



Decarbonization Trend in International Shipping Sector

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ABSTRACT

This paper was motivated to review and discuss the current issues and challenges for decarbonisation in the international shipping sector. It was mainly focused on international and local efforts to reduce greenhouse gas (GHG) emissions from shipping activities while introducing new strategies, agreements, and regulations to meet the target on GHG reduction levels. It firstly reviewed the impact of the Clydebank Declaration made at 26th UN Climate Change Conference in Glasgow, 2021. Then, the review was moved to UK and EU policies and activities. Findings from this research offer some insights into local governmental authorities and shipping companies in terms of how to respond to gradually stringent environmental regulations as well as their roles to make the shipping sector cleaner.

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Introduction

It has been seven years since the Paris Agreement was signed for our human mission to keep the average global temperature rise below 1.5°C compared to the pre-industrial levels. In the meantime, countries and governments around the world have made their great efforts to mitigate greenhouse gas (GHG) emissions through development of policies and technologies along with international cooperation.

The shipping sector currently accounts for 2.5 ~ 3% of the total GHG emissions, which is highly expected to increase steadily in the future. In response, the International Maritime Organisation (IMO) adopted a resolution addressing the initial strategy for GHG emission reduction from shipping activities in 2018 (IMO 2018). The resolution encouraged flag states to take proactive steps forward to make shipping sector carbon-neutral.

In particular, the last few years were monumental moments as international cooperation has been accelerated to curb GHG emissions from shipping. Given this, this paper focused on some notable points on decarbonisation in the international shipping.

COP 26 Clydebank “Green Corridor”

Background

In November 2021, at United Nations Framework Convention on Climate Change (UNFCCC) 26th UN Climate Change Conference (COP 26) held in Glasgow, UK, the Clydebank Declaration was made to develop at least six Green Corridors by 2025, supported by 19

member countries: United Kingdom; Australia; Belgium; Canada; Chile; Costa Rica; Denmark; Fiji; Finland; France; Germany; Ireland; Japan; the Marshall Islands; the Netherlands; New Zealand; Norway; Sweden; and the United States. As of September 2022, the number of countries joined to the Clydebank Declaration has been increased to 24 countries with the new members of Italy, Morocco, Palau, Singapore, and Spain.

This declaration has been proposed with the goal of achieving net-zero GHG emissions in the shipping sector by 2050, which is much higher than the current IMO’s reduction target (50% reduction by 2050, compared to 2008). Given this, the declaration was viewed as a positive step to prompt the great efforts to be made by the international shipping sector to achieve a low-carbon future.

Green Corridor plans by countries

Los Angeles - Shanghai

The United States (US), one of 19 countries to have signed the Clydebank Declaration, has recently published an initial strategic document for the designation of the Green Corridor. The US announced that their determination to active cooperation with the international partners to achieve zero-carbon emissions in the shipping sector by 2050.

In particular, at the end of January 2022, the US established a network partnership with cities, ports, and shipping companies to develop one of the largest container shipping routes in the world, Los Angeles – Shanghai, as a Green Corridor (Offshore Energy 2022). Such initiatives are highly expected to produce great

momentum in promoting the decarbonization in maritime transportation between the two largest ports in the US and China.

Port of Antwerp - Port of Montreal

At COP 26, the Port of Antwerp and the Port of Montreal signed a cooperation agreement to support the establishment of the first Green Corridor in the North Atlantic. Port of Antwerp and Port of Montreal have had a strong partnership since 2013, and have joined this agreement to integrate and share their expertise and experience, and actively participate in creating economic values and in achieving international goals to mitigate climate change through continuous mutual cooperation (2022).

The agreement is believed to promote the use of low-carbon fuels and the establishment of clean infrastructure for ocean transportation between Europe and North America. In particular, it plans to promote the direct and indirect electric propulsion in the international shipping by breaking through the production, supply, and utilisation of green hydrogen.

Singapore – Notre Dame

To achieve decarbonization between Singapore in the Far East and Rotterdam in Europe, a new agreement between Singapore and the Port Authority of Rotterdam to develop the longest Green Corridor in the world is currently under discussion. Through multi-faceted cooperation with the governments and industries, the

discussion is aimed to support the use of alternative fuels as well as the promotion of digitalization in the shipping sector (The Maritime Executive 2022).

The plans for green corridor introduced above are shown in Figure 1.

As mentioned above, although some international ports are making great efforts to realize the Clydebank Declaration, it is worth pointing out that the level of participation and activeness of the international community is still below the expected level. As can be seen in Figure 2, Greece (1st), China (2nd) and the Republic of Korea (South Korea) (4th), which have relatively high international shipping volumes, have not yet joined this Declaration.

High lifecycle costs for green shipping are considered as one of the key hindrances that make many countries, including South Korea, hesitant to participate in Green Corridors. As one of supporting examples, as part of the preparatory process for the Clydebank Declaration, a series of feasibility studies were conducted for three specific shipping routes with the participation of 30 research organizations and industries. The results show that there is a 25–65% cost gap between fossil-based shipping and carbon-neutral shipping. Therefore, in order to reduce these cost burdens, the active financial support from the flag states should follow.

Research from the authors’ recent research are also considered to be a good evidence to support this argument (Park et al. 2022). The author’s research team

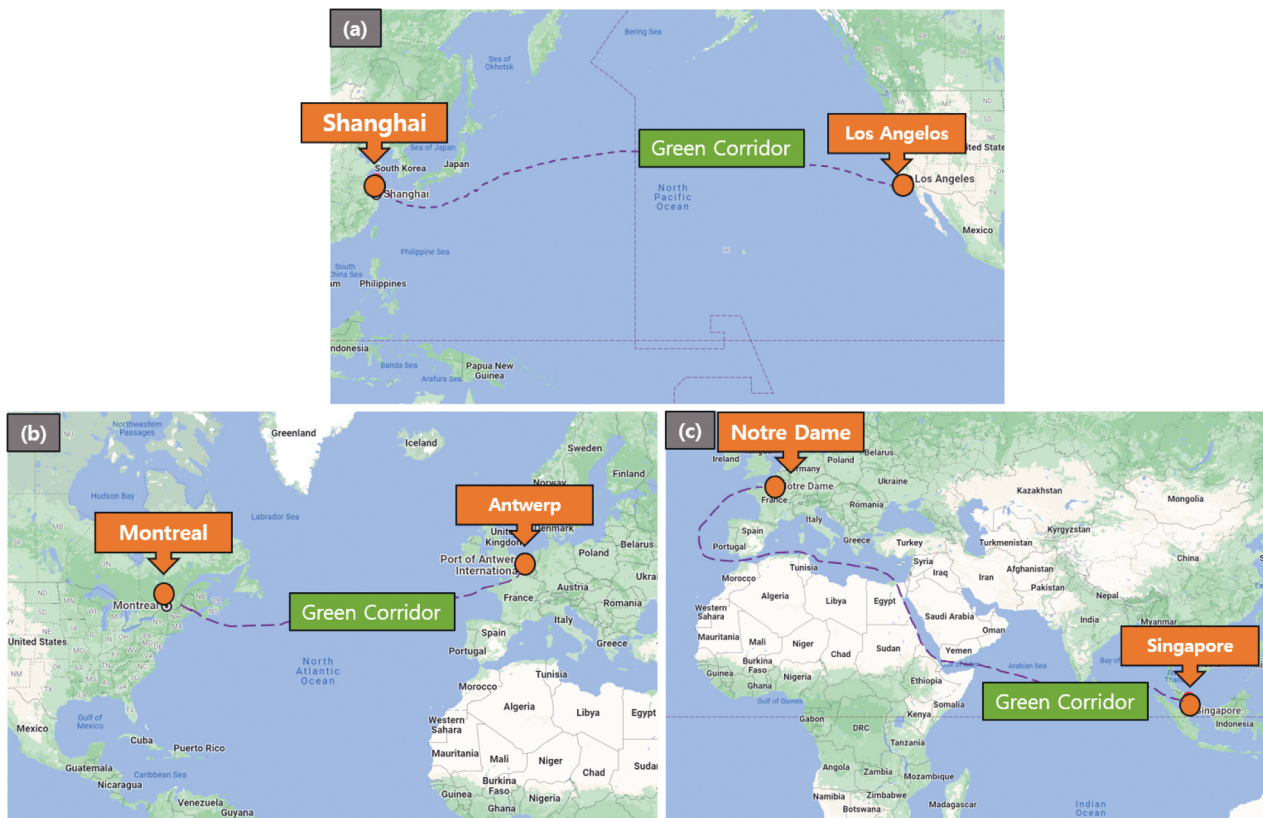


Figure 1. Green Corridor planned: (a) Los Angeles – Shanghai; (b) Antwerp – Montreal; (c) Singapore – Notre Dame.

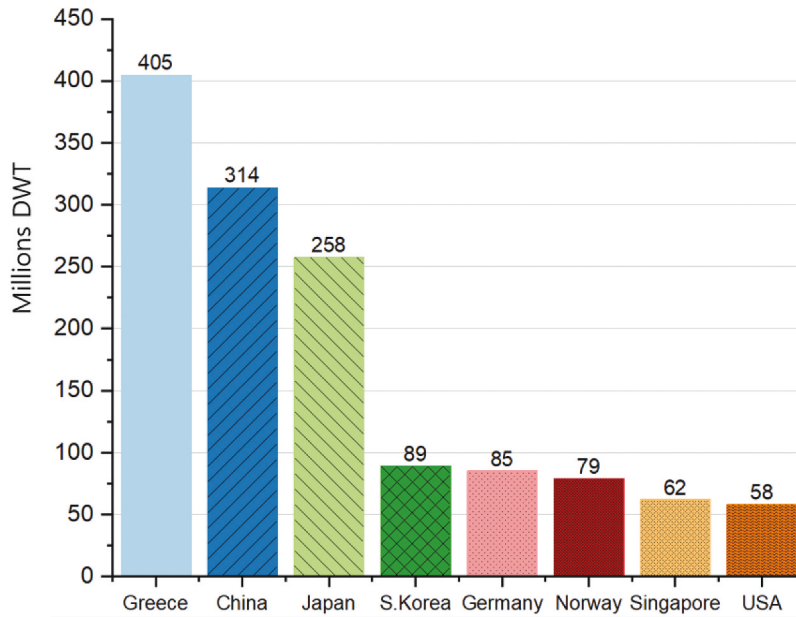


Figure 2. Top 8 countries with the largest shipping fleets (as of January 2021) ((ShippingNewsNet 2021).

recently reviewed the feasibility of using alternative fuels for a total of 27 small passenger ships sailing along the West Coast of Scotland through life cycle cost and environmental evaluation. As a result, as shown in Figure 3, it was estimated that the use of electricity-, ammonia- and hydrogen-powered ships would increase the cost of the entire process by at least 100% to a maximum of 450% compared to the existing diesel-powered ships. This is a number that is quite burdensome for shipping companies and governments. It leaves a question of whether countries with high shipping volumes like Greece and China are willing to take such high costs.

Trends in national and private initiatives

United Kingdom (UK)

In April 2018, the UK was a leading Member State of IMO in proposing an initial strategic resolution to reduce GHG emissions and is strongly committed to the goal of mitigating GHG emissions in the shipping sector by at least 50% by 2050. In response, the UK government published the Maritime 2050 Report, which presents a strategic vision for the eco-friendly future in the shipping sector in January 2019 (UK Department for Transport 2019).

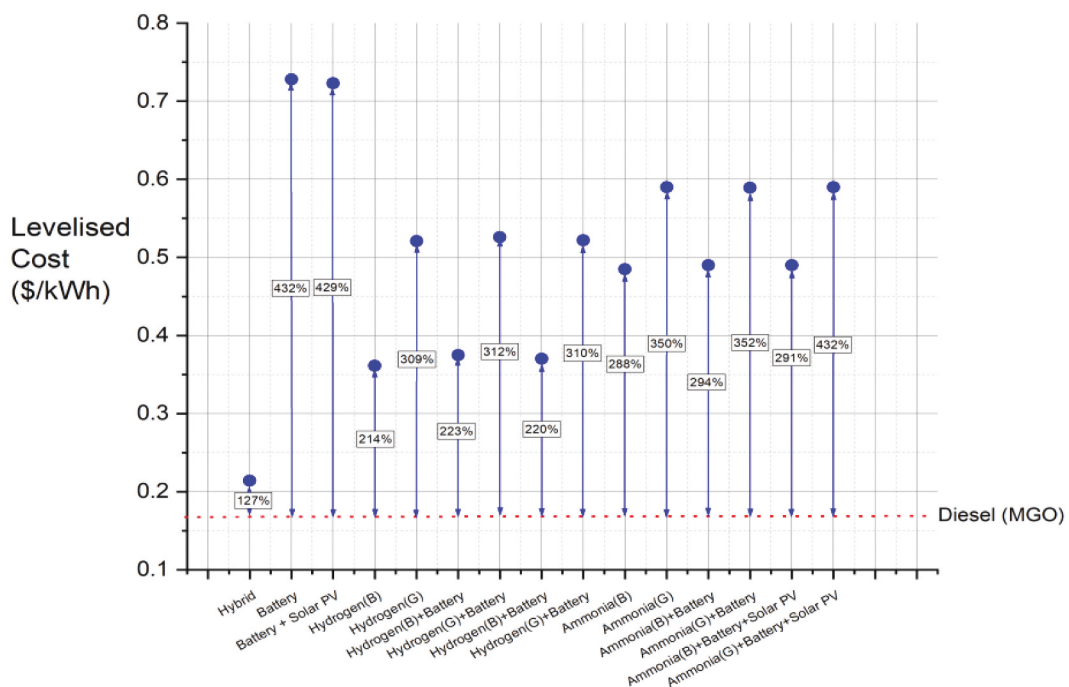


Figure 3. Lifecycle cost analysis for Scotland's short route ferries.

It also declares an ambitious plan to secure economic benefits through the transition to alternative fuels in the UK shipping sector. According to the report, the global clean shipping market is projected to create a value of \$15 billion per year by 2050, which is expected to bring the UK \$690 million annually by 2050. The government has taken a proactive step since 2020. Some representative examples are summarized below.

(a) UK SHORE

To achieve goals set in the Maritime 2050, the UK Government has decided to support the conversion of thousands of green ships through an investment of £206 million (\$279 million). As part of this effort, in the first half of 2022, the UK Government launched a new type of government-led shipping office, UK SHORE (UK SHipping Office for Reducing Emissions) (Port Technology 2022).

UK SHORE is drawing attention as it will greatly contribute to the construction and operation of green ships through continuous cooperation with domestic industry, academia, and research, including the development of various R&D programmes. In addition, UK SHORE is expected to play a major role in the development and the dissemination of industrial facilities to achieve zero GHG emissions in shipping. The strategy includes the development of various technologies and facilities for the conversion of cleaner fuels including hydrogen, electricity, and ammonia, and is expected to be a major driving force in the transition of UK shipping from conventional carbon-based fuels to carbon-free fuels.

(b) MarRI-UK (Innovation through Maritime Research and Innovation UK)

MarRI-UK is an industry/university/research-led cooperative organization (or center), established in July 2019 to encourage the development and cooperation of clean technologies in UK shipping.

The center is based at the University of Strathclyde in Scotland, UK, and supports various R&D and cooperation in the maritime sector. As of September 2022, 7 industry institutions, 7 universities in UK, 4 associate institutions, and 3 partner institutions are affiliated with the organization as shown in Figure 4.

Recently, MarRI-UK submitted a tender requesting a £530 million government co-investment to the UK Government to develop a clean maritime transport network. If the bid is successful, the UK will convert more than 25% of land freight transport to green sea transport by 2030, which will reduce land-based carbon emissions by 30%, including revenues of £1.8 billion and the creation of 39,000 additional jobs with 30–40% carbon reduction (MarRI-UK 2022).

(c) CMDC (Clean Maritime Demonstration Competition) Round 1 & 2

Meanwhile, the UK Government launched a clean maritime research and development programme called the Clean Maritime Demonstration Competition (CMDC) in March 2021 to promote the design and development of carbon-neutral ship technologies and clean ports with total public funding of £23 million (GOV.UK 2021).

Our research team also performed a life-cycle environmental assessment of low and zero-carbon energies in British shipping together with Caledonian Maritime Asset Ltd., a passenger ship company owned by the Scottish government, and the research results were submitted as data for the British government’s future planning.

In March 2022, CMDC Round 2 was launched, promising public investment of up to £12 million (GOV.UK 2022). The project proposal results have already been announced in early September 2022, and 31 projects have been selected and will be conducted for 8 months from January 1 to 31 August 2023.

As can be seen in Figure 5, a project for the development of a small-scale hydrogen bunkering station proposed by the authors’ consortium has also been successful. It will spur research and development together with the four consortium members in the future: Unitrove Innovation Ltd., University of Strathclyde, Zero Emissions Maritime Technology Ltd., and Acua Ocean Ltd.

The results from the CMDC programme are directly introduced at various events held by the British government (Maritime Week, COP 26, etc.). In addition, it is expected to become a major venue for UK industry/academic/research cooperation in the energy and shipping sector to lead active cooperation.

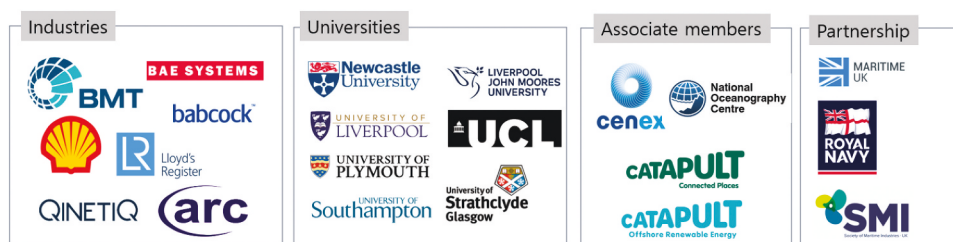


Figure 4. MarRI-UK members.

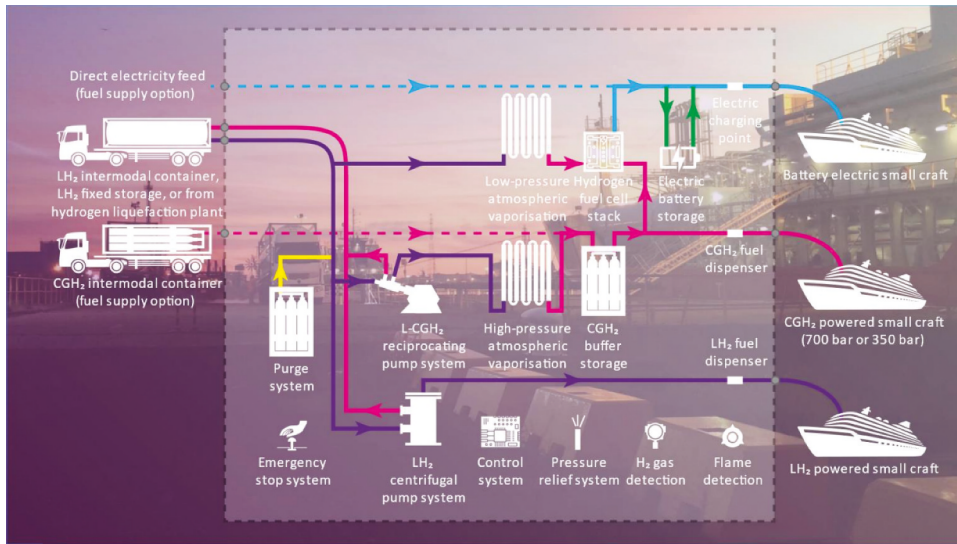


Figure 5. Overview of CMDC Round 2 Project of Zero-Emission Multi-Fuel Station (ZEMFS) for Hydrogen and Electric Small Craft.

EU Fit for 55

The European Commission (EC) has recently announced its commitment to achieving climate neutrality by 2050 through amendments to the EU Green Deal, well known as the European climate law. The EC has pledged to reduce GHG emissions by at least 55% (compared to 1990 levels) by 2030, while adopting the “Fit for 55” package with 13 proposals in July 2021 (European Council 2022). Among the proposals, this

paper discusses four proposals (legislations) that have a direct impact on the shipping sector as follows (marked as red in Figure 6).

(a) EU Emission Trading System (EU-ETS)

Based on the “Cap and Trade” principle, EU-ETS sets an upper limit on the total amount of GHG emissions from ships as shown in Figure 7. When it exceeds this limit, it is a representative market-based action system that buys and sells emission rights through a trading system. The upper limit is gradually lowered each year

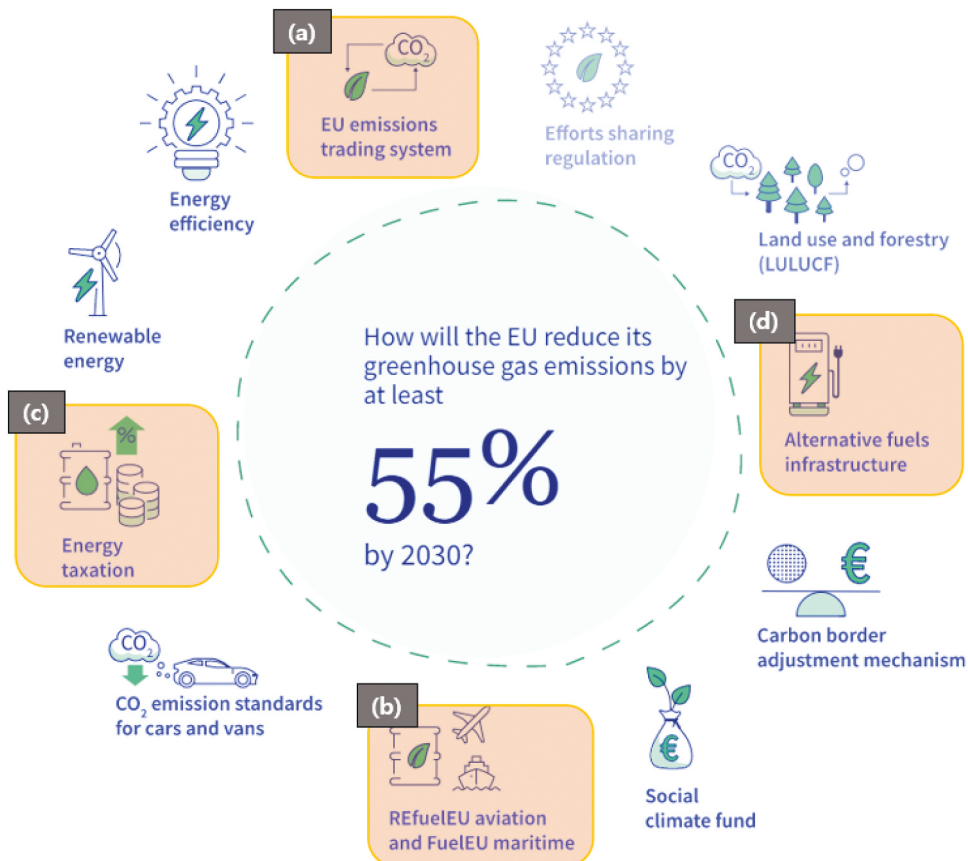


Figure 6. Fit for 55 Packages (European Council 2022).

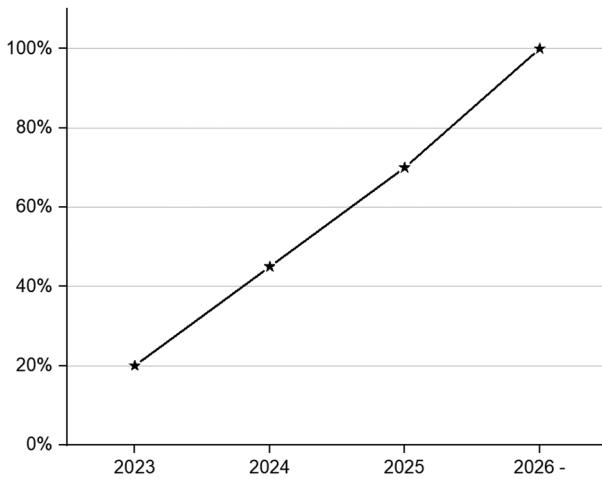


Figure 7. EU plan for the progressive application of EU-ETS (%) (European Council 2022).

and is ultimately targeted to achieve industry-wide carbon-neutral in Europe.

In other words, for ships engaged in EU voyages, additional emission rights must be purchased, or the emission level must be reduced within the upper limit. It is expected that a fine of at least 100 euros per ton of GHG emission will be imposed for the excess of the emission allowance. The implementation of the EU-ETS for the shipping sector is expected to begin in early 2023 and be phased out over a four-year period. This applies to all vessels of 5,000 Gross Tonnage (GT) and above calling in Europe, regardless of their flag states.

Meanwhile, it is worth paying attention to the consensus reached in COP 26 regarding Market-Based Measures (MBMs). Whereas existing MBMs were limited to transactions or taxation within individual countries, this agreement introduces a cooperative approach called the “International Carbon Market Mechanism.” In other words, it is possible to implement Nationally Determined Contribution (NDC) through voluntary cooperation so that carbon credits can be bought or sold through consultation not only between companies but also between countries. It is also noteworthy how the COP 26 agreement will affect international shipping.

(b) FuelEU Maritime

As part of the effort to achieve “Fit for 55,” the FuelEU Maritime proposal was submitted in July 2021, proposing an active code of action to lead to decarbonization in the shipping sector. The focus of this proposal is to promote the sustainable use of marine fuels by addressing market barriers and actively developing cleaner technologies.

This proposal targets all ships of 5,000 GT or above that call in Europe regardless of flag state. The carbon reduction goal is to set the intensity of average GHG generated on board ships in 2020 as the standard value, and to reduce it in stages as shown in Figure 8. In other words, it aims to achieve a reduction of 75% by

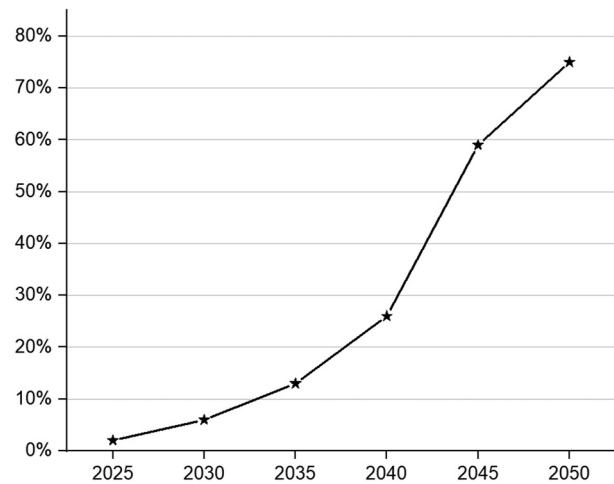


Figure 8. Plan for GHG intensity reduction proposed in FuelEU Maritime (European Commission 2021).

2050, starting with a 2% reduction in GHG emissions by 2025 (European Commission 2021).

Meanwhile, it should be noted that reduction target of the FuelEU Maritime does not simply take into account the onboard emissions (Tank-to-Wake, TtW), but also the life cycle GHG emissions (Well-to-Wake, WtW) of various fuels and related engine technologies.

According to the proposal regarding future marine fuels in Europe, it is recommended that the environmental impact of the fuel throughout its life cycle be specified in the Bunker Delivery Note (BDN). In addition, this evaluation method will be directly applied to MRV (Monitoring, Reporting and Verification), a system that monitors the fuel consumption and air pollution emissions from European ships, and is expected to be applied to MBMs discussed above.

(c) Energy Taxation Directive (ETD)

This proposal is a guide to the new tax structure and tax exemption benefits for marine fuels used and sold within the European Economic Area (EEA) from 2023, essentially encouraging the use of alternative fuels for ships in the EU. A recent revision was made to contain the core of reducing the tax rate of cleaner fuels used in passenger ships, fishing vessels, and merchant ships in Europe to a minimum (European Parliament 2022).

This is thought to be somewhat helpful in encouraging shipowners to use eco-friendly fuels, but it is uncertain whether it will have a decisive effect.

(d) Alternative Fuel Infrastructure (AFI)

As one of measures to support the FuelEU Maritime, this proposal is to secure Liquefied Natural Gas (LNG) bunkering infrastructure by 2025 and supply power to the port that can meet the demand of more than 90% of container ships and passenger ships in ports. It was proposed to prepare the facilities for installing the device (European Parliament 2022).

However, from the authors’ point of view, it is not expected that natural gas will be of direct help in reducing GHG emissions, and the installation of the

power supply also has different environmental impacts throughout the entire process depending on the method of generating electricity so that it is recommended that a careful analysis is necessary.

Climate change in shipping sector

Response of IMO

Despite the efforts of the international community to reduce GHG emissions discussed above, according to the 4th IMO GHG Study published in 2020, the total GHG emissions from the shipping sector (international, domestic, and fishery) were 977 million tons in 2012 to 1,076 million tonnes (as of 2018) with an increase of 9.6%.

From 2012 to 2018, the carbon emission reduction rate of international shipping improved to about 11%, but the actual total amount of carbon emission increased due to the steady increase in shipping volume. If this trend continues, GHG emissions from the shipping sector are predicted to increase by 50% to up to 200% by 2050.

To prepare countermeasures against this, the 75th Marine Environment Protection Committee (MEPC 75) of the IMO held in November 2020 deliberated on additional measures to reduce GHG emissions from international shipping. As a result, in June 2021, at MEPC 76, amendments to MARPOL Annex VI were adopted to reflect technical and operational goal-based measures to reduce the carbon intensity of international shipping.

Limitations

In COP 26, 2021, the Marshall Islands, the US and Denmark, which led the declaration of carbon neutrality in the shipping sector by 2050, raised their existing GHG reduction targets before 2023 based on the COP 26 agreements. Strong pressure was applied to adjust, including the Clydebank Declaration and the First Movers Coalition to establish Green Corridor, as discussed earlier in the paper.

However, despite the active agreement and target presentation at COP 26, the Member States of IMO have not reached an agreement on the upward adjustment of the GHG emission reduction target. In particular, the Marshall Islands, along with Kiribati and the Solomon Islands, submitted a resolution to MEPC 77 following COP 26 to achieve a target of zero GHG emissions in the shipping sector by 2050.

Also, above all, results from the COP 27 which will be held in Egypt in November 2022 are not expected to directly affect the work of MEPC 79 to be held in December. This can be seen as a limitation in that the discussions and agreements at COP 27 are non-

binding agreements rather than direct pressure on IMO.

Lifecycle environmental assessment

As mentioned above, the EU is making the introduction of a life cycle environmental assessment in the shipping sector through the FuelEU Maritime proposal. This is quite different from the “Eco-friendly Ship Act,” which is our domestic corporation.

According to the results from life cycle environmental assessment in EU, alternative fuels for ships, which are currently in the spotlight, such as hydrogen, ammonia, methanol, and electricity, also emit more environmental pollutants than conventional carbon-based ship fuels according to their production methods. This also led to the same results in the authors’ recent research results. In other words, the introduction of life cycle environmental assessment into the shipping sector is expected to act as a catalyst for shifting from the problem of what kind of fuel is used to the problem of how the fuel is produced as a marine fuel.

Europe as well as IMO started to discuss the introduction of a full-process analysis technique for ship fuel. At MEPC 73 in October 2018, as one of the short-term measures of the IMO initial strategy, the development of “Lifecycle GHG – carbon intensity guidelines for ship fuels” was adopted and the discussion began in earnest (MO 2018).

The guideline aims to complete development by 2023. Once the guideline is developed, the IMO will begin to discuss how to apply it to ships. There is a strong possibility that it will be enforced later.

This is expected to have a significant impact especially on shipping industries in the Republic of Korea. Since “eco-friendly technologies” specified in the domestic law are defined based on shipboard emissions, there is a sufficient possibility that there will be cases in which they would not be recognized in Europe in the future. Considering the characteristics of ships engaged in international voyages, understanding and active response to laws and regulations of other countries is essential. Accordingly, it is judged that the introduction of a new domestic law that reflects the international movement for decarbonization in shipping sector is more important and urgent.

Conclusions

This paper was focused on the review of international and local efforts to reduce GHG emissions from ships in terms of strategy, agreement, and regulation.

First, the impact of Clydebank Declaration made at COP 26 in 2021 was reviewed. The declaration proposed the goal of achieving net-zero GHG emissions in the shipping sector by 2050 with specific measures

such as Green Corridor. Until now, three Green Corridors have been agreed or are under discussion at bilateral level. However, transition from conventional fuels to alternative fuels such as electricity, ammonia, and hydrogen currently would increase the cost of the entire process which would burden shipping companies and governments. Therefore, consideration on financial support from government, international cooperation, and other measures such as energy taxation would be needed with development of innovative technologies to reduce the burden.

Second, international policies and activities, especially in UK, EU, and IMO, were discussed with introduction of specific programmes for the development of technologies and facilities, and policies to facilitate cleaner future in the maritime sector. It should be noted that life cycle assessment into the shipping sector is under discussion and is expected to act as a catalyst for shifting from the problem of what kind of fuel is used to the problem of how the fuel is produced.

Currently, it is expected that GHG emissions from shipping sector would be increased by at least 50% by 2050. Therefore, in order to achieve the ultimate target set in the Paris Agreement for reduction of GHG emissions, creative and innovative approaches rather than traditional and incremental approaches with a wide range of technological solutions and international cooperation are needed at national and international levels.

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References

- European Commission. (2021). *Proposal for a regulation of the European parliament and of the council on the use of renewable and low-carbon fuels in maritime transport and amending Directive 2009/16/EC*. https://ec.europa.eu/info/sites/default/files/fueleu_maritime_-_green_european_maritime_space.pdf.
- European Council. (2022). *European Green Deal - Fit for 55*. <https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/>.
- European Parliament. (2022). *Revision of the Directive on Deployment of Alternative Fuels Infrastructure*. <https://www.europarl.europa.eu/legislative-train/carriage/revision-of-the-directive-on-deployment-of-alternative-fuels-infrastructure/report?sid=6101>.
- European Parliament. (2022). *Revision of the Energy Taxation Directive: Fit for 55 Package*. [https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/698883/EPRS_BRI\(2022\)698883_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/698883/EPRS_BRI(2022)698883_EN.pdf).
- GOV.UK. (2021). *Clean Maritime Demonstration Competition (CMDc)*. <https://www.gov.uk/government/publications/clean-maritime-demonstration-competition-cmdc>.
- GOV.UK. (2022). *Clean Maritime Demonstration Competition Round 2 - Feasibility*. <https://apply-for-innovation-funding.service.gov.uk/competition/1190/overview>.
- IMO. (2018). *Lifecycle GHG - carbon intensity guidelines*. Retrieved 2022 24, October, from <https://www.imo.org/en/OurWork/Environment/Pages/Lifecycle-GHG—carbon-intensity-guidelines.aspx>.
- IMO. (2018). *Resolution mepc.304(72) - initial imo strategy on reduction of ghg emissions from ships*.
- The Maritime Executive. (2022). *World's Longest Green Corridor Planned Between Singapore and Rotterdam*. <https://maritime-executive.com/article/world-s-longest-green-corridor-planned-between-singapore-and-rotterdam>.
- MarRI-UK. (2022). *Zero-carbon coastal highway*. <https://www.marri-uk.org/zero-carbon-coastal-highway>.
- Offshore Energy. (2022). *US steps up efforts to enable green shipping corridors*. <https://www.offshore-energy.biz/us-steps-up-efforts-to-enable-green-shipping-corridors/>.
- Park, C., Jeong B, Zhou P, Jang H, Kim S, Jeon H, Nam D, Rashedi A. (2022). "Live-Life Cycle Assessment of the Electric Propulsion Ship Using Solar PV." *Applied Energy* 309: 118477. doi:10.1016/j.apenergy.2021.118477.
- Port of Antwerp Bruges. (2022). *The Port of Antwerp and the Port of Montreal Pledge to Create a Green Shipping Corridor*.
- Port Technology. (2022). *UK Government launches SHORE green shipping project*. <https://www.porttechnology.org/news/uk-government-launches-shore-green-shipping-project/>.
- ShippingNewsNet. (2021). *Top 8 countries with the largest shipping fleets as of January 2021 (unit: Million DWT)*. <https://www.shippingnewsnet.com/news/articleView.html?idxno=44283>.
- UK Department for Transport. (2019). *Maritime 2050 Navigating the Future*.