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SOUTH KOREAN MARKET INTELLIGENCE REPORT 2021

MARINE INDUSTRY 4.0

Department for International Trade

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FOREWORD

This report highlights the opportunities in South Korea for UK companies. The South Korean government and institutions have prioritised the shipbuilding market and as a result it sits firmly on the top step of any shipbuilding ranking. If UK companies want to work in the global maritime industry they will at some point need to enter the market and it is with this type of report that they will begin to understand the scale of the market and opportunities within it. Whether you are an experienced practitioner, perhaps with local offices and manufacturing, or a new start-ups looking to unlock the market, this report is required reading to refresh and inform strategic planning.

The UK is a leading maritime nation and continues to enjoy a world-class reputation in areas such as technical engineering and professional services. This report will provide details on some of the levers in encouraging more of the UK industry to analyse the market and begin their market entry plans. There is support from the Department for International Trade and trade associations to help and inform companies. Please make use of this report to refresh and revise your South Korean strategy.

Tom Chant
Chief Executive
Society of Maritime Industries

FOREWORD

I wish to congratulate both the Department for International Trade, British Embassy Seoul and Intralink on the release of this Market Intelligence Report. I believe this will help to promote cooperation between the marine industries of Korea and the UK.

The Covid-19 pandemic has had serious consequences for the world economy, whilst accelerating the transformation of the industrial paradigm by highlighting the need to address climate change and environmental protection.

In response, Korea is developing technologies and facilities for the decarbonisation and digitalisation of ships. The industry is actively investing in the development of autonomous ships and eco-friendly propulsion systems such as those using alternative fuels in preparation for the low-carbon era.

Korean shipbuilders are making bold investments in developing eco-friendly ships for the transition to clean fuel and smart ships/smart yards that can increase productivity by sharing design information based on ICT and introducing intelligent unmanned automation systems.

This report includes a broad range of information on the Korean marine industry. It explores the ecosystem of the Korean maritime industry, industrial policies, on the shift towards digitalisation and decarbonisation, and future market opportunities in Korea.

Byeong-Cheol Lee
Executive Vice-Chairman
Korea Offshore & Shipbuilding Association

There is a long history of cooperation between Korea and the UK which has secured advanced companies, research institutes, and excellent human resources in the marine industry. To build successfully a future-oriented industrial system in Korea under the new paradigm, it is essential that we continue to work closely with countries like the UK who have an advanced maritime industry consulting service and technologies related to renewable energy. I sincerely hope this report raises awareness of the importance of ongoing bilateral cooperation in the marine industry.

01 INTRODUCTION

South Korea (Korea) is making huge investments in digitalisation and decarbonisation across the marine sectors of shipbuilding, ports, and offshore energy. The country is already a global leader in shipbuilding and investing billions in eco-friendly, smart ship technologies in an effort to stay ahead of their regional rivals. The government has committed £30bn to support the private sector in the roll-out of automation and connectivity technologies with a view to ensuring the country's ports remain competitive. Offshore wind, tidal and wave energy projects together form a major part of Korea's ambitious renewable energy plans, which should further boost Korea's marine economy over the coming decade. All these investments, part of a national growth strategy based on the so-called Fourth Industrial Revolution (4IR) technologies, present strong opportunities for British companies with innovative technologies in the marine industry.

Korea's shipbuilding industry is forecast to grow by 50% to KRW 44 trillion (£30.1bn) by 2030 from KRW 30 trillion (£20.8bn) in 2019. This growth will be backed by investments from Hyundai Heavy Industries and Samsung Heavy Industries, who increasingly see smart and autonomous ships as a key future growth engine. Hyundai alone has earmarked almost KRW 2 trillion (£1.3bn) R&D spend for its shipbuilding business to develop eco-friendly and smart ships, enhancing offshore engineering capability, and establishing smart shipyards. The major domestic players are also investing in eco-friendly technologies such as fuel cells and propulsion enhancement systems to reduce both carbon emissions and energy costs.

In order to increase the speed and quality of port logistics while also reducing carbon emissions through clean energy solutions, the Korean government announced a KRW 43 trillion (£29.1bn) project to develop 12 smart ports by 2040. The government will introduce automation and 5G connectivity into the country's five largest ports, starting with Busan in the south, before expanding it to seven other ports in the coming years.

Korean President Moon Jae-in announced his Energy 3020 policy in 2017, which aims to generate 20% of energy nationwide from new and renewable sources by 2030. The plan outlined a 12GW target for offshore wind power and a separate target of 1.2GW has recently been set by the government for other marine energy solutions such as wind and tidal energy. Offshore wind is still a fledgling industry in Korea, but the government's target of 12GW by 2030 could drive the growth of a substantial market on par with leading European markets such as the UK.

As the Korean marine industry develops and evolves, opportunities for British service providers are sure to appear. Korea is the seventh-largest insurance market globally and foreign firms have a small but growing market share. Also, specialised engineering and consulting services in the marine sector are in demand and growth in this area is expected to continue into the future.

The marine industry is of key strategic importance to Korea, but the country lags behind its regional rivals China and Japan in the development of smart ships and smart ports. Korea is keen to cooperate with companies with relevant commercialized technologies in the marine industry and, as the UK is known to be strong across the board in the marine industries, British companies with strong offerings will find a warm reception from Korean firms.

02

KOREA: AN OVERVIEW

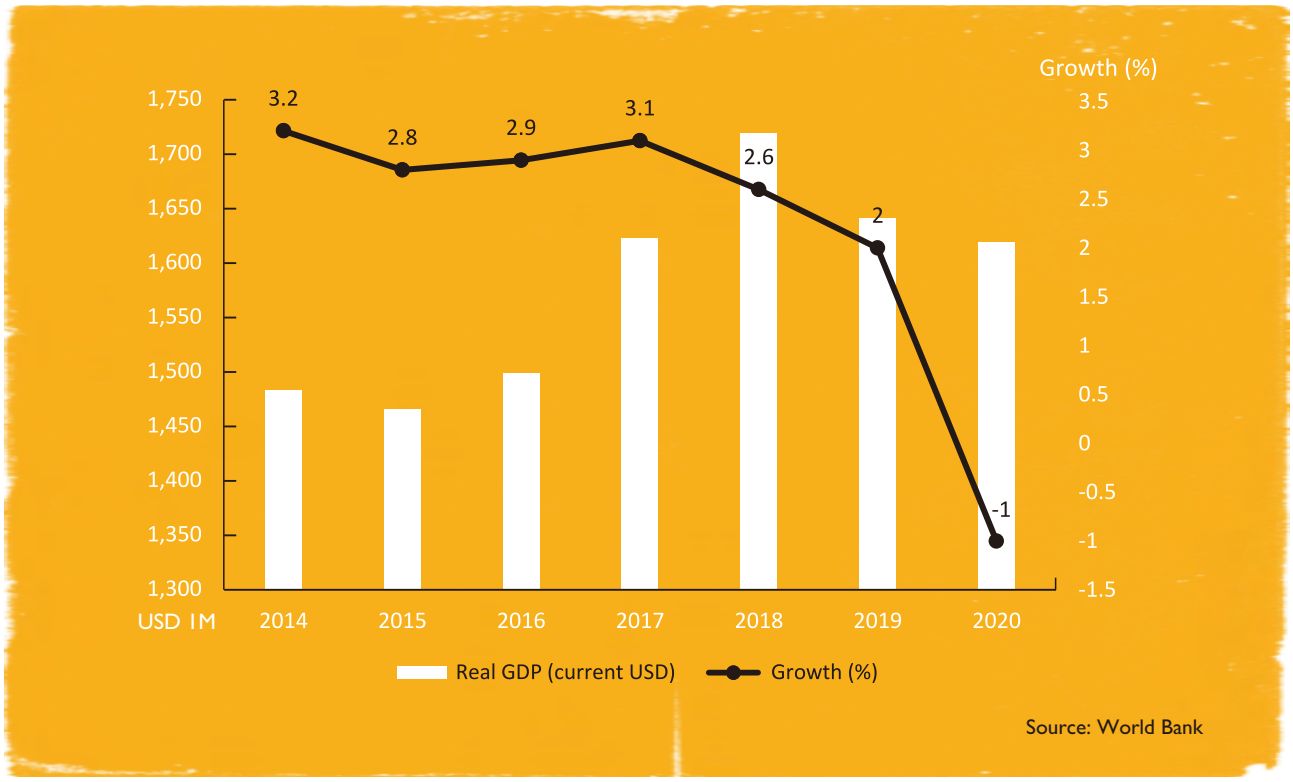
In the space of just 60 years, Korea has transitioned from an agricultural economy to one driven by high-value industries such as automotive, shipbuilding and advanced manufacturing. Perhaps most remarkable of all is the country's success in the area of information communications technology where the country has become world class in terms of semiconductor, consumer electronics and ICT infrastructure.

With a population of 51 million people, Korea boasts the 10th largest economy in the world, a GDP of £1.05 trillion in 2020 and a per capita GDP of £22,575 that same year. Whilst no longer experiencing the dizzying growth rates that characterised its early growth phase in the second half of the twentieth century, Korea has maintained strong growth for a developed economy of close to 3% in recent years. The country has won recognition for its adept handling of the coronavirus pandemic which appears at the time of writing to have helped it fair better than many of the world's other major economies.

The local economy contracted by 1% in 2020 from a year earlier, the third-best among the group of 20 major economies after China and Turkey.

Korea's trade dependency ratio is extremely high at over 80% and its economic performance is heavily affected by the economies of China, the US and Japan. Trade and investment flows between Korea and the EU are growing as a result of the FTA that came into effect in 2011. Trade between the UK and Korea has grown rapidly over that period and the two countries signed a continuity Free Trade Agreement in August 2019 ensuring that the trading framework will remain largely unchanged from 2021.

Figure 1: GDP and Growth Rates (2014-2019)



03

THE MARINE INDUSTRY

ECOSYSTEM AND KEY PLAYERS

Overview

The Korean marine industry can broadly be divided into four main categories: shipbuilding and offshore plants, energy, logistics, and services. Korea has a well-developed marine industry particularly in the shipbuilding sector, where it has been among the leaders globally since a boom period in the early 2000s. However, global ship orders have been declining at an average of 11% annually since 2015, with a further 60% reduction in 2020 due to the COVID-19 pandemic. Korean shipbuilders won a total of 37 orders over Q1 and Q2 of 2020. This is equivalent to just 40% of the 92 orders received in the first half of 2019, and a quarter of the 150 ships ordered during the same period in 2018.

Korea is looking to spur growth and improve competitiveness in key sectors of the marine industry such as shipbuilding and marine infrastructure through the introduction of digitalisation and clean energy technologies. This is part of a broader national strategy to generate economic growth through the development of Fourth Industrial Revolution (4IR) technologies, the signature economic policy of the current Moon administration. Korea is focusing on technologies such as autonomous ships, smart ports and improved navigation systems that raise efficiency and

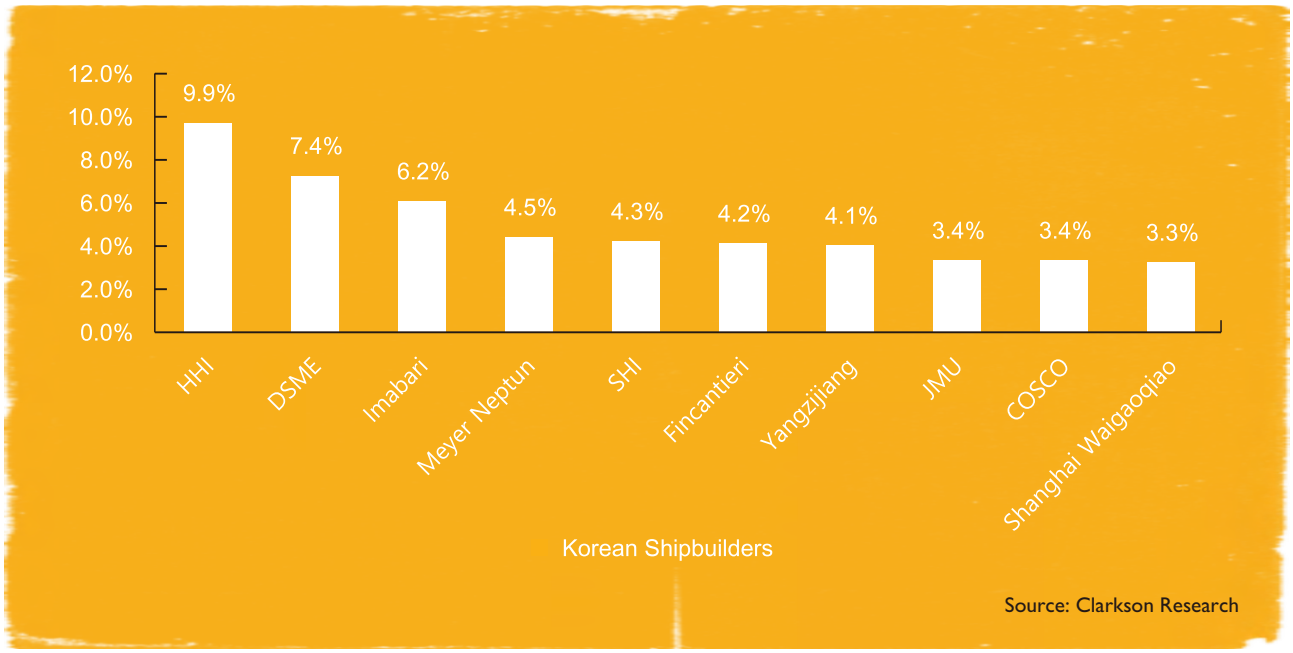
Figure 2: Marine Industry Ecosystem

productivity through higherspeed, quality of service and a reduction in accidents caused by human error. Clean energy solutions such as fuel cells are becoming part of both shipbuilding and ports. Stricter regulations of fuel content on ships that enter Korean waters are another eco-friendly policy newly implemented at ports nationwide.

Korea is also increasingly looking towards its maritime territory as a source of renewable energy such as offshore wind, wave and tidal, amidst a ten-year plan to sharply increase the country's supply of renewable energy. Government plans released in 2017 call for significant investments in renewable marine energy in order to reach 1.2GW in wave and tidal power, to go alongside a targeted capacity of 12GW in offshore wind power, by 2030 from a few hundred kW of capacity today. In relative terms, this would increase the share of wave and tidal power in the overall renewable energy mix of Korea from less than 0.1% in 2020 to 2% by 2030, even as substantial investments are made in other types of renewable energy, most notably solar.

Shipbuilding is a central component of the Korean marine industry and represents one-third of the country's heavy manufacturing output. The Korean shipbuilding industry produces a wide variety of ships, but 80% or so of production occurs in three types of vessels: container ships, oil (crude) tankers, and dry bulkers. Offshore vessels and structures such as anchor handling tug supply (AHTS) vessels, platform supply vessels and fixed production platforms are also an important part of the industry's output.

Figure 3: Share of Global Ship Orders (2019)



Hyundai Heavy Industries, Daewoo Shipbuilding & Marine Engineering and Samsung Heavy Industries are the three largest in Korea and ranked first, second and fifth globally in 2019 for orders won, accounting for more than 20% of worldwide orders between them. In terms of revenue, Hyundai Heavy was the largest as of 2019 with turnover of KRW 9.4 trillion (£6.5bn) followed by DSME at KRW 8.3 trillion (£5.8bn) and Samsung Heavy with revenues of KRW 7.9 trillion (£5.5bn). The three leading shipbuilders make up 85% of the local industry, which is valued at KRW 30 trillion (£20.8bn).

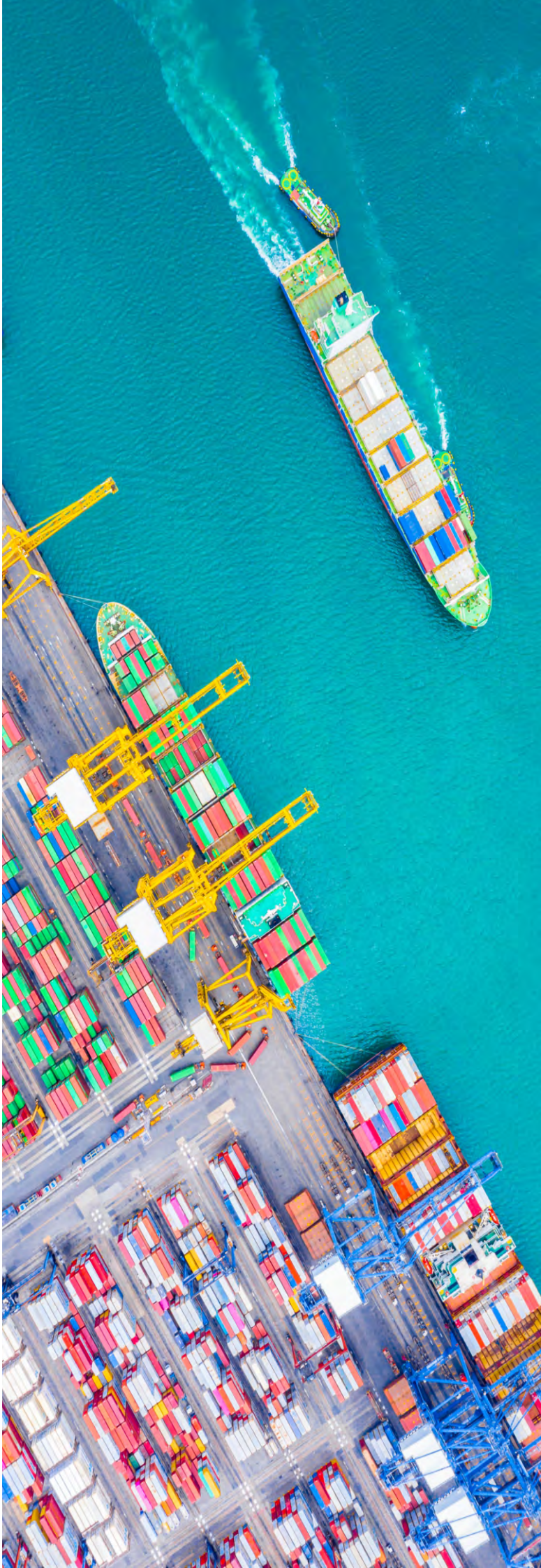
There are more than 70 small and mid-sized shipbuilders, including STX Offshore and Shipbuilding, Daehan and HSG Sungdong. Domestic shipbuilders rely on approximately 500 system integrators and component suppliers such as Sejin Heavy, Hankuk Carbon, Dongsung FineTec and Samyoung M-Tek. Despite the well-developed ecosystem around design, manufacturing, and infrastructure, Korean shipbuilders have recently been experiencing financial difficulties mainly due to the global oversupply and low demand for water vessels. One way in which the Korean government is addressing this issue is through supporting the development of new and innovative technologies in this sector. For example, Ministry of Trade, Industry and Energy (MOTIE) announced KRW 160 billion (£109m) in public investment for R&D in the smart and autonomous ship sector from 2020 to 2025.

Ports are a vital part of the Korean marine industry as 87% of the country's international trade passes through 31 international ports nationwide. In 2019, Korea was ranked third after China and Singapore by UNCTAD in terms of liner shipping connectivity. In addition to the 31 trade ports used for international logistics, there are another 29 coastal ports used as logistics hubs for domestic trade. Busan port is the busiest in Korea and handled 21.7 million twenty-foot equivalent units (TEU) of containers in 2019. This ranks Busan sixth globally after Shanghai, Singapore, Shenzhen, Ningbo-Zhoushan and Guangzhou. Other major ports in Korea include Ulsan, Incheon, Pyeongtaek-Dangjin and Yeosu-Gwangyang ports. In 2019, the Ministry of Oceans and Fisheries (MOF) announced a plan combining KRW 17 trillion (£11.5bn) in government funds and KRW 26 trillion (£17.6bn) from the private sector to build 12 new smart ports and introduce (IoT), Artificial Intelligence (AI), and 5G network into the ports across Korea.

Korea heavily relies on imported fossil fuels to meet its energy consumption demands. Oil represents 38% of primary energy supply, followed by coal (29%) and gas (15%). However, there is a huge shift underway from fossil fuel dependence to renewable energy as indicated by a 177% increase in renewable energy consumption between 2013 and 2018. This rapid growth has come from solar and onshore wind power as the marine energy sector, consisting of offshore wind, tidal, wave and Ocean Thermal Energy Conversion (OTEC) technologies, is very much in its early stages. There is no commercial tidal energy power plant in Korea, except the 254MW Sihwa Lake Tidal Power Plant. Wave energy is also at the early stage of development and there is only one operational wave energy power plant, with 500kW capacity, operated by MOF on Jeju island.

The marine service sector includes R&D services, marine insurance, and financing. The marine R&D service market was worth KRW 880 billion (£597m) in 2018, larger than other industries such as automotive and civil engineering which were KRW 730 billion (£502m) and KRW 684 billion (£471m) respectively. Local experts believe Korea lags behind other advanced economies in terms of investment in basic research, indicating potential for cooperation between the UK and Korean marine service companies and R&D institutes.

Korea's marine financing structure is designed to support the domestic shipbuilding industry and the export of domestic shipbuilders' products abroad. The overall size of marine financing in Korea peaked during the early 2000s but was still worth about KRW 32.3 trillion (£21.9bn) in 2018. The government supported the manufacture of up to 75% of domestic ships through public funding until 1989 under the Planned Shipbuilding Policy. Government support continues to a lesser extent today in the form of deferred-payment export financing from the Korea Export-Import Bank, ship financing insurance and guarantees from the Korea Trade Insurance Corporation, funds for the purchase of ships by the Korea Development Bank, and investment funds from the Korea Asset Management Corporation.



04

MARINE INDUSTRY POLICIES

ENVIRONMENTAL POLICIES

Korea began limiting fuel sulphur content in vessels navigating in its waters starting in 2020. The MOF announced new regulations in 2019 on marine fuel standards within Korea's Emission Control Area (ECA) in order to limit shipping emissions through fuel contents. The announcement made Korea the second Asian country after China to set a timeline for requiring vessels to switch to ultra-low sulphur fuel when navigating at or near its major ports.

The regulations went into effect on January 1, 2020 and require ships operating inside Korea's Port Air Quality Control Zones (Control Zones) to use fuel with sulphur content below 0.5%. This is in line with the stricter global marine fuel sulphur standards set by the IMO which also took effect in January 2020. Furthermore, from September 1, 2020, vessels are required to switch to 0.1% sulphur fuel when berthing or anchoring at ports within the Control Zones, which cover Korea's five main seaports: Incheon, Pyeongtaek-Dangjin, Yeosu-Gwangyang, Busan and Ulsan. From January 2022, this limit also applies when navigating in the Control Zones.

Korea's ECA regulation is part of a package of comprehensive measures to tackle port and shipping air pollution. In March 2019, Korea's National Assembly passed a 'Special Act on Air Quality Improvement in Ports and Other Areas' to combat air pollution from shipping and port activities, which account for 10% of air pollution from local sources. The Special Act stipulates a series of measures, including setting a stricter marine fuel standard, restricting vessel speeds, prohibiting old diesel vehicles from entering port areas, and encouraging port equipment and yard tractors to switch to liquefied natural gas (LNG) from diesel.

The MOF and the Ministry of Environment (ME) are jointly implementing these measures, which are expected to reduce fine particulate pollution at ports by more than half by 2022. To support successful implementation, the annual budget for controlling port pollution and improving the overall environment at ports will be quadrupled to KRW 119.3 billion (£81.2m), from the current KRW 31.2 billion (£21.2m).

Industry Insider's Thoughts

The implementation of ECA regulations in Korea is the long-awaited result of close cooperation between the Korean and the European, in particular the UK, regulatory bodies. We would like to continue collaboration and knowledge sharing with our colleagues in these countries.

Mr Jung Yeol SEO, Director – Policy Planning Unit, Ministry of Environment

GOVERNMENT INITIATIVES

The Korean government recently announced a KRW 160 trillion (£102.5bn) package of investments in economic, environmental, and social reforms, targeting digitalisation and green technologies, called the Korean New Deal. As part of the New Deal, the government earmarked KRW 148 billion (£99.4m) to develop and commercialise smart technology for ships and ports. According to the government initiative, Busan port will lead a government project involving 11 other port authorities, to develop and commercialise core technologies for a smart port logistics system.

In January 2019, MOF announced a Smart Maritime Roadmap that incorporates 4IR technologies in maritime logistics, fisheries, marine environment, and accident prediction. The roadmap is still at the planning stage, but as an initial step, MOF, MOTIE, and the Ministry of Science and ICT (MSIT) have already set a plan to develop technologies for level 3 autonomous ships and smart ports by 2025, and level 4 ships by 2030. As part of this plan, the city of Daejeon launched a government task force in March 2020 to develop and commercialise related 4IR technologies for ports and ships. According to MOTIE, KRW 160 billion (£109m) budget has been jointly allocated by three ministries over five years to develop smart coastal and ocean navigation technologies with the Korea Research Institute of Ships and Ocean Engineering (KRISO).

Table 1: Smart Maritime Roadmap - 2030

Category	2019	2030
Smart Logistics	R&D stage	50% of world market share of autonomous ships
Smart Fisheries (supply rate)	2.5%	50%
Smart Marine Environment	R&D stage	Install 1,000 IoT port air quality measurement networks
Accident Prediction	12 hours	4 hours

Source: MOF

Another major initiative by the Korean government is its Renewable Energy 3020 plan, which aims to increase the share of renewable energy to 20% by the year 2030 from 8.8% in 2020. The 3020 plan broadly aims to apply a range of new energy solutions to achieve its target but does not specify any new or planned marine energy facilities except for offshore wind installations. Government support for the development of tidal and wave energy is handled by the MOF's 'Strategic Plan for Development and Support of New and Renewable Energy', which has targets of completing 1GW of tidal energy and 220MW in wave energy plants by 2030.

The MOF 2017 plan will proceed in four phases:

- Phase 1: Expansion of R&D in marine energy and establishment of sea test bed
- Phase 2: Construction of large-scale marine energy farms
- Phase 3: Enter the global market and expand domestic supply
- Phase 4: Establishment of certification system and strengthening of policy support

Industry Insider's Thoughts

The Korean New Deal opens vast opportunities to the development of new energy solutions, smart technologies that can be applied across all fields of industry. We welcome western technologies to Korea and our companies are eager to work together on building the post-pandemic economic future.

Deputy Director – New Energy Division, Ministry of Trade, Infrastructure and Energy

05

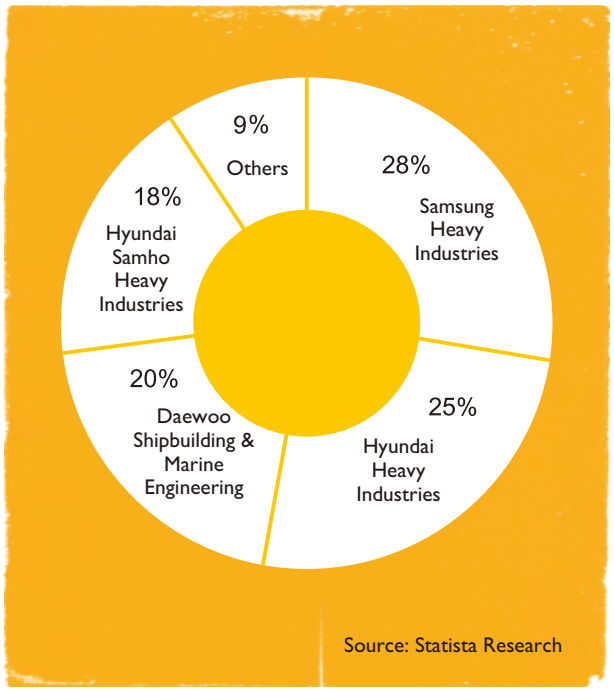
DIGITALISATION IN INDUSTRY SECTORS

SHIPBUILDING

The Korean shipbuilding industry began its early development in the 1970s and entered a period of high growth starting in the 1980s and 1990s, surpassing Japan as the world's largest shipbuilding nation in the early 2000s. In recent years, Korean shipbuilders have shifted their focus towards digitalisation and sustainability in order to maintain their competitive advantage over Chinese manufacturers. Although China appears to be overtaking Korea as the global leader in the industry, Korean shipbuilders retain a distinct advantage in complex designs, particularly LNG-powered vessels, where they control more than two-thirds of the market. The local industry is dominated by Hyundai Heavy Industries and its affiliate companies, who control 43% of the market, followed by Samsung Heavy industries (28%) and DSME (20%).

Domestic shipbuilders are in the middle of a structural reorganisation in response to financial difficulties amidst a period of continued low demand. In June 2019, Hyundai Heavy Industries Group was split into two entities: Korea Shipbuilding & Offshore Engineering (KSOE), Hyundai Heavy's holding company, and a reorganised Hyundai Heavy Industries that includes three shipbuilding companies: Hyundai Heavy, Hyundai Mipo Dockyard, and Hyundai Samho. Hyundai Heavy is also in the process of merging with DSME, a process that is expected to be finalised by 2022 pending an anti-trust review from regulatory bodies in Korea, Japan, China, Singapore, and the EU. Several other smaller shipbuilders, including Hanjin Heavy Industries and STX Offshore & Shipbuilding, are in the process of being sold by their creditors.

Figure 4: Korean Shipbuilding Market (2019)



China replaced Korea as the world's leading shipbuilding country in 2017 when it launched ships totalling 23.6 million gross tons, followed by Korea with 22.6 million and Japan with 13 million. However, Korea reclaimed the top spot in 2020 outpacing China with new orders totalling 990,000 gross tons, representing 60% of the 1.64 million gross tons ordered globally that year. According to KRISO, the average price per vessel for orders placed with Korean companies is KRW 91 billion (£62m), 60% higher than China's KRW 52 billion (£35.5m) per vessel, but down 20% from the 2018 average of KRW 112 billion (£76.5m). The cut is largely attributable to the absence of orders of highly profitable LNG carriers.

Korean shipbuilders are making major advances in autonomous ship technology, having already developed level 2 autonomous ships, effective semi-autonomous ships that are managed by humans but rely on automated systems for data collection and decision-making. The leading shipbuilders aim to reach level 3 autonomous ships capable of autonomous steering by 2025 and level 4 ships increasingly reliant on autonomous driving by 2030. Full automation in the form of unmanned ships has been suggested as a goal by 2040. Despite this, Korea is believed to lag behind its competitors such as China and Japan in smart ship development mainly due to the lack of core technology and clear regulations in this field.

Korean shipbuilders started working towards smart ships as early as 2009, when a local telco KT and Hyundai Heavy Industries began a collaboration on providing solutions for cable and wireless communications required for smart ships. In 2017, Hyundai Heavy Industries developed its Integrated Smart Ship Solution (ISS) based on IoT technology. The ISS, developed by Hyundai Heavy with its sister company Hyundai Electric, is connected to the Engine Diagnosis System (EDS) and the Data Collection System (DCM) developed by WinGD, an IoT solution specialist based in Switzerland.

Hyundai Heavy further developed an autonomous navigation system called HiNAS (Hyundai Intelligent Navigation Assistant System) in 2018 and installed it on a 250,000-ton bulk carrier owned by SK Shipping, a local marine transport firm. Through the installation of HiNAS, Hyundai Heavy Industries became the world's first shipbuilder to apply autonomous navigation technology for sailing on a large ship already in service. Hyundai's autonomous navigation system automatically recognises surrounding vessels through camera analysis to determine and alert the risk of collision based on augmented reality.

HHI-EMD, the engine manufacturing arm of Hyundai Heavy, developed a new brand of marine engine called 'HiMSEN' in 2010 as part of HHI's eco-friendly ship business. The initial models of the engine allowed the replacement of heavy crude oil or diesel with LNG resulting in 20% less carbon dioxide emission. However, the company announced the development of a new model of HiMSEN in 2020 which uses as AI and IoT technologies that claims to allow vessel operators to reduce fuel costs by an average 10% per year.

Industry Insider's Thoughts

Smart ship technology has a long way to go and it requires global collaboration as more standardised and reliable ships will be essential if they are to operate at international seas. We are interested in working with potential partners on R&D of smart navigation and autonomous shipping technologies with a view to creating a global smart ship network.

Mr Byoung-hun KWON, Senior Vice President – Digital Technology Research Institute, KSOE

Samsung Heavy Industries is planning to finalise the development of autonomous ship systems for all types of vessels, including oil tankers and container ships, with the application of 4IR technologies by 2030. In December 2019, Samsung announced an autonomous ship platform called the Samsung Autonomous Ship (SAS), which allows remote autonomous navigation for small-sized vessels. The system was tested on a 38-meter-long, 300-ton tugboat, Samsung T-8, connecting Daejeon with Geoje Island via a 5G network provided by SK Telecom, the country's leading mobile telecommunications company.

Samsung is also developing eco-friendly technologies aimed at saving fuel and producing fewer emissions. The company has developed and applied an air lubrication system on LNG carriers, claiming to reduce their energy use by 5%. Apart from this, Samsung is investing in the development of eco-friendly water vessels. In September 2019, the company signed an agreement with Bloom Energy, the US Solid Oxide Fuel Cell (SOFC) specialist, to develop a fuel cell system to replace the main engines and generators on LNG carriers.

DSME is focusing on technologies for environmental measurement, maintenance, repair, and safe navigation with a view to ultimately realising autonomous vessel navigation. DSME teamed up with Hyundai Merchant Marine (HMM) in 2019 to develop smart ship technology and is planning to deliver to HMM a smart ship based on DSME's own smart ship platform. DSME is also in the process of developing ships that use advanced technologies to detect risks in advance, an axial power generation motor system that produces electricity by rotating the axis of a ship's engine while sailing, and an air lubrication system that uses air to reduce resistance.

Industry Insider's Thoughts

We see a great value in a smart ship as it is a good 'bridge' towards unmanned ships in the future. For remote and autonomous shipping to become a reality we need change at all regulatory levels at home and abroad. In this field, we hope to establish cooperation on regulatory assistance with advanced countries such as the UK.

Director – Ship & Offshore Performance Research Centre, Samsung Heavy Industries

STX Heavy Industries became the first of Korea's mid-sized shipbuilders and ship engine manufacturers to expand its business into fuel cell-powered vessels. In 2020, STX signed a development and licensing agreement with Korea Institute of Ceramic Engineering and Technology (KICET) on the development of kW-level SOFC technology with a view to commercialising the technology by 2022. STX plans to apply the technology to power generation, supplying electricity to commercial buildings as well as replacing the main diesel engines and generators on its vessels.

Doosan Fuel Cell, which recently signed a collaboration and licensing deal with the UK SOFC technology firm Ceres Power, has also signed a preliminary deal with Singaporean shipping company Navig8 to develop fuel cells for ships. Under the deal, Doosan will provide SOFC technology for a 50,000-ton ship and Navig8 will offer regulatory assistance and supporting technologies to mount the SOFC system on the ship.

There are several companies such as Hyundai Seasall and Doosan Marine Engines that manufacture engines for small-size boats and yachts. Hyundai Seasall, a sister company of the Hyundai Motor Group leverages Hyundai's automotive powertrain technology and develops engines for marine applications. The company signed an agreement in 2020 with the Korea Advanced Institute of Science and Technology (KAIST) for the development of autonomous navigation and control systems for small-sized fishing boats. Hyundai Seasall is also planning to roll out fuel cell boats based on Hyundai Motor's 95kW fuel cell system by 2022.

Industry Insider's Thoughts

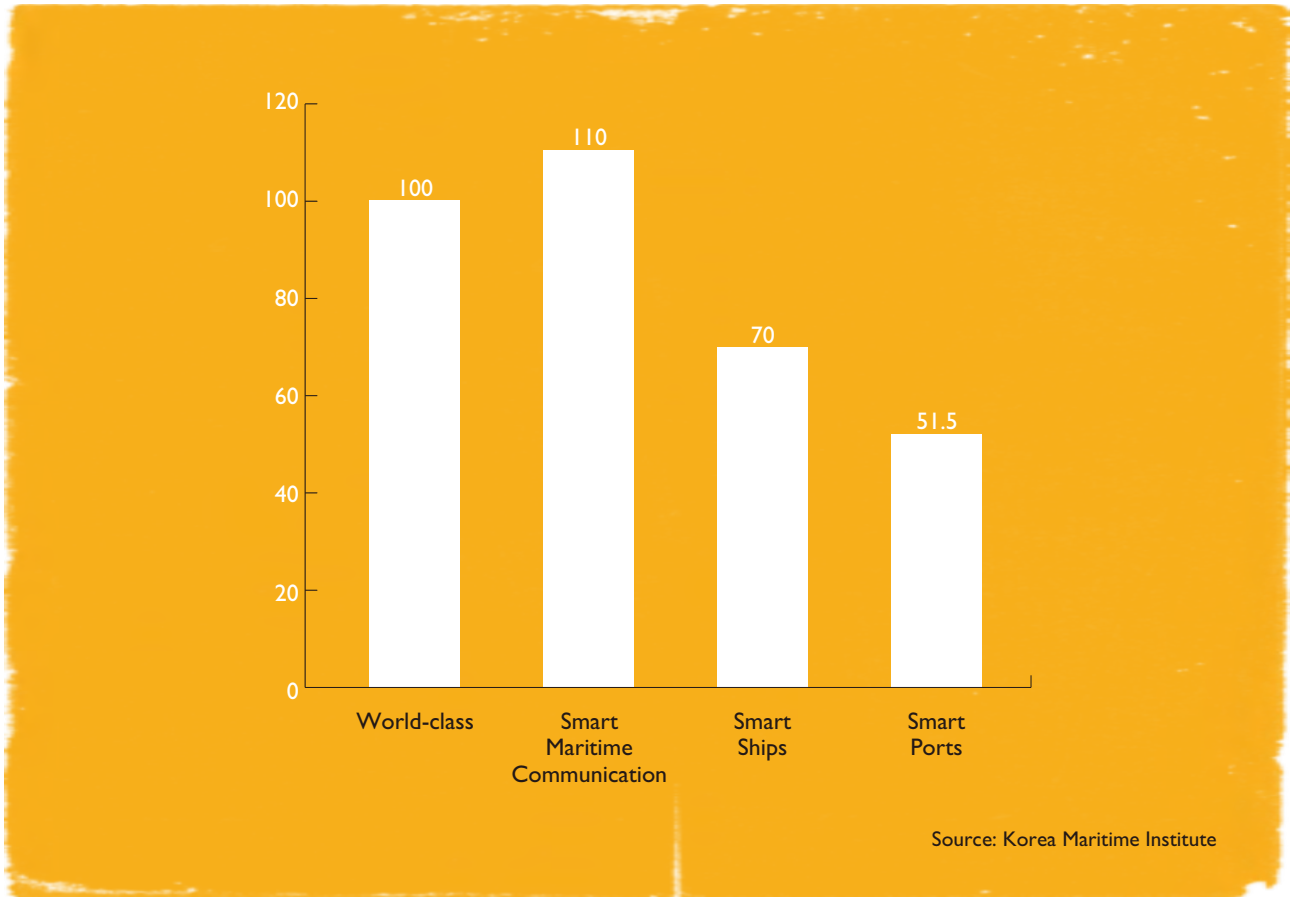
We welcome the strong commitment of the UK government to invest in technologies such as zero-emission vehicles, hydrogen and carbon capture, use and storage, which will help in tackling climate change. We already collaborate with several British companies in fuel cell system integration for marine applications and we look forward to expanding our business in the UK market and in return supporting British companies with their business in Korea.

Mr Won-Moon JUNG, Director – R&D Division, Hyundai Seasall

MARINE INFRASTRUCTURE AND LOGISTICS

Almost half of all international trade in Korea flows through five major ports in Busan, Ulsan, Incheon, Pyeongtaek-Dangjin and Yeosu-Gwangang. The Korean government developed container hub ports in Busan, Incheon, and Ulsan by investing KRW 54 trillion (£37bn) in infrastructure between 2010-2018 as social overhead capital (SOC) to support export-led growth. However, according to KMI, the current status of automation and ICT convergence in Korean ports is far behind the Chinese, Japanese and Singaporean ports. For example, the recently developed new ports of Busan and Incheon have semi-automated platforms in the yards sections only while the connection with inland logistics and the cargo information sharing system between ports are insufficient.

Figure 5: Smart Marine Technology Evaluation (World vs Korea)



The MOF announced a KRW 23 trillion (£29.1bn) plan in 2019 to create smart ports with the goal of increasing container handling capacity through the integration of 4IR technologies. The government will focus on the five major ports initially before expanding it to seven other ports by 2040. As part of this plan, MOF plans to build a maritime high-speed wireless communication network (LTE-M) that can communicate with a port control tower up to 100 km (currently 30 km) offshore. In order to achieve this goal, 156 out of the needed 388 base stations were installed on the east and west coasts in 2020, with the intention of building 109 more off the south coast in 2021 and conducting a pilot project across the entire network in 2022.

Table 2: Planned Smart Ports

Port Name	Total Project Cost (bn £)
1. North Incheon	1.5
2. New Incheon	1.5
3. Pyeongtaek	1.9
4. Boryeong	0.067
5. Saemangum	1.9
6. Mokpo	0.027
7. Jeju	1.9
8. Gwangyang	4.9
9. Busan	9.2
10. Ulsan	4.6
11. Pohang	0.9
12. Donghae	0.9

Source: Intralink Research

Busan port was chosen as the first smart port project by the government in 2019. For the Busan Smart Port project, MSIT with MOF have jointly allocated a budget of KRW 13 trillion (£9.2bn). The transformation of Busan Port will result in the implementation of AI and smart city technology between 2019 and 2024 to reduce traffic congestion and logistics costs. The new port project includes the application of electric and fuel cell vehicles as well as power generation to supply electricity to the port through fuel cell power plants.

The Busan Port Authority (BPA) is also building a new LNG bunkering port on the western side of the existing Busan Port, slated for completion in 2023. The new port is largely built for LNG bunkering and in order to utilise stored LNG, the port authority is considering the installation of on-site Steam Methane Reformers (SMR) to produce hydrogen, which then will be used both to generate power and potentially refuel fuel cell vehicles. This is in line with BPA's plan to develop an eco-friendly transport system using LNG yard tractor in the short-term and hydrogen trucks in the longer term. The government is planning to change the regulations to require only LNG-based yard tractors to run within the ports beginning from 2021. According to the plan, BPA and MOF will provide 50% of the KRW 60 million (£40,000) cost of LNG-based yard tractors to encourage warehouse operators to use cleaner vehicles.

Industry Insider's Thoughts

Apart from being the largest port, Busan will be the first smart and eco-friendly port in Korea. It is a huge responsibility for us, and we are planning to implement smart management system and lead the creation of safe and efficient ports in the country. In this regard, we hope to build long-term collaboration in sharing knowledge and expertise with the UK port operators.

Mr Ki-hoon KIM, Manager – Busan Port Authority

Table 3: Smart Port Projects by Telcos

Company	Technology	Partnership	Application Area
SK Telecom	5G network	BPA, MOF	Logistics, port operation
LG Uplus		Seoho Electric	LG Container handling
KT		Korea Naval Academy	Training monitoring

Source: Intralink Research

Korea's telecommunication companies SK Telecom, KT and LG Uplus are partnering with local port authorities to develop 5G-based platforms for smart ports. In October 2020, SK Telecom announced the development of smart ports using 5G network services by partnering with the MOF and the Busan Port Authority. LG Uplus has also agreed to develop smart ports with Seoho Electric, Korea's largest manufacturer of port crane control systems and the second largest worldwide. LG Uplus will provide 5G-based communication and control services for integration into Seoho's automated port crane system.

In the logistics space, major companies such as Hyundai Merchant Marine are focusing on the application of blockchain and big data technologies to improve marine logistics service. HMM tested blockchain technology on container ships in 2017, proving that the entire logistics process could be managed with this technology. In the same year, Samsung SDS, the systems integrator arm of the Samsung Group, formed a shipping logistics blockchain consortium with ports, shipping companies, and financial institutes to expand pilot projects for its solutions.

Industry Insider's Thoughts

We are interested in partnering with British companies to develop IoT solutions such as motion sensor technology for port logistics infrastructure utilizing a 5G network.

Manager – ICT Infra Centre, SK Telecom

MARINE ENERGY

Offshore Wind Power

Korea ranks fifth in the Asia in terms of installed offshore wind power capacity after China, Taiwan, Vietnam, and Japan. Under the Renewable Energy 3020 plan, new offshore wind facilities with a capacity of 12GW are planned to be built in Korea between 2018 and 2030. This would mark a massive increase over the 124.5MW of current capacity, but the Korea Energy Agency projects Korea's total wind power capacity could reach as much as 39GW, more than 50% coming from offshore wind.

There are currently three offshore wind farms in commercial operation near Jeju Island (30MW), Yeonggwang county (34.5MW) and Buan county (60MW, part of the Southwest Offshore Wind Complex) and 22 projects across five large-scale offshore wind farms in preliminary development totalling 11.2GW. Although the original plan for Southwest Offshore Wind Complex was 400MW in capacity, little progress has been made due to difficulties in securing residents' agreement to the wind farm since the beginning of the project in 2011 by MOTIE, KEPCO and Korea Wind Power.

Table 4: Offshore Wind Farms in Korea

	Facility	Capacity (MW)	Status
1.	Tamla Offshore Wind Farm	30	Operating
2.	Yeonggwang Wind Complex	34.5	Operating
3.	Southwest Offshore Wind	60 (400)	Operating
4.	Jeonbuk Area Offshore Wind	2,400	Planned
5.	Shinahn Offshore Wind	1,200	Planned
6.	Ulsan Offshore Wind	6,000	Planned
7.	Jeju Offshore Wind	600	Planned
8.	Incheon Offshore Wind	600	Planned

Source: Korea Energy Agency

Korea does not yet have an operational floating offshore wind farm (FOWF), but the public and private sectors are heavily investing in the development of this energy solution. In June 2020, the city of Ulsan announced it would invest KRW 6 trillion (£4bn) in a 1GW FOWF complex near Donghae gas field by 2025 with a view to increasing the capacity to 6GW by 2030. Local shipbuilders such as Hyundai Heavy, Samsung Heavy and DSME are also entering the FOWRF sector by leveraging their expertise in offshore plant engineering. Hyundai Heavy announced a partnership in 2020 with Doosan Heavy Industries and the Korea National Oil Corporation (KNOC) to develop a 200MW FOWF located 58km off the coast of Ulsan. In the same year, Samsung Heavy launched a project in collaboration with DNV GL, a Norwegian ship quality assurance company, to develop floaters that work to stabilize offshore wind turbines and remote-control maintenance technologies.

Korea is focusing on offshore rather than onshore wind due public concerns regarding noise, safety, and the limited availability of land. Korea's lack of a track record in large-scale commercial offshore wind projects has hindered the development of projects to date. Most offshore wind projects to date have been led by government agencies announcing development plans and soliciting private companies to invest in the projects. A lack of consistency in policies related to offshore wind have resulted in a long development periods of up to 7 years, compared with approximately 6 months for renewable energy projects such as solar farms. Another challenge for offshore wind projects in Korea is the lower intensity of wind compared with Europe, causing power companies to develop low-velocity offshore wind power generation facilities.

However, Korea will need to significantly increase its capabilities in developing offshore wind projects. The UK is substantially ahead of Korea in establishing and deploying offshore wind projects and this track record will create opportunities for UK companies. Korea has a significant industrial base that can supply much of what is needed for offshore wind projects from its shipbuilding and offshore plant industry, but it lacks specialist expertise in some areas, particularly sub-sea operations. UK companies with efficient offshore wind solutions could enter the Korean market to address these issues in various forms, including a collaborative technology development programme.

Tidal Power

Korea is home to the world's largest capacity tidal energy installation, the 254MW Sihwa Tidal Power Station located on Sihwa Lake southwest of Seoul. There are many coastal areas in Korea with strong currents, particularly on the southern and western coasts, making them suitable for tidal power stations. These areas typically also feature high tidal range and allow water to accelerate through the narrow channels between islands. According to Korea Energy Agency, Korea's realisable tidal energy could reach up to 6GW.

While tidal power construction technologies are relatively advanced in Korea, key generation technologies such as turbine and generators are sourced mainly from Europe. The Korean government funds the development of domestic tidal power generation technology and provided about KRW 500 billion (£340m) of funding in 2019. The Korea Institute of Ocean Science and Technology (KIOST) is developing active control tidal generation technology with the goal of commercialising it by 2023.

There are a few ongoing tidal power projects in Korea. In 2010, Hyundai Heavy Industries developed its own 500kW tidal current generator and successfully tested it in Uldolmok, South Jeolla province in 2011. In 2017, Korea South-East Power (KOEN) company committed to invest KRW 1 trillion (£680m) with POSCO Energy to develop a 260MW tidal power complex in Sinan, South Jeolla province. Korea East-West Power (EWP) company is conducting a feasibility study with plans to develop two power plants (150MW and 250MW) with KRW 1.5 trillion (£1bn) investment in cooperation with POSCO E&C, Renetec, and Voith Hydro of Germany.

Table 5: Tidal Power Clusters in Korea

Facility	Capacity (MW)	Status
1. Haeju Bay	N/A	Planned
2. Ganghwa	420	Planned
3. Incheon Bay	1,140	Planned
4. Sihwa	254	Operating
5. Garorim Bay	520	Planned
6. Cheonsu Bay	720	Planned
7. Saemangum	400	Planned

Source: Korea Energy Agency

Wave Power

Korea ranks third in the world after the UK and China with a cumulative 500kW installed capacity of wave power. According to Korea Energy Agency, the total wave energy capacity of the country is about 6.5GW and just 10% of this potential can supply electricity to 220,000 households. MOF is planning to invest in wave energy development, improve systems, and roll out power generation facilities of 220MW by 2030. First, the plan is to secure core technologies at the level of advanced countries by 2022, and then expand large-scale commercial development complexes by 2025 using Jeju Wave Power Plant as a model. MOF and KIOST installed 150W wave energy facility in 2006 as a test station in the sea near Chagwi, Jeju Island.

Following the successful test, MOF invested a total of KRW 10.5 billion (£7m) in a 500kW wave power plant at the same site and the plant entered operation in 2016. The Jeju wave power plant is based on grounding vibration type technology and is equipped with two 250kW turbines. It is expected to produce 580MWh of electricity per year that 120 households can use. MOF has invested KRW 25.5 billion (£17.4m) to develop core technologies such as turbines and power controllers. This is a major step for Korea as currently only a few countries such as the UK, France, and China have developed technologies for wave power generation.

MOF is also supporting a project of identifying test sites for wave energy which started in May 2016 with a view to finishing in June 2021. KRISO has been in charge of the project, and the total allocated budget is about KRW 18.7 billion (£12.8m). Under the project, the R&D institute selected a test site west of Jeju island and the same site will be the test bed for developing Oscillating Water Column (OWC) wave power plants.

Industry Insider's Thoughts

We have gained tremendous experience in building and operating a tidal power plant over the past few years. However, despite strong government backing, Korea still lacks core generation technology used at tidal power plants. We plan to localise power generation technologies through cooperation with R&D institutes and companies with advanced technologies in this area.

Mr Jaewon JEONG, Deputy General Manager – Water Energy Department, K-Water

Although there is some early progress in the localisation of basic technologies, Korea lacks the technology that can evaluate environmental changes for efficient operation of wave power stations. Korea sources this technology mainly from Europe. However, in 2019, the Korea Institute of Construction Technology (KICT) announced the development of a new wave power generation technology which, it is claimed, more than doubles the power generation efficiency compared to the existing technology, capable of producing stable power for 24 hours.

Industry Insider's Thoughts

Like the UK, Korea has remarkable marine energy resources that allow both countries to potentially lead the world in the development of technologies to capture clean energy from the sea. There are numerous opportunities between the UK and Korean governments to collaborate in the field of decarbonising economies and building resilience to the impacts of climate change.

Ms Jin-sil HWANG, Director – Marine Development Division, Ministry of Oceans and Fisheries

Ocean Thermal Energy Conversion (OTEC)

Korea is the fourth country in the world after the US, France and Japan to have conducted testing of an OTEC plant with over 10kW capacity. In 2014, KRISO and the Korea Institute of Ocean Science and Technology (KIOST) built a 20kW pilot OTEC plant at the Seawater Utilisation Plant Research Centre in Gosung, Gangwon province. A closed OTEC cycle was designed and fabricated for the pilot plant and the temperature of the heat source and heat sink were 26℃ and 5℃ respectively. Based on the successful testing of the 20kW OTEC plant in 2014, KRISO achieved another milestone by building and operating a 200kW OTEC plant in 2015. KRISO is currently designing a 1MW OTEC plant, the ultimate goal of this project. As the country's thermal conditions are not suitable for testing the larger-scale unit, Korea signed an agreement with the Republic of Kiribati in 2019 for installation and testing of the 1MW capacity OTEC plant.

MARINE SERVICES

Marine R&D

Local companies specialising in shipbuilding and offshore engineering such as Hyundai Heavy Industries, Samsung Heavy Industries and DSME provide planning and design services through subsidiaries and divisions to a number of marine-related industries in Korea and abroad. Typical fields include ships, offshore plants, ports, marine survey, technology consulting and software development.

Although major companies have separate R&D divisions, scientific research in the marine sector is mainly carried out by public research institutes such as universities or government-funded institutes. Private companies typically hire Contract Research Organisations (CRO) to develop certain technologies or sign licensing agreements with those who have already developed a key technology that companies need.

In the areas related to civil engineering such as ports, marine and coastal structures, local engineering companies have basic design capabilities, and there are a number of service companies such as Hyundai E&C that take designing, engineering, and construction as their main task. However, most of the activities in these fields are conducted offshore and rarely target deep ocean developments.

Most of the domestic offshore plant companies started with construction services including large shipbuilders, have now expanded their scope to the detailed designing capacity. Despite their efforts so far, local companies are not fully equipped with Front End Engineering Design (FEED) capability for offshore plants. There are a few local R&D institutes such as KRISO that can offer such services at all stages of engineering, procurement, construction, installation, and commissioning.

Table 6: Marine Technology Services in Korea

Service Type	Details
Plan, Design, R&D	Planning, feasibility study, basic design, R&D
Marine Survey and Research	Marine survey, exploration, monitoring, measurement, research
ICT Service	Software, system development
Ocean Works and Technology Support	Technology consulting, inspection, auditing, authorisation, purchase procurement, safety management, test driving, instalment, operation, maintenance, dissolution

Source: Korea Maritime Institute

Despite a promising marine energy market in Korea, there is a limited number of domestic specialists providing services such as marine impact analysis, Supervisory Control and Data Acquisition (SCADA) measurements, seismic and other environmental impact analyses. Most of the established UK-based technical consultancies have a limited presence in Korea meaning that there is a substantial room for cooperation in this field.

Industry Insider's Thoughts

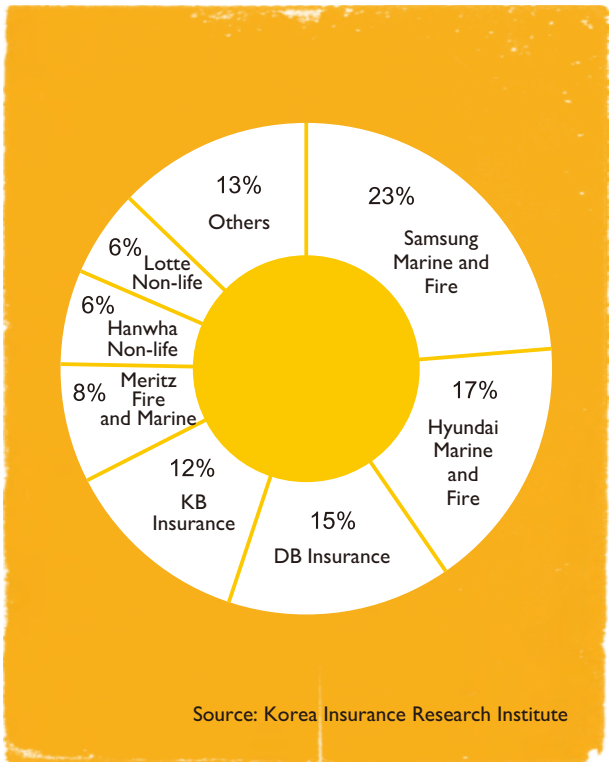
As the only government-funded research institute in the field of ships and offshore plants under MOF, our institute is equipped with cutting-edge technologies and industry specialists to conduct extensive R&D in the space. We are interested in cooperation with the UK's relevant R&D institutes and centres to co-develop advanced maritime equipment and ICT convergence technologies.

Mr Taehwan JOUNG, Head of Centre – International Maritime Strategy Research Centre, KRISO

Marine Insurance

The Korean insurance market ranks seventh in total premiums in the world and the Korean market made up 3.5% of the world market in 2019. There are 30 non-life insurers in the market, divided between 13 domestic and 17 foreign firms, though Korean firms dominate. The share of foreign insurers in the non-life insurance market increased in 2018 but was still just 2.1%. Major non-life insurance companies in Korea include Samsung Fire & Marine Insurance, Hyundai Marine & Fire Insurance, Meritz Fire & Marine Insurance, Lotte Non-life Insurance, and Heungkuk Fire & Marine Insurance.

Figure 6: Non-life Insurance Market in Korea



Source: Korea Insurance Research Institute

Korean companies in the marine insurance sector closely collaborate with companies within the same group that are active in the marine industry. For example, Samsung Marine and Fire Insurance has Samsung Heavy Industries as its main client while Hyundai Marine and Fire similarly has a close relationship with Hyundai Heavy Industries. These types of synergies across marine insurance and shipbuilding within major conglomerates limits the ability of new players to penetrate the market.

Under the regulations of Korea's Financial Services Commission (FSC), only stock corporations, mutual companies, and licensed foreign insurers are permitted to enter the insurance market, with regulatory permission granted by the same body. The minimum capital required to enter the insurance business is KRW 30 billion (£20.3m).

Korean insurance companies are increasingly expanding their collaboration with British companies. In 2019, Samsung Fire & Marine Insurance became the first Korean insurer to make a strategic investment in the UK Lloyd's market. Although in 2014, Korean reinsurer Korea Re entered Lloyd's market in partnership with Beazley, Samsung became the first company that directly advanced into Lloyd's market by taking over a stake in a Lloyd's insurer. Following the £112.4 million equity investment in Canopius, Samsung made an additional investment of £82.4 million in October 2020 with a view to becoming a member of Canopius board. According to Samsung Fire and Marine, the collaboration allows Samsung to continue its operations in the UK after Brexit and gives Canopius the opportunity for greater cooperation with Samsung in Asian markets.

Industry Insider's Thoughts

In terms of insurance policy, we have largely benchmarked the UK regulations for our operations in Korea and abroad. This allowed us to better understand the UK insurance market and cooperate with British companies as demonstrated by our recent strategic investment in Canopius.

Mr Oscar KWON, Principal Underwriter – Marine Department, Samsung Fire and Marine Insurance

The amount of new ship financing provided by the K-EXIM Bank is estimated to be around KRW 2-3 trillion (£1.3-2bn) per year. Until recently, newbuilding orders declined due to the downturn in the shipbuilding industry, which gradually reduced the amount of ship financing. However, despite the reduction in ship financing, the balance of ship financing in 2018 amounted to 9.3% of the total loans of the K-EXIM Bank of KRW 103 trillion (£70bn).

Marine Finance

Marine financing increased in the early 2000s at an average 8% year on year in Korea due to the fast growing global economy. Following the 2008 financial crisis, the industry declined somewhat but due to the US shale boom in 2016 orders for LNG carriers increased which in turn resulted in total KRW 32.3 trillion (£21.9bn) of marine financing in 2018.

Marine financiers are divided into public and private financial institutions in Korea. Major public finance and policy institutions in the marine space are K-EXIM Bank, K-Sure, Korea Development Bank (KDB), KAMCO, and Korea Ocean Business Corporation (KOBC), etc. K-EXIM Bank is a financial institution established to provide the support necessary for external economic cooperation such as importing, exporting, overseas investment, and overseas resource development.

Table 7: Marine Financing in Korea (£bn)

Category	2014	2015	2016	2017	2018	2019.6
Domestic shipyard orders	25.1	18	3.3	13	20.6	5.3
Domestic shipping companies	0.8	2.4	5.3	1.7	2.6	0.8
Foreign shipping companies	24.1	15.6	2.8	11.3	17.9	4.4
New orders for domestic shipping companies	1.2	3.4	0.8	2.5	3.8	1.2
Domestic shipbuilding	0.8	2.4	5.3	1.7	2.7	0.8
Foreign shipbuilding	3.8	1	2.3	0.8	1.1	3.8
Purchase amount of domestic used ships	1.3	6	4.5	0.9	3	2.3
Domestic total financing	26.7	19.7	4	14.6	22	5.9

Source: Korea Maritime Institute

KDB was the first financial institution in Korea to offer ship finance in the 1970s. KDB has continued to provide financial services such as senior and subordinate loans or capital investment, playing a role as a key financial institution providing funds for shipbuilding. Through its Ocean Value-up Fund in 2015, KDB has supplied subordinate ship finance to new orders and used ship sales with the goal of supplying up to KRW 20 trillion (£13.7bn) worth of financial services by 2020.

Private financial institutions such as commercial banks, asset management and leasing companies used to account for about one quarter of total domestic marine financing in the early 2000s. While the total amount of ship financing provided by local commercial banks was KRW 300-400 billion (£200-270m) per year before the bankruptcy of Hanjin Shipping in 2017, it is currently estimated to be slightly above KRW 100 billion (£67m). Due to the long-term recession in the shipping market, the scale of international commercial banks' ship financing is also shrinking, but the drop in domestic commercial banks' ship financing trend has been much more pronounced.

Table 8: Marine Financing Services of K-EXIM Bank

Financial Services	Foreign Shipping Company	Domestic Shipping Company
Loan	Export-based loan	Foreign business loan Local business loan
Guarantee	External debt guarantee External bond guarantee	Ship bond guarantee
Investment	Eco-ship Fund	

Source: K-EXIM Bank

Table 9: Annual Ship Financing of KDB (£bn)

Years	2013	2014	2015	2016	2017	2018
Amount	4.8	3.5	3.4	3.8	3.7	1

Source: Marine Money Newspaper

OPPORTUNITY AREAS

Smart and Autonomous Ships

Local shipbuilders and R&D institutes are already conducting large-scale R&D projects on smart and autonomous ships. Most of the technological cooperation is taking place involving only domestic players. However, there is a growing interest among shipbuilders in cooperating with foreign companies, particularly UK companies, that can offer solutions for AI-based navigation, accident prediction, remote performance monitoring and diagnosis systems, fuel optimisation, emissions control, high-speed wireless communication, data sharing and processing technologies.

Smart Ports

Smart ports are at an early stage of development in Korea, as the country has just recently begun rolling out its first smart port project in Busan with a view to expanding to 11 other ports across the country. Local port authorities and systems integrators told us there is a demand for IoT-based warehouse logistics and inventory management, automatic loading, dispatching, and transporting solutions, port traffic optimisation technologies as well as eco-friendly energy solutions such as hydrogen refuelling stations and fuel cell power generation technologies.

Marine Energy

The Korean energy sector is on the verge of a major change as the country is seeking to achieve 65GW installed capacity of renewable energy including offshore wind, tidal and wave power by 2030. However, there is a significant technological gap between Korea and countries with advanced technologies and expertise in the space such as the UK. This creates opportunities for UK companies with solutions such as optimal offshore wind site determination technologies, efficient tidal and wave power generators and turbines, technologies for evaluation and prediction of environmental changes, efficient OTEC technologies, project development expertise, etc.

Marine Services

Korea has a well-developed service sector in the ship design, construction supervision, technical and management consultancy, marine insurance, and ship financing fields. UK companies can find opportunities in R&D services related to marine engineering as well as the marine insurance sector. Korean insurance companies are increasingly seeking collaboration with their UK counterparts, while the presence of international firms in the Korean insurance market continues to grow, pointing to the appeal of the market for foreign insurers.

For further information please contact:

Hyekyung Suh
Trade Officer(Marine), DIT South Korea
Hyekyung.suh@fcdo.gov.uk

Great.gov.uk

Dilshod Akbarov
Project Manager, Intralink Korea
dilshod.akbarov@intralinkgroup.com
+82 (0)10 9386 1121

Adeel Ahmad
Project Director, Intralink Korea
adeel.ahmad@intralinkgroup.com
+82 (0)10 9399 2604

www.intralinkgroup.com

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Published November 2021
by Department for international Trade
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