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GREEN SHIPPING. STUDY ON REGULATIONS AND SUSTAINABLE OPTIONS FOR DECARBONISATION

Grațiela BRÂNZĂ [1]

[1] Constanta Maritime University, Faculty of Navigation and Maritime Transport, 104 Mircea cel Batran Street, 900663, Constanta, Romania, e-mail address:gratielabranza@gmail.com

Abstract: The maritime sector is responsible for more than 90% of world trade. This generates increasing international shipping fleet, that means significant contribution to environment pollution. In this context, appears the need for a cleaner maritime transport, a green one. The paper presents the concepts of "green shipping", "eco-ship" and regulations that must be respected in relation to environment protection. This study highlights also the IMO's regulations for green shipping, as IMO is the most important organization that support the reduction of greenhouse gas emissions from ships. The work examines briefly few options for decarbonisation in shipping, outlining the role of government policies, for huge investments in new and clean technologies and, also, in infrastructure for the production, distribution and utilisation of alternative marine fuels and biofuels.
Key words: ammonia, decarbonisation, fuel, green shipping, greenhouse gas emissions, ships .

1. INTRODUCTION

Transportation is an essential sector of activity in a society. It influences the level of development in a country and the life quality of its citizens. Every open economy uses all means of transport to interact with other economies, especially on trade issues. Almost 90% of international trade is possible due to maritime transportation. Beside positive effects of transportation on the economy and the society, as a whole, there must be mentioned the negative effects of this activity, especially on the environment, through greenhouse gas emissions.

Shipping is responsible for over 10% of transport CO_2 emissions and if its environmental impact is growing in this pace, shipping could double its greenhouse gas emissions by 2050. In order to reduce shipping's impact on climate change, international institutions elaborate and adopt regulation in this framework. One of the most important institution, The International Maritime Organization (IMO), adopted different conventions, amendments and measures, presented in this paper, addressing the minimisation of CO_2 emissions from international shipping. The applying of these regulations globally can lead to a cleaner maritime transportation, so called "green shipping".

2. LITERATURE REVIEW

Specialized literature in the field define Green Shipping like "the use of resources and energy to transport people and goods by ship and concerns the reduction in such resources and energy in order to preserve the global environment from greenhouse gases and environmental pollutants generated by ships".[11]

Green shipping is a sustainable maritime transport. This kind of transport demands eco-friendly means of transport. An *eco-ship* or *green ship* is a vessel that use alternative fuels and the most developed technologies for fuel savings, in order to reduce greenhouse gas emissions.

Green shipping must respect all IMO's regulations related to environment protection, such as: MARPOL 73/78, the Ballast Water Management Convention, the Ship Recycling Convention, the Anti-fouling Systems Convention. Emission guidelines of IMO are in force since 2020 and new guidelines for ballast water in 2022. IMO and European Union are the driving forces behind green shipping.

Other authors define Green Shipping like an "efficient marine transport with minimal health and ecological damage" [13] or the efficient transport "in controlling pollution emissions and in achieving a more friendly environment"[10] According to Felicio, J.A., Rodrigues, R. and Caldeirinha , V.,, Green Shipping refers to "the set of practices and eco-environmental efficiency adopted in shipping, including the improvement of procedures and technological innovations for environmental sustainability and trade, while encouraging ecopreneurship"[1].

The transition to the green shipping is possible only by minimising the greenhouse gas emissions. An effective way of reducing emissions is to use alternative fuels, for example, liquid natural gas (LNG), which produces almost none of the pollutants. Due to this reason, the European Commission is encouraging the use

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of LNG for shipping activity and is forcing all major ports from European Union to provide facilities for LNG supply. [7]

3. IMO'S REGULATIONS FOR GREEN SHIPPING

If necessary measures are not taken to make the transition to green shipping, the specialists' predictions are that the greenhouse gas emissions from maritime sector will be triple by 2050. In this context, we mention the amendments to MARPOL Annex VI, adopted by IMO in 2011, which regulates technical and operational energy efficiency measures to decrease the value of CO_2 emissions from international shipping. This has taken the form of Energy Efficiency Design Index (EEDI), that entered into force in 2013.

The EEDI requires all new ships built globally to meet a minimum level of fuel efficiency related to a baseline. A large share of new-build ships in 2017 already complies with the 2025 standard – 30% more efficient for ships delivered after 2025.[12] It is anticipated that by 2030, application of the EEDI will generate a decrease of global greenhouse gas ship emissions of 10-20 %, only if new more fuel efficient ships replace those taken out of service.

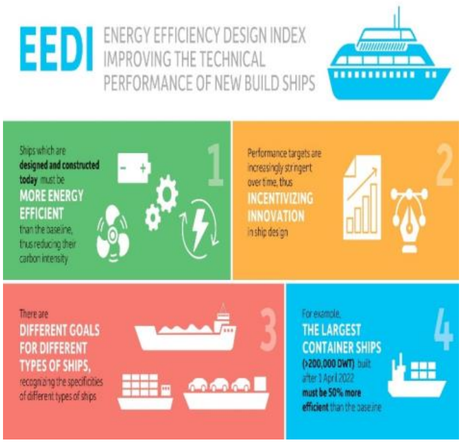

Figure 1 Main characteristics of IMO's EEDI [14]

The IMO has also agreed the Ship Energy Efficiency Management Plan (SEEMP) for new and existing ships, establishing best practices for fuel efficient operation of ships.

There are several measures that can be taken to achieve the required EEDI, such as: reducing installed engine power, hull, propeller and propulsion system improvements, waste heat recovery, air lubrication, the use of wind power- sails, kites and so on.[12]

EEDI is the first globally-binding climate change measure applying to the transport field.

2023 IMO Greenhouse Gas Strategy is the latest essential contribution of the International Maritime Organization to global efforts of minimising greenhouse gas emissions from international shipping, having in view the goals of Paris Agreement and SDG13 from the United Nations 2030 Agenda for Sustainable Development, regarding "urgent action to combat climate change and its impact".[8]

The main targets of the 2023 IMO Greenhouse Gas Strategy are:

- To decline carbon intensity of the ship through further improvement of the energy-efficiency for new ships;
- To decrease CO_2 emissions of international shipping per transport work by at least 40% by 2030, compared to 2008;
- To obtain net zero or near-zero greenhouse gas emissions from international shipping, through the intensive use of clean technologies, alternative fuels, biofuels.

There are many relevant IMO initiatives that support the reduction of greenhouse gas emissions from ships. One of these is the Global Maritime Technologies Cooperation Centres Network project, with support from the European Union and a value of approximately 11 million USD for the period 2016-2022.[8] This project established five Maritime Technologies Cooperation Centres in China, Fiji, Kenya, Panama, Trinidad and Tobago, with the main goal to support maritime decarbonisation in the respective regions.

The Green Voyage 2050 is another project, supported by Norway, with a value of 7,1 million USD for the period 2019-2023.[8]The aim of the project is to guide partnering countries to make assessments of maritime emissions at national level, in order to develop national action plans and to implement MARPOL Annex VI. They are also supported in the identification and implementation of low and zero-carbon pilot projects on board ships and in ports.

Another relevant project is the Greenhouse Gas – SMART Programme (Sustainable Maritime Transport Training Programme to Support the Implementation of the GHG Strategy), with a value of 2,5 million USD, for the period 2020-2025, funded by the Republic of Korea.[8] This project includes a series of annual training programmes online, followed by individual training plans, a practical training and study visit, combined with an opportunity of two trainees (one female and one male, with equal chances) to benefit from a World Maritime University scholarship.

In essence, all the projects initiated under the IMO emblem seek to find the most effective solutions, both from an economic, technological, political, legislative and social point of view, to obtain a green shipping.

4. SUSTAINABLE SOLUTIONS FOR DECARBONISATION IN SHIPPING

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Decarbonisation in the maritime industry is possible mainly due to the use of alternative fuels. First of all, LNG is an alternative fuel option for ships. Using LNG as a fuel will reduce CO_2 by 20%, along with considerably decreasing SO_x and NO_x.

Among the available maritime fuel options for decarbonisation, ammonia (NH_3) is identified as a zero-carbon fuel that can enter the global market relatively quickly and help meet the greenhouse gas reduction target for 2050 set by the International Maritime Organization. [15] Ammonia is a versatile fuel for stationary power and heat and for maritime transport that can be used in internal combustion engines, gas turbines, industrial furnaces, generator sets and fuel cells. [6]

Worldwide production of ammonia was 183 million tonnes (Mt) in 2020 and existing markets are expected to increase demand to 223 Mt by 2030 and reach 333 Mt by 2050 in a 1,5^{0}C scenario. [6] New markets for ammonia are expected to develop in the next decades, especially as a fuel for maritime sector. The perspectives of the development and use of this type of fuel determined the appearance of the first ammonia-fuel vessel in the world, “Kriti Future”. It is a crude oil tanker of 149987 t DWT, built in 2022 and is sailing under the flag of Greece. The vessel meets the ABS LNG Fuel Ready Level 1 and ABS Ammonia Ready Level 1 requirements, being designed to be converted to run on ammonia in the future.

Even if ammonia is a hazardous chemical, there are strong commitments from ship owners, operators, ports and classification societies to identify risks, to elaborate strategies and to promote clean energy technologies, in order to ensure that the use of ammonia as a fuel complies with the existing safety standards. Many classification societies, like Bureau Veritas, American Bureau of Shipping, Lloyds Register, Korean Register, Class NK have recently produced documents for the future ammonia code. Also, the Port of Singapore serves as a living laboratory with a physical and digital test environment to develop safe bunkering procedures for ammonia and gain operational experience. [6]

A first step to decarbonise shipping is to convert ammonia tankers to use ammonia as a fuel. Ammonia is not yet approved as a fuel by the IMO and for now, every ship needs individual approval to use this chemical. The support of a flag state can aid to introduce ammonia as a fuel, similar to the case of methanol as a fuel. As ammonia-fuelled vessels are expected to be operating at sea by 2024 or 2025, maritime engine manufacturers expect to commercialise ammonia-fuelled two-stroke and four-stroke engines for new builds and retrofits. [6]

Ammonia is considered as one of the dominant options for the maritime sector, as it is already available at a relevant scale with international port infrastructure in place [9]. To outline again the importance of ammonia in the process of reduction greenhouse gas emissions from shipping, we can see a comparison of properties for various fuels in the table below, where: HFO- Heavy fuel oil, LNG- Liquefied natural gas, LPG- Liquefied petroleum gas,CBR- Corvus , battery rack, Tesla 3- Tesla model 3 battery cell 2170 .

Table 1 Physical and chemical fuel properties for international shipping [6]

Fuel	Supply energy (MJ/kg)	CO_2 emission from complete combustion (g/km)	SO_x emission from complete combustion (g/km)
HFO	40,5	49	0,36
LNG	50	37	0,02
LPG	46	-	-
Methanol	19,9	43	0,02
Ethanol	26	-	-
Ammonia	18,6	0	0
Hydrogen	120	0	0
CBR	0,29	0	0
Tesla3-2170	0,8	0	0

While ammonia is expected to become the dominant fuel for decarbonised deep sea shipping, other biofuels, like methanol and hydrogen may be used for passenger ships and large ferries. Compared to methanol, ammonia has an advantage, due to lower cost of nitrogen purification versus CO_2 purification. But, there are certain limits regarding the use of ammonia as a fuel and hydrogen carrier, related with ammonia infrastructure, that requires huge annual investment in storage and transport assets. Renewable ammonia represents another sustainable solution of decarbonisation for industries and especially, maritime industry. It is produced from renewable hydrogen, which in turn is produced through water electrolysis using renewable electricity. This kind of hydrogen is converted into ammonia, using nitrogen that is separated from air. In the long term, renewable ammonia is likely to become the main commodity for transporting renewable energy between continents. [6] Around 80 Mt of existing ammonia production capacity constitutes an early opportunity for decarbonisation. Each year, 18-20 Mt is transported by ship, 170 vessels being in operation with ammonia, of which 40 carry ammonia on a continuous basis. [3][4] Cost-competitive renewable ammonia can have an important contribution to a global sustainable objective – 70% reduction of the world’s energy-related CO_2 emissions by 2050 [5].

In order to achieve this goal, the support of governments is needed. They must establish decisive, predictable policies and solid mechanisms regarding investments in the field of renewable energy technologies and standards related to fuels used by industry.

Through an appropriate policy framework, stakeholders can focus on implementing existing renewable ammonia technologies at scale, retrofit

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technology towards renewable ammonia production and re-asses the role of ammonia in hydrogen strategies, having in view its potential as a fuel and hydrogen carrier. [6],[16]

5. CONCLUSIONS

For a long time, the lack of concrete actions in the field of environmental protection turned maritime transport into one of the biggest producer of greenhouse gas emissions, considering its contribution to the development of international trade. In order to reduce shipping's impact on climate change, the International Maritime Organization offers efficient instruments, which regulate technical and operational energy efficiency measures to decarbonize international shipping, turning it into a green shipping, with eco-friendly vessels. Green ships use alternative fuels, like LNG or biofuels, like hydrogen, methanol, ammonia. First ammonia-fuelled vessels are expected to be operating at sea by 2024 or 2025. Renewable ammonia represents another sustainable option for decarbonisation of maritime transport, opening new markets for ammonia as a fuel in the future. To realise a safe and efficient transition to green shipping, strong, stable, predictable, investment-encouraging governmental policies to reduce GHG emissions are needed.

6. ACKNOWLEDGMENTS

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