuating during the period). Between 2012 and 2018, global seaborne greenhouse gas emissions (including international, domestic and fishing vessel emissions) increased from 977 million tons to 1.076 billion tons (CO2e), an increase of about 9.6 per cent. Of this total, CO2 emissions increased by about 9.3 per cent from 962 million tons to 1.056 billion tons, and the global share of emissions rose from 2.76 per cent to 2.89 per cent.

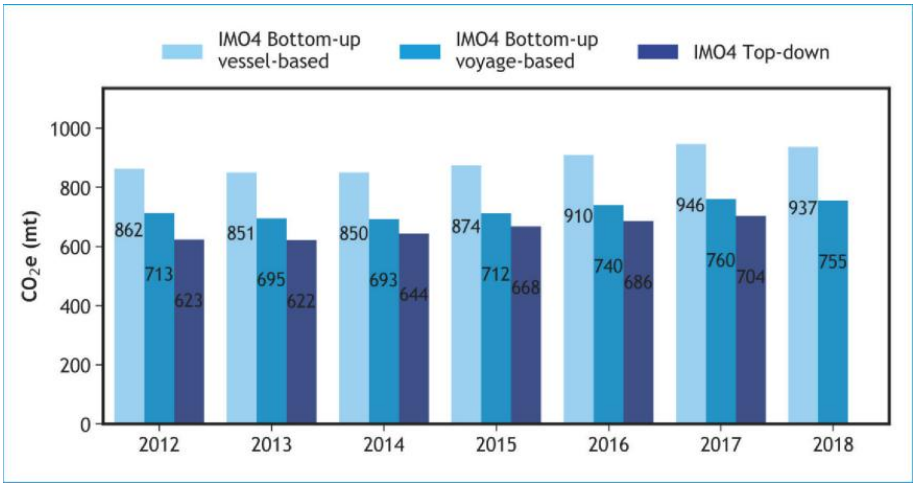

Figure 3 – Annual greenhouse gas emissions (in CO2e) for international shipping,

Source: Fourth IMO Greenhouse Gas Study

2. The operating carbon intensity of international shipping as a whole continues to decline, but the rate of decrease slows down gradually. The international seaborne carbon intensity, based on the ship's energy efficiency operation index (EEOI), is 31.8% lower than that of 2008 in 2018.

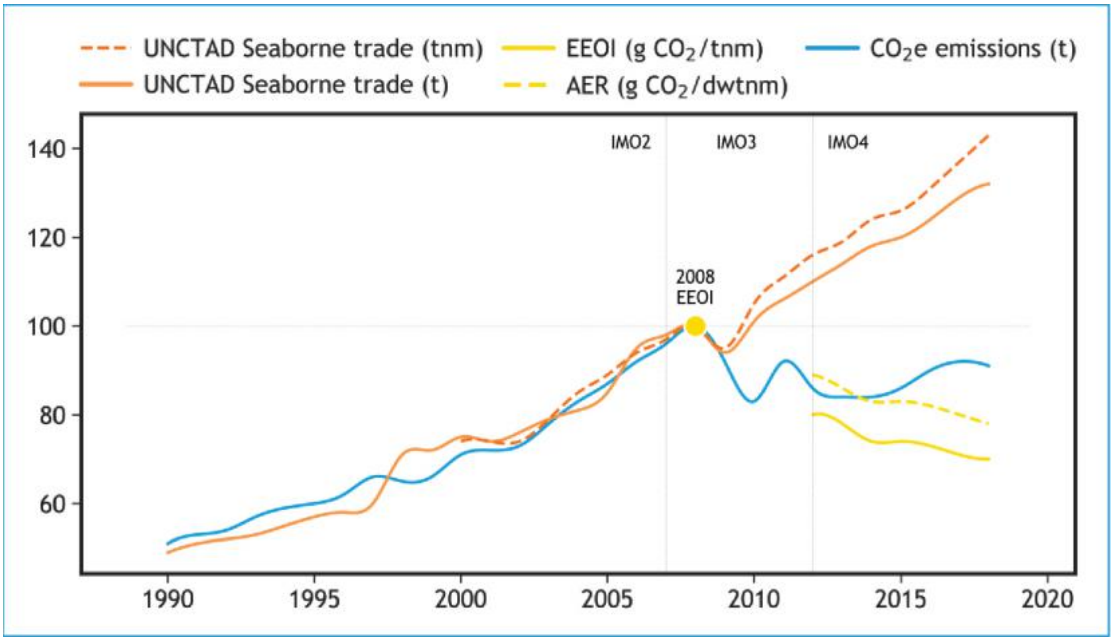

Figure 4 – Trends in seaborne trade, carbon, carbon intensity metrics (EEOI and AER) and CO2-equivalent emissions for international shipping, 1990-2018, indexed to 2008

Source: UMAS.

In addition, the proportion of exhaust gas emitted during navigation is different from that in the stage of maneuvering, mooring or berthing, which should also be considered in the application of EEOI and AER. These three types of ships are also the main force of the international maritime fleet, accounting for 65% of CO2 emissions and 84% of transport turnover. Compared with 2008, the largest decline in operating carbon intensity was also bulk carriers, whose EEOI and AER fell by 38% and 31% respectively in 2018. EEOI for both oil tankers and container ships fell by about 26%, but AER fell by about 10% and 27%, respectively.

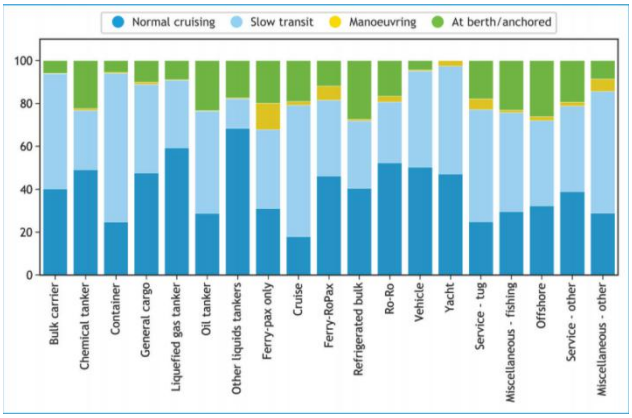

Figure 5 – Proportion of international greenhouse gas emissions (in CO2e) by operational phase in

2018.

Source: Fourth IMO Greenhouse Gas Study

3. The seaborne carbon intensity will continue to decrease in the future, but CO2-year emissions will continue to increase or decrease slightly. By 2050, global CO2 emissions are expected to reach 90% and 130% of 2008 levels. However, the forecast does not take into account the impact of the COVID-19.

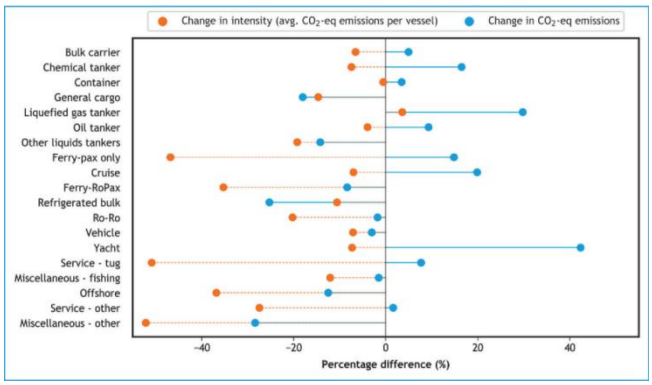

Figure 6 – Change in total international greenhouse gas emissions (in CO2e) and average vessel-specific greenhouse gas emissions (in CO2e) between 2012 and 2018

Source: Fourth IMO Greenhouse Gas Study

Through the analysis of the research report on marine greenhouse gases, it can be recognized that after the implementation of the new standard (EEDI), the operating strength of bulk carriers, oil tankers and container ships with the largest market share shows an overall downward trend, which is closely related to the legal framework of greenhouse gases jointly formulated by the United Nations, IMO and the shipping industry.

2.3 Legal framework for greenhouse gases

Climate change is affected by the balance between energy entering the earth, solar radiation and energy leaving the earth and outward radiation. Human activities in the industrial era upset this balance. Due to the rapid increase in anthropogenic GHG,there is currently a slight imbalance between solar radiation and outward radiation,leading to a global warming situation (IPCC, 2020a). The greenhouse gases emitted by ships mainly include methane (CH4) and dinitrogen oxide (N2O), of

which CO2 dominates the global warming potential. According to the combustion of fuel, ships also emit other gases that have an impact on the climate, such as black carbon with warming potential and sulfate particles with cooling effect.(Styhre, L. Winnes, H., & Black, J, 2017) The marine greenhouse gases analyzed in this paper mainly refer to the carbon dioxide emitted by ships, especially the carbon dioxide emitted by international ships in various application scenarios in the whole life cycle, excluding domestic vessels such as small yachts, fishing boats and engineering ships.

Therefore, the framework of greenhouse gas emission reduction at the international level is developing from the initial cognitive stage to a more mature implementation stage.

2.3.1 IPCC

The World Meteorological Organization and (UNEP) of the United Nations Environment Programme established the Intergovernmental Panel on Climate change (IPCC), in 1988 and became a specialized agency of the United Nations. The organization publishes climate assessment reports on a regular basis, and its assessment is mainly based on carefully reviewed and published scientific / technical literature. The report mainly provides a reference for national policy formulation and does not have policy binding force in itself.

In terms of marine greenhouse gases, IPCC has mainly developed a shipping emission inventory, which is defined in the following table:

Source Classification	Coverage area
Marine CO2 emissions	CO2 emissions from marine fuel generated by various ships, including hovercraft and hydrofoils, except fishing vessels. The scope of international / domestic marine CO2 emissions depends on the port of call and the place of arrival, and has nothing to do with the flag State or the State of ownership of the ship.
CO2 emissions from international shipping	CO2 emissions from marine fuel generated by ships engaged in the international carriage of goods by sea (not limited to flag States). International shipping activities may occur on the high seas, along the coast, and the voyage begins at the port of one country and ends at the port of another country. CO2 emissions from fishing vessels are not included in CO2 emissions from international shipping.
Domestic marine CO2	CO2 emissions from the activities of vessels engaged in the

emissions	domestic carriage of goods by sea, that is, vessels belonging to the same country at the port of departure and the port of arrival (not limited to Flag States), do not include CO2 emissions from fishing vessels.
CO2 emissions from fishing vessels	CO2 emissions from vessels engaged in inland, coastal and deep-sea fishing activities, covering CO2 emissions from international fishing activities

Table 1 – Classification of CO2 emission sources in marine transportation

Source:IPCC

2.3.2 UNFCCC

The IPCC pointed out that climate change caused by global warming will cause sea level rise, the collapse of ecosystems, and even food crises. In the context of the urgent need for cooperation between the international community and various industries, the United Nations Conference on Environment and Development (UNCED) was held in 1992 by the United Nations. At the Earth Summit, more than 150 countries and the European Economic Community signed the UNFCCC.

It is worth mentioning that UNFCCC has formulated a principle for developing countries, namely "common but differentiated responsibilities (CBDR)". This principle is inconsistent with the principle of "mandatory and equal application to all flag States" which establishes the legal system of marine greenhouse gas emission reduction stipulated by MEPC. The following will analyze how to reconcile these two principles in combination with IMO's preliminary emission reduction strategy.

2.3.3 Kyoto Protocol and Paris Agreement

The Kyoto Protocol is adopted by the Third COP in 1997 and stipulates an international approach to climate change based on the UNFCCC regulations. Affected by the above CBDR principles, the Kyoto Protocol, as a commitment of developed countries to climate change, provides developed countries with responsibilities and timetables for quantitative emission reduction of greenhouse gases such as carbon dioxide. In view of the particularity of international aviation and international shipping industries, the Kyoto Protocol does not include these two industries, but

requires industry competent organizations to regulate and control greenhouse gas emissions in the industry. The European Union, as one of the largest developed economies in the world, has established the EU-ETS system under the mechanism of the Protocol, and is considering to integrate the shipping industry into the mechanism of EU-ETS, which will be analyzed below.

The Paris Agreement was adopted at the 21st United Nations Climate change Conference on December 12, 2015, and became the second legally binding climate agreement, according to Article 4.1 of the Agreement, the process to reach the target twice will be divided into the following three processes. after The Kyoto Protocol. At least peak the total amount of GHG as a target set for 2030,to make rapid reductions based on the best science as a target set for 2050,and as a target set after 2050 on a global scale to make the total amount of GHG zero. Unlike the Kyoto Protocol, which is mainly implemented by developed countries, the Paris Agreement has the following three characteristics:

While the United Nations continues to make agenda arrangements and legal frameworks around greenhouse gases, IMO, as a specialized agency of the United Nations, is responsible for developing regulations on maritime safety and security and the prevention of marine pollution by ships. It also updates policies on reducing marine greenhouse gases and constantly improves the top-level design to adapt to the development of global green action. The following will mainly discuss the policy development of IMO in supporting greenhouse gas emission reduction, including MARPOL,GHG-WG and the preliminary strategy of greenhouse gas emission reduction.

2.3.4 Development and policy agenda of the MARPOL Convention

Similar to the SOLAS Convention, the emergence and revision of the MARPOL Convention are related to major maritime accidents. For example, the major oil spill accident of the "Cadiz" oil tanker in 1977 made both SOLAS 1974 and MARPOL 1973 Convention amended. The earliest ship anti-pollution regulations are mainly

aimed at ship oil pollution (Fan, Y.J, 2021). As human society pays more and more attention to the problem of air pollution, ship air pollution control, as the last MARPOL bylaw, officially came into effect to ships in 2005. At the beginning of entry into force, ship air pollutants mainly refer to substances that are harmful to biological survival, such as sulfur oxides and nitrogen oxides. The convention has strict restrictions on the emission of air pollutants from ships, and strict emission control areas such as (SECA), To address the issue of sulfur oxide emissions from ships, IMO adopted the MARPOL Annex VI Amendment at the 73rd Session of the Marine Environmental Protection Commission in 2018 and banning ships from carrying fuels with sulfur content exceeding 0.5 for combustion purposes. have been set up for specific sea areas such as the Baltic Sea. International ships must carry compliant low sulphur oil to operate, making the sulphur cap the most stringent air pollution restriction for IMO ships.

In view of greenhouse gases, which is a relatively special ship exhaust, carbon dioxide does not belong to air pollutants and is not harmful to organisms. From MEPC62 to MEPC75, mandatory provisions such as EEDI, SEEMP, DCS, initial IMO Strategy on the reduction of GHG emissions from ships, EEXI and CII were examined and adopted in turn.

During the progress of the MEPC agenda, the latest ISWG-GHG 7 report details the draft amendment to the MARPOL Annex VI for the implementation of targeted technical and operational measures to reduce the carbon intensity of international shipping, which is to be formally adopted at the MEPC 76 meeting.

To sum up, as the last protocol to deal with ship emission control, MARPOL ANNEX VI embodies the concept that IMO conveys to the outside world: to reduce ship emissions from a technical and operational point of view. The following chapters mainly introduces the main contents of the ship Energy efficiency Code in the MARPOL ANNEX VI amendment: EEDI and SEEMP.

2.3.5 Regulatory measures from MARPOL ANNEX VI amendments

As an important performance subject, shipping companies should consider not only

the attitude of the competent authority, but also the impact of cost when investing in new equipment. IMO's initial strategy was to technically improve fuel efficiency.Technically, EEDI,EEXI standards are mainly developed for ships, while shore-based support equipment such as shore power standards are also in force. The SEEMP,CII standard is established for the ship in operation.

2.3.5.1 Technical compliance: EEDI and EEXI

EEDI is mainly aimed at newly built ships, which will come into effect on January 1, 2013. As a technical measure, EEDI is an indicator of the energy efficiency of ship design and construction. The calculation method of this index has been defined by MEPC.1/Circ.681,17 August 2009, that is,

$$EEDI = \frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}\right) + \left(\left(\prod_{j=1}^{M} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}\right)}{f_i \cdot capacity \cdot V_{ref} \cdot f_w}$$

The calculation result of the formula is the physical quantity of EEDI (Attained EEDI that can be achieved by ship design [1].

EEDI represents Ship speed V is one of the important indicators concerned by shipowners, which determines the economy of ship operation. Therefore, although the concept of EEDI has stimulated the innovation of shipbuilding equipment manufacturers in designing new high-efficiency and energy-saving technologies. However, the difference between EEDI calculation and ship operation and market mechanism has resulted in a lack of incentive for shipping companies to pursue energy efficiency.

According to the different ship types and the requirements of phased implementation of EEDI in the amendment, EEDI divides the EEDI stage of the ship into 0 to 3 (as shown in the following figure) according to the effective time. However, in recent years, in order to speed up the pace of greenhouse gas emission reduction, the third stage of EEDI of five types of ships, such as container ships and LNG carriers, has been advanced to April 1, 2022, and the reduction coefficient has been raised.

Existing ships are required to meet the requirements of EEXI in technology and CII

in operation, and will be formally adopted at the MEPC76 meeting.

EEXI is mainly aimed at ships in operation, and its calculation method is similar to that of EEDI, which is an energy efficiency index based on the inherent technical parameters of the ship and considering the limited power of the main engine. At present, ships in operation are mainly divided into four categories, as follows.

Category	EEXI below the baseline value.	EEDI Phase	Whether the new requirements are met	Market share of transport capacity	Solutions
1st	EEXI≥30%	Phase 3	Satisfy	1%	
2nd	20%≤EEXI＜30%	Phase 2	Satisfy	9%	
3rd	10%≤EEXI＜20%	Phase 1	Not satisfied	45%	Technical transformation
4th	0≤EEXI ＜ 10%	Phase 0	Not satisfied	30%	Major technical transformation;
5th	EEXI＜0		Not satisfied	15%	Transport capacity withdraws from the market

Table 2– Existing Ship Carbon Emission Reduction (EEXI) Classification Table

Source：China Ship Survey

It should be noted that EEXI involves the transformation of existing ships, including existing ships holding EEDI-related certificates, as well as ships built before the entry into force of EEDI. If it is not satisfied after the conversion, it is required to forcefully limit the power of the main engine or install energy-saving equipment. For shipping companies, the mandatory provisions of EEXI will have a significant impact on the existing fleet, especially before the entry into force of EEDI, a large number of ships need to be docked to complete major conversions, such as modification of bulbous bow, replacement of low energy consumption auxiliary engine, etc. (Xu, H. Z., Ge, X.R, 2021). The above technical standards need to be examined and approved by the ship inspection agency before the ship can be allowed to operate.

2.3.5.2 Ship operation management measures: SEEMP and CII

When SEEMP and EEDI enter into force, Ship Energy Efficiency Management Plan (SEEMP) is established for a company and/or a ship to improve the energy efficiency of ship's operations (IMO, 2009a at the same time), the amendment requires that SEEMP be linked to the ship ISM system, and IMO has also formulated 2012 Guidelines for the development of a Ship Energy Efficiency Management Plan (IMO Resolution MEPC.213 (63) and Guidelines for Voluntary use of The Ship Energy Efficiency Operational Indicator (IMOMEPC.1/Circ.684) for this purpose. After MEPC70, ships also need to formulate a data collection plan for ship fuel consumption according to Part II, in SEEMP guidelines and incorporate it into ship SEEMP, which marks the formal implementation of DCS system.

The SEEMP is regulated by Regulation 22 and consists of Part I,required for all ships,and Part I, required for ships over 5000 tons.Part l is to reduce CO2 emissions by continuing the PDCA cycle as a measure.Part2 defines the procedure for DCS established as a reporting system to verify CO2 emissions, analyze emission data, and improve control measures described later.

Different from the above ship EEDI,EEXI design standards under static conditions, the energy efficiency in ship operation is inevitably affected by the ship type, speed, voyage, loading and route, especially closely related to the loading or operating status of the ship. However, at present, there is not a set of feasible methods to scientifically evaluate the energy efficiency performance of ship operation, which has become the biggest technical obstacle affecting the construction of international mechanisms. Zhang et al. comprehensively consider the volatility characteristics of the energy efficiency performance of individual ship operations and the distribution characteristics of the overall carbon emission intensity of the maritime fleet. a five-level evaluation mechanism of ship operation energy efficiency (Zhang, S et al, 2021)) is established.

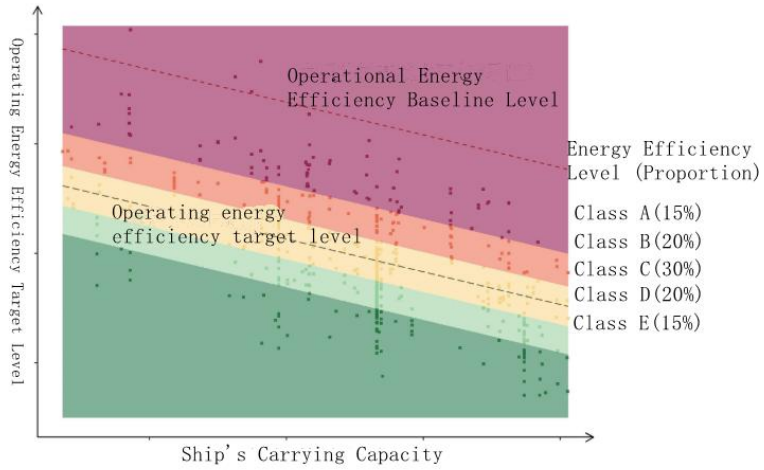

Figure 7 – A Five-grade Rating Mechanism for Operational Energy Efficiency of Ships

Source: China Ship Survey

In order to further speed up the construction of the global ship operation energy efficiency rating mechanism, on the basis of the implementation of DCS, IMO put forward the ship operation energy efficiency index, namely CII, the ship carbon intensity index, in the draft amendment of MEPC75. The energy efficiency level of ship operation is expressed by the ratio of energy consumption to transport work in the actual operation of the ship. After the annual verification of the CII, the ship CII will also be rated annually, and the ships with poor performance need to develop a correction plan and incorporate it into the ship energy efficiency management plan (SEEMP) (ISWG-7). As for the specific measurement indicators of CII, according to GHG's fourth greenhouse Gas Research report of IMO, four typical indicators are used to evaluate carbon intensity.

However, the types of ships used by these four indicators are different. EEOI, AER, EEPI and DIST are suitable for passenger and cargo transport ships, while TIME and DIST are mainly suitable for non-transport ships, such as all kinds of service ships. According to the latest progress of MEPC75, AER and cgDIST will be used as mandatory indicators(Zhang, S et al, 2020). As for the positioning of CII, the intention of IMO is to take it as an important basis for the classification of ship energy efficiency, and it is restricted by the competent authority of the port State, and even

affects its operation in the shipping market.

2.3.6 General legal framework for marine greenhouse gases: IMO INITIAL STARTEGY

In response to the Paris Agreement, IMO examined and adopted a initial strategy for the reduction of greenhouse gas emissions from ships in April 2018. The strategy incorporates the principle of CBDR under the framework of the Convention and the principle of not preferential treatment for ships that are not parties under the conventions, and puts forward phased targets in three aspects: energy efficiency, carbon emission intensity and ship design. The follow-up and timetable for implementing the initial IMO strategy is shown in figure 1.

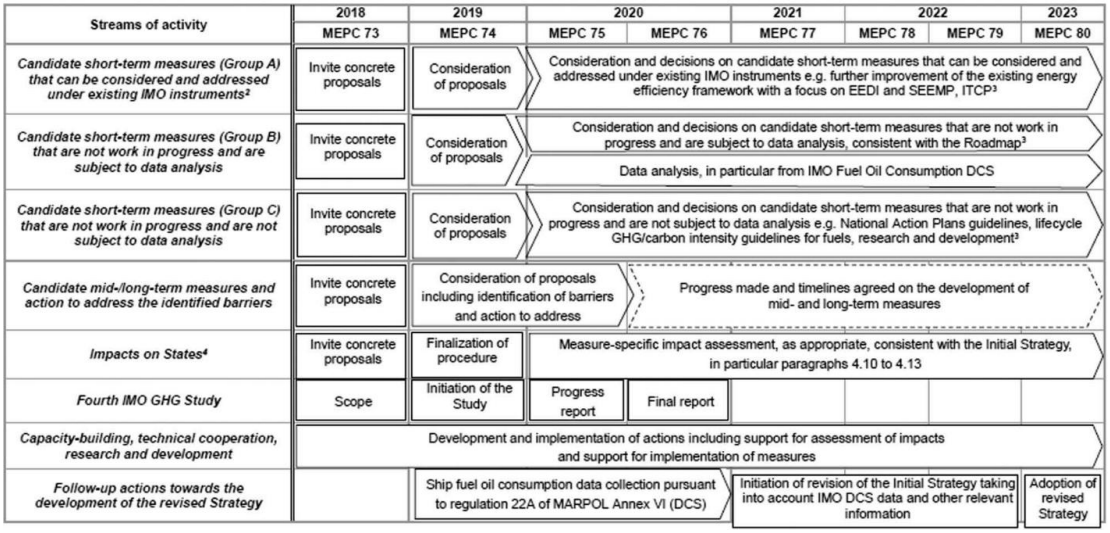

Figure 8:Follow-up actions & programs (IMO MEPC73 2018).

Source:Journal of International Maritime Safety, Environmental Affairs, and Shipping

It is worth mentioning that the strategic plan lists the market operation mechanism as an alternative method for emission reduction. The market-based mechanism for reducing greenhouse gas emissions from ships means that shipping companies are urged to install energy-saving equipment and carry out hull transformation to improve energy efficiency and reduce greenhouse gas emissions through economic means such as carbon emissions trading and carbon tax (or fuel tax).

2.4 Concluding remarks

To sum up, this paper gives a detailed overview of the legislative framework of UN

and IMO for marine environmental protection, focusing on the analysis of the design standards of MARPOL Annex VI, that is, EEDI, EEXI and CII,. The relevant requirements of SEEMP are analyzed. In particular, the various stages of the IMO preliminary strategy are summarized, and the basic principles and reasons for future implementation are emphasized. Policy formulation and adoption includes the definition of objectives- what should be achieved with the policy-and the consideration of different action alternatives (Mejia,2020) . However, due to the different national conditions of Member countries, especially the responses and action plans of developing countries to this initial emission reduction strategy may be different. The first obstacle is politics. policy makers do not give high priority to greenhouse gas management, and make it difficult to develop strategies at the national level. Secondly, financial endurance, developing countries are more concerned about contributing to emission reduction under the premise of economic development, Finally, due to the different roles of Member States in the shipping supply chain, especially for countries with open ship registration, the supervision of ships and companies is usually insufficient.

This paper mainly considers to enhance the performance ability of the Member States as much as possible under the IMO implementation system. From a formal point of view, the audit mechanism is a periodic assessment and inspection of the implementation of Member States by the IMO in order to find problems and improve the effectiveness of the implementation of the Convention. At the same time, it must be recognized that the IMO mandatory audit mechanism plays an important role in assessing the compliance capacity of Member States. Therefore, on the basis of the analysis of IMO compliance mechanism, the next chapter will focus on the relevant measures of Member States to meet the requirements of marine greenhouse gases.

Chapter 3

MEASURES TAKEN BY Member States TO MEET THE REQUIREMENTS OF MARINE GREENHOUSE GASES

3.1 Introductory remarks

In the previous chapters, the article has discussed and analyzed the international standards that have been established by the United Nations and the International Maritime Organization. EEDI, as a technical standard formulated by IMO, and SEEMP, as a tool of ship operation, is the first international rule generally applicable to both developed and developing countries in the world. At present, the International Maritime Organization is continuing to study EEDI, EEXI and SEEMP regulations under the framework of MEPC. GHG STUDY, which is a short-term and medium-term measure under the framework of the initial strategy for greenhouse gas emission reduction, which makes it more forward-looking. As the important implementation entities, the key for Member States to implement relevant IMO conventions and standards lies in the understanding and effective implementation of policies, especially the establishment of mechanisms to supervise and manage ships and shipping companies. Therefore, in essence, the management of marine greenhouse gases is not only a matter of national action, but also to exert influence on their ships and companies, which belongs to the "top-down" policy implementation. This chapter mainly analyzes the compliance mechanism established by IMO and the problems and challenges of Member States in implementing the above regulations and standards under this mechanism, and explains the importance of strengthening IMO mandatory audit of marine greenhouse gases.

3.2 Reference of regional laws and regulations

The European Union, as one of the largest developed economies in the world, has been aggressive in environmental concepts and regulatory measures in various industries, under the framework of the Kyoto Protocol. Under this framework, the

E.U. has formulated EU-Emission Trading Scheme (EU-ETS) to help Member States fulfill their commitments, and it includes 31 countries,and covers over 11000 power stations and industrial plants (Jessen,H,2020). At present, the European Commission has not considered integrating the shipping industry into the EU-ETS system, but with regard to the EU monitoring, reporting and verification (EU- MRV), DCS system and other fuel reporting systems), the EU 2015/757 regulation was adopted in April 2015, and fuel consumption data have been collected since January 2018. The global MBM needs to comprehensively consider many factors, such as the probability of absolute carbon emission reduction, the difficulty of implementation, the probability of preventing carbon leakage, the efficiency of raising funds, the stimulation of new technologies and so on, of which the most important point is the pricing of carbon emissions. (Shen,W, 2020) with regard to the implementation of EU-MRV, in May 2020, the European Commission issued the 2018 MRV annual report, which pointed out that the activities of MRV vessels generated a total of 138 million tons of carbon dioxide emissions, accounting for 3.7% of the total EU emissions and 15% of the global shipping industry emissions (2019 Annual Report on CO2 Emissions from Maritime Transport).

Therefore, the establishment of EU-MRV for the European Union and the implementation of Member States can be used for reference as follows: 1. Checking the data of energy consumption and carbon emissions of incoming ships is an important prerequisite for effective supervision of ships; 2. If a market-based carbon emissions trading mechanism is to be run, it must be through a globally uniform fuel tax policy rather than unilateral regional action.

3.3 Role of stakeholders

The management of ship carbon emissions is not only related to the level of ship design and construction, but also related to ship transportation management. Therefore, ship carbon emission supervision is bound to involve transportation, maritime safety, ship inspection and other sectors.

3.3.1 International technical and financial cooperation on shipping decarbonization

The Getting to Zero Coalition was established in October2018,and currently,it has more than I10companies and organizations from maritime,energy,infrastructure, and finance sectors around the world, including MAERSK, CTTl, and Lloyds Register.A roadmap divided from Phase I to Phase 4 was formulated, and the challenge of introducing Zero-Emission Vessels is taken up continuously (The Global Maritime Forum, 2020). The goal of the alliance is to realize the operation of zero-emission fuel ships in the commercial international shipping industry by 2030 in order to promote decarbonization in the shipping industry.

3.3.2 Public-private partnerships at the national level

Ship classification societies (Recognized Organizations) provide important technical support for the continuous innovation and development of the shipping industry. Lloyd's Classification Society, as one of the largest classification societies in the world, has a rich technical reserve. In order to meet the market demand in the future, Lloyd's Classification Society has studied and judged the influencing factors and application feasibility of zero-emission ship technology development. Through the construction of different regulatory and economic schemes, seven feasible zero-emission ship technologies are combined with five ship types (bulk carriers, container ships, oil tankers, passenger ships, ro-ro passenger ships). The life cycle of each technology and ship combination and its income capacity and cost impact are evaluated.

	New energy technologies /	Main composition
1	Power	Battery / motor
2	Mixed hydrogen	Hydrogen storage / battery / fuel cell / motor
3	Hydrogen fuel cell	Hydrogen storage / fuel cell / motor
4	Hydrogen + internal combustion engine	Hydrogen storage / spare tank / a dual-fuel internal combustion engine
5	Ammonia fuel cell	Ammonia storage / reformer / fuel cell / motor
6	Ammonia + internal combustion engine	Ammonia storage / spare tank / a dual-fuel internal combustion engine
7	Biofuel	Biofuel tank / internal combustion engine

Table 3: Key Technologies and main composition of Zero Emission ships in the UK

Source: China Ship Survey

In addition, the shipping supply chain also includes port enterprises, logistics enterprises and so on. Shore power technology is one of the important means to promote the reduction of carbon emissions from ships. The Chinese government's plan for the promotion and use of shore power puts forward such requirements as "promoting the establishment of a mechanism and incentive mechanism for ships to use shore electricity, reducing the cost of the use of shore power, and guiding ships docking to use shore electricity." By 2020, 90% of the major ports use shore electricity for ship berthing and official ship berthing, and 50% of the specialized terminals for containers, passenger rollers and cruise ships have the ability to supply shore electricity to ships (Li, K, 2021).

To sum up, when implementing the relevant regulations on marine greenhouse gases, Member States must also consider the relationship with relevant domestic implementing parties, such as domestic shipping enterprises, industry organizations and recognized organizations, and adopt policy guidance, economic support and other ways to encourage relevant stakeholders to invest and adopt new carbon emission reduction technologies to ensure that newly built ships meet EEDI and other industry standards. For developing countries, the "common but differentiated responsibilities(CBDR)" is a legitimate demand, which means to act independently according to their respective national conditions and capabilities, but taking into account the particularity of the shipping industry, the shipping industry is highly internationalized, the operation of shipping routes and ports are flexible, and the universality of "flag of convenience" ships and the diversity of chartering modes make the relationship of ship ownership quite complicated. Therefore, it is not reasonable and feasible to reflect national differences in ship technology and operation standards. Therefore, the "CBDR" should receive financial and technical support from developed countries in developing countries, through various projects, funds and other financing means, to help it build ports and energy infrastructure, promote supporting facilities for zero-carbon fuels, and carry out professional training.

After understanding the role of cooperation among and within Member States, it is necessary to further explore the implementation mechanism of Member States under the legal framework of IMO, in order to study the difficulties and challenges of Member States in implementing the relevant provisions of IMO.

3.4 Implementation mechanisms of Member States

The implementation mechanism of Member States mainly includes the following four aspects: the application of the Convention, the subject of implementation (the subject of maritime supervision), supervision and law enforcement and corresponding safeguard measures such as personnel training. Therefore, the implementation mechanism of IMO is essentially a system of interaction between the application of international conventions by Member States, the duties of competent authorities and the implementation of treaties.

First of all, it is necessary to clarify the relationship between IMO and its Member States: IMO develops regulations and standards for international shipping, and supports Member States in ensuring the consistency and effectiveness of the Convention. The implementation of international conventions and the supervision of ships belong to the obligations of Member States. However, each country of, By virtue of geography and circumstance, some States may have a greater role as a flag State than as a port State or as a coastal State, (IMO INSTRUMENTS IMPLEMENTATION CODE (III CODE), plays a different role in the shipping industry, so it is very important to implement a set of unified audit standards to measure the performance of Member States. The results of the audit and a comprehensive analysis of non-conformities can effectively measure and assess the country's performance in implementing and enforcing existing regulations.

3.4.1 Development of IMO compliance rules

As for the conventions and standards formulated by IMO, Member States have the obligation to incorporate them into their domestic laws in the form of legislation to supervise the implementation of the provisions on ships, crew and companies. The analysis to the previous PSC inspection results shows that due to the lack of expertise,

experience and resources, there are some differences in the performance of governments, and at that time, Member States mainly evaluate their own performance from the perspective of flag States, so under the guidance of IMO, the self-assessment mechanism of Member States has evolved into a voluntary IMO mandatory audit scheme (VIMSAS). Measuring the performance of Member States is the focus of IMO's attention. The Flag State implementation Committee was established in 1992 and renamed the III Committee in 2013. Since then, the IMO mandatory audit mechanism was implemented since 2016. The positive results of the implementation of the mandatory audit programme include:

1.Transparency of the information collected from the audits

2.Advancement of the performance of IMO instruments

3.Enhancement of the homogeneity in regulations of maritime safety globally

As an important legal basis for IMO to carry out mandatory audit, the III Code was adopted in 2005 and has become a mandatory requirement since 2013. It provides a series of international standards to promote maritime safety and environmental protection for Member States to implement international maritime conventions from the point of view of flag, port and coastal States. According to the requirements of the III Code, countries should formulate maritime policies and strategies, implement legislation, monitor and evaluate implementation and implementation, and finally correct non-conformities to enhance compliance capacity through regular review.

This section presents the results of 58 audits collected by the audited Member States for the analysis of the root causes in relation to the major areas identified in the audits. All root causes have been reviewed and categorized in four main areas: Legislation, Policy and Procedures, Management and Implementation taking into account the nature of the difficulties for effective implementation (Figure 9).

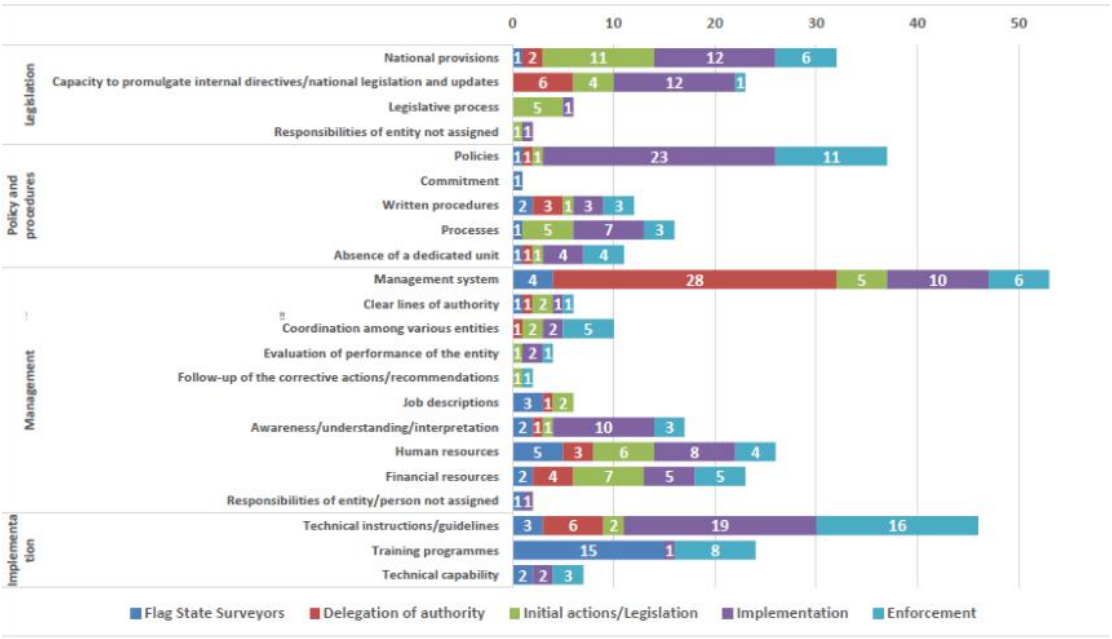

Figure 9 : Most recurrent findings for root causes classified in main areas

Source: Figure 24 of the IMO III 3/INF.29, 2016

3.4.2 Domestic legislation and implementation of national strategies

International maritime conventions have strong professionalism and obvious industry characteristics. in accordance with General Assembly Resolution A.1121 (30) (item 9 of the agenda) of the UN in 2017, the transformation of international conventions can formulate effective laws and regulations in accordance with the classification of ship management, navigation management and crew management. In addition, the supporting documents also include various technical circulars, guidelines, standards, etc., There are many technical issues and amendments involved. Therefore, Member States either directly incorporate international conventions into their own laws, or transform international conventions into domestic laws, but they all need to endow specific competent authorities with certain legislative and enforcement powers through their own legislative procedures.

The key to ensuring the implementation of international maritime conventions is to establish a corresponding safeguard system. Maritime safety and environmental management involves marine, meteorological, law enforcement and environmental protection, which are generally managed by different government entities of Member countries, and it is difficult to fully deploy the necessary resources only by the

transport sector. but it can be used as the main coordinating body. Therefore, in developed countries, such as the United States, to ensure the smooth implementation of their maritime legislation in the form of maritime initiatives and maritime national strategies, in which maritime initiatives are usually proposed by maritime authorities and implemented with the cooperation of other government entities, problems arising in the process of implementation can be effectively solved. For example, the management of ballast water for foreign ships includes steps such as sampling and inspection. Other departments are required to play a role in the closed-loop management of ballast water. In addition, in view of the development trend of the shipping industry, especially the increasingly stringent environmental protection requirements, the maritime national strategy, as a phased development plan, is not only to coordinate national internal institutions, but also as an important guarantee for international cooperation.

3.4.3 Obligations of Flag States

As the core subject for implementing international conventions, ocean-going ships should be strictly supervised by flag States. Article 94 of UNCLOS defines the obligation of the flag State, saying that the flag States must "effectively exercise jurisdiction and control in administrative, technical and social matters over ships flying their flag" (UNCLOS, Art. 94). Therefore, the flag State must first ensure that the ship flying its flag meets the requirements of the international maritime convention, in which the flag State inspection of (FSC) is an important means of its supervision. In addition, the III CODE also defines the standard of flag State performance: in addition to flag State inspection, it also includes port State control, casualty statistics, communication and information processing, which are used to measure the effectiveness of flag State management of its ships in terms of administrative means, personnel quality, infrastructure construction and so on.

3.4.4 Obligations of Port States

Due to the global and negotiable characteristics of the shipping industry, coupled with the operation of the open registration system, different from the aviation industry,

the flag State is unable to effectively supervise the whole process of its international ships. Therefore, as another important part of the compliance of Member States, port State control plays an important role in cracking down on low-standard ships and promoting the effective implementation of international conventions and standards by ships on international voyage. the compliance obligations of port States also include ship waste reception facilities and fuel supplier filing. Port State Control ((PSC)) has the following characteristics: first, it is professional. PSCO must be trained by the competent authority of the port State, hold an inspector's certificate, and inspect ships in strict accordance with international standards. The second is internationality. in order to effectively implement the authority of port States, many Member States have signed a memorandum of understanding on regional cooperation among local port States and agreed to establish a common database system to achieve coordination. For example, the Paris Memorandum of understanding on PSC was the first regional agreement on ship inspection signed in January 1982.

3.5 Description and discussion of related problems under the IMO GHG Mechanism

Under the background of the large-scale ship and the substantial increase in port turnover, in order to deal with the large amount of greenhouse gases produced by ships, the main strategy of IMO is mainly stick to under the framework of the preliminary strategic plan. By revising MARPOL Annex Ⅵ, ships adopt new ship energy efficiency evaluation tools such as EEDI,SEEMP, and DCS as an auxiliary means, and are linked to the ISM rules. Next, the article mainly from the Member countries, In particular, the relevant issues under this mechanism are discussed from the perspective of flag State and port State implementation.

3.5.1 Flag State

The flag State part mainly refers to the management of its ships, to ensure that the ships meet the requirements of the amendment and follow technical indicators, and the indicators can be divided into design and construction (EEDI and EEXI), operation (CII) and management (SEEMP) according to their functions.

3.5.1.1 EEDI and EEXI

For the newly built ship, the ship needs to implement the EEDI standard, and the flag State needs to authorize an authorized organization to inspect the ship before it is allowed to operate. According to the amendment to Annex 4 of MARPOL, new ships will have to meet the requirements of EEDI by 2019 at the latest from 2013. However, according to 2019 data, global fleet CO2 emissions total about 800m tonnes(Xu, H. Z., Ge, X.R, 2021). Of these, 67 per cent of the emissions come from existing ships with tonnage above 400GT built before January 1, 2013, which do not meet the EEDI requirements. Therefore, IMO has designed the improvement measures of EEXI for energy saving and emission reduction of existing ships, including limiting the power of ship engines, changing fuel or installing energy-saving equipment, and retrofitting old ships, and so on. However, the flag State has limited influence on shipping companies and recognized organizations at the initial stage of the entry into force of the amendment, so it is difficult to play the role of the Convention. The reason is:

The standards of EEDI and EEXI are difficult to implement effectively. According to the relevant survey statistics, If the EEDI minimum requirement is lowered by another 10% from the current level, only about 20% of China's existing ships will comply with the requirements. Therefore, the implementation standard of EEDI in the new ship puts forward higher requirements for the ship design, production technology and supporting equipment of the Member States. EEXI is mainly aimed at existing ships, and the energy efficiency index is evaluated according to the inherent technical parameters of the ship and considering the limited power of the main engine. For ships built after the entry into force of EEDI, only through general technical transformation, such as reducing the power of the main engine, the original EEDI certificate can be adopted and the IEE certificate can be issued by an authorized organization, but the existing calculation guidelines may be for ships with high technical energy efficiency. There may be the case that the speed of the EEXI is seriously underestimated. However, for old ships, major technical transformation is needed, such as the transformation of the hull, the use of alternative fuels and so on.

The cost and timing of docking is a major problem for shipping companies.

3.5.1.2 CII

The key to the implementation of CII for ships is the data of ship fuel consumption. All kinds of equipment related to ship fuel consumption, such as propulsion system, rudder and course control system, are calculated through specific indicators such as EEOI, AER, and taking into account external factors such as ship route, operation characteristics, port dispatching and so on. Before ships fully comply with the CII standards, the following problems must be solved: first, there is a lack of standards for automatic collection and on-line monitoring of ship emission data. The acquisition and evaluation of basic data is an important guarantee for shipping companies to optimize ship operation arrangements. In addition, crew Members do not pay enough attention to ship emission data and lack of external supervision mechanism. As far as ship management is concerned, CII is not included in the SEEMP plan at present, which is restricted by ISM rules. The second is the selection of calculation indicators, according to the conclusions of the fourth greenhouse gas report of IMO, for the same shipping data, the proportion of emission reduction obtained by using different operating carbon intensity indicators will be different, and ship operation activities are largely restricted by port arrangements, such as port use of shore electricity, reducing ship berthing time and so on. Finally, for ships with poor operation classification, there is a lack of information disclosure and mutual supervision mechanism. according to the current draft amendment, ships with poor performance will not directly lead to punitive consequences for the time being, but it is necessary to formulate a correction plan and incorporate it into the ship energy efficiency management plan (SEEMP), this is doubtful about the role of improving ship energy efficiency.

3.5.1.3 SEEMP

As a management tool, SEEMP, by incorporating it into the company and ship system, urges ship owners, operators and other relevant parties to formulate targeted plans for each ship, including planning, implementation, monitoring and

self-assessment, to reflect the specific energy efficiency indicators of ships under actual operating conditions, that is, the quality of carbon dioxide emitted per unit transport turnover. However, due to the lack of effective external supervision and correction mechanism of the plan itself, shipping companies are more inclined to fulfill the requirements of SEEMP voluntarily. The reason lies in the lack of effective supervision means at present, which only depends on the FSC inspection of the flag State, the external audit mechanism of SMS, and the lack of port State supervision and control. In addition, due to the lack of unified standards for specific energy efficiency indicators, it is difficult to verify the effect of SEEMP on ships. Therefore, there must be indicators that can calculate or estimate actual carbon dioxide emissions and establish uniform global emission standards for all ships, taking into account factors such as ship type, route, and cargo.

3.5.2 Port State

The port State part mainly refers to the management of incoming ships, and its main role lies in the parts that are difficult to manage by the flag State, such as FSC, port operation and ship fuel supply management, etc., so it can be divided into PSC and DCS according to the supervision mode and basis.

3.5.2.1 PSC

Unlike common pollutants such as oil pollution and sulfur oxides and other air pollution, carbon dioxide is not essentially a pollutant, but a kind of greenhouse gases. Therefore, the restrictions on greenhouse gases in the MARPOL Convention are not as strict as those on the sulfur content of fuel oil, but are more designed more to meet the requirements of EEDI,SEEMP. The port State takes action against incoming ships mainly through PSC,. For port countries, there is no uniform standard on whether ships emit too much greenhouse gases and how to take the next action against offending ships, so it is impossible to confirm the effect of ships fulfilling greenhouse gases, which further weakens the role of port States in ship energy conservation and emission reduction.

3.5.2.2 DCS

The implementation of the above-mentioned ship energy efficiency standards needs adequate data support. IMO has begun to implement this mechanism by building a carbon data collection mechanism based on ship fuel consumption records (DCS), and regularly submit energy consumption records to accredited organizations, which are included in the second part of SEEMP and confirmed by accredited organizations. The competent authority of the port State mainly examines the documents issued by the accreditation organization and verifies the data. However, in terms of the effectiveness of implementation, according to a study by Ronyet, artificial reporting and recording lead to inaccurate energy consumption data. To some extent, it hinders the IMO to collect and analyze the data of Member countries and carry out the next stage of work under the framework of greenhouse gas emission reduction strategy.

3.5.3 Challenges in the future

Future challenges mainly refer to the trends and challenges of marine greenhouse gas management in the shipping industry under the MEPC review process and a series of carbon reduction goals and framework initiatives. IMO will continue to implement the preliminary strategy for reducing greenhouse gas emissions, and medium-and long-term measures include technological progress, rationalization of operations and the adoption of market mechanisms. Some short-and medium-term tasks may be implemented in the medium to long term, and some medium-and long-term tasks may start relevant work in the short to medium term. The comprehensive application of low-carbon and zero-carbon fuels will be the overall path to reduce greenhouse gas emissions by international shipping in the future.

3.5.3.1 Continue to improve the existing ship energy efficiency level.

According to the seventh meeting of IMO Greenhouse Gas Working Group, on the basis of the existing scheme, ships are required to meet not only the requirements of technical energy efficiency (EEXI), but also the requirements of operational energy efficiency (CII), study and determine the relevant indicators of CII, formulate new guidelines for CII calculation, verification and rating, and classify ships according to annual operational energy efficiency. The future implementation will take the ship

rating mechanism as the center, through a unified energy efficiency calculation standard, urge flag countries to include ships with poor performance in the rectification plan, and give incentives to ships with excellent performance.

3.5.3.2 To promote the rationalization of ship operation.

As the main source of emissions from the port, the main engine and auxiliary engines are started at the same time during the voyage, the emissions caused by navigation in the port account for about 60% and 80% of the total emissions of the ship (Zeng, Q.G et al, 2020). Ship operation is inseparable from the interaction between the ship, the company and the port, which mainly includes the rational allocation of the arrival time of the ship, the economic speed of the arriving ship, the reduction of the waiting time for ship anchoring, and the use of port shore power system to reduce the use of auxiliary machines. and provide clean energy, and so on.

3.5.3.3 Implement a market-based regulation approach.

IMO took MBM as one of the medium-term measures in the ship GHG emission reduction strategy formulated in 2015. Ship energy consumption data is an important basis for the implementation of market regulation, that is, ships with more energy consumption need to buy corresponding carbon emission credits so as to urge shipping companies to improve their mode of operation, the use of large-scale ships, and alternative fuels.

At present, the EU's 2015 Universe 757 fuel reporting system regulation came into effect in April 2015. fuel consumption measurement data have been collected since January 2018, namely in the EU-MRV system, which is in parallel with the above-mentioned DCS system to provide the basis for the follow-up implementation of marketization. Under the condition that the means of monitoring and reporting are becoming more and more mature, the next factors to be considered in the implementation of global MBM include the probability of absolute carbon emission reduction, the means of implementation, and the purpose of tax collection. The realization of fuel substitution is the most effective way to achieve carbon neutralization. How to maximize the role of MBM and use the funds raised to

promote the development of technology is an issue that must be discussed by IMO and its Member countries.

3.6 Concluding Remarks

According to the above analysis of the problems and challenges in implementing the relevant provisions of MARPOL Annex IV, the following items related to marine greenhouse gases need to focus on: 1. The implementation of EEXI on existing ships still needs further evaluation to meet the requirements of the new regulations; 2. Lack of external supervision over the performance of SEEMP by ships, port countries are unable to take effective measures; 3.DCS data need to be verified by additional means to ensure the authenticity of the data; 4. The way to implement MBM needs further discussion and unified global action to meet the needs of fuel technology renewal. Therefore, it can be analyzed that in order to promote the reduction of marine greenhouse gas emissions, IMO mainly depends on technical means to restrict ship design and operation, certification, supervision and management by Member States, and consider using market mechanism to raise funds, so as to achieve the wide application of sustainable fuel and thoroughly solve the problem of ship carbon emissions. These topics are mainly related to the implementation mechanism, hull equipment, personnel management, information communication and implementation effect evaluation and so on. The IMO audit scheme can be used to promote the effective implementation of relevant regulations by Member States:

3.6.1 Implement the national strategy

Ship carbon emissions are not only related to ship design, construction and inspection, but also closely related to ship safety operation management and key emission reduction technical support, which is bound to involve national maritime, ship inspection, shipyards and environmental protection and other government entities. Therefore, if the Member States want to implement the strategy of ship carbon emission management, they should mainly manage the shipping enterprises to fulfill the relevant obligations with the transportation department as the main body, and at the same time formulate the guarantee mechanism with the technical service agency

as the supporting sector. Adopting the form of national legislation, formulating corresponding plans and clarifying the division of responsibilities of various departments are important prerequisites for Member States to effectively implement the regulations on reducing greenhouse gas emissions by sea.

3.6.2 Construct a healthy implementation system

The most important link after legislation is effective implementation. According to the analysis to 58 audited Member States, the main reason for the poor performance of Member States is the lack of management systems and policies (Figure 10). The implementation of the system is considered to be the most effective way to meet the requirements of III Code. The IMO mandatory audit is based on the quality management system of Member States and complies with the standards of ISO 90012015. The quality management system is similar to III CODE, which can be divided into flag State, port State and coastal State. in addition, most of the non-conformities can be corrected by the effective operation of the system. For example, the collection and reporting of ship energy consumption data need to be regulated by competent authorities and shipping companies through the quality management system.

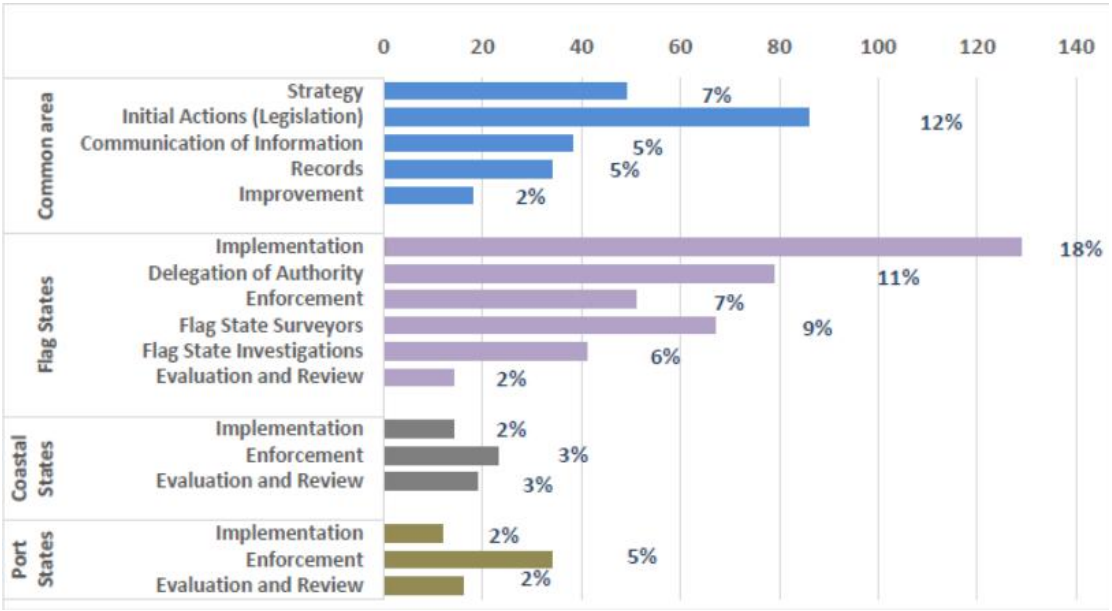

Figure 10: Overview of the findings (percentage) classified by sections under the four areas of the Code

Source: Figure 8 of the IMO III 3/INF.29, 2016)

3.6.3 Evaluate the effectiveness of implementation

The management of marine greenhouse gases is a systematic project, and it is necessary for Member States to conduct a comprehensive assessment of the effectiveness of compliance. The assessors can entrust senior auditors to participate in the assessment in the form of international cooperation, and effectively cover the main competent authorities. The effectiveness of marine greenhouse gas compliance mainly includes: the implementation of EEDI/EEXI by ships, the adoption of PSC and the implementation of DCS and so on. Evaluation methods can be used to collect, survey (including questionnaires), interviews, verification and other methods to obtain the basic data of the evaluation, through data analysis, expert discussion and summary.

Chapter 4

ESTABLISHMENT OF A MARINE GREENHOUSE GAS IMPLEMENTATION MECHANISM UNDER THE FRAMEWORK OF IMO MADATORY AUDIT

In the previous chapters, the article focuses on the importance of implementing the IMO compulsory audit mechanism for the implementation of marine greenhouse gas emission reduction. However, in dealing with the mandatory review of marine greenhouse gas of IMO, Member States will face the problems of numerous provisions of the convention, complex calculation indicators and numerous sectors, so it is necessary to sort out the provisions of government obligations, analyze the characteristics of marine greenhouse gases, and put forward suggestions for improvement.

First of all, through the analysis of what IALA has in common with VTS's implementation guidelines, this paper points out the role of the guidance documents in implementing mandatory audits on IMO. Secondly, the characteristics of VTS compliance guidelines are compared and analyzed, and the key points of marine greenhouse gas management are defined. Thirdly, the paper puts forward some suggestions on the analysis of the effective implementation of the relevant provisions of marine greenhouse gases by Member countries.

4.1 IALA VTS audit guidelines and analysis

VTS is an important organization providing services for ships entering and leaving ports, and its functions has been defined in SOLAS 74. Services concerning ships entering and leaving ports, maritime search and rescue and related meteorological services are all provided by the VTS in the area concerned.

Due to the differences in the level of economic development and management mechanism of Member countries, the operation of VTS in different regions exhibits an unbalanced situation. According to the IALA global survey report, nearly 10 % of the VTS authorities have not been appointed by law, and 42 % of the authorities have

indicated that they have not appointed the VTS authorities（Yang, T.L., Song, S, 2019). At the same time, the SOLAS also stipulates that VTS should, as far as possible, follow the guidelines established by the IMO and guidelines developed by IALA. In the mandatory audit of IMO, VTS audit items accounts for a large proportion, which is mainly related to the performance of duties by coastal States. Therefore, in order to promote Member States to comply with the relevant regulations and standards of VTS, on the basis of IMO Resolution A.857 (20)-Guidelines for Vessel Traffic Services, IALA formulated IALA guidelines on Preparing for an IMO Member State Audit Scheme (IMSAS) on Vessel Traffic Services (IALA,2015) and VTS Auditing Assessing in 2013(IALA,2013), which provides an important reference for VTS audit and evaluation of Member States.

The structure of 1115 is mainly divided into introduction, review, international legal framework, pre-audit preparation and two annexes are GUIDANCE FOR AUDIT PREPARATION and CHECKLIST FOR AUDITORS-VESSEL TRAFFIC SERVICES (VTS) ELEMENTS respectively. In the introduction, it expounds the purpose and significance of implementing IMO mandatory audit (general part), and emphasizes the definition of VTS in IMO and IALA organization. The legal framework mainly includes international conventions, resolutions related to IMO mandatory audit and relevant IALA guidelines, which provide a legal basis for the implementation of VTS compulsory audit. The preparatory work before the audit puts forward specific requirements for Members in defining the policy and legal framework, formulating audit plans and establishing audit coordination guidelines. The most important part of the document is the two annexes. For this reason, IALA elaborated the audit requirements and possible audit problems from 19 major items and 53 small items, and developed a preparation list for Member States to respond to VTS audits.

Document 1101 lists 41 audit questions in four aspects: basic information of VTS departments, audit principles and requirements, VTS implementation, and VTS management system, which can be used as a reference for internal pre-evaluation. In

addition, the IALA 1101 Guide emphasizes that VTS should be operated under a quality management system, and that VTS authorities should ensure the continuous integrity of the quality management system through regular revision or review of the VTS manual and the description of IALA 0132 recommendation "quality management of authority in charge of navigation marks".

Therefore, the role of the VTS audit guidelines developed by IALA on Member States is discussed below:

4.1.1 Promote the domestic legal transformation of VTS-related conventions and standards

By combining the relevant policies and frameworks of IMO audit, SOLAS and IALA, we can provide important reference for Member States to formulate policies and standards according to their own situations, clarify the legal status of VTS through legislation, authorize relevant government entities to perform their obligations, ensure that the development goals of VTS are consistent with the responsibilities.

4.1.2 Establish a quality management system

According to the IALA global survey report, 52% of the competent authorities have run the quality management system (QMS), 75% of the VTS authorities have used the safety management system (SMS)(Li, Y.H, 2017). First of all, the guide defines the responsibilities of the competent authorities and specific entities, and the government / competent authorities are required to conduct internal audits or regular evaluations. Secondly, it is emphasized that assessments from third parties should not replace the responsibilities and obligations of the competent authorities. The above responsibilities, division of labour and evaluation procedures need to be based on the quality management system.

4.1.3 Promote the implementation of audits

The preparatory work is essential for the smooth implementation of the audit. The document explains the coordination mechanism, audit plan and promotes Member States to carry out VTS internal audit and evaluation self-inspection activities in the

form of annex.

As the management of VTS is an important part of coastal countries in Member States under the framework of III Code, it involves personnel training, hardware equipment, technological innovation and so on. Although the responsibilities of Member States are very different from those of marine greenhouse gas management, the carding of the legal framework and the implementation of the audit process can be used as a reference for marine greenhouse gases. Therefore, the following paragraphs mainly discuss the feasibility of establishing guidelines for shipping greenhouse gases in combination with the above guidelines.

4.2 Reference of the Guidelines to the Management of marine greenhouse gases

Greenhouse gas emissions from ships are different from industrial and other domestic carbon emission sources, and they are also different from other air pollutants such as sulfur oxides and nitrogen oxides from ships. However, it is necessary for Member States to establish a new regulatory mechanism in the whole life cycle of ships. In terms of implementation, Marine greenhouse gas management mainly involves the responsibility of flag State and port State. Compared with VTS implementation, The characteristics are discussed below:

4.2.1 Common characteristics of the the two

First of all, both of them are carried out under the framework of IMO's III Code, and they are also part of the mandatory audits carried out by Member States. Secondly, the way to carry out the audit is roughly the same, basically according to the requirements of the quality system, reviewing relevant documents, interviews with officers, and carrying out on-site verification to specific ports. In addition, for the feedback of the audit report, it is required to track the audit results and correct the non-conformities in a timely manner.

Management characteristics of marine greenhouse gases:

4.2.2 Duties of the Flag State

In IMO's initial greenhouse gas strategy, the management of marine greenhouse gases involving technical indicators such as ship EEDI,CII is mainly achieved by the

flag State performing the corresponding duties to the ship during the building and operation stages. in addition, the competent authority is responsible for the supervision and management of energy consumption and carbon emissions of operating ships. VTS mainly aims at the management of incoming ships and follows the principle of non-differential treatment between foreign ships and domestic ships.

4.2.3 Duties of the port State

The Member States mainly manage whether the foreign ships arriving at the port comply with the requirements of the relevant conventions by means of PSC and on-line monitoring of carbon emissions. VTS does not involve the duties of the port State.

4.2.4 More government entities are involved, as well as other stakeholders

Ship carbon emissions are not only related to the level of equipment manufacturing, but also related to ship transportation management. Therefore, ship carbon emission regulation involves not only maritime affairs, ship inspection and other government entities, but also other stakeholders, such as research institutions, certification institutions.,etc. On the other hand, VTS is generally dominated by maritime authorities, and is generally closely related to the management departments of navigation aids.

4.2.5 The mechanism of post-evaluation is different

VTS pays more attention to service quality, accident rate. The management of marine greenhouse gases pays more attention to the effect of the implementation of the convention by shipping companies, RO and other sectors.

A summary of the comparison between the VTS guideline and greenhouse gas management :

Unlike marine greenhouse gas management, the scope of VTS management of Member States is relatively small. According to IMO Resolution A.857 (20)-Guidelines for Vessel Traffic Services, this guide describes the operating principles and general requirements for VTS and the management of ships in ports. The guidance to the Member States is mainly the VTS center and operators, the

direction and objectives are relatively fixed, there will not be much change, and the establishment of audit guidelines is highly targeted.

While marine greenhouse gas management involves ships, shipping companies, port facilities and so on. According to MEPC.304 (72): INITIAL IMO STRATEGY ON REDUCTION OF GHG EMISSIONS FROM SHIPS,), its purpose is to improve energy efficiency to achieve these goals; gradually reduce the carbon intensity of new ships; strengthen the ship energy efficiency index (EEDI), and provide phased measures, supportive measures and subsequent phased review, which belongs to the technical route.

Therefore, the guidance documents should be established for shipping greenhouse gas management, and the structure of the documents can be analyzed from the following perspectives:

First of all, marine greenhouse gases are part of the MARPOL Convention, and the mandatory audit is more inclined to the review of documents and records, together with other supplementary provisions of MARPOL, such as ship low sulfur oil, ship domestic sewage management, etc., Secondly, marine greenhouse gas management involves many objectives and needs close cooperation from all aspects. Third, the initial strategy will be revised regularly according to the implementation of the ship, focusing on the technical route, operation route and market-based mechanism to regulate the Member countries. therefore, the establishment of corresponding audit guidelines lack sufficient legal support and lack of pertinence.

In order to enhance the relevance of guidance to Member States, a supporting document for shipping greenhouse gas audit, similar to IALA, should be developed in the absence of relevant guidelines, and an assessment tool should be provided in the form of an annex for the assessment and monitoring of international obligations, and to support Member States to fully assess compliance with the relevant provisions on marine greenhouse gases. It can be used as an IMO proposal to inform Member States of the effectiveness of their application of the tool, and can also be used as a basis for Member States to communicate with each other within the framework of regional

cooperation. The following discussion is mainly based on China's experience and practices, with a view to put forward suggestions for Member countries to effectively implement the relevant regulations on marine greenhouse gases.

4.3 Analysis of Member States' effective implementation of relevant regulations on marine greenhouse gases

4.3.1 Development of a national strategy for the management of marine greenhouse gases

Under the legal framework of IMO, the key to effectively promoting ships to reduce carbon emissions lies in the flag State's compliance with relevant international conventions and industry standards, including shipbuilding, industry supervision, safeguard measures and so on. Therefore, it is necessary for Member countries to raise the management of marine greenhouse gases to the level of national strategy, improve the top-level design, and formulate a national strategy at the flag State level.

Therefore, for Member States, the formulation of their own strategies or plans needs to be based on the core of the IMO's initial strategy, which is divided into the goals of reducing the carbon intensity of the shipping industry in the near and medium term and reducing absolute emissions in the medium and long term, the Member States should carry out periodic internal audits by means of data collection, evaluation and feedback.

4.3.2 Recommendations for effective implementation of the regulations on marine greenhouse gas

4.3.2.1 Establishment of a Policy Guarantee System

The first is to formulate corresponding domestic normative documents according to the initial strategy of IMO emission reduction and the progress of issues related to marine greenhouse gases. For example, in terms of monitoring, reporting and verification of ship carbon emissions, in accordance with the requirements of MEPC.278 (70) on ship energy consumption data collection in the amendment to Annex 4 of MARPOL, China proposed the measures for the Administration of ship Energy consumption data Collection in 2018, requiring ships of more than 400 gross

tons entering and leaving the port to fill in energy consumption data forms（Li, W et al, 2020). In addition, the relevant legislation on carbon emission control is mostly to improve energy efficiency, promote carbon emissions trading and other ways to achieve the purpose of controlling the total amount of carbon emissions. However, there is an overall lack of a cooperative management mechanism for the departments involved in the shipping supply chain.

Therefore, Member States need to establish a "top-down" organizational guarantee system with layers of implementation and a clear division of labor, through the establishment of maritime initiatives, with the national transport department as the leading management sector. The department should coordinate other government entities such as environmental protection and maritime law enforcement to jointly manage marine greenhouse gases. For example, under the unified shipping carbon emission reduction target, the transport department is responsible for the management mode of ship energy consumption and emissions in accordance with air pollution, ship energy consumption and other national laws and regulations and industry management regulations. Maritime authorities at all levels are specifically responsible for ship energy consumption and carbon emission data collection, information management, and on-site verification, and environmental protection departments are responsible for the monitoring and management of atmospheric emissions. Shipping companies are the main body of ship carbon emission management and should take measures to reduce carbon emissions. This set of management mechanism needs to be supported by enterprises that provide professional services, such as the verification of shipping companies' carbon emission monitoring plans and emission reports, the assessment of ship CO2 emission levels, and the construction of ship CO2 emission online monitoring system.

4.3.2.2 Establishment of a regulatory system

The regulatory system should be able to fully cover the whole life cycle phase of the operating ship, including the design and construction, operation phases. And establish the corresponding system list, as shown in the following tables:

Stage	Institutional demand
Building	CO2 access system for ship emissions
Operation	Monitoring, reporting and verification of ship CO2 emissions
	The project of The shipping industry included in the management scheme of the carbon Emissions Trading System.
	Measures for the Evaluation and Management of ship CII levels
	Construction of Information platform for ship CO2 Emission Monitoring
	On-site verification mechanism of ship CO2 emission standard

Table 4: List of proposed regulatory regimes for carbon emissions from ships

Source: China Ship Survey

Stage	Standards, specifications and key technologies	Main content
Building	Market access limits for CO2 emissions from ships	Develop standards for different types of ships
Operation	Guidelines for carbon emission accounting and reporting of shipping enterprises	Provide uniform report format and content
	Technical specification for verification of carbon emissions from ships of shipping companies	Specify the scope and main points of verification
	Technical Scheme for Shipping companies to participate in Carbon Emissions Trading	Total carbon emission allocation scheme for shipping companies, pricing mechanisms, trading schemes
	Measures for the Evaluation of ship CII levels	The method of evaluating levels and setting up a system of rewards and punishments for different levels
	Guidelines for the Construction of Marine CO2 Emission Monitoring Information platform	Specify monitoring indicators, monitoring data requirements, monitoring platform functions, data transmission requirements, etc.
	On-line Monitoring Technology of ship CO2 Emission at ports	Technical standards, scope of application, technical application conditions, etc.

Table 5:Ship carbon emission regulatory standard specification and key technology list

Source: China Ship Survey

In the stage of design and construction, the authorized organization appointed by the Flag State shall examine the compliance of the ship under construction with the standards of carbon emission control, especially the requirements for the entry into force of EEDI at all stages, the calculation and verification methods of the Attained EEDI of the new ship, and clarify the other necessary conditions and requirements for the ship before entering the formal operation stage, so as to realize the supervision of

CO2 emissions at the source of the ship. At present, in the stage of ship construction, based on EEDI and Chinese industry standard "limits and Verification methods of CO2 emissions from operating ships" (JT/T 827-2012), China has proposed a ship CO2 emission access system.

In the ship operation stage, according to the results of the 7th session of Intersessional Meeting of theWorking Group on Reduction of GHG Emissions From Ships (ISWG-GHG 7), a target-based (goal- based)-based technical and operational energy efficiency integration scheme for existing ship energy efficiency requirements was finally formed, and based on this, a draft amendment to the MARPOL Annex VI on the Enforcement of Target Technology and operational measures to reduce the carbon intensity of International Shipping was drafted. Therefore, the existing ships need to meet the requirements of both technical measures (EEXI) and operating measures (CII), and be classified according to the annual operating energy efficiency (AME). Therefore, the flag State has two main management measures for the ship operation stage: to restrict the ship equipment and to use DCS data to manage the energy efficiency of ship operation.

The main measures to limit the equipment of existing ships are to limit the power of the main engine to meet the requirements of EEXI, which is similar to EEDI and needs to be evaluated by EEXI speed calculation. Therefore, on the one hand, the flag State needs to formulate a unified calculation standard according to the situation of its own fleet, on the other hand, the flag State needs to strengthen the examination of RO and punish the inspection institutions for deliberately falsifying data to issue certificates of conformity to ships.

On the other hand, the flag State needs to establish a ship CO2 emission monitoring, reporting and verification mechanism. The main purpose of the establishment of DCS by the International Maritime Organization is to establish a database of international fuel consumption records. The flag State shall formulate the requirements of the ship fuel consumption monitoring plan, and clarify third-party verification institutions and verification methods. Ships need to adopt the combination of ship electronic data

collection and manual collection, and the collection and processing of DCS data can be used as the basis for the implementation of CII.

In terms of verification, the source of DCS data is mainly from ship fuel consumption. Information management of ship emission data should be carried out. For port States, the management and control measures for the ship operation stage mainly include PSC inspection, PSCO mainly through the ship SEEMP verification, the implementation of SEEMP is to change the operation method to reduce fuel consumption, in addition, PSCO also verifies whether the ship meets the requirements of marine greenhouse gas emissions by checking IEEC,EEDI File,. As the implementation of SEEMP is incorporated into the ship SMS system, the deficiencies of SEEMP can be included in the defects of ISM rules if the circumstances are serious. However, the Tokyo MOU PSC report in recent years shows that there are very few deficiencies related to marine greenhouse gases, and the number of defects in EEDI documents and IEEC is relatively small because they mainly involve parties. As SEEMP is mainly managed by shipping companies, it is assumed that individual ships have a lower work priority from the deficiency level.

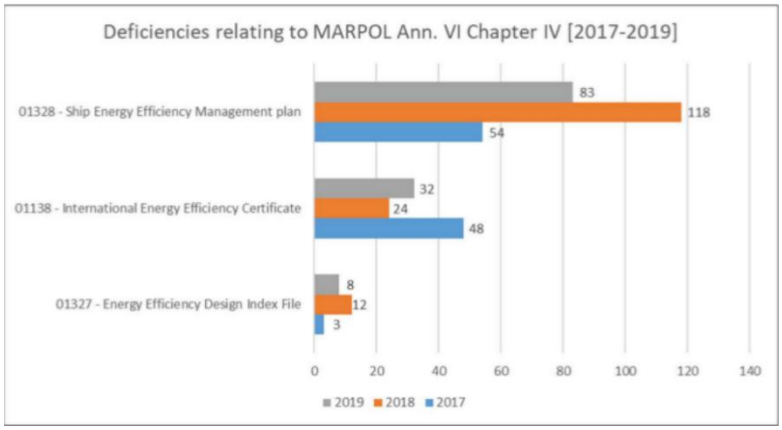

Figure 11 Deficiencies relating to MARPOL AnnexVI Chapter IV from 2017 to 2019

Source: Tokyo MoU. (2020).

According to the Tokyo MoU's Annual Report 2019, the percentage of deficiencies related to the ISM Code pointed out in the Tokyo MoU region in 2019 was 2.02 Which was the sixth most frequent deficiency factor in 31 deficiency

categories(TOKYO MOU 2019) .

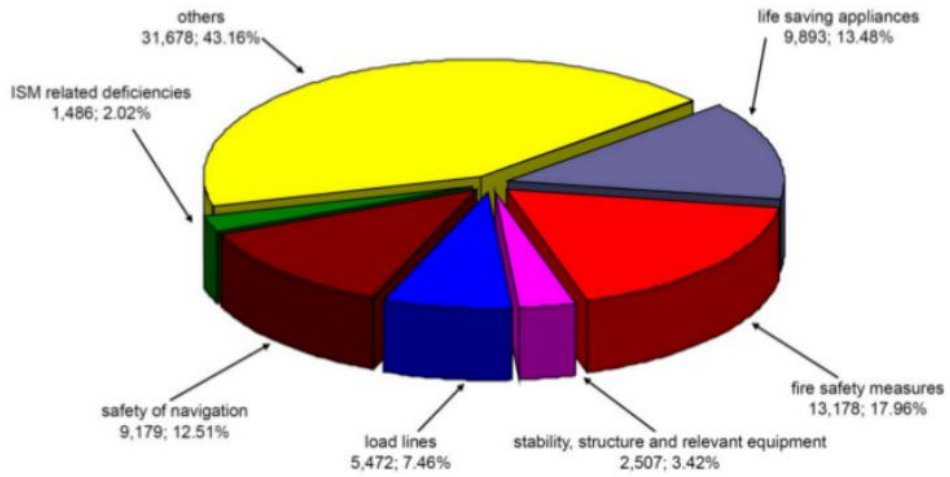

Figure 12: Deficiencies by main categories in 2019

Source: Tokyo MoU. (2020).

The verification of SEEMP involves only clerical deficiencies. This is obviously due to the fact that at the beginning of the initial strategy of IMO, the existing ships failed to implement EEXI effectively on a large scale, and the PSC inspection only inspected the ship-related documents and failed to verify the relevant data.

Therefore, the PSC inspection involving marine greenhouse gases should focus on the effectiveness of the implementation of SEEMP in ships. The flag States should strengthen the monitoring, reporting and verification mechanism of CO2 emissions, as well as the effective operation of DCS, which can be used as an important basis for PSCO inspection. The IMO is currently considering formulating standards such as mandatory carbon intensity reduction targets based on DCS and limiting the power of ship main engines. The key lies in the visualization of the above-mentioned ship fuel consumption and other data, which can be verified by inspectors at any time.

Although the relevant issues of the PSC are still continuing, from the analysis of the results of the IMO test, the necessity of determining standards and indicators is obvious. Therefore, the port State should, within the framework of the PSC memorandum mechanism, formulate guidelines for rapid verification of SEEMP-related data, similar to the rapid detection of ship low sulfur oil, calculate and

analyze ship fuel consumption data and emission data, and quickly determine whether the ship meets the requirements of EEXI.

In order to verify the fairness and accuracy of the ship's carbon emission data, it is suggested that the port country should build a ship greenhouse gas monitoring platform to carry out on-line monitoring of ship greenhouse gas emissions in key waters in the port area, and the monitoring data can include other ship exhaust gases such as sulfur oxides, nitrogen oxides and so on. The monitoring data are regarded as an important supplement to PSC inspection. If there is a ship emission control zone, put forward the ship CO2 emission standard inspection system, clear inspection organs, inspection basis, relevant requirements and inspection methods. For example, the China Maritime Safety Administration has established a ship exhaust emission monitoring system, for high-risk areas and vessels, the officers can lock the target ship through UAV, helicopter and other telemetry facilities.. Finally, the officers carry out on-board inspection at sea, take fuel samples, and send them to professional laboratories for identification.

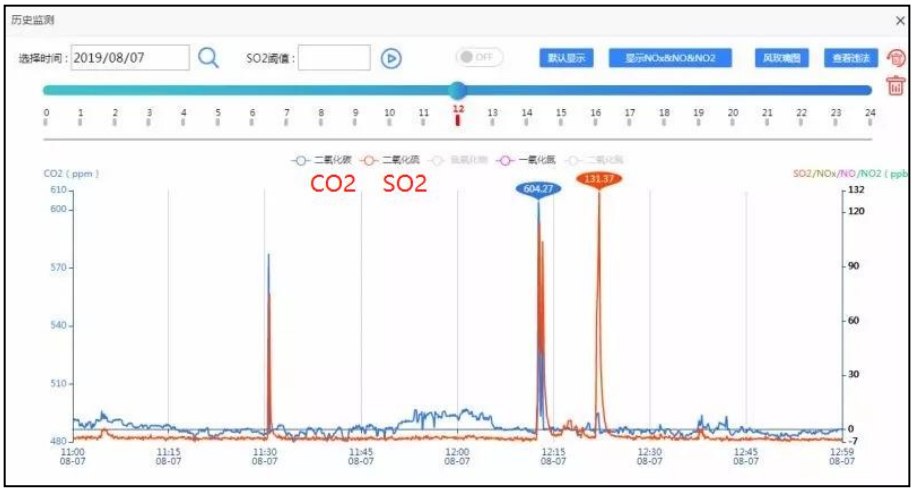

Figure 13:Data on Ship Emissions Detected by Sniffer Equipment(UAV)

Source：China MSA

4.3.2.3 Improve the efficiency of port and ship operations

Due to the commercial characteristics of the shipping industry, ship operation largely depends on port scheduling, and the arrival time of ships will also affect the carbon emissions of ships. Therefore, the supervision and management of ships and

companies alone is far from enough, the virtuous circle of ships and ports is of great significance to improve the carbon emissions of ships. Therefore, the port need to provide support to ships in reducing the arrival time of ships and the use of shore electricity in the whole process of arrival.

Reduce the stay time of ships by optimizing port operation. The turnaround time can be enhanced, for example, by increased productivity, reduced waiting time for stevedores to start loading/unloading and for pilot, reduced congestions, and more efficient clearance procedures (Johnson and Styhre, 2015). According to the "immediate arrival" (Just in Time Arrival) guidelines issued by IMO in August 2020, the competent authorities need to strengthen cooperation with ports, and other parties to share data, optimize voyages and port calls, especially for ships with short arrival time, such as tankers and container ships, reducing waiting time can minimize carbon emissions. However, too many ships entering the port by drifting will increase the risk of ship collision. the port authorities should formulate relevant emergency plans, strengthen on-site supervision, so as to prevent the occurrence of ship collisions.

To promote ship-shore power system and reduce the use of auxiliaries in ships. China attaches great importance to the use of port shore electricity by ships, and has formulated a shore power layout plan. By the end of 2019, the shore power facilities of the five types of berths covered a total of 787 berths（Zhou, H.Y., Zheng, R.J., & Su, W.C, 2021). With the continuous exploration of port operators and the effective support of the government, more than 40% of China's major ports have installed power infrastructure to provide shore power for berthing ships, but at present, the economic benefit of ships using shore electricity is not high. Therefore, the port State needs to strengthen its support to port enterprises, reduce the cost of ship using shore electricity, and improve the ease of use and reliability of shore power facilities.

4.3.2.4 The importance of Member States in implementing a carbon emissions trading mechanism

The EU-ETS system implemented by the European Union has covered 31 countries and more than 10, 000 greenhouse gas emission entities. These enterprises account for

more than 50% of the total greenhouse gas emissions in Europe, while carbon dioxide accounts for more than 80%. The EU's total greenhouse gas emissions in 2017 were 25.2% lower than in 1990, exceeding the target (Qin, A. H., Hou, X.X, 2021). However, it should also be recognized that the regional regulatory measures implemented by the European Union can not fully adapt to the commercial characteristics of the shipping industry, which is embodied in the risk of "carbon leakage". On the other hand, due to the limitations of fleet size or high carbon tax, the R & D investment and attitude of developing countries in the development of green shipping will be affected. Therefore, if EU-ETS is included in the shipping industry, it will affect the unity and standardization of the implementation plan of IMO carbon emissions rules (Tong, J. Y., Ling, L.H, 2021).

From the perspective of the implementation of Member States, first of all, it is prudent to implement the domestic and regional carbon emissions trading mechanism, which will not only weaken the competitiveness of their own ports, but also encounter reciprocal countermeasures. The second is to solve the problem of climate change under the leadership of IMO. At least for international shipping, it is very important to strive to achieve a set of requirements set by IMO and to avoid the establishment of decentralized systems that exceed their own regional requirements.

4.3.2.5 Making more contributions to emission reduction through cooperation mechanisms

The realization of the strategic goal of greenhouse gas emission reduction by the United Nations and IMO largely depends on the mutual cooperation and cooperation of various countries. First of all, the Member States of IMO need to take advantages of domestic and foreign resources with the concept of opening and cooperation. As an international industry, the shipbuilding industry is still dominated by EU Member States, Japan and other developed States in the direction of scientific and technological development. Developed countries should take the initiative to assume more responsibility for emission reduction. In order to achieve emission reduction targets by 2050, it is necessary to deploy new zero-carbon technologies and

propulsion systems, such as environmental protection.

At present,hydrogen and ammonia, fuel cells, batteries technologies are not suitable for large commercial ships in ship type and scale, especially those engaged in global navigation area and dependent on fossil fuels. Therefore, the proposal for an international maritime research and development plan with the assistance of IMO can effectively integrate the technological advantages of developed countries and the human and manufacture resource advantages of developing countries.

Secondly, for developed countries and developing countries that take up a large share of the shipping market (also including China, India and other emerging economies), in addition to the cooperation between various sectors within the national shipbuilding industry system, it also involves the cross-application of new materials, new energy maximize the integration of superior resources inside and outside the industry and work together to tackle key problems.

Finally, in view of the shortage of talents in developing countries, we should set up international joint research and development programs, scientific and technological cooperation projects, joint personnel training and other ways to learn from advanced technology and introduce high-level technical personnel.

4.3.3 Effectiveness of compliance by Member States needs to be maintained and improved for continuous review and verification

The effective implementation of the Convention by the Flag and Port States mentioned above requires a scientific system as a policy guarantee. The development of a certified ISO quality management system can bring consistency in implementation to all Member States and ensure continuous improvement in the management of greenhouse gases in maritime transport.

According to paragraph 7 of the III CODE, when new or amended IMO mandatory instruments enter into force for flag States, they must be implemented and enforced by the appropriate national legislative process. In order to complete the transformation from international law to domestic law, China has established a compliance system with the Maritime Traffic Safety Law as the core and subordinate

enforcement regulations and rules as supplementary, which has been voluntarily reviewed and found by the IMO since 2009. The items of non-conformance and observation mainly focus on legislation, communication to IMO, authorization and supervision of accredited organizations, record management, personnel qualification management and so on. In response to the requirements of the mandatory IMO audit mechanism in 2016,

The China Maritime Safety Administration has started the construction of China's maritime implementation system since 2010, and has successively formulated documents such as "China Maritime implementation Management Mechanism Promotion Plan", "China Maritime implementation rules" and "Maritime implementation system Management Standards". From the implementation objectives, strategies, general principles, scope, implementation legislation and arrangements, information communication, records, As well as flag State, coastal State, port State and other aspects of the management made norms and requirements(Wang, L, 2015).

In terms of marine greenhouse gas management, Member States need to carry out self-assessment before being audited, by combing the current legislation, the implementation of relevant international conventions, the management of accredited organizations, the operation of the quality management system, personnel and equipment, etc., and finally form a questionnaire.

The following self-assessment checklist of Member States for marine greenhouse gas management provides a robust and flexible framework for ensuring that compliance by flag and port States can be assessed in a manner that promotes consistency in marine greenhouse gas management. This checklist is based on the format of the IALA guidelines, combined with the characteristics of greenhouse gases by shipping Audit and evaluation are necessary management tools for verifying objective evidence of the process, how the assessment process is successfully implemented, judging the effectiveness of reaching any defined target level, and providing evidence to reduce and eliminate problems.

A 1. General Information

No.	Issue / question	Authority Notes	Auditor Notes
1	Date		
2	Name of auditing body		
3	Name of the Competent authority		
4	Date of last audit: Provide a copy of the audit report.		
5	Are internal audits carried out? Provide a copy of the assessment / audit report.		
6.	Any other issues to discuss?		

Table 6: Audit checklist for the assessment of Marine GHG management(General Information)

References	Title		
IMO Res. MEPC.203 (62)	Amendments to the annex of the protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the protocol of 1978 Relating Thereto		
IMO Res. MEPC.213 (63)	2012 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP)		
IMO MEPC.1 / Circ.684	Guidelines for Voluntary use of The Ship Energy Efficiency Operational Indicator (EEOI)		
IMO Res. MEPC.304 (72)	Initial IMO Strategy on Reduction of GHG Emissions from Ships		
IMO Res. A.1070 (28)	IMO Instruments Implementation Code (III Code)		
IMO Res. A.1067 (28)	Framework and Procedures for the IMO Member State Audit Scheme		

Table 7: Audit checklist for the assessment of Marine GHG management(Documents)

No.	Issue / question	Authority Notes	Auditor Notes
1.	Which government body is responsible for the implementation and enforcement of MARPOL ANNEX Ⅵ (regulations on energy efficiency for ships)		
2.	What national legislation is in place to enable laws to be passed to give domestic effect to MARPOL ANNEX Ⅵ obligations, such as: Regulatory provisions? Compliance and enforcement provisions?		

3.	Describe the legislative framework in place and the measures taken to ensure compliance with IMO Resolution MEPC.304(72)?		
4.	Any national strategy (or National Action Plan, NAP) and to prepare short-, mid-, long-term measures and sys- tematic approach to implement the IMO GHG reduc- tion strategy to the relevant sectors？		
5.	If yes, is this consistent with IMO Resolution MEPC.304(72) Initial IMO Strategy on Reduction of GHG Emissions from Ships		
6.	List any internal or external stakeholder arrangements for the management of ship GHG emissions.		
7.	Is there a multi-sectoral cooperation mechanism in place?		
8.	Does the ship GHG emission extend beyond the emission control area?		
9.	Any other issues to discuss?		

Table 8: Audit checklist for the assessment of Marine GHG management(Requirements)

No.	Issue / question	Authority Notes	Auditor Notes
1	Do you have documented operational procedures/standards about ship design and building for carbon emission reduction in place?		
2	Have you published the CO2 emission admission system for ships to shipping companies and reported the IMO， For example, do you publish via User Guides, or website?		
3	Do you have procedures in place to monitor the Recognized Organizations to ensure that new ships are built to EEDI standards?		
4	Do you have response plan(s) or relevant disciplinary measures to ensure the availability of the verification by Recognized Organization (i.e. The act of deliberately fabricating data to inspection institutions to issue certificates for new build ships?		
5	Have you established a mechanism for monitoring, reporting and verifying CO2 emissions from ships （ How shipping companies comply with this provision; Whether to establish the corresponding data analysis platform）		
6	Any other issues to discuss?		

Table 9: Audit checklist for the assessment of Marine GHG

management(Procedures:Flag State)

No.	Issue / question	Authority Notes	Auditor Notes
1	Is the Flag State Control officer/Port State Control officer appropriately staffed, according to an established ratio of surveyors?		
2	How do you manage personnel rosters and schedules? Provide documents.		
3	Have training courses been conducted for the inspection of the FSCO and PSCO on the SEEMP of ships?		
4	Does your training program meet the requirements of IMO Resolution MEPC.213(63) on the 2012 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP)		
5	Is there a ship selection plan and inspection procedure in place to address the need for Marine GHG inspection		
6	Whether the PSC has established procedures for notifying the flag State of serious SEEMP Deficiencies of the ship		
7	Is there any cooperation mechanism with other PSC MOU organizations on Marine greenhouse gas management?		
8	Any other issues to discuss?		

Table 10: Audit checklist for the assessment of Marine GHG management(Procedures:Port State)

No	Issue / question	Authority Notes	Auditor Notes
1	Have you build a ship CO2 emission monitoring and data analysis platform, conduct information management on the reported ship energy efficiency and carbon emission data, and form a ship carbon emission inventory.		
2.	Has a platform for monitoring greenhouse gas emissions from ships been established to strengthen online monitoring of greenhouse gas emissions from ships in key areas and channels?		
3.	What is your maintenance program, i.e. how do you ensure reliability of your equipment?		
4.	Whether the vessel exhaust gas testing device meets relevant international standards		
5.	Any other issues to discuss?		

Table 11: Audit checklist for the assessment of Marine GHG management(Equipment)

No.	Issue / question	Authority Notes	Auditor Notes
1.	Do you have any measures in place for identifying and managing opportunities for improvement? For example, do you conduct customer satisfaction surveys with your stakeholders?		
2.	Do you have a process for taking corrective and/or preventative action as part of continually improving of the management system?		
3.	What performance measures are in place to assess and monitor that the objectives of reducing GHGs from ships are being met? For example, do you collect any data on the fuel consumption of ships,FSC & PSC detentions , near-misses, and pro-active interventions by competent authorities?		
4.	Any other issues to discuss?		

Table 12: Audit checklist for the assessment of Marine GHG management(Management system)

4.4 Concluding remarks

Through the audit guidelines of VTS Member States issued by the above-mentioned IALA and China's experience in complying with marine greenhouse gas regulations, the following characteristics can be obtained:

1. The important role of establishing a national strategic plan;

2. The implementation of ISO9001:2008 quality management system as an important guarantee for the compliance with the Conventions;

3. The organization of a FSC & PSC team to prepare inspections;

4. Using scientific and technological means to strengthen the collection and analysis of ship fuel consumption and carbon emission data;

5. Member States optimize port operations and strengthen cooperation with other Member States;

For Member States, it is very important to carry out domestic legislation and implement the Convention. Therefore, the marine greenhouse gas compliance guarantee system (quality management system) should be further upgraded to provide more functions and better play the role of Member States, for example, Member States shall exchange information with IMO, monitor recognized organizations,

regulate inspectors and surveyors, and strengthen flag State and port State surveillance and inspections

CHAPTER 5

SUMMARY AND CONCLUSIONS

The MARPOL Annex VI Amendment “mandatory goal-based technical and operational measures to reduce carbon intensity of international shipping”, which is to be adopted at MEPC76, will formally implement the update of the SEEMP plan to incorporate the CII targets and operation measures. These measures mean that the IMO and industry organizations are eager to promote mandatory emission reduction measures, and at a time of frequent extreme weather in the world, and the return of the United States to the Paris Agreement, all parties in the shipping industry must work closely to meet various challenges.

However, in the situation of greenhouse gas emission reduction, it is important to respond flexibly according to the actual situation. In addition, unified technology and operation mode can never be applied to all ships, which is due to different ship types and modes of operation, such as liner shipping of container ships, chartering of oil tankers and so on. Furthermore, the economic conditions and management concepts of different shipping companies will also be different in the same industry, and the differences between Member States will also affect the effectiveness of implementing the relevant regulations on marine greenhouse gases. Therefore, where regulatory deficiencies in the overall emission reduction targets can be considered to be remedied, the IMO mandatory audit scheme will be appropriately introduced to encourage Member states to conduct self-assessment of their compliance capabilities.

This paper first makes a brief introduction to the international marine greenhouse gas management framework, and then tries to clarify the implementation mechanism of IMO Member States, especially the importance of IMO mandatory audit, and its impending impact on Member States.

For policy makers, the key lies in the management concept and implementation of the system, taking into account the economic and policy environment.

Firstly, in order to explain the research goal of this paper, in which the interaction

between IMO audit scheme and Member States' compliance with marine greenhouse gas regulations is put forward in order to direct to the theme of this paper, and then the feasibility of implementing marine greenhouse gas compliance guidelines is proved theoretically by comparing with the relevant IALA VTS compliance guidelines. Starting from reality, drawing lessons from China's relevant implementation experience, this paper analyzes the suggestions of Member countries to deal with the challenges related to marine greenhouse gases from the aspects of national strategy, supervision system, integrated guarantee system and the establishment of quality management system.

Secondly, this paper also discusses the challenges to be addressed by the shipping industry in the future, one of which is the implementation of market-based regulation methods, such as a carbon emissions trading scheme, in the future. Shipping is essentially a natural adjustment of the law of demand and supply. At the same time, the shipping industry is also a periodic market, and there will inevitably be fluctuations in freight rates. at the same time, the cost of ship operation is largely affected by fuel prices. At present, due to the continuous influence of COVID-19, the price of ship freight has been on the rise, especially in the liner shipping industry, the shipping giant is making huge profits. Therefore, if Member States want to establish their own shipping carbon emissions trading mechanism, in addition to meeting the requirements of the IMO program, they also need to investigate and analyze if there is no statistical data set reflecting past trade performance, and through understanding the actual situation to estimate the future development of domestic shipping, so that the policies made can not only meet the law of economic development, but also meet the needs of ship energy conservation and emission reduction.

Thirdly, at a time when the current global political situation is unstable, especially when the influence of COVID-19 is still there, IMO, as the agency responsible for developing international shipping regulations, should fully shoulder its responsibilities. The principle of "common but differentiated responsibilities" is also applicable in the field of international shipping, because it can not only ease the

pressure on developing countries to reduce emissions, but also attract developing countries to make use of the IMO mandatory audit scheme. The IMO shall encourage Member States to speak out on MEPC and other international conferences, fully evaluate the effectiveness of their marine greenhouse gas management by using the above-mentioned audit tools, and submit proposals for discussion at the General Assembly. After all, in order to reduce greenhouse gas emissions from the international shipping industry, we must be fair and ensure that the participation of developing countries in the international shipping industry does not decline while ensuring that developed countries fulfill more of their emission reduction responsibilities.

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