

Study on the Path to Achieve Carbon Neutrality of China's Shipping under the Background of "Double Carbon" and Compliance

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Keywords: GHG s; emissions; compliance; carbon neutrality; path

ABSTRACT

In order to reduce greenhouse gas(GHG)s emission, the international community has made great efforts to explore the system of GHGs energy saving and emission reduction, carbon emissions trading and carbon tax. International Maritime Organization in the initial strategic objectives of GHGs to carry out the revision, to discuss the increase of GHGs emission reduction in shipping, and as a short-term measure into the International Convention for the Prevention of Pollution from Ships,1973,As Modified by the Protocol of 1978 Relating thereto (MARPOL Convention). China is a party to the MARPOL Convention, and once the amendment to Annex VI of the Convention enters into force, China must comply with the requirements of the Convention. In line with the international trend of emission reduction, China has also made a commitment to achieve carbon neutrality by 2060. The latest measures taken by the international community to reduce GHG emission are introduced through the elaboration of the latest revision of GHGs emission reduction strategies. The current situation of China's shipping fleet and CO₂ emissions is analyzed, and on the basis of profound elaboration on the possible impact of the international community's GHGs emission reduction policies and carbon tax policies on China, the proposed pathway for China to achieve carbon neutrality, including the construction of the rule of law for energy conservation and emission reduction, research and development of energy conservation and emission reduction technologies, matching funds for emission reduction, and early implementation of carbon emission trading and carbon tax policies, is proposed with a view to providing support for China to carry out research on GHGs emission reduction in shipping industry.

1. Introduction

In order to meet the obligations under the United Nations Framework Convention on Climate Change and the Paris Agreement, President Xi Jinping has made a solemn commitment to the international community to "reach the peak of CO₂ emissions by 2030 and achieve carbon neutrality by 2060." Achieving carbon neutrality of shipping is an important part of China's goal of reaching the peak and being carbon neutral. March 14, 2020, the European Environment Agency recently released a report that the shipping industry is "currently one of the most unregulated air pollution sources." The international community has made tremendous efforts to reduce carbon emissions. In 2011, the Marine Environmental Protection Committee (MEPC) of the International Maritime Organization adopted the Amendment to Annex VI to the Revised International Convention for the Prevention of Pollution from Ships, 1973, as amended by Protocol 1978 (MARPOL Convention) at its 62nd meeting, which added two regulatory requirements, namely, the Energy Efficiency Management Program for Ships (SEEMP) and the Energy Efficiency Design Indicator for Ships (EEDI). Therefore, the international community has established a complete set of technical standards for marine shipping energy saving and emission reduction. [1] In April 2018, the International Maritime Organization Maritime Environmental Protection Committee deliberated and adopted the Preliminary International Maritime Organization Greenhouse Gas Emission Reduction Strategy of Ships at its 72nd meeting, which proposes to reduce CO₂ emissions by 40% compared with 2008 by 2030, and by at least 70% by 2050. The International Maritime Organization also realized the important role that the carbon emission trading system plays in the carbon emission reduction, and discussed the carbon emission trading. At the current meeting, IMO also proposed a seaborne carbon tax to be incorporated in Annex VI of MARPOL. In addition to the IMO, the European Union is the first region to start the carbon emission trading legislation. In November 2014, a bill to reduce carbon emissions from international shipping was passed for ships over 5,000 gross tons. [2] The EU is also discussing a marine carbon tax to create a Marine Fund to develop zero-carbon fuel technologies.

The IMO's goal of carbon neutrality is a decade earlier than China's goal of achieving carbon neutrality by 2060. With the development of carbon emission reduction in international shipping, we have to consider how China's shipping industry will be the first to achieve carbon neutrality. To carry out energy-saving and emission reduction of carbon emissions, implement carbon emission trading and carbon tax system are the main measures for realizing carbon neutrality of China's marine transportation. Based on the data, this paper analyzes the status quo of China's shipping greenhouse gas emissions and the impact of the latest policies on China's shipping industry, and puts forward some suggestions on how to carry out carbon neutrality in China.

2 Latest measures and policies adopted by the international community on carbon emission reduction

2.1 IMO's greenhouse gas emission reduction objectives

At the MEPC 77 meeting of IMO in November 2021, IMO considered the issue of revising the preliminary GHG emission reduction strategy. Delegations had an extensive discussion on the rationality and feasibility of revising the GHG emission reduction strategy to achieve zero or net zero emissions by 2050. They expressed the views that the shipping industry should reduce emissions as soon as possible in order to be in line with the goals of the Paris Agreement, reflecting IMO's determination to reduce emissions, and that the current status of technology development, the unbalanced economic and technological levels of countries, and the impact of the revision of the strategy on international shipping should be fully assessed. Upon deliberation, the Conference deemed it necessary to open the revision of IMO's greenhouse gas emission reduction strategy and to allow sufficient time for consideration, with a view to final adoption by MEPC 80 in the spring of 2023.

The European countries, the United States and the European Union proposed that, in order to facilitate the consideration of short-term measures and the development of medium-and long-term measures, the mandatory collection of ship energy efficiency index and carbon intensity index rating information should be added to the collection of ship energy consumption data, and the corresponding amendment of Annex VI of MARPOL was given. At the same time, it was proposed that the IMO's collection system of ship energy consumption should be opened up to facilitate policy discussion and formulation.

2.2 Updated IMO policy on carbon tax in maritime transport

At the 75th meeting of the Maritime Environment Protection Committee, eight international shipowners' organizations (ICS, INTERFERRY, CLIA, INTERCARGO, BIMCO, INTERTANKO, IPTA and WSC) put forward a joint proposal for the establishment of an IMO Maritime Research and Development Committee and an IMO Maritime Research Fund to raise \$5 billion through a mandatory levy of US \$2 per ton of maritime fuel consumed, to be levied over 10 to 15 years, mainly to accelerate research into low- and zero-carbon technologies and fuels. At the 76th meeting of the Maritime Environment Protection Committee, 10 member States including Singapore, Denmark and Japan and International Maritime Contractors Association joined the proposal and

considered that it should be included in the amendment of Annex VI of the MARPOL Convention as a short-term measure. The Marshall Islands and Solomon Islands together with other co-sponsors also put forward that a mandatory universal carbon tax should be imposed to reduce greenhouse gas emissions and that IMO should play a leading role in the development of a universal carbon tax. The sponsors considered that a mandatory universal carbon tax was the best economic tool for controlling greenhouse gas emissions from international shipping. The IMO Preliminary Strategy on Reducing Greenhouse Gas Emissions from Ships requires an assessment of the impact of a carbon tax on countries. According to the preliminary assessment, the overall impact of the proposed carbon tax on the shipping sector is positive. At that meeting and the subsequent 77th meeting of the Marine Environment Protection Committee, the International Chamber of Shipping and relevant shipowners' organizations and member States submitted a number of proposals to the General Assembly, describing in detail the urgency and operation mode of the IMO Maritime Research Fund package. [3] Each delegation made a statement of its position. Given the complexity of the issue, IMO will continue its discussion at subsequent meetings.

The European Union is the first region to propose a carbon tax on maritime transport. In 2000, the EU unilaterally launched the EU Climate Change Initiative, and in November 2008, the EU incorporated a carbon tax on aviation into its ETS. Subsequently, in June 2012, the price list of carbon tax on navigation was launched. Many countries opposed it, believing that it violated the multilateral cooperation mechanism, went against the spirit of the United Nations Framework Convention on Climate Change, the United Nations Convention on the Law of the Sea, the Paris Accord and the principle of "common but differentiated responsibilities". In September 2020, the European Parliament voted to include international maritime transport in the EU Emissions Trading System from 2022. On 15 March 2022, the EU adopted the Carbon Border Adjustment Mechanism Bill, which will impose carbon tariffs on ships entering the EU area. As a result, the EU is making joint efforts to achieve its goal of becoming the first carbon-neutral region by 2050.

3 Analysis of the current situation of CO₂ emissions from maritime transport in China

3.1 The size of China's maritime fleet continues to grow

With the rapid development of the shipping market, the capacity of the international maritime fleet is also growing rapidly. In 2009, the capacity was about 1.2 billion dwt, and by 2018, the size has reached about 1.9 billion dwt. [4] China's fleet is the second largest in the world. The size of China's maritime fleet has maintained rapid growth after 2010, from 100 million dwt in 2010 to 190 million dwt in 2015, more than 200 million dwt in 2016 and 310 million dwt in 2020 (see figure 1). The growth of China's fleet is faster than China's shipping demand and the growth of the world fleet, and its proportion in the world fleet is also gradually increasing. [5] With the growth of the fleet, it has a direct impact on China's CO₂ emissions from maritime transport, and also on the world's CO₂ emissions from maritime transport.

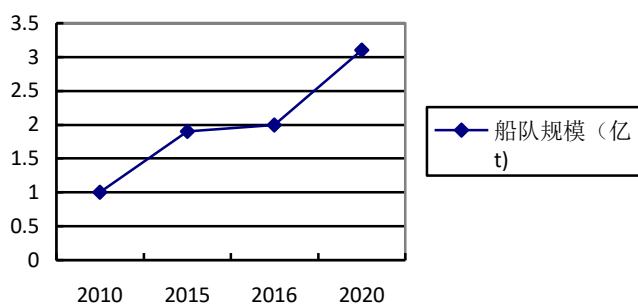


Figure 1 Growth of China's fleet

3.2 The size of CO2 emissions from maritime transport in China continues to grow

According to statistics, from 1990 to 2010, the carbon emissions from international maritime transport increased from 468 million dwt to 912 million dwt. [6] According to the IMO Greenhouse Gas Study Fourth in 2020, the CO2 emissions from international maritime transport increased year by year from 2012 to 2018 (see figure 2). [7] The peak of CO2 emissions from international maritime transport reached 927 million dwt in 2017. At the same time, the IMO report also said that if the shipping industry does not control carbon emissions, the amount of carbon emissions will increase by 50% to 250% by 2050. [8] Converging to the year-on-year growth of CO2 emissions from international maritime transport, the CO2 emissions from China continue to grow. According to statistics, in 2020, the Asia-Pacific region will account for more than half of the world's total carbon emissions, with a total of 52%, China's share of 30.7%, far exceeding that of other regions. [9]

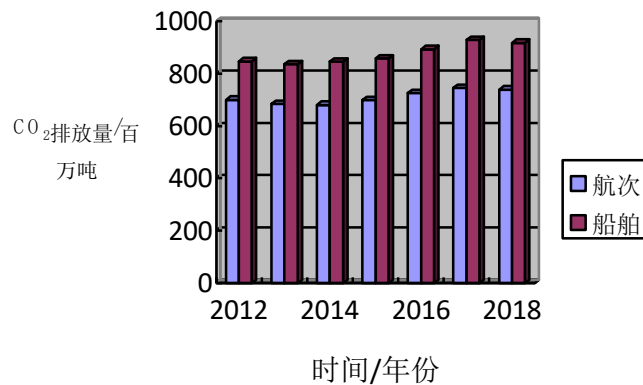


Figure 2 Total CO2 Emission Statistics by Ship Transport and Voyage from 2012 to 2018 (million tons)

3.3 The CO2 emissions from different types of ships vary

According to the IMO GHG study, different ship types generate different amounts of CO2 emissions at different stages of their operation for navigating, maneuvering, anchoring or lying at sea (see figure 3). Chemical tankers and oil tankers emitted the largest proportion of total CO2 emissions at the port or terminal or its adjacent stage. Cruise ships and oil tankers emit the smallest proportion of CO2 emissions during the cruising phase as they are primarily designed for slow cruising; liquid cargo ships emit the largest proportion of CO2 emissions during the cruising phase while in port or its adjacent stage. Container ships emit the largest amount of CO2 and cause the most serious pollution among all ship types. China's container throughput ranks the first in the world, and the container throughput of Chinese coastal ports accounts for 32.1% of the container throughput of global ports in 2020. [10]

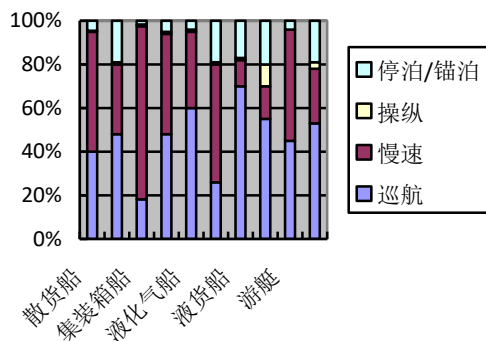


Figure 3 The proportion of CO₂ emissions from different types of ships at different voyage states based on voyages in 2018

4 Analysis of the impact of latest GHG emission reduction policies on international ships on China

Maritime transportation plays an important role in China's international trade, more than 90% of China's international trade of cargo is done by sea. By the end of 2020, China's shipping volume will reach 310 million DWT, ranking 2nd in the world, accounting for 30% of global seaborne cargo import and export. Among the top 10 ports in terms of cargo handling capacity, China accounts for 7 seats. After decades of development, the overall level of China's maritime transportation has been improved, but the fleet structure is not very reasonable, and the management level is not high. The revised IMO strategy on reducing GHG emissions from ships and the proposed carbon tax policy on shipping will bring challenges to the development of China's international shipping related industries, and will have profound impact on China's shipping, shipbuilding and other industries.

4.1 Impact on China's shipping market

China's carbon energy-saving and emission reduction technologies in shipping industry are relatively backward, and there are a lot of old ships with large carbon emissions. Compared with developed countries, the imposition of carbon tax on international shipping will impose more carbon tax on China's ships. Without adequate preparation by China's shipping industry, the traditional shipping industry will face the risk of being eliminated. On the other hand, the implementation of carbon tax system on international shipping will force Chinese shipping companies to innovate ship energy-saving technology and improve management level. Firstly, we shall promote shipping companies to improve their fuel use efficiency, and to make more extensive use of new energy, clean energy and other alternative energy, such as natural gas and LNG fuel for ships, to achieve energy conservation and emission reduction. Secondly, we shall promote green development of shipbuilding industry. Green shipbuilding will drive green shipping, and green shipping will promote the further development of green shipbuilding. Third, the imposition of carbon tax on international shipping will stimulate a green revolution in the international shipping industry, resulting in the appearance of a large number of new energy ships, clean-energy ships, which will urge shipping companies to upgrade their ships and have a great impact on the traditional shipbuilding and construction industry.

4.2 Possible imposition on shipping enterprises

The imposition of carbon tax on shipping will have a direct impact on shipping companies operating international routes, increasing the cost of China's exports by sea to some extent, and then forcing them to pass on the cost to their exports, which will directly affect their operating profits. China's carbon emissions are not high, but the growth rate is significantly higher than that of other countries. As a result, the growth rate of carbon tax on shipping will be higher than that of other countries. China's shipping industry is in a stage of slow recovery, and the imposition of carbon tax may adversely affect the recovery of shipping. Although the International Maritime Organization has assessed the full impact of a \$2 carbon tax on countries, the assessment shows that the impact of a \$2 carbon tax on fuel prices would be small, as well as on iron ore trade, perishable container trade, coal, crude oil and petroleum products freight and prices. But if a universal long-term carbon tax is imposed, it will aggravate the burden on shipping enterprises to some extent.

4.3 Impact on Chinese ships

4.3.1 Impact on existing ships

After the revision of IMO's Greenhouse Gas Reduction Strategy, the control of shipping greenhouse gas emissions will be further strengthened. In order to save energy and reduce emissions, the international community has put forward higher requirements for ship energy efficiency. The revised IMO's Greenhouse Gas Reduction Strategy will put forward higher requirements for ship energy efficiency. In terms of existing ships, higher technical energy efficiency requirements will further increase the cost of fuel oil for shipping companies, and it is likely to take the most awkward ways of reducing emissions, such as limiting the power of main engines, forcing them to reduce their speed. From 2023 onwards, most existing ships shall be technically transformed to reach the corresponding level of ship energy efficiency design index system in 2022, otherwise they will not be granted the corresponding certificates. It will also require mandatory limitation of main engine power or mandatory installation of energy-saving equipment until the technical energy efficiency requirements (EEXI) of existing ships are met. The

compliance rate of China's fleet with EEXI is better than that of the global fleet. Most ships can meet the EEXI requirements by reducing power, so energy saving measures are very important. Existing ships should also consider how to more reasonably carry out EEXI speed estimation to improve the technical energy efficiency of ships, and the relevant technical issues need to be further studied.

4.3.2 Impact on new shipbuilding

China is a big shipbuilding country. Although the scale is large, the core technology has not been mastered and the competitiveness is weak. Major developed countries in Europe and the United States have accumulated more advanced experience in green shipbuilding and advanced energy saving and low carbon technologies for a long time. [11] The main core technologies are still in the hands of Japan, Europe and the United States, and China relies greatly on technology. China's traditional shipbuilding industry is more developed, but shipbuilding in the field of new technologies such as green and low carbon still has a greater deficiency. Although the new carbon emission standards can force China's shipbuilding industry to innovate, they will be difficult to catch up with the level of developed countries in a short period of time. Therefore, China's shipbuilding industry will have a great impact. In terms of new shipbuilding, how to set the Phase IV EEDI requirements will be a problem. Current energy-efficient technologies and new fuels and new power are enough to support increased emission reduction targets. Whether it is necessary to consider emission reduction from the life cycle of the fuel, whether it is necessary to develop independent energy efficiency technologies rules under the existing legal framework, etc., requires further discussion.

4.4 Impact on shipping's carbon emission regime

The main impact is in two areas. First, in the carbon emissions trading market. Although China formally launched its national carbon emissions trading in 2017, because China's carbon emissions accounting system is not yet mature, a carbon emissions accounting system for the shipping industry has not yet been established, [12] and the relevant trading is still blank. Foreign countries have established relatively mature systems in carbon emissions trading, and some have been operating for many years, such as Japan, the United Kingdom, the European Union, and so on. [13] We can draw on its good experience for our own use. Second, in the area of carbon tax system. Worldwide, both carbon taxes and carbon emissions trading can promote carbon reduction. While the maritime carbon emissions trading system is not mature, carbon taxes will be an important option. Judging from the existing experience of foreign countries, levying carbon taxes is conducive to promoting maritime carbon emission reduction. For example, after Sweden introduced a carbon tax in 1991, greenhouse gas emissions in 2017 were 26% lower than in 1990. [14] At present, China also has not established a maritime carbon tax system suitable for China's national conditions. It is necessary for China to start the study of maritime carbon tax legislation as soon as possible so as to better implement the international convention.

4.5 Undermining the competitiveness of China's maritime services

China's maritime transport service system is still relatively weak, mainly concentrated in the traditional areas such as production and auxiliary services, and still weak in the areas of maritime law, maritime insurance, finance, energy conservation technology R&D, ship inspection, etc. The implementation of carbon tax, carbon emissions trading system and the EU's carbon tariff system in international shipping will promote the transformation and upgrading of China's maritime services. The Chinese government has also been actively advocating the healthy development and transformation of the maritime industry. Given China's weak foundation, the transformation and upgrading of maritime services will be a gradual process. In the early adaptation stage, the competitiveness of China's maritime services will be weakened to some extent.

5 Suggested path for China's shipping to achieve carbon neutrality

China is a party to the MARPOL Convention, the United Nations Framework Convention on Climate Change and the Paris Agreement. China is one of the most urgent tasks to reduce greenhouse gas emissions by maritime transport. In general, from 2023, relevant short-term measures to reduce emissions will be implemented, and the promulgation and implementation of these measures will have an important and far-reaching impact on the development of the shipping and shipbuilding industry.

According to the current development situation, carbon emissions trading has become a relatively mature means of emission reduction in the international community. Many countries have implemented shipping carbon emissions trading; the IMO has proposed a carbon tax and there is the possibility of including it as a long-term measure. As a big shipbuilding and shipping country, China faces an arduous task of emission reduction. With the great attention of the Chinese government, China has formulated a series of energy conservation and emission reduction policies, which have achieved preliminary results, but there is still a big gap with the requirements of the international community. China is a developing country, and China is unswerving to achieve the goal of energy conservation and emission reduction in its shipping industry. The process of decarbonization in China is characterized by great challenges and the implementation of carbon

neutrality is under great pressure. The situation of international community's emission reduction forces China to take active measures to cope with the situation.

5.1 Launch research on energy-saving and emission reduction technologies in marine transportation

5.1.1 Shipping enterprises shall make efforts to carry out the R&D of carbon emission reduction technologies

The shipping enterprises shall implement more refined management, fully understand the operation of their own fleets, find out the bottom line of the fleets, collect data at the early stage, and make good planning and arrangement in advance for the subsequent selection of the energy efficiency measures for existing ships, the selection of the energy efficiency indicators for operating ships, responses to the key types of ships, as well as the building and replacement of fleets.

Attention shall be paid to the energy efficiency of existing ships, the information about the EEXI requirements of different ships shall be understood as soon as possible, and targeted measures, such as reducing power or adopting energy-saving technologies, shall be taken in light of different situations. Zero-carbon technology is crucial for the emission reduction of ships, and great efforts shall be made to research and develop zero-carbon technology to tackle key problems. New energies, clean energies and other alternative energies shall be used on a wider scale, such as biofuels, natural gas, LNG fuels of ships, hydrogen, methanol, etc. Low carbon and zero-carbon fuels shall be effectively adopted. With regard to the energy efficiency of existing ships in operation, efforts shall be made to continue to strengthen the collection of energy efficiency data of Chinese ships in operation, carry out more accurate analysis of the fleets' compliance with the energy efficiency indicators of existing ships in operation, and provide reference basis for the operation and management of fleets and the subsequent formulation of market strategies.

5.1.2 Shipbuilding industry shall promote the manufacturing of clean energy ships.

Shipyards shall build more energy-saving ships and facilities, and new energy may be further popularized. It is imperative to establish an energy saving and emission reduction system and promote good experience and practices. Shipbuilding enterprises shall strengthen the exchange with ship owners, operators and other industries to jointly discuss matters concerning the emission reduction of ships. After the Regulations of 2023 take effect, the workload of rectification and transformation of existing ships will be huge which needs time. Shipbuilding enterprises shall properly deal with the situation in this regard. For new ships, we should use low-sulfur oil as far as possible and develop low-carbon or carbon-free fuel technologies. It is imperative to carry out new ship type reserve, and develop and design new types of energy-efficient ships or new carbon-free energy ships. The foreign shipbuilding industry of new energy ships has developed rapidly, for example, CMA CGM and Maersk have built or will build ships fueled by LNG or biomethane. China is also catching up, for example, China State Shipbuilding Corporation has built and delivered the world's first dual-fuel (LNG and diesel) luxurious ro-ro passenger ship; Guangzhou Ship International is actively researching and developing hydrate and other new energy -fueled ships.

5.1.3 Maritime administrative authorities shall strengthen the regulation of carbon emission reduction

Energy saving and emission reduction of ships play a vital role in carbon emission reduction of the shipping industry. Operation of ships is a complicated system, and energy saving and emission reduction thereof involve many aspects such as ship structure, marine fuel and ship energy efficiency. Maritime authorities shall be fully prepared to respond. Taking the energy efficiency of ships as an example, in order to meet the performance requirements of IMO carbon intensity rules by January 1, 2023, the Ministry of Transport is preparing to establish a national energy efficiency management center for ships in Shanghai, specially responsible for managing the energy efficiency of China's ships and achieving the goal of carbon neutrality of the shipping industry. At present, the following work shall be carried out: revising the Administrative Measures for the Collection of Ship Energy Consumption Data, issuing the annual operating carbon intensity (CII) rating of ships and the statement of conformity, and introducing the carbon intensity rating and penalty mechanism; comprehensively collecting and grasping the carbon intensity data of Chinese ships engaged in international and domestic voyages, and implementing the list system of greenhouse gas emissions from ships.

5.2 Make good preparation for international performance of carbon tax

China has not established a dedicated carbon tax under tax system. Although the imposition of a carbon tax was discussed at the Maritime Environment Protection Committee meeting as a short-term measure and the total amount of revenue was not large, in the long run, in order to achieve carbon neutrality by 2060, regardless of whether the IMO imposes a carbon tax, levying a carbon tax on maritime transport may be a better option, not to mention that some of the sponsoring countries have proposed imposing a mandatory universal carbon tax. The international community has already promised to achieve zero-carbon shipping by 2050. In order to show the image of a responsible country, China should make greater efforts. No matter how great the impact of the imposition of a

carbon tax on global shipping is on China, once the amendment to Annex VI of the MARPOL Convention enters into force, China must unconditionally abide by it. Therefore, before the draft Revised IMO Strategy on Greenhouse Gas Emissions from Ships comes into force, China must respond actively, plan in advance and be ready to promote the achievement of carbon neutrality as soon as possible.

We should actively participate in the formulation of international carbon tax rules and contribute China's plan. Although the global maritime carbon tax policy is still under discussion, the low carbon and zero carbon development of maritime transport will be the future and irresistible. The international community's understanding on low-carbon emission reduction in the maritime transport industry is common, but the difference is on how to shoulder the responsibility. The core issue for those who oppose the EU's maritime carbon tax is not whether it should be levied, but the issue of "differentiated responsibilities". As a Category A member of the IMO, China should play its role as a maritime power and establish the image of a responsible power. The specific standards of maritime carbon tax have not yet been fully determined, the Chinese Government should take this opportunity to actively participate in the rulemaking of maritime carbon tax. We should take an active part in the discussion of IMO's energy-saving and emission-reducing measures, including carbon tax, make our voice heard, expand China's influence in international maritime affairs, fight for greater preferences for China's maritime carbon tax policy and enhance China's voice.

Specifically, on the one hand, China's maritime authorities should strengthen dialogue and coordination with the international community, including coordination with the sponsoring countries, explain China's positions, and strive for the necessary buffer time for the development and transformation of China's maritime industry and ship renewal. If, on balance, it is considered that imposing a carbon tax is difficult to achieve in the short term, other alternatives can be used, and China's alternative plans and reasons should also be presented. Under the guidance of the principles of the climate change regime established by the United Nations Framework Convention on Climate Change, we should advocate an international framework for carbon emission trading that is in line with the development interests of China's maritime industry, contribute China's wisdom, put forward China's program, and strive for a greater voice in international maritime activities. On the other hand, China must accelerate the establishment of a domestic maritime carbon tax policy, and strive for the initiative. The main reasons why the sponsoring countries and the EU put forward a maritime carbon tax policy are that these countries have implemented carbon tax policies early, accumulated rich experience, and walked in the world's leading energy-saving and emission reduction technology. In order to take the initiative in the international maritime carbon tax policy, China shall explore and establish its own maritime carbon tax mechanism according to its actual conditions as soon as possible, catch up with the developed countries in energy-saving and emission reduction technologies, and make its contribution to the global CO₂ emission reduction.

5.3 Promote Legal Construction of Marine Energy-saving and Emission Reduction

Energy-saving and emission reduction in international shipping has prompted China to promulgate a series of greenhouse gas emission reduction policies. On October 24, 2021, the CPC Central Committee and the State Council issued the Opinions on Implementing the New Development Concepts in a Complete, Accurate and Comprehensive Manner and Doing a Good Job in Carbon Reaching Peak and Carbon Neutrality. The documents propose the main development objectives of the following three stages, focusing on building a green, low-carbon and cyclic development economic system, improving energy utilization efficiency, and enhancing the carbon sequestration capacity of the ecosystem. On October 26, 2020, the State Council issued the Action Plan for Reaching Peak Carbon Before 2030, and the Ministry of Transport also issued the Guiding Opinions on Promoting the Construction of New Infrastructure in the Field of Transport. [15]

But the above documents focus on the policy aspects of emission reduction, not laws and regulations, and there are few laws and regulations related to greenhouse gas emission reduction in China. It is very complicated and the task is heavy to achieve low-carbon emission of ships, and we should use systematic means. Low-carbon policies alone can not achieve low-carbon transition, we also need a set of special laws and regulations to protect and guide us. [16] Many countries have passed legislation or amendments to climate change to provide for the rule of law for the realization of the "two-carbon". For example, the revised Climate Change Act of the United Kingdom, the Climate Protection Act of Germany, the Canada Net Zero Emissions Accountability Act of Canada, and the draft European Climate Act issued by the European Commission have clarified their medium- and long-term greenhouse gas emission reduction targets through legislation. At present, there is no special law on carbon reaching peak and carbon neutrality in China, and the provisions involving this area are sporadically distributed in some laws (see table 1). For example, Article 2 of the Air Pollution Prevention and Control Act, the legal provisions are relatively weak. These laws are all more principled, and without specific provisions on carbon emissions, the carbon neutrality goal cannot be set. In addition to legal provisions, sectoral rules include the Administrative Measures for Carbon Emission Trading (for Trial Implementation) issued by the Ministry of Ecology and Environment. Compared with the international community, there is still a gap in the construction of rule of law in China to respond to climate change. It is necessary for China to further speed up the legislation progress and promulgate relevant special laws as soon as possible.

Table 1 Climate change legislation enacted by country

Time	Name of law	Country by country	Enacted body
2019 (revision)	Climate change Act	United Kingdom	Parliament
2019	Climate Protection Act	Germany	Parliament
2020	Canada Net Zero Emissions Accountability Act	Canada	Parliament
2020	Draft European Climate Law	Europe	Parliament
2018 (revision)	Law on the Prevention and Control of Atmospheric Pollution	China	National People's Congress
2021	Administrative Measures on Carbon Emissions Trading (Trial Implementation)	China	Ministry of Ecology and Environment
2021	Act to Combat Climate Change and Enhancing Resilience to its Consequences	France	Parliament

5.3.1 Domestic laws, regulations and rules on carbon tax

As an important tax to deal with climate change and improve the economic transition, carbon tax has begun to be implemented in many developed countries. Japan, the United Kingdom and other countries have more experience in carbon tax, while China is still at the initial stage of exploration. While China's carbon tax legislation is not yet issued, marine carbon tax may be implemented first. But the implementation of a shipping carbon tax still requires legislation first. In order to achieve the goal of carbon peaking and carbon neutrality, China should analyze and evaluate foreign carbon tax systems and the development direction of international carbon taxes as soon as possible, consider China's national conditions and strategic objectives, start exploration and practice of carbon tax system, and build China's carbon tax legal system from the perspectives of determining the form of legislation, clarifying the elements of carbon tax, and setting up the supporting systems. Specifically, firstly, about the legal form of carbon tax collection. According to the "Legislation Law", laws should be formulated in respect of the basic economic system matters such as finance and taxation. Carbon tax is obviously the basic economic system involving taxation, and laws should be formulated. Secondly, the National People's Congress can authorize the State Council to formulate relevant administrative regulations, such as the "Interim Regulations on Carbon Tax", to carry out carbon tax in the maritime industry in advance. Second, on the scope of the tax. Although China has resource tax and consumption tax, there is no carbon tax specifically on carbon emissions, and the regulation of CO₂ emissions is limited. In theory, CO₂ should be the most suitable tax scope, but because China's existing technology cannot yet achieve a convenient measurement of CO₂ emissions, it may be difficult to operate in practice. At present, many countries levy taxes on the consumption of fossil fuels, but the IMO levies carbon tax on the consumption of fuel oil. Therefore, in light of China's national conditions, it is appropriate to impose carbon tax on the actual consumption of fuel oil. Third, on the rate of carbon tax. The current standard of carbon tax set by the IMO is a carbon tax of US \$2 for each 1t of fuel oil consumed, i.e. a flat tax rate. China should weigh the pros and cons of this new tax rate, and conduct research and demonstration on whether this new tax rate is in line with the actual conditions in China. Those who believe this tax rate is too high and is not in line with the actual conditions in China should provide their own tax rate standard with convincing reasons. It may also be clarified in the plan that different countries shall adopt different tax rate standards based on their actual situations, that is, different countries of registry adopt different tax rates and implement differentiated tax rates instead of a one-size-fits-all approach. Fourth, on the taxpayer. Taxpayers are the persons who bear the carbon tax. Taxpayers of the carbon tax are usually the producers, sellers or consumers of fossil fuels. As the ships operated by shipping enterprises directly use ship fuel, the IMO levies tax on the fuel oil consumed by ships, so as the consumers of ship fuel, shipping enterprises shall become taxpayers. Fifth, the preferential tax policies. In order to encourage shipping enterprises to conserve energy and reduce emissions, preferential tax policies for low-carbon and zero-carbon development need to be improved. With the goal of carbon peaking and carbon neutrality put forward, the levy of carbon tax will urge shipping enterprises to improve low-carbon and decarbonization equipment and technology, and promote the development of low-carbon economy. The tax credit policy for ship's energy-saving and environmental protection equipment should be included in the preferential catalogue, and shipping enterprises that adopt new technologies and new equipment should be given corresponding tax reductions or exemptions, so as to encourage enterprises' technological innovation.

5.3.2 Amendment to the Marine Environment Protection Law

The Marine Environment Protection Law is a special law on marine environmental protection, and a special chapter thereof stipulates the prevention and control of marine environmental pollution from ships. In this Law, green shipping can be incorporated and legal provisions on decarbonization and low carbon can be added. First, more provisions on ship energy efficiency in the use of clean energy. In order to implement Annex VI of MARPOL Convention, China has

set up different levels of ship air pollution control areas along the coast of China to urge ships to use low-sulfur oil. In terms of ship energy efficiency, similar provisions can be adopted as in low-sulfur emission, and carbon emission control areas can be established. But to achieve zero carbon emissions, ships should use shore power when docking. Second, more provisions on the control of greenhouse gas emissions. China needs to control greenhouse gas emissions through domestic legislation. In general, atmospheric pollutants and greenhouse gases are emitted from the same source, so it can be considered to incorporate the control of marine greenhouse gas emissions at the same time as the control of marine atmospheric pollutants in the amendment of the Marine Environment Protection Law, so as to encourage ships to use new and renewable energy and reduce greenhouse gas emissions.

5.4 Early Initiation of China's Shipping Carbon Allowance Trading and Carbon Tax System

Carbon allowance trading and carbon tax are both means to reduce carbon emissions, but in different ways. In terms of effect, carbon allowance trading is a system to adjust each unit of carbon emissions without changing the total amount of carbon emissions, [17] and the imposition of a carbon tax will directly promote the reduction of the total amount of carbon emissions. Therefore, carbon tax has better effect on emission reduction than carbon allowance trading.

But for China, as long as it is in line with China's national conditions, it can be used. Carbon tax and carbon trading are both carbon pricing policies, and they can be used concurrently, each has its own advantages and disadvantages. Fifteen countries and regions, such as France, Japan and the United Kingdom, have implemented carbon tax and carbon trading at the same time. The fusion of carbon tax and carbon emissions is also the future direction. [18] Therefore, carbon tax and carbon trading can be used as soon as their studies are mature. On the one hand, we should speed up the study of maritime carbon emission accounting system, and strive to carry out maritime carbon emission trading as soon as possible; on the other hand, we should speed up the feasibility study of carbon tax to pave the way for shipping emission reduction.

5.5 Strengthening the Supporting Fund for Energy Conservation and Emission Reduction in Maritime Transportation

Financial support is needed for technology research and development of energy conservation and emission reduction. The IMO and the International Chamber of Shipping have proposed the establishment of the IMO Maritime Research Fund, requiring shipowners to impose a mandatory carbon tax of \$2 for each ton of marine fuel consumed for technology research and development. So far, the proposal has received the support of many governments, including Japan, Singapore, Greece, Denmark and other major shipping countries. It looks increasingly likely that the proposal will become a reality.

In order to meet the compliance requirements by 2023, China also needs supporting funds. Some parts of China have already carried out this exploration, for example, Hubei has established a 10 billion yuan Carbon Neutrality Fund. Although the Fund is not only for the development of green and low-carbon industries and carbon sequestration products in the transportation sector, it is a good beginning for the establishment of a national carbon neutrality Fund in China. The trend is still to establish a national carbon neutrality Fund, including marine transportation. The source, use and management of the Fund still need to be studied in depth.

6 Conclusion

A series of international measures and actions to reduce emissions will have a far-reaching impact on China. There is still a big gap between China's shipping greenhouse gas emissions and the latest policies of the international community. China's shipping carbon reduction faces a huge challenge. This paper analyzes China's historical CO₂ emissions in detail, and puts forward suggestions and countermeasures on how to carry out carbon reduction and achieve carbon neutrality in China. The main conclusions are as follows: (1) It is an irresistible trend for the shipping industry to achieve zero carbon emission, and China, as a big shipping country, should make its due contribution to this goal. (2) According to China's current development status, the possible measures to achieve carbon neutrality include carbon emission reduction and energy saving technology R&D, carbon emission trading, and carbon tax. (3) The shipping and shipbuilding industries and relevant authorities should take precautions and plan in advance to prepare for China's achievement of carbon neutrality as soon as possible. (4) While intensifying R&D of energy saving and emission reduction technologies, new and renewable energy should be vigorously promoted. (5) Achieving the accounting and reporting system of shipping carbon emissions technically as soon as possible, and including shipping carbon emissions in China's carbon emission trading system as soon as possible. (6) Intensifying the research on China's carbon tax system, and starting the legislation and levying of carbon tax as soon as possible.

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