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대한민국 해양 산업에서 수소 벙커링 도입을 위한 법적 분석 및 실행 방안

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Legal Analysis and Directions for Implementing Hydrogen Bunkering in the Republic of Korea's Maritime Industry

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Abstract >> The maritime industry, responsible for 80% of global freight transport, heavily pollutes the environment through traditional fossil fuels. The International Maritime Organization aims to reduce sulfur and greenhouse gas emissions, but faces technical and financial challenges. Hydrogen fuel cells present a promising alternative with high efficiency and low emissions. This study examines the legal and regulatory frameworks needed for hydrogen bunkering across land, port, and sea. Key legislation includes the High-pressure Gas Safety Control Act, Hydrogen Economy Promotion and Hydrogen Safety Management Act, Harbor Act, Harbor Authority Act, Marine Transportation Act, and Harbor Transport Business Act. The study identifies overlapping regulations and proposes integrated solutions. The findings underscore the necessity of strict safety standards and legislative amendments to recognize hydrogen as a ship fuel. Establishing a comprehensive legal framework is essential for safe and efficient hydrogen bunkering. Continuous updates through international cooperation and standardized regulations are crucial for adopting hydrogen fuel cells, ensuring a sustainable and environmentally friendly maritime industry.

Key words : Maritime industry(해양 산업), Legal frameworks(법적 체계), Regulatory frameworks(규제 체계), Hydrogen bunkering(수소 벙커링), Legislative amendments(법률 개정)

1. Introduction

The maritime industry accounts for 80% of global freight transport and plays a crucial role in trade[1]. However, the use of traditional fossil fuels leads to environmental pollution[2]. To address this, the International Maritime Organization (IMO) has set regulations to limit sulfur content to 0.5% starting in 2020 and aims to re-

duce greenhouse gas emissions by 50% by 2050. Despite these efforts, compliance with regulations faces technical challenges, and low-sulfur fuels come with increased costs and technical issues. Consequently, the maritime industry is considering hydrogen fuel cells as a promising alternative energy source[3,4].

Hydrogen, an abundant element with high energy density, allows hydrogen fuel cells to produce electricity without combustion, offering high efficiency and low emissions. This makes hydrogen fuel cells crucial in reducing carbon emissions in the maritime industry. They do not emit CO_2, NO_x, SO_x, or particulate matter, making them an environmentally friendly alternative[5,6]. However, ensuring safety and efficiency during the bunkering process is essential due to hydrogen's flammability and explosiveness, requiring high safety standards. High-pressure tanks or cryogenic storage technology are necessary, along with international cooperation and standardized regulations[7,8].

Initial investment costs are high, necessitating cooperation between governments and the private sector. Many countries are investing in hydrogen infrastructure. Pilot projects have demonstrated technical feasibility, but further research and development are needed due to a lack of specific technical standards and regulations. Establishing safe bunkering procedures and international standards will promote the adoption of hydrogen fuel cell systems[9].

Moreover, climate change issues extend beyond environmental dimensions to political, economic, and social aspects, highlighting the need for legal frameworks to support the adoption of new energy sources. To introduce hydrogen bunkering for ships on land and at sea, relevant legislation needs to be revised, and specific technical standards must be established. Legal and institutional support is essential for the safe and efficient supply of hydrogen fuel[10].

This study aims to analyze the legal requirements and regulatory frameworks needed to introduce hydrogen bunkering in alignment with Korean legislation. It seeks to present implications and future directions for each regulation, thereby ensuring the safety and efficiency of hydrogen bunkering and providing a concrete legal foundation for the sustainable development of the maritime industry within the context of South Korea's legal landscape.

2. Hydrogen bunkering related legislation

2.1 Relevant laws

To analyze South Korea's legislation related to hydrogen bunkering, it is necessary to check the applicability of the law according to the methodology of hydrogen bunkering. Therefore, it can be checked by dividing it into laws for land, port, and sea, as shown in Fig. 1[10].

Legislation on land can be applied through the High-pressure Gas Safety Control Act and the Hydrogen Economy Promotion and Hydrogen Safety Management Act. The High-pressure Gas Safety Control Act aims to prevent hazards caused by high-pressure gas and ensure public safety by regulating the manufacture, sale, storage, and use of high-pressure gas. The Hydrogen Economy Promotion and Hydrogen Safety Management Act aims to lay the foundation for promoting the hydrogen economy, systematically foster the hydrogen in-

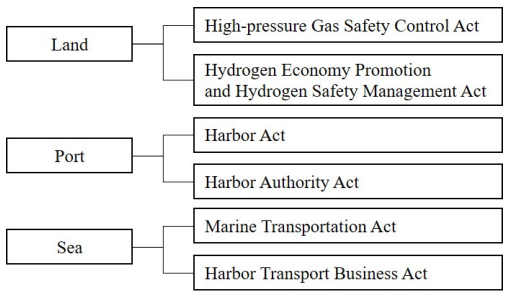

Fig. 1. Legislation for land, port, and sea

dustry, and ensure public safety by stipulating matters related to hydrogen safety management.

Legislation in ports can be applied through the Harbor Act and the Harbor Authority Act. The Harbor Act aims to promote port development projects and contribute to the development of the national economy by regulating the designation, development, management, and use of ports for efficient management and operation. The Harbor Authority Act aims to contribute to the development of the national economy by establishing harbor authorities to enhance the professionalism and efficiency of harbor facilities' development, management, and operation, fostering ports as competitive maritime logistics hubs.

Legislation at sea can be applied through the Marine Transportation Act and the Harbor Transport Business Act. The Marine Transportation Act aims to maintain order in maritime transportation, promote fair competition, ensure the sound development of the maritime industry, and ensure the safe transportation of passengers and cargo, contributing to the development of the national economy and public welfare. The Harbor Transport Business Act aims to establish order in harbor transportation, promote the sound development of the harbor transport business, and enhance public welfare.

2.2 Implications and method for deriving legislative measures

First, review the objectives and key contents of each legislation. Carefully analyze how relevant laws such as the High-pressure Gas Safety Control Act, the Hydrogen Economy Promotion and Hydrogen Safety Management Act, the Harbor Act, the Harbor Authority Act, the Marine Transportation Act, and the Harbor Transport Business Act can be applied to hydrogen bunkering. During this process, clarify the topics addressed by each law, the subjects of regulation, and the scope of application.

Next, compare and analyze the regulations and requirements of each law. Identify overlapping regulations or conflicting aspects among the laws and seek integrated solutions to resolve these issues. Additionally, consider the interactions between the laws to draw comprehensive implications. This involves analyzing how each law can be applied at different stages of hydrogen bunkering and focusing on establishing an integrated legal framework.

Finally, derive implications by considering economic and technical aspects together. Evaluate the economic costs and technical requirements of building hydrogen bunkering infrastructure in conjunction with the legal analysis, emphasizing the need for cooperation between the government and the private sector. This approach presents comprehensive implications that consider the legal, economic, and technical aspects of hydrogen bunkering. Based on these integrated implications, propose specific application measures and assess the need for amendments or the establishment of new laws.

3. Implications and measure for hydrogen bunkering

3.1 Implications

3.1.1 Land-based legislation (High-pressure Gas Safety Control Act, Hydrogen Economy Promotion and Hydrogen Safety Management Act)

The High-pressure Gas Safety Control Act defines hydrogen as a ‘flammable gas’, providing legal standards to ensure the safe handling of hydrogen during the bunkering process. This legislation aims to minimize risks that may arise during hydrogen bunkering by regulating the safe manufacture, storage, transportation, and use of high-pressure gases. The 2019 amendment clarified the management system for hydrogen, playing a crucial role in strengthening the management system for land-based hydrogen bunkering. Key elements ensuring

the safety of hydrogen bunkering include standards for the installation of high-pressure gas storage facilities, safety management procedures for flammable gases, and regulations for transporting high-pressure gases. Therefore, strict compliance with safety management standards set by the High-pressure Gas Safety Control Act is essential throughout the entire hydrogen bunkering process to ensure public safety.

The Hydrogen Economy Promotion and Hydrogen Safety Management Act, abbreviated as the Hydrogen Act, stipulates safety management and systematic development at all stages of the hydrogen industry, including production, storage, transportation, charging, and sales. By clearly defining the legal requirements for the installation and operation of hydrogen bunkering facilities, the Hydrogen Act ensures the safety and efficiency of hydrogen bunkering. This law encompasses all activities related to the hydrogen industry, providing a legal basis to address various situations that may arise during the hydrogen bunkering process. The scope of the Hydrogen Act includes both port and land-based facilities where hydrogen bunkering takes place.

The implications of these two pieces of legislation highlight the importance of clearly defining the legal requirements and support measures necessary to safely and efficiently introduce hydrogen bunkering within ports. They emphasize the need to ensure the installation and operation of hydrogen bunkering facilities within ports through an integrated approach with related laws.

3.1.2 Port legislation (Harbor Act, Harbor Authority Act)

The Harbor Act provides a clear legal basis for the installation and operation of hydrogen bunkering facilities through explicit regulations on various facilities that can be established within ports. The addition of facilities related to new and renewable energy to port facilities in 2013 implies that hydrogen bunkering facilities can be included within this category. This legislation allows hydrogen bunkering facilities to directly refuel hydrogen-carrying ships or supply fuel via land through fuel supply facilities, water supply facilities, and ice production and supply facilities within the port. Therefore, it is crucial to thoroughly comply with the regulations of the Harbor Act and meet the legal requirements when installing hydrogen bunkering facilities. The implication of this legislation is the necessity of clearly defining the legal requirements to ensure the safe and efficient hydrogen bunkering within ports.

The Harbor Authority Act provides a legal foundation for port authorities to demonstrate professionalism and efficiency in the development, management, and operation of port facilities. This implies that legal and administrative support necessary for the installation and operation of hydrogen bunkering facilities can be provided. The port authority has a broad range of business scopes, including projects related to new and renewable energy, allowing the integration of hydrogen-fueled ships. This legislation supports all procedures related to the installation of hydrogen bunkering facilities by following the basic plan according to article 5 of the Harbor Act and the basic plan under article 4 of the Act on the Creation and Management of Marina Ports. Furthermore, the port authority can provide the professionalism and efficiency required for the construction and operation of hydrogen bunkering infrastructure and establish an integrated management system in harmony with other related laws. The implication of this legislation is that by providing legal and administrative support for the installation and operation of hydrogen bunkering facilities, the port authority can ensure a safe and efficient hydrogen bunkering system.

The implications of these two pieces of legislation emphasize the importance of clearly defining the legal requirements and support measures necessary to safely and efficiently introduce hydrogen bunkering within

ports. They stress the need to ensure the installation and operation of hydrogen bunkering facilities within ports through an integrated approach with related laws.

3.1.3 Maritime legislation (Marine Transportation Act, Harbor Transport Business Act)

While the Marine Transportation Act does not directly address specific maritime transportation businesses such as ship fuel supply, it supports various activities within the shipping industry to ensure fair and safe operations by maintaining order and promoting fair competition. Article 2 (definitions) paragraph 3 of the Marine Transportation Act defines 'marine cargo transportation business' as anything other than the port transportation business defined in article 2 paragraph 2 of the Harbor Transport Business Act, explicitly including ship fuel supply within the scope of the Harbor Transport Business Act. This implies that while hydrogen bunkering is not directly governed by the Marine Transportation Act, the act indirectly supports the legal framework for hydrogen bunkering through its close connection with the Harbor Transport Business Act. The implication of the Marine Transportation Act is that it is necessary to ensure that hydrogen bunkering activities at sea are regulated under the Harbor Transport Business Act, thereby creating an environment where hydrogen bunkering can be carried out safely and consistently.

The Harbor Transport Business Act defines and regulates the scope of various port transportation-related businesses, including ship fuel supply, to promote the sound development of the port transportation business. Although the scope of the ship fuel supply business was expanded in the 2018 amendment to include the supply of fuel for ships, there is no clear legal basis for including hydrogen as a ship fuel. This lack of clarity can be an obstacle in formally recognizing and regulating hydrogen bunkering. Therefore, it is necessary to clarify the definition of ship fuel in article 2 paragraph 3 of the enforcement decree of the Harbor Transport Business Act and include hydrogen as a ship fuel. This would allow hydrogen bunkering to be legally recognized and systematically build the related infrastructure and procedures. The implication of the Harbor Transport Business Act is that it is important to clearly define hydrogen as a ship fuel and regulate it to ensure that the hydrogen bunkering business can obtain official legal status and operate safely and efficiently.

The implications of these two pieces of legislation highlight the importance of clearly defining the legal requirements necessary for the introduction and operation of hydrogen bunkering at sea. They emphasize the need to systematically manage the hydrogen bunkering business through an integrated approach with related laws.

3.2 Implications from the perspective of bunkering

To ensure the safety and efficiency of hydrogen bunkering, it is essential to comply with the strict safety management standards of the High-pressure Gas Safety Control Act and the Hydrogen Act, minimizing risks throughout the entire process. This can be achieved through standards for the installation of high-pressure gas storage facilities, safety management procedures for flammable gases, and regulations for transporting high-pressure gases. Additionally, the regulations of the Harbor Act and the Harbor Authority Act must be followed to clearly define the legal requirements for the installation and operation of hydrogen bunkering facilities and to ensure strict compliance. It is necessary to allow hydrogen-carrying ships to directly refuel at port fuel supply facilities, water supply facilities, and other ship supply facilities or to receive fuel via land routes.

The Marine Transportation Act and the Harbor Transport Business Act should be interconnected to legally support the hydrogen bunkering business and en-

sure its safe and efficient operation. The Marine Transportation Act indirectly supports hydrogen bunkering by ensuring it is regulated under the Harbor Transport Business Act, while the Harbor Transport Business Act needs to clarify the definition of ship fuel supply business to include hydrogen as a ship fuel.

By integrating the implications of these laws, it is crucial to establish a consistent legal framework encompassing land, port, and sea to ensure the safety and efficiency of hydrogen bunkering throughout the entire process.

3.3 Legislative proposal

As an application measure of the High-pressure Gas Safety Control Act, it is necessary to comply with its regulations when supplying fuel to hydrogen-powered ships. This includes standards for the installation of high-pressure gas storage facilities, safety management procedures for flammable gases, and regulations for the transportation of high-pressure gases. Since hydrogen is defined as a flammable gas under the High-pressure Gas Safety Control Act, strict adherence to the safety management standards of this act is required during the hydrogen bunkering process. Therefore, hydrogen bunkering facilities should be treated as high-pressure gas storage facilities and must comply with the installation standards and management procedures for such storage. Additionally, to minimize any risks that may arise from hydrogen bunkering facilities, regular inspections and strict implementation of safety management procedures are essential.

According to article 4, paragraph 1 of the Hydrogen Act, the installation and operation of hydrogen bunkering facilities must strictly comply with the safety management standards of the hydrogen industry. When installing hydrogen bunkering facilities, it is essential to clearly establish and coordinate the relationship with the Harbor Act, the Harbor Authority Act, and the Harbor Transport Business Act. Safety management procedures and response plans must be prepared to address various situations that may arise during the hydrogen bunkering process. Additionally, economic support and incentive measures should be developed to promote cooperation between the government and the private sector for the construction of hydrogen bunkering infrastructure.

The application measures for the Harbor Act involve strictly adhering to its regulations to meet legal requirements when installing and operating hydrogen bunkering facilities within ports. Legal requirements must be clarified to allow hydrogen-carrying ships to refuel directly at port fuel supply facilities, water supply facilities, and other ship supply facilities, or to receive fuel via land routes. Furthermore, related legislation should be amended or supplemented to ensure that hydrogen bunkering facilities are recognized as facilities related to new and renewable energy. All procedures necessary for the installation and operation of hydrogen bunkering facilities should be consistently followed in accordance with the procedures and requirements specified in the Harbor Act.

The application measures for the Harbor Authority Act involve providing legal and administrative support for the installation and operation of hydrogen bunkering facilities. Relevant legislation should be reviewed, and necessary amendments should be prepared to include hydrogen bunkering facilities within the scope of the port authority's business. Additionally, adherence to the basic plan for ports as per article 5 of the Harbor Act and the basic plan for marina ports as per article 4 of the Act on the Creation and Management of Marina Ports should be ensured to support consistent procedures for the installation of hydrogen bunkering facilities. The port authority should train and deploy relevant experts to provide the professionalism and efficiency required for the construction and operation of hydrogen bunkering infrastructure.

Table 1. Summary of implications and legislative proposal for hydrogen bunkering

Legislation	Implications	Proposal
High-pressure Gas Safety Control Act	· Defines hydrogen as a 'flammable gas' · Ensures safe handling of hydrogen during the bunkering process · 2019 amendment clarified hydrogen management system	· Treat hydrogen bunkering facilities as high-pressure gas storage facilities · Comply with installation standards and management procedures for storage · Regular inspections and strict implementation of safety management procedures
Hydrogen Economy Promotion and Hydrogen Safety Management Act	· Stipulates safety management and systematic development of the hydrogen industry · Defines legal requirements for the installation and operation of hydrogen bunkering facilities	· Clearly establish and coordinate relationships with Harbor Act, Harbor Authority Act, and Harbor Transport Business Act · Develop economic support and incentive measures to promote government and private sector cooperation
Harbor Act	· Provides legal basis for the installation and operation of hydrogen bunkering facilities within ports · 2013 inclusion of facilities related to new and renewable energy	· Ensure compliance with legal requirements when installing hydrogen bunkering facilities · Amend related legislation to recognize hydrogen bunkering facilities as facilities related to new and renewable energy
Harbor Authority Act	· Provides legal and administrative support for port facilities development and management · Includes projects related to new and renewable energy	· Provide legal and administrative support for hydrogen bunkering facilities · Ensure compliance with port basic plan and marina port basic plan · Train and deploy relevant experts within the port authority
Marine Transportation Act	· Does not directly regulate specific maritime transportation businesses such as ship fuel supply · Supports fair and safe operations within the shipping industry	· Ensure that hydrogen bunkering is regulated under the Harbor Transport Business Act · Strengthen connection between Marine Transportation Act and Harbor Transport Business Act
Harbor Transport Business Act	· Defines and regulates various port transportation related businesses · 2018 amendment expanded ship fuel supply business	· Clarify the definition of ship fuel to include hydrogen · Establish legal basis for hydrogen bunkering · Clearly define legal requirements and safety management procedures for hydrogen bunkering facilities

Although the Marine Transportation Act does not directly regulate hydrogen bunkering, it should ensure that hydrogen bunkering is safely operated through its connection with the Harbor Transport Business Act. The Marine Transportation Act should indirectly support the legal framework for hydrogen bunkering by ensuring that it is regulated under the Harbor Transport Business Act. Strengthening the connection between the Marine Transportation Act and the Harbor Transport Business Act is necessary to ensure that hydrogen bunkering activities at sea are safely regulated.

The application measures for the Harbor Transport Business Act involve clarifying the definition of ship fuel in article 2, paragraph 3 of the enforcement decree and including hydrogen as a ship fuel. This would allow hydrogen bunkering to be legally recognized and systematically build the related infrastructure and procedures. The scope of the ship fuel supply business should be expanded to include hydrogen-carrying ships, providing the necessary legal basis. Additionally, the legal requirements and safety management procedures necessary for the installation and operation of hydrogen bun-

kering facilities should be clearly defined to ensure that the hydrogen bunkering business operates safely and efficiently. This content is summarized in Table 1 as implications and measures.

Therefore, through the close interrelationship between each law, specific measures for hydrogen bunkering for hydrogen-powered ships and transport can be proposed. To achieve this, it is crucial to establish a complementary and consistent regulatory system that can respond to various situations that may arise during the hydrogen bunkering process. The High-pressure Gas Safety Control Act defines hydrogen as a 'flammable gas' and provides strict safety management standards, including installation standards for high-pressure gas storage facilities, safety management procedures, and transportation regulations, ensuring the safety of hydrogen bunkering. These standards should be linked with the Hydrogen Act, ensuring strict adherence to the safety management standards of the hydrogen industry during the installation and operation of hydrogen bunkering facilities. Furthermore, economic support and incentive measures should be developed to promote cooperation between the government and the private sector for the construction of hydrogen bunkering infrastructure.

The Harbor Act and the Harbor Authority Act provide the legal basis and administrative support necessary for the installation and operation of hydrogen bunkering facilities within ports. The Harbor Act stipulates that hydrogen-carrying ships can directly refuel at port fuel supply facilities, water supply facilities, and other ship supply facilities or receive fuel via land routes. It also requires amending or supplementing related legislation to ensure that hydrogen bunkering facilities are recognized as facilities related to new and renewable energy. The Harbor Authority Act provides legal and administrative support for the installation and operation of hydrogen bunkering facilities, ensuring that all procedures are consistently followed in accordance with the basic plan for ports and the basic plan for marina ports. It also emphasizes the need to train and deploy relevant experts within the port authority to provide the professionalism and efficiency required for the construction and operation of hydrogen bunkering infrastructure.

The Marine Transportation Act and the Harbor Transport Business Act indirectly support the legal framework to ensure the safe operation of hydrogen bunkering. The Marine Transportation Act ensures that hydrogen bunkering is regulated under the Harbor Transport Business Act, strengthening the connection between the two laws to ensure that hydrogen bunkering activities at sea are safely regulated. The Harbor Transport Business Act clarifies the definition of ship fuel in article 2, paragraph 3 of the enforcement decree, providing the legal basis to include hydrogen as a ship fuel. This ensures that hydrogen bunkering is legally recognized and that related infrastructure and procedures are systematically established. It also clearly defines the legal requirements and safety management procedures necessary for the installation and operation of hydrogen bunkering facilities, ensuring that the hydrogen bunkering business operates safely and efficiently.

4. Conclusion

This study presents the implications and directions for each legislation necessary for the introduction of hydrogen bunkering.

The High-pressure Gas Safety Control Act and the Hydrogen Act provide strict safety management standards to ensure the safety of hydrogen bunkering. The High-pressure Gas Safety Control Act minimizes the risks of hydrogen bunkering through standards for the installation of high-pressure gas storage facilities, safety management procedures, and transportation regulations. The Hydrogen Act clarifies safety management standards at all stages of the hydrogen industry, including

production, storage, transportation, charging, and sales. These two laws provide the legal requirements necessary for the installation and operation of hydrogen bunkering facilities, strengthening the management system for hydrogen bunkering on land and in ports.

The Harbor Act and the Harbor Authority Act provide the legal basis and administrative support necessary for the installation and operation of hydrogen bunkering facilities within ports. The Harbor Act stipulates that hydrogen-carrying ships can directly refuel at port fuel supply facilities, water supply facilities, and other ship supply facilities, or receive fuel via land routes. It also requires amendments or supplements to related legislation to ensure that hydrogen bunkering facilities are recognized as facilities related to new and renewable energy. The Harbor Authority Act provides legal and administrative support for the installation and operation of hydrogen bunkering facilities, ensuring that all procedures are consistently followed in accordance with the basic plan for ports and the basic plan for marina ports.

The findings underscore the necessity of strict safety standards and legislative amendments to recognize hydrogen as a ship fuel. Establishing a comprehensive legal framework is essential for safe and efficient hydrogen bunkering. Furthermore, continuous updates through international cooperation and standardized regulations are crucial for promoting the adoption of hydrogen fuel cells, ensuring a sustainable and environmentally friendly maritime industry.

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