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KR Decarbonization Magazine

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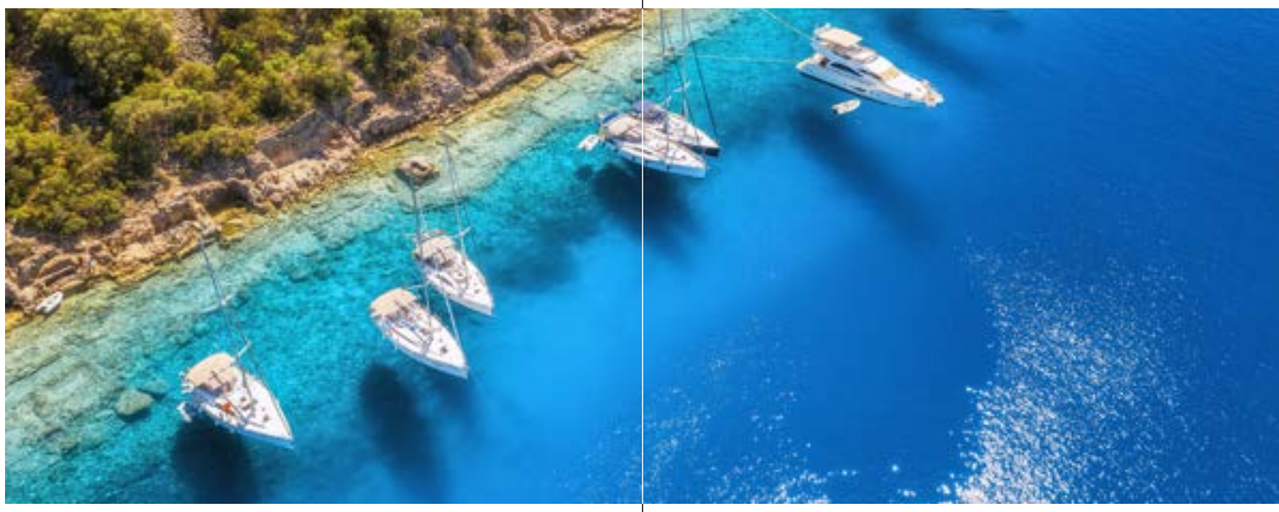
# Decarbonization Magazine



Vol. 07
Summer 2024

# 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.

# CONTENTS

The IMO's mid-term measures for greenhouse gas reduction are scheduled to be finalized in 2025 and implemented in 2027. It is difficult to gauge the full impact of these regulations on the future maritime industry. Currently, discussions among IMO MEPC member states, both formal and informal, are underway to develop drafts of these mid-term measures. However, significant differences in opinions persist regarding the imposition of carbon taxes, the scale and allocation of GHG funds among nations, which remain challenging to reconcile. Despite this regulatory uncertainty, shipping companies are tasked with finding appropriate strategies to comply with international environmental regulations.

KR has been collaborating with several domestic and international shipping companies to support their greenhouse gas regulation strategies. Specifically, after setting reduction targets, shipping companies have developed around ten proposals by combining various technological and operational measures to achieve these goals. Each proposal was evaluated for cost-effectiveness, estimating overall costs such as carbon taxes based on EU's ETS and FuelEU Maritime regulations, CAPEX, and OPEX. This Summer issue presents detailed analyses and outcomes of these strategies, providing valuable information to shipping companies currently formulating decarbonization strategies.

Globally, nations are declaring hydrogen economies to achieve their NDC goals, focusing efforts on clean hydrogen production, transport, and supply. The maritime industry is particularly interested in clean hydrogen transport, with expectations for large-scale orders of ammonia carriers and liquefied hydrogen carriers. This issue analyzes global forecasts for hydrogen production, transport, and demand, comparing the advantages and disadvantages of ammonia carriers and liquefied hydrogen carriers, and examining the development status of liquefied hydrogen carriers in Korea and Japan.

HMM has been preparing for years to use biofuels and is currently using them directly on container ships deployed in European routes. This issue features an interview with Mr. SEO Dae-sik, Manager at HMMOS, who shares insights on biofuel as ship fuel, discussing supply logistics, technical challenges, compensation from shippers, and pilot plans for B100 fuel. The comprehensive information obtained from this interview will undoubtedly assist shipping companies currently using biofuels or planning to use them soon.

In this issue's regulatory update, detailed progress and discussions on the drafting of IMO mid-term measures are covered. With the measures needing to be finalized by spring 2025, bridging the gap in opinions between nations remains a pressing issue.

The Inside KR in this issue highlights the technological developments that are currently of most interest to three major Korean shipbuilders and examines trends in future ship demand based on these developments. Particularly noteworthy are hydrogen, ammonia, and carbon dioxide. KR awarded several AIP certificates related to these topics at the Posidonia 2024 in Athens, Greece.

The recent MacNet Strategy Seminar focused on the establishment of green shipping routes, a joint initiative among governments, shipping companies, and ports worldwide. Discussions at the seminar covered fuel supply, port bunkering infrastructure, crew education, and policy support necessary for establishing green shipping routes. Progress in feasibility studies for the US-Korea methanol container ship green route, scheduled to commence this year, was also shared.

The maritime industry is currently facing diverse alternative fuels and new technologies amid unprecedented regulatory uncertainties. KR's Decarbonization Magazine aims to swiftly disseminate regulatory developments, share expert insights on the pros and cons of various new technologies, and propose directions for the future of the maritime industry.

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

KR Decarbonization Magazine

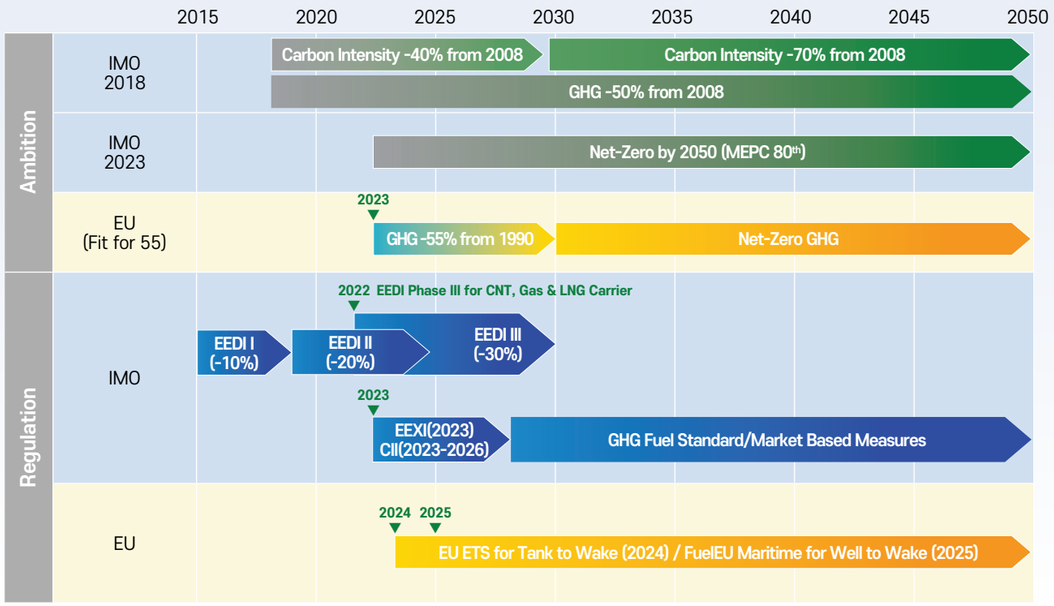
# Insights_

# Customized Decarbonization Strategy for Shipping Company

**CHO Joonho,** Technical Business Development Team

## Background and Action Plan

Due to strengthening IMO environmental regulations, shipping companies' concerns about building a sustainable future are increasing. At the MEPC 80 meeting held in 2023, IMO set a goal of reaching Net-Zero by around 2050, and it will be regulated through medium-term measures that combine the GFS (GHG Fuel Standard) based on LCA (Life Cycle Assessment) guideline and market-based measures in addition to existing short-term measures.



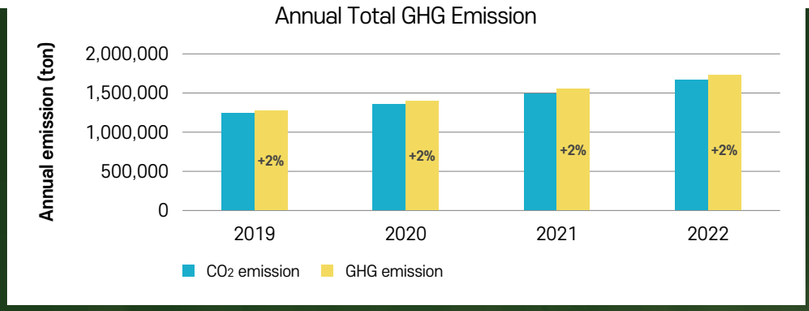



Therefore, it is essential for each shipping company to establish a decarbonization strategy to increase energy efficiency and reduce GHG emissions. To effectively achieve decarbonization, a customized decarbonization strategy is required according to the status of each shipping company's fleet, and furthermore, action plans that optimize the operational, technical, and economic aspects of each ship must be prepared. In 2023, KR conducted a joint study on decarbonization strategies with a Korean shipping company, and we will introduce the contents. This content is a summary of the joint study results. The company name, ship type, and vessel name have been anonymized, and some contents of the table have been edited or deleted to protect the anonymity.

## Identify Fleet GHG Emissions

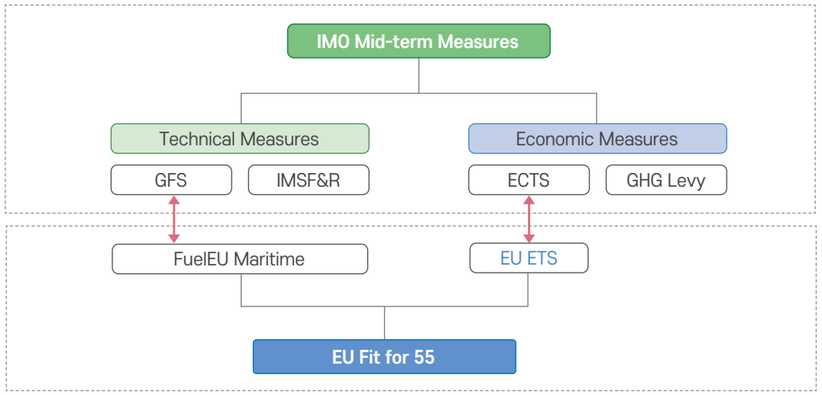
The vessels subject to the shipping company's customized decarbonization strategy are 46 vessels registered on the KR GEARs platform, including 32 vessels of type A, 8 vessels of ship type B, 5 vessels of ship type C, and 1 vessel of ship type D.

Based on DCS data reported through KR Gears, $CO_2$ emissions for four years from 2019 to 2022 were reviewed, and total GHG emissions, including methane ($CH_4$) and nitrous oxide ($N_2O$), were also predicted.



## Expected Penalty Costs

At the time of conducting this study, since the penalty impact of IMO's mid-term measures could not be confirmed, it was assumed that the EU ETS and FuelEU Maritime regulations of EU Fit for 55, which currently apply only to ships calling at EU ports, were applied to the entire route. The figure below shows the EU Fit for 55 regulations corresponding to the IMO medium-term measures.




The annual penalty costs for IMO medium-term measures and EU Fit for 55 evaluated based on the shipping company's 2022 IMO DCS (Data Collection System) and EU MRV (Monitoring, Reporting & Verification) reporting data are as follows. Assuming the penalty-based cost is the same amount, the cost incurred due to EU port calls was approximately 7% of the total operation based on IMO DCS, and it can be seen that it increases rapidly over time.

(Unit: mil. USD)

| Year | | 2024 | 2025 | 2026 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| IMO DCS Base | ECTS | 62 | 109 | 159 | 159 | 159 | 159 | 159 | 159 |
| | GFS | 0 | 34 | 34 | 90 | 208 | 437 | 868 | 1,118 |
| EU MRV Base | EU ETS | 4 | 7 | 11 | 11 | 11 | 11 | 11 | 11 |
| | FuelEU Maritime | 0 | 2 | 2 | 6 | 14 | 29 | 58 | 74 |
| Total (IMO DCS) | | 62 | 143 | 193 | 249 | 367 | 596 | 1,027 | 1,277 |
| Total (EU MRV) | | 4 | 10 | 13 | 17 | 24 | 40 | 68 | 85 |

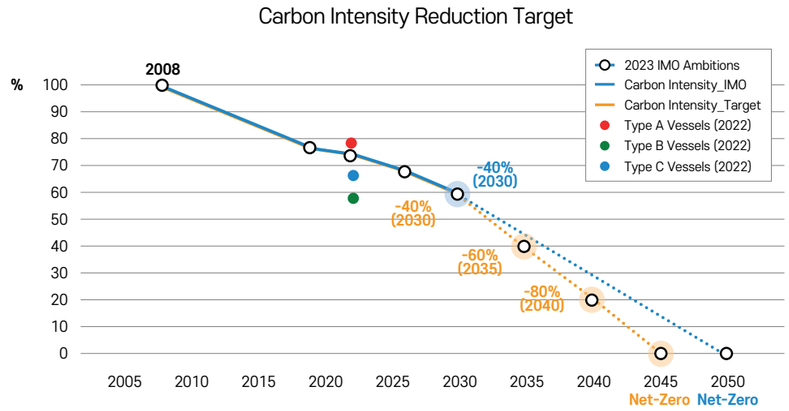
*Assumption: ECTS(≈ EU ETS): 90USD/ton$CO_{2eq}$, GFS(≈ FuelEU Maritime): (2,400Euro/tonFuel)





## Setting of own GHG reduction goals by shipping company

The IMO 2023 GHG reduction strategy aims to achieve Net-Zero by 2050. However, in order to achieve faster decarbonization, the shipping company has set a Net-Zero goal of 2045, five years ahead of the IMO goal. Accordingly, this study also set 2045 as the Net-Zero target deadline, and as an intermediate goal, the carbon intensity target of individual ships was set at 40% in 2030 and 80% in 2040 to evaluate the overall GHG emissions reduction.




If the carbon intensity target for the 46 ships carried out in this project is set as mentioned above, GHG emissions can be reduced by 20% in 2030 compared to 2022, reduced by 73% in 2040, and Net-Zero can be achieved in 2045.

## Reduction Measures for Each Vessel

### CII Calculation and Expected Rating for Each Vessel

We reviewed the expected CII rating for each vessel of this shipping company, which has been in effect since 2023. It was calculated based on IMO DCS data for 2022, and the expected CII rating until 2026 was evaluated as follows.

In particular, for some ships of Ship Type A, SEEMP Part III re-approval including corrective action plan was required due to low CII rating, but for Ship Types B, C, and D, no additional action was expected to be required.

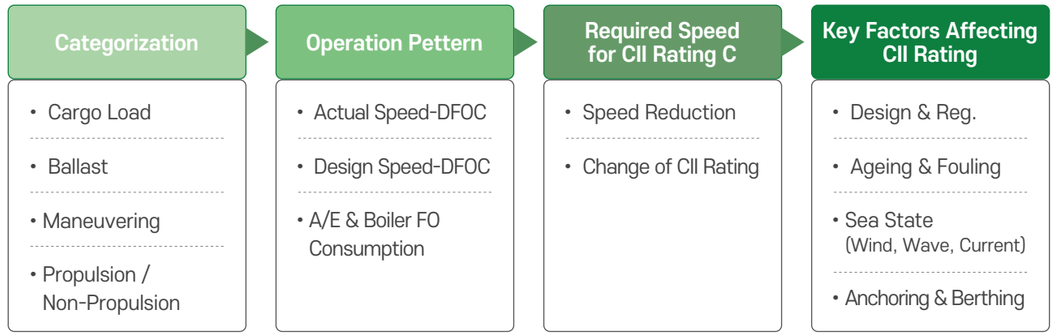
| No. | Ship type | Name | Delivery | Expected CII Rating | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 |
| 1 | A | A1 | 2017 | D | B | B | C | C | C | C | C |
| 2 | | A2 | 2017 | A | A | C | C | C | C | C | C |
| 3 | | A7 | 2016 | C | B | C | C | C | D | D | D |
| 11 | | A11 | 2015 | D | C | C | D | E | E | E | E |
| 12 | | A12 | 2015 | D | C | D | D | D | E | E | E |
| 29 | | A29 | 2011 | E | E | E | E | E | E | E | E |
| 36 | B | B4 | 2019 | A | A | B | B | B | B | B | B |
| 37 | | B5 | 2015 | A | B | B | B | B | B | B | B |
| 41 | C | C1 | 2016 | - | B | C | B | C | C | C | C |
| 42 | | C2 | 2015 | - | B | B | A | B | B | B | B |
| 46 | D | D1 | 2016 | C | D | D | B | C | C | C | C |

### Review operational measures (speed, operating pattern, etc.)

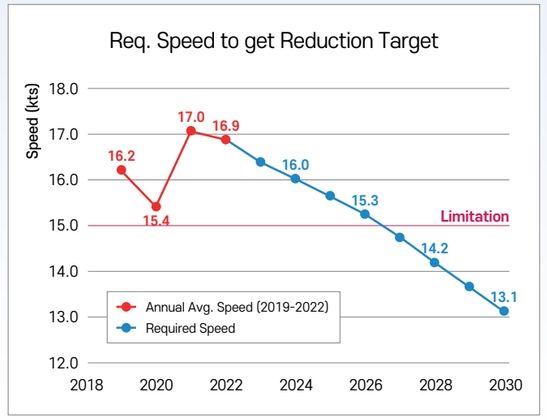
To mitigate GHG emissions, it's essential to initially assess the operational patterns of each vessel and evaluate improvement strategies through operational measures. This entails systematically gathering data on key factors such as operating speed, power, berth days, cargo volume, etc., for each ship annually or per voyage to analyze the reasons behind low CII ratings and operate ships with higher CII ratings. Optimized operational guidelines must be developed by benchmarking these patterns. For $CO_2$ emissions analysis, daily fuel consumption was scrutinized using IMO DCS data and the ship's Noon Report. Consequently, operational patterns were examined, fuel consumption was categorized, and feasible speeds for maintaining CII Rating C were assessed. Furthermore, factors such as design, fouling, sea conditions, anchoring, and berthing effects, which influence the CII grade, were analyzed.

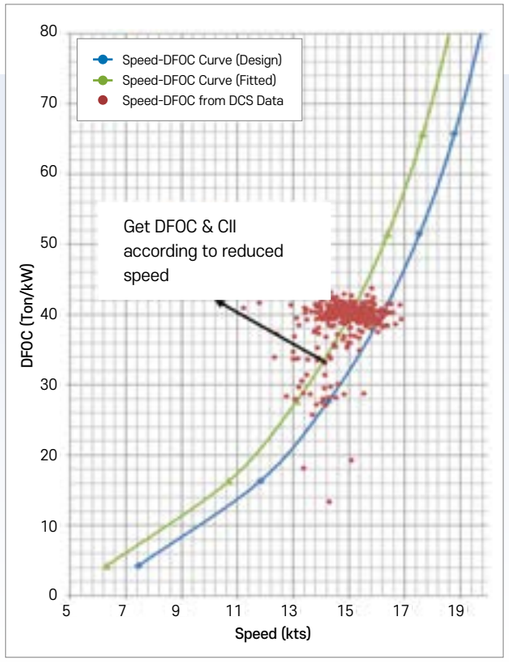


IMO DCS Data Analysis




Following the analysis of operational patterns, aging effects were not identified; however, fouling was observed two years after dry docking. The influence of design characteristics was examined, and the degree of speed loss based on sea conditions was also analyzed. Furthermore, vessels with high anchoring and berthing frequencies were identified.

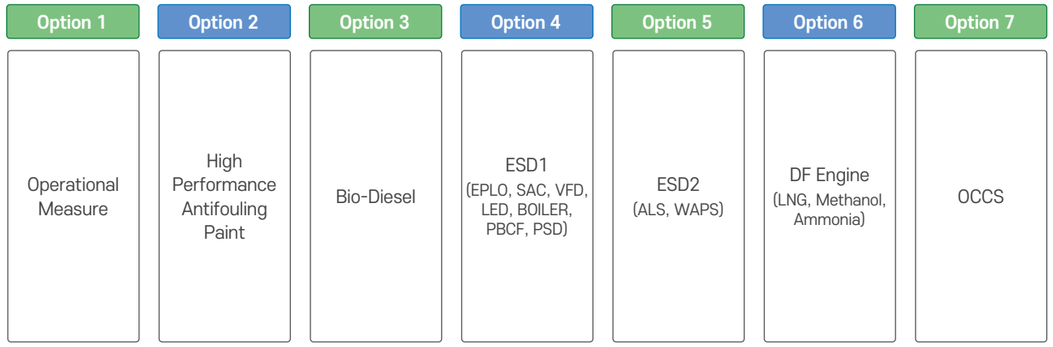


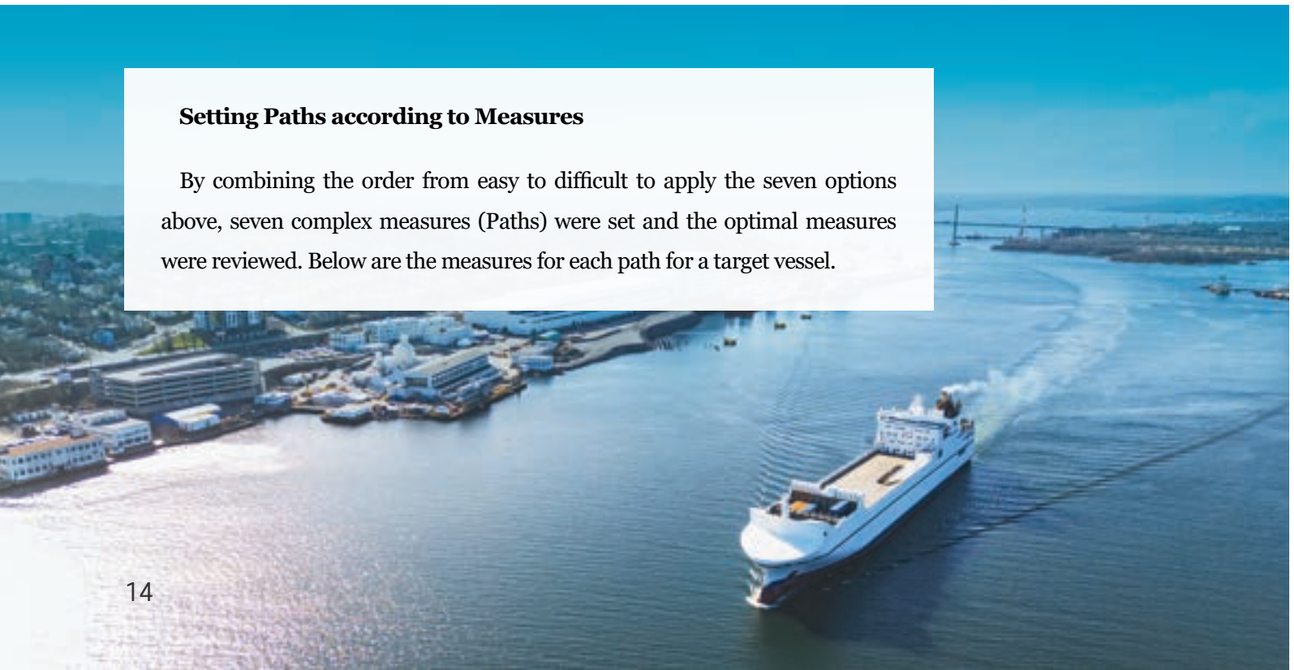
### Review Measures

Seven options were implemented to reduce $CO_2$ emissions, encompassing the operational measures examined earlier, as well as high-performance antifouling paint, biodiesel, energy-saving devices, modifications to alternative fuel engines, and shipboard carbon capture devices.

The measures were optimized by combining options for each ship to comply with the designated $CO_2$ emissions target, and detailed measures, costs, $CO_2$ reduction were omitted due to space constraints.

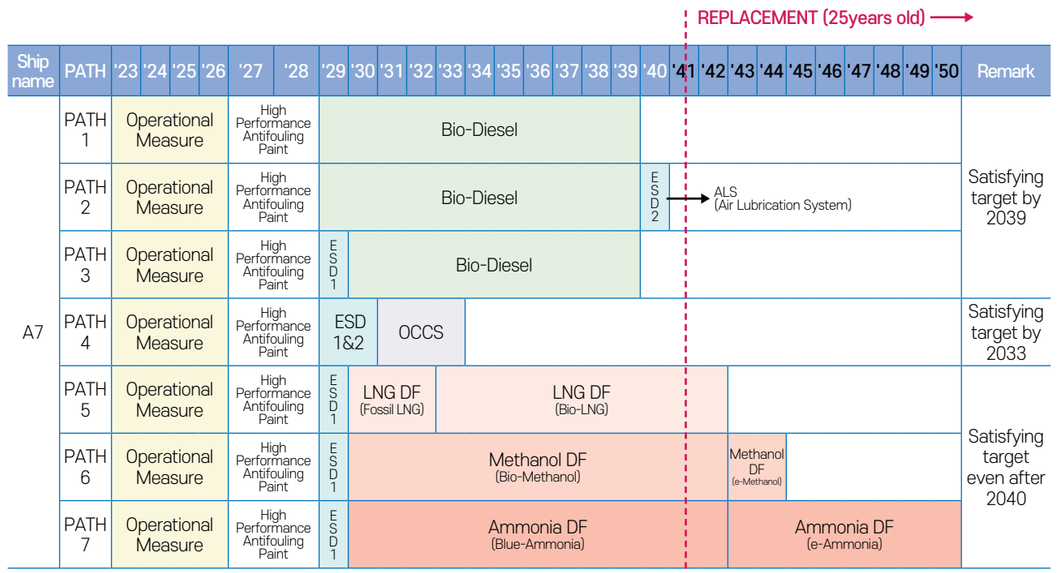



ESD: Energy Saving Device
EPLO: Engine Part Load Optimization
SAC: Scavenge Air Cooler
VFD: Variable Frequency Drive
PBCF: Propeller Boss Cap Fin
PSD: Pre-Swirl Duct
ALS: Air Lubrication System
WAPS: Wind Assisted Propulsion System
OCCS: Onboard Carbon Capture System



### Setting Paths according to Measures

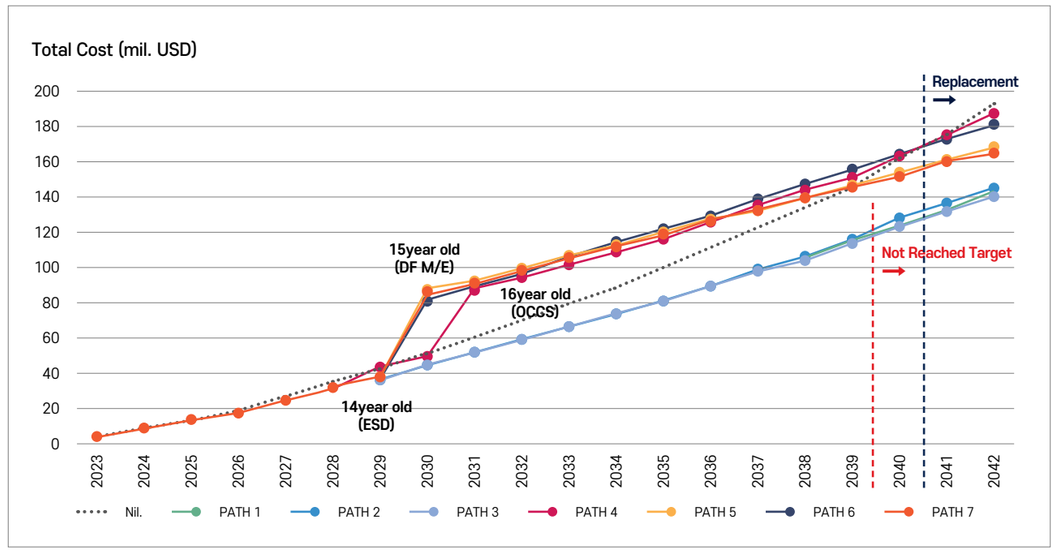
By combining the order from easy to difficult to apply the seven options above, seven complex measures (Paths) were set and the optimal measures were reviewed. Below are the measures for each path for a target vessel.




### Economic Evaluation base the Paths

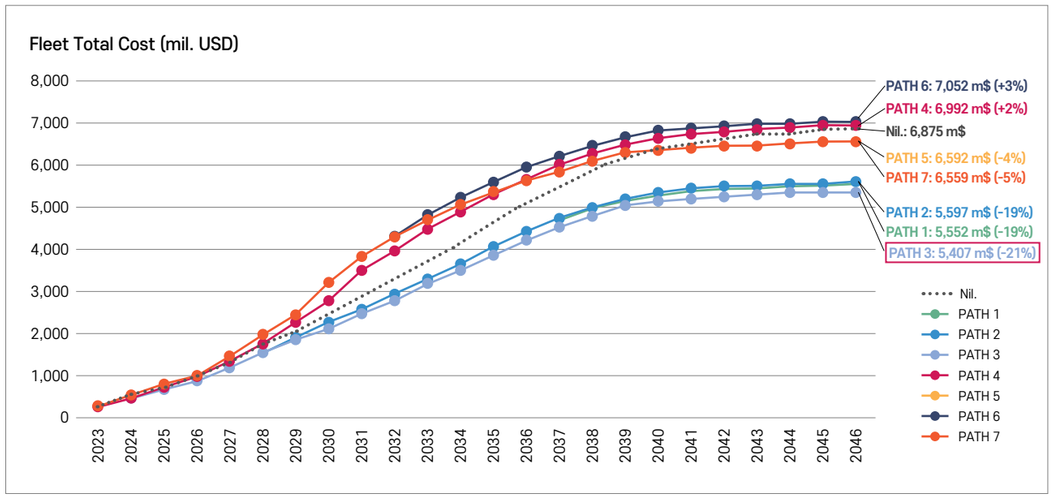
The above measures were created in the same way for all ships, and an economic feasibility assessment was conducted by reflecting the costs for each option.

The below figure shows the cumulative cost by Paths for the A7 ship. While the cumulative costs of Path 2 and Path 3 are low, it can also be seen that ships that choose this Paths will not meet the target until after 2039. Therefore, in the case of this ship, it should be needed additional measures (e.g. change of ship route, etc.) before 2039.



## Customized Decarbonization Strategy

Using the same method as above, the entire ship was reviewed and evaluated under the assumption of sale at 25 years of ship age. The difference between the total cost of 46 ships based on 25 years of age when the optimal path is adopted and when no measures are taken and the ship operates in its current state is “1,468 million USD,” which can result in a cost reduction of approximately 21%.




The figure below shows the optimal application year for each option for the fleet.

| No. | Ship type | Ship name | Built year | End year | Satisfying target year | Optimum Pathway '23 | '24 | '25 | '26 | '27 | '28 | '29 | '30 | '31 | '32 | '33 | '34 | '35 | '36 | '37 | '38 | '39 | '40 | '41 | '42 | '43 | '44 | '45 | '46 | Total Cost ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | A | - | 2017 | 2041 | 2039 | | | | | | | | | | | | | | | | | | | | | | | | | 143,905,073 |
| 2 | | - | 2017 | 2041 | 2039 | | | | | | | | | | | | | | | | | | | | | | | | | 136,123,864 |
| 3 | | - | 2017 | 2041 | 2039 | | | | | | | | | | | | | | | | | | | | | | | | | 136,076,178 |
| 11 | | - | 2015 | 2039 | 2039 | | | | | | | | | | | | | | | | | | | | | | | | | 118,520,319 |
| 12 | | - | 2015 | 2039 | 2039 | | | | | | | | | | | | | | | | | | | | | | | | | 119,450,535 |
| 29 | | - | 2011 | 2035 | 2039 | | | | | | | | | | | | | | | | | | | | | | | | | 98,275,630 |
| 36 | B | - | 2019 | 2043 | 2050 | | | | | | | | | | | | | | | | | | | | | | | | | 243,235,104 |
| 37 | | - | 2015 | 2039 | 2040 | | | | | | | | | | | | | | | | | | | | | | | | | 207,060,944 |
| 41 | C | - | 2016 | 2040 | 2040 | | | | | | | | | | | | | | | | | | | | | | | | | 62,438,649 |
| 42 | | - | 2015 | 2039 | 2040 | | | | | | | | | | | | | | | | | | | | | | | | | 74,255,767 |
| 46 | D | - | 2016 | 2040 | 2039 | | | | | | | | | | | | | | | | | | | | | | | | | 46,528,237 |

Operational Measure · Antifouling Paint · ESD 1 · Bio-Diesel · Ammonia DF (Blue-Ammonia)
Ammonia DF (e-Ammonia) · Bio-Diesel (Target Dissatisfaction)





## Conclusion

In order to achieve IMO's carbon reduction goals, it is necessary to switch to low-carbon, zero-carbon, eco-friendly fuel ships in the mid- to long-term. However, if we establish an effective customized decarbonization strategy for existing ships and apply it to ships, we believe that it will be able to have a great effect in reducing GHGs of shipping company and sufficiently secure market competitiveness throughout the ship's life cycle.

In particular, decarbonization strategies should be updated through continuous updates of the following items.

1. Setting annual decarbonization goals
2. Application of a digital platform that can systematically manage operational measures
3. Review of application of energy saving technology suited to individual ships
4. Review biofuel supply and engine modification feasibility
5. Setting the optimal route through economic evaluation: bio-diesel fuel (short-term), alternative fuel conversion (long-term)
6. Monitoring of technologies related to ammonia fuel conversion and shipboard carbon capture storage and processing
7. Continuous update of decarbonization strategy

# Navigating the Future of Hydrogen Transport

**ROH Giltae,** Principal Surveyor of Alternative Fuel Technology Research Team

In implementing the Paris Agreement, the Nationally Determined Contributions (NDCs) are crucial benchmarks aiming for an average reduction of greenhouse gas emissions by 40% by the year 2030. To achieve these ambitious targets, countries are increasingly turning to hydrogen imports. In particular, South Korea, Japan, and Taiwan face a substantial shortfall, as their local production relying on fossil-fuel-based blue hydrogen and renewable-based green hydrogen cannot meet their energy demands, leading them to import over 80% of their hydrogen needs. Similarly, Europe and China are enhancing their domestic production of clean hydrogen but are still categorized as net importers. On the other hand, regions such as the Middle East, Australia, the USA, and South America are emerging as potential hydrogen exporters due to their abundant natural resources including renewable energy.



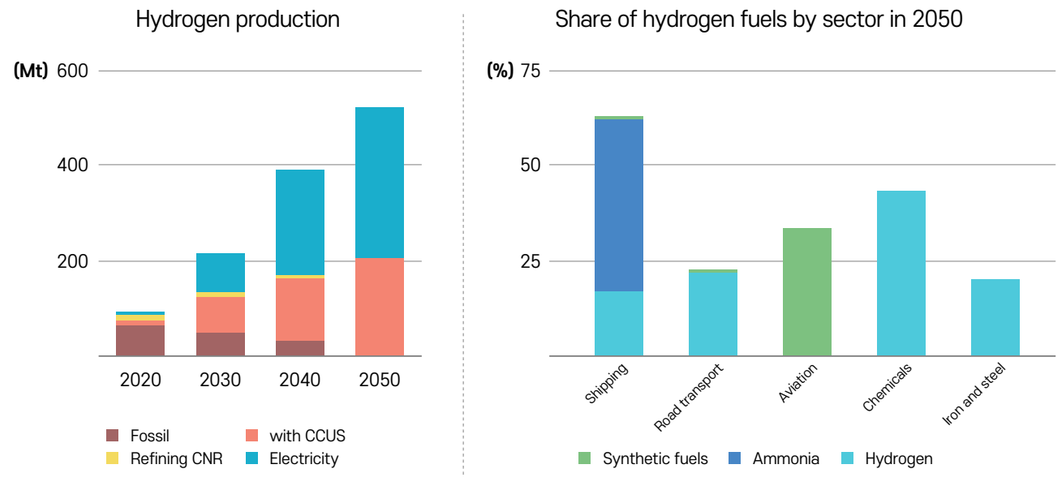


Currently, LNG serves as a primary method of energy transportation from continent to continent. However, hydrogen is expected to take over as the clean energy transportation method of the future. The International Energy Agency (IEA) predicts that by 2030, around 200 million tonnes, and by 2050, up to 500 million tonnes of hydrogen will be produced worldwide for use in ships, road transport, aviation, and industry.

## Hydrogen Transport Options

### Ammonia as a Hydrogen Carrier

Ammonia offers a viable solution for the global transport of hydrogen, particularly because it liquefies at -33 degrees Celsius, facilitating easier storage and transport. Currently, the global production of ammonia is primarily for fertilizer use, with an annual output of about 200 million tons and trade volumes around 18 million tons. However, projections suggest a significant increase to 340 million tons by 2035 as ammonia begins to play a role in coal power generation and serves as a zero-carbon fuel for ships. Despite these advantages, ammonia's toxicity and the energy-intensive process required to separate nitrogen and hydrogen for energy uses pose challenges.



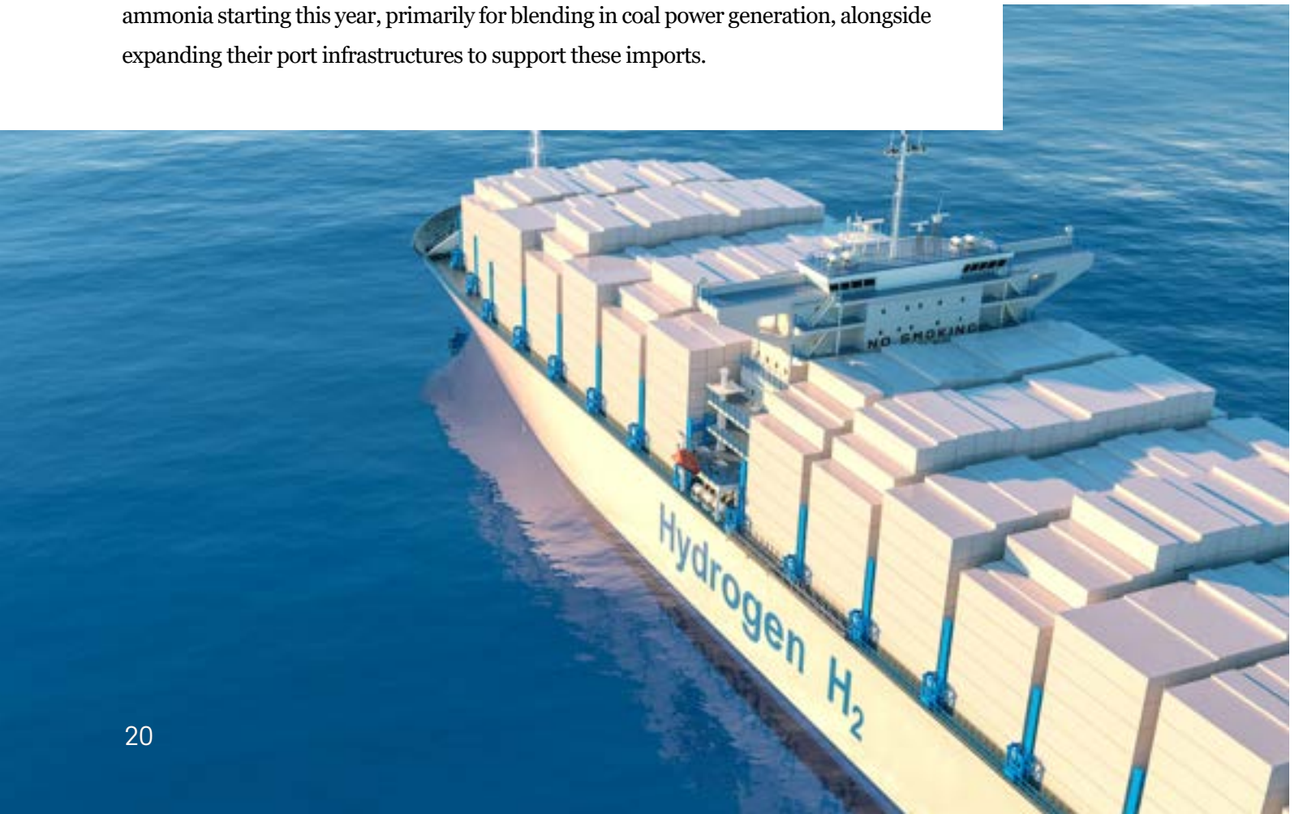

Sources: IEA

### Liquefied Hydrogen Carriers

On the other hand, liquefied hydrogen offers the advantage of transporting hydrogen in a high-purity form, making it directly usable in industries that require hydrogen. However, it must be liquefied at a very low temperature of -253 degrees Celsius, which presents challenges. Compared to LNG, liquefied hydrogen experiences higher evaporation losses during transport and has a lower energy density per volume.

## Hydrogen Transport Strategies in South Korea, Japan, and Europe

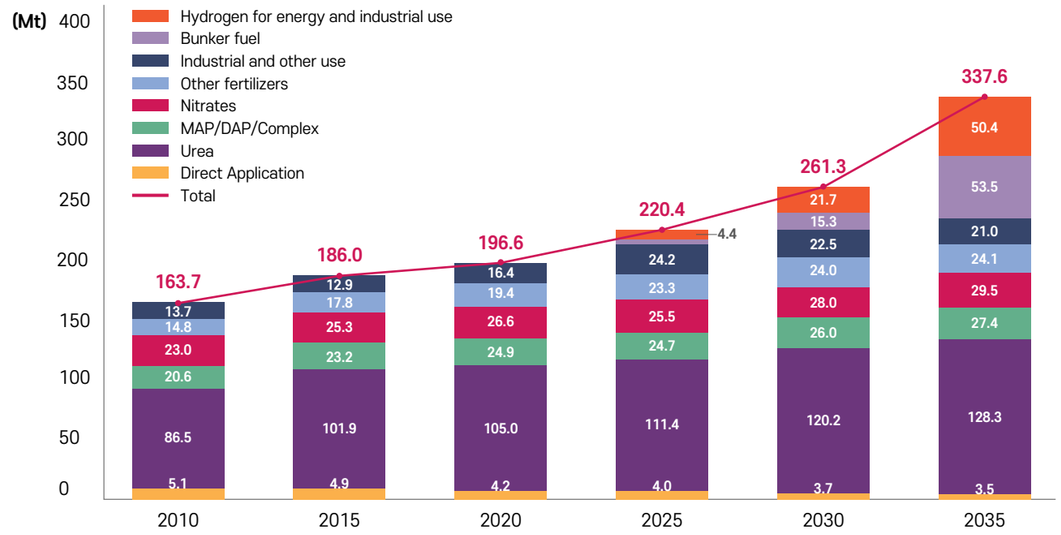
South Korea and Japan are currently at the forefront of the hydrogen economy, with parallel strategies for importing hydrogen. Initially, they plan to utilize ammonia as a transport medium due to its lower technological requirements. As advancements in liquefied hydrogen transport technology develop, both nations expect to use a dual approach, incorporating both ammonia and liquefied hydrogen. Meanwhile, Europe is also heavily involved in the hydrogen importation strategy, planning to supply a considerable portion of its hydrogen needs through ammonia imports. Europe is also preparing to establish large-scale plants capable of cracking the imported ammonia for further use. Concurrently, South Korea and Japan are preparing to import clean ammonia starting this year, primarily for blending in coal power generation, alongside expanding their port infrastructures to support these imports.








World ammonia demand outlook




Source: S&P Global Commodity Insights, 2023.08.

## Scaling Up Ammonia Carriers

When ammonia is used as a hydrogen transport medium between continents, traditional ammonia carriers, designed for transporting fertilizers with capacities between 80K to 90K, may not be sufficiently large for economical transport. Consequently, shipyards are now designing ultra large ammonia carriers with capacities ranging from 150K to 200K. If these supersized carriers are designed using the traditional method of independent Type A tanks, they face challenges such as the need to split tanks due to crane capacity limitations. Additionally, the increased weight and width associated with these tanks can complicate port entry and canal navigation. To address these issues, major shipyards are developing new concepts for cargo hold designs, in active collaboration with KR, to innovate and improve these designs.

## Development of Liquefied Hydrogen Carriers: Korea and Japan

In the field of hydrogen transport, Japan's Kawasaki Heavy Industries has taken a pioneering step by building the world's first 1.25K class liquefied hydrogen carrier, the Suiso Frontier, which has successfully transported liquefied hydrogen from Australia to Japan. Kawasaki has announced plans to construct a 160K class liquefied hydrogen carrier by 2030. Meanwhile, South Korea is planning to build a 2.0K class liquefied hydrogen carrier by 2028, with ambitions to scale up to a 40K class by 2030 and eventually to more than 160K.

The strategic increase in capacity is crucial for the development of large-scale liquefied hydrogen carriers. This involves a step-by-step approach starting with pilot projects to test cargo hold technology, Boil-Off Gas (BOG) handling technology, and various equipment technologies. As the infrastructure for large-scale hydrogen production and liquefaction matures and the demand for hydrogen increases, the construction of commercial-sized liquefied hydrogen carriers becomes economically feasible. This growth is driven by the economies of scale in both supply and demand aspects.

In addition to the ongoing advancements in hydrogen transportation technology, regulatory frameworks are also evolving. The International Maritime Organization's Maritime Safety Committee (IMO MSC) was set to finalize interim guidelines for liquefied hydrogen carriers this year. However, as the South Korean government's proposal to include various cargo hold technologies beyond the Type C has been accepted by IMO MSC, the development of these guidelines is expected to be extended by approximately two to three years.






## The Future Prospects of Hydrogen Transportation

The role of ammonia as a hydrogen transport medium appears increasingly secure. The existing volume of trade via sea and the well-developed port infrastructure make ammonia a robust candidate for hydrogen transport. This is further supported by the fact that ammonia can be used directly for power generation without the need for cracking back into hydrogen. Additionally, with the development of ammonia engines expected post-2025, its use as a ship fuel is likely to see significant growth.

Conversely, the path for liquefied hydrogen carriers is fraught with challenges. The construction of liquefied hydrogen plants and overcoming technical hurdles associated with the carriers themselves remain substantial. As a result, it is anticipated that hydrogen transport via ships will primarily utilize ammonia in the short to medium term, with liquefied hydrogen taking a dual-track approach as technology development and demonstration progress concurrently.

These developments highlight the dynamic nature of the hydrogen transport industry and underscore the importance of flexible regulatory and technological strategies to accommodate both current capabilities and future innovations.

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# Interview_

# Interview with Biofuel Experts

**SEO Daesik,** Senior Manager of R&D Team at HMM

Biofuels are being prioritized, especially for addressing GHG regulations for existing ships, due to their advantage of effectively reducing GHG emissions by blending a certain amount with traditional fossil fuels without modifying the engine or fuel supply system. Additionally, the recent surge in biofuel production has stabilized prices, making them even more preferable. In this issue, we feature an interview with Dae-Sik SEO, the Senior Researcher of HMM, who has been preparing for the use of biofuels for several years. Currently, HMM is using biofuels on container ships operating on European routes, playing a role as a first mover by reducing the Scope 3 emissions of shippers through their Green Sailing Service. The interview covers various aspects such as the purpose of using biofuels, fuel supply, demonstration, and technical solutions.

**Q. HMM is one of the most proactive first movers in the maritime industry regarding decarbonization. Could you share HMM's approach to preparing for the decarbonization era?**

**A** The topic of HMM's decarbonization policy is quite broad, so if I limit my discussion to the R&D sector, it is essential to be thoroughly prepared for all applicable technologies as new alternative fuels and various GHG reduction technologies are being developed. Without this preparation, we would face numerous trial and error phases at the actual implementation stage, which would cause us to miss the optimal time for application and result in significant opportunity costs for the company. Additionally, as regulations change and technologies advance rapidly, our R&D team aims to remain open-minded and flexible towards new and diverse technologies, free from preconceived judgments, and to always be prepared for their potential application.

**Q. Recently, there has been a growing interest among shipping companies worldwide in using biofuels. Could you explain the reasons for this?**

**A** When ordering new ships, our company primarily considers methanol and LNG fuels, and we are also considering ammonia fuel in the future. However, for existing ships, we see biofuels, which can be blended with existing HFO without any modifications, as the most economical solution. Biofuels are already being proactively applied to ships operating in the EU because the EU ETS is already in effect, and the FuelEU Maritime regulation will come into force next year. Furthermore, biofuels are necessary to improve the CII rating currently enforced by the IMO. While currently, ships with lower CII ratings are only required to establish corrective action plans, cargo owners and charterers are expected to begin avoiding ships with lower CII ratings from this year. Additionally, cargo owners are providing partial compensation for fuel costs as an incentive when using alternative fuels like biofuels to reduce Scope 3 GHG emissions. Therefore, HMM is offering a Green Sailing Service for cargo owners, and ultimately, the use of biofuels is driven by the need to comply with IMO and EU regulations as well as to meet cargo owner requirements.

**Q. You have explained the importance of using biofuels very well. However, there are several concerns about whether it will be possible to provide sufficient quantities at reasonable prices, given the limitations of feedstock and competition with other industries. How do you view the supply and demand issues for biofuels?**

**A** From the shipping company's perspective, the most important factor for the sustainable use of biofuels, which are considerably more expensive than conventional HFO, is to secure fuel supply at a stable and acceptable price with minimal price volatility. The problem of limited feedstock cannot be easily overcome until breakthrough production methods, such as third-generation biofuels using algae, are developed. However, on the positive side, production volumes are rapidly increasing both domestically and internationally, along with a sharp rise in demand. Regarding competition with other industries, if the transition to electric vehicles accelerates in the automotive sector, which currently uses the most biofuels, aviation and shipping will eventually become the most significant demand sectors for biofuels. Especially in aviation, only high-quality biofuels can be used, which restricts feedstock and processes, making it very expensive. In contrast, the shipping industry can use a variety of feedstock, processes, and fuel qualities, giving it an advantage in terms of price and applicability compared to other industries.

**Q. Next, I would like to ask about technical issues. What technical problems arise when using biofuels compared to conventional fossil fuels, and what methods are there to address these issues?**

**A** Since biofuels are organic compounds, they are prone to oxidation. Simply put, it can be compared to food spoiling. Additionally, they contain bacteria that can proliferate and cause various problems. In short, biofuels contain unnecessary biochemical impurities compared to conventional fossil fuels, and these impurities can multiply over time, altering the fuel's properties. Therefore, continuous management is more necessary, which is a key difference from conventional fossil fuels.

Specifically, there are material issues. Metal parts of the fuel supply system or engine can corrode, and rubber components can harden. There can also be problems with pipes or valves becoming clogged with impurities.

Regarding engines, the engine itself can encounter issues due to impurities, or there can be an increase in nitrogen oxides. Fortunately, it has been reported that there are no problems with blends up to B30, and even B100 biofuels in the FAME series are known to be stable.



To address the issues with biofuels, methods such as removing moisture or heating to inhibit bacterial growth can be employed. However, the most crucial solution is to use up the fuel before problems arise. Therefore, our current principle is to consume all biofuels within three months after bunkering, and we plan to gradually extend the storage period after verification through testing.

**Q. It seems that testing and demonstration are crucial for identifying and solving technical issues. Could you tell us about the demonstrations conducted so far and any future plans?**

**A** Demonstration is the key to the use of biofuels, so our company has been proactively conducting demonstrations since 2019. First, because biofuels vary by producer, we test biofuels on land at KR's Green Ship Equipment Test and Certification Center (TCC) to check engine performance, exhaust gases, and any engine abnormalities. Additionally, we have completed successful demonstrations of B30 biodiesel and bio heavy fuel oil on actual ships, which are now being successfully used on vessels operating on European routes. Starting this year, we are preparing for the B100 demonstration in collaboration with fuel suppliers and KR.

**Q. Since environmental regulations are just beginning to take effect, B30 should be sufficient to meet the regulations. Why are you rushing to demonstrate B100?**

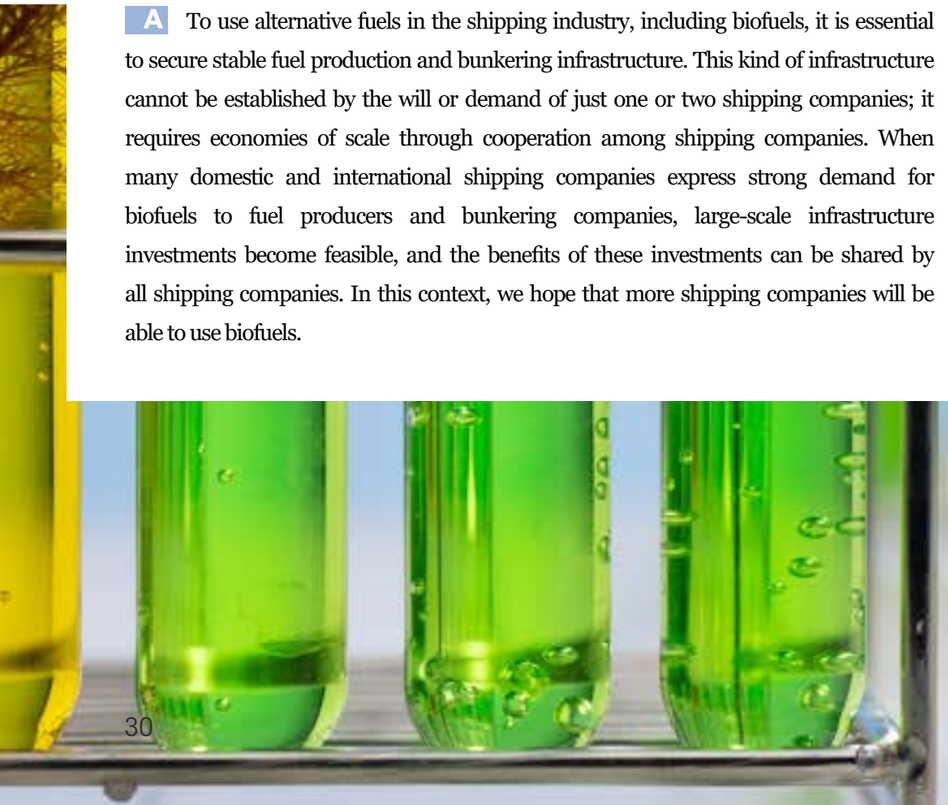
**A** Currently, FuelEU Maritime has a flexibility mechanism called pooling. This system allows not only individual ships but also the entire fleet to meet regulatory compliance. In simple terms, even if some ships do not meet the regulations, if other ships in the fleet exceed the requirements and offset the non-compliant ships, the entire fleet is considered compliant. Therefore, deploying ships using B100 allows other ships in the fleet to use fossil fuels, providing more flexibility and freedom in fleet operations compared to using only B30. Another reason, as mentioned earlier, is that without prior testing and experience, we may encounter issues or miss the optimal application timing when we actually need to implement the fuel. Hence, we believe that proactively responding, even if it incurs some costs now, is ultimately a cost-saving measure.

**Q. We understand that you plan to develop biofuel usage guidelines in collaboration with KR through this biofuel demonstration and make them available to all shipping companies. Could you explain the reason for this?**

**A** To use alternative fuels in the shipping industry, including biofuels, it is essential to secure stable fuel production and bunkering infrastructure. This kind of infrastructure cannot be established by the will or demand of just one or two shipping companies; it requires economies of scale through cooperation among shipping companies. When many domestic and international shipping companies express strong demand for biofuels to fuel producers and bunkering companies, large-scale infrastructure investments become feasible, and the benefits of these investments can be shared by all shipping companies. In this context, we hope that more shipping companies will be able to use biofuels.

**Q. Thank you for your intention to promote the development of HMM by improving the collective benefits of the entire shipping industry. As a first mover with extensive experience in biofuels, what suggestions or advice would you give to shipping companies considering the use of biofuels?**

**A** While biofuels are the focus of today's interview, we are considering various alternative fuels, including retrofitting existing ships. The key to selecting alternative fuels lies in how economically they can reduce greenhouse gases and how reliable the fuel supply can be secured. Especially regarding fuel supply, it is time to take immediate action. It is not desirable for large shipping companies to monopolize the alternative fuel supply chain for the continuous growth of the shipping industry. In this regard, joint response from shipping companies is crucial, and the later the participation, the more difficulties they may face in future fuel supply or technical issues.



KR Decarbonization Magazine

# Regulatory Updates_

# IMO Regulatory Trends

MEPC 81 continued the discussion to develop a basket of candidate measures that designated Goal-based Marine Fuel Standard with a phased reduction of GHG Fuel Intensity ($CO_{2eq}$/MJ) per energy of marine fuels over time as a technical measure and GHG Pricing Mechanism as an economic measure for the purpose of collecting revenues to support the implementation of the technical measure. In particular, it focused on setting a pathway that can meet the intermediate goals of the 2023 revised strategy containing the overarching elements such as 5~10% uptake of zero or Near-Zero GHG emission fuels, technologies and/or energy sources to increase by 2030, reducing total annual GHG emissions from international shipping by 20~30% by 2030 and 70~80% by 2040, and ultimately reaching Net-Zero GHG emissions by 2050.

The uptake of alternative fuels needs to be introduced in the international shipping to meet Goal-based Marine Fuel Standard as a technical measure, while a Flexible Compliance Mechanism which enables non-compliant ships using fossil fuels to be continuously operated would be introduced. The non-compliant ships using fossil fuels that cannot meet Goal-based Marine Fuel Standard may comply with the standard by purchasing Flexible Compliance Units (FCU) from the ships using alternative fuels with low GHG emissions or GHG Remedial Units (GRU) from GFS Registry. At the same time, ships using alternative fuels with low GHG emissions can receive incentives to compensate for the capital expenditure put into new building construction and the price gap between alternative fuels and fossil fuels. In addition, the possibility of introducing pooling compliance for non-compliant ships by teaming up with over-compliant ships will be discussed, this mechanism would permit over-compliant ships to share their emission credits with non-compliant ships in the same pool.

But, there was opposition raised that such a flexibility mechanism would lead to possible unintended consequences and inequal access to such compliance options between States, in particular, countries which are served by older shipping tonnage. Above all, it was also noted that a separate GHG Pricing Mechanism should not be implemented to reduce the significant economic effects of international shipping, since the transaction method itself which enables GHG emission credits to be traded between ships or through GFS Registry can also be considered as an economic measure.

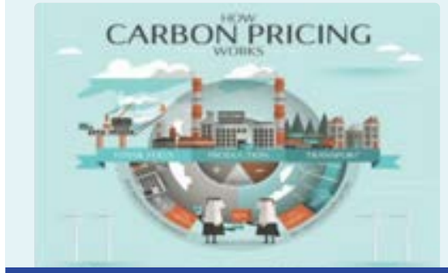
**GHG Fuel Intensity**
* Technical elements for fuels

**GFS (Goal-Based Fuel Standard)**

In calculating GFS Fuel Intensity, application of **WtW (full life-cycle)** GHG emission factor

**VS**

Application of **TtW (onboard)** GHG emission factor to calculate GFS Fuel Intensity, and WtW GHG emission factor to calculate **over-compliant units** for compliant ships




**Economic penalty to fossil fuels Incentives to alternative fuels**

**Whether to introduce GHG Levy**

**GHG Levy mechanism** In addition to GFS (to reduce price gap, incentives, RD&D for decarbonization, etc)

**VS**

**No additional GHG Levy** (under the GFS flexibility mechanism, **emission trades and transactions** occur between over-compliant ships and non-compliant ships)



The discussions to develop Mid-term measures for further reducing GHG emissions from international shipping will be continued by future ISWG-GHG and MEPC meetings. In particular, while it is anticipated that the details on technical and economic measures surrounding Mid-term measures would be determined at MEPC 82, which will be held in October 2024, the disbursement of the revenues which will be generated through the economic measures will also be holistically discussed. In addition, draft amendments to MARPOL Annex VI for implementation of Mid-term measures will be approved at MEPC 83, which will be held in the first half of 2025, and then after adoption of those amendments by extra session of MEPC will be held in the latter half of 2025, it will enter into force in 2027.

In this regard, it needs to be considered regarding the implications and preparations as per introduction of IMO GHG Mid-term measures. The IMO GHG reduction strategy will be strengthened over time and fossil fuels will have significant environmental and economic disadvantage in terms of more GHG emissions and penalties. But, early introduction of alternative fuels will have significant environmental and economic benefits in terms of incentives, and it can secure competitiveness in achieving 2050 Net-Zero GHG emissions. Above all, in implementing GHG Pricing Mechanism, an economic feasibility assessment should be made in a timely manner on whether to maintain fossil fueled ships continuing to impose taxes per GHG emissions or to receive incentives by introducing alternative fueled ships.

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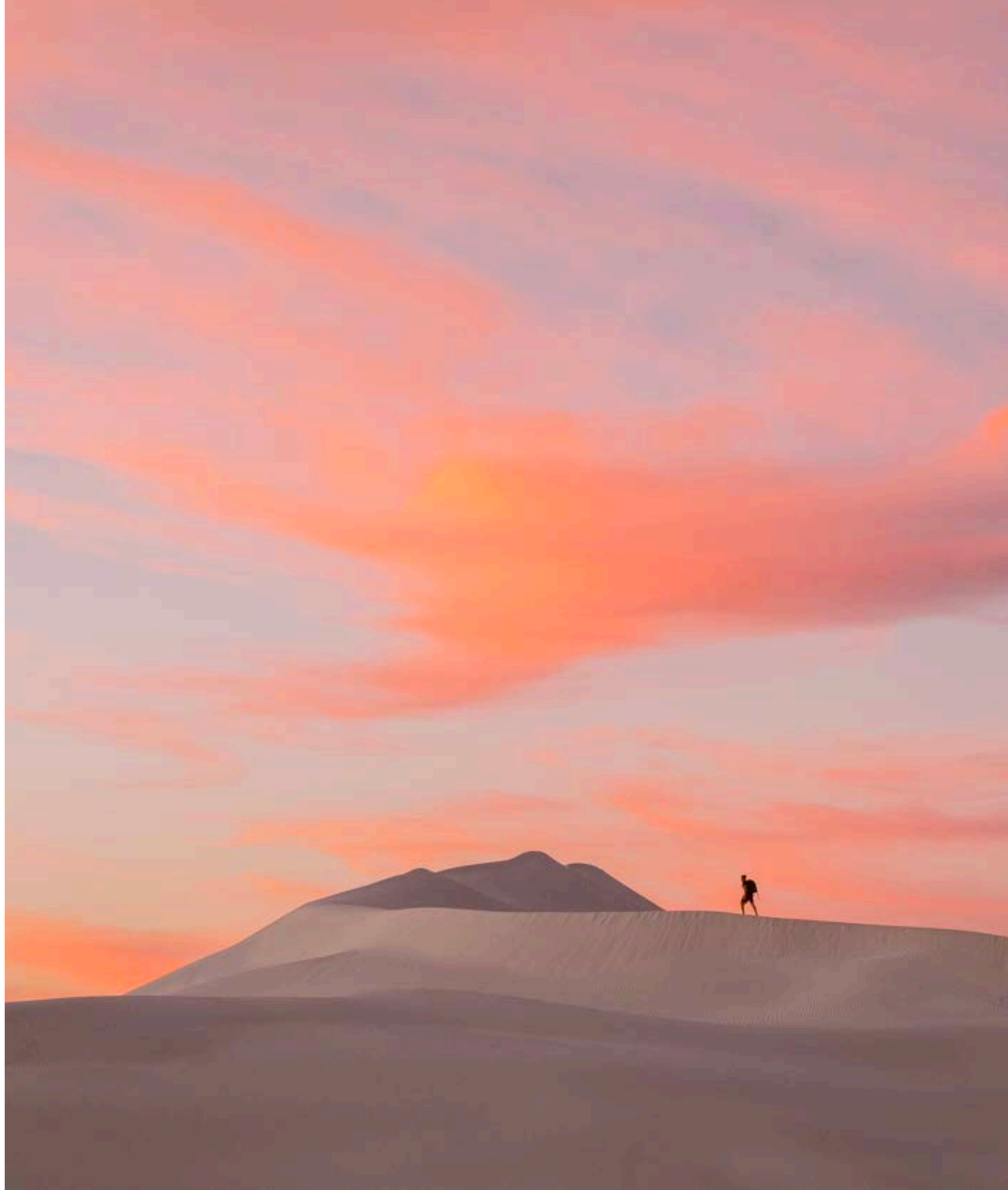
# Inside KR_



# KR has awarded AIP for Hanwha Aerospace's Onboard Hydrogen Fuel Cell

On May 30th, KR has awarded AIP (Approval In Principle) for Hanwha Aerospace's Onboard hydrogen fuel cell.

The award ceremony, held at Hanwha Aerospace's R&D center, was attended by KIM Daeheon, Executive Vice President of KR's R&D Division, and Moon Seunghak, Head of E-Propulsion System Business Group at Hanwha Aerospace, among others.

The AIP is a certification process that verifies the safety and compliance with international regulations of new technologies applied to ships and equipment, starting from the basic design phase. With this AIP certification, Hanwha Aerospace has officially been recognized for the stability of hydrogen fuel cells.

With this AIP certification, Hanwha Aerospace has not only been officially recognized for the stability of hydrogen fuel cells but has also built the foundation for type approval of onboard hydrogen fuel cells based on polymer electrolyte membrane fuel cells (PEMFC) for future use.






# KR Grants Approval to HD HHI's Next Generation K-AmmoniaStorage & Powered PCTC

KR has awarded an Approval in Principle (AIP) for the Next Generation K-Ammonia Storage & Powered PCTC, developed by HDHyundai Heavy Industries (HD HHI) withthe participation of Hyundai Glovis and G-Marine Service, at Posidonia 2024.

Currently, to address the increasinglystringent global greenhouse gas regulations, the development of alternativefuel technologies is actively underway, and ammonia fuel technology is one ofthe most highly regarded in the market. However, ammonia is more toxic andcorrosive compared to other alternative fuels, requiring additional safetyverifications considering the fuel propulsion system design and ship operationcharacteristics.

The ship that received the AIP was designedby HD HHI, taking into account the characteristics of ammonia. It includes an ammonia fuel containment system, specificallydesigned to handle the toxicity and corrosiveness of the ammonia fuel. KR verified the technical suitability of this system based on classificationrules and domestic and international regulations. Hyundai Glovis and G-MarineService jointly participated in the risk assessment process, enhancing thetechnical completeness.

JEON Seungho, Senior Executive Vice Presidentof HD HHI, stated, “The Next Generation K-ammonia Storage & Powered PCTC developed this time applies HD HHI’s market-leading eco-friendly technology. We will continue to pursue technological development to achieve carbon neutrality as a leading company in the maritime industry.”

YEON Kyujin, Senior Vice President of KR, said, “This AIP has laid an important foundation for the commercialization of ammonia-fueled car carrier ship technology. Based on this, KR will work to support not only ammonia fuel propulsion technologies but also decarbonization technologies for our customers.”





# KR Grants AIP for 150K Ultra-Large Ammonia Carrier

KR announced that it has granted an Approval in Principle (AIP) for the 150K ultra-large ammonia carrier developed by Samsung Heavy Industries (SHI) on June 5th at Posidonia 2024.

The 150K ultra large ammonia carrier was developed as part of a joint development project between KR and SHI. It is designed to transportlarge quantities of ammonia while using ammonia as a propulsion fuel, ensuring zero carbon emissions during operation.

SHI performed the conceptual design of the fuel system, addressing the characte-ristics of ammonia, including fuel supply, ventilation, and gas monitoring systems, and ensured that the basic design of the large tanks met the regulatory requirements.

KR verified the safety of the ammonia fuel system, checked the suitability of the tank arrangement, and reviewed domestic and international regulations to confirm the design compliance of the ultra-large ammonia carrier.


JANG Haeki, Executive Vice President of SHI, stated, “Clean ammonia is expected to play a significant role as an eco-friendly energysource and in energy transport for the future hydrogen society. We anticipate high market demand for ultra-large ammonia carriers to accommodate the expected increase in cargo volumes. The AIP will enable the rapid commercialization of ultra-large ammonia carriers, and based on this, we will collaborate with KR to lead the next-generation ship market by developing 9,300 TEU container carriers.”

# KR and SHI Sign MOU for Development of Ammonia-Fueled Container Ships

KRsigned a Memorandum of Understanding (MOU) with them for the development of 9,300 TEU ammonia-fueled container ships on June 5th at Posidonia 2024.

SHI will design the main system layout for applying ammonia fuel to neo-panamax 9,300 TEU container ships, and KR will verify the design compliance through the review of classification rules as well as domestic and international regulations, ultimately granting an AIP.

YEON Kyujin, Senior Vice President of KR, stated, “The collaborative projects with SHI focusing on ammonia-fueled ships are pivotal in establishing a solid groundwork for the commercialization of ammonia fuel ship technology. KR remains committed to furthering the advancement of ammonia fuel propulsion technology and supporting decarbonization initiatives.”





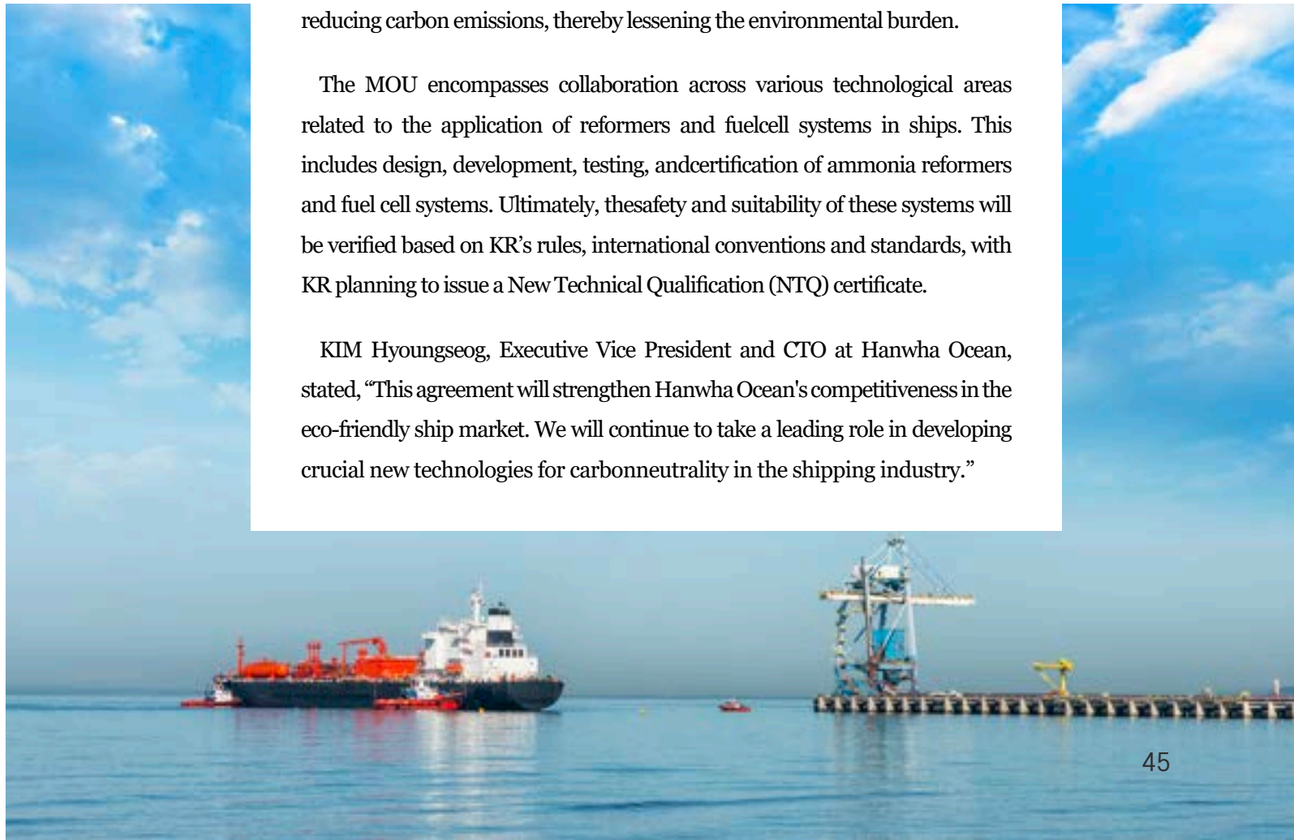

# KR, Hanwha Ocean, Amogy and Hanwha Aerospace Team Up for Application of Ammonia Reformers and Ammonia Fuel Cellsystems to Ships

KR has announced a Memorandum of Understanding (MOU) with Hanwha Ocean, Amogy, and Hanwha Aerospace. The MOU, signed at Posidonia 2024 in Athens, Greece, focuses on the technical collaboration and certification for the application of ammonia reformers andammonia fuel cell systems to ships. The ammonia reformers, used to produce gaswith hydrogen as the main component and supply it to fuel cell stacks, areessential equipment for the adoption of fuel cell systems.

Amid the increasing global decarbonization regulations, ammonia is emerging as a highly efficient alternative fuel. This agreement aims to apply reformers and fuel cell systems to ships, enhancing energy efficiency and reducing carbon emissions, thereby lessening the environmental burden.

The MOU encompasses collaboration across various technological areas related to the application of reformers and fuelcell systems in ships. This includes design, development, testing, andcertification of ammonia reformers and fuel cell systems. Ultimately, thesafety and suitability of these systems will be verified based on KR’s rules, international conventions and standards, with KR planning to issue a New Technical Qualification (NTQ) certificate.

KIM Hyoungseog, Executive Vice President and CTO at Hanwha Ocean, stated, “This agreement will strengthen Hanwha Ocean's competitiveness in the eco-friendly ship market. We will continue to take a leading role in developing crucial new technologies for carbonneutrality in the shipping industry.”



Amogy's CEO, WOO Seonghoon, expressed hisdelight, stating, “This agreement brings us one step closer to the commercialization of eco-friendly ships using Amogy's ammonia-based fuel cell systems. I believe multi-party collaboration is vital for the decarbonization of the shipping industry, and we will continue to do our best to ensure the safe introduction of ammonia and ammonia-based fuel cell systems into the ship market.”

MOON Seunghak, Head of E-Propulsion SystemBusiness Group at Hanwha Aerospace, commented, “The introduction ofammonia-based fuel cell systems is essential for the decarbonization of theshipping industry. We expect to maximize synergy through the cooperation of thefour companies. This technological development will play a key role inestablishing a carbon-neutral ecosystem in the ship transportationmarket.”

YEON Kyujin, Senior Vice President of KR, added, “This agreement will be an important milestone in applying ammonia technology to ships. KR will continue to drive the decarbonization of the maritime industry, by providing technical support to ensure that reformers and fuel cell systems can be safely applied to ships.”






# KR and Hanwha Ocean Sign Business Agreement for Smart Navigation Solution


KR and Hanwha Ocean jointly signed a business agreement on June 5th for the purpose of developing the Smart Navigation Solution for economic voyage of vessels at Posidonia 2024 in Athens, Greece.

Amidst the global trend of increasing decarbonization regulations, Hanwha Ocean is leading digital innovation in the maritime industry by developing the Smart Navigation Solution—a fuel-saving solution based on optimal route analysis. This system collects real-time weather data, marine conditions, and vessel operational data, using AI-based analysis to propose the best routes. The goal is to reduce fuel consumption and contribute to environmental protection by lowering carbon emissions.

The agreement includes technical collaboration on fuel-saving effects based on data analysis and optimal routes using Hanwha Ocean's Smart Navigation Solution. Ultimately, it aims to verify fuel-saving procedures and system installation and operation according to class rules and relevant standards, leading to KR's AIP (Approval in Principle).

LEE Joonghyuk, Team Leader of Hanwha Ocean, stated, "Through joint development project with KR, we will further advance economic operational technology and provide enhanced digital solutions with credible institutional certification. We anticipate increased competitiveness for Hanwha Ocean in project acquisition."

YEON Kyujin, Senior Vice President of KR, commented, "This agreement serves as a good example of applying digital technology to address decarbonization regulations. We will continue to support Hanwha Ocean's system implementation on vessels and validate the effectiveness of their solution."





# KR has granted AIP (Approval In Principal) to 12K CBM Liquefied Carbon Dioxide Carrier

Amidst global decarbonization efforts, Carbon Capture and Storage (CCS) technology is increasingly popular, leading to rising demand for liquefied carbon dioxide carriers. KR has granted an AIP to a 12K CBM liquefied carbon dioxide carrier developed jointly by Dongsung Fintec, K-Shipbuilding, and Sunbo Industries on May 27th.

In this project, Dongsung Fintec developed $LCO_2$ cargo tanks and LNG fuel tanks, K-Shipbuilding handled the basic and structural design of the carrier, and Sunbo Industries developed cargo handling and fuel supply systems. KR verified safety and suitability and ultimately awarded the AIP.

Developed through collaboration among KR, Dongsung Fintec, K-Shipbuilding, and Sunbo Industries, this 12K CBM class liquefied carbon dioxide carrier is expected to play a crucial role in achieving future carbon neutrality.

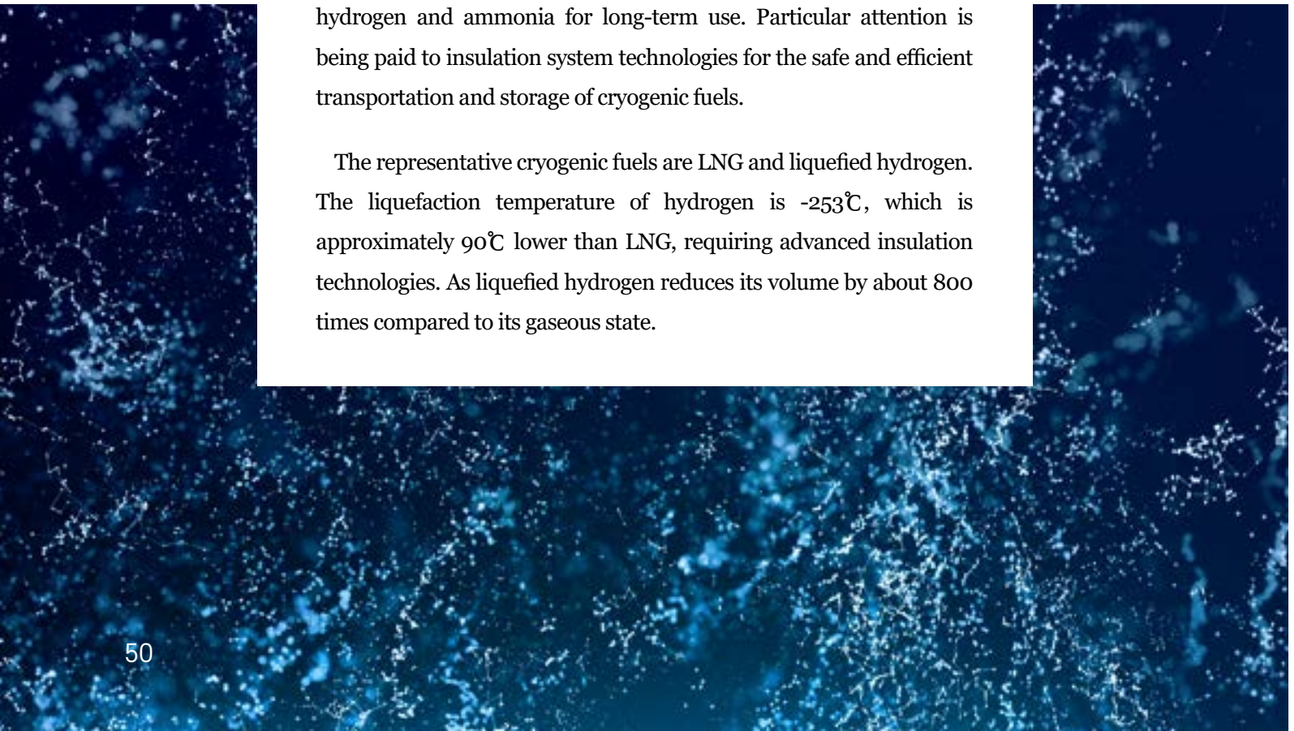
# KR Releases Guide to Selection of Thermal Properties for Cryogenic Insulation Materials

KR has published a research report titled “Guide to Selection of Thermal Properties for Cryogenic Insulation Materials” to ensure the safe storage of cryogenic cargoes (LNG or liquefied hydrogen) on ships.

Last year, the International Maritime Organization (IMO) adopted the 2023 IMO Strategy on Reduction of GHG Emissions from Ships with the goal of achieving international maritime carbon neutrality by 2050. The strategy aims to reduce greenhouse gas emissions by at least 20%, striving for 30%, by 2030, by at least 70%, striving for 80%, by 2040, compared to 2008 and achieving Net-Zero emissions by or around, i.e. close to 2050.

In response to these strengthened environmental regulations, the maritime industry is focusing not only on liquefied natural gas (LNG), which is currently widely used, but also on alternative fuels such as hydrogen and ammonia for long-term use. Particular attention is being paid to insulation system technologies for the safe and efficient transportation and storage of cryogenic fuels.

The representative cryogenic fuels are LNG and liquefied hydrogen. The liquefaction temperature of hydrogen is -253℃, which is approximately 90℃ lower than LNG, requiring advanced insulation technologies. As liquefied hydrogen reduces its volume by about 800 times compared to its gaseous state.




In this regard, KR, in collaboration with the Korea Institute of Machinery and Materials (KIM Yongjin and LEE Taehyun), Pusan National University (Professor KIM Jeong-Hyeon), and Seoul National University of Science and Technology (Professor PARK Changkyoo), has published the “Guide to Selection of Thermal Properties for Cryogenic Insulation Materials” to propose essential insulation system technologies for the cryogenic fuels.

The research report explains the insulation systems for LNG at -163℃ and for liquefied hydrogen at -253℃ applied to ships, as well as analyzes environmental factors affecting their designs such as heat transfer mechanisms. Based on this, it is expected to serve as a technical guide in the material selection stage when designing insulation systems for cryogenic environments or developing innovative insulation systems.

KR will continuously provide customers with various technical services through the proactive development of alternative fuel technologies.

# | MacNet Strategy Seminar | Strategy for Establishing a Green Shipping Corridor to Achieve Net-Zero


On May 9th, the Maritime Cluster Networking in Korea (MacNet) held the “MacNet Strategy Seminar 2024 – I, Strategy for Establishing a Green Shipping Corridor to Achieve Net-Zero”.

The seminar, hosted by MacNet and supported by Busan Metropolitan City and KR, focused on the strategy for establishing a Green Shipping Corridor to achieve Net-Zero by 2050 in international shipping. The government and related industries gathered to delve into the conditions and preparations for the introduction of the Green Shipping Corridor, especially in ports such as Busan and Ulsan.

The seminar comprised three sessions. In the first session, presentations were given on the global Green Shipping Corridor initiative by LEE Chigyung from the Ministry of Oceans and Fisheries, and on the strategies for building a Green Shipping Corridor by KIM Youngsun from HMM.

The second session featured presentations on the challenges of eco-friendly fuel bunkering as part of the role of Busan Port as a container hub by Lee Eunhyuk from Busan Port Authority, and on the establishment of an eco-friendly ship fuel supply network in cooperation with Busan Port by Kim Byeonggu, Ulsan Port Authority.

The final session comprised a comprehensive discussion on the topics presented in the previous two sessions. SONG Kanghyun, Head & Senior Vice President of KR’s Decarbonization Ship R&D Center, chaired the discussion, with participation from officials from the Ministry of Oceans and Fisheries, the Busan Metropolitan City Port Authority, and the four presenters from the earlier sessions.

◀ Find out more

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 emissions and fuel usage, using these advances
to enable our customers to meet their environmental goals.

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Korean Register

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