KR

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PROVIDING THE BEST SERVICES, CREATING A BETTER WORLD

KR is a world-leading, technical advisor
to the maritime industry, safeguarding life,
property and the environment through
the pursuit of excellence in its rules and standards.

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Since the IMO declared its goal in 2023 of achieving Net-Zero greenhouse gas emissions in the shipping industry by 2050, the global shipping industry has been paying close attention to the upcoming MEPC 83rd session scheduled for this April. The mid-term measures expected to be approved at this meeting will significantly impact the global shipping industry. Ongoing intersessional working group discussions are addressing sharp divisions among member states regarding these measures. In particular, there has been intense debate over establishing standards for the Goal-based Fuel Standard (GFS) as a technical measure and whether to introduce carbon taxes as an economic measure.

This winter issue delves into the definition of the Goal-based Fuel Standard (GFS) - a cornerstone of achieving the IMO's 2050 net-zero emissions target -and provides scenario-based projections of the regulatory levels anticipated by 2050. Establishing GFS regulations requires a sustainable, practical, and balanced approach, grounded in a thorough understanding of the industry's dynamics and their profound impact.

Achieving decarbonization goals necessitates a transition to zero-carbon or carbon-neutral fuels such as biofuels, methanol, and ammonia. However, these alternatives are significantly more expensive than conventional fossil fuels, prompting shipping companies to explore every possible energy-saving device to reduce fuel consumption. Among these, wind-assisted propulsion systems stand out as particularly effective for ships operating on routes with favorable environmental conditions. By directly harnessing wind power, these systems achieve high efficiency and may qualify for separate incentives under FuelEU Maritime. Despite their benefits, wind-assisted propulsion systems involve high costs, and their efficiency varies depending on the ship and route. Consequently, shipping companies must carefully evaluate their cost-effectiveness before making installation decisions. This issue highlights KR's method for predicting actual fuel savings when installing wind-assisted propulsion systems for specific routes and vessels.

We are also excited to feature an exclusive interview with Mr. LEE Won, Team Leader at Hyundai Glovis, a leading company advancing decarbonization policies. He discusses the company's roadmap for decarbonization, adoption of energy-saving technologies, compliance strategies for IMO and EU greenhouse gas regulations, and plans to transition to alternative fuel-powered vessels. In addressing the specific needs of its PCTC (Pure Car and Truck Carrier) shippers, Hyundai Glovis is strengthening its ESG management practices and implementing robust safety measures to address Scope 3 emissions reduction goals and mitigate risks associated with electric vehicle fires. This interview offers valuable insights for shipping companies seeking to develop effective decarbonization strategies.

KR has been conducting extensive research into fire risks aboard PCTCs, and this issue highlights KR's report on the safe maritime transport of electric vehicles. The issue also covers KR's recent signing of MOUs with domestic shipyards, shipping companies, and flag states to establish ammonia bunkering safety standards, as well as its participation in NEMO (Nuclear Energy Maritime Organization), an international private organization dedicated to the application of nuclear energy in the maritime sector. Additionally, KR is actively involved in developing IMO safety regulations for ammonia and hydrogen, and revising the Carbon Intensity Indicator (CII). Updates on these initiatives will continue to be featured in future editions of this magazine.

At the end of 2024, KR hosted a green conference titled "Time for Action Towards Green Shipping". The conference featured diverse presentations, including KR's decarbonization support services, shipping companies' decarbonization strategies, and technological advancements by shipyards. It served as a platform for participants to share the understanding that the shipping industry can no longer afford to hesitate but must actively pursue and implement decarbonization strategies. There is no such thing as the perfect moment to start-now is the time to set sail. KR is fully committed to supporting these efforts and will remain a reliable partner throughout our customers' green journey.

Head of KR Decarbonization · Ship R&D Center SONG Kanghyun

KR Decarbonization Magazine

Insights_

Sailing Toward 2050 Decarbonization: Pathways and Challenges for GHG Reduction in International Shipping

HA Seungman, Principal Surveyor of KR Machinery Rule Development Team

GHG Emission Reduction Mechanism in the 2023 IMO Strategy

The International Maritime Organization (IMO) established its 2023 GHG Strategy for the Reduction of GHG Emissions from Ships, setting the ambitious goal of achieving Net-Zero greenhouse gas (GHG) emissions by or around 2025 in the international shipping sector. To realize this objective, adopting sustainable marine fuels with near-zero lifecycle GHG emissions is critical. This can be achieved through mid-term measures, such as the Goal-based Marine Fuel Standard (GFS), which regulates the phased reduction of GHG intensity in marine fuels.

Among the mid-term measures discussed at IMO, GFS, as a technical measure, is closely related to the annual GHG emissions of international shipping. As illustrated below, the annual GHG emissions of international shipping can be calculated as the product of total energy consumption and GHG fuel intensity (g CO2eq./MJ). This calculation is based on a Well-to-Wake (WtW) perspective. While completely eliminating energy consumption is practically impossible, Net-Zero GHG emissions can be achieved by utilizing fuels with near-zero GHG intensity.

Mechanism of Annual GHG Emission Reduction Through GFS

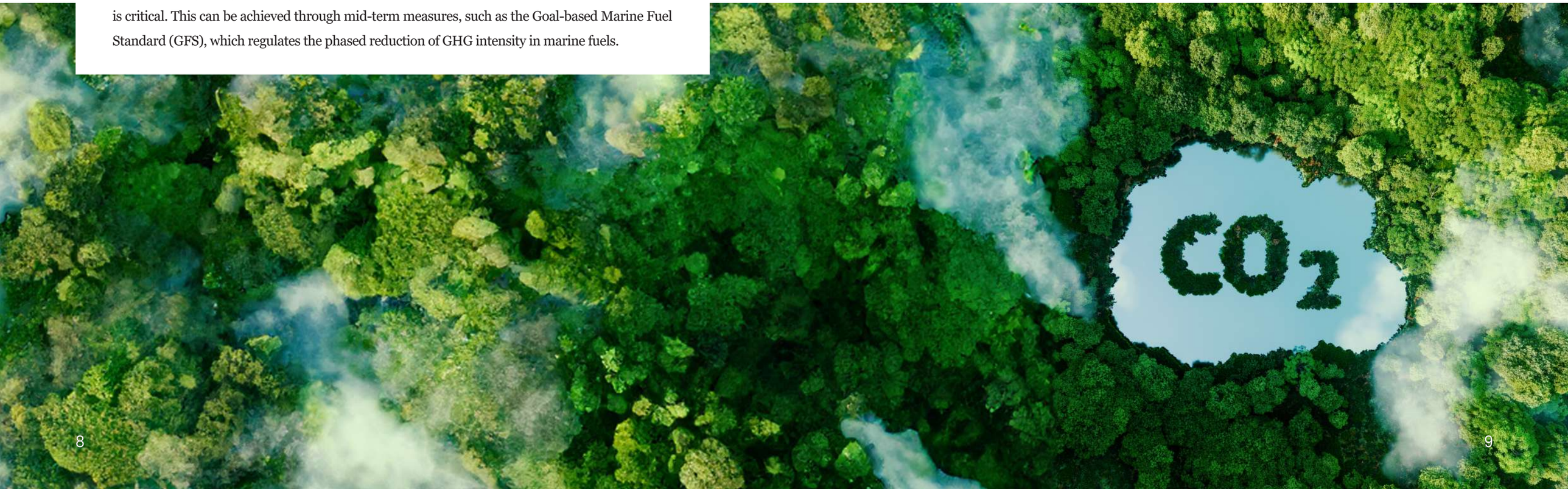
IMO Net-Zero Framework

Mid-Term Measure

Goal-based Fuel Standard(GFS) + Economic Mechanism

▸ **GFS** regulating the phased reduction of the marine fuel's GHG intensity

The **total annual GHG emissions** from international shipping (Targets) ≥
The total energy consumption (MJ) from international shipping X
GHG fuel intensity (g $CO_{2eq.}$/MJ)



Analysis of GHG Emission Reduction Pathways in the IMO 2023 Strategy

To establish clear emission reduction pathways aligned with the IMO 2023 strategy, it is essential to analyze the factors influencing GHG emissions in international shipping.

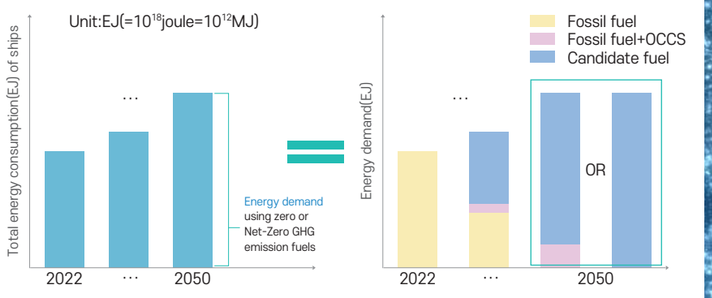
1. Calculation of Annual WtW GHG Emissions

The trajectory of annual GHG emissions in international shipping is assumed to be determined by two primary factors: total energy consumption and GHG fuel intensity (GHG Fuel Intensity).

1-1. Total Energy Consumption

The left graph in Figure below illustrates the potential increase in total energy consumption driven by global trade expansion and the rising demand for international shipping. The graph on the right conceptually depicts the transition to sustainable fuels required to achieve Net-Zero GHG emissions by 2050. This transition is expected to occur as fossil fuels are gradually replaced with zero-GHG emission fuels or fossil fuels equipped with Onboard Carbon Capture Systems (OCCS). This suggests that the projected total energy consumption in international shipping will serve as a key indicator for assessing the future demand for alternative fuels.

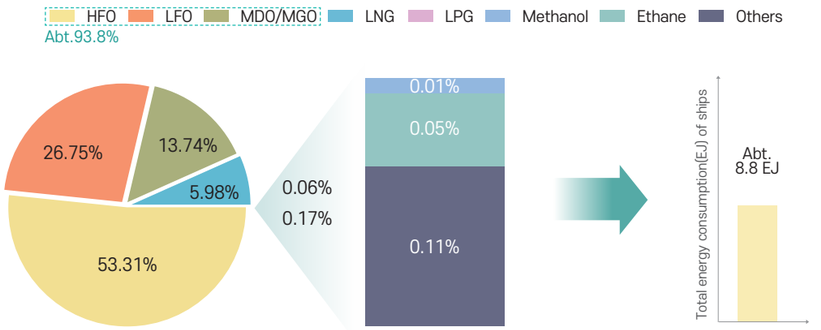
Changes in Energy Consumption and Transition to Sustainable Fuels in International Shipping



Based on the 2022 IMO DCS data, total energy consumption in international shipping was estimated using projections for transport work and assumptions regarding energy efficiency improvements.

Baseline Year (2022) Energy Consumption: According to data from the IMO Data Collection System (DCS), the total energy consumption for the baseline year was approximately 8.8 EJ (10^{18} J). Of this, approximately 94% relied on fossil fuels, while alternative fuels accounted for a relatively small share.

Fuel Consumption in the IMO Data Collection System (DCS)



Projections for Transport Work: Using the low-growth scenario (OECD_RCP 2.6_G) and the high-growth scenario (SSP2_RCP2.6_L) from the 4th IMO GHG Study, transport work is projected to increase significantly by 2050. Compared to 2022 levels, the low-growth scenario assumes an increase of approximately 32%, while the high-growth scenario projects an increase of about 92%.

Assumptions on Transport Work Growth

Scenarios	2008	2018	2022	2030	2040	2050
Low Growth (OECD_RCP 2.6_G)	0.67	0.95	1.00	1.08	1.22	1.32
High Growth (SSP2_RCP2.6_L)	0.67	0.95	1.00	1.32	1.63	1.92

Energy Efficiency Improvements: Technological advancements and regulatory measures, such as the Energy Efficiency Design Index (EEDI) and the Carbon Intensity Indicator (CII), are projected to improve the energy efficiency of international shipping from approximately 30% in 2022 to 50% by 2050.

Assumptions on Energy Efficiency Improvement

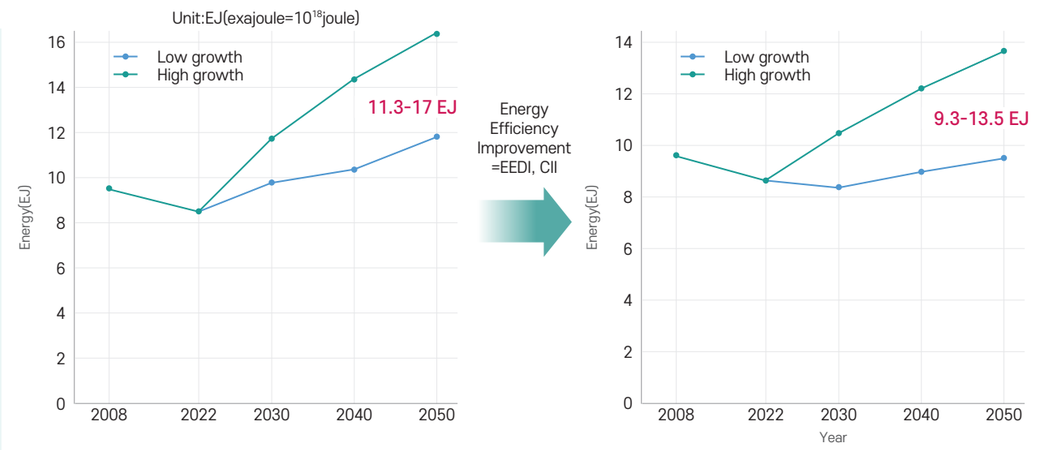
Year	2008	2022	2030	2040	2050
Improvement Rate	0%	29.95%	40%	45%	50%

1-2. Energy Consumption Projections in International Shipping

Projections for total energy consumption in the future are based on changes in transport work (considering both low-growth and high-growth scenarios) and energy efficiency improvements in the international shipping sector.

Under the high-growth scenario without energy efficiency measures, total energy consumption is estimated to reach up to 17 EJ by 2050. In contrast, with energy efficiency measures in place, total energy consumption is projected to decrease to between 9 EJ and 13.5 EJ, depending on the scenario. This indicates that energy efficiency improvements play a critical role in effectively reducing overall energy demand, especially given the limited availability of alternative fuels.

Projections for Energy Consumption Based on Efficiency Improvements



2. Annual WtW GHG Emission Targets

The IMO 2023 strategy sets out annual GHG emission reduction targets for 2030 and 2040, as shown in the figure below, based on 2008 as the baseline year.

Reduction Targets in the IMO 2023 Strategy

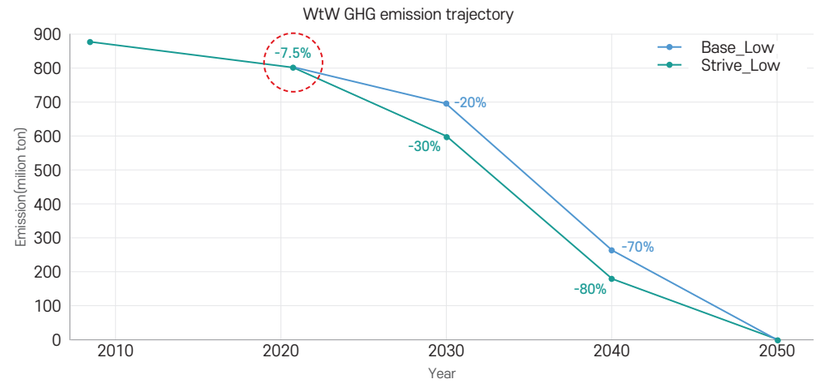
Levels of ambition	Indicative checkpoint
"to reach Net-Zero GHG emissions by or around 2050"	· at least 20%, striving for 30%, by 2030, compared to 2008 · at least 70%, striving for 80%, by 2040, compared to 2008

2008 WtT Emissions were calculated based on fuel consumption data (HFO, MDO, LNG) from the Third IMO GHG Study and emission factors from the FuelEU Maritime framework.

2008 TtW Emissions were derived using 2022 IMO DCS data, with retrospective estimation of 2008 transport work and energy efficiency levels (see Tables 1 and 2).

The analysis indicates that total emissions in 2022 were approximately 7.5% lower than in 2008, which implies that an additional 12.5% reduction is required to meet the 2030 target of 20% reduction.

Emission Reduction Targets Based on the IMO 2023 Strategy



The estimated WtW emissions for vessels above 5,000 GT in 2008 have direct implications for setting annual emission targets for 2030, 2040, and 2050 in international shipping. They also significantly affect the determination of GHG fuel intensity targets, with the following structural considerations:

If 2008 emissions are underestimated: More stringent GHG fuel intensity values will be required.

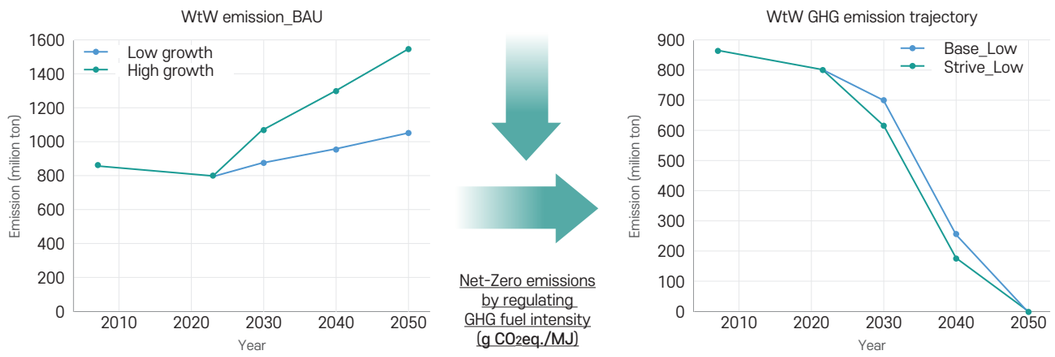
If 2008 emissions are overestimated: Relatively lenient GHG fuel intensity values may suffice.

Accurate calculation and assumptions for 2008 emissions are therefore essential for establishing fair and achievable targets that align with the IMO's reduction strategy and regulatory framework.

3. GHG Fuel Intensity Requirements

The requirements for GHG Fuel Intensity (GFI) are currently under review as part of the technical measures in the IMO's mid-term measures. To achieve the GHG reduction targets outlined in the IMO strategy, it is essential to significantly reduce the GFI of international shipping. This pathway analysis underscores the urgency of reducing GFI and improving energy efficiency in the maritime sector.

GHG Emissions from International Shipping



Source: KR estimation

Source: KR estimation and 2023 IMO GHG strategy

BAU (Business as Usual) Emissions: The left graph in Figure 7 above illustrates the Well-to-Wake (WtW) emission trajectory under the BAU scenario, indicating a significant rise in emissions by 2050, particularly under the high-growth scenario.

Projected Emission Pathway under IMO 2023 Strategy Targets: The right graph visually represents how Goal-based Marine Fuel Standards (GFS) measures can reduce emissions to Net-Zero by 2050.

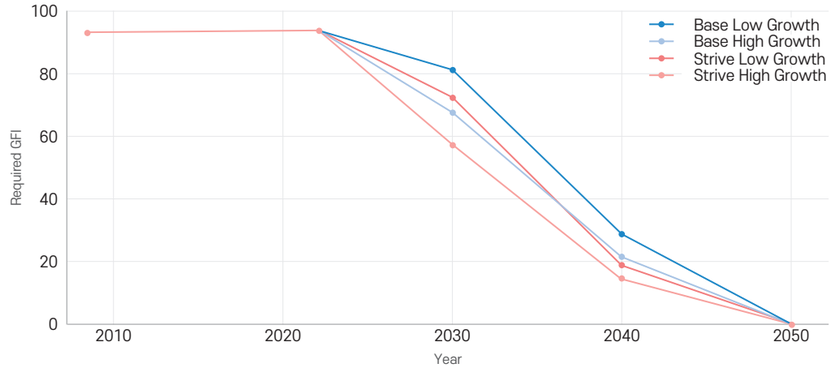
What Levels of Required WtW GFI are Necessary to Meet the Targets?

The figure below summarizes the required GFI values for key years (2030, 2040, 2050) under various scenarios and outlines a gradual reduction pathway toward achieving Net-Zero emissions by 2050.

Example of Required GFI Values Aligned with Reduction Targets

Required GFI	Scenario	2008	2022	2030	2040	2050
Base (20% Reduction)	Low Growth	91.8	91.3	80.9	28.6	0
	High Growth	91.8	91.3	66.2	21.3	0
Strive (30% Reduction)	Low Growth	91.8	91.3	70.8	19.0	0
	High Growth	91.8	91.3	57.9	14.2	0

Required GFI to Meet the Targets in IMO GHG Strategy



This analysis highlights the necessity of transitioning to low-carbon and zero-GHG emission fuels, particularly under high-growth scenarios. Below are the examples of Required GFI values for 2030.

· Base, Low Growth (20% reduction) : The GFI target for 2030 is set at 80.9g $CO_{2eq.}$/MJ, reflecting moderate transport work growth.

· Base, High Growth (20% reduction) : Under high-growth scenarios, the 2030 GFI target decreases to 66.2 g $CO_{2eq.}$/MJ, accounting for increased energy demand.

· Strive, Low Growth (30% reduction) : For a 30% reduction target, the strive scenario sets a 2030 GFI target at 70.8 g $CO_{2eq.}$/MJ.

· Strive, High Growth (30% reduction) : Under high-growth conditions, the GFI target further reduces to 57.9 g $CO_{2eq.}$/MJ by 2030.

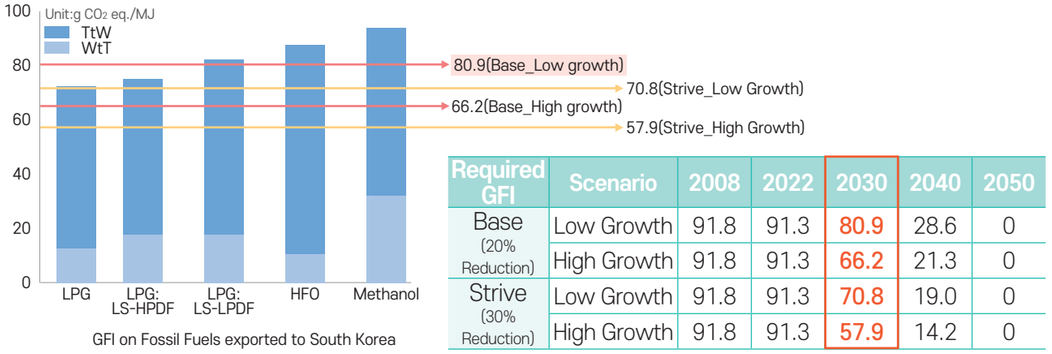
The Required WtW GFI value of 80.9 g $CO_{2eq.}$/MJ derived under the low-growth scenario aligns closely with the Required WtW GFI value presented in Table 2 of the European/Japanese proposal document ISWG GHG 17/2/2 (Austria et al.). However, this value is slightly higher than the 2030 target set by FuelEU Maritime (85.69 g $CO_{2eq.}$/MJ), due to differences in 2050 target-setting approaches. While the IMO aims for Net-Zero emissions, FuelEU Maritime targets an 80% reduction in WtW GHG intensity compared to 2020 levels.

Given the sensitivity of Required WtW GFI values to changes in transport work under low- and high-growth scenarios, a cautious approach and additional analysis based on realistic growth scenarios are necessary. For instance, if the actual growth rate turns out to be lower than the low-growth scenario outlined above due to reasons such as an economic downturn, the reduction target should be adjusted to a more relaxed value than the one previously set.It is expected that these considerations will be adequately reflected during the final review of reduction rates at the IMO MEPC 83rd meeting scheduled for March 2025.

The following figure compares the Required WtW GFI levels for 2030 under various scenarios with the GFI values of commonly used fossil fuels currently imported to South Korea. It includes LPG, LNG* (HPDF and LPDF), HFO, and methanol, set against the Required WtW GFI targets. The reduction targets are indicated by dashed lines: pink for the base scenario and yellow for the strive scenario. This comparison demonstrates the challenges of achieving the 2030 targets.

*HPDF : High-Pressure Dual-Fuel
LPDF: Low-Pressure Dual-Fuel

Comparison of Current Fossil Fuel GFI with Required WtW GFI for 2030



GFI on Fossil Fuels exported to South Korea

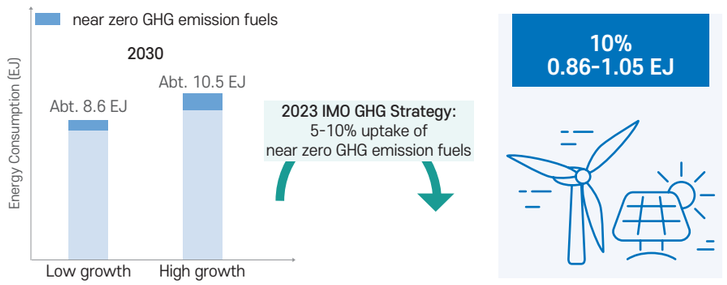
Required GFI	Scenario	2008	2022	2030	2040	2050
Base (20% Reduction)	Low Growth	91.8	91.3	80.9	28.6	0
	High Growth	91.8	91.3	66.2	21.3	0
Strive (30% Reduction)	Low Growth	91.8	91.3	70.8	19.0	0
	High Growth	91.8	91.3	57.9	14.2	0

4. Scenario Analysis for Achieving the IMO GHG Strategy's 2030 Targets

The IMO has committed to achieving Net-Zero emissions by 2050 while setting a near-term target to ensure that at least 5% (with a goal of 10%) of energy used in international shipping by 2030 is derived from zero or near-zero GHG emission fuels, energy sources, and technologies.

By 2030, the total energy consumption in international shipping is expected to reach approximately 8.6 EJ under the low-growth scenario and 10.5 EJ under the high-growth scenario. Under these conditions, achieving a 10% adoption of zero-GHG emission fuels would account for approximately 0.86 EJ (low-growth) to 1.05 EJ (high-growth) of total energy consumption. This necessitates a thorough examination of whether approximately 1 EJ of such fuels can be integrated into international shipping by 2030.

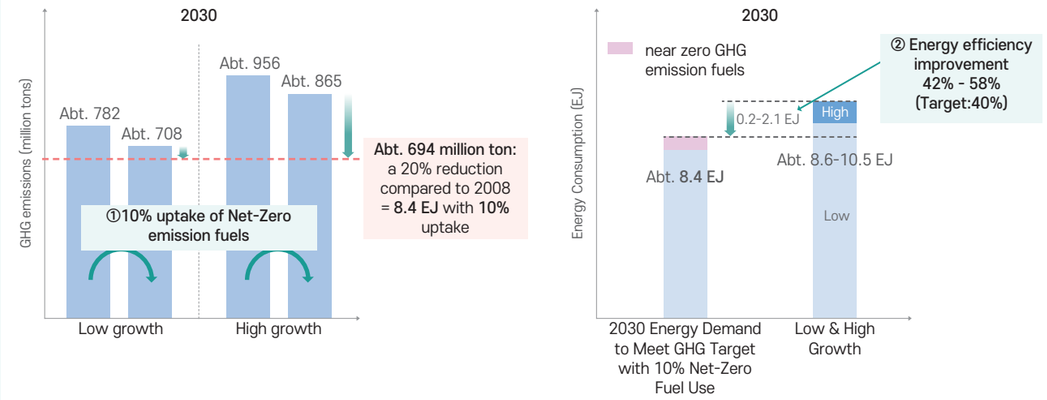
Required Zero-GHG Emission Fuels for Achieving the 2030 Target



To meet the IMO's 2030 GHG reduction target (20%), it is essential to integrate zero-emission fuels such as biofuels and e-fuels into international shipping. This evaluation identified two key scenarios: ① Adoption of Near Zero GHG Emission Fuels, ② Improvements in Energy Efficiency.

As illustrated in the left graph of Figure 11, assuming zero-GHG emission fuels have an intensity of 5 g CO_2eq./MJ, their adoption at a 10% rate is projected to reduce total emissions in 2030 to approximately 708 million tons under the low-growth scenario. In contrast, total emissions in the high-growth scenario would reach around 860 million tons. Both scenarios fall short of the 2030 reduction target of 694 million tons.

Scenario Analysis for Achieving the 2030 Target:
① Adoption of Near Zero GHG Emission Fuels, ② Energy Efficiency Improvements



To achieve the 2030 reduction target, total energy consumption in international shipping should decrease from the projected range of 8.6 EJ to 10.5 EJ down to approximately 8.4 EJ. This requires further improvements in energy efficiency beyond the current 2030 target of 40% (refer to Table 2). These improvements would need to reduce energy consumption by approximately 0.2 EJ in the low-growth scenario and up to 2.1 EJ in the high-growth scenario. Based on the analysis, energy efficiency in international shipping should improve by approximately 42% to 58% by 2030.

Enhancing energy efficiency is likely to be achieved through advancements in vessel technology, optimized operational practices, and compliance with stringent regulations such as the Energy Efficiency Design Index (EEDI) and Carbon Intensity Indicator (CII). However, this analysis is based on 2022 IMO DCS data, and the results may vary due to transitional factors, such as the increased adoption of fossil-based LNG fuel post-2023.

Challenges and Opportunities for Achieving the 2030 GHG Reduction Targets in International Shipping

To meet the IMO's 2030 GHG reduction targets, international shipping should focus on two key pillars: the adoption of zero-GHG emission fuels and improvements in energy efficiency. This analysis highlights the critical role of changes in energy consumption and GHG fuel intensity in determining the feasibility of achieving the 2030 targets.

In both low-growth and high-growth scenarios, the rapid adoption of near-zero GHG emission fuels is essential to align current annual emissions with reduction targets. It is particularly urgent to evaluate the feasibility of fuel adoption by 2030 and implement the necessary policy and technological efforts to support it. Additionally, improving energy efficiency through the application of advanced technologies and optimized operational practices, such as EEDI and CII measures, will be necessary. These improvements are expected to further reduce energy consumption (for example, achieving efficiency gains of 42% to 58% by 2030).

However, it is important to note that this analysis is based on 2022 IMO DCS data and does not account for recent developments, such as the increased adoption of fossil-based LNG fuels after 2023. Moreover, estimates of 2008 WtW emissions and growth scenarios (e.g., changes in international transport work) can significantly impact the setting of annual emission reduction targets for 2030, 2040, and 2050.

Changes in transport work under low- and high-growth scenarios significantly impact total energy consumption, resulting in variability in the Required WtW GFI values needed to meet annual GHG emission targets. Given the high level of uncertainty associated with long-term transport work projections, it is essential to regularly review and monitor the Required WtW GFI values to ensure alignment with the IMO’s reduction targets.

When designing regulatory frameworks, the IMO should adopt a realistic approach that considers the readiness of the industry and the principles of sustainable development. It is expected that the IMO MEPC meeting scheduled for March 2025 will finalize reasonable and feasible regulations regarding the WtW GFI targets required for international shipping. These regulations should be designed to promote technological innovation and decarbonization while collaborating with the industry to achieve tangible climate change mitigation goals. Therefore, effective reduction strategies should be based on a cautious approach and realistic growth scenarios, supported by further research and analysis.

Achieving the 2030 targets represents a critical turning point for international shipping as it progresses toward the long-term goal of Net-Zero emissions by 2050. As a key stakeholder in the global shipping industry, KR is committed to providing actionable insights and technological solutions to support the achievement of both 2030 and 2050 targets.

KR will continue to accelerate decarbonization across the maritime industry by strengthening international cooperation and regulatory alignment, supported by data-driven analysis and innovative technology development.

Wind-Assisted Propulsion System (WAPS) for Responding to International Environmental Regulations (EEDI/EEXI, CII)

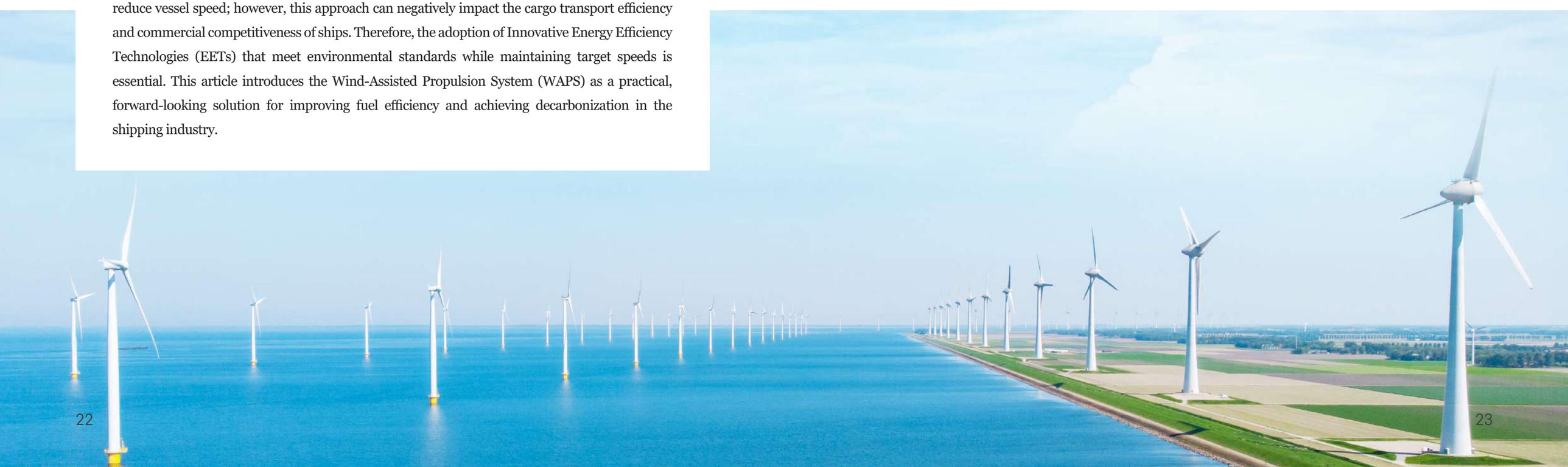
KIM Sangyeob, Senior Researcher of KR Ship & Offshore Technology Team

Introduction

The shipping industry, responsible for approximately 80% of global cargo transport, is facing increasing environmental pressure due to greenhouse gas (GHG) emissions. To address this issue, the International Maritime Organization (IMO) has implemented stricter GHG reduction regulations, including the Energy Efficiency Design Index (EEDI), the Energy Efficiency Existing Ship Index (EEXI), and the Carbon Intensity Indicator (CII), while pursuing gradual tightening of these standards. The first step to comply with these regulations is to limit engine output and reduce vessel speed; however, this approach can negatively impact the cargo transport efficiency and commercial competitiveness of ships. Therefore, the adoption of Innovative Energy Efficiency Technologies (EETs) that meet environmental standards while maintaining target speeds is essential. This article introduces the Wind-Assisted Propulsion System (WAPS) as a practical, forward-looking solution for improving fuel efficiency and achieving decarbonization in the shipping industry.

WAPS

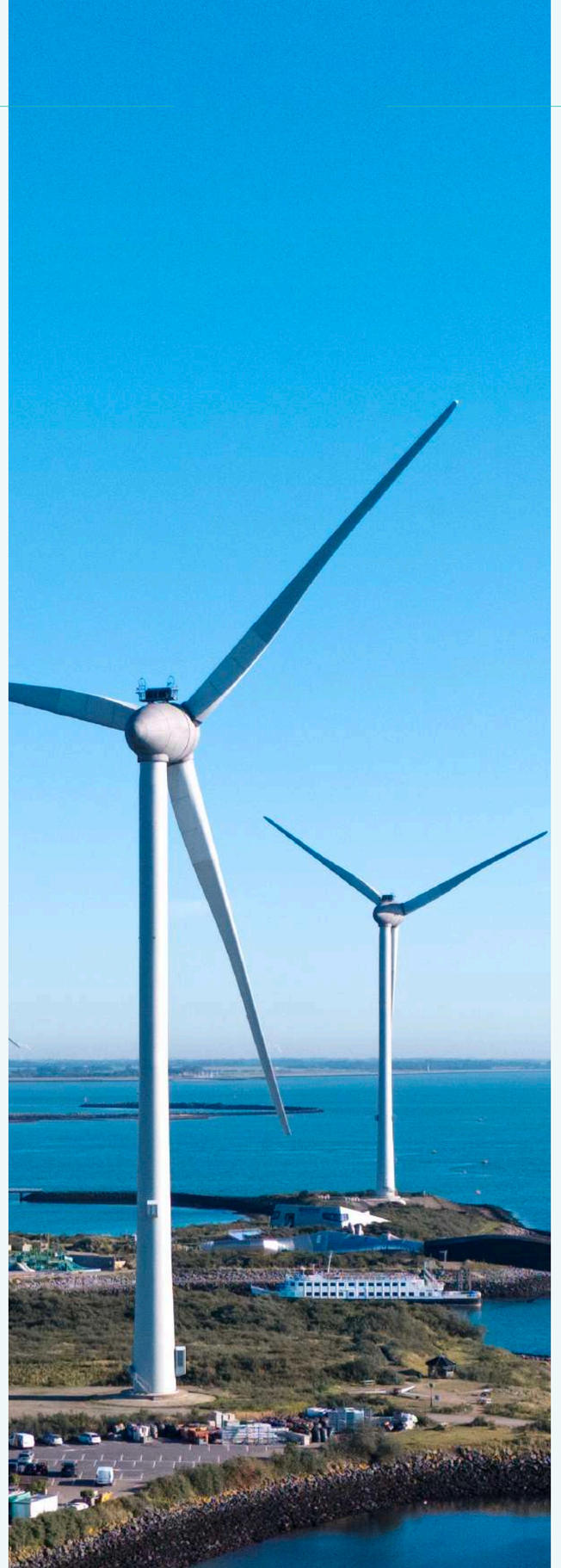
The Wind-Assisted Propulsion System (WAPS) is a technology that harnesses wind energy to generate propulsion for ships, with performance varying significantly depending on wind direction and speed during operation. WAPS includes various types such as soft sails, hard sails, and rotor sails. Recently, hard sails, often referred to as wing sails, and rotor sails have gained notable attention. Hard sails generate forward propulsion by adjusting the angle of attack, creating a velocity difference around the sail. Their performance depends largely on the cross-sectional shape of the sail. Rotor sails, on the other hand, utilize a rotating cylindrical sail to induce a velocity difference in the airflow around the sail, generating propulsion through the Magnus effect. Both hard sails and rotor sails share a similar characteristic in that they achieve propulsion by controlling airflow around the sails. The thrust generated by WAPS is heavily influenced by the system's wind projected area, or the area exposed to wind. Hard sails generally have a larger installation area compared to rotor sails, making them well-suited for large vessels. Conversely, rotor sails, despite being relatively compact, offer a high thrust-to-size ratio, making them an efficient choice for vessels with limited deck space. When adopting WAPS, it is essential to comprehensively evaluate factors such as the ship's design and operational characteristics, the required thrust level, the available deck space, and the size of the system that can be installed.



Additionally, several technical challenges must be addressed during the design and implementation of Wind-Assisted Propulsion Systems (WAPS). First, the sail shape (cross-sectional profile and aspect ratio) has a direct impact on thrust efficiency. It must be optimized to maximize the effective utilization of wind energy. Second, when multiple sails are installed, interference effects between the sails may occur, which can reduce overall thrust efficiency. Therefore, precise positioning and configuration of the sails are essential to mitigate such effects. Third, vortex shedding around the sails may cause resonance, which could negatively affect structural stability and operational safety. This potential risk requires thorough analysis and careful consideration during the design phase.

Performance Evaluation of WAPS in terms of Green House Gas Regulations

The International Maritime Organization (IMO) uses key indicators, such as the Energy Efficiency Design Index (EEDI) and the Carbon Intensity Indicator (CII), to evaluate environmental compliance. These indicators serve as benchmarks for assessing a ship's design and operational efficiency, respectively. EEDI calculates a vessel's energy efficiency during its design phase under standardized conditions, including calm seas, fixed draught, and specific power output. It focuses primarily on evaluating the efficiency of design technologies and equipment. However, EEDI has limitations as it does not account for operational improvements or variations due to different sea states, operating conditions, or slow steaming strategies. On the other hand, CII assesses the annual average energy efficiency of a ship based on actual operational data. It evaluates real-world fuel consumption and CO_2 emissions across various draughts, speeds, and sea states.



As a result, CII performance can vary significantly depending on the ship's operational strategies and management, even for vessels with identical designs. While EEDI emphasizes static, design-based performance and is suited for regulatory compliance during the construction phase, CII highlights the importance of continuous improvement and management of operational efficiency. This makes CII a dynamic metric aligned with IMO's long-term decarbonization goals.

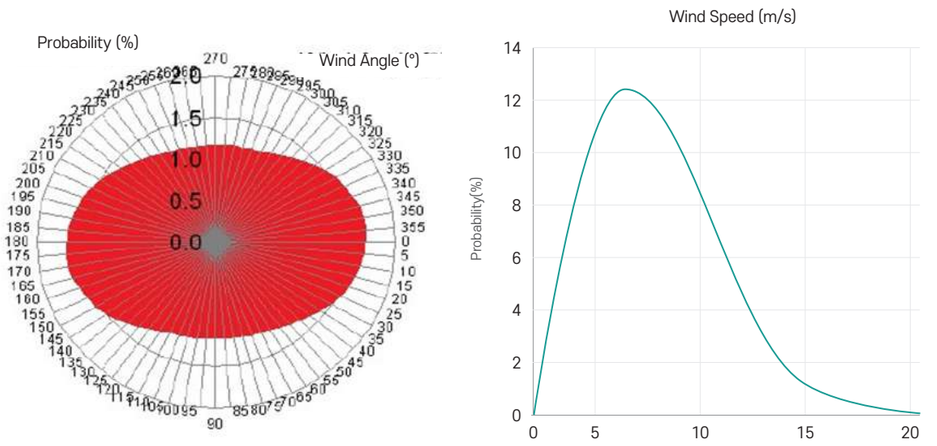
Principles of EEDI/EEXI and CII calculation

$$EEDI/EEXI = \frac{CO_2\ Emmision}{Capacity \times Speed}\Bigg|_{at\ reference\ power}$$

$$\frac{CO_2\ Emmision}{Capacity \times Distance}\Bigg|_{annual\ accumulation}$$

Due to these differences, the energy-saving performance of WAPS is quantified differently under EEDI and CII frameworks. For EEDI, the performance of WAPS is evaluated based on the expected reduction in main engine power achieved through its implementation. This evaluation relies on calculating a weighted average using the Global Wind Probability Matrix, which accounts for variations in wind speed and direction. This approach is considered a reasonable method for addressing the performance fluctuations of WAPS under different wind conditions. To derive the weighted average, it is necessary to estimate the thrust generated by WAPS for each wind speed and direction condition defined in the Global Wind Matrix. Typically, such estimations are performed using model testing or Computational Fluid Dynamics (CFD) simulations. These methods provide reliable data to quantify WAPS performance for EEDI compliance.

Wind properties of global shipping route



Source: MEPC.1/Circ.896

Since CII evaluates a vessel's energy efficiency based on actual operational data, it does not directly quantify the impact of WAPS on the overall energy efficiency of the ship, unlike EEDI. Therefore, when considering the adoption of WAPS for compliance with CII regulations, it is more effective to focus on the specific operational routes of the vessel rather than relying on the Global Wind Probability Matrix used in EEDI assessments. To achieve this, it is advisable to evaluate the fuel-saving potential of WAPS by taking into account the wind approach enables an accurate estimation of WAPS performance in real-world operating conditions. Consequently, such an approach can provide valuable insights into how WAPS contributes to CII compliance and supports practical regulatory adherence.

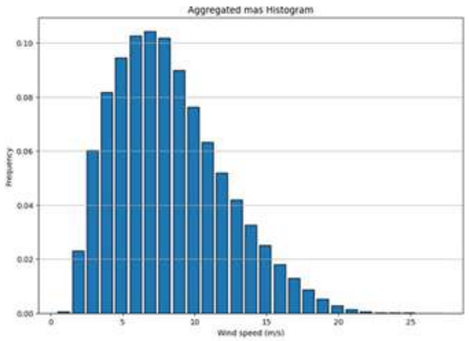
KR's Developments of WAPS Technology

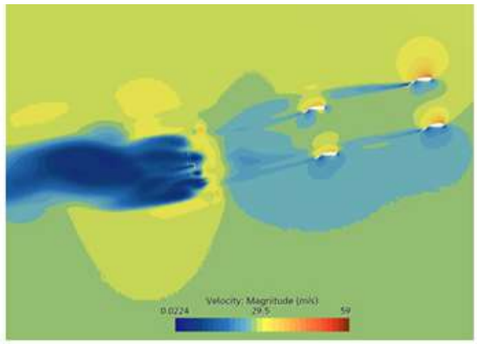
KR is actively leading the decarbonization of the shipping industry and conducting various research activities related to WAPS to provide professional technical services to its clients. One of the key methods for evaluating WAPS performance is Computational Fluid Dynamics (CFD), which, despite its importance, can yield varying results depending on the methodology and conditions applied. To overcome this limitation and enhance the reliability of CFD techniques, KR is collaborating with HD Hyundai Heavy Industries on a joint project to develop a "Numerical Simulation Guideline for Energy Efficiency Technologies (EETs) for EEDI Calculation." The draft of this guideline, designed to provide consistent and reliable evaluation standards for energy-saving devices—including WAPS—defined by IMO, is set to be published in 2025.

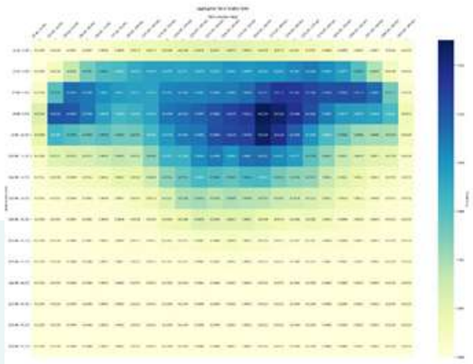
In addition, KR has established its own CFD-based performance analysis methods for key WAPS technologies, such as wing sails and rotor sails. Using tools like the Global Wind Probability Matrix, KR has developed techniques to calculate the average fuel-saving potential of WAPS and to quantify their impact on EEDI calculations or determine reward factors under the FuelEU Maritime framework. KR has further leveraged its Global Environmental Database (1940–2024) to create methodologies for estimating the energy-saving performance of WAPS under historical conditions for specific routes and timeframes. This approach enhances the accuracy and reliability of WAPS performance predictions in real operational environments. These methodologies go beyond simple aerodynamic analysis of WAPS to include comprehensive evaluations

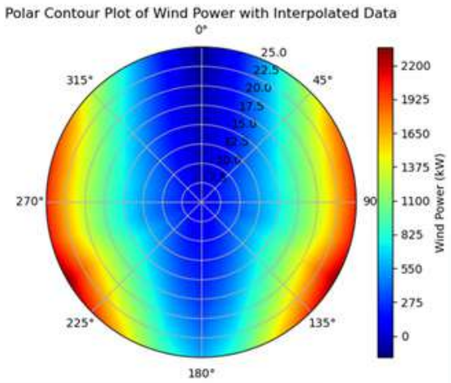
of ship resistance, added wave resistance, and propulsion performance. To continuously improve this integrated approach, ongoing research and development of key technologies are being conducted. Through these efforts, KR provides practical and reliable solutions to its clients, contributing to compliance with IMO regulations and meeting the demands of a sustainable shipping industry.

Evaluation of power saving performance of WAPS based on CFD

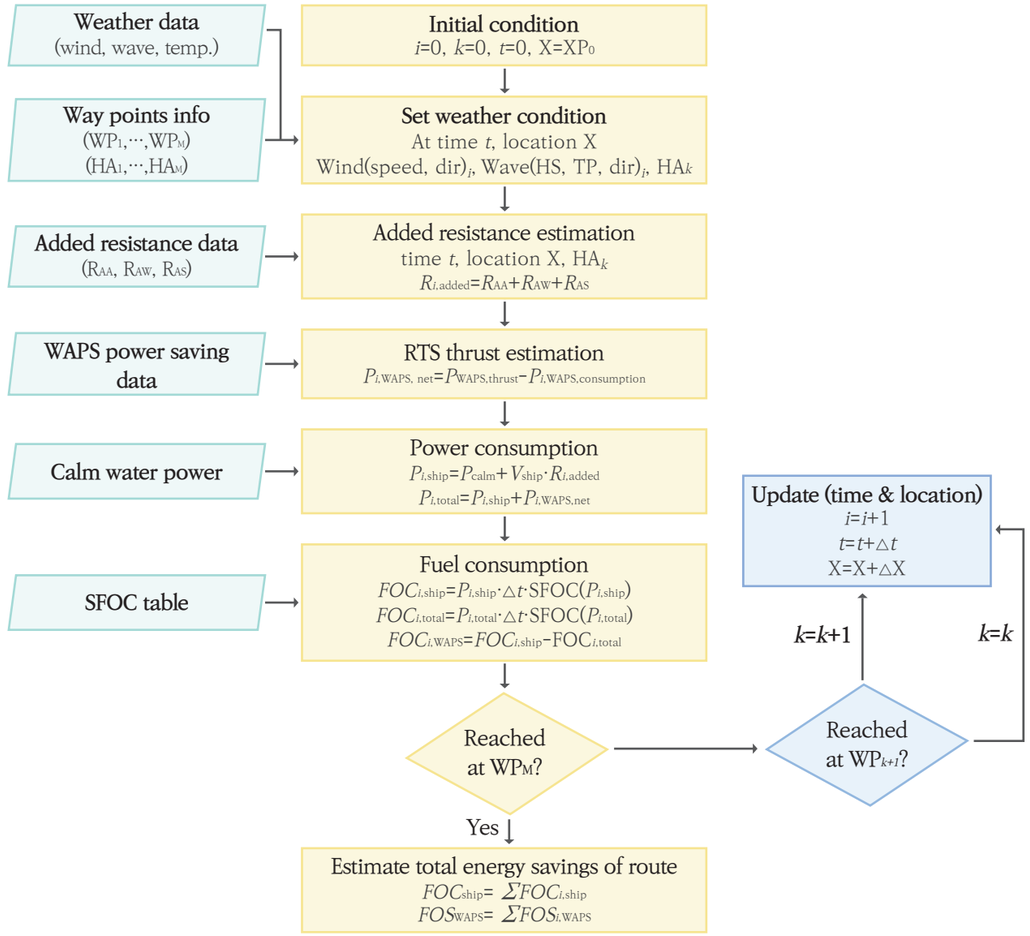








Flowchart of route-based WAPS performance evaluation procedure



KR Decarbonization Magazine

Interview_

Interview with Hyundai Glovis

LEE Won, HYUNDAI GLOVIS End to End Integrated Strategy Team, Team Leader

Q. Hyundai Glovis established End to End Integrated Strategy Team to advance decarbonization and enhance future competitiveness. Could you briefly introduce this initiative?

A Hyundai Glovis has taken a significant step toward securing sustainability in the shipping industry by establishing the End to End Integrated Strategy Team.

This team plays a pivotal role in developing effective strategies to optimize logistics from a comprehensive, end-to-end perspective. Its scope encompasses global logistics, supply chain management (SCM), inland transportation, storage, and customs clearance at the point of origin, as well as sea, air, and rail transportation, along with customs clearance, storage, and inland transportation at the destination. Moreover, from this end-to-end perspective, the team supports the development of eco-friendly carbon-neutral implementation strategies, emissions management, and responses to customer needs related to carbon emissions.

Q. According to the Net-Zero Special Report published in 2023, Hyundai Glovis declared its goal of achieving Net-Zero by 2045, five years ahead of the IMO's 2050 target. Could you explain the roadmap Hyundai Glovis has developed to achieve this?

A To achieve carbon neutrality in our shipping division by 2045, we have established two core strategies supported by a detailed roadmap. These strategies adopt a gradual and systematic approach to reduce carbon emissions in stages and ultimately realize carbon neutrality.

Hyundai Glovis's key strategies are the following two:

1) Enhancing energy efficiency in vessel operations to reduce fuel consumption and minimize carbon emissions.

2) Transitioning to eco-friendly fuels to decrease reliance on conventional fossil fuels and accelerate decarbonization.

Moreover, we have designed a detailed roadmap divided into short-term, mid-term, and long-term phases to enhance the execution of these strategies.

Short-term (2024–2030) | During this period, Hyundai Glovis plans to actively adopt LNG dual-fuel propulsion ships to achieve initial carbon emission reductions. Simultaneously, we will utilize digital navigation optimization technologies to establish efficient shipping routes and maximize energy efficiency through optimized vessel speeds. Additionally, we aim to validate the feasibility of alternative fuels through pilot projects using biofuels and assess their potential for future application.

Mid-term (2031–2040) | In the mid-term phase, Hyundai Glovis intends to introduce vessels powered by carbon-free fuels, such as ammonia and hydrogen, increasing the proportion of eco-friendly ships in its fleet. Furthermore, we will work on establishing infrastructure at major ports to utilize renewable energy, aiming to reduce carbon emissions not only from ships but also during port operations.

Long-term (2041–2045) | By 2045, Hyundai Glovis aims to fully transition its fleet to be powered by LNG and ammonia-based fuels. This will enable us to achieve carbon neutrality in our shipping division, which currently accounts for 97% of total emissions.

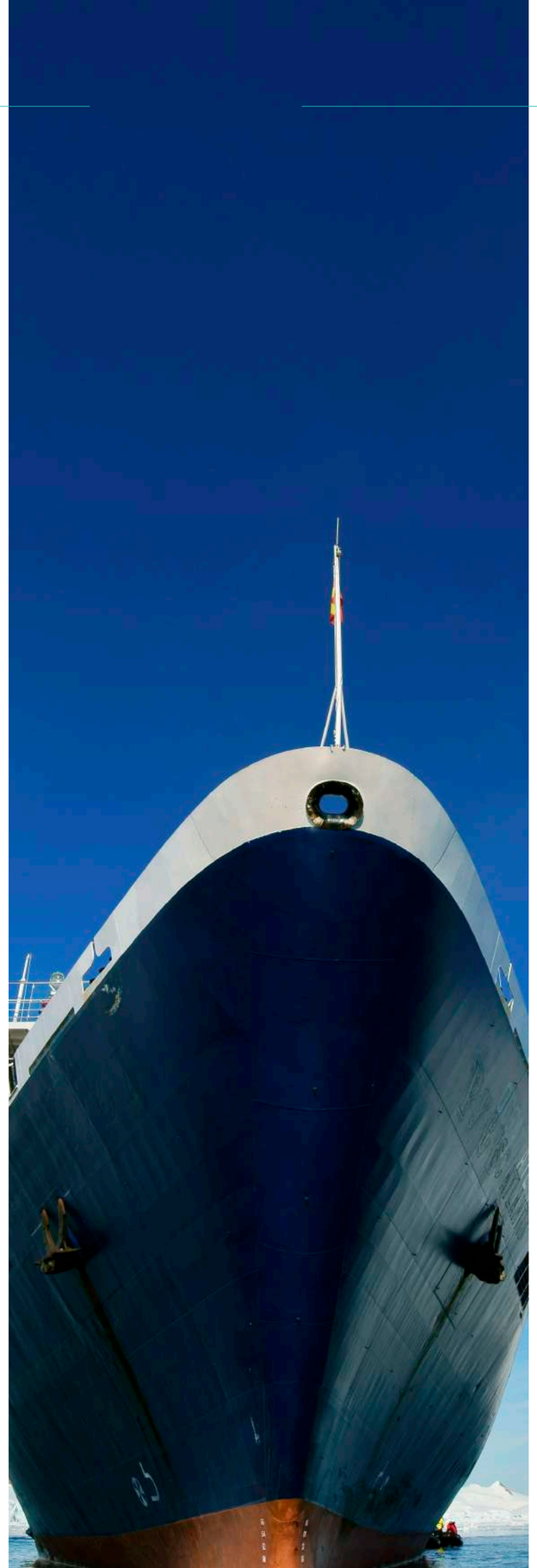
Q. Could you tell us about energy saving technologies that Hyundai Glovis is using as short-term measures for decarbonization?

A We are proactively pursuing and adopting a variety of energy-efficient technologies for our vessels. By leveraging IT solutions, we monitor and assess vessel performance, which allows us to identify and implement tailored strategies. Our energy-saving initiatives can be broadly divided into operational and technical measures.

For operational measures, we are utilizing Weather Routing services to optimize sailing routes and piloting autonomous navigation assistance systems to enhance both safety and efficiency during voyages.

On the technical side, we apply low-friction coatings to reduce hull resistance, conduct hull cleaning, and polish propellers. These actions help remove contaminants from the hull, improve vessel speed, and reduce fuel consumption. Furthermore, we consider vessel age and return on investment when selecting and implementing suitable energy-saving Devices (ESD) to maximize energy efficiency.

Proven technologies are currently being implemented across our fleet, while untested solutions are undergoing trial phases to determine their potential for broader application.



Q. Hyundai Glovis operates numerous vessels that call at ports around the world, each with its own unique decarbonization requirements. Notably, vessels calling at European ports are subject to EU ETS regulations starting in 2024, with the FuelEU Maritime regulations coming into effect in 2025. Could you share how the company plans to respond to these regulatory challenges?

A Hyundai Glovis has developed structured and efficient strategies to address the varying decarbonization regulations globally.

To comply with the EU ETS regulations, we purchase carbon allowances corresponding to CO_2 emissions generated both within and outside the EU ports and submit them to the relevant EU authorities. Furthermore, we have implemented internal systems and workflows to manage this process effectively.

In response to the FuelEU Maritime regulations, we actively track and manage emissions data for our fleet operating in and out of Europe. To achieve GHG intensity reduction targets, we aim to utilize the Flexible Mechanism and replace approximately 8% of the existing fossil fuel with B30 biofuel. Looking ahead, we plan to deploy LNG-fueled vessels starting in 2028 and introduce zero-emission ships, such as those powered by e-LNG or ammonia, from 2040. These measures are part of our broader strategy to minimize penalties, with detailed internal guidelines set to be implemented in 2025.

To mitigate the financial impact of environmental regulations, we aim to prioritize the use of eco-friendly fuels for European operations and strategically assign our green fleet to European routes.

The successful implementation of these strategies depends on close collaboration across various departments. Teams responsible for fuel procurement, vessel operations, fleet planning, and chartering are required to work together to ensure a coordinated and effective response to these evolving regulatory demands.

Q. Hyundai Glovis recently placed an order for LNG-fueled car carriers. Could you share the reasons behind choosing LNG over other alternative fuels?

A Hyundai Glovis has selected LNG-powered Pure Car and Truck Carrier (PCTCs) as part of its shift toward alternative fuels. The LNG dual-fuel vessels we are introducing offer the flexibility to switch between eco-friendly and conventional fuels, making them well-suited for adapting to evolving environmental regulations.

As LNG emits up to 25% less carbon than traditional bunker oil, LNG dual-fuel engines also provide significant advantages in reducing emissions of carbon, sulfur oxides (SOx) and particulate matter, contributing to cleaner and more sustainable operations.

Given our global operations and the extensive deployment of our car carrier fleet across international routes, the availability of an established global LNG bunkering infrastructure was a crucial factor in our decision. The continued expansion of LNG bunkering facilities further supports its viability as a practical choice for global shipping.

With these considerations, Hyundai Glovis has strategically adopted LNG as a transitional decarbonization fuel, viewing it as an effective bridge solution during the early stages of the industry's shift toward achieving full decarbonization.

Q. Hyundai Glovis recently announced its plan to expand the car carrier fleet to 128 vessels by 2030. Will LNG fuel remain your primary choice for these vessels, or are other fuels being considered?

A We have unveiled our intention to operate a fleet of 128 car carriers (PCTCs) by 2030. This plan goes beyond simply increasing fleet size, incorporating vessel upsizing and the efficient introduction of newbuild ships to adapt to the changing demands of the global shipping industry and the growing emphasis on sustainability.

A key component of Hyundai Glovis's strategy is the adoption of larger vessels. By operating larger ships, the company aims to leverage economies of scale, allowing more cargo to be transported with lower energy consumption and reduced carbon emissions per unit. This approach enhances both operational efficiency and cost-effectiveness.

In addition, we are committed to continuing the deployment of high-efficiency LNG dual-fuel vessels. These ships not only support fleet expansion but also enhance energy performance and meet higher environmental standards. Moving forward, the company is exploring fuel diversification, including designs for vessels capable of utilizing next-generation zero-carbon fuels such as ammonia and hydrogen. As these technologies advance, we plan to actively integrate them into our operations.

In summary, by growing its car carrier fleet to 128 vessels, Hyundai Glovis aims to balance carbon reduction, operational efficiency, and profitability through the deployment of larger, energy-efficient LNG dual-fuel ships. These efforts reflect the company's commitment to sustainability and maintaining its competitive edge in the global shipping industry.

Q. Although it is a separate topic from vessel decarbonization, I understand that Hyundai Glovis is making significant efforts in the transportation of eco-friendly electric vehicles. With the recent focus on electric vehicle fires, how does Hyundai Glovis manage fire risks during electric vehicle transport?

A In 2023, approximately 11% (370,000 units) of the 3.24 million vehicles we transported were electric vehicles. For 2024, electric vehicles are projected to account for about 10.6% (360,000 units) of the expected 3.34 million total vehicles transported. Market research results indicate that the global share of electric vehicles will rise significantly, reaching 26% in 2025, 42% in 2028, and 56% in 2030, surpassing internal combustion engine vehicles.

As the importance of ESG management grows globally, safety awareness has also increased. In response, Hyundai Glovis is proactively implementing measures that go beyond the mandatory safety standards set by international conventions and domestic laws, positioning ourselves at the forefront of safety innovation for car carriers.

Operating in a maritime environment presents unique challenges, as external assistance is often unavailable. This requires vessels to function independently, with all crew members holding professional maritime qualifications. However, regulatory gaps and cost constraints can slow the adoption of advanced technologies. To overcome these challenges, Hyundai Glovis collaborates with technology forums, new technology providers, and classification societies to introduce equipment and facilities tailored to managing eco-friendly vehicles like electric vehicles alongside traditional internal combustion engine vehicles.

Our fire risk management strategy focuses on prevention, early detection, and effective firefighting. If a fire cannot be extinguished, ensuring the crew's safe evacuation becomes the priority. To mitigate risks, Hyundai Glovis has prohibited the transport of second-hand eco-friendly vehicles with uncertain battery conditions and banned onboard vehicle charging. As part of our safety measures to minimize risks from physical impacts, such as ship-to-ship collisions, we have set limitations on electric vehicle charging rates for manufacturers.

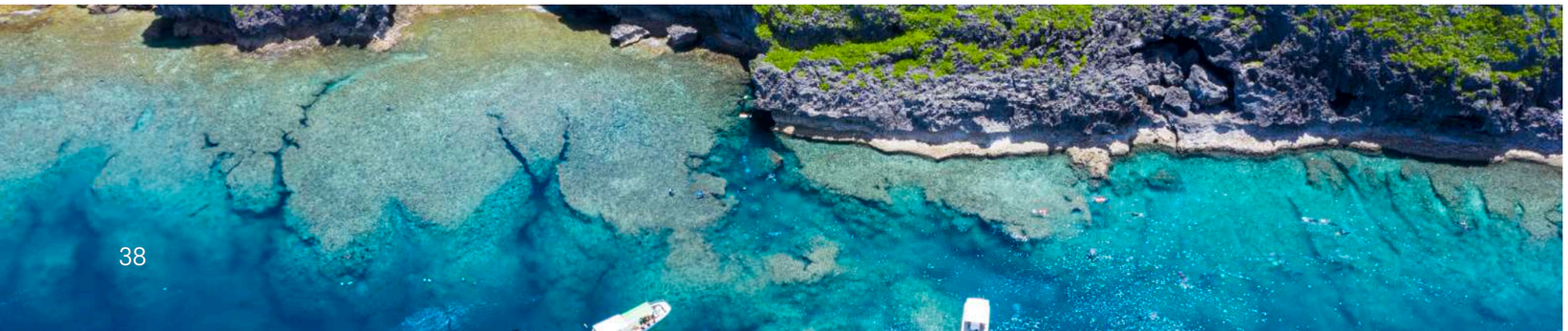
For early fire detection, we have implemented advanced fire detectors capable of identifying both heat and smoke, as well as portable explosion-proof thermal imaging cameras. CCTV systems have been installed on decks to enable continuous monitoring from the bridge and cargo control rooms. Using real-time AI vision analysis, these systems provide alerts for any abnormal fire-related activity. Currently, this AI technology is deployed on one pilot vessel, with plans for broader implementation based on evaluation results. Furthermore, fire monitoring systems (SMiG) have been installed to provide real-time incident location data upon detecting heat and smoke, addressing the limitations of traditional equipment in pinpointing fire locations within cargo spaces.

To enhance the initial fire response, foam extinguishers have been added to complement the required number of dry powder extinguishers. In addition, a separate water spray nozzle has been installed for spraying inside the vehicle. An EV-drill lance, capable of spraying directly through the underside of vehicles where electric vehicle batteries are located, has also been developed for maritime use and distributed across our fleet.

To complement these measures to ensure crew safety, specialized fire escape masks have been provided to facilitate safe evacuation from hazardous environments.

Fires onboard ships are fundamentally managed by the crew. To address the unique challenges of electric vehicle fires, Hyundai Glovis has developed and distributed a dedicated response manual to all vessels. Practical drills have been conducted on ships carrying used cars to confirm the effectiveness of firefighting equipment mentioned above in the confined spaces created by loaded vehicles.

In addition to these measures, Hyundai Glovis has conducted large-scale joint exercises with government agencies to continuously enhance fire response capabilities. Crew members also undergo training at the Fire School to develop real-life firefighting skills.



Q. Regarding Hyundai Glovis's decarbonization activities, could you introduce specific projects currently underway in collaboration with other companies or organizations?

A Hyundai Glovis works with various professional institutions and organizations to develop and implement detailed strategies for decarbonization. Through technological innovation and diverse partnerships, Hyundai Glovis is dedicated to advancing the decarbonization of the shipping industry. Specifically, in collaboration with KR, Hyundai Glovis has undertaken detailed consultations targeting currently operating vessels to address environmental regulations. These consultations provide precise solutions to enhance the efficiency of Hyundai Glovis vessels and ensure compliance with international environmental regulations, thereby improving both operational efficiency and eco-friendliness. Beyond meeting mandatory requirements, we are investigating zero-emission fuel alternatives. This includes exploring the technical feasibility of ammonia, methanol, and hydrogen as future fuel sources. Hyundai Glovis is also participating in the GRC (Global Ro-Ro Community) program hosted by the Smart Freight Center (SFC). SFC is an international non-profit organization established to promote decarbonization and sustainability in the freight sectors. It is establishing unified standards for greenhouse gas emissions reporting in logistics, shipping, and aviation sectors, which are becoming global standards. Through collaboration with SFC, Hyundai Glovis is contributing to the GRC program, which aims to develop standardized frameworks for carbon emissions from Ro-Ro ships for shippers. This enables the establishment of standardized carbon emission levels for Ro-Ro ships and allows for comparative evaluations of each shipping company's eco-friendliness.

Furthermore, Hyundai Glovis is deeply engaged in the research and development of LCO2 (Liquefied Carbon Dioxide) transport vessels and hydrogen carriers. These initiatives aim to provide sustainable cargo transportation solutions for the future and play a crucial role in the global energy transition. Specifically, the development of hydrogen carriers is essential for the global hydrogen economy.

Hyundai Glovis is equally committed to ocean environmental protection. We are collaborating with The Ocean Cleanup to promote ocean plastic removal projects. This partnership directly supports marine ecosystem preservation and reduces the ecological impact of plastic waste.

Additionally, Hyundai Glovis is involved in a battery recycling business, managing the collection, transportation, disassembly, and recycling of EV batteries to promote a circular economy. Recycled materials are utilized in the production of new batteries, contributing to a reduction in the carbon footprint and bolstering the sustainability of the electric vehicle industry.

Through these diverse collaborative initiatives and research projects, Hyundai Glovis demonstrates its proactive approach to decarbonization and leadership in driving sustainability within the global shipping and logistics industry. These efforts position Hyundai Glovis as a frontrunner in establishing innovative standards for future eco-friendly shipping.

Q. Hyundai Glovis is reportedly preparing for Scope 3 alongside direct carbon emissions of Scope 1 & 2. Could you provide more details on how you are currently addressing this?

A In July 2023, we established our carbon neutrality roadmap, which included reduction strategies for Scope 3 emissions—where carbon emissions from supplier-related transportation represent the largest share. By applying reduction strategies for transportation methods (vehicles, ships, etc.) associated with Scope 1 and 2 emissions to Scope 3 supplier transportation activities with a 5-year time lag, we have outlined a roadmap to achieve a 100% reduction in Scope 3 greenhouse gas emissions by 2050.

To advance Scope 3 reductions, our international subsidiaries have formed a hydrogen cargo vehicle joint venture and introduced 21 hydrogen trucks. In the domestic market, we are working with partners in the automotive and steel industries to implement a pilot project for hydrogen cargo vehicle transportation. This initiative aligns with Hyundai Motor Group's hydrogen ecosystem development, further solidifying the groundwork for reducing Scope 3 emissions.

Q. What changes or innovations does Hyundai Glovis believe are necessary for the shipping industry to achieve decarbonization?

A Decarbonization is a global challenge that is too complex and wide-ranging for any single shipping company to tackle alone. It requires collective action and collaboration across the entire global shipping industry, transcending the efforts of individual companies. Achieving decarbonization goals demands an international and inclusive cooperation framework.

First and foremost, shipping companies must work closely with government agencies, classification societies, and shipyards to establish and implement strategies aligned with decarbonization objectives. Government agencies play a key role in setting regulations and policies, classification societies ensure technical standards and safety, and shipyards focus on developing and constructing eco-friendly vessels. Organic collaboration among these entities forms a critical foundation for the shipping industry to meet global regulations and market demands while achieving tangible carbon emission reduction targets.

Furthermore, international solidarity and cooperation are crucial to addressing shared challenges through a unified vision and common goals. Several key challenges exceed the capabilities of any single company. These include commercializing alternative fuels, developing global bunkering infrastructure, standardizing carbon emission data, and advancing energy-efficient vessel technologies. These challenges necessitate pooling expertise and resources across stakeholders to develop innovative solutions.

Efforts toward decarbonization must also extend beyond the shipping industry itself. Collaborations with energy companies, technology providers, academia, and international organizations are essential for advancing alternative fuel technologies, improving carbon emission monitoring technologies, and fostering a sustainable maritime ecosystem.

Ultimately, decarbonization is not just about regulatory compliance but also about fulfilling the shipping industry's broader responsibility to preserve a sustainable environment for future generations. Achieving this requires open communication, mutual trust, and unified action among all stakeholders. Hyundai Glovis recognizes the critical importance of such collaboration and remains committed to driving meaningful change toward a sustainable future for the global shipping industry.

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Regulatory Updates_

MEPC 82 Key Highlights

1.IMO Mid-term measures to further reduce GHG emission from international shipping

▸ Technical measures allow non-compliant ships using fossil fuels to purchase Surplus Compliance Unit from ships using low-GHG alternative fuels or purchase Remedial Compliance Unit from GFS Registry at predetermined prices to meet fuel standards. Additionally, ships using alternative fuels with low GHG emissions can receive incentives to offset initial investment costs for ship construction and to bridge the price gap between alternative fuels and fossil fuels.

▸ However, it remains undecided whether the calculation of the attained GHG Fuel Intensity (GFI) will consider the lifecycle GHG emissions of marine fuels (on a Well-to-Wake basis) in accordance with LCA guidelines or only the onboard GHG emissions (on a Tank-to-Wake basis). Additionally, no decision has been made on whether to introduce a separate levy per tonne of GHG emissions as an economic measure, in addition to the trading or purchase of GHG credits.

▸ The MEPC 82 session agreed to convene two intersessional working group meetings: one from February 17 to 21, 2025 (5 days), and another two-day meeting in the week before the MEPC 83 session in April 2025. These meetings will focus on advancing the development of mid-term measures. In alignment with the 2023 revised strategy for reducing greenhouse gas (GHG) emissions from international shipping, the approval of amendments to MARPOL Annex VI (scheduled for the MEPC 83 session in April 2025) and their adoption (anticipated during a special MEPC session in October 2025) are expected to proceed as planned.

2.Review of short-term measures (Carbon Intensity Indicator, CII)

▸ Relevant data on CII metrics, correction factors and voyage adjustments, enhancement of the enforcement mechanism, improvement of the IMO DCS, revision of CII reduction factors, and other elements have been collected to review short-term measures. A two-step approach was agreed upon : first, focusing on the CII reduction rates and correction factors, and second, on substantial modifications to the CII implementation framework. This approach aims to assess the effectiveness of the CII framework using different implementation data.

▸ During MEPC 82, it was further agreed to establish a Correspondence Group and an Inter-sessional Working Group (ISWG, meeting for three days a week before MEPC 83) to conduct a detailed review of short-term measures. Discussions are expected to prioritize strengthening the SEEMP implementation framework, determining CII reduction factors for the period from 2027 to 2030, and developing correction factors for port waiting times and ships engaged in short-sea voyage.

▸ Considering that the review of short-term measures must be finalized before 1 January 2026, as per regulation 28.11 of MARPOL Annex VI, the first step of the review is expected to be completed at MEPC 83, scheduled for April 2025.

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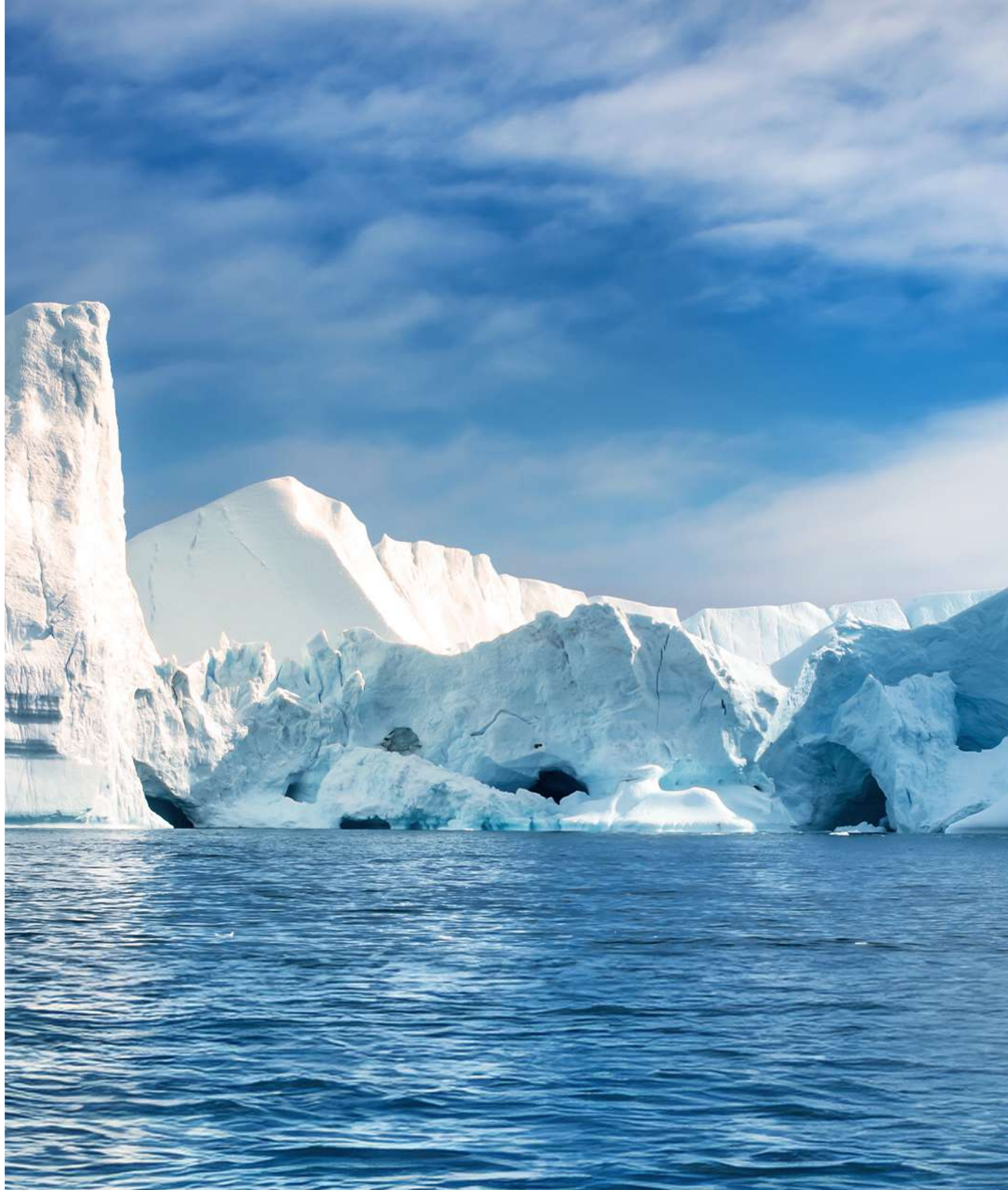


KR Publishes Report on Safe Maritime Transport of Electric Vehicles on PCTCs

KR has published a report on the safe maritime transport of electric vehicles on Pure Car and Truck Carriers (PCTC).

Electric vehicle fires are known to be difficult to extinguish completely once they occur. This is particularly concerning for PCTCs, which transport a large number of vehicles, including electric vehicles, as a fire could lead to a major accident. To address these concerns, KR held a HAZID (Hazard Identification) workshop in early 2024, inviting experts from various fields, including PCTC operators, shipyards, and the National Fire Research Institute, to discuss fire safety management of electric vehicles transported by PCTCs.

The newly published report compiles expert opinions from the HAZID workshop and outlines the fire hazards associated with electric vehicles on PCTCs. It provides a comprehensive review of recommendations to consider during ship construction and operation, aiming to enhance fire safety for electric vehicles transported on PCTCs.

KIM Yeontae, Executive Vice President of KR's Technical Division, commented, "We expect this report to serve as a valuable guideline for PCTC operators and shipyards. KR will continue to provide technical services to support the safe construction and operation of ships."

The "Safe Maritime Transport of Electric Vehicles on PCTCs" report is available for public access on KR's official website.

▶ Find out more

KR, HD KSOE, HD HHI, KSS Line, and Liberian Registry Partner to Develop Safety Guidelines for Ship-to-Ship Ammonia Bunkering

A landmark partnership to develop the safety guidelines for ship-to-ship ammonia bunkering has been established through a Memorandum of Understanding (MOU) between KR, HD Korea Shipbuilding & Offshore Engineering (HD KSOE), HD Hyundai Heavy Industries (HD HHI), KSS Line, and the Liberian Registry.

As the demand for ammonia-fueled vessels rises, this partnership aims to establish robust safety standards for STS ammonia bunkering, an efficient method for supplying fuel to ammonia-fueled vessels. The safe bunkering of alternative fuels, like ammonia, requires rigorous risk assessment and the establishment of controlled zones. While standards for LNG and methanol bunkering have already been defined through various international industry standards, ammonia currently lacks relevant guidelines, highlighting the urgent need for the partnership's research.

To address this industry need, the five organizations involved will work together to develop standardized safety procedures that will set international benchmarks for ship-to-ship ammonia bunkering.

As part of the initiative, HD KSOE will perform risk assessments aligned with international industry standards, while HD HHI and KSS Line will utilize their expertise and experience in alternative-fuel vessels and ammonia carriers to evaluate controlled zones and safety procedures for ammonia STS bunkering. KR will verify the compliance of these safety procedures and issue an Approval in Principle (AIP) certificate. The Liberian Registry, overseeing the world's largest registered fleet, will further review the validity of these safety procedures.

KIM Yeontae, Executive Vice President of KR's technical division, commented, "With the expected rise in ammonia bunkering demand driven by the construction of more ammonia-fueled vessels, this collaborative effort to establish safety standards is highly significant. Through this partnership, KR is committed to advancing ammonia fuel technology and supporting the industry's decarbonization efforts."

KIM Jungsik, Managing Director of the Korea Office at the Liberian Registry, stated, "Just as we observed with the initial adoption of LNG STS bunkering, it is critical to establish regulations and procedures for ammonia as well. Our Innovation and Energy Transition team will thoroughly review the safety protocols and support the development of international standards."

KR Awards AiP for Eco-Friendly Hybrid CTV for Offshore Wind Farms

KR has granted Approval in Principle (AIP) for the Crew Transfer Vessel (CTV), a passenger and cargo transport vessel dedicated to offshore wind farms, developed by MARCON, a Korean maritime service company.

What is CTV?

CTV is widely used in Europe for transporting workers and equipment necessary for offshore wind farm construction and maintenance.

A Shift Toward Sustainability

While the conventional models rely on diesel engines, the new CTV adopts an eco-friendly hybrid electric propulsion system. This is designed for addressing environmental regulatory issues, as well as offering fuel cost savings and supporting safer operations of offshore wind farms.

Key Technologies

· Immersion-type Energy Storage System (ESS): The ESS, provided by Hanwha Aerospace, employs an immersion-type lithium-ion battery. This design enhances insulation strength, improves cooling efficiency, prevents thermal runaway transfer, and ensures safety against fire with a smothering extinguishing function.

· Linear Jet: This eco-friendly propulsion system, provided by YusinHR, boasts an efficiency rate of up to 70% and is capable of achieving speeds of 25 knots.

Expectation

This CTV is expected to reduce operating time by approximately 34% and cut carbon dioxide emissions by around 70% compared to traditional internal combustion engine vessels.

KR conducted a thorough review to verify the CTV's design safety and compliance with both domestic and international regulations. The construction of this innovative CTV began at a Korean shipyard in September 2024, with plans for its launch scheduled for 2025.

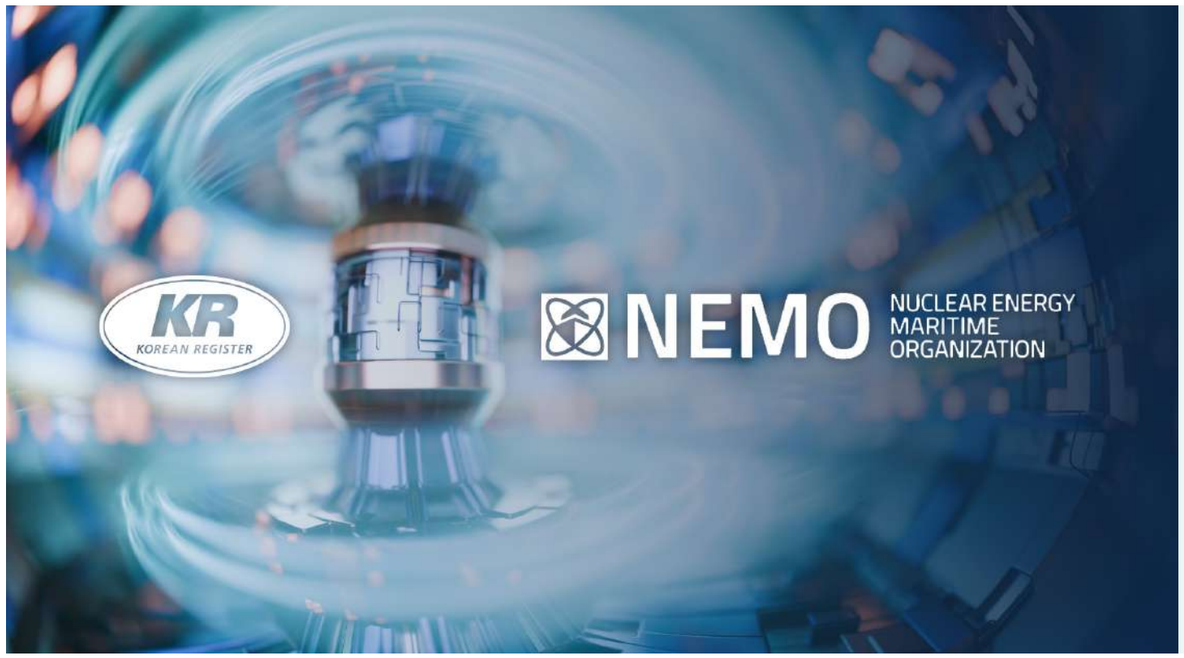
KR, Stepping into Advanced Nuclear-Maritime Applications with NEMO

KR recently joined the Nuclear Energy Maritime Organization (NEMO) as a full member, strengthening its commitment to safe and eco-friendly maritime solutions.

NEMO, founded in March 2024 with headquarters in London, aims to develop global standards and regulations covering the deployment, operation, and decommissioning of nuclear energy in the maritime sector.

This organization brings together a wide range of global leaders including Westinghouse Electric Company, TerraPower, and HD Korea Shipbuilding & Offshore Engineering Co., Ltd. (HD KSOE), along with insurers, shipowners, classification societies, and energy companies. Members will collaborate to ensure the highest levels of safety and security in emerging nuclear technologies and develop international standards and regulations.

Amid rising carbon mitigation demands, Small Modular Reactors (SMRs) are gaining momentum as a potential solution for greenhouse gas reduction in the maritime industry, while Advanced Reactor (AR) technology is also drawing significant interest. The anticipated commercialization of marine SMR technology promises both decarbonization efforts and a stable, sustainable energy source.



Through its NEMO membership, KR will play a role in establishing international regulatory frameworks for maritime nuclear technology and will continue its efforts to provide innovative, sustainable solutions for the industry.

KR Shortlisted for 'The World LNG Shipping Award 2024'

KR was shortlisted for The World LNG Shipping Award 2024 at the 24th World LNG Summit & Award, held in Berlin, Germany, from December 9 to 12, 2024.

The World LNG Shipping Award is a prestigious honor granted to companies or organizations that demonstrate exceptional innovation and contributions to the global LNG shipping industry. KR's nomination highlights its pivotal role in spearheading the revision of the IGC Code's cargo tank filling limit regulations through collaborative efforts with the International Maritime Organization (IMO) over recent years.

The 2016 revision of the IGC Code restricted the filling limit of LNG membrane cargo tanks to 98% of their design capacity, necessitating costly design modifications and additional equipment to exceed this threshold. These requirements imposed significant economic burdens on shipyards and shipping companies.

Recognizing the challenges posed by this restriction, KR raised concerns about the overly restrictive nature of the regulation in 2019 at the IMO's Carriage of Cargoes and Containers Sub-committee (CCC). KR's proposal was supported by extensive research, including quantitative risk analyses, economic cost-benefit assessments, and environmental impact evaluations.

Following rigorous deliberations, the proposed revisions were reviewed at the 10th IMO CCC meeting in September 2024 and received final approval at the 109th IMO Maritime Safety Committee (MSC) meeting on December 6, 2024. The updated regulations will take effect retroactively from January 1, 2028.

With the revised regulations, shipyards and shipping companies can now fill LNG cargo tanks beyond the previous 98% limit without requiring design alterations. For instance, a 174K LNG carrier will gain an additional loading capacity of approximately 1.2–1.4% (equivalent to 2,000–2,500m³), enabling more cost-efficient operations. Furthermore, the enhanced cargo capacity is expected to deliver environmental benefits by lowering emissions per unit of transported cargo.

LEE Hyungchul, KR's Chairman & CEO, expressed his gratitude, stating, "This nomination acknowledges KR's technical expertise and influential role in the global shipping industry, and it is deeply meaningful to us. Through this recognition, we aim to further enhance KR's global presence and lead the way in developing innovative technologies and regulatory advancements to drive the maritime industry forward."

The World LNG Summit & Award is an annual event that brings together industry leaders to share the latest trends and innovations in the global LNG sector, fostering sustainable development and progress within the industry.

KR Hosts Groundbreaking Green Ship Technology Conference

On November 28, KR successfully hosted the 'KR Green Ship Technology Conference 2024' at The Plaza Hotel in Seoul, addressing pivotal challenges in maritime decarbonization.

Centered around the theme, 'Time for Action Towards Green Shipping', the conference drew significant attention amid intensifying GHG regulations from the International Maritime Organization (IMO) and European Union (EU). The event showcased innovative strategies and technologies for reducing maritime sector emissions.

The conference featured two comprehensive sessions and a panel discussion, highlighting KR's commitment to supporting the industry's transition towards sustainable shipping:

Session 1: GHG Reduction Technologies and Strategies

- KR's Decarbonization Support Services for Vessels
- Alternative Fuel Engine Development Towards 2050 Carbon Neutrality
- Fuel Consumption Analysis Tools Based on Maritime Environment and Vessel Operation Data
- Performance Prediction of Ship Energy Saving Technologies Using CFD

Session 2: Green Alternative Fuel Transition

- HMM's Net-Zero Strategy
- GHG Regulation Preparedness and Green Fuel Engine Development
- Marine Molten Salt Reactor (MSR) Technology Development

The panel discussion followed the sessions, gathering experts from KR, the Ministry of Oceans and Fisheries, and Korea Planning & Evaluation of Industrial Technology (KEIT) under the theme ‘Actionable Decarbonization Plans’.

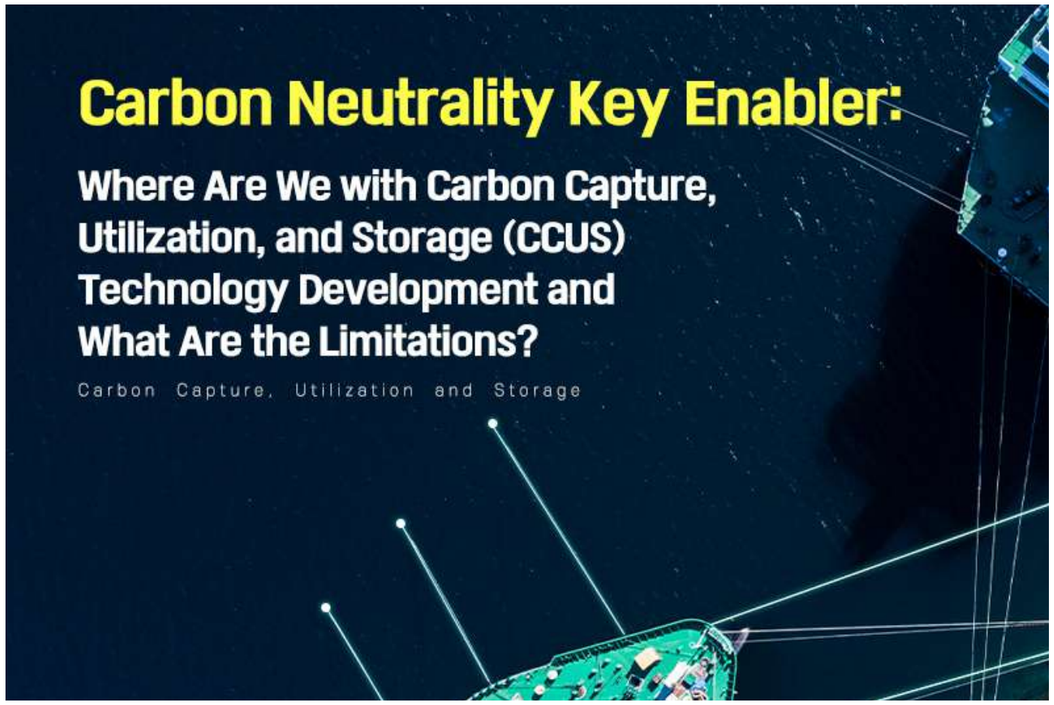
KIM Daeheon, Executive Vice President of KR’s R&D Division, stated, "This conference provided an invaluable platform to discuss practical solutions for GHG regulations and green alternative fuel transitions. KR remains committed to collaborating with the industry stakeholders to create a sustainable future."

MacNet Strategic Seminar Discusses CCUS Development Status and Challenges

On November 6, The Maritime Cluster Networking in Korea (MacNet) held the strategic seminar-Ⅱ titled “Carbon Neutrality Key Enabler: Where Are We with Carbon Capture, Utilization, and Storage (CCUS) Technology Development and What Are the Limitations?”.

Organized by MacNet with support from Busan Metropolitan City and KR, the seminar provided a platform to discuss CCUS technology development as a key enabler for achieving Net-Zero carbon emissions by 2050. It also focused on exploring strategies for collaboration with related industries.

The event comprised three sessions:



Session 1

- Overview of International CCUS Projects and Strategies for Demonstrating CCUS Using Donghae Gas Fields
- Cross-Border CCS Strategies under International Regulations

Session 2

- Strategies for Securing Overseas Carbon Storage Sites for Carbon Neutrality
- Greenhouse Gas Reduction Potential and Economic Feasibility Analysis of OCCS

Session 3

- A comprehensive panel discussion on the topics from Sessions 1 and 2

As nations globally work toward achieving complete decarbonization by 2050, CCUS—a technology to capture and store carbon while converting it into valuable resources—is gaining significant attention. The International Energy Agency predicts that CCUS will contribute approximately 18% to carbon neutrality efforts, making it an essential tool in combating climate change.

Despite active CCUS research and development, challenges such as economic feasibility and unforeseen technical issues remain barriers to commercialization.

A MacNet representative highlighted that the seminar successfully identified collaboration opportunities across industries to overcome technical challenges and drive advancements in CCUS, emphasizing the importance of sustained cooperation in the future.

In keeping with our passion for the protection of the natural environment,
KR offers survey and certification services for renewable energies, including wind and ocean power.
KR is continuously working on new and innovative green ship technologies
to reduce emissi

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