The Institute for Peace and Unification Studies Seoul National University

IPUS HORIZON | No. 12 (30 August 2022)

Development Strategies of Marine Renewable Energy in North Korea

Yong Sung Park
Department of Civil and Environmental Engineering

0. Author's Note

This paper is the result of a study conducted by the Institute for Peace and Unification Studies' "Laying the Groundwork for Peace and Unification" in 2021, and includes the insights and experiences of various experts.

1. Background and Necessity of Research on the Development of marine renewable Energy in North Korea

There are mixed opinions on whether and how to reunify the two Koreas, but the common consensus is that South and North Korea should be able to advance together. Thus, it is generally agreed that it is important to build a foundation. However, the economic gap between the two Koreas at the moment is quite big to achieve this ideal. According to a report issued by the government, based on GDP in 2018, North Korea's GDP must grow at an annual rate of 8 percent for over 30 years in order to grow as much as South Korea. In order to follow the precedent of Germany's reunification, building the foundation for growth comes first. Our researchers reviewed previous studies when we first applied for 'Laying the Groundwork for Peace and Unification', and found many significant studies in various fields. Previous studies covered many areas such as land, infrastructure, cities, healthcare systems, and labor market improvements, and commonly emphasized the importance of stable energy supply for growth.

Traditionally, North Korea's power generation is concentrated on hydro and coal-fire power. However, all power generation facilities are now aging, and energy supply continues

to decrease or stagnate for various reasons such as economic sanctions. While energy is not evenly supplied throughout North Korea, the Yellow Sea Belt on the west coast is expected to play an important role in inter-Korean cooperation. Thus, we began this research with an aim of having the two Koreas develop marine renewable energy together in the Yellow Sea, where the tidal range is large. This is not something I came up with for the first time, but what has been discussed for a long time. Last year, we held two major meetings while conducting the research. In the first event, Dr. Jung-soo Shin of Korea Energy Economics Institute (KEEI) and Dr. Min-ah Kim of Korea Research Institute for Human Settlements (KRIHS) explained the current status and prospects of energy supply and demand and urban development in North Korea. At the second conference, Ji-young Kim, a senior researcher at Korea Electric Power Corporation (KEPCO), and Sung-hoon Lee, a deputy director of K-water explained offshore wind energy and tidal power generation. Many other professors from leading universities in Korea in my field of research, coastal engineering, which mainly deals with ports development and coastal defense, also attended to have a heated discussion until late at night. I shall briefly present the contents of the discussion at the two meetings.

2. The Current Status of Marine Renewable Energy Development in South Korea

Major sources of marine renewable energy promoted in South Korea are offshore wind power generation, wave-power generation and tidal power generation. Wave-power generation is very small in scale, and it was intensively studied in the UK during the oil crisis in the 1970s. Wave power was studied mainly in Scotland at the time, and I happened to have worked in Scotland for the last eight years. You can say that all forms of wave power design that you can imagine have already been tested. However, the reason that wave power generation has not yet been commercially successful is because it is way too small and too expensive to be economical. To this date, wave power generation has been studied for more than 50 years, and no significant results have been made, but other industries derived from studying wave power have developed. Wave generator, a wave-generating machine using energy-absorbing technology from moving water bodies, was created. The UK tried to make

a wave generator out of floating concrete, for a wave generator made of iron is unprofitable, but there is no news of success in this method yet.

On the other hand, offshore wind power is operating very successfully, especially in Northern Europe. There are large offshore wind farms in the North Sea and the North Atlantic, and in fact, the Scottish Government had planned to cover all the energy needed with renewable energy by 2020, which was already achieved before 2019. I recently had a chance to meet people in charge of the energy and power business and was informed that Korea also has offshore wind power, but its generating efficiency is only about 20 to 30 percent. In Europe's case, the power generation efficiency exceeds 60 percent, and thus offshore wind power holds great business value. Meanwhile, tidal power generation is rare abroad, so South Korea currently has the world's best power generation technology in tidal power. In conclusion, there is an alternative possibility that offshore wind and tidal power can be operated on a reasonable scale in South Korea. As for the current status of wind power, 9.7GW around the UK is the highest in the world. As previously stated, Scotland is at a level where all of its electricity needs can be covered by wind power. Although South Korea is also building several commercial complexes, the total capacity is 135MW, which is less than 1 percent in the global standard. However, this is not our fault. There is just not much wind around South Korea. The wind strength in South Korea is somewhere in the middle, and it is not easy to develop into wind power with this much wind. In other words, the stronger and faster the wind is in the region, the higher the level of wind power. Because power generation efficiency is proportional to the cube of the wind speed, the difference in power generation efficiency is much larger when there is a difference in the wind speed. The wind itself is not so strong at the global scale, but there are some areas where wind power generation is possible in South Korea.

In South Korea, wind power generation facilities are operated in shallow water as much as possible, because the monopiles for wind turbines are directly anchored to the ground. Installing wind farms at greater depths is a growing trend in Europe, which is comparatively advanced in wind power. There are two main reasons for this trend, first of which is that the deeper the sea, the stronger and better the wind. This is because wind keeps blowing in a certain direction. Another important reason is that there are fewer complaints from residents.

In South Korea, there are many complaints from fish farms and fishermen and in Europe, there are many complaints related to the scenery from hotels and resorts. In this regard, fish farms using floating offshore wind farms in the deep sea are also being studied. There is a study that fish farms operated in the deep sea supplement environmental pollution problems and raise healthier fish. It seems that South Korea is also keeping pace with the global trend.

The simplest of the two types of offshore wind farm construction is the gravity foundation system. In short, this method makes the ground heavy and places the farm on the ground. The most commonly used method is the monopile foundation, which anchors the monopiles directly to the ground. Although it may seem simple, there has been active research in ground engineering over the past 20 years because it requires constantly vibrating foundations, unlike foundations on land that deal mainly with stationary loads.

Next, there is a method using jacket which is more stable in truss structure. The latest method of using jacket is a suction bucket jacket. Suction buckets are installed at the seabed, and when water is sucked from above the buckets, the pressure inside of the buckets decreases and the pressure of the water surrounding them increases, leading the structures to be installed on their own. This method is advantageous in terms of the speed of installation, for the bucket can be installed in a day just by placing it on the ground and draining water. In particular, suction buckets are expected to be used a lot in the future in that the technology for installing suction buckets have been actively developed in South Korea. 〈See Table 1〉

<Table 1> Current Status of Offshore Wind Installation Technology in South Korea (Fixed Type)

Category	Gravity	Monopile	Jacket	Suction Jacket
Overview	Structure is mounted on top of the ground and supported by a heavy weight and ground friction	Steel cylinder pile is installed on the sea bed through pile driving or perforation	Jacket structure is mounted on the sea bed and installed on the ground through pile driving	Bucket-shaped large steel is anchored to the ground using internal and external hydraulic pressure differences

Category	Gravity	Monopile	Jacket	Suction Jacket
Specialty (Strength)	• onland production available • no pile driving / penetration required • simple structure / lots of experience	• simple production, minimum production cost • simple construction (in the presence of special pile driving equipment) • applicable on various ocean floor • reduced duration of construction (within 10 days)	• onland production / quality assurance • multiple construction experiences • high technology reliability • pre-piling available • many domestic construction companies	• advantageous in the deep water (constant water pressure↑) • applicable to sandy/ clayey ground • minimum cost / shortest construction (1 day) • no noise / vibration, no suspended sediment • can be dismantled and reused
Limitations (Weakness)	• seabed refinement required • large construction equipment required • ballast required • large-scale onland production facilities required	• disadvantageous in the mid/deep water • special pile driving equipment required • T/P stability issues • noise from pile driving	• expensive construction costs (for drilling) • large equipment |operation required (jackup rig) • unfavorable on clayey ground • noise from pile driving	• highly skilled manpower required • not applicable on bedrock area • few local construction companies

There are many forms of floating offshore wind power, the future of offshore wind power. Draft means submerged depth, which can be divided into different formats depending on the floating structure. A floating structure must moor, so it needs to be tied in order to stay in the place. Thus, foundation must be used and anchored, and cannot avoid some movement. Considering these unavoidable conditions, various studies are conducted on the optimal arrangement for large-scale offshore wind power generation.

In case of tidal power generation, the most recently built Sihwa Tidal Power Plant has the largest power generation capacity in the world at 254MW. Sihwa Tidal Power Plant was developed to improve water quality problems. The water pollution problem in Sihwa Lake became very serious in the mid-1990s when a seawall was constructed for agricultural purposes. Water quality has significantly improved by building drainage and operating tidal power plants. Sihwa Lake's tidal energy is an unconventional power generation. It takes a form in which the water level is lowered and maintained inside the dam, and the generator is run on tidal inflows. Sihwa Lake is an area where flooding must not occur, for Ansan is located to the inside of Sihwa Lake and Songsan New Town to the south. According to the

principle of power generation, water should be locked at high water level, but in Sihwa's case, the water level is kept as low as possible. However, in order to increase the efficiency of power generation, K-water plans to review whether the water level currently maintained is best or should be lowered or raised. Besides, there is not only a tidal power plant near Sihwa Lake, but also a lot of renewable energy generation, so I advise you to visit if you have a chance.

3. The Current Status of Energy in North Korea

Since 1990 to the present, North Korea's primary energy supply has been on the decline due to the famine, known as the March of Suffering, from 1990 to 1998 and the rapid increase in coal exports since 2010. In 2015, North Korea experienced an energy shortage, breaking the record with 8.7 million TOE. In 2012, as the result of the Kim Jong-un regime's policy to expand small and medium-sized hydroelectric power plants, the primary energy supply gradually increased since 2015, but the domestic energy supply decreased again as coal exports increased. The reason that North Korea focuses on anthracite exports is because most of the existing distribution system has been practically breaking down since the Kim Jong-un regime, and as it has converted into a dual economy of the communist system and the market economy, the entrepreneurs and money owners known as 'donju' have created an infrastructure that is favorable for exports. With the adoption of the UN Security Council's Resolution 2371 (2017), coal exports have been banned altogether, resulting in a decrease in both production and exports.

The main source of energy in North Korea is coal. There are two types of coal in North Korea: anthracite and brown coal, with about 4.5 billion tons and 16 billion tons, respectively, totaling about 20.5 billion tons. Given that South Korea has 1.3 billion tons of coal reserves, North Korea has abundant reserves of coal. Although there is a large amount of coal reserves, the facilities for mining coal are run down and many have been flooded recently. Despite the difficulties, Kim Jong-un took power and increased the production, and as North Korea's own market economy took root, there have been many cases in which entrepreneurs and local officers create systems together and export them on their own.

Oil usage has significantly decreased. There are two major oil companies in North Korea

and two lines where crude oil is supplied. One is from China and the other is from Russia, but was suspended when the Soviet Union collapsed. Crude oil supply from China has been maintained so far. According to Dr. Jung-soo Shin, the amount of crude oil available in 2019 has decreased compared to 1990, but North Korea's economic system itself has been inured over a long period of time, especially after the March of Suffering, and thus, is doing well with the amount of crude oil supplied at the present.

In the case of the power industry, it is mainly hydropower and coal-fire power. Formerly, hydropower was primary and now, coal-fire power is becoming more popular. The reason for the decrease in hydropower generation is that it is not easy to build more and bigger power stations, and North Korea's power generation facilities are aging. On the other hand, coal-fire power plants are increasing in proportion because they can be built in a relatively short period of time. Among North Korea's total energy supply facilities, hydropower plants are predominant, with 32 around the nation, followed by 7 coal-fire power plants and 4 tidal power plants in Haeju. Although this figure does not include 4 hydropower plants built since 2018, it provides an approximate status of power generation facilities. The characteristic of coal-fire power plant is that it is built near coal mines and there is an industrial complex nearby.

If we evaluate the condition of power generation facilities in North Korea by above average, average and below average, most of them are judged to be aging and fall under below average. If the deterioration is serious, renovation itself is difficult, and the return of investment are very small, making it difficult to carry out inter-Korean cooperation projects for energy facilties. The construction of the Dancheon Hydropower Plant began around May 2017. Eight dams and six power plants are being built to allow the water system of the Yalu River, including Jangjin river, Heocheon river, Garimcheon, Unchong river, and Bujeon river, to be discharged to the East Sea through a system of tunnels that is 160km long in total. The first stage of the construction is known to have been completed, and the installed capacity of the power plant is about 600MW. This is a significant power generation capacity, given that Sihwa Tidal Power Plant has a total power output capacity of 250MW.

Officially, there are four tidal power plants in Haeju, and Kim Jong-un also mentioned tidal power generation at the party convention. In 2007~8, there was an active attempt by Daewoo Engineering & Construction to develop a tidal power generation business. In terms

of technology and energy potential, our experience in South Korea is applicable in North Korea, so it is important to prepare other conditions.

4. Candidate Areas for Marine Renewable Energy Development

So, which part of North Korea is suitable to build a power plant? It is necessary to first look at the industrial structure of North Korea. North Korea's industrial structure was originally based on manufacturing and heavy industry. However, as the heavy industry sector declined after the 1990s, the current structure shows a similarity to South Korea in the 1970s, where a primary sector took a high proportion. The causes of such change in the industrial structure include shortage of energy and aging of manufacturing facilities, which eventually led to poor performance in the steel and chemical industries, which are key industries in North Korea. In response, under the Kim Jong-un regime, coal, metal, power and railway sectors were selected as leading sectors of the people's economy in the basic economic development strategy, and these were designated as the most important industrial sectors. In particular, since the Kim Jong-un regime, science and technology sectors such as ICT technology and renewable energy technology have been emphasized or mentioned before other sectors, raising a need for South Korea to respond on this development as well.

There are three economic belts of the Korean Peninsula's New Economy Initiative: Pan Yellow Sea Belt, Pan East Sea Belt, and DMZ Belt. In particular, Pan Yellow Sea Belt is connected to the capitals of the two Koreas and includes a plan to foster high-tech industries. Thus, Haeju, which is located in between Pyeongyang and Seoul, is favorable in its location. In the case of Kaesong, industrial clusters are not established and industrial production is not high, but it is considered an area to be strategically approached in Inter-Korean relations considering the potential of future development. Kaesong is traditionally a bigger city, but since it is inland, it is less favorable in terms of transportation. In the case of Haeju, it has Haeju port, which is connected to the city by rail, so there is no need to invest too much initial cost in infrastructure necessary for development, and there is a high potential for future development in terms of external economy.

Around 2007~8, Daewoo Engineering & Construction met with North Korea's

Committee for the Promotion of External Economic Cooperation and drafted a Letter of Intent for the tidal power project. If a tidal power plant is built based on the proposals reviewed at the time, the power generation capacity of 2,600MW is possible, and even when calculated at a conservative estimate, the capacity of 500MW is possible, which is comparable to the total energy supply from five rivers in Dancheon area. This is expected to be an economical alternative if we find a way to maximize the efficiency of power generation by drawing up plans for the water level.

Pyeongyang and Nampo region are often mentioned as candidates for marine renewable energy, but in order to connect Pyeongyang and Seoul, new bases that can complement the two regions, such as Kaesong and Haeju, are needed. Kaesong is often referred to as this new hub, but we need to take a preemptive approach to Haeju, because Kaesong has weak infrastructure connected to the external economy such as ports and airports. Therefore, it can be expected that the development of the Gyeongi Bay Area on the west coast, including not only Pyeongyang and Nampo region but also Kaesong and Haeju, will play an important role in determining the economic zone of the Korean Peninsula. In particular, Gangnyeong International Green Pilot District in the Kaesong-Haeju Industrial Zone is an economic development zone that focuses more on eco-friendly industries, and seems to be an appropriate area to apply marine renewable energy. If it is possible to develop Kaesong Industrial Complex as the hinterland and utilize the green pilot zone-related plans, the area is expected to grow into a strategically significant area, connecting Pyeongyang and Seoul in the long run.

5. Conclusion

As power experts all know, the quality of power is the key, not just the creation of power itself. Reliable power is supplied with constant current, voltage and frequency. If electricity suddenly comes in large and then small, industrial machinery could be severely damaged. It seems urgent to expand the overall power supply net. Moreover, North Korea does not have technical standards for industrial products in place, and there is a compatibility problem with parts or electricity. It is difficult to hire professional technicians, and also difficult to communicate with dispatched managers due to difference in ideology and interests. It is

challenging to restrict access and movement to construction sites. If a compatibility issues arising with just one equipment could cause interruption and there is a difficulty in procuring the right manpower locally. There is also a risk that the inter-Korean cooperation project loses its original purpose and is regarded as a simple means of earning foreign currency, resulting in excessive demand for equipment or materials used in the field or material compensation when moving goods. Furthermore, even if power facilities are built to supply for citizens in the first place, there is a chance that they can be turned into military facilities in the future. Thus, it is crucial to discuss the accurate amount of materials and equipment required before implementing the project, and to continuously monitor whether energy facilities are used to improve civilian life in North Korea after the project is completed.

In conclusion, the energy supply and demand in North Korea is in serious condition, and it seems that various energy sources need to be established. In response, the North Korean government is very much interested in establishing policies related to renewable energy development. Traditionally, coal-fire power generation has prevailed in North Korea, but carbon neutrality must be considered in developing North Korean infrastructure, so the chances of generating new renewable energy are high. North Korea's sources of marine renewable energy (wind, wave, tidal resources, etc.) are abundant enough, but more specific technical and economic analysis is needed. According to research so far, the Kaesong-Haeju industrial area is considered a priority development area for marine renewable energy, for it has a high potential for power generation near the coast and is expected to require a lot of energy in the future. Currently, the technology for developing marine renewable energy at home and abroad is mature, but active cooperation at the government level is needed to settle in the early stages. In the future, it is necessary to discuss the accurate scope of cooperation before implementing the project and continuously monitor the use of energy facilities after the project. Last study reviewed the overall context and the ongoing research this year analyzes from more engineering perspective, such as the amount of power generation and kind of design. Once the research is completed, we look forward to sharing the results in the future.

Author **Yong Sung Park**

Department of Civil and Environmental Engineering

Education

2009	**Cornell University** Ph.D., Civil and Environmental Engineering
2001	**Seoul National University** Master of Civil and Environmental Engineering
1999	**Seoul National University** Bachelor of Civil and Envrionmental Engineering

Experience

2019-Present	**Seoul National University** Associate Professor Department of Civil and Environmental Engineering
2016-2019	**University of Dundee, UK** Senior Lecturer Department of Civil Engineering
2014-2015	**The University of Rhode Island, USA** Visiting Professor
2013-2018	**Royal Society of Edinburgh/Scottish Government Personal Research** Fellow co-funded by the Marie-Curie Actions
2013-2016	**University of Dundee, UK** Lecturer Department of Civil Engineering
2011-2013	**Royal Academy of Engineering, UK** Newton International Fellow,
2009-2011	**Cornell University, USA** Researcher/Lecturer Department of Civil and Environmental Engineering