Decarbonizing Shipping and the Role of LNG: International Law and Policy Trends

Ruixuan Zhuo[*] & Hui Wang[**]

Abstract

Decarbonization in the shipping sector calls upon special attention as shipping is a significant contributor to global greenhouse gases emissions. This article examines the current

[*] Dr. Ruixuan Zhuo is an assistant professor at Shanghai Maritime University Law School, Shanghai, People's Republic of China. She received a Doctor of Juridical Science (S.J.D.) degree from Tulane Law School, United States of America, an LL.M. in Admiralty from Tulane Law, and an LL.B. in Maritime Law from Dalian Maritime University, Dalian, China. Dr. Zhuo is devoted to teaching and researching on marine pollution law, maritime and admiralty law.
Special thanks go to Ms. Siyun Ding, LL.M. candidate (23') at Shanghai Maritime University Law School, for her assistance with the American Psychological Association [APA] Style format.
[**] Professor Hui Wang is an associate professor at Shanghai Maritime Univeristy Law School, Shanghai, People's Republic of China; Ph.D. in Law (Southwest University of Political Science & Law), Master of Law (Hainan University), LL.B. (Gansu University of Political Science & Law). Professor Wang's teaching and research interests include climate change law and policy, environmental law and taxation law.

international treaties, regulations and policy measures on curbing GHG emissions from ships. Based upon analysis of the legal and policy framework, we assert that it is critical for the maritime industry to deliver GHG mitigation in line with the Paris Agreement climate goal by switching traditional marine fuel to LNG immediately and rapidly.

Keywords

Decarbonization, Shipping, MARPOL, Initial IMO Strategy, LNG

I. Introduction

The term "decarbonization" literally means cutting down *one of* the greenhouse gases, i.e., *carbon dioxide*. But given their potentials to cause global warming as well as atmospheric harm, *other* GHGs that contain or do not contain carbon element should be also regulated as a package (Bodansky,1993, p. 455; Lindstad et al., 2015, p. 94). As it is, the 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change listed six types of GHGs in its Annex A, namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). The Doha amendment to the Kyoto Protocol (2012) Article 1.B added a seventh greenhouse gas, nitrogen trifluoride (NF_3). Considering their environmental and health impact, other relevant substances

such black carbon,[1] and sulphur oxides (SO_x)[2] may also be included in the decarbonization realm.

Today, more than 11 bllion tons of commodities are transported by sea and "shipping is backbone of global trade and global economy."[3]Ships operated with diesel engine systems generate GHGs such as CO_2, NO_x, particulate matters (PM) and SO_x (Yau et al., 2012, p. 299). The International Maritime Organization [IMO] Fourth Greenhouse Gas Study (2020) told us that the GHG emissions of total shipping (international, domestic and fishing) have increased from 977 million tonnes in 2012 to 1,076 million tonnes in 2018, with a 9.6% increase.[4] The Study also showed that in 2012 the shipping industry's total CO_2 emissions were 962 million tonnes, while in 2018 the amount grew 9.3% to 1,056 million tonnes.[5] This Fourth IMO GHG Study also proved that shipping emissions are projected to increase from about 90% of 2008

[1] See, for example, U.S. Energy Information Administration [EIA]. (2011, March). Emissions of Greenhouse Gases in the United States. EIA Report Number: DOE/EIA-0573(2009). https://www.eia.gov/environment/emissions/ghg_report/ghg_overview.php (last accessed April 2021). This report gave special attention to black carbon and its global warming effects.

[2] Lindstad et al. (2015), p. 94.

[3] As declared by UN Secretary-General Ban Ki-moon on World Maritime Day in September 2016, see SG/SM/18129-OBV/1663-SAG/486, 22 SEPTEMBER 2016, available at https://www.un.org/press/en/2016/sgsm18129.doc.htm (accessed April 2021).

[4] IMO MEPC. (2020, July 29). Reduction of GHG emissions from ship: fourth IMO GHG study 2020 – Final report. MEPC 55/7/15, Annex 1. p. 1.

[5] Ibid.

emissions to 90-130% of 2008 emissions by 2050 for a plausible long-term economic and energy scenario.[6] Notwithstanding the COVID-19 impacts on shipping and global trade, the actual emissions over the next decades may be a few percent lower than projected at most, depending upon the recovery trajectory.[7] Although shipping is a relevant carbon-efficient mode of transportation, yet, the industry seeks to further improve the fuel efficiency and carbon footprints of its vessel in order to address the global warming issue and meet the world's climate goals (Nast, 2013, pp.29-30).

This chapter will begin by framing the current states of United Nations' climate regimes and IMO's efforts in order to outline the recent outputs in international regulations on this shipping decarbonization issue. Several UN's treaties will be discussed insofar as they have influenced the climate change debate in the shipping industry. Then, the IMO's law and policy updates designed to reduce GHG emissions from shipping will be explored in details, giving highlights to the EEDI, SEEMP, fuel oil consumption data collection system, market-based measures, and the Initial IMO Strategy on Reduction of GHG Emissions from Ship. It is important to keep in mind that for the shipping industry to achieve virtually full decarbonization, carbon neutral fuels such as liquefied natural gas (LNG) play a key role in both near and long term. Then, the possibilities and challenges of LNG as marine fuel transition will be examined. We conclude with a forward looking statement that LNG's future is bright and any delay in the transition will diminish the chances of meeting the Paris Agreement's temperature commitments.

[6] Ibid. p. 5, Figure 1.

[7] Ibid. p. 4.

II. Decarbonizing Shipping under the Current Climate Change Legal Framework

A. The United Nations Framework Convention on Climate Change

At least three international treaties address climate change. Being one of them, the United Nations Framework Convention on Climate Change (UNFCCC, 1992) has described climate change as the "common concern of mankind,"[8] and therefore set down the legal framework for international cooperation against global warming. The UNFCCC entered into force in 1994, and to this day, it boasted over 197 states parties and is more accepted worldwide.The UNFCCC is "the ultimate source of mandate of the UN climate regime over GHG from international shipping," and such a mandate is manifested in Articles 2, 3, 4, and 7 of the Convention (Chircop et al., 2018, pp. 9-10).

UNFCCC Article 2 established an ultimate objective of stabilizing greenhouse gas concentrations in the atmosphere at a level that would avoid "dangerous human interference with the climate." Article 3 articulated the general principles that serve as the lodestar to guide the parties in implementing and developing the Convention. Namely, these principles are:

- the principle of equity for present and future generations;

- the principle to take preventive measures to anticipate and mitigate, prevent or minimize the effects of climate change;

- the principle of sustainable development;

[8] UNFCCC, Preamble. Para. 1.

- the principle that concerns the need for a supportive and open international economic system; and

- the principle of common but differentiated responsibilities and respective capabilities (CBDR-RC).[9]

Among these principles, CBDR-RC asked that developed country parties should take the lead to resist climate change and the adverse effects thereof, because their historical emissions have caused greater contributions to the climate change, while developing countries' specific needs and specific circumstances shall be given full consideration.[10] Article 4 gave reference to efforts to reduce emissions from transportation sector, such as financial resources[11] and technology transfer.[12] Article 7 established the institutions and mechanisms for the UNFCCC's implementation by making the Conference of the Parties ("COP") the supreme decision-making body of the Convention.

The above articles show that the UNFCCC has assigned responsibilities to "parties", i.e., those countries that have ratified, accepted, approved or acceded to it and are subject to the general commitments to respond to climate change. Therefore, it is incontrovertible that each

[9] UNFCCC, Art. 3.

[10] UNFCCC, Art. 3.

[11] For example, Articles 4(3) involves implementation costs which may provide basis for generating a fund via carbon taxes, emission fees, or fines, and Article 4(4) that focuses on adaption costs, i.e., who should pay for measures to abate climate change. See also Bodansky (1993), p.524.

[12] UNFCCC, Art. 4(5).

state party shall be responsible for reducing GHG emissions from its *domestic* shipping in order to satisfy the country's emission quota. Yet, *international* shipping appear to be very difficult to integrate into this "state party - emission allowance" scheme, since the global nature of international shipping makes it scarely possible to calculate what amount of GHG emissions should each country be responsible for (Doelle & Chircop, 2019, p. 269).[13] Specialized approaches to manage and control emissions from international shipping[14] would seem to be required. Although the UNFCCC Secretariat and its Subsidiary Body for Scientific and Technological Advice (SBSTA) have proposed ideas on the allocation of ship-borne GHG emissions, no consensus have been reached among the UNFCCC states parties (Oberthür, 2003, as cited in Doelle & Chircop, 2019, p. 269).[15] Negotiations centered on the shipping emissions

[13] Meanwhile, aviation with international character is also precluded, and the Kyoto Protocol assigns responsibility to the International Civil Aviation Organization (ICAO) to administer GHG emissions from aviation sector.

[14] "International shipping" refers to "shipping between ports of different countries," and excludes military and fishing vessels engaged in such voyages. Buhaug et al., (2009) Definitions.

[15] The SBSTA has come up with five options as solutions to allocate GHG emissions from marine bunker fuel, namely, the "no allocation", allocation to the state where the bunker fuel is sold, allocation to the state of registration or ownership of the vessel, allocation to the state of origin or destination of the vessel, and allocation to the state of origin or destination of the cargo or passengers. See UNFCCC. (1995, April 7). Decision 4/CP.1, Methodological Issues. UN Doc FCCC/CP/1995/7/Add.1, para 1(f). https://unfccc.int/resource/docs/cop1/07a01.pdf (accessed April 2021).

allocation issue was resurfaced every now and then, but each time the UNFCCC parties failed to come up with a solution.[16]

To summarize, the UNFCCC is an epoch-making convention that represents the first globally inclusive effort to tackle climate change, but it lacks regulatory teeth (Carlson et al., 2012, p. 589). As a framework convention, the UNFCCC has left emissions from ships to be decided.

B. Kyoto Protocol

[16] For example, the Bali Action Plan (2007-2012) specifically provided for international transport under Cooperative Sectoral Approaches but resulted in no agreed outcome. Decisions Adopted by the Conference of the Parties, Decisions 1-10/CP.18, Report of the Conference of the Parties on its Eighteenth Session, held in Doha from 26 November to 8 December 2012. (2013, February 28). UN Doc FCCC/CP/2012/8/Add.1. The Durban Platform (2012-2015) also agreed to continue its consideration of issues related to addressing emissions from maritime transport. Decisions Adopted by the Conference of the Parties, Decisions 2/CP.18, Report of the Conference of the Parties on its Seventeenth Session, held in Durban from 28 November to 11 December 2011. (2012, March 15). UN Doc FCCC/CP/2011/9/Add.1. A proposal to generate capital from international shipping levies to establish a Green Climate Fund was opposed at Durban. See Bateman, B. (2012, March 22). Explaining the Durban Platform: what lies ahead? Clayton Utz. https://www.claytonutz.com/knowledge/2012/march/explaining-the-durban-platform-what-lies-ahead (last accessed April 2021).

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (Kyoto Protocol, 1997) was to offset the UNFCCC's lack of regulatory mechanism by exerting legally binding commitments to emission cuts (Carlson et al., 2012, p. 589). Entered into force in early 2005, the Kyoto Protocol requested industrialized nations (the so-called "Annex I parties") to limit their collective GHG emissions during a five-year commitment period from 2008 to 2012 (Kyoto Protocol, 1997, Art 3.1). Each Annex I party must ensure that its total GHG emissions do not exceed its emissions budget,[17] and its yearly emissions should be 5% less than that of a base year (Kyoto Protocol, 1997, Art 3.1).[18]

In order to achieve compliance with emission reduction targets, the Kyoto Protocol also broke new grounds with three market-based mechanisms ("MBMs"), namely the emissions trading scheme, the joint implementation ("JI"), and the clean development mechanism ("CDM"). The trading scheme allows an Annex I country to make use, in meeting its emission targets, of units[19] held by other countries through emissions purchase and sales (Kyoto Protocol,

[17] The allowed emissions are divided into assigned amount units ("AAUs"). Kyoto Protocol, 1997, Art 3.10. Annex B of the Kyoto Protocol set emissions target.

[18] For most state parties, the base year is 1990, but any state party may chose a base year of either 1990 or 1995 for its emissions of HFCs, PFCs and SF_6. Kyoto Protocol (1997), Art. 3.8.

[19] Each state party must maintain enough AAUs or other forms of units such as emission reduction units ("ERUs") and certified emission reductions ("CERs") to cover its actual emissions. Kyoto Protocol, 1997, Arts. 3.10, 3.11 and 3.12.

1997, Art. 17).[20] JI allows Annex I Parties to implement emission cutting projects in other Annex I countries (Kyoto Protocol, 1997, Art. 6). CDM is a mechanism under which Annex I Parties can invest in emission reduction projects or afforestation or reforestation projects in non-Annex I countries, and receive credits for the emission reductions or removal achieved (Kyoto Protocol, 1997, Art. 12). To be eligible to participate in these MBMs, Annex I Parties must comply with rigorous statistic and reporting requirement to count accurately for its emissions and assigned amount units.[21]

Since Kyoto Protocol has requested Annex I parties to cut emissions primarily through national measures (Kyoto Protocol, 1997, Art. 3), therefore, domestic shipping activities and emissions therefrom are within individual state's regulatory arena. Nevertheless, emissions caused by international shipping was not a priority within the Kyoto Protocol's rulebook (Chircop et al., 2018, p. 11).[22] Instead, the Kyoto Protocol has passed the ball to the International

[20] A state party who has reduced emissions lower than its cap could then sell its remaining share to other state parties whose emissions exceed the limits. This process is also recognized as buying and selling the right to pollute. See Telesetsky (1999), p. 804.

[21] Articles 5, 7 and 8 of the Kyoto Protocol were designed to ensure that decisions about compliance and the use of the mechanisms are based on accurate, reliable and consistent information from all parties.

[22] Professor Chircop and his colleagues noted that although it has once be put on the agenda to include emissions from international shipping to individual parties, no elaboration on the inclusion of emissions from international shipping to individual parties were included in the

Maritime Organization (IMO) to regulate ocean shipping emissions as it provides: "The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from . . . marine bunker fuels, working through . . . the International Maritime Organization respectively." (Kyoto Protocol, 1997, Art. 2(2)) Accordingly, this article "establishes a formal link to the IMO" by authorizing the IMO to regulate the GHG issue (Hackmann, 2012, p. 90), and implies that the IMO should "take the lead" on this issue (Harrison, 2012, p. 1).

C. Paris Agreement

The most recent development regarding to decarbonization is the Paris Agreement which became effective in 2016. Paris Agreement set the ambitious climate change mitigation goal of limiting the global temperature increase to below 2 degrees Celsius and ideally 1.5 degrees Celsius (Paris Agreement, 2015, Art. 2.1(a)). As the heart of the Paris Agreement, this temperature goal has put a severe constraint on the remaining global GHG emissions budget and as a result, parties to the Agreement are committed to ensure emissions peak as soon as possible, and to reach a balance of emissions removals in the second half of the century (Paris Agreement, 2015, Art. 4.1). This goal would be pursued by each state's future nationally determined contributions ("NDCs") reflecting "equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances"

Kyoto Protocol, nor agreed under in negotiations on the implementation of the first commitment period of the Kyoto Protocol.

("CBDR-RCNC"), and the five-year cycles of NDC communication (Paris Agreement, 2015, Arts. 4.3 & 4.9).

Like the UNFCCC and Kyoto Protocol, the Paris Agreement did not mention emissions from the international maritime sector. This was due to the difficulties in apportioning such emissions to individual nation both in theory and in practice (Traut et al., 2018, p. 1068). But bear in mind the Paris Agreement's radical temperature goals, GHG emissions *from all sources and all sectors*, including international shipping, need to be ultimately removed from the atmosphere (Wan et al., 2018, p. 428). For the shipping industry to deliver its GHG mitigation contribution in line with the Paris Agreement, virtually full decarbonization needs to be achieved (Doelle & Chircop, 2019, p. 271; Traut et al., 2018, p. 1073). With this insight, the IMO, as the regulatory body for the shipping industry, is under the pledge of GHG emissions reduction from shipping and meeting the Paris Agreement's temperature commitments (Tanaka, 2016, p. 333).

III. The IMO and Its Efforts in Reducing GHG Emissions from Ships

The International Maritime Organization is a specialized agency of the United Nations, and is responsible for the safety of shipping and the prevention of marine and atmospheric pollution by ships.[23] IMO's main task is to develop and maintain a comprehensive regulatory framework for shipping that includes safety, environmental concerns, legal matters, technical co-

[23] International Maritime Organization. (n.d.). Introduction to IMO. https://www.imo.org/en/About/Pages/Default.aspx (last visited April 2021).

operation, maritime security and the efficiency of shipping.[24] In support of the need for urgent action on climate change manifested by the 2030 Agenda for Sustainable Development,[25] IMO has committed itself to fight against climate change and decarbonize the international maritime shipping sector. IMO Assembly - the Organization's supreme body - adopted during its thirtieth session in December 2017 a strategic direction entitled "Respond to Climate Change."[26]

Ever since the Kyoto Protocol delegated the responsibility to regulate air pollution and emissions from ships to IMO, this inter-governmental organization has cooperated with the UNFCCC secretariate and the SBSTA to establish rules and regulations on the shipping decarbonization programs.[27] IMO's efforts to reduce greenhouse gas emissions from ships

---

[24] Ibid.

[25] United Nations. (n.d.). Transforming our world: The 2030 agenda for sustainable development. A/RES/70/1. Goal 13 is "take urgent action to combat climate change and its impact." The document is available at https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf (last visited April 2021).

[26] IMO Assembly. (2017, December 8). Strategic plan for the organization for the six-year period 2018 to 2023. Resolution A.1110(30). p.6. https://wwwcdn.imo.org/localresources/en/About/strategy/Documents/A%2030-RES.1110.pdf (last visited April 2021).

[27] There are divergence of views on IMO's mandate to regulate GHG emissions from ships. Some scholars claimed that IMO received authorization from the 1982 United Nations Convention on the Law of the Sea ("UNCLOS" or "LOSC"), the IMO Convention, and IMO

comprise of organizational settings, GHG Studies, international treaties on the technical and operational standards for ships, proposals on market based measures, an Initial Strategy and follow-up actions.

A. The MEPC and IMO GHG Studies

IMO's GHG emissions reduction work is mainly directed by its Marine Environment Protection Committee ("MEPC") (Shi, 2014, p. 90). Back in 1997, an IMO Air Pollution Conference has adopted Resolution 8 on CO_2 emissions from ships.[28] Resolution 8 invited the MEPC to undertake a study on GHG emissions from ships, and to consider what CO_2 reduction strategies might be feasible in light of the relationship between CO_2 and other atmospheric and marine pollutants. Since then, MEPC has become the decision making body to identify

---

Resolution 8. Others argued that Article 2(2) of the Kyoto Protocol handed IMO such authority. There was a third compromise theory indicating that "the IMO Convention and the LOSC provide the IMO with general competence to regulate GHG emissions from ships, while the Kyoto Protocol gives the IMO specific mandate to regulate this matter." Disputes upon this matter fall on the potential conflicts between UNFCCC's "Common but Differentiated Responsibilities and Respective Capacities" ("CBDR-RC") principle and the "No More Favorable Treatment" principle ("NMFT") incorporated in LOSC and all IMO treaties. For a full discussion, see Shi (2014), pp. 81-86.

[28] IMO MEPC. (2000, October 16). Report of the Marine Environment Protection Committee on its forty-fifth session. MEPC 45/20. p. 55.

shipping's GHG emissions conditions, and to develop mechanisms needed to achieve the limitation and reduction of GHG emissions from international shipping.[29] The MEPC establishes a Working Group on Reduction of GHG Emissions from Ships ("WG-GHG"), which meets during each MEPC session and reports to the plenary of the Committee. When necessary, inter-sessional meetings of the Working Group ("ISWG-GHG") are also held.[30] In 2000, 2009, 2014 and 2020 respectively, the MEPC has published four IMO GHG Studies, revealing key findings on shipping emissions and their significance relative to other anthropogenic emissions during a certain period of time.[31] On December 5, 2003, the IMO adopted Resolution A.963(23) requiring

[29] Ibid.

[30] For instance, MEPC 72 adopted resolution MEPC.304(72) on Initial IMO Strategy on reduction of GHG emissions form ships in April 2018. See *infra*. In order to facilitate the implementation of the Initial Strategy, several subsequent discussions and negotiations were held via the ISWG-GHG. A recent seventh meeting of the ISWG-GHG took place remotely ahead of the MEPC 75 in October 2020. The ISWG-GHG seventh meeting agreed on drafting new mandatory measures to cut the carbon intensity of ships, building on current mandatory energy efficiency requirements to further reduce greenhouse gases emissions from shipping. A significant output of this meeting are the proposed amendments to MARPOL Annex VI. The drafted amendments were then forwarded to the MEPC 75 that was also held remotely in November, 2020.

[31] These IMO GHG Studies are archived at http://docs.imo.org (registration required). Documents are also on file with the authors.

that the MEPC to regulate shipping CO_2 emissions through technical, operational, and market-based measures.

B. The MAPOL Convention Annex VI Framework on Energy Efficiency of Ships

The International Convention for the Prevention of Pollution from Ships ("MARPOL") governs the technical aspects of ship-source pollution prevention and control. Annex VI of MARPOL consists of regulations to eliminate air pollution by sulphur oxide and nitrogen oxide, emissions (MARPOL Annex VI, Regulations 13, 14). In July 2011, the IMO amended MARPOL by adding a new chapter 4 "Regulations on the Energy Efficiency for Ships" to reduce GHG emissions from ships as the response to the global warming crisis.[32]

Chapter 4 covers mandatory technical and operational energy efficiency measures, namely the Energy Efficiency Design Index ("EEDI") and the Ship Energy Efficiency Management Plan ("SEEMP"). EEDI aims at using *technical* means to improve ships' energy efficiency, thereby reducing the CO_2 impact per capacity mile. SEEMP tried to induce changes at *operational* level that would cut down energy consumption among the world fleet. EEDI and SEEMP entered into force on January 1, 2013, representing "a breakthrough in the lengthy deadlock of the negotiations" between IMO member states on the shipping emissions issue (Shi,

[32] Such amendments took place as the aftermath of Resolution MEPC.203(62) adopted at the MEPC sixty-second meeting.

2014, p. 93).[33] IMO spoke highly of these measures as they represent the first ever mandatory global energy efficiency standard for an international industry sector, the first legally binding instrument to be adopted since the Kyoto Protocol that addresses the GHG emissions and the first global mandatory GHG reduction regime for an international industry sector.[34]

1. EEDI

EEDI applies to ships of 400 gross registered tonnage ("GRT") and above, and are built as of January 1, 2013. Put it another way, EEDI applies to newly constructed ships only, and exempts those existing ships from its coverage. A ship's EEDI is calculated according to provisos in MARPOL Annex VI Regulations 20 and 21, based upon the complex formula provided in various MEPC Resolutions.[35] A sketchy interpretation of the formula is that the

[33] However, the decision to adopt EEDI was not a consensus, because developing countries such as China, India, Brazil, Saudi Arabia, South Africa and others were firmly against the agreement. Psaraftis (2019), p. 354.

[34] IMO. (n.d.). Energy efficiency measures. https://www.imo.org/en/OurWork/Environment/Pages/Technical-and-Operational-Measures.aspx (last visited April 2021).

[35] The formula to calculate Required EEDI is provided in Regulation 21. Two MEPC documents provide measuers to calculate the Attained EEDI, they are:

numerator is the total CO_2 emissions produced by the ship and is a function of all power generated by the ship's main engine and auxiliaries; the denominator is a product of the ship's capacity multiply by its "reference speed," defined as the speed corresponding to 75% of the maximum of the ship's main engine. The units of EEDI are grams of CO_2 per capacity mile (expressed as "ton-mile"). For a given ship, its calculated EEDI ("the attained EEDI") will be compared with an EEDI reference line ("the required EEDI"), and should be equal to, or less than the required EEDI (MARPOL Annex VI, Regulation 21 Table 1.; see also Psaraftis, 2019, pp. 355-356). A lower attained EEDI shows the better energy efficiency, while the required EEDI vary as per vessels types and size segments (MARPOL Annex VI, Regulation 21 Table 2.; see also Halim et al., 2018, p. 3). New ships' required EEDIs are lower than those for ships of similar type and size but built earlier,[36] and this arrangement reflects the IMO's expectation that newer ships will become more energy efficient (Chircop & Shan, 2020, p. 106). IMO has set up

- IMO MEPC. (2018, October 26). 2018 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships. Resolution MEPC 308(73), MEPC 73/19/Add.1 Annex 5.

- IMO MEPC. (2019, May 17). Amendments to the 2018 guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships. Resolution MEPC.322(74), MEPC 74/18/Add.1 Annex 16.

[36] For example, ships constructed in 2025 will be required to be at least 30% more energy efficient than those constructed in 2014. See MARPOL Annex VI, Regulation 21 Table 2 "Phase 3".

phase objectives which require that the EEDI be progressively scaled up over time (MARPOL Annex VI, Regulation 21).[37]

The drawbacks of EEDI are, nevertheless, obvious. First, the restricted scope of application would arguably undermine the effectiveness of the EEDI. Second, as per the formula explained above, the EEDI figure can be yielded by decreasing the numerator or increasing the denominator. Thus, the shipowner and operator could, by limiting the installed power on board or enabling higher vessel speed, to meet the EEDI criterial. However, scholars pointed out that in practice, installing less power on board does not necessarily trigger the utilization of high energy efficient engines, instead, the shipowner may attempt to use higher revolutions-per-minute engines that consume more fuel (Devanney, 2011, p. 367, as cited in Wan et al., 2018, p. 429). Meanwhile, increasing vessels' speed capacity draw further apart from the trends to reduce vessel speed, which has been proved as a valid contribution to less GHG emissions (Wan et al., 2018, pp. 429-430). Another argument could be that by building a larger ship, the EEDI is reduced because the ship's capacity term is in the denominator. Third, the EEDI only reflects the efficiency of ship design but totally neglects the operational variation that determine the real energy efficiency (Cichowicz et al., 2015, p.49, p.60). A ship could consume more energy per goods transported in half loaded than fully loaded (Wan et al., 2016, p. 275).

[37] Following a two-year grace period, the CO_2 reduction level for the first phase (January 1 2015 – December 31 2019) is set at 10%; for the second phase (January 1, 2021 – December 31, 2024), the reduction level is set at 20%. In the third phase, from January 1 2025 onwards, the reduction level is set at 30% from a reference line representing the average efficiency for ships built between 2000 and 2010. The EEDI reduction factors are correspondingly set.

2. SEEMP

SEEMP works parallel to EEDI to improve the ships' energy efficiency through operational means. Unlike EEDI, SEEMP is applicable to both new and existing ships of 400 GRT and above according to MARPOL Annex VI Regulations 19 and 22. Each ship must carry on board a ship-specific SEEMP as a protocol that incorporates the best practices for fuel efficiency management, as well as indicators that allow shipowner to monitor ship and fleet's efficiency performance (MARPOL Annex VI Regulation 22.1).[38] SEEMP is further developed through IMO's 2016 Guidelines for the Development of A Ship Energy Efficiency Management Plan.[39] SEEMP consists of four key components: planning, implementation, monitoring, and self-evaluation and improvement, and these four steps collectively establish a flexible and cost-effective mechanism for shipowners and ship operators improve the ships' energy efficiency (Xu et al., 2015, pp. 228-229). The effectiveness of SEEMP was challenged inasmuch as it lacks regulatory teeth or tangible means of gauging vessel energy efficiency (Tanaka, 2016, p. 335).

[38] See also IMO MEPC. (2016, October 28). 2016 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP). Resolution MEPC.282(70), MEPC 70/18/Add.1 Annex 10, at paragraph 1.2. SEEMP seeks to provides "a possible approach for monitoring ship and fleet efficiency performance over time and some options to be considered when seeking to optimize the performance of the ship."

[39] Ibid.

3. Mandatory Fuel Oil Consumption Data Collection System ("DCS")

In 2016, MEPC 70 approved a *Roadmap for developing a comprehensive IMO strategy on reduction of GHG emissions from ships*,[40] which includes a three-step approach consisting of: (1) collecting data on ships' fuel oil consumption, (2) analyzing this data and (3) make decision on what further measures to enhance the energy efficiency shipping, if any, are required.[41] In this regard, MEPC 70 adopted mandatory MARPOL Annex VI requirements for ship to record and report their fuel oil consumption. Under these amendments, starting from January 1, 2019, ships of 5,000 gross tonnage and above are required to collect consumption data from each type of fuel oil they use, as well as other, additional, specified data including proxies for "transport work". The aggregated data will be reported to the Flag State after the end of each calendar year and the Flag State, having determined that the data have been reported in accordance with the requirements, will issue a Statement of Compliance to the ship. Flag States will be required to subsequently transfer this data to an IMO Ship Fuel Oil Consumption Database. The Secretariat is required to produce an annual report to the MEPC, summarizing the data collected.

[40] This *Roadmap* also foresaw the adoption of an initial GHG reduction strategy in April 2018. See *infra*.

[41] IMO. (2016, October 28). New requirements for international shipping as UN body continues to address greenhouse gas emissions. https://www.imo.org/en/MediaCentre/PressBriefings/Pages/28-MEPC-data-collection--.aspx (last visited April 2021).

C. Market-Based Measures ("MBMs")

IMO has clearly indicated that market-base measures could supplement the deficiencies of technical and operational measures.[42] Currently there is no internationally unified MBMs for the reduction of maritime CO_2 emissions. Frustrated by the slow progress in achieve international consensus (Dobson & Ryngaert, 2017, p. 296), EU has acted unilaterally and issued Regulation 2015/757 on monitoring, reporting and verification ("MRV") of CO_2 emissions for vessels over 5,000 gross tonnage calling at EU ports, regardless of the vessel's flag.[43] Companies are responsible for the vessels' operation and should monitor, report, and verify the CO_2 emissions data from 2018 on per voyage basis (Regulation 2015/757, Arts. 2, 4, 8, 9). The European Maritime Safety Agency ("EMSA") oversees companies' compliance with the MRV requirements (Regulation 2015/757, Arts. 20.2).[44] The MRV is only the first step towards a further MBM, EU also envisaged to create a target-based compensation fund financed by

[42] IMO. (n.d.). Market-based measures. https://www.imo.org/en/OurWork/Environment/Pages/Market-Based-Measures.aspx (last visited April 2021).

[43] Regulation (EU) 2015/757 of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC. https://op.europa.eu/en/publication-detail/-/publication/c895b0b3-fdf7-11e4-a4c8-01aa75ed71a1/language-en (hereinafter "Regulation 2015/757"). Arts. 1, 2.1 and 3(d).

[44] Regulation 2015/757, Art. 20.

auctioning emissions allowance under EU's emissions trading system to incentivize the development of green shipping (Dobson & Ryngaert, 2017, p. 311).

Inspired by EU's pioneering attempts and experiences, IMO received several proposals from its member states (mostly advanced industrialized nations) on possible emission trading system to tackle CO_2. Representative proposals include MEPC/60/4/22 by Norway, MEPC/60/4/26 by the United Kingdom, MEPC/60/4/41 by France, and MEPC 60/4/54 by Germany. Other countries have also come up with proposals on various MBMs. At the MEPC sixty-third session, measures to reduce GHG emissions by market-based mechanisms have received widespread attention and was intensively discussed; however, opinions differed widely between developed and developing countries and no consensus has been reached.[45]

D. Initial IMO Strategy on Reduction of GHG Emissions from Ships

To obtain the full potential benefical environmental and health-related impacts of shipping decarbonization, IMO believed that it is crucial to install a comprehensive package of actions to regulate vessels' GHG emissions. Given this consideration, in early 2018, IMO adopted the Initial Strategy on the Reduction of GHG Emissions from Ships (hereinafter "Initial

[45] IMO. (n.d.). Market-based measures. https://www.imo.org/en/OurWork/Environment/Pages/Market-Based-Measures.aspx (last visited April 2021).

Strategy").[46] The Initial Strategy has set out a "vision" that confirmed IMO's commitment to reducing GHG emissions from international shipping, and as a matter of urgency, to phasing them out as soon as possible in this century).[47]

The Initial Strategy included a specific reference to "a pathway of CO_2 emissions reduction consistent with the Paris Agreement goals"[48] and defined three levels of ambitions.[49] Firstly, the Initial Strategy affirmed that the total annual GHG emissions from international shipping should peak as soon as possible in 2020, fall by at least 50% by 2050 relative to 2008 levels, and continue to be phased out entirely within this century. Secondly, it destined a 40% reduction of the average carbon intensity by 2030 and a 70% reduction by 2050 with reference to 2008. Last but not least, the Initial Strategy envisaged a strengthened EEDI for new ships. In order to achieve these ambitions, the strategy was also underlined by a list of short-, mid- and long-term measures with expected timelines and their impacts on States.[50]

For the short-term period (2018 - 2023), a quick win was to begin reducing the shipping industry's carbon intensity. This goal has been implemented by enhancing the EEDI for new ships, tightening SEEMP, reducing ship speed, establishing an Existing Fleet Improvement

[46] IMO MEPC. (2018, April 13). Initial IMO Strategy on reduction of GHG emissions from ships. Resolution MEPC.304(72), MEPC 72/17/Add.1 Annex 11.

[47] Ibid. 2 Vision.

[48] Ibid. 3.1.3 Levels of Ambition; 1.7.1 Objective of the Initial Strategy.

[49] Ibid. 3.1 Levels of Ambition.

[50] Ibid. 4 List of Candidate Short-, Mid- and Long-term Further Measures With Possible Timelines And Their Impacts on States.

Programme, developing and updating national action plans ("NAPs"), introducing incentives for first movers to take up new technologies, etc.[51]

For the mid-term phase (2023 - 2030), possible candidate measures included most of the short-term measures carried into this phase, plus a program for the effective uptake of alternative low-carbon and zero-carbon fuels, and innovative market-based emission reduction measures, such as a carbon pricing/trading program or carbon levy.[52]

The long term measures (after 2030) would possibly include deeper and continuous pursuit of prior measures, depending on timely technological innovation and global availability of alternative fuels and/or energy resources.[53]

It should be obvious that, as reflected in the Initial Strategy, IMO forsters the development of neutral-carbon fuels and innovative energy efficient technologies. The Initial Strategy is, according to IMO's Secretary-General Mr. Kitack Lim, a platform for future actions.[54] Reactions from both the shipping industry and the environmental community toward the Initial Strategy seemed mostly positive and many observers were ardently looking awaiting it being enforced.[55] But unsurprisingly, there were also voices that worried about the successful

[51] Ibid. 4.7 Candidate short-term measures.

[52] Ibid. 4.8 Candidate mid-term measures..

[53] Ibid. 4.9 Candidate long-term measures.

[54] The Maritime Executive. (2018, April 13). IMO agrees to CO2 emissions target. http://maritime-executive.com/article/imo-agrees-to-co2-emissions-target (last visited Arpil 2021).

[55] Ibid.

implementation of Initial Strategy, claiming that it lacked substance, and was merely "a political declaration rather than a legally binding treaty, and it is a framework document that is light on detail."(Doelle & Chircop, 2019, p. 271)

E. IMO's Post-2018 Progresses

After delivering the Initial Strategy, MEPC took steps further to support achieving of the objectives stated in the Strategy. In October 2018, the ISWG-GHG Fourth Meeting proposed eight "follow-up" programs.[56] MEPC 73 approved these programs, and scheduled a revision to

[56] These follow-up actions included:

(1) Inviting concrete proposals for three groups of concrete short-term measures (Groups A-C),

(2) Inviting concrete proposals for mid- and long-term measures to address the identified barriers,

(3) Inviting concrete proposals for a process to assess the impacts on States,

(4) Launching a Fourth IMO GHG Study and defining its scope,

(5) Developing and implementing capacity-building actions, technical cooperation, and research and development (R&D), and

(6) Proposing the adoption to a revised Strategy in 2023.

For details, see International Maritime Organization. (22 October 2018). Next steps to deliver IMO GHG strategy, available at

the Initial Strategy by 2023, based upon the inputs from the follow-up programs (including information from the Data Collection System that already commenced in 2019).[57]

MEPC 74 approved amendments to MARPOL Annex VI to "significantly strengthen the EEDI phase 3" for several ship types, including gas carriers and LNG carriers.[58] As a result, from 2022 onwards, new ships will be required to be considerably more energy efficient. MEPC 74 also adopted Resolution MEPC.323(74).[59] This Resolution suggested that appropriate actions of voluntary cooperation may include Onshore Power Supply such as renewable power to ship, efficient and safe handling and bunkering of alternative low-carbon and zero-carbon fuels, incentives promoting sustainable low-carbon and zero carbon shipping, as well as support for the optimization of port calls including facilitation of just-in-time arrival of ships.[60] The Procedure for assessing the impacts on States of candidate measures for the reduction of GHG emissions

---

https://www.imo.org/en/MediaCentre/PressBriefings/Pages/18-MEPCGHGprogramme.aspx (last visited April 2021).

[57] Ibid.

[58] IMO. (2019, May 20). UN agency pushes forward on shipping emissions reduction. https://www.imo.org/en/MediaCentre/PressBriefings/Pages/11-MEPC-74-GHG.aspx (last visited April 2021).

[59] IMO MEPC. (2019, May 17). Invitation to Member States to encourage voluntary cooperation between the port and shipping sectors to contribute to reducing GHG emissions from ships. Resolution MEPC.323(74), MEPC 74/18/Add.1 Annex 19.

[60] Ibid. para. 2.

from ships was also approved by the MEPC 74.[61] One more milestone achieved at MEPC 74 was the establishment of a voluntary multi-donor trust fund for GHG ("GHG TC-Trust Fund") to provide a dedicated source of financial support for technical cooperation and capacity-building activities.[62]

Due to the COVID-19 outbreak, MEPC 75 was held remotely during November 16-20, 2020. MEPC 75 reviewed and agreed amendments to the MARPOL Convention developed by the ISWG-GHG Sixth and Seventh Meetings. The highlights of the 75th Session include:

- Adopted amendments to significantly strengthen the EEDI "phase 3", with expected entry into force on April 1, 2022;[63]

[61] IMO MEPC. (2019, May 21). Procedure for assessing impacts on states of candidate measures. MEPC.1/Circ.885 Annex.

[62] IMO. (2019, May 20). UN agency pushes forward on shipping emissions reduction. https://www.imo.org/en/MediaCentre/PressBriefings/Pages/11-MEPC-74-GHG.aspx (last visited April 2021).

[63] IMO MEPC. (2020, November 20). Procedures for sampling and verification of the sulphur content of fuel oil and the Energy Efficiency Design Index (EEDI). Resolution MEPC.324(75), MEPC 75/18/Add.1 Annex 1.This Resolution contains three additional measures affecting all existing cargo and cruise ships, inter alia, the retroactive application of the EEDI to ships, known as the Energy Efficiency Exiting Ship Index (EEXI); a mandatory Carbon Intensity Indicator rating ("CII") and an enhanced SEEMP.

- Adopted a resolution that urged IMO Member States to develop and update a voluntary National Action Plan with a view to contributing to reducing GHG emissions from ships;[64]

- Approved the Fourth IMO GHG Study in which contained an overview of GHG emissions from shipping during 2012 to 2018;

- Agreed the terms of reference for assessing the possible impacts of the new requirements on States, paying particular attention to the need of developing countries, in particular Small Island Developing States (SIDS) and least developed countries (LDCs); and

- Introduced regulations for the purpose of confirming compliance with the MARPOL sulphur requirements and the carriage ban for fuel oil with a sulphur content exceeding 0.50%..[65]

These above measures are subject to adoption at MEPC 76 in June 2021.

IV. Using LNG as Marine Fuel

[64] IMO MEPC. (2020, November 20). Encouragement of member states to develop and submit voluntary national action plans to address GHG emissions from ships. Resolution MEPC.327(75), MEPC 75/18/Add.1 Annex 4.

[65] IMO MEPC. (2020, November 20). 2020 Guidelines for monitoring the worldwide average sulphur content of fuel oils supplied for use on board ships. Resolution MEPC.326(75), MEPC 75/18/Add.1 Annex 3.

The Fourth IMO GHG Study found that the shipping sector's annual CO_2 share estimate has increased 2.2% in 2012 to around 2.9% in 2018. This negative trend was accompanied by an even worse outcome that the absolute amount of emissions has also increased. Under the business-as-usual scenario, shipping's emissions are expected to grow 90%-130% as compared to 2008 levels.[66] It is therefore urgent to take every helpful decarbonization measures, such as optimizing vessel speed, improving propulsion devices, strengthening energy efficiency standards for new ships, and developing carbon-neutral fuels. Among others, LNG is becoming more popular as alternative "clean" fuel (Xu et al., 2015, p. 226), and many maritime industry insiders believed that LNG could be an excellent solution to the CO_2 emission problem (Nast, 2013, p. 31).

A. Benefits of LNG

First of all, LNG has been proved to be cleaner than heavy fuel oil (HFO) as it could significantly reduce CO_2 emissions (Deniz & Zincir, 2016, Table 1; Halim et al., 2018; Schinas & Butler, 2016). Studies have shown that the operation of LNG-fueled ships can result in a reduction of 20% CO2 emissions, 80% fewer NOx emissions, and can also reduce nearly all

[66] IMO MEPC. (2020, July 29). Reduction of GHG emissions from ship: fourth IMO GHG study 2020 – Final report. MEPC 55/7/15, Annex 1, p. 36.

emissions of SO_x and particulate matter (CNBC, 2020; DNV GL, July 2020).[67] LNG can operate with the current available diesel dual-fuel engines and when being injected at high pressure, LNG generates much less CO_2 with complete combustion (Lindstad et al., 2015, p. 96).[68] However, another research carried out by the International Council on Clean Transportation (ICCT) raised opposite findings that high pressure duel fuel engines might emit more *life-cycle* GHG when using LNG as a fuel as compared to emissions by using marin gas oil (Pavlenko et al., 2020).[69] This observation, on one hand, should remind the readers that when assessing LNG's strengths and weaknesses, it is important to consider the emissions released *both over the full life-cycle and during the fuel combustion*, given that the LNG supply chain, including gas production, liquefaction for handling, regasification, and gas consumption, is prone to some

[67] LNG, a groundbreaking choice for the shipping industry. (2020, January 10). In CNBC. https://www.cnbc.com/advertorial/2020/01/10/lng-a-groundbreaking-choice-for-the-shipping-industry.html (last visited April 2021). See also DNV GL. (2020, July 22). Achieving the IMO decarbonization goals. https://www.dnvgl.com/expert-story/maritime-impact/How-newbuilds-can-comply-with-IMOs-2030-CO2-reduction-targets.html#slideshow (last visited April 2021).

[68] See also DNV GL. (2020, September 23). Scenario modelling shows possible decarbonization pathways. https://www.dnvgl.com/expert-story/maritime-impact/Prepare-for-a-decarbonization-pathway.html (last visited April 2021).

[69] Pavlenko, N., Comer, B., Zhou, Y., Clark, N., & Rutherford, D. (2020, January 28). The climate implications of using LNG as a marine fuel. The International Council on Clean Transportation [ICCT]. https://theicct.org/publications/climate-impacts-LNG-marine-fuel-2020 (last vistied April 2021).

degree of methane slip.[70] On the other hand, this result implicitly suggested that the upstream emissions are not attributed to the shipping sector.

A second advantage for LNG to gain significant uptake under the decarbonization pathways is its great availability. When there is a rapid increase in demand for alternative ship fuel, it will require a steep increase in production capacity. According to the annually published data by the International Gas Union [IGU] and Shell, global demand for LNG grew to around 360 million tonnes in 2019 (IGU, 2020; Shell, 2020).[71] In contrast, other cleaner fuels seem to encounter the supply problem. For instance, hydrogen-based fuels are currently not available in sufficient quantities for deep-sea shipping, just short-sea (DNV GL, 2018).[72] What is more, the

---

[70] Ibid.

[71] International Gas Union [IGU]. (2020, April 27). 2020 world LNG report. https://www.igu.org/resources/2020-world-lng-report/#:~:text=2020%20World%20LNG%20Report%20This%2011th%20annual%20Global,flexibility%20of%20access%20to%20abundant%20global%20gas%20supplies (last accessed April 2021). Shell. (n.d.). LNG outlook 2020. https://www.shell.com/promos/download-the-full-lng-2020/_jcr_content.stream/1582140325378/ddcfff9e5f778ee9e8876b3b564e7337599b0d61/lng-outlook-twentytwenty-factsheet-final.pdf.

[72] DNV GL. (2018, October 9). Alternative fuels; the options. https://www.dnvgl.com/expert-story/maritime-impact/alternative-fuels.html#:~:text=The%20cleanest%20fuel%20is%20hydrogen%20produced%20using%20renewable,from%20being%20used%20directly%20in%20international%20deep-sea%20shipping (last visited April 2021).

process of extracting hydrogen from chemical compound is a stiff task because pure hydrogen does not exist on earth (Latarche, 2020).[73] Synthetic fuels produced from green energy will require significant efforts to increase the production capacity, but at present is difficult to enlarge the production scale (Heyne et al., 2019, p. 5).

A third praise of LNG is that as a fuel for merchant ships, it is subject to the IMO's International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels (the IGF Code). LNG is currently the only advanced regulated alternative fuel, and regulations for low-flashpoint fuels, including methanol, are under development. Flag states can grant exceptional permissions for other fuels, but such a newbuilding project will be more complex and time-consuming compared to LNG. Early involvement of all stakeholders is necessary to facilitate the process.

The authors opine that given its cleaner features and easy accessibility, LNG could to play an integral role as a transitional marine fuel to curb emissions of CO_2, NO_x, SO_x and other harmful emissions in the shipping industry. In combination with other technical and operational solutions, LNG is a suitable immediate measure to meet the targets delineated in the IMO Initial Strategy.

B. Dissents Against LNG

[73] Malcolm Latarche, Hydrogen—the pros and cons of a potential future fuel, https://shipinsight.com/articles/hydrogen-the-pros-and-cons-of-a-potential-future-fuel/.

The main criticisms against LNG focus on its economic feasibility such as the extra costs of liquefaction, storage and delivery.[74] Once liquified, LNG will be transported by special pipelines that are fitted to hold gas in liquid form at a -160 degrees Celsius with very little evaporation at atmospheric pressure (Cook-Clarke, 2015). The facilities and auxiliaries on board that are directly exposed to LNG shall be made of stainless steel in order stand the low temperatures and to prevent low temperature brittleness. The containment system of LNG ships generally has a barrier on the liquid side that is called the primary barrier, which withstands the pressure of stored LNG. Insulation is installed outside of the primary barrier to maintain the temperature of LNG. Moreover, effective insulation must be installed in the facilities in order to control the amount of vapor produced (boil off gas) and duplicate countermeasures for leakage of LNG must be taken. Such tank system are complex, highly engineered, and inevitably, expansive (The International Group of Liquefied Natural Gase Importers [GIIGNL], n.d.).[75] Because LNG

[74] DNV GL. (n.d.). Current price development oil and gas. https://www.dnvgl.com/maritime/lng/current-price-development-oil-and-gas.html (last visited April 2021).

[75] The International Group of Liquefied Natural Gas Importers [GIIGNL]. (n.d.). Implementation of the HNS Convention in the LNG industry: Singularities, stakes, issues and GIIGNL proposed solutions. https://giignl.org/system/files/hns_convention_giignl.pdf, p.5.

needs more space in the fuel storage system as compared to oil-based fuels,[76] developing new propulsion system and updating on-board storage space would incur stupendous costs.

From shipowners or ship operators' perspective, maintaining an LNG vessel costs differently than that of a regular fleet. The properties of LNG give particular constraints to the ship's operation. It is customary always to leave in the ship tanks a small quantities of LNG (LNG heel) for the return trip (ballast trip) in order for the tanks to remain in cold state, and to avoid a long and costly cooling process during the next loading operations. Thus, ship operators must take care to smoothly schedule their loading and unloading operations in order for their ships to stay chilled, and to use the least time possible. It is foreseeable that shipowners and operators would occur extra expenses on the maintenance of LNG tankers and their annual inspections. Another possible outgo depends upon recalculation of the ships' routes by balancing the transport capacity and the LNG tanker volume on board.

In addition, LNG ships also rely on a supporting LNG-charging infrastructure network. Switching to LNG fuel requires not only technical breakthroughs in an economically feasible way but also rapid and transformative adoption by the industry.

V. The Future of LNG Fuel: The Legal and Policy Trends

[76] DNV GL. (2020, July 22). Achieving the IMO decarbonization goals. https://www.dnvgl.com/expert-story/maritime-impact/How-newbuilds-can-comply-with-IMOs-2030-CO2-reduction-targets.html#slideshow (last visited April 2021).

A. The IMO Regulations on LNG Fuel's Safety

For vessels using LNG and other low-flashpoint fuels, the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels ("IGF Code") provides mandatory requirements for the arrangement, installation, control and monitoring of machinery, equipment and systems (IGF Code, 2015, Preamble).[77] The updates in IGF Code have triggered amendments to some other important IMO conventions, in particular, the 1974 International Convention for the Safety of Life at Sea ("SOLAS"),[78] and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers ("STCW").[79]

[77] IMO Maritime Safety Committee [MSC]. (2015, June 11). Adoption of the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code). Resolution MSC.391(95).

[78] The IGF Code includes a new Part G in SOLAS chapter II-1 "Construction – Subdivision and stability, machinery and electrical installations" related to ships using low-flashpoint fuels, requiring such ships to comply with the IGF Code; and related amendments to SOLAS chapter II-2 "Fire protection, fire detection and fire extinction," covering to the use of fuel with a low flashpoint. IMO. (2017, January 1). Safety for gas-fuelled ships- new mandatory code enters into force. https://imo.org/en/MediaCentre/PressBriefings/Pages/01-IGF.aspx (last visited April 2021).

[79] New requirements in the STCW in line with the SOLAS amendments related to the IGF Code include basic and advanced training for personnel sailing on ships subject to the IGF Code. Specifically speaking, masters, engineering officers and all personnel with immediate

Safe navigation of LNG-fueled ships is realized through compliance with the Safety Management System ("SMS") based on the International Safety Management Code ("ISM Code").[80] According to the ISM Code, the ship managers shall prepare and practice the SMS, develop the Safety Navigation Manual and provide it for each vessel, and prepare and establish countermeasures and procedures for emergency situations.[81] All ship masters shall also practice the SMS on board and report to the Designated Person Ashore ("DPA"), and the DPA has the responsibility and authority to monitor the ships' operation safety as well as pollution prevention.[82] Security of LNG ships against marine terrorism and acts of piracy is based on compliance to the International Ship and Port Facility Security Code ("ISPS Code") which amended in 2002 the SOLAS.

---

responsibility for the care and use of fuels and fuel systems on ships subject to the IGF Code shall receive appropriate training as set out in set out in STCW Code regulation V/3, paras 5 and 8, and hold a certificate for service on LNG tankers. See International Transport Workers' Federation. (n.d.). International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code). p. 4. https://www.itfseafarers.org/sites/default/files/node/resources/files/ITF%20Guideline%20on%20IGF%20Code.pdf (last visited April 2021).

[80] IMO Assembly. (1993, November 4). International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code). Resolution A.741(18), together with subsequent amendments.

[81] ISM Code, 1.1.2, 1.4, 11.3.

[82] Ibid. 4, 5.

B. LNG Fuel Bunkering Services: the Status Quo

Currently, the supply infrastructure for LNG-powered vessel are not sufficient (Xu et al., 2015). The development of LNG bunkering service are still in its infancy as the world's first LNG bunkering vessel ("LBV") was reported in February 2017.[83] The home port of the vessel, Zeebrugge in Belgium, marks a milestone in the development of the European LNG bunkering chain.

As one of Asia's shipping centers, Singapore's first commercial ship-to-ship LNG bunkering operation took place in May 2019. Singapore also facilitates financial supports and technical references to LNG programs. Singapore is actively implementing the IMO measures by launching the Maritime Singapore Green Initiative ("MSGI").[84] The MSGI contains four programs with the objective of reducing the environmental impact of shipping and shipping related activities. One of the four programs contained in the MSGI is called "Green Ship Programme." This particular program provides fee discounts and tax rebates for Singapore-flagged ships voluntarily adopt engines capable of using LNG or alternative low-carbon fuels.

[83] ENGIE. (2017, February 15). World's first purpose-built LNG Bunkering Vessel delivered to ENGIE, Fluxys, Mitsubishi Corporation and NYK. https://www.engie.com/en/journalists/press-releases/lng-fluxys-mitsubishi-corporation-nyk (last visited April 2021).

[84] Singapore Encourages Investment Toward Decarbonizing Shipping. (2020, July). Jones Day. https://www.jonesday.com/en/insights/2020/07/singapore-encourages-investment-toward-decarbonizing-shipping (last visited April 2021).

Another separate program under the MSGI is the "Green Port Programme" which reduces port dues for ocean-going vessels that use LNG to fuel its engines while in Singapore Port limits, with additional incentives for vessels using services provided by LNG-fueled harbor craft within port limits.

C. Liability and Compensation for Damages Caused by LNG as Fuel

Compensation for damage caused by the carriage by sea of LNG is regulated by the 2010 Protocol to the 1996 International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea ("HNS Convention").[85] The HNS Convention covers not only pollution damage but also the risks of fire and explosion which are inherent risks of LNG, including loss of life or personal injury as well as loss of or damage to property (HNS Convention, 2010, Art. 4.3). A two-tier compensation system was established under the HNS Convention, with the strict but limited liability shouldered by the shipowner and his deep-pocket insurers (HNS Convention, 2010, Arts. 1.3, 7, 9 & 12), and a supplementary compensation covered by the "HNS Fund" levied by post-incident contributions from HNS cargo receivers (HNS Convention, 2010, Arts. 1.4, 13 & 14). Both the shipowners' and industry's maximum compensation are limited to a certain amount in the form

[85] Article 1.5 of the HNS Convention defines hazardous and noxious substances (HNS) as per a series of IMO Conventions and Codes, and all liquified gases which are transported in bulk are included, such as LNG. See HNS Convention, Art. 1.5(v).

of Special Drawing Rights ("SDR").[86] The HNS Convention creates a specific system for contributions related to the LNG industry, for annual contributions to a separate LNG account shall be made with respect to each State party to the HNS Convention "by any person who in the preceding calendar year [...] immediately prior to its discharge, held title to an LNG *cargo* discharged in a port or terminal of that State." (HNS Convention, 2010, Arts. 16 & 19.1bis(b)) The HNS Convention does not mention contribution by titleholder of LNG as *fuel*.

However, the HNS Convention regime was neither in force, nor applied to the damage caused by LNG *as fuel*. That is to say, the HNS Convention applies to damage caused by LNG carried *as cargo*, and this could be manifested by the Convention's definition of "receiver," "carriage by sea," and "contributing cargo." (HNS Convention, 2010, Arts. 1.4, 1.9 & 1.10)

VI. Conclusion

The UN climate regime upheld the non-inclusion of shipping within its regulatory mandate, instead, IMO has acted progressively to curb the GHG emissions from maritime activities by adopting various treaties and policy incentives. Among these measures, it has been realized that clean fuel transition is of critical importance as LNG would produce much less CO_2, NO_x and SO_x. Although the "methane slip" problem during LNG's circulation chain needs to be watched carefully, LNG has a sound effect on decarbonizing the shipping industry in both short and long term.

[86] HNS Convention, Art. 1.12. The Special Drawing Rights is a monetary unit established by the International Monetary Fund; as at 28 April, 2021, 1 SDR = 1.434610 US Dollar.

References

Balcombe, P., Brierley, J., Lewis, C., Skatvedt, L., Jamie Speirs, J., Hawkes, A., & Staffell, I. (2019). How to decarbonise international shipping: Options for fuels, technologies, and policies. *Energy Conversion and Management*, 182, 72-88. https://doi.org/10.1016/j.enconman.2018.12.080

Bateman, B. (2012, March 22). Explaining the Durban Platform: what lies ahead? Clayton Utz. https://www.claytonutz.com/knowledge/2012/march/explaining-the-durban-platform-what-lies-ahead

Bodansky, D. (1993). The united nations framework convention on climate change: A commentary. *Yale Journal of International Law*, 18(2), 451-558.

Buhaug, Ø., Corbett, J., Endresen, Ø., Eyring, V., Faber, J., Hanayama, S., Lee, David, Lee, Donchool, Lindstad E., Mjelde, A., Pålsson, C., Wu W., Winebrake, J., & Yoshida, K. (2009). Second IMO Greenhouse Gas Study 2009.

Carlson, J., Palmer, G., & Weston, B. (2012). International environmental law and world order: A problem-orientated course book (3rd ed.). *West Academic Publishing*.

Chircop, A., Doelle, M., & Gauvin, R. (2018, September 6). Shipping and climate change: International law and policy considerations special report. Centre for International Governance Innovation [CIGI]. https://www.cigionline.org/sites/default/files/documents/Shipping%27s%20contribution%20to%20climate%20change%202018web_0.pdf

Chircop, A., & Shan, D. (2020). Governance of international shipping in the era of decarbonisation: New challenges for the IMO? In Mukherjee, P. K., Mejia, M. Q. Jr., & Xu, J. (Eds.), *Maritime Law in Motion* (pp. 99-113). Springer.

Cichowicz, J., Theotokatos, G., & Vassalos, D. (2015). Dynamic energy modelling for ship life-cycle performance assessment. *Ocean Engineering*, 110(B), 49-61. https://doi.org/10.1016/j.oceaneng.2015.05.041

Cook-Clarke, W., Jenden, J., Lloyd, E., Wong, K., & Jason Donev J. (2015). Energy Education - Transportation of liquefied natural gas. https://energyeducation.ca/encyclopedia/Transportation_of_liquefied_natural_gas.

Decisions Adopted by the Conference of the Parties, Decisions 2/CP.18, Report of the Conference of the Parties on its Seventeenth Session, held in Durban from 28 November to 11 December 2011. (2012, March 15). UN Doc FCCC/CP/2011/9/Add.1.

Decisions Adopted by the Conference of the Parties, Decisions 1-10/CP.18, Report of the Conference of the Parties on its Eighteenth Session, held in Doha from 26 November to 8 December 2012. (2013, February 28). UN Doc FCCC/CP/2012/8/Add.1.

Deniz, C. & Zincir, B. (2016). Environmental and economical assessment of alternative marine fuels. Journal of Cleaner Production, 113, 438-449. https://doi.org/10.1016/j.jclepro.2015.11.089

Devanney, J. (2011). The impact of the energy efficiency design index on very large crude carrier design and CO_2 emissions. *Ships and Offshore Structures*, 6(4), 355-368. https://doi.org/10.1080/17445302.2010.546651

DNV GL. (n.d.). Current price development oil and gas. https://www.dnvgl.com/maritime/lng/current-price-development-oil-and-gas.html

DNV GL. (2018, October 9). Alternative fuels; the options. https://www.dnvgl.com/expert-story/maritime-impact/alternative-fuels.html#:~:text=The%20cleanest%20fuel%20is%20hydrogen%20produced%20using%20renewable,from%20being%20used%20directly%20in%20international%20deep-sea%20shipping

DNV GL. (2020, July 22). Achieving the IMO decarbonization goals. https://www.dnvgl.com/expert-story/maritime-impact/How-newbuilds-can-comply-with-IMOs-2030-CO2-reduction-targets.html#slideshow

DNV GL. (2020, September 23). Scenario modelling shows possible decarbonization pathways. https://www.dnvgl.com/expert-story/maritime-impact/Prepare-for-a-decarbonization-pathway.html

Dobson, N. L., & Ryngaert, C. (2017). Provocative climate protection: EU extraterritorial regulation of maritime emissions. *International & Comparative Law Quarterly*, 66(2), 295-333. https://doi.org/10.1017/S0020589317000045

Doelle, M., & Chircop, A. (2019). Decarbonizing international shipping: An appraisal of the IMO's Initial Strategy. *Review of European, Comparative & International Environmental Law*, 28(3), 268–277. https://doi.org/10.1111/reel.12302

ENGIE. (2017, February 15). World's first purpose-built LNG Bunkering Vessel delivered to ENGIE, Fluxys, Mitsubishi Corporation and NYK. https://www.engie.com/en/journalists/press-releases/lng-fluxys-mitsubishi-corporation-nyk

Lindstad, H., Eskeland, G. S., Psaraftis, H., Sandaas, I., & Strømman, A. H. (2015). Maritime shipping and emissions: A three-layered, damage-based approach, *Ocean Engineering*, 110(Part B), 94-101. https://doi.org/10.1016/j.oceaneng.2015.09.029

Hackmann, B. (2012). Analysis of the governance architecture to regulate GHG emissions from international shipping. *International Environment Agreements: Politics, Law and Economics*, 12, 85-103. https://doi.org/10.1007/s10784-011-9155-9

Halim, R. A., Kirstein, L., Merk, O., & Martinez, L. M. (2018). Decarbonization pathways for international maritime transport: A model-based policy impact assessment. *Sustainability*, 10(7), 2243. https://doi.org/10.3390/su10072243

Harrison, J. (2012). Recent developments and continuing challenges in the regulation of greenhouse gas emissions from international shipping. *Edinburgh School of Law Research Paper No. 2012/12*. http://dx.doi.org/10.2139/ssrn.2037038

Heyne, S., Bokinge, P., & Nyström, I. (2019, May 6). Global production of bio-methane and synthetic fuels-overview. CIT Industriell Energi AB. https://www.miljodirektoratet.no/globalassets/publikasjoner/m1421/m1421.pdf

International Convention for the Prevention of Pollution from Ships, November 2, 1973, as amended by the 1978 Protocol to the 1973 Convention [MARPOL 73/78], Annex VI. Air Pollution from Ships, May 19, 2005.

International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, 1996, and the Protocol of 2010 to the Convention (not yet in force), https://www.hnsconvention.org/wp-content/uploads/2018/08/2010-HNS-Convention-Consolidated-text_e.pdf

International Gas Union [IGU]. (2020, April 27). 2020 world LNG report. https://www.igu.org/resources/2020-world-lng-report/#:~:text=2020%20World%20LNG%20Report%20This%2011th%20annual%20Global,flexibility%20of%20access%20to%20abundant%20global%20gas%20supplies

International Group of Liquefied Natural Gas Importers [GIIGNL]. (n.d.). Implementation of the HNS Convention in the LNG industry: Singularities, stakes, issues and GIIGNL proposed solutions. https://giignl.org/system/files/hns_convention_giignl.pdf

IMO. (n.d.). Energy efficiency measures. https://www.imo.org/en/OurWork/Environment/Pages/Technical-and-Operational-Measures.aspx

IMO. (n.d.). Introduction to IMO. https://www.imo.org/en/About/Pages/Default.aspx

IMO. (n.d.). Market-based measures. https://www.imo.org/en/OurWork/Environment/Pages/Market-Based-Measures.aspx

IMO. (2016, October 28). New requirements for international shipping as UN body continues to address greenhouse gas emissions. https://www.imo.org/en/MediaCentre/PressBriefings/Pages/28-MEPC-data-collection--.aspx

IMO. (2017, January 1). Safety for gas-fuelled ships- new mandatory code enters into force. https://imo.org/en/MediaCentre/PressBriefings/Pages/01-IGF.aspx

IMO. (2019, May 20). UN agency pushes forward on shipping emissions reduction. https://www.imo.org/en/MediaCentre/PressBriefings/Pages/11-MEPC-74-GHG.aspx

IMO Assembly. (1993, November 4). International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code). Resolution A.741(18).

IMO Assembly. (2017, December 6). Strategic plan for the organization for the six-year period 2018 to 2023. Resolution A.1110(30). https://wwwcdn.imo.org/localresources/en/About/strategy/Documents/A%2030-RES.1110.pdf

IMO MEPC. (2000, October 16). Report of the Marine Environment Protection Committee on its forty-fifth session. MEPC 45/20.

IMO MEPC. (2016, October 28). 2016 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP). Resolution MEPC.282(70), MEPC 70/18/Add.1 Annex 10.

IMO MEPC. (2018, April 13). Initial IMO Strategy on reduction of GHG emissions from ships. Resolution MEPC.304(72), MEPC 72/17/Add.1 Annex 11.

IMO MEPC. (2018, October 26). 2018 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships. Resolution MEPC 308(73), MEPC 73/19/Add.1 Annex 5.

IMO MEPC. (2019, May 17). Amendments to the 2018 guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships. Resolution MEPC.322(74), MEPC 74/18/Add.1 Annex 16.

IMO MEPC. (2019, May 17). Invitation to Member States to encourage voluntary cooperation between the port and shipping sectors to contribute to reducing GHG emissions from ships. Resolution MEPC.323(74), MEPC 74/18/Add.1 Annex 19.

IMO MEPC. (2019, May 21). Procedure for assessing impacts on states of candidate measures. MEPC.1/Circ.885 Annex.

IMO MEPC. (2020, July 29). Reduction of GHG emissions from ship: fourth IMO GHG study 2020 – Final report. MEPC 55/7/15, Annex 1.

IMO MEPC. (2020, November 20). Procedures for sampling and verification of the sulphur content of fuel oil and the Energy Efficiency Design Index (EEDI). Resolution MEPC.324(75), MEPC 75/18/Add.1 Annex 1.

IMO MEPC. (2020, November 20). 2020 Guidelines for monitoring the worldwide average sulphur content of fuel oils supplied for use on board ships. Resolution MEPC.326(75), MEPC 75/18/Add.1 Annex 3.

IMO MEPC. (2020, November 20). Encouragement of member states to develop and submit voluntary national action plans to address GHG emissions from ships. Resolution MEPC.327(75), MEPC 75/18/Add.1 Annex 4.

IMO Maritime Safety Committee [MSC]. (2015, June 11). Adoption of the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code). Resolution MSC.391(95).

International Ship and Port Facility Security Code [ISPS Code], December 12, 2002.

International Transport Workers' Federation. (n.d.). International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code). https://www.itfseafarers.org/sites/default/files/node/resources/files/ITF%20Guideline%20on%20IGF%20Code.pdf

Kyoto Protocol to the United Nations Framework Convention on Climate Change [Kyoto Protocol], December 10, 1997, https://unfccc.int/resource/docs/convkp/kpeng.pdf

Latarche, M. (2020, December 1). Hydrogen-the pros and cons of a potential future fuel. ShipInsight. https://shipinsight.com/articles/hydrogen-the-pros-and-cons-of-a-potential-future-fuel/

LNG, a groundbreaking choice for the shipping industry. (2020, January 10). In CNBC. https://www.cnbc.com/advertorial/2020/01/10/lng-a-groundbreaking-choice-for-the-shipping-industry.html

Nast, T. (2013). The response of the international shipping industry to global climate change. *Journal of Maritime Law and Commerce*, 44(1), 29-46.

Oberthür, S. (2003). Institutional interaction to address greenhouse gas emissions from international transport: ICAO, IMO and the Kyoto Protocol. *Climate Policy*, 3(3), 191-205. https://doi.org/10.1016/S1469-3062(03)00060-3

Paris Agreement, 12 December 2015, https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

Pavlenko, N., Comer, B., Zhou, Y., Clark, N., & Rutherford, D. (2020, January 28). The climate implications of using LNG as a marine fuel. The International Council on Clean Transportation [ICCT]. https://theicct.org/publications/climate-impacts-LNG-marine-fuel-2020

Psaraftis, H.N. (2019). Decarbonization of maritime transport: to be or not to be? *Maritime Economics Logistics*, 21, 353–371. https://doi.org/10.1057/s41278-018-0098-8

Regulation (EU) 2015/757 of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC. https://op.europa.eu/en/publication-detail/-/publication/c895b0b3-fdf7-11e4-a4c8-01aa75ed71a1/language-en

Schinas, O., & Butler, M. (2016). Feasibility and commercial considerations of LNG-fueled ships. *Ocean Engineering*, 122, 84-96. http://dx.doi.org/10.1016/j.oceaneng.2016.04.031

Shell. (n.d.). LNG outlook 2020. https://www.shell.com/promos/download-the-full-lng-2020/_jcr_content.stream/1582140325378/ddcfff9e5f778ee9e8876b3b564e7337599b0d61/lng-outlook-twentytwenty-factsheet-final.pdf

Shi, Y. (2014). Greenhouse gas emissions from international shipping: The response from china's shipping industry to the regulatory initiatives of the international maritime organization. *International Journal of Marine and Coastal Law*, 29(1), 77-115.

Singapore Encourages Investment Toward Decarbonizing Shipping. (2020, July). In JonesDay. https://www.jonesday.com/en/insights/2020/07/singapore-encourages-investment-toward-decarbonizing-shipping

Tanaka, Y. (2016). Regulation of greenhouse gas emissions from international shipping and jurisdiction of states. *Review of European, Comparative & International Environmental Law*, 25(3), 333-346. https://doi.org/10.1111/reel.12181

Telesetsky, A. (1999). The Kyoto Protocol. *Ecology Law Quarterly*, 26(4), 797-814.

The Maritime Executive. (2018, April 13). IMO agrees to CO_2 emissions target. http://maritime-executive.com/article/imo-agrees-to-co2-emissions-target

Traut, M., Larkin, A., Anderson, K., McGlade, C., Sharmina, M., & Smith, T. (2018). CO_2 abatement goals for international shipping. *Climate Policy*, 18(8), 1066-1075. https://doi.org/10.1080/14693062.2018.1461059

United Nations (n.d.). Transforming our world: The 2030 agenda for sustainable development. A/RES/70/1. https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

United Nations Framework Convention on Climate Change [UNFCCC], May 9, 1992, https://unfccc.int/resource/docs/convkp/conveng.pdf.

UNFCCC. (1995, April 7). Decision 4/CP.1, Methodological Issues. UN Doc FCCC/CP/1995/7/Add.1. https://unfccc.int/resource/docs/cop1/07a01.pdf (accessed April 2021).

U.S. Energy Information Administration [EIA]. (2011, March). Emissions of Greenhouse Gases in the United States. EIA Report Number: DOE/EIA-0573(2009). https://www.eia.gov/environment/emissions/ghg_report/ghg_overview.php

Wan, Z., Makhloufi, A., Chen, Y., & Tang, J. (2018). Decarbonizing the international shipping industry: Solutions and policy recommendations. *Marine Pollution Bulletin*, 126, 428-435. https://doi.org/10.1016/j.marpolbul.2017.11.064

Wan, Z., Zhu, M., Chen, S., & Sperling, D. (2016). Pollution: Three steps to a green shipping industry. *Nature*, 530(7590), 275–227. http://doi.org/10.1038/530275a

Williamson, P. (2016). Emissions reduction: Scrutinize CO_2 removal methods. *Nature*, 530(7589), 153–155. http://doi.org/10.1038/530153a

Xu, J., Testa, D., & Mukherjee, P. K. (2015). The use of LNG as a marine fuel: The international regulatory framework. *Ocean Development & International Law*, 46(3), 225-240. https://doi.org/10.1080/00908320.2015.1054744

Yau, P. S., Lee, S. C., Corbett, J. J., Wang, C. F., Cheng, Y., & Ho, K. F. (2012). Estimation of exhaust emission from ocean-going vessels in Hong Kong. *Science of The Total Environment*, 431, 299-306. https://doi.org/10.1016/j.scitotenv.2012.03.092.