
EXECUTIVE SUMMARY

1. Purpose

1) Seeking cooperation in the energy sector with New Southern and New Northern countries

- As part of its national agendas of the New Southern Policy and the New Northern Policy, the Korean government established committees in relevant regions, selecting strategic tasks to be performed in a variety of sectors and identifying key projects.
- From the first formulation of the New Southern Policy, the energy sector has been seen as one of the four main sectors in the New Southern region due to its rapidly increasing demand for energy.
- With regard to Russia, the largest supplier of natural gas to Europe, if gas pipelines are constructed from the New Northern region to a unified Korea (assumption), energy can be supplied much more cheaply than at present.

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- This study reviews Korea's ecosystems of industries that have driven the hydrogen economy. This study intends provides basic information to promote energy cooperation with both New Southern and New Northern countries.

2) Developing Korean ports to import and export hydrogen energy

- In the short term, Korea's supply of hydrogen will be concentrated on use in steam reforming of natural gas. In the mid-to-long term, Korea plans to produce water electrolysis hydrogen by connecting renewable energy to power plant complexes or by importing clean hydrogen from overseas.
- By 2040, Korea's annual demand for hydrogen is expected to reach 5.26 million tons, the majority of which will depend on foreign imports for its satisfaction.
- In preparation for the era of hydrogen energy, base data suggest that Korea's ports are underdeveloped. Furthermore, data on energy imports and exports relevant to hydrogen also fall short of what is required.
- This study investigates the role of ports in the import and export of hydrogen energy source and suggests appropriate responses.

2. Methodology and Features

1) Methodology

- Literature analysis
 - After reviewing domestic and foreign preceding studies, including utilizing renewable energy, structural changes in global energy value chains, and methods of utilizing hydrogen as a renewable energy, this study identified limitations of existing studies while establishing differentiations of this study.
 - A review of domestic and foreign national policies relevant to renewable energy, the renewable energy industry, and the hydrogen economy enabled a correlation to be drawn between the energy import industry and ports.
 - This study analyzed the role of ports and utilization measures to import and export renewable energy sources such as natural gas and hydrogen.
- Quantitative analysis 1 (Visualization Analysis and Origin-Destination Analysis)
 - Visualization analysis and origin-destination analysis were carried out with regard to the import and export status of domestic and foreign hydrogen-related energy.
 - To represent large amounts of data, visualization analysis can represent the present status of the import and export of energy sources relevant to hydrogen production by nation, port, and domestic region.

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- Origin-destination analysis allows an intuitively understanding of the origins and destinations of importing and exporting energy sources to be clarified, as well as the process and flows of imports and exports between origins and destinations.
 - In an origin-destination analysis, a Sankey diagram is a visualization tool used to depict flows and transaction quantities of importing and exporting energy sources required for hydrogen production in proportion to one another.
 - Quantitative analysis 2 (Analysis of hydrogen energy export and import traffic volumes utilizing statistical theories)
 - Adopting the demand and supply quantities suggested by the Korean government's Hydrogen Economy Roadmap, this study extracted a distribution by repeatedly extrapolating forecasts of traffic volumes within a certain range while applying the Law of Large Numbers and the Central Limit Theorem.

2) Features

- A collaborative study was conducted between the Korea Maritime Institute (KMI) and the Korea Institute for Industrial Economics and Trade (KIET).
- KMI analyzed future traffic volumes for hydrogen energy, analysis of domestic and foreign advanced cases and analysis of the present status of hydrogen-related energy imports and exports.
- KIET performed analyses of the hydrogen economy value chain

as well as of industrial ecosystems. Furthermore, based on the analysis of traffic volumes by KMI, KIET deduced major industries in Korea that may use hydrogen energy.

- Regarding the role of ports in realizing the hydrogen economy, this study differentiates itself from preceding studies in the following three areas.
 - Port traffic volumes were forecasted based on the hydrogen demand of energy roadmap.
 - A case analysis of the import and export of hydrogen energy, including an in-depth interview with relevant experts and drawing implications, was carried out, primarily with reference to Japan, where demonstration projects have been already been implemented
 - This study presents a hydrogen energy carrier method available for introduction to Korea in the short- to mid-term and long-term perspectives.

3. Results

1) Summary

- With the energy paradigm shift of achieving carbon neutrality becoming a key countermeasure to mitigate the climate crisis, a variety of policies have been implemented in many nations to produce and expand the distribution of eco-friendly energy sources.

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- Moving towards decarbonization by shifting the paradigm of energy policies, major countries such as South Korea, the United States, Japan, and Europe have countered problems surrounding energy security threats arising from environmental pollution and resource depletion that have resulted from the use of fossil fuels.
 - Under a shifting paradigm towards renewable energy, many developed countries are considering hydrogen energy as an alternative source. This energy has drawn much attention as a renewable source capable of overcoming limitations coming from batteries of electric drive systems as well as complementing intermittent power generation of renewable energy.
 - With the National Innovation Program Hydrogen and Fuel Cell Technology, Germany has provided strong support at the government level with an aim to expand the influence in the hydrogen technology market and relevant infrastructure.
 - Japan intends to introduce the Hydrogen Energy Supply Chain by 2030, which utilizes carbon capture and storage technology, securing profitability. To achieve this goal, specific strategies should be implemented to initiate the production of hydrogen.
 - Having established its “Korea Hydrogen Economy Roadmap,” South Korea set up a goal of joining the ranks of hydrogen-producing countries through the production of green hydrogen, seeking to rank No. 1 in the global hydrogen vehicle and fuel cell markets.
 - As hydrogen energy stands out as an eco-friendly energy source for decarbonization, the need to develop novel

infrastructure is increasingly required to serve the central role in the energy value chain such as loading and unloading, storing, and stocking energy.

- Japan has been implementing a demonstration project for constructing the liquefied hydrogen supply chain as well as hydrogen transportation. The Netherlands aims to build a hydrogen grid by establishing hydrogen-related facilities at ports of Rotterdam and Amsterdam.
- This study analyzed the present status of hydrogen-related gas energy import and export through Korean ports through a number of categories, including year, country, port, and region of Korea. In particular, visualization analysis and origin-destination analysis allowed a review of importing and exporting status of hydrogen-related energy (LNG, LPG, and ammonia).
- Using origin-destination analysis, this study identified the routes and import quantities per route from origins overseas to Korean destinations via domestic ports, following the invigoration of the hydrogen economy. Following this, the present status of gas energy imports related to hydrogen was analyzed according to different ports, with the resulting data suggested for use as a reference to present the current and future roles of ports.
- Visualization analysis was utilized to produce a result on the present status of imports and exports of existing energy sources (LNG, LPG, propane, butane, and ammonia).
- Because the demand and supply data of hydrogen energy has

not been established, it is difficult to track long-term traffic volumes. Therefore, this study conducted a demand analysis of traffic volumes based on two scenarios.

- [Scenario 1 (Conservative)] According to estimated port traffic volumes in 2030 and in 2040 obtained based on a quantitative methodology, the import traffic volume required in 2030 is estimated to be 530 thousand tons to reach 2.61 million tons in 2040 as a maximum.
- [Scenario 2 (Optimistic)] It was forecasted that the import traffic volumes required in 2030 and 2040 would be 2.45 million tons and 6.16 million tons, respectively. In 2050, on this view, 11.83 million tons of imports will be needed.
- After analyzing the ecosystems of hydrogen industries that are currently established in individual sectors, this study investigated the demand of major industries based on the industrial demand and the hydrogen economy roadmap.
- From the policy for promoting the hydrogen industry, this study identified the value chain in areas of hydrogen mobility and power generation and analyzed their industrial ecosystems. The hydrogen mobility sector is expected to enter a growth period by 2030, while the proportion of hydrogen energy will be expanded under the government's roadmap, in areas including hydro fuel cells, hydro power generation, steel, and petrochemicals.
- Japan has preemptively begun to implement a strategy for expanding port functions to achieve the hydrogen society and carrying out a relevant demonstration project.

- In a plan for a carbon-neutral port: Specific implementation measure are suggested and implemented to achieve the hydrogen society.
- Through its partnership with Australia, Japan has started verifying the economic feasibility of hydro energy transportation. This study analyzed the case of Japan's project, centering on the supply chain of hydrogen energy for imports and exports between Japan and Australia.
- The Japanese government plans to utilize existing LNG facilities as storage for liquid hydrogen.
- The storage temperature of LNG and liquefied hydrogen may vary. However, the Japanese government took into account compatible storage facilities and proceeded with the project, which allows LNG storage tanks to be converted to those storing liquid hydrogen.

2) Policy suggestions and policy-making activities

- Drawing on the conclusion analysis that Korea's hydrogen energy-related demand is forecasted to be highly dependent on imports, this study provides five suggestions, as follows, in categories including infrastructures, governance, legal system, basic planning, roadmap, and HR training.
- For infrastructure, suggestions are divided into hardware area from the perspective of short-to-mid-term perspective and software area including securing an import base

targeting the New Northern and the New Southern regions, as well as diversification.

- In the short term, flexible operation is necessary. such as the use of idle facilities at ports that are capable of processing LNG, LPG, and ammonia etc. simultaneously, along with the establishment of facilities considering need for demand as well as inland transportation cost.
- In the long run, it is necessary to construct power generation facilities based on hydrogen energy for establishing carbon neutral ports, while introducing hydrogen fuel cells to port management equipment and facilities.
- Targeting the New Southern countries, the Korean government should create a variety of areas for cooperation and invigorate the network of future energy sources. Among the New Northern nations, Russia should be placed at the center and cooperative steps should be taken toward a Korea-Russia hydrogen economy.
- This study established a pan-governmental cooperative system and provided roles for relevant organizations in constructing hydrogen base ports and carbon-neutral ports.
- In connection with the Green Hydrogen overseas business center of the Ministry of Trade, Industry and Energy, the Ministry of Oceans and Fisheries should prepare a maritime transport system capable of importing hydrogen which will be produced in foreign production bases.
- Moreover, continued discussion is necessary through a pan-governmental cooperative system to establish the laws and systems required

for the development of a variety of technologies to invigorate hydrogen energy at port facilities.

- Port authorities should rearrange regulations for establishing carbon neutral ports and devising measures for the designation of specialized zones. Research institutions such as KMI should study measures for the supply chain management for importing hydrogen, while extracting implementation tasks. Terminal operators should establish a safety management system for the adoption of hydrogen energy facilities. Finally, infrastructure-related companies should devise plans for developing and distributing equipment.
- This study proposed that the role of port authorities be expanded following legislation relevant to a transition to the hydrogen economy, recognizing the necessity for the establishment of a management system related to hydrogen infrastructure and reviewing the designation of port-type free trade zones, as well as hydrogen-specialized complex-targeting port hinterlands.
- This study also suggested the necessity and specific content of basic plans for the promotion of hydrogen ports, while proposing the establishment of a mid-to-long term roadmap to build a port-oriented hydrogen supply system.
- The transition to the hydrogen economy will increase the demand for a professional workforce across all industries. Therefore, basic knowledge of the hydrogen economy should

be learned from secondary education. In line with this, this study proposed opening hydrogen-related majors in universities and establishing graduate schools specializing in hydrogen, as well as industrial liaison programs. Because safety management of hydrogen will be a strictly requirement, this study proposes safety management educational programs.

3) Expected benefits including policy contribution

- Data produced through this study can be utilized as basic data for ports, including on hydrogen energy traffic volume, export & import status of hydrogen-related energy. and so on.