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Impact of GHG mitigation regulations on China's shipping industry and suggestions

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IMPACT OF GHG MITIGATION POLICY ON CHINA'S SHIIPPING INDUSTRY AND SUGGESTIONS

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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: **Impact of GHG Mitigation Regulations on China's Shipping Industry and Suggestions**

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To combat GHG emission, IMO are making a draft on new GHG mitigation policy on shipping industry, including phase 4 of EEDI, a goal-based SMEEP, introduction of MBMs and new energy resources. This thesis would introduce potential GHG mitigation policy and analyze the impact of the potential regulations regarding GHG reduction on China's shipping industry, involving shipping building industry and shipping market.

In term of shipbuilding industry, it reviews the current status of the China's shipbuilding industry, severe competition from international companies and lack of core technology of green shipping. It then reveals that China's ship building industry would be serious challenged by new regulations from phasing out the backward productivity ship building companies to shipbuilding market share reduction. An assessment of the impact of EU ETS promotion on the shipping market in China is conducted. Considering the large fleet owned by China and trade structure between China and EU, several issues are worthy of consideration by China. Some suggestions from enhancing core technology and MBMs policy selection as well as measures to cope with EU ETS are proposed in the hope that Chinese shipping industry can get better prepared to respond to IMO GHG mitigation regulatory in an efficient and accurate manner.

KEYWORDS: Climate Change, GHG emission reduction, GHG regulations, Core technology, MBMs

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LIST OF ABBREVIATIONS

CBDR	Common but Differentiated Responsibilities
EEDI	Energy Efficiency Design Index
EIS	Efficiency Incentive Scheme
ETS	Emissions Trading System
GHG	Greenhouse gas
HFO	Heavy Fuel Oil
IMF	International Monetary Fund
IMO	International Maritime Organization
IPCC	Intergovernmental panel on climate change
LDC	Less Developed Country
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MBMs	Market-based Measures
MEPC	Maritime Environment protection committee
MRV	Monitoring, Reporting and Verification
NMFT	No More Favorable Treatment
PSL	Port State Levy
RM	Rebate Mechanism
SEEMP	Ship Energy Efficiency Management Plan
SID	Small Island State
SECT	Ship Efficiency and Credit Trading

CHAPTER 1 INTRODUCTION

1.1 Background

1.1.1 Climate change

The alarming signals such as frequent occurrences of extreme weather and the speedy melting glaciers in the polar areas have drawn the universal attention to climate change and the rising global temperature to which GHG is the major contributor. To combat this worrying trend, a global goal to limit global warming growth below 2 ℃ by the end of this century was set in Paris Agreement. To achieve the goal, the global net greenhouse gas emissions need to be cleared after 2050. However, the global carbon emissions have been reportedly increased rather than decreased in the past decade, which will cause added reduction quota in the next ten years. According to Emissions Gap Report 2019, to achieve the temperature control goal, four times efforts are required of all countries. In other words, the task for the world to respond to climate change is more urgent (UN Environment Programme, 2019).

The global climate assessment report published by IPCC pointed out that the average temperature had risen 0.6 ℃ during the last century and was projected to increase by 1.4 ℃ to 5.8 ℃ in this century (IPCC, 2019). This is horrifying because the temperature growth can bring about rising sea level, more frequent extreme weather and other environmental problems. Compared with the land blocked by mountains and rivers, the marine ecosystem is more vulnerable, therefore, the temperature change in the ocean has a wider range of influence and sudden changes are more obvious. If the goals set by the Paris Agreement are not adequately met, by 2100, 51% of the marine ecosystem as opposed to 38% of the terrestrial ecosystem will be affected (Trisos , Merow & Pigot, 2020).

1.1.2 Emission from shipping

The GHG emissions of total shipping, including international, domestic and fishing, have increased from 977 million tonnes in 2012 to 1,076 million tonnes in 2018, representing a 9.6% increase.

Table 1- Total shipping and voyage-based international shipping CO2 emissions 2012-2018 (million tonnes)

Year	Total shipping CO2	Total shipping as a percentage of global	Voyage-based international shipping CO2	Voyage-based international shipping as a percentage of global
2012	962	2.76%	701	2.01%
2013	957	2.74%	684	1.96%
2014	964	2.74%	681	1.93%
2015	991	2.81%	700	1.99%
2016	1026	2.90%	727	2.05%
2017	1064	2.97%	746	2.08%
2018	1056	2.89%	740	2.02%

Source: IMO, The Forth GHG Study

As is presented in Table 1, voyage-based international shipping has emitted 711 million tons of CO2 per year on average between 2012 and 2018 which represents approximately 2.0% of global anthropogenic GHG emissions. The total shipping CO2 emission and CO2 emission from voyage-based international shipping both saw an increase from 2012 to 2018. In 2012, 962 million tonnes were total shipping CO2 emissions, while in 2018 the amount grew by 9.3% to 1,056 million tonnes. The share of shipping emissions in global anthropogenic emissions has increased from 2.76% in 2012 to 2.89% in 2018. In terms of voyage-based international shipping CO2 emission, CO2 emissions have also increased over the period from 701 million tonnes in 2012 to 740 million tonnes in 2018 (5.6% increase), but at a lower growth rate than total shipping emissions.

IMO initial strategy is to reduce the global shipping industry carbon emissions by 50% compared with 2008 (1 billion tons) by 2050, about half a billion. It is worth noting that the carbon emissions from shipping industry accounted for less than 3% of global carbon emissions in 2019 with about 60 trillion ton nautical miles and 14 tons per million ton-km carbon emission intensity. Compared to other transportation methods (rail transportation: 160-190 tons/million-ton-km; road transportation: 128-190 tons/million-ton-km; air transportation: 700-2,900 tons/million-ton-km), the carbon efficiency of the shipping is the highest (Clarkson Research, 2019). However, considering that maritime transport accounts for as high as 85% of international commercial transport, it is still an enormous challenge for the shipping industry to achieve the goal of emissions reduction.

In addition, the Fourth IMO GHG Study estimates that 2008 international shipping GHG emissions were 794 million tonnes rather than 940 million tonnes from the Third IMO GHG Study. Therefore, to achieve the GHG emission task of initial strategy is still very challenging, considering the fact that during the past decade the global commerce added by 37% and fleet capacity increased by 74%, while, the global fleet speed dropped by 16% (Clarkson Research, 2019).

As is seen Figure 1, the fuel consumption of various ship types is different. Over the period of study, three ship types remain the dominant source of international shipping

GHG emissions: container shipping, bulk carriers and oil tankers, which contributed to over 65% of the international CO2 emissions in 2018.

HFO is still the main fuel used in international shipping accounting for 79% market share in 2018. The proportion of HFO consumption dropped by about 7% (absolutely reduced by 3%), while the consumption of marine diesel oil (MDO) and liquefied natural gas (LNG) increased by 6% and 0.9% respectively (absolutely increased by 51% and 26%) (IMO,2020a).

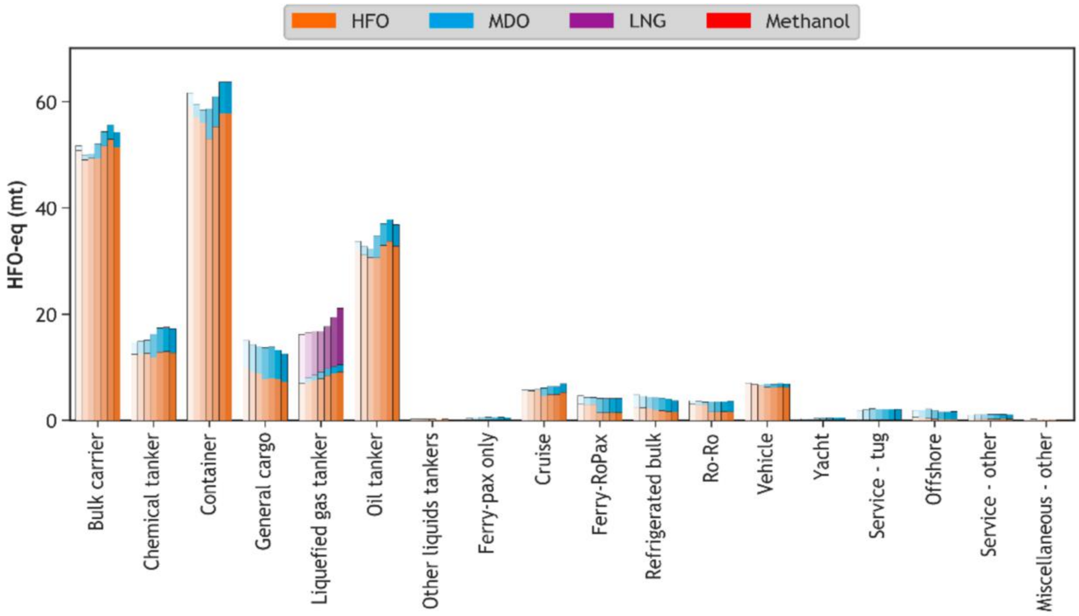


Figure 1- International HFO-equivalent fuel consumption per ship type, according to voyage-based allocation of international emissions

Source: The Fourth IMO GHG Study.

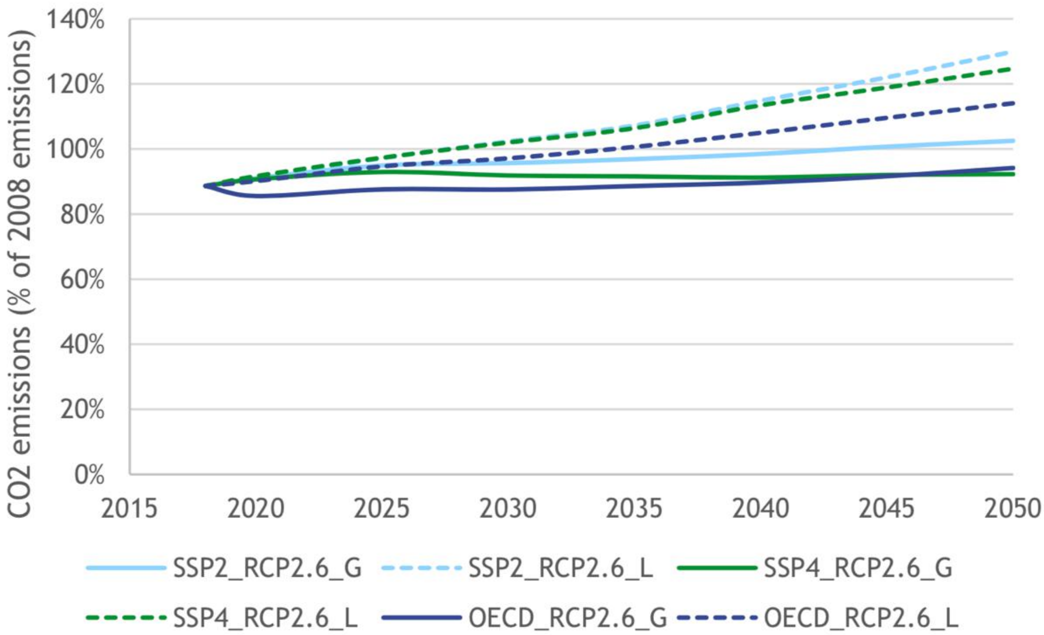


Figure 2- Projections of maritime ship emissions as a percentage of 2008 emission

Source: The Fourth IMO GHG Study.

As is shown in Figure 2, emissions are projected to increase from about 90% of 2008 emissions in 2018 to 90-130% of 2008 emissions by 2050 for six plausible long-term economic and energy scenarios (IMO, 2020). Though the new projection is less than the previous one, it is still challenging to meet the upmost potential. Therefore, shipping sectors are required to take active actions to mitigate GHG from atmosphere.

IMO has established a target for global shipping to reduce CO2 emissions per transport work by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008 and to decarbonize by at least 50% from 2008 levels by 2050. To achieve the goal, a series of operational and technical measures was adopted by the IMO in 2011 and 2014, such as EEDI, In October 2018 (MEPC 73), IMO approved an initial strategy on GHG emissions from ships, setting out a vision about its commitment to reducing GHG emissions from international shipping and to phasing them out as soon as possible (IMO, 2018).

1.2 Objectives of research

The primary objective of this thesis is to target the possible IMO GHG mitigation relevant regulations, and their influence on the shipping industry, on the basis of which some constructive suggestions are put forward for Chinese shipping industry to fully comply with the regulations. In fact, this dissertation is to answer the following questions:

1. What are the IMO potential measures to achieve the goal set in the initial strategy?
2. To what extent would the shipping industry be influenced by the relevant regulations?
3. What should the Chinese shipping industry do to get fully prepared to meet the challenge from GHG mitigation regulations?

1.3 Methodology

This study mainly uses literature review as a research method, and the main literature works covered in this thesis are IMO regulatory instrument, books and papers and electronic journal or online articles on climate change, Chinese shipbuilding industry, new energy resources, EEDI, SEEMP, MBMs, economic impacts, etc. Some internet websites were also searched such as UNCTAD, GLOMEEP, Pengpai NEWS, IMO, , to name but a few.

1.4 Structure of the dissertation

This dissertation consists of six chapters. In Chapter 2, the development of GHG emission reduction legal framework and mandatory regulations are reviewed and the possible measures to be taken by IMO also are analyzed, including phase 4 of EEDI, a goal-based SEEMP, restart of MBMs and introduction of new energy resources. Chapter 3 introduces the influence of GHG emission regulation on shipbuilding industry and the severe competition from international companies. The lack of core of technology is the major drawback in shipbuilding industry and the factors affecting the drawback are analyzed. Chapter 4 discusses the current MBMs, especially for EU ETS because the EU's plan to implement the EU ETS before 2021. The current development of EU ETS is also synthesized, and some concerns from China have been put forward. In Chapter 5, suggestions are put forward for Chinese shipping industry including core technology promotion, measures to cope with EU ETS and shipowners' options appropriate to mitigate the GHG emission Finally, conclusion is given in the last chapter.

CHAPTER 2 DEVELOPMENT OF REGULATORY FRAMEWORK FOR GHG EMISSIONS REDUCTION

2.1 IMO GHG regulatory instrument development

To combat the global warming, the United Nations framework for climate change (Kyoto Protocol and Paris Agreement) was adopted. However, GHG emissions from international shipping stay unregulated and are subject to the regulations by the IMO. Therefore, it is imperative for the IMO to regulate the GHG emission issue for shipping. In 1997, the Annex VI was adopted and added in the MARPOL 73/78 to extend environment protection to air area. At the 62nd MEPC meeting in 2011, IMO adopted amendments to Annex VI to MARPOL 73/78 which is regarded as the first global and legally binding regulation on the reduction of GHG emissions from ships. The new Chapter 4 of Annex VI introduces mandatory requirements of the energy efficiency design index for new ships and the Ship Energy Efficiency Management Plan for all ships. EEDI sets a minimum energy efficiency level for ships so that the ship designer and shipbuilder can choose the method to meet the requirement at the designing stage. SEEMP, as an operational measure, requires ship operators to run ships in an energy-efficient manner during the operation period. MBMs is an widely disputed economical approach to limit GHG emission and no consensus has been reached so far among parties of interest concerned, therefore, the IMO decided to postpone the MBMs strategy during the 65th MEPC meeting.

At the 66th MEPC meeting, amendments to Annex VI to MARPOL 73/78 were adopted to extend the application scope of the EEDI to include an extra five types of ships. In 2016, MEPC adopted mandatory requirements about collecting consumption data of each type of fuel oil in use, as well as specified data including proxies for transport work. Ships of 5,000 gross tonnage and above produce about 85% of CO2 emissions from international shipping. The data will be used as the foundation for making future decision on additional measures.

At the 66th MEPC meeting, an initial IMO strategy on reduction of GHG emissions from ships was adopted , aiming to facilitate the achievement of the goal in line with temperature goals set in the Paris Agreement and the goal of zero emission of GHG by the end of this century. This is the first time for the shipping industry to set the GHG emission reduction goal, and it also sends the signal that shipping is quickening the pace to reduce GHG emission. Amendments to MARPOL Annex VI approved At MEPC 74th session significantly strengthen the Energy Efficiency Design Index requirements. The timeline for the entry into effect of Phase 3 regarding some categories of new ships, including containerships, gas carriers, general cargo ships and LNG carriers is advanced from 2025 to 2022, among which the reduction rate for container ships is changed significantly, for instance, for containerships of 200,000 DWT and above, it is set at 50% from 2022 rather than 30% from 2025 (IMO, 2019a);

2.2 Development in regulating GHG emissions

The initial strategy is a milestone for GHG emission from the shipping industry, and the specific goal presents a clear timetable of IMO's plan, which can urge the member states and shipowners to act actively to realize the goal. The short term measures are mainly technical and operational oriented, relatively easy to be accepted by the shipping sector. In order to achieve the goals set in the initial strategy, the follow up actions are also planned and scheduled to 2023 through several MEPC meetings to prepare for a revised strategy. At this stage, the work mainly focuses on data collection, aiming for adoption of a revised IMO Strategy, including short-, mid- and long-term further measures, as required, with implementation schedules. Technical, operational, and market-based measures are considered the three pillars in the IMO itinerary addressing the GHG emission reduction. The possible measures relevant to these three pillars that IMO may put forward to promote all the parties to act actively to reduce the GHG emission will be discussed in the following part.

2.2.1 Phase 4 of EEDI

EEDI is a new ship energy efficiency indicator, showing the amount of CO2 emission per capacity mile with the aim of encouraging introduction of an array of new technologies and innovations such as new type of engines, hull shape, air lubrication and to name a few, at ship designing stage. EEDI sets a minimum energy efficiency by tightening a target of 10% reduction of CO2 levels by 2015, 20% by 2020 and 30% by 2025 (Balcombe & Brierley, 2019). This means that new ships must be significantly more energy efficient than the baseline, which also reflects IMO's determination to reduce GHG emissions.

To further limited EEDI, MEPC 74 established the Correspondence Group on the Possible Introduction of EEDI Phase 4. On the basis of the information collected from the EEDI database, shipyards, naval architects and engine manufacturers, etc., the Correspondence Group will analyze a series of current and potential technologies (e.g. engine technologies, materials, alternative fuels, reduction of engine power and speed, hull improvements) that may be applied on ships for meeting the more stringent EEDI requirements, including cost-benefit analysis, safety implications understanding and assessment of the capability of shipbuilders, designers and engine manufacturers to apply such technologies. The possible framework of EEDI Phase 4 needs to be conducted by identifying GHG reduction potential, expected year of practical use, potential challenges, and prospects of the fuel supply for each technology. It needs to emphasized that most members support the idea that alternative fuels or propulsion systems as well as other innovative technologies should be also taken into account in possible EEDI Phase 4, and meanwhile members also hold the view that the possible EEDI phase 4 should set different discount rates according to different types and size of ships as in EEDI Phase 1 to Phase 3 (IMO, 2019b).

Given a number of challenges and urgency to reduce GHG in accordance with the Strategy, the introduction of EEDI phase 4 will promote transition from fossil fuels towards low GHG energy and utilization of new technologies. According to the interim report of possible Introduction of EEDI Phase 4, new EEDI will focus on target 2050 of the initial strategy rather than CO2 emission reduction in 2030, so substantial reduction rates rather than simple extension of those in the previous phases should be expected in EEDI Phase 4 . This study bases on the IMO EEDI Database, the current CO2 emission reduction compared in 2008, and the Fourth IMO GHG Study (IMO, 2019c). By 2022, some types of ships are required to comply with EEDI Phase 3 while other ships will start to meet the standard in 2025. Until now, certain types of ships, in particular, tankers and bulk carriers still have problems in fulfilling the standard of phase 3 without conducting certain design changes. Hence, there is adequate time to determine the starting year and reduction rate of EEDI Phase 4. Considering the timing of the legal process of the regulations, it is expected that it will be around 2030.

2.2.2 A goal-based SEEMP

Ship Energy Efficiency Management Plan (SEEMP) is a mandatory operational approach for new and existing vessels greater than 400 GT for international voyage, entered into force in January 2013. It is to establish a mechanism for company to improve energy management capability during ship operation, and such measures as slow steaming, weather routing, optimized ship trim, hull cleaning, engine maintenance, etc. are recommended. Normally, these measures do not require high capital cost, but may achieve promising energy saving. Shipowners and operators can monitor energy efficiency of the fleet and operate the ship in a more cost-effective manner through four steps: planning, implementation, monitoring and self-evaluation.

Considering EEDI is for the long-term approach, SEEMP is the major approach to meet IMO 2030 goal in short term. However, SEEMP is made by shipping companies, until now, and no specific requirements for SEEMP has been established in current regulations except for ships obtaining an SEEMP certificate and keeping it on aboard, which is left entirely up to the shipowners. Hence, shipowners and operators are lack of willingness and incentive to improve energy efficiency in terms of regulation aspect.

Given the fact that the initial Strategy and GHG emission of shipping need to be reduced as soon as possible, the member states submit proposals to strengthen the scope of SEEMP. A common agreement is that goal-based SEEMP which directly target GHG emission would have a great potential for each ship. As goal-based SEEMP provide flexibility for shipowners to choose the emission reduction solutions most appropriate for their circumstances, this seems the only way to realize the target of initial strategy.

After setting the target, it is necessary to introduce an operational efficiency indicator on ships, unfortunately, however, no operational indicator is really representative of a ship's actual operating efficiency and the lack of a standard indicator is still a problem, which can explains why many companies use their own indicators to assess the energy efficiency of their ships, according to sailing areas, ship characteristics and many other factors. Therefore, a standard indicator should be applied on board ships, before any target set for each ship. The indicator will be further proposed and discussed by member states. For example, China made a commendable effort to provide a 'better' indicator in document ISWG-GHG 6/2/10 (IMO, 2019e).

Another issue is how to supervise the implementation of SEEMP and make sure that shipowners and operators strictly follow SEEMP to reduce GHG emission. An assumption is that an audit scheme is needed to assure adequate compliance. For instance, a mandatory audit for SEEMP is an option, similar to the auditing scheme in the ISM Code carried out by flag state control; in this way, shipowners and operators are more willing to develop better SEEMP and execute them. Similar to EEDI, the specific target for different ships and reasonable indicator need to be set base on the data analysis and the IMO 4th GHG Study. As the only major short-term measure, its application will be much earlier than EEDI Phase 4, projected to be around 2023.

2.2.3 Restart of MBMs

MBMs for GHG emission reduction have been discussed through several previous MEPC meetings. In 2006, at MEPC56, a substantive review of the market mechanism was initiated, and a new work plan was formulated in 2009. In 2010, MEPC established an expert group to evaluate 10 market mechanism implementation plans on carbon tax, emissions trading, funds, and so on, but the evaluation results did not reach a consensus. Due to the complex and sensitive factors involved in establishing a market mechanism, and also considering urgency of introducing energy efficiency measures for existing ship operations, the MEPC65 held in 2013 decided to suspend discussions on the market mechanism and left it to future discussion (Shi, 2016).

Although, member states have controversial views on the adoption of MBMs to tackle GHG emission from international shipping, it is predicted that MBMs will be introduced into shipping industry as a supplementary method.

Firstly, until now, the mandatory measures of IMO regulations are EEDI and SEEMP, however, studies have indicated that using EEDI and SEEMP alone would not achieve the goal of initial strategy. The EEDI has been developed for the new ships, setting the reduction factor reaching as high as 30% more for the certain types of ships built in 2022 than those constructed in 2014. EEDI may have a better effect in long term, while the effect is much less in the short-term period as new ships account for a small percentage of world fleet. A study shows the EEDI will contribute 1% to 6% GHG emission reduction in 2030 (Wan & Chen, 2018). Meanwhile, the lack of a reduction target reduces the effectiveness of the SEEMP, despite IMO's continuous efforts on it, and it is still questionable whether the shipping company can strictly follow SEEMP because of the auditing; on the other hand, some of effective operational measures have negative impacts on international seaborne trade, for instance, slow steaming.

Secondly, MBMs can take into account two basic principles, the No More Favorable Treatment (NMFT) principle under IMO conventions and the common but differentiated responsibilities (CBDR) principle under the United Nations framework convention on climate change. Kyoto Protocol and Paris Agreement are the two basic foundations in developing legal instrument to address GHG emission. CBDR means all countries have the common responsibilities to protect the environment, but owing to differences in social statues and economic situations, they undertake different responsibilities. CBDR highlights justice and equality in terms of undertaking responsibility, so the initial strategy also considers the side effects to the developing countries, in particular, the least developed countries and small island developing states.

The flag of convenience policy in shipping industry makes the NMFT principle really important, as it enables port states to apply uniform standards to ships calling at their ports. Until now, all the IMO treaty instruments are based on this principle. However, the climate change relevant regulatory are following the two principles. The main debate is that most developing states insist CBDR should be used for GHG regulations while many developed states believe only NMFT should be applied. The developed countries represented by the European Union advocate achieving absolute emission reductions through market mechanisms, which can stimulate the shipowners' enthusiasm by adding trading the emission rights to reach certain emissions level. Developing countries believe long-term industry development of developed countries has caused excessive GHG emission and the developed countries are more liable to address the GHG emission issues with the abundant capital and advanced technology. In addition, the main target of developing countries is economy development and eliminating poverty, so less responsibility should be borne (Li, 2015). Different views imply the difficulty in reaching a balanced MBMs plan. Although they have different preferences on the MBMs form, different from EEDI and SEEMP, MBMs can provide considerations to both principles.

Thirdly, owning to the slow progress for the IMO to adopt a data collection system for ships, in 2013, the European Commission established an EU Regulation on Monitoring, Reporting and Verification (MRV) as the first step, while the ultimate goal is to achieve a global agreement promoted by the IMO, paving the way for carbon emission trading system.

In summary, all these factors, including the pressure of achievement of IMO reduction goal, incorporation of two principles plus EU's strong desire to promote MBMs, signify a restart of MBMs. Nevertheless, due to the uncertainties surrounding the form of MBMs and their economic impacts, lack of the CBDR principle, and the absence of the IMO regulations governing MBMs, a lengthy journey can be expected of MBMs adoption. However, these barriers can potentially be addressed through well-designed mechanisms and better institutional arrangements. Revenue from carbon tax can be distributed to countries to mitigate the negative impacts on imports and exports or allocated to improve capability of developing countries to reduce CO2 emission Since MBMs are listed in the mid-term measures in the initial strategy, these possible mid-term measures are expected to be finalized and agreed by the Committee between 2023 and 2030 (IMO, 2018).

2.2.4 Introduction of New Energy Resources

In the mid - term measures of the initial strategy, alternative low-carbon and zero-carbon fossil fuel programs will be developed and long-term strategy will also focus on zero-carbon or fossil- free fuels to achieve zero carbon in the second half of the century. The current operational, technical and even MBMs are not adequate to achieve the ultimate goal of zero emission in shipping industry. Therefore, the zero-carbon or fossil- free fuels are the promising energy in the future.

Alternative fuels have their own advantages and disadvantages and currently there is no consensus on which is the best choice. The fuel cost proportion ranges from 24%-42% for the operational cost, hence the fuel prices become the overriding factor in choosing fuel and propulsion system together with other relevant factors such as the maturity of the technology, infrastructure support, the capital cost of the propulsion system, etc. (IRENA, 2019). At present, there are various advanced liquid gaseous biofuels and hydrogen and hydrogen derivatives, such as methanol, hydrogen and energy liquefied fuel.

2.2.4.1 LNG

In recent years, LNG, cleaner fossil fuels, are more popular, as LNG powered ships can meet EEDI Phase 3 and sulfur emission requirements. Although the price of ING is cheaper than HFO, the main barrier is the capital cost of refitting and the lack of infrastructures for gas refilling, which make the costs higher than HFO (Balcombe & Brierley, 2019). Therefore, the development of LNG needs the government support. Recently, the Ministry of Transport of China issued the 'Outline for the Development of Inland Waterway Navigation'. Specifically, the outline encourages the promotion and application of new energy and clean energy, LNG powered ships, and LNG bunkering service systems. It can be expected that the outline will play a positive role to promote the application of LNG powered ships, and this will be more attractive in countries with sufficient LNG bunkering service systems. But given the fact that it takes relatively long period of time for the LNG powered ship to join international voyages, in term of GHG emission mitigation, LNG is still an interim method, whereas, the ultimate goal of zero emission in shipping industry can only be achieved through the transformation from fossil fuel to zero-carbon or fossil- free fuels.

2.2.4.2 Biofuels

Some alternative fuels, such as biofuels, already have a certain degree of maturity and only a small modification or no modification of existing infrastructure is required, and mixing these fuels with traditional fuels will also have a significant and direct impact on emission reduction. Although alternative fuels are not competitive from the perspective of economic gains, they are more promising in the long-term strategy with the development of new technology (IRENA, 2019).

Biofuels are not yet widely used in the shipping industry, but they may play a vital role in decarbonization. Compared with fossil fuels, they emit less greenhouse gases, nitrogen oxides and sulfur oxides. Meanwhile, the cost of refitting is relatively low because of their high technical compatibility with currently used transportation and refueling infrastructure. However, there are currently three major obstacles that limit the widespread adoption of biofuels in shipping. Firstly, the cost of biofuels are high, which is about double the price of fossil fuels. Secondly, the availability of biofuels is limited. If it is necessary to completely replace the currently employed marine fuels, biofuels will not be able to meet global demand. In order to meet future demands, the production need to be substantially increased. Thirdly, sustainable development is essential. If the scale of biofuel production is expanded to the level necessary to meet future demands, social and environmental impact is necessary to be carefully assessed because safe, long-term, low-cost, and sustainable supply of raw materials is pivotal to the economic development of biofuels (IRENA, 2019).

2.2.4.3 Renewable electric energy stored in batteries

This type of energy source requires an electric motor driven by battery power. Compared with internal combustion engines, electric motors enjoy efficiency advantages. At the same time, the cost of renewable energy and batteries is falling sharply. In fact, battery technology has been developing rapidly in recent years, bringing better performance and reduced costs. As a result, batteries are becoming more and more attractive in new applications, especially lithium-ion batteries whose energy density is eight times higher than traditional storage technologies such as lead-acid and nickel-cadmium.

Nevertheless, there are still some drawbacks such as the fire hazards when operated in extremely high and low temperatures. Therefore, the storage of lithium-ion batteries requires a powerful battery management system, as well as thermal management components including temperature sensors, cooling systems and adequate ventilation. With the current technology, all-electric ships usually can travel no more than 95 kilometers, so that electric driven ships are only suitable for relatively small ships intended for a short voyage. Considering the rise of the energy density and life cycle of batteries and the cost decrease, it can be expected that electric propulsion may be economically attractive for large ships traveling international voyage in the long run.

The production cost of methanol, hydrogen, and ammonia and the cost of equipment modification are much higher than the cost of fossil fuels used today, which makes it difficult for the industry to choose these fuels on a large scale.

New energy is the future of the shipping industry and is liable to bring about great changes to those parties including ship building industries, manufacturers, shipping companies, the energy companies. In fact, it is not only critical for future shipping industry but is also a national strategy because whoever owns the next new energy technology would play the leading role in the world economy, similar to the impact of 5G technology on the telecommunication industry. As the new energy is far from mature, its impact on the shipping industry would be minimum in recent years. Therefore, the impact of the short and middle term measures will be focused on in the following chapters.

CHAPTER 3 INFLUENCE ON SHIPBUILDING INDUSTRY

3.1 Challenging of Shipbuilding sector

The entry into force of GHG regulation and further possible stricter amendments mentioned above will have an impact on the shipping industry, especially for the shipping building sector who is responsible for transforming all the requirements into ship design and construction. Different from other regulations, GHG emission reduction measures cannot be implemented by just installing an equipment, for instance, scrubber for sulphur control and ballast water management system for ballast water treatment, and it requires a combination of technical measures to reach an EEDI standard. Therefore, the capability to establish cooperation with marine equipment manufacturers and suppliers, promote partnerships with technical institutes to stimulate innovative energy-saving and eco-friendly technologies as well as application of the environmentally friendly technology on new ships has become important measure of shipbuilders' competitiveness.

	China	Japan	Philippines	Republic of Korea	Rest of world	World total	Percentage
Oil tankers	4 505	2 819	288	6 046	865	**14 524**	25.0
Bulk carriers	9 274	5 134	654	352	91	**15 505**	26.7
General cargo ships	416	159	-	74	234	**884**	1.5
Container ships	6 630	3 020	992	2 632	341	**13 614**	23.5
Gas carriers	762	1 754	52	4 709	26	**7 302**	12.6
Chemical tankers	466	647	-	274	64	**1 452**	2.5
Offshore vessels	774	18	-	472	453	**1 718**	3.0
Ferries and passenger ships	162	72	2	51	1 573	**1 860**	3.2
Other	270	816	-	24	76	**1 186**	2.0
Total	**23 260**	**14 440**	**1 988**	**14 633**	**3 724**	**58 045**	**100.0**
Percentage	40.1	24.8	3.4	25.2	6.4	**100.0**	

Figure 3- Deliveries of new building by major vessel type and countries of construction, 2018(Thousand gross tons)

Source: Review of maritime transport 2019

It should be noted that most of the large tonnage bulk carrier and tankers built in China cannot meet the EEDI phase 3 standards (Fan & Jiang, 2019). As is shown in Figure 3, according to the deliveries of new buildings by major vessel types and countries of construction in 2018, China delivered 31% of tankers and 60% of bulk carriers in world total in terms of gross tons. As phase 3 of two types of ships will enter into force in 2025, Chinese shipbuilding industry will be challenged. In addition, there is a trend that the regulation is becoming stricter, with EEDI phase 4 being adopted and entry into force. In general, the research of green shipping can meet the current IMO-related GHG emission requirements. Therefore, the shipping building pattern would not suffer big changes in recent years before adoption of EEDI phase 4, but the change will occur inside shipbuilding industry in China. Of the more than 1200 ship building companies in China, those who cannot meet EEDI phase 3 will lose new ship orders. It is undeniable that environment relevant regulatory would be an important factor to phase out the backward productivity ship building companies. It can be predicted that the number of shipbuilding companies will become smaller, and another trend is the consolidation of companies to ensure competitiveness in face of declining orders, and to mitigate the impact on a labor-intensive sector and develop a modern vessel-construction model fit for the future. A case in point is the merger between two main shipbuilders in China, namely China State Shipbuilding Corporation and China Shipbuilding Industry Corporation.

3.2 The competition from international companies

3.2.1 Competition from South Korea and Japan

After world financial crisis, China, South Korea and Japan dominates the shipbuilding market share, totally accounting for 90%, with China 40 per cent, Japan 25 per cent and Republic of Korea 25 per cent respectively. In comparison, other emerging shipbuilding countries such as Brazil and Vietnam, have a limited influence on the world shipbuilding pattern because of the large gap.

In 2018, China built 60% of the global delivery of bulk carriers, 49% of containers, 47% of general cargo ships and 45% of offshore vessels. The South Korea led globally in gas carriers building (with a share of 64%), followed by oil tankers (42 %). The top sector in Japan was chemical tankers representing 45% of global newbuilding deliveries, and 33% of bulk carriers. (NUCTAD, 2019).

Although China still has a labor cost advantage over other two countries, it is in an inferior position in terms of technology and efficiency. For instance, Japan shipbuilding industry has shifted to the high-end industrial chain where the standard maker of the industry is that the shipping building companies strive for every ship built in its own shipyard using its own core technology As early as the mid-1970s, shipbuilding in Japan formed a complete and high-tech supporting industry and it is still a world-class shipbuilding equipment manufacturer and through technology patent authorization and manufacturing high-end ships, its shipbuilding industry maintains the superior technical level and earns considerable and sustainable profit (Lv, 2017).

3.2.2 Competition from EU and the United States

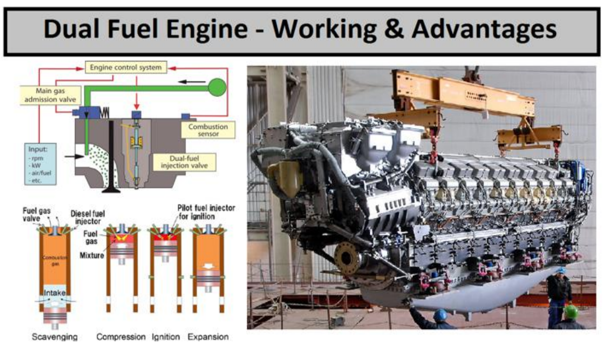
Though the world shipbuilding center is in east Asia, the United States, Germany, Britain, Finland and some other European countries are still strong shipbuilding nations because they own the core technology including the concept of the design and the ship support equipment, such as the electronically controlled fuel injection device technology for marine engine, the automatic control technology of the ship conduction system, and the dynamic positioning system. The cost of all those high technology equipment installed on a ship accounts for more than 80% of its cost.

In the aspect of the GHG emission sector, Chinese technical research on the future higher green environmental protection equipment still lags behind other nations. As is shown in Table 2, the majority of advanced GHG emission mitigation technologies are developed by foreign companies.

Table-2 Lists of advanced GHG emission mitigation technology of shipping

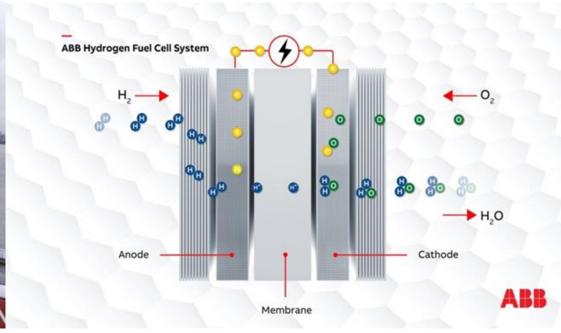
New technology	Nationality	Companies
Dual-fuel engines and pure gas engines	Germany, Finnish	MAN, Wärtsilä
Spinner sails	Finnish	Norsepower
Fuel cells battery	Switzerland	ABB
Air lubrication systems	Japan	Mitsubishi Heavy Industries and Japan Yusen Group
Hydrogen and ammonia as engine fuels	Japan	NMRI
New high-efficiency propeller	American	Sharrow Engineering Company
New fuel (LNG, methanol, ethane)	The United States, Japan, South Korea and EU	

Source: Author

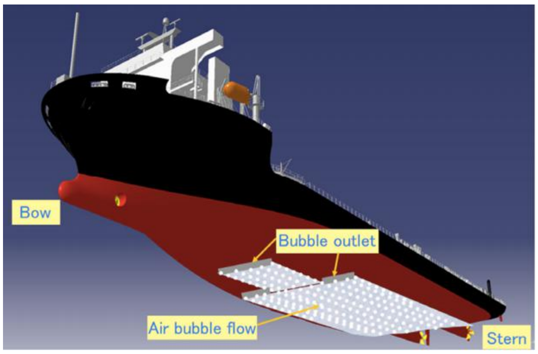


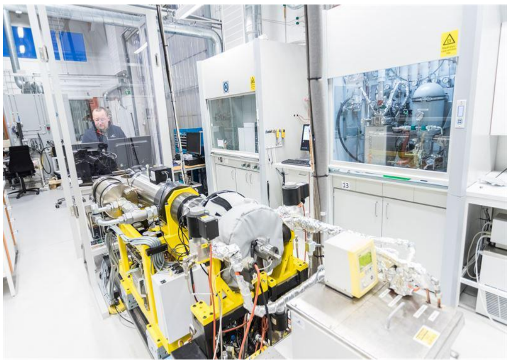
(1) Dual-fuel engines and pure gas engine

(2) Pure gas engines



(3) Spinner sails (4) Fuel cells battery





(5) Air lubrication systems (6) Hydrogen and ammonia as engine fuels

(7) New high-efficiency propeller (8) LNG powered ship

Figure 4-Figures of new technologies

Source: Internet

3.2.3 Latest attempts by international companies on green shipping

The international shipping companies also carried out a series of attempts on application the new technology on ships.

According to the concept of the zero-emission ship launched by Japan Mail, NYK Super Eco Ship 2050 uses fuel cells, solar panels, electric propulsion systems, air lubrication systems, lightweight materials and other technical measures to achieve no greenhouse gas emissions during navigation.

In 2018, Maersk promised to achieve zero-emission alternative fuels and achieve zero carbon emissions in 2050. It believes that the next 5 to 10 years will be crucial and have invested approximately US $ 1 billion annually and employed more than 50 engineers to develop and deploy energy saving and emission reduction solutions in last four years.

From 2020, the ultra-large LNG power container ships ordered by CMA will be delivered one after another. As the first capacity of the series, the ship design has been optimized for hydropower to achieve higher energy efficiency. The bulbous bow is integrated into the hull, making the bow straight, and the propeller and rudder blades have also been improved.

After successfully conducting a biofuel test, Mediterranean Shipping decided to continue providing biofuel on a regular basis, and looked forward to making biofuels an ordinary source of energy on ships. Mediterranean Shipping stated that when mixed fuel was used, the absolute carbon dioxide emissions were expected to be reduced by 15% to 20%. The potential carbon dioxide reduction of biological components in these fuels may reach 80% ~ 90% (Zhao, 2020).

3.3 Lack of core technology

3.3.1 Drawbacks of shipbuilding in China

Based on the above analysis, it is safe to say China is a major maritime country not a powerful maritime nation. Under the severe competitions from international shipping industry, it remains a question whether Chinese shipbuilding can maintain the first place, earn more market share and become more competitive after the adoption of stricter environment regulation.

Since 2010, China has ranked first with respect to the three major indicators of shipbuilding, namely completions, new orders and hand-held orders, and meanwhile, Chinese shipbuilding industry has made some progress in the aspect of high-value-added and high technology sector. For example, the 320,000-ton VLCC EEDI developed by Waigaoqiao ship building company is 37.5% lower than the baseline, meeting the requirements of phase 3, and it is currently the largest tonnage dual-fuel super-large tanker approved by the classification society. (Lv, 2018). However, despite the progress made in Chinese shipbuilding industry, its weakness is still apparent. For instance, as for the high-end products such as LNG ships, drilling ships, large container ships, and luxury ro-ro passenger ships, most of conceptual designs and basic designs come from foreign design companies and most of China shipbuilding companies can only provide detailed design and production design. In addition, the software used in China's shipbuilding industry from fluid simulation and structural finite element analysis to preliminary design, detailed design, and production design is basically developed by foreign institutions.

Meanwhile, the domestic supporting rate of high-tech ships and offshore equipment is only 20%. The generator, power system, DP3 dynamic positioning system of the No. 981 deep-water semi-submersible drilling platform are imported from abroad.

On the whole, the weaknesses are showing particularly in the following five aspects. Firstly, the design and development capabilities are insufficient, as most of the ship design softwares are imported, and the designed ship type are limited; secondly, shipbuilding efficiency is far lower than that of developed countries, and the per capita output value of shipbuilding is only 1/5 of that of Japan; thirdly, there are still common problems such as lack of standard system, inconsistency of design and production procedure, insufficient application of simulation technology research; fourthly, ship supporting technology is lagging behind, so that most of the core components rely on imports; fifthly, production management, material demand and supply management, resource planning and production cost control are incompatible with modern shipbuilding requirements (Lv, 2018).

3.3.2 Factors affecting the development of core technology

The fundamental reason of those drawbacks is lack of the core technology. From my perspective, four factors have caused the slow development of core technology in shipping building industry: first of all, independent research and innovation capability of the parties involved are the vulnerable spot. Although the number of patents has increased, few of them involve core technology and are normally with low promotion value; secondly, the fundamental industry is not mature and the lack of such basic compnents as precision machine tools and high-tech materials hindered shipbuilding industry's research in core technologies; Besides, many researchers are devoid of enthusiasm, patience and concentration in scientific research and innovation, pursuing success in a quick manner; Fourthly, the application of new technologies and the effect of market promotion are unsatisfactory, since the degree of recognition of domestic production in shipbuilding industry has remained at a low level for a long time (Lv, 2018).

Over-reliance on other countries' core technology will not only jeopardize the economic interest but also pose a security threat to Chinese shipbuilding industry, which can be manifested by the occurrence of some events beyond the shipping industry such as ZTE chip embargo or the block of Tiktok. Chinese shipbuilding industry can only master its own destiny when it possesses the core technology or irreplaceable competitiveness like Huawei and WeChat.

CHAPTER 4 MARITIME GHG EMISSION REDUCTION MARKET-BASED MECHANISM

4.1 MBMS

4.1.1 Introduction of MBMs

Since MEPC 57th session in 2008, 10 GHG market emission reduction proposals have been put forward. Based on regulated objects (fuel and energy efficiency) and regulation tools (tax and transaction mechanism), those 7 mechanisms can be divided into three categories:

Table-3 Lists of MBMs

	MBM proposals	Proponents
Fuel tax	GHG Fund	Cyprus, Denmark, the Marshall Islands, Nigeria, and the International Parcel Tankers Association (IPTA)
	Port State Levy (PSL)	Jamaica
	Rebate Mechanism for a market-based instrument for international shipping	IUCN (WWF provides add-on options)
Emission trading scheme	Global Emissions Trading System (ETS) for international shipping	Norway (later added as co-sponsor, Germany) United Kingdom, France
Energy efficiency	Efficiency Incentive Scheme (EIS)	Japan and World Shipping Council (WSC)
	Ship Efficiency and Credit Trading (SECT)	United Sates
	Penalty on Trade and Development	Bahamas

Source: Author

EIS and SECT are two MBMs based on EEDI. The main problem of the SECT proposal is that it is designed for all ships, which means existing ships have to comply with the mandatory performance efficiency standard. However, EEDI is widely considered to apply only to new ships, not to existing ships. Therefore, it is not feasible to apply SECT to the entire shipping industry.

In terms of EIS, the EEDI rules only applies to new ships, while the existing ships need to pay fees. Therefore, the new ships will be subject to dual supervision and impact in two ways: first, they will be directly affected by technical measures; second, they will be also affected by the MBM, which is unfair to new shipowners. In addition, these two methods fail to incorporate CBDR principles into the scheme , which is inconsistent with IMO's CBDR and NMFT principle.

Bahamas only proposed some regulatory principles for designing MBM, which has not yet developed into a mature MBM. Similarly, the PLEF proposal has not solved the key issues such as the calculation method of tax rates and tax purposes, so PLEF is also gradually marginalized (Shi, 2016).

The most commonly mentioned market measures are emissions trading systems and carbon taxes. As EU are willing to extend ETS into the maritime sector in 2021, a further analysis would be given.

4.1.2 Introduction of EU ETS

There are two main types of emissions trading systems: the cap-and-trade system is to set the total amount of carbon emission that all participating companies can emit according to the total carbon emission reduction plan , then allocate carbon emission to participating companies and the emission quota (each quota represents the right to emit one ton of carbon dioxide) would be traded through auction according to specific standards. It should be noted that the total amount of carbon emissions allocated each year will decrease, so the total emissions would also be reduced in emission cap model.

The other method, the emission intensity reduction mechanism, is based on the proportion of the emission amount of standard year. As emissions are not only controlled by emission technology, but also affected by economic fluctuations and demands, the absolute emission reduction control cannot monitor economic changes, emission intensity mechanism has been adopted by many countries (Wang, 2014).

In both models, when the annual carbon emission of an enterprise is lower than the allocated quota, the excess quota can be sold in the carbon trading market; similarly, when the annual carbon emission of the enterprise is higher than the allocated quota, it will have to purchase the required carbon emission allowances in the carbon trading market or international carbon credits from emission reduction projects around the world. Each company must get enough quotas to cover all of its emissions every year, otherwise a high fine will be imposed (NUCTAD, 2018).

4.1.3 The development of ETS

Owning to its large share in economy and growing environment awareness, EU has been an indispensable pioneer in mitigating global climate change. In 2005, for the purpose of reducing greenhouse gas emissions, EU established the first global trading system, using market mechanisms to reduce carbon emissions, and this is currently the largest and earliest carbon trading mechanism in the world. The trading volume accounts for more than 3/4 of the global carbon trading volume, covering approximately 45% of the greenhouse gas emissions in the EU (Hou, 2019).

In 2013, the European Commission proposed a mechanism for GHG emission accounting, reporting and verification.. In April 2015, Regulations of Shipping

Greenhouse Gas Emissions Accounting, Reporting and Verification Mechanisms was formally adopted. This regulation applies to ships with a total tonnage more than 5,000 tons, but it does not apply to warships, naval auxiliary equipment, fishing or fish processing ships, or government ships for non-commercial use. The actual monitoring of maritime emissions officially began on January 1, 2018. The shipping operators must formulate a monitoring plan and then submit an annual emission report. Monitoring and reporting pollution is considered a prerequisite for establishing market-based emission reduction measures (Wang, 2014). This mechanism obviously is a necessary pilot procedure for the EU's unilateral climate action to incorporate the shipping sector into its carbon emissions trading market.

One of the EU’s considerations is whether the maritime greenhouse gas emissions should be included in the EU ETS. In 2017, at the EU Transport Ministers Meeting, EU member states expressed concerns about expanding the carbon emissions trading system to the maritime sector for fear that the EU's unilateral action to curb shipping emissions may harm shipping competition. Some member states prefer to focus efforts on the IMO work unless no progress will have been made by 2023. Anyway, EU members are willing to boost the MBMs project.

At the end of 2019, the European Green Deal, a new growth strategy, starting with more ambitious climate action in the coming decade, has been adopted. In the deal, the commission proposes to extend EU ETS to the maritime sector, and to reduce the EU ETS free allowances allocated to airlines.

At July 7, 2020, the European senator agreed to incorporate international carbon emissions from the shipping industry into the EU carbon trading market, and also required shipping companies to set binding targets (International Shipping, 2020). By 2030, the average annual CO2 emissions of all ships in operation will be at least 40%

lower than 2018 level, a step further than the European Commission's original recommendations. It should be noted that the IMO also sets a goal that average annual CO_2 emissions of all ships in operation should be reduced by 40% based on 2008 level;as 2008 is considered to be the highest average annual CO_2 emissions from ships, EU's goal is stricter.

The European Environmental Committee also called for the establishment of an Ocean Fund from 2023 to 2030. The source of funds is the revenue from auction subsidies under ETS to improve the energy efficiency of ships and support investment in innovative technologies and infrastructure. The parliament is going to convene a meeting in September this year to consult with member states on the final form of legislation (International Shipping, 2020).

4.2 Status of shipping industry in China

4.2.1 Status of greenhouse GHG reduction

Since China is one of the largest developing countries in the world, economic development is still the major task at present stage. The port scale in China ranked first in the world with more than 2,400 berths above 10,000 tons and 7 ports among the top 10 ports in throughput worldwide are in China. According to statistics, in 2007, the GHG emissions in maritime transportation sector accounted for about 5.49% of the total GHG emissions in the national transportation industry. In 2019, China was the largest annual GHG emissions in the world, accounting for 27.2% of global GHG emission (Tanjiaoyi news, 2020). Moreover, considering development of the social economy and the increase in shipping trade, the fuel consumption from shipping will continue to rise, so that GHG emissions from shipping will continue to increase correspondingly

4.2.2 The MBMs development in China

At present, Chinese emission trading market is far from mature and is not yet a free trading market mechanism since only some transactions have been made through emission trading market under the UNFCCC framework, and the vast majority of which are pushed forward by the government.

In 2011, China launched pilot projects for carbon emission trading in 7 provinces and cities including Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong and Shenzhen. The domestic carbon emission trading market had not been developed in China until 2013 when Shenzhen Emissions Trading Market officially opened its market, making it the first carbon emission trading in China. As of the end of June 2019, 7 pilot carbon markets covered nearly 3,000 key emission units in multiple industries such as power, steel, cement, etc. The cumulative transaction volume exceeded 330 million tons, and the cumulative transaction value was approximately 7.1 billion yuan (Shi, 2020). Both the total carbon emissions and intensity of the enterprises in the pilot area had been reduced, showing the good effect of the carbon market in controlling carbon emissions at a lower cost. At the initial stage, the national carbon market was an intensity-based carbon market, rather than a total carbon amount limitation. However, with respect to the shipping industry, there has not been relevant carbon trading attempts yet, and there is no legal basis and support to establish a maritime GHG market mechanism (Luan, 2015).

4.2.3 Fleet status

The shipping industry is a high energy-consuming industry, which mainly uses fuel oil as the main fuel, causing a large amount of carbon emissions. In the 2010s Chinese fleet size was continuously expanding at the average expansion rate of approximately 11.7%, much higher than that in the 2000s (approximately 8.8%), and the growth rate was the fastest among major shipowners in the same period. By the end of the 2010s, Ships owned by Chinese shipowners ranked third by dead-weight tonnage, accounting for 10.51% of total world fleet, while China owned the highest number of world ships (6215) with 3987 flying national flags and 2138 flying foreign flags, among which, a considerable part of them were engaged in domestic trade transportation (Clarkson Research, 2020).

Table 4- 2019 Domestic Coastal Cargo Ships Analysis Report

Types of ship	Numbers of ships	Average age of ships	Old ships	New ships	Ships out of the market	Old ships /total numbers of ship
Bulk carrier	1752	10.67	245	140	220	14%
Container ship	290	9.35	35	46	8	12.1%
Tanker	1249	10.51	499	29	76	40%
Chemical ship	281	10.69	135	8	15	48%
LNG	73	12.31	31	1	0	42.5%
Total number	3645		945	224	319	26%

Source: Author

The age distribution of domestic coastal cargo ships is presented in Table 4, the dead weight tonnage of domestic coastal cargo ships is relatively small compared with those for international voyage and majority of them are relatively old. The bulk carrier and tanker are the major types of domestic coastal cargo ships with old ships accounting for 14% and 40% respectively. The percentage of old ships for chemical ships and LNG reaches more than 40%.

In 2019, the average age of the world merchant fleet was 21 years. However, this is not uniform across vessel types. Ships below 10 years of age represent a high proportion of the carrying capacity of bulk carriers (71 %), followed by container ships (56 %) and tankers (54 %). On the other hand, only 35 % of the carrying capacity of general cargo ships and 41 % of other types of vessels correspond to ships below 10 years of age, suggesting that these two segments are not undergoing fleet renewal. The age of more than half of the three major types of ship, (bulk carriers, container ships and tankers), are under ten years, which means the new ships are favorable by the market.

As is presented in Table 5, the average age of Chinese ships is younger than the global average age except that the age of bulk carriers in China is slightly higher than the world average. This trend also reflects in the percentage of old ship with container ships and tankers lower than the world and bulk carriers higher than the global age. Generally speaking, Chinese domestic coastal ships are younger than the world average.

Table-5 Age distribution of world merchant fleet by vessel type, 2019

Type of ship	Average age (World)	Average age (China)	Percentage of 0ld ships (World)	Percentage of 0ld ships (China)
Bulk carriers	9.72	10.67	Around 9.74	14
Container ships	12.34	9.35	16.28	12.1
tankers	18.87	10.51	54.49	40

Source: Author

However, the energy-saving and emission-reduction technologies used on these ships are relatively backward and it is still difficult to meet the emission reduction standards for those ships, as most shipowners do not have sufficient resources to update the energy saving equipment. Compared with developed shipping industries, many Chinese shipping companies give more regards to operating costs and pay little attention to environmental interests, and they tend to refuse to use and update advanced technologies. As is mentioned in the last chapter, the national green technologies are backward, so for shipowners the capital cost of applying the green technology and equipment would be relatively higher. Moreover, the scale of ships currently owned and controlled is huge and it is a long and costly process to upgrade ships.

4.3 Trading between EU and China

EU was the Chinese largest exporter trading partner in 2019 with 2955.06 billion RMB. At the same time, China was also EU's second largest exporter (1906.26 billion RMB) (Ministry of Commerce, 2019).

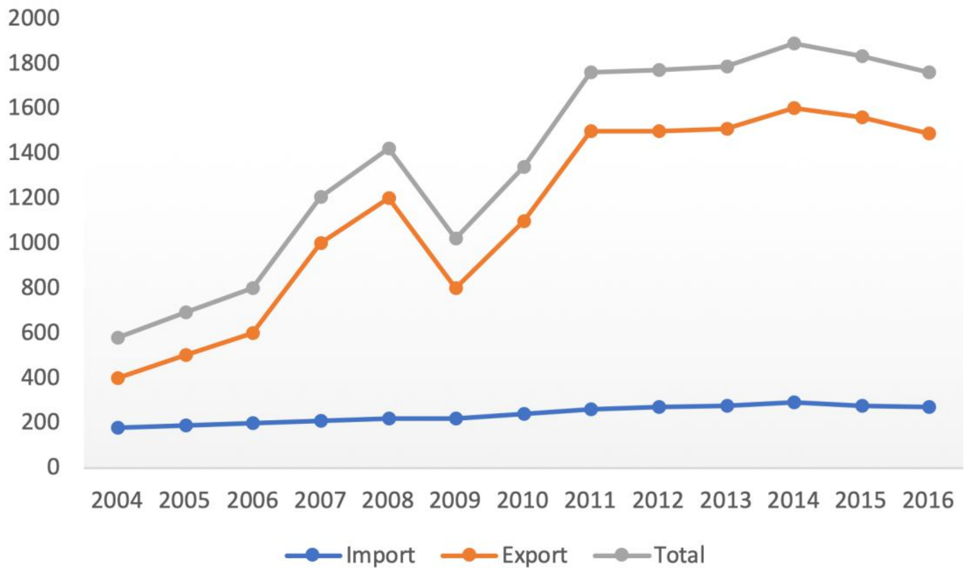


Figure 5- The China-EU resource and labor-intensive products trade volume (Billion dollars)

Source: Uncomtrade

Figure 4 shows the development of the import and export trade volume of China-EU resource and labor-intensive products from 2004 to 2016. Resource and labor-intensive products mainly include textiles, clothing, footwear, and simple metal processing products and plastic products. Capital technology-intensive products refer to automobile, ships, machinery and other automation or engineering industrial products, electronic telecommunications, medical equipment, optical instruments, and aviation products.

From the data in Figure 5, it can be seen that the import and export trade volume of China-EU resources and labor-intensive products has shown general increase trend in recent years. The import trade volume has increased from 15.54 billion US dollars in 2004 to 395.7 billion in 2016. The export trade volume grew rapidly, from 38.15 billion US dollars in 2004 to 158.4 billion US dollars in 2016 (Chen,2018).

As is present in Figure 6 and Figure 7, China exports resource and labor-intensive products, reaching 46.84% of total value of export cargo. Although China’s total exports of technology-intensive products to the EU have a relatively high ratio, this ratio has shown a clear downward trend, from 59.37% in 2004 to 50.12% in 2016. In contrast, EU main export products are capital and technology-intensive products, accounting for about 70%. The proportion of resource and labor-intensive products is relatively stable, but the proportion is only 20% (Chen, 2018).

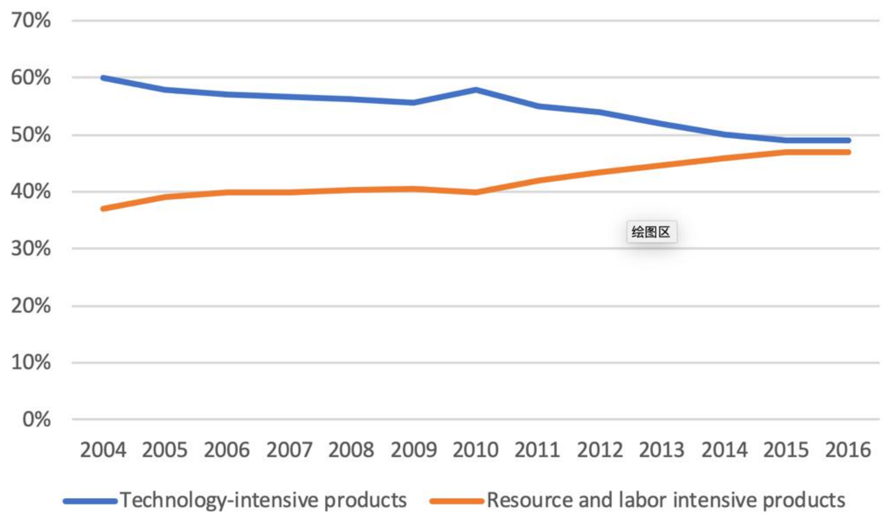


Figure 6- Chinese export structure to EU

Source: Uncomtrade

Generally speaking, China mainly exports low-value-added products, most of which are daily necessities, while EU exports mainly high value-added technology-intensive products, which are generally high-end consumer goods, luxury goods, and precision instruments.

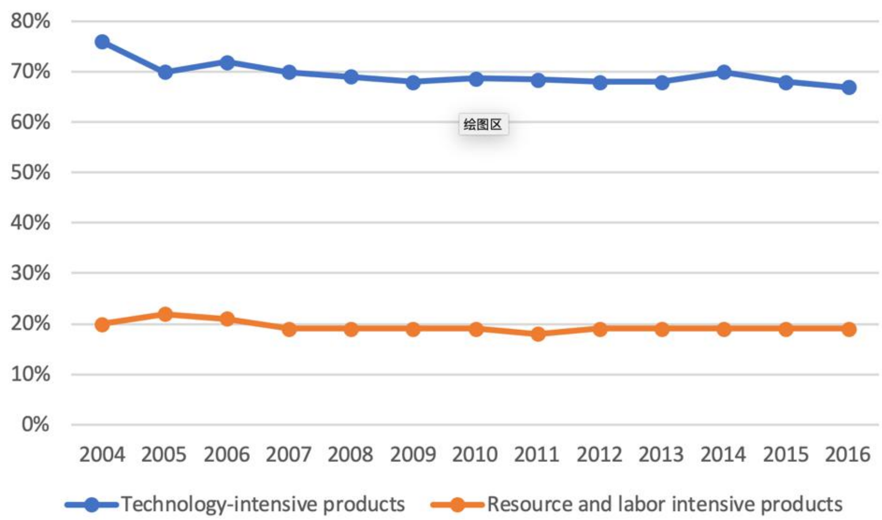


Figure 7- Chinese import structure from EU

Source: Uncomtrade

4.4 EU ETS's impact on the shipping market

More than 90% of the import and exports from China are carried by shipping. Based on the above analysis, a larger amount of the exported products are low-value-added daily necessities, which are more cost-sensitive. If the European Union imposes a maritime carbon tax, it is clear that this GHG mitigation measures will increase the transport cost. These may not be incurred immediately depending on market structures, trade balances, or possible cross-subsidies, but it can safely be assumed that higher transport costs will eventually lead to higher cargo prices.

The capability to pass the additional cost on to shippers would be an indicator of competitiveness of shipping companies. Normally, it would be easy to transfer the additional cost to shippers in a demand- driven market, but difficult in a supply-driven market. This can be seen by comparing the market conditions in 2006-2007 and 2012-2013. During 2006-2007, the shipping market presented high demand and high freight rates, if an assumed carbon tax is added in the bunker, 48% of the tax will be paid by the carrier and 52% by the shipper. However, during 2012-2013, shipping market ran into overcapacity problem, then it is estimated that 90.3% of the tax will be spent by the carrier and 9.7% by the shipper (UNCTAD, 2018).

Under the circumstances of covid-19 attack to the whole world, the world shipping industry are experiencing a hard time. Clarkson's research shows that the downward trend in the number of port calls since mid-March has appeared in some regions, especially the number of port calls of large European ships decreased by 18% compared with the same period in April last year, and the frequency of the port calls of large ships in U.S. ports during the same period also fell by 8% from the same period last April. This downward trend is expected to deepen in the second quarter. In terms of shipping demand, affected by the epidemic, a sharp drop in shipping transportation demand are due to reduced cargo volumes and lower freight rates. Until April 5, there were 212 suspended routes worldwide, of which the Asian and European markets had withdrawn the most capacity.

Therefore, the added cost from EU ETS is hard to shift to the carrier, and a large amount would be undertaken by the shipper. If the epidemic continues, many companies will fall into cash shortages and business interruptions. If the companies cannot cope with the extra cost, marginal profit could be further reduced resulting in further consolidation and bankruptcy of the most financially vulnerable carriers.

Because of the great demand of ship transportation for the trade between EU and China, Chinese shipping companies will have to spend extra costs to purchase carbon emissions shares and even pay high fines, when the ETS is officially launched. Since there is no specific plan regarding the ways to charge the money, and ships sail mostly on the high seas, it is difficult to evaluate the exact impact of transport cost.

At present, the European credits is around 30 Euro/ton, as one ton of fuel can generate about three ton of CO2, which means the fuel price is around 90 Euro/ton. If Chinese fleet has to pay 10% of total emission, it means that each ton of fuel would cost Chinese shipping company about 9 Euro/ton and this price has limited impact on the shipping companies. However, as the total amount of emission is reduced, the cost of limiting carbon emissions will gradually rise. The price of the credits is determined by the EU as the total emission cap is made by them. The ultimate manifestation of this increase would cause a rise in Chinese commodity prices. The price advantage would be smaller due to the extra cost, which will result in further unsalable Chinese goods and further increase the overcapacity of Chinese manufacturing industry. In particular, it will have a greater impact on Chinese small and medium-sized manufacturing and processing enterprises. In the short term, technological transformation will become difficult to achieve, and the survival space of enterprises will be further compressed.

4.5 Concerns from China

As far as the EU ETS is concerned, several issues are worthy of consideration by China. The emission cap of the ETS measure needs to be determined according to factors such as technological development and the market price of fuel. However, these factors are changing with time and market conditions, the upper limit of carbon emissions is uncertain. Such uncertainty is likely to cause unfair distribution of ship quotas, which is particularly detrimental to developing countries due to developed countries' valuable experience in the operation of the carbon trading system, and advanced carbon emissions technology.

Second, although the current EU ETS proposal combines CBDR and NMFT principles, it does not clearly reflect the principle. For instance, the main method in Norway emissions trading system incorporates the CBDR principle by providing two exemptions, including ships below a certain tonnage and ships travelling internationally to SIDS and least developed countries. Such exemptions may allow some shipowners and ship operators to choose emission exemptions through certain transport routes in SIDS, which may reduce the effectiveness of MBMs. Many developing countries are not included in the exemptions, so they may oppose to it. Third, EU ETS allows EU to impose levy taxes on shipping companies in various countries and rules about how to charge taxes on ships docked at EU ports are formulated by the EU. In this case, EU has a considerable initiative on achieving the profits, and such profit would be used to develop green technology, which may end up in their greater superiority to the developing countries. At present, EU is playing a leading role in terms of emerging green low-carbon equipment and environmentally friendly energy technologies. By restoring Europe competitiveness, for example in maritime technology, the European Green Deal has the potential to become a game changer and it should not be seen exclusively as a Climate Deal but also as a Strategy for Growth. As other countries' shipowners have to comply with ETS rules through applying green technology on ships to reduce GHG emission. Thus, the EU green shipbuilding and energy-saving technologies will gradually open up international shipping market and consequently the domestic shipbuilding industry and marine equipment and other maritime-related industry would be seriously affected.

Forth, the relationship between major maritime countries about MBMs would be intense. One purpose of expanding EU ETS into maritime sector is to amplify their voice in introducing a new MBM in IMO. Considering the great influence of EU member countries on IMO (four seats in the A-type council and five seats in the B-type council) and the indifference of unrelated countries, plus the 'default acceptance' procedure of the IMO amendments, it is highly possible that EU ETS can get approved when it is incorporated into MARPOL Annex VI in the form of amendments. The EU's action may accelerate IMO's work for MBMs and how IMO react to EU unilateral action in the mitigating GHG from international maritime transportation is still unknown.

CHAPTER 5 SUGGESTIONS FOR CHINESE SHIPPING INDUSTRY

5.1 Enhancing core technology

The absence of core technologies in manufacturing industry in China has been an chronical issue, and, the fact that the aviation and high-speed railways finally through years of endeavor own core technologies with independent intellectual property rights sets a benchmark for Chinese manufacturing industry. In recent years, Chinese shipbuilding industry has made substantial efforts in researching and development of core technologies and major achievements include marine high-speed diesel engines, high-power integrated electric propulsion systems, navigation radar, and deck machinery, but these are far from enough for a powerful maritime nation. GHG emission mitigation regulation is not only a challenge, but also an opportunity for the shipping industry. To better adopt the latest GHG mitigation regulation and improve the core technology in the shipping sector, some valuable experience needs to be learned from other countries.

5.1.1 Valuable experience of some maritime countries

5.1.1.1 Germany

In recent years, though the global shipbuilding industry is experiencing its worst crisis, the number of merchant ship orders received by German shipping companies has reached a high level. With the technology advantage in building cruise ships, passenger ships and special ships, German shipbuilding industry orders have continued to grow against the trend and become a highlight of the global shipbuilding industry. At the same time, the German government provides the maritime research and innovation funds and various financing methods to focus on improving the competitiveness and innovative capabilities of the maritime industry.

First, the small and middle enterprise Market Support Program. The German launched a market-oriented program ‘Innovation and Competition in the Shipbuilding Industry’ subsidy policy. Since 2005, the government has subsidized German shipbuilders to encourage the German shipbuilding industry to develop and create more innovative products. In 2016, the government provided 25 million euros in special funds to promote shipbuilding innovation, and plans to continue to increase subsidies with annual special funds of 30 million euros in the next few years. In addition, large enterprises can cooperate or directly participate in small and medium-sized shipbuilding projects. Between 2010 and 2016, the government approved 129 million euros for 87 projects (Yue, 2018).

Second, Export Credit Guarantee (Hermes) and Ship CIRR (Commercial Reference Rate). When building special ships, shipyards will face major financing challenge due to high construction cost, long construction time and technology potential risk where banks pay attention to when reviewing financing applications. German domestic shipyards are supported through the country export credit guarantees and government commercial reference. Since 2008, under the premise of CIRR equilibrium guarantee, the federal government has been financing for ships under construction. At the time of signing the construction contract (several years before the ship delivery date), the ship financing bank will provide a fixed reference interest rate for the shipyard. At present, 24 shipping companies in Germany have received 4.9 billion euros in interest compensation. It is safe to say export credit guarantee and made great contribution on development of shipbuilding industry.

5.1.1.2 Norway

With the intensified competition from the Asian shipbuilding industry, the

Norwegian shipping industries have suffered major setbacks. Norwegian shipyards shifted their business to technologically advanced ships and offshore oil and gas industries.

First, Green Coast Shipping Plan. Norway Green Coast Shipping Plan is to establish a future Norwegian fleet. The fleet will use batteries, liquefied natural gas and other ecological fuels for offshore vessels, ferries, container ships, tankers, tugboats, aquaculture and fishing vessels. DNV GL has established partnerships with 30 members, aiming to provide a green coastal transportation route map of reducing greenhouse gas emissions to 60% of the current level by 2030 and to zero by 2050.

Second, 'PILOT-E' project. The new project 'PILOT-E' funded by the Norwegian government with 70 million euros to help develop environmentally friendly ship technology through creative methods. This project will be a powerful drive for the growth of green shipping. The project funds are not only applicable to small coastal ferries, but also to other ships that can achieve zero emissions, such as fast passenger ferries, supply ships and aquaculture support ships.

Third, in 2016, Norway has set up a sea area for testing unmanned ships. Norway's Kongsberg, Rolls-Royce, and Norwegian Marintek have set up an unmanned ship test base. The Norwegian shipyards have also delivered technologically advanced ships, including the unmanned multi-purpose craft Hrönn and the smart container ship Yara Birkeland.

5.1.1.3 South Korea

First, finance support. In 2020, South Korea was reported to spend an additional 70 billion won (approximately $ 61 million) for the shipbuilding industry, mainly to assist Korean domestic shipping companies further develop the market for environmentally friendly ships such as LNG-powered ships.

The South Korean government decided to order 140 LNG-powered ships by 2025 and provided 1.7 trillion won (approximately US$1.478 billion) in financial support and also invested 2.8 trillion won (approximately US$2.434 billion) to build LNG-powered ship infrastructure. At the same time, the scale of advance payment guarantee funding for small and medium-sized shipping companies will also be increased from the current 100 billion won to 200 billion won (about 174 million US dollars) (International Shipping, 2020a).

Second, policies support on LNG carrier development. LNG carrier is recognized as the ship with the highest technical and manufacturing process requirements in the world. Since 1990s, South Korean government have started to develop its own LNG industry, providing LNG ship order for domestic shipbuilding industry and a series of policies to support the shipbuilding industry especially the financial policies that Korea Bank offer guarantee for LNG orders for its cost price or even at a loss. With the continuous support from government and accumulated technological advantages over the past years, South Korea LNG shipbuilding technology has developed into the most advanced LNG shipbuilding companies with three shipping companies owing LNG building capabilities (South Korea's Daewoo Shipbuilding, Samsung Heavy Industries, Hyundai Heavy Industries). In recent years, South Korea plays a leading role in achieving LNG orders, and South Korea's three major shipbuilding giants successfully won orders for LNG ships from Qatar to meet the future demands for 100 LNG ships, with a project scale of 23.6 trillion won (approximately RMB 137.4 billion) (Sina news, 2020).

5.2 Suggestion for enhancing core technology

5.2.1 government support

First, Government should actively participate in the development of green shipping and core technology and develop it as a national strategy. As mentioned above, though China, as a major maritime country ranks the first place in shipbuilding scale, it is earning limited profit. Therefore, the shipbuilding companies have limited resource to innovate core technology especially under the serious impact. of Covid-19. The support from the government is extremely important for shipbuilding industry, because the development needs fund, researchers and other policy support, such as tax relief.

Second, the strategic document 'Made in China 2025' for a stronger manufacturing country emphasizes the importance of research and development of advanced energy-saving and environmental protection technologies, the green transformation and upgrading of the manufacturing industry, and marine engineering equipment and high-tech ships. To adhere to and implement this strategy, the government needs to encourage shipbuilding industry by continuing investing in green technology and high value-added ships, and actively upgrade ships. Although Chinese shipbuilding companies have competitiveness in several types of ships such as oil tankers and bulk carriers, more attention should be paid to the high value-added ships such as floating production storage and offloading equipment, offshore plant, leisure boats, and green ships. Meanwhile, domestic market green technology such as dual-fuel engines and new fuel engines the hydrogen fuel cell, LNG fuel cell application technology, and high-power electric energy storage systems should be developed to promote emission reduction in the shipping industry.

Third, it is necessary to actively promote domestically-made marine equipment, and introduce supporting policies such as the ‘Guiding Catalog for the Promotion and Application of the First (Set) of Major Technical Equipment’ and ‘Opinions on Promoting the Demonstration and Application of the First (Set) of Major Technical Equipment’, to encourage the use of more domestic made marine equipment on the ships.

The implementation of the strategy mentioned above is extremely important, so the fund, technology, researchers and other valuable resources should be invested to the most promising companies. As shipbuilding industry is a capital-intensive business, the support from government plays an important role in its sustainable development. In particular, in face of severe competition from other countries and lack of core technology, the shipbuilding companies need government support to gradually master the core technology.

5.2.2 The development of core technology by shipping industry

Shipbuilding companies need to innovate independently, developing cutting-edge core technology innovation research institutes with international competitiveness. Meanwhile, the joint cooperation among the shipbuilding companies, scientific research institutes and universities is also important to establish an innovation consortium to strengthen collaborative innovation in strategy, technology, standards, and markets. In recent years, Chinese shipbuilding industry has increasingly reached a consensus on this, and some joint institutions have emerged, but the number is still relatively small. Therefore, cooperation needs to be further strengthened (Lv,2018).

Shipping innovation institution should be willing to invest in scientific research, and concentrate on the core technologies. The acquisition of core technology requires cost and long-term accumulation. As the patent system becomes more and more stringent, the introduction of high-end technology will become harder. In the past, the way of using market to exchange technology, buying technology with funds or recruiting expert to create technology may not be feasible in the future. Only through a large amount of accumulation, continuous summary, improvement, adjustment and improvement, can we produce good products. It can be seen that focusing on the foundation, strong innovation, honestly and conscientiously rooted in independent research is the way for ship enterprises to master the core technology.

5.3 Suggestion for ETS

After the EU included the aviation sector in the carbon emissions trading mechanism in 2008, China and 26 countries jointly issued the ‘Delhi Declaration’ to jointly oppose the EU's unilateral measures to solve aviation carbon emissions. This approach has brought great international pressure to the EU, and finally theyd chose to suspend the implementation of the EU aviation carbon emissions trading mechanism.

In the field of shipping emission reduction, China can proceed from two perspectives at the same time, through diplomatic negotiations and develop domestic emission trading mechanism.

5.3.1 Diplomatic negotiations

After the European Union introduced a maritime carbon tax, it has already aroused resistance and opposition from many countries around the world. Su Wei, Director of the Climate Change Department of the National Development and Reform Commission, stated that China clearly opposes the EU unilaterally levying aviation carbon emissions and maritime carbon emissions taxes（Ji，2020）. At the same time, countries with similar positions should be coordinated, using diplomatic actions and putting pressure on the EU from the political perspective. To be specific, China should actively communicate with the United States, Japan, South Korea, Singapore and many developing countries that oppose the EU ETS project, and unite with them to take actions against the EU unilateral legislation. Under the basic legal framework of the 'United Nations Framework Convention on Climate Change' and its 'Kyoto Protocol', China opposes the violation of the principle of 'common but differentiated responsibilities'. Since the IMO has already designed strategy to address the GHG emission, reasonable global solution should be formed under the frame of IMO, rather than unilateral EU ETS.

5.3.2 Improve the domestic carbon emission trading mechanism

China has begun to establish a domestic carbon emissions trading market, and launched pilot carbon emissions trading in Beijing, Tianjin, Shanghai, Chongqing, Hubei and Guangdong. As for the international shipping industry, China shall develop Chinese maritime carbon tax policy under the situation of the EU maritime carbon tax. The reason why the EU wants to unilaterally propose a maritime carbon tax policy is largely because the EU has advantages in energy-saving technologies, policies, and carbon tax mechanisms for maritime ships. If China wants to eliminate the possibility of being affected by EU ETS, the establishment of carbon tax mechanism in the maritime industry is extremely important.

In December 2017, the National Development and Reform Commission issued the 'carbon emission trading market construction plan (power generation industry)', and the power generation industry took the lead in launching the national carbon emissions trading system with as a breakthrough. The carbon market, gradually expanded the scope of industries and increased the types of transactions, and finally established a mature carbon market.

China has already issued a basic legal framework for the national carbon market, called 'Interim Regulations on the Management of Carbon Emissions Trading'. It is possible to incorporate the shipping industry into the carbon emission trading system. This measure can not only promote the steady improvement of the emission reduction level of Chinese shipping industry, but also can be used as an equivalent measure to seek exemptions in EU shipping carbon emissions trading.

5.3.3 MBMs selection

There is a high probability that the IMO will incorporate market-based carbon emissions measures into GHG emission reduction measures. China should make active preparations for MBMs selection and the preference of MBMs selection for China is as following: RM>GHG fund> ETS

The priority is the RM program, because this program is extremely beneficial to developing countries. In terms of RM, developing countries would recover the cost of MBM through a rebate mechanism, enjoying 'no net incidence' and receiving extra assistance for GHG mitigation, which can bring additional benefits to developing countries. In particular, the most vulnerable countries can obtain the maximum benefit through funding and assistance.

Under the proposed RM, each developing country will be entitled to receive unconditional payments equal to the burden of its participation in MBM. The rebate amount will be calculated annually based on the share of the country's imports. As developed countries do not have the right to receive any rebates, the net income raised after the rebates would be only from consumers in developed countries, which conforms to the principles and regulations of UNFCCC.

Secondly, GHG fund is also an option for China. The carbon tax used as a fuel tax directly determines the price of carbon dioxide. Contrary to the emissions trading system, the emission reduction results are not predetermined, but the carbon price is predetermined. GHG funds is the MBM, based on the amount of marine fuel purchased or consumed on board, and the carbon tax is added on bunker of the ship. In general, the RM and GHG funds schemes are very similar but also different in that RM better integrates the CBDR principle. Under the Greenhouse Gas Fund, the CBDR principle only distributes income used for mitigation activities to developing countries, particularly the least developed countries, small island developing States and landlocked developing countries. If the revenue only focuses on just a few countries, the majority developing countries would in fact carry a share of the MBM burden with limited benefit.

Thirdly, EU ETS shall be absolutely opposed. In the future, there is a possibility that ETS is incorporated into IMO GHG mitigation strategy, and in that case, several suggestions should be put forward: first, relative emission reduction intensity should be set rather than setting absolute emission reductions; second, more free quotas shall be allocated to developing countries due to CBDR principle; third, China shall not access the international market before establishing a relatively mature domestic carbon emissions trading market. Fluctuation in carbon price will increase the instability of the international carbon market and cause unfair trading. For example, if a country achieves 100% emission reduction intensity through hydrogen energy technology, technologically advanced countries will collect taxes from technologically backward countries through the international carbon market (Peng, 2020).

5.4 Shipowners' options

A rise in the capital cost is mainly due to the investment of green technology to improve energy efficiency. A series of green technologies have been researched in the aspect of ship design and technical specifications. The cost and potential of common GHG emission technology are shown in Table 6.

Table 6- The cost and potential of common GHG emission technology

Name	Cost (USD)	Reduction potential (main engine total fuel consumption)	Technical maturity	Average reduction potential /average cost (1/100million)
Engine de-rating	\$60,000 to \$3,000,000	2% to 10%	Semi-mature	3.9
Engine performance optimization (automatic)	\$3,000 to \$7,000 per cylinder	1% to 4%	Semi-mature	83(six cylinders)
Engine performance optimization (manual)	\$5,000 to \$10,000	1% to 4%	Mature	333
Waste heat recovery systems	\$5,000,000 to \$9,500,000	3% to 8%	Semi-mature	0.75
Hull cleaning	\$5,000 to \$50,000	1% to 5 %	Mature	105
Shaft generator	\$240,000 to \$600,000	2% to 5%	Mature	8.9
Hull from optimization	\$150,000 to \$500,000	4% to 8%	Mature	18.5
Propeller polishing	\$4,000 to \$8,000	3% to 4%	Mature	583
Hull retrofitting	\$250,000 to \$700,000	3% to 5%	Mature	8.4
Propeller retrofitting	\$400,000 to \$500,000	2% to 5%	Semi-mature	8.3
Fixed sails or wings	\$170,000 to \$300,000	1% to 10%	Not mature	2.3
Autopilot adjustment and Use	no cost of implementation assuming that autopilot is already installed	0.25% to 1.5%	Mature	None available
Speed management	no investment costs	10% to 50%	Mature	None

				available
Trim and draft optimization	$15,000 to $75,000	0.5% to 3%	Semi-mature	39
Weather routing	$15,000	0% to 5%	Mature	16.7

Source: GLOMEEP

To illustrate economic benefit, a typical midsize vessel Panamax container ship with 3000 TEU is chosen. The rate power of main engine is set at 18000 kW, and the average speed is 20.7 knots, and the fuel consumption of HFO is assumed as 70t/day, (Clarkson Research, 2014). Assume that the ship is sailing 300 day/year, fuel cost by main engine is 60t/day, heavy fuel oil with Sulphur content less than 0.5% is $550 usd/ton. Therefore, the Avenal cost =60*300* 550= $99,000,000 USD. If the ship chooses the Propeller retrofitting, and as the reduction potential is 2% to 5%, considering the average reduction potential is 3.5%. If the propeller retrofitting is applied on the ship, the Avenal fuel oil cost saving = $99,000,000*3.5%= $3,465,000 USD, this is about 7 times higher than the propeller retrofitting cost. In this assumption,a container ship with a relative higher fuel consumption is employed, but if the fuel consumption is low, the payback time of a new equipment installation would be longer. Due to differences in ship types, sailing time and HFO price, the payback time for equipment installation varies.

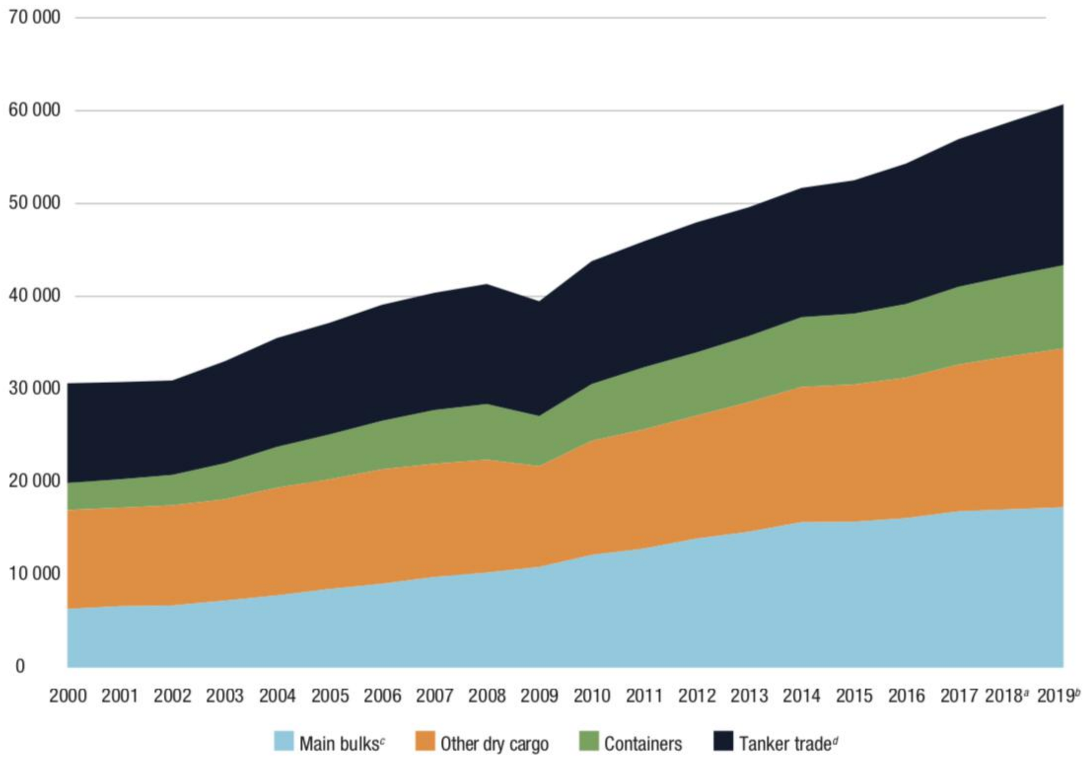


Figure 8- International maritime trade in cargo ton-miles, 2000-2019

Source: UNCTAD secretariat calculations, based on data from Clarksons Research, 2019a, Shipping Review and Outlook, spring.

In general, the last indicator in the Table 6 is average reduction potential /average cost, which means the higher the value the more cost effective the measure is. It can be seen that the speed management is the most cost-effective measure, because the reduction potential can reach up to 50% even without cost. Although, slow steaming can significantly reduce shipping emissions, but slow speed means less cargo transported in a certain time which have a negatively impact on supply chains and competition in the shipping market. Therefore, the effect of slow steaming might be affected by several factors with an unstable effect. As is presented in Figure 8, seaborne trade keeps increasing during the past 20 years, and volumes increased at the historical average of 3.0% from 1970–2017 (UNCTAD, 2019). Growth in international maritime trade reflects developments in the world economy and trade activity. It is expected that the volumes would keep increasing which means the demand in supply chain would also increase. In this case, slow steaming means more ships are needed for transportation.

The higher value is mainly limited to operational measures, such as, speed management, hull cleaning, propeller polishing, trim, draft optimization and etc. It should be noted that some maintenance measures are constrained; for example, hull cleaning can only be conducted in the dry dock. In general, since the operational measures are more cost-effective, Chinese shipowners should pay more attention to SEEMP to achieve higher operational energy efficiency, which also constitutes a preliminary preparation for the approaching goal-based SEEMP. In addition, owning to initial high investment, the payback time would be relatively long for technical measures, for instance, propeller retrofitting or hull retrofitting, and this may not be the first choice for shipowners.

CONCLUSION

After the implementation of the 2020 global sulfur content limitation, GHG mitigation will become a major work of MEPC. On account of the goal setting in the initial strategy, IMO will take more stringent measures to reduce GHG emissions, including phase 4 of EEDI, goal-based SMEEP, and a potential MBM. As Chinese ship fleet ranks third in the world, it occupies an important proportion of global import and export trade, so stricter policies will have an impact on shipbuilding industry in China, involving shipbuilding companies, and import and export trade. GHG emission reduction policies are not only a challenge but also an opportunity. Since Chinese shipbuilding industry has long been in need of core technology, focusing on high value-added ships and green technology will be a breakthrough for shipping industry. Therefore, shipping industry should concentrate resources on core technologies such as green equipment, so as to transform China from a maritime nation to a powerful maritime nation.

EU's attempt to incorporate ETS into the carbon emissions trading mechanism would inevitably cause controversy. EU unilaterally applies ETS and ignores the differences in diverse conditions of countries, disregards the existing international conventions and regulations, and this has a great negative impact on the global maritime industry, especially for shipping in developing countries. Large number of ships and relevant maritime technology owned by Chinese companies cannot meet EU green standards. Therefore, Chinese shipping industry will have to pay many unfair shipping costs for a long period of time, which may inevitably lead to a significant reduction in China’s maritime market share. To cope with this issue, China should cooperate with other counties and take IMO’s pace for the GHG mitigation. At the same time, the domestic carbon emissions trading system should be extended to the maritime sector and domestic maritime carbon tax policies should be established in line with international standards as an equivalent measure to seek exemptions in EU shipping carbon emissions trading.

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