# GHG Reduction Strategy for International Shipping and Related Solution Technology of Mitsubishi Shipbuilding

KOICHI SATO*[1]

*In July 2023, the International Maritime Organization (IMO) extensively revised its GHG Strategy and set the target for 2050 at net zero, strengthened from the previous target of 50%. The IMO also made the interim target for 2030 more challenging. This report analyzes the impact of the 2023 IMO Strategy on Reduction of GHG Emissions from Ships (2023 IMO GHG Strategy) and describes the tasks for its realization and evaluates the impact of the transition to zero emissions in ship design. It is considered that the environment-related technologies being developed by Mitsubishi Shipbuilding Corporation (hereinafter Our company) will be effective as measures to comply with future environmental regulations, and that the use of our comprehensive shipbuilding engineering technologies will be effective as well.*

## 1. Introduction

Shipping is a so-called "hard to abate" sector, i.e., its decarbonization is more difficult than other sectors. On the other hand, GHG emissions from shipping account for about 3% of total GHG emissions and are therefore not negligible. In response to the actions of the IPCC, COP, etc., the shipping industry has also set emission reduction targets. In international shipping, the International Maritime Organization (IMO) set in 2018 a target to reduce total carbon dioxide ($CO_2$) emissions from international shipping to 50% of its 2008 level by 2050. In addition, at IMO's July 2023 meeting, it adopted the 2023 GHG Strategy, which includes a target of net zero GHG emissions by around 2050. **Figure 1** shows the timeline of the reduction target. This report describes the content of the 2023 IMO GHG Strategy, which will have a significant impact on the international shipping industry, and discusses its impact on shipbuilding design and the technologies required to deal with it.

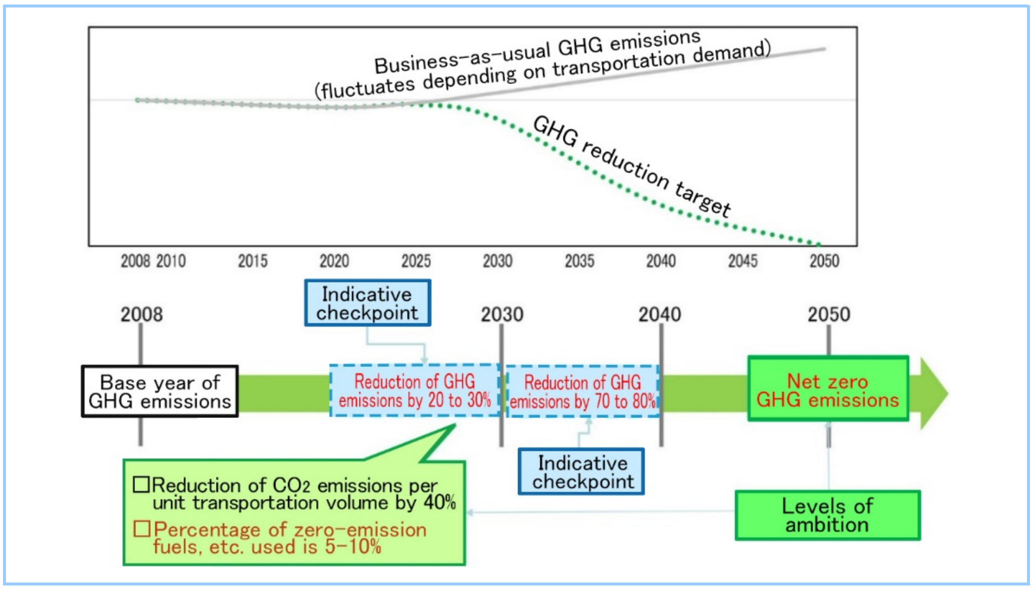


**Figure 1 Target and timeline for reducing GHG emissions from international shipping**

*1 Deputy Director, Ship & Ocean Engineering Department, Marine Engineering Center, Mitsubishi Shipbuilding Co., Ltd.

## 2. Content of 2023 IMO GHG Strategy and its impact

The content of the IMO GHG Strategy revised in July 2023 is as follows:

(1) GHG emissions from international shipping to reach net zero to peak GHG emissions from international shipping as soon as possible and to reach net-zero GHG emissions by or around, i.e., close to, 2050, taking into account different national circumstances, whilst pursuing efforts towards phasing them out as called for in the Vision consistent with the long-term temperature goal set out in Article 2 of the Paris Agreement.

(2) Carbon intensity of international shipping to decline to reduce $CO_2$ emissions per transport work, as an average across international shipping, by at least 40% by 2030, compared to 2008; (tank-to-wake)

(3) Uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources to increase uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources to represent at least 5%, striving for 10%, of the energy used by international shipping by 2030.

With the indicative checkpoints;

- To reduce the total annual GHG emissions from international shipping by at least 20%, striving for 30%, by 2030, compared to 2008; and
- To reduce the total annual GHG emissions from international shipping by at least 70%, striving for 80%, by 2040, compared to 2008.

At this point, there is no clear common understanding within the industry regarding the specific impact of the above numerical targets and the means to achieve them, and now analyses and proposals are being made by the classification societies and industry associations.

The above (2) is a reduction target for shipboard $CO_2$ emissions per unit transportation volume, and is the same as the target as of 2018. This corresponds to the effectiveness of the regulations currently being applied by the IMO for new and existing vessels (EEDI/EEXI) and corresponds to the effect of the fuel efficiency rating in terms of operation, known as the Carbon Intensity Index (CII).

The above (1) and (3) are the targets that have been strengthened in 2023. These targets will have a significant impact on future ship design, due to the inclusion of GHGs other than $CO_2$ such as methane ($CH_4$) and nitrous oxide ($N_2O$) as targets of the regulation, and the introduction of well-to-wake assessments, etc. First, we analyze the target for the most recent year, 2030. According to an analysis by Nippon Kaiji Kyokai (Class NK) [(1)], if only the conversion to zero-emission fuels is considered as an additional measure to the current efforts including (2), it is estimated that the 10% introduction set by (3) is insufficient to achieve the 20% reduction target for 2030, and that it is necessary to replace 25% of fossil fuels with zero-emission fuels. The 25% of the total energy consumption of international shipping is equivalent to about 110 million tons of ammonia per year, which is about 60% of the current ammonia production for all sectors. Considering that the energy consumption of shipping accounts for about 3% of current total energy use, it is predicted that the replacement of more than 10% with zero-emission fuels, which is the target set in (3), is quite difficult to achieve. The Maersk Mc-Kinney Moller Center for Zero Carbon Shipping (MMMCZCS) in Denmark, a research institute established to promote the decarbonization of ships, has conducted a similar analysis[(2)], and suggests that the replacement with zero-emission fuels may be limited to about 10% and that the target be achieved through further energy savings. **Figure 2** shows an image of the MMMCZCS analysis. Even with a 10% zero-emission fuel substitution, 40 to 50 million tons of ammonia would be required annually, equivalent to 30% of the current total sector supply for marine fuel. As for the remaining measures, namely energy saving, the baseline before reduction already incorporates a considerable amount of the effects of the regulations currently being applied, and further energy savings will require low-speed operation and the introduction of new technologies. Thus, there are issues in both zero-emission fuel substitution and further promotion of energy conservation, and the image of the contribution ratio between the two in achieving the 20% reduction target for FY2030 has not yet been determined.

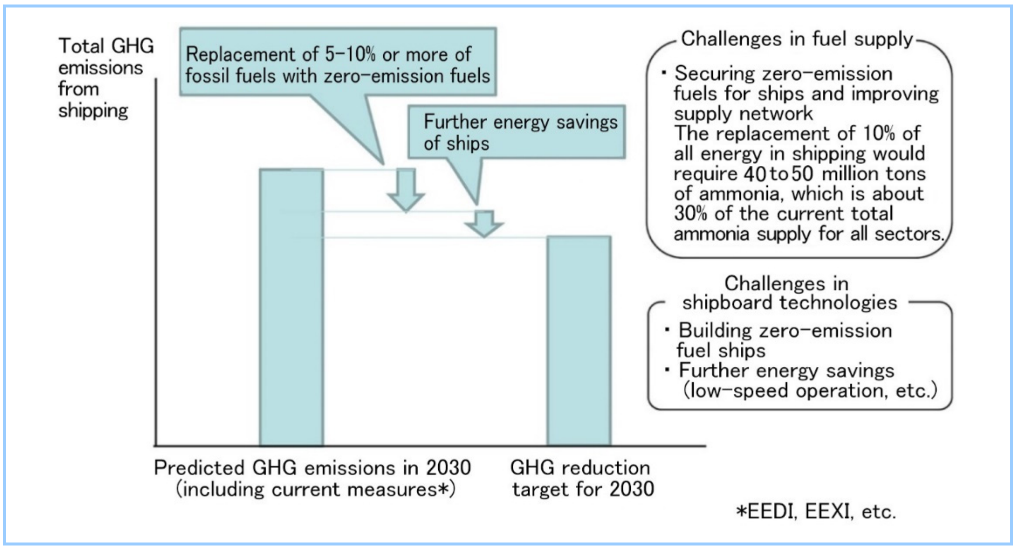


**Figure 2 Illustration of scenario for achieving targets of 2023 IMO GHG Reduction Strategy**
This figure shows the impact of the reduction target strengthened in 2023.

As described above, the specific solution scenarios for the 2023 IMO GHG Strategy are still being explored even for the realization of the most recent 2030 target, the IMO is also discussing mid-term measures to achieve net-zero emissions by 2050 with a view to post 2030, and the proposed measures, including a system to gradually strengthen the control of annual GHG emissions of ships (GFS), a charging system based on GHG emissions (Levy), and a system combining a charge for fossil fuel ships and a refund for zero-emission fuel ships (Feebate) are to be fleshed out in the future. The 2023 IMO GHG Strategy also stipulates the agreed schedule aiming at the adoption of a concrete system of the mid-term measures by the end of 2025 and the entry into force of the system in 2027.

Prior to this, in Europe, where decarbonization is a major concern, the target of reducing emissions by 55% or more compared to the 1990 level by 2030 ("Fit for 55") has been set, and for shipping, the EU Emissions Trading Scheme (EU-ETS) and FuelEU Maritime will be introduced in January 2024 and January 2025, respectively. The extension of the EU-ETS to the shipping sector will require the purchase and amortization of emissions quotas equivalent to the annual GHG emissions of ships on EU-related voyages. Any under-amortized quota will be subject to a fine of 100 euros per ton of $CO_2$ equivalent and must be amortized in the following year. FuelEU Maritime is a system to promote the transition to low-carbon or zero-emission fuels, in which GHG intensity regulations for fuels and the mandatory use of shore power at anchor (for containerships and passenger ships) will be scheduled. In the U.S., subsidies under the Inflation-Reduction Act (IRA) may accelerate the production of zero-emission fuels. Thus, in addition to IMO regulations, regional and national policies and regulations are expected to have a significant impact on the future of shipping.

## 3. Impact of transition to zero emissions in ship design

Candidate technologies to promote the transition to zero-emission ships include: further operational optimization through low-speed operation, energy savings through new technologies (e.g., wind power utilization and air lubrication), fuel conversion (e.g., LNG, methanol, ammonia, biofuel and hydrogen), shipboard $CO_2$ capture, electrification, enlargement, weight reduction, and nuclear power.

The effects of conventional technologies such as hull shape optimization, additional stern equipment, and low-friction paints are considered to have already been partly incorporated into the transportation efficiency target (40% of the 2008 level) of IMO GHG Strategy. For further energy savings in addition to the above, it is expected that new technologies such as wind power assistance and friction reduction by air lubrication will be additionally applied, in addition to the reduction of ship speed. It is also important to optimize propellers in response to lower vessel speeds and additional stern equipment for energy savings.

International shipping involves long-distance, large-volume transport and there are many challenges to electrification. Among the above, in addition to energy-saving technologies, fuel conversion, shipboard $CO_2$ capture, and a combination of these are considered to be candidates for the solution to said challenges.

Whether the future application of fuel conversion and shipboard $CO_2$ capture is promoted depends significantly on conditions such as the improvement of onshore fuel supply, fuel prices, and the location of the bunkering base (required range of ships). In addition, carbon taxes due to regulations, subsidies, and other factors will also have a significant impact. In future ship design, it is important to combine new zero-emissions ship technologies with conventional technologies in consideration of these external conditions, and to evaluate and optimize the obtained design solution based on the Total Cost of Ownership (TCO), which is the sum of capital expenditure (ship cost), operating expenditure, and fuel cost.

**Figure 3** shows an example case study of estimating and comparing the change in total costs for a medium-sized oil tanker with the transition to zero-emission (i.e., the conversion to ammonia fuel and the application of a shipboard $CO_2$ capture system). The estimation results show that the total cost of an ammonia-fueled ship and a ship with a shipboard $CO_2$ capture system are comparable to that of a conventional oil-fueled ship when $CO_2$ is charged at about 250 USD/ton. This suggests that strong regulations, such as carbon charges or subsidies, are necessary to promote the transition to zero-emission. Furthermore, there is no clear preference among the means of the transition to zero-emission at this point, and the choice of means will be influenced by the development progress of related technologies, the progress of the onshore supply chain, regulatory changes, and the progress of safety measures for new fuels. Therefore, it is considered that being prepared to respond to these conditions is necessary at this time, and that accumulating general-purpose zero-emission technologies is important.

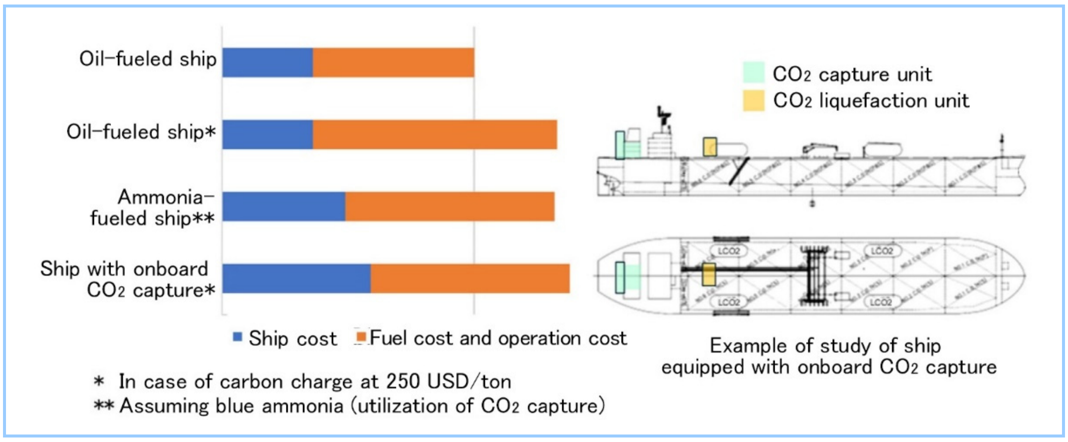


**Figure 3 Example of estimation of change in total cost due to transition to zero-emissions**

## 4. Solution technology of Our company

As described above, the transition to zero-emission ships is greatly influenced by trends in fuel supply and regulations, and thus it is important to develop related equipment and elemental technologies, and to prepare a design capability that enables responses to these trends in a versatile manner. Necessary technologies to combine these factors and establish zero-emission ships include the following.

(1) Elemental technologies for hull design
- Hull form development technology
- Arrangement design technology and structural design technology (advanced structural analysis technology)
- Tank design technology (structural design, material development, thermal protection design, and construction method)

(2) Equipment system design technology
- Gas handling technology
- Propulsion plant design technology
- Electrical system design technology

A ship with alternative fuel requires a dual fuel (DF) engine and a related fuel gas supply system (FGSS)[3]. The development of ammonia DF engines is proceeding as planned, with the target being for a ship to be delivered in 2026; the number of ammonia-fueled ships in service is expected to gradually increase after 2026. **Figure 4** shows a conceptual view of the design procedure to convert conventional ships to zero-emission ships using these elemental technologies. The transition to zero-emission ships will be achieved by adding new technologies such as ammonia main engines, ammonia handling, and onboard $CO_2$ capture, based on general shipbuilding engineering technologies and gas handling technologies (liquefied gas-related technologies) that have been accumulated over the years.

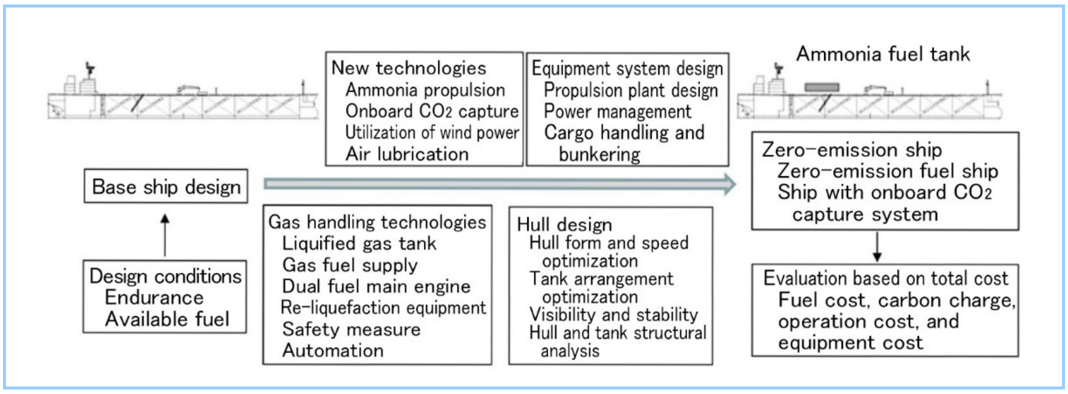


**Figure 4 Conceptual view of zero-emission ship design**

As specific examples, **Figure 5** shows the elemental technologies required for the transition to zero-emission ships and the corresponding products and services of Our company. The gas handling technology, based on our long-cultivated technologies for designing and building liquefied gas carriers, is a package of zero emission-related technologies consisting of extracted core technologies for gas carriers. The energy-saving hull form development technology, which is as important as fuel conversion, incorporates the abundant experience in hull shape development and technologies for tank testing and CFD analysis we and Mitsubishi Heavy Industries Co., Ltd Research & Innovation Center have cultivated to enable the evaluation of hull forms and the design of propellers according to operating conditions, such as lower speeds, and is applied to the ships we build and engineering services we provide.

The advanced structural analysis technology contributes to securing the structural reliability of liquefied gas tanks on gas carriers and is indispensable for ensuring the safety of large-capacity ammonia fuel tanks, in particular. The 3D design technology, which is a general ship design technology, is also an elemental technology necessary for zero-emission ships with complicated equipment arrangements.

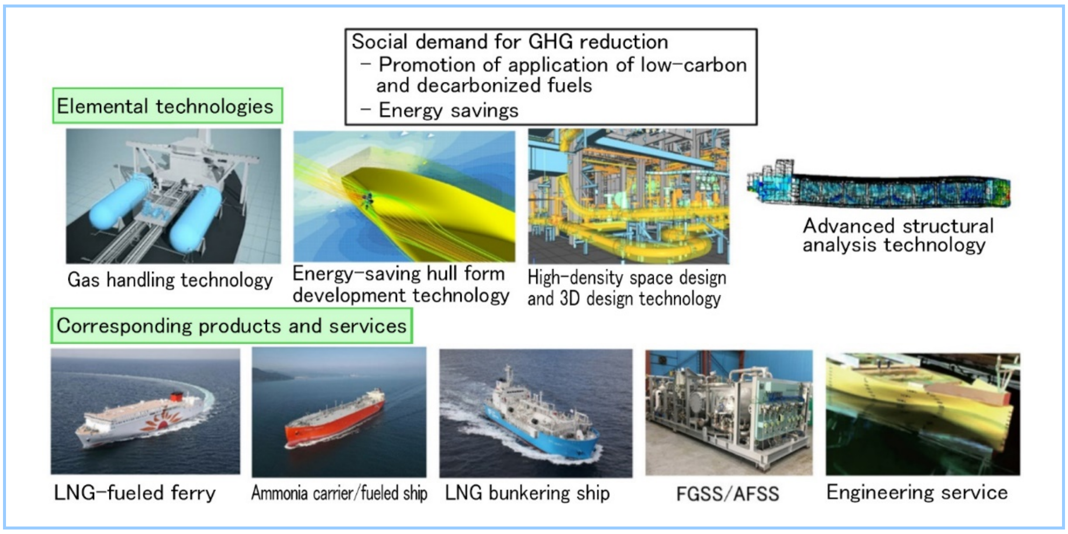


**Figure 5 GHG reduction-related technologies of Mitsubishi Shipbuilding**

In this Technical Review Vol. 61 No. 2 (2024), the reports providing details of the gas handling technology and introduction of related newbuilding ships, follow.

## 5. Summary

The IMO has extensively revised its GHG Strategy and set the target for 2050 at net zero, strengthened from the previous target of 50%. Our analysis of the impact of the 2023 GHG Strategy showed that achieving the target of international shipping requires a strong promotion of fuel conversion and further energy savings. In conjunction with the necessary development of regulatory and the infrastructure of the onshore fuel supply, there are many uncertainties in ship design conditions. So, general-purpose zero-emission technologies are required. We believe that our environment-related technologies and comprehensive shipbuilding engineering technologies can contribute to the zero emission of ship.

The reduction of GHG emissions is a major issue, and we promote it not only by ourselves but also in cooperation within the Mitsubishi Heavy Industry Group and with external organizations. Examples of the cooperation within the Group include a joint project "Project MaTIS: Marine Technology, Integration & Solutions" with Mitsubishi Heavy Industries Marine Machinery & Equipment Co., Ltd. in addition to cooperation with the MHI Research & Innovation Center. We participate in the Planning and Design Center for Greener Ships (GSC), a core organization that continuously plans and disseminates cutting-edge ships for the transition to zero-emission international shipping, in order to promote the commercialization of next-generation eco-friendly ships. In terms of research and development, we, as a member of the Mitsubishi Heavy Industry Group, are participating in and contributing to the aforementioned Maersk Mc-Kinney Moller Center for Zero Carbon Shipping as a founding partner. MODE, which is a joint industry-academia research program for shipbuilding and shipping at the University of Tokyo, and in which we are participating, also considers the transition to zero-emission shipping to be a major issue.

We will continue developing our technologies to contribute the transition to zero-emission of the international shipping.

## References

(1) ClassNK, Pathway to Zero-Emission in International Shipping – Understanding the 2023 IMO GHG Strategy – (2023), https://www.classnk.or.jp/hp/en/index.html

(2) Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, Implications of the 2023 IMO GHG Strategy for the Shipping Industry, (2023), https://www.zerocarbonshipping.com/

(3) Shin Ueda et al., "LNG as fuel" to "Ammonia as fuel" (Ship's fuel transition to achieve carbon neutrality) Mitsubishi Heavy Industries Technical Review Vol. 59 No. 2 (2022)