EXECUTIVE SUMMARY

A Study on Response Strategies for the Transition to Green Ammonia as Marine Fuel

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1. Background and Purpose

1) Background

- As environmental regulations for international shipping vessels become increasingly stringent, the importance of low-carbon and zero-carbon marine fuels continues to grow.
  - The IMO has increased its 2050 carbon emissions reduction target for the shipping sector to 100% and has officially approved mid-term measures (the Net-Zero Framework) to reduce greenhouse gas emissions from ships.
  - The EU has mandated a minimum share of 1.2% for renewable fuels of non-biological origin (RFNBOs) in the maritime sector's total energy consumption through the application of the EU Emissions Trading System (EU ETS) and the FuelEU Maritime

regulation.

- Improving ship energy efficiency alone has limitations in responding to international environmental regulations. Ultimately, a transition to zero-carbon fuels is necessary.

▪ As the lifecycle approach to marine fuels gains prominence, the environmental sustainability of fuel production processes must be considered.

- The IMO, the EU, and other regulatory bodies have introduced lifecycle assessments for marine fuels. These assessments consider greenhouse gas emissions not only from shipboard operations (Tank-to-Wake) but also from fuel extraction, production, and distribution processes (Well-to-Tank).
- As a result, it is difficult to utilize fossil fuel-based ammonia as a low-carbon or zero-carbon fuel, making green ammonia produced from renewable energy appropriate fuel option.
- The International Energy Agency (IEA) projects that ammonia will account for 44% of the maritime sector's energy mix by 2050.

▪ In Korea, efforts have generally focused on utilization, such as developing and deploying eco-friendly vessels, However plans for green ammonia fuel supply remain insufficient.

- A systematic framework for transitioning to green ammonia as a marine fuel needs to be established.
- This requires a comprehensive review of the conditions necessary for introducing green ammonia as a marine fuel.

2) Relevance to National Projects

- This study supports the following national policy agendas: 'Building a K-Maritime Powerhouse Leading the Arctic Route Era (National Agenda No. 56)' and 'Achieving Carbon Neutrality for a Sustainable Future (National Agenda No. 40)'.
  - Supporting the transition to green ammonia as a marine fuel will enhance the competitiveness of the maritime industry, centered on eco-friendly vessels and contribute to advancing the shipbuilding industry through zero-carbon ships.
  - Developing port infrastructure for green ammonia fuel supply can strengthen the carbon competitiveness of the maritime industry.

3) Purpose

- This study provides a comprehensive analysis of the conditions for introducing green ammonia as a marine fuel in Korea and presents policy recommendations for establishing a stable fuel system.
  - The study examines conditions from various perspectives, including demand and supply, technology, and institutional frameworks for green ammonia as a marine fuel.
  - It also proposes policy measures for establishing a stable green ammonia marine fuel system.

2. Methodology

- (Domestic and International Literature Review) Examining the characteristics of green ammonia as a marine fuel; supply and demand; technological trends; overseas policy cases; and the domestic introduction environment.
- (Expert Survey) Investigating the domestic and international status and prospects related to the introduction of green ammonia as a marine fuel.
  - The survey identifies the current status and prospects of marine fuels, the level of technological and institutional preparedness for supplying and utilizing green ammonia as a marine fuel, the challenges involved in introducing green ammonia-fueled vessels, and policy needs.
- (System Dynamics) Analyzing the dynamic interactions among supply and infrastructure preparedness, and institutional and technological preparedness for establishing the green ammonia marine fuel mechanism.
  - The analysis identifies the factors influencing the stable introduction, operation and diffusion of the green ammonia marine fuel system and the degree of their impact.
- (Expert Consultation) Assessing the conditions for introducing green ammonia as a marine fuel in Korea and reviewing the appropriateness of the expert survey questionnaire.

▪ (Policy Consultation Meeting) Discussing research directions and exploring the policy implementation of research findings.

3. Results

1) Summary

▪ As international environmental regulations for the maritime sector intensify, interest in green ammonia as an alternative marine fuel is growing.

- The IMO approved the Net-Zero Framework in 2025, which evaluates the intensity of greenhouse gas emissions on a lifecycle basis and imposes carbon taxes. The EU is limiting the carbon intensity of greenhouse gas emissions from ships under FuelEU Maritime, which comes into effect in 2025.
- Green ammonia produced from renewable energy minimizes CO_2 emissions during the production process, and offers advantages as a zero-carbon fuel when lifecycle assessment is applied. However, toxicity and low energy density remain challenges to be addressed.
- Ammonia bunkering technology is currently at the demonstration stage, while ammonia marine engine technology is approaching commercialization.
- Major countries including Japan, China, Singapore, Australia, and the Netherlands, are actively pursuing green ammonia

production and developing and demonstrating vessel technology, building bunkering infrastructure, creating safety guidelines and training systems, and supporting public-private partnerships.

- Korea's conditions for introducing green ammonia as a marine fuel:
- (Production) Korea imports all of its ammonia and is primarily considering it as a means of importing clean hydrogen from overseas.
- (Policy and Regulation) Under current legislation, ammonia is classified as a toxic substance and a high-pressure gas rather than as a marine fuel. Bunkering operations within ports are being demonstrated through special exceptions, such as in Regulatory-Free Special Zones.
- (Infrastructure) Korea has ammonia storage facilities with a total capacity of 187,000 tons. The government plans to build a 210,000-ton storage tank in Ulsan Port, as well as clean ammonia import terminals in Yeosu and Gwangyang Ports by 2030.

▪ Expert perception survey results on the conditions for introducing green ammonia as a marine fuel in Korea:

- (Adoption Outlook) Ammonia is likely to be used as a major marine fuel starting in 2040, with the appropriate introduction period for green ammonia forecasted to be between 2030 and 2040.
- (Challenges) Currently, 'technological uncertainty (51.9%)' shows the highest response rate. However, after 2030, 'fuel cost burden (44.4%)' and 'fuel supply chain shortages (29.6%)' are

expected to be the main challenges.

- (Policy Priorities) Policy priorities for promoting green ammonia-fueled vessels are ranked in the following order: ‘strengthening carbon emission regulations for ships (22.2%)’, followed by ‘establishing and supporting fuel supply bunkering infrastructure (20.9%)’.

▪ Analysis of factors influencing the green ammonia marine fuel mechanism in Korea:

- (Infrastructure Development) The level of bunkering infrastructure development is a leverage variable that drastically amplifies the volatility in the supply-demand gap for green ammonia marine fuel during the 2036-2044 period.
- (Institutional Preparedness) Sensitivity analysis of the degree of institutional preparedness (regulations and incentives) shows that differences in the speed and intensity with which effective policy instruments are implemented significantly affect the supply-demand gap. This indicates that early and proactive policy intervention is necessary.
- (Technological Preparedness) The degree of technological preparedness alone cannot resolve the issue of supply-demand gap. However, it promotes long-term stability and the diffusion of marine fuel supply.
- (Implications) The transition to green ammonia as a marine fuel must be pursued through integrated policies that organically combine infrastructure development, institutional preparedness, and technological stability.

2) Policy Recommendations

- The basic policy directions are divided into legal and institutional improvements, infrastructure development and operation, and support for green ammonia marine fuel utilization.
- (Legal and Institutional Improvements) Clarifying the legal status of green ammonia marine fuel supply and establishing a clean ammonia certification system.
  - Low-flashpoint fuel (ammonia, etc.) supply vessels should be added as a separate category to Annex 6, 'Registration and Reporting Standards for Port Transportation-Related Businesses', of the Enforcement Decree of the Port Transportation Business Act. Safety operating procedures for ammonia bunkering vessels should be established.
  - Ammonia cleanliness standards for marine fuel use should be added in conjunction with the clean hydrogen certification system. Annex 22, 'Format for Fuel Oil Supply Vessels', of the Rules on the Prevention of Pollution from Ships should be amended.
- (Infrastructure Development and Operation) Pursuing green ammonia port infrastructure development, ensuring green ammonia fuel supply stability, and securing a specialized workforce for green ammonia fuel.
  - A green ammonia port development strategy should be established to support the construction of ammonia storage

facilities and the introduction of ammonia bunkering vessels.

- To ensure the stability of the green ammonia fuel supply, safety measures and a leak response system to prevent accidents during ammonia bunkering should be developed.
- A specialized workforce for green ammonia fuel should be secured by developing and operating curricula related to ammonia marine fuel and supporting the establishment of educational infrastructure.

▪ (Support for Green Ammonia Marine Fuel Utilization) Establishing a green ammonia marine fuel cooperation system, expanding technology development and demonstration support, and expanding fuel transition regulations and incentives.

- A green ammonia marine fuel cooperation system should be established to support collaborative projects between fuel producers and shipping companies, and a green ammonia marine fuel supply roadmap should be developed.
- To expand technology development and demonstration support, key technologies for public-private collaboration should be selected and supported, and a green ammonia marine fuel research and innovation program should be implemented.
- Penalties for the use of fossil fuels in the maritime sector should be maintained and the use of RFNBOs should be mandated. In conjunction with this, incentives should be expanded by applying green ammonia-fueled vessels to eco-friendly vessel and equipment certification systems.

4. Expected Outcomes

1) Policy Effects

- Resolving legal and institutional gaps related to green ammonia marine fuel and expanding its utilization
  - Registration and examination standards for ammonia marine fuel supply operators will be clarified through an official government statement confirming that green ammonia is included as an eco-friendly fuel.
- Improving supply readiness for green ammonia marine fuel
  - Stable bunkering support for green ammonia marine fuel should be provided through the development of port infrastructure and support policies.
  - Establishing a cooperation system between fuel suppliers and shipping companies will enable proactive responses to supply chain risks for green ammonia marine fuel.
- Resolving technological uncertainties related to green ammonia marine fuel.
  - Technological safety is expected to be secured through support for technology development and demonstration projects.

2) Social and Economic Effects

- Creating highly skilled jobs.

- A specialized workforce can be secured through green ammonia bunkering and maritime education, enabling the safe handling of green ammonia marine fuel.

▪ Expanding social acceptance of green ammonia marine fuel

- Acceptance among shipping companies, cargo owners, and port area residents can be increased by establishing green ammonia bunkering safety protocols and building safety incident response systems.