January 26, 2022

Challenges in the Large-Scale Introduction of Offshore Wind Power Generation and the Potential for Japan's International Contributions through the Use of Marine Energy (Bringing Soft Sharp Power to Asia)

KINOSHITA Takeshi
Professor Emeritus, University of Tokyo

1. Introduction

A public-private council has been established to strengthen the competitiveness of the offshore wind power industry, as well as a working group set up toward achieving carbon neutrality by 2050 that has begun to work actively.[1] Amidst steady progress based on the Act of Promoting Utilization of Sea Areas in Development of Power Generation Facilities Using Maritime Renewable Energy Resources, which entered into force in 2019, in order to make offshore wind power a main power source, it is important to strengthen the competitiveness of the industry and to firmly promote cost reduction. However, in regard to decarbonization, Japan is in fact lagging behind the developed countries of Europe and the United States, as well as Asian countries such as China and Taiwan.

2. Japan's Lagging Offshore Wind Power Generation

Looking ahead to 2050, offshore wind power, along with solar power, are seen worldwide as being promising.[2] However, if we look at the ratio of the total amount of power generated in various countries by wind power and solar power, which are the main renewable energy sources, Japan ranks only 22nd out of 35 OECD countries according to the data from 2019.[3] This is not because Japan is not blessed with suitable locations for the introduction of renewable energy. For example, the amount of offshore wind power alone that can be introduced is estimated to be 0.92-4.6 times the total amount of electricity generated in 2018.[4]

Suitable locations for wind and solar power generation are selected according to their respective conditions. It can be said that Japan is more suitable for solar power as it is located at a lower latitude than Europe. However, with few plains and many mountainous areas, it is difficult to find many suitable sites for solar power generation while maintaining the environment. In the case of wind power, Japan definitely has handicaps as the wind is disrupted by mountains and introduction routes are limited. In Europe, as the number of wind turbines increased, the physical effects of low-frequency noise became a major problem as the turbines were built closer to inhabited villages. Therefore, suitable locations were sought in coastal areas, and the number of wind turbines further increased. Finally, a large number of wind turbines were erected in "nearshore" coastal areas. Now, suitable locations further off the coast are being sought, with successive plans for projects in "offshore" marine areas over 500 km from the coast.

3. Global Areas with Major Wind Power Development

The renewable energy industry is closely related to regional development and regional revitalization. It is essential to develop new industries based on reliable future projections, and offshore wind power generation is an industry with major supporting industries and a large employment capacity.

In Europe, in addition to the natural conditions of stable westerly winds and shallow sea beds, social conditions such as industrial infrastructure for North Sea oil fields and port infrastructure were in place, leading to the large-scale introduction of offshore wind power from the 1990s onward, and the formation of a supply chain for wind turbine manufacturing in the region. In this region, transportation costs have been kept low by locating factories close to the demand areas, while investments have been made in large-scale and mass-produced wind turbines. This has led to progress in cost reductions over the past decade, including cases where the tender price has fallen below 10 yen/kWh and cases of market price (zero subsidies).

The global offshore wind power market is growing steadily. According to an analysis by an international organization, 562 GW is expected to be introduced worldwide in 2040, which is about 24 times the amount in 2018.[5] The wind power industry is currently growing into a huge industry centered on Europe, and is expected to overtake the scale of the oil and natural gas industry in the near future. This section describes the cities that are at the center of this new industrial development.

3.1 Bremerhaven, Germany[6]

Located in the northwest of Germany, Bremerhaven is the outer port of the old city of Bremen, and was once a port town for deep-sea fishing. Due to the decline of the deep-sea fishing industry, the area used to have a high unemployment rate. However, it has been revived as a major center of offshore wind energy know-how. A network for the wind energy industry has been created and serves as a contact point for the German offshore wind industry. More than 300 companies and research institutes are currently members, covering the entire value chain of the wind power industry. The traditional harbor facilities and locations have made the city the center of the German offshore wind industry.

3.2 Esbjerg, Denmark[7]

Esbjerg is the central hub port for construction and maintenance of offshore wind power projects in the waters around the North Sea. The capacity of wind turbines shipped from the port of Esbjerg accounts for 67% of the total offshore wind capacity. Esbjerg is the world's largest hub port in both name and substance, with an area for offshore wind measuring one million square meters (Japan's area starts at about 120,000 square meters).

3.3 City of Hull and the Humber Region, United Kingdom[8]

Hull is located in the northeast of England in the United Kingdom. It once thrived as a fishing port for trawlers, but had become one of the poorest cities in the United Kingdom. From the mid-2010s, the existing supply chain related to the development of North Sea oil and gas fields began to be diverted to offshore wind power, creating demand for continuous construction and O&M services for wind power, and a supply chain for the offshore wind industry was constructed.

3.4 Sing Da Harbor in Kaohsiung[9] and Tainan Port[10], Taiwan

A jacket foundation manufacturing plant has been established in Sing Da Harbor, which is capable of manufacturing up to 50 jackets per year.

Taiwan also has the advantage of being close to Southeast Asian markets such as Vietnam. Since the beginning of 2018, a new factory with a local production contract has been established in Taichung Port to manufacture blades, related to the supply of turbine blades, towers and other materials.

The center of the wind power market is now shifting from Europe to East Asia, and cooperation is being promoted with local companies for manufacturing bases for turbine blades, towers, and support structures. The Asian market is expected to grow rapidly going forward, with some predictions indicating that 41% of the global market share will be in Asia by 2030.[11] Therefore, European and U.S. wind turbine manufacturers are entering the Asian market in earnest, and competition to attract interest has begun in Asian countries.

4. Cost Structure and Project Finance

It is no small feat for Japan to make up for more than a decade's delay. Let's first look at a breakdown of the costs of offshore wind power in Europe in order to recover from the current situation, which is said to be three laps behind and have five-fold costs.

Table 1 shows the operating costs of fixed-bottom offshore power generation, including the interest cost of large-scale project financing. In this example, half of the total cost is the interest cost.[12] In other words, we can see that it is important how much the period between the start of the project and the start of operation can be shortened to speed up the recovery of funds. We can also see that it is necessary to optimize the overall cost of the project, not just the wind turbines or support structures alone.

Table 1: Example of cost structure of offshore wind power including the interest[12]

	Cost structure of offshore including interest rate
Wind turbines	13%
Operation and maintenance	20%
Support structures	5%
Electrical equipment	5%
Installation	8%
Interest	48%

Next is an explanation of project finance. Figure 1 shows a typical contractual relationship concluded by an offshore wind power project entity.[12] Each contract involves risk, and one extremely major risk is the maritime area possession and usage rights. It can be said that Japan is burdened with higher costs for all these risk factors than Europe because of its inexperience. This is the main reason for the high cost of offshore wind power in Japan, which is said to be five times higher than in Europe. To reduce these risks, in regard to maritime area possession and usage rights, the government can, for example, make it possible to plan projects in Japan's territorial waters and EEZ, as in Europe, so that large-scale projects can be carried out in a stable manner. It can also streamline the system for offtake of the electricity generated. EPC contractors, wind turbine suppliers, and operators can reduce completion, technical, and operational risks while building a careful track record. As these risks are reduced, the cost importance of wind turbines, installation, support structures, and electrical equipment would increase, and the technical capabilities of the overall design would become more crucial.

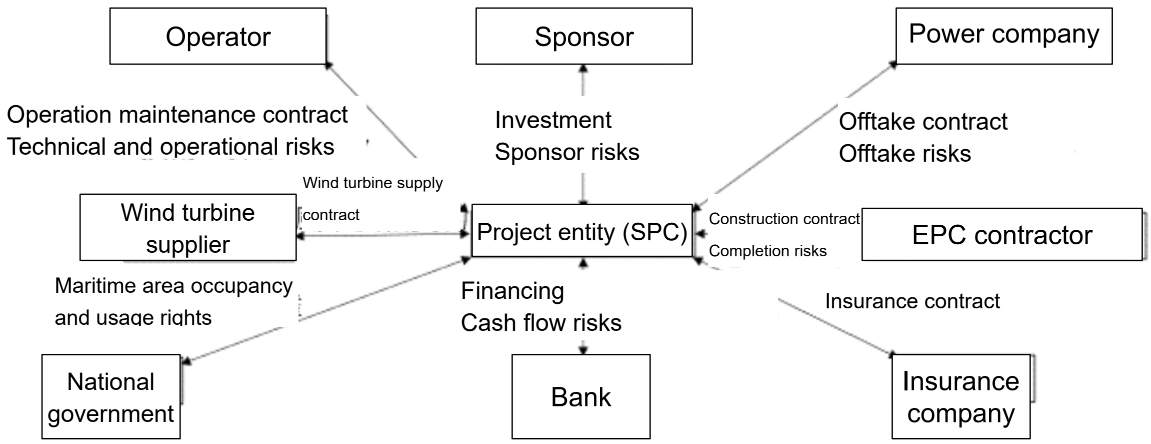

Figure 1: Structure of project financing for offshore power generation[12]

5. What strengths can Japan bring out?

Unfortunately, Japan currently imports wind turbines from overseas because there is no domestic manufacturing base for them. Japan has not been able to fully utilize the potential of domestic component manufacturers, who have technological capabilities based on their experience with onshore wind power, and the domestic manufacturing base. Therefore, let us consider where Japan should find a role it can play with what strengths it has, by referring to prior examples.

The Japan Wind Power Association (JWPA)[14] is at the center of Japan's Bremerhaven style (network-centered) of wind power. A public-private council meeting was held in 2021 to present a vision for the offshore wind industry.[1] This was a great first step, but we need to pay close attention to the differences between Japan's position for wind power, which is three laps behind, and that of thermal and nuclear power generation, especially with regard to large-scale deployment, which is a prerequisite for cost reduction, and maritime area possession and usage rights (in cooperation with fishermen). The role of the Ocean Energy Association - Japan (OEAJ)[14] will also become important, as many of the technological innovations for cost reduction are related to marine technology.

The Japanese version of the Esbjerg port style has four ports: Akita Port, Noshiro Port, Kashima Port, and Kitakyushu Port, but a large area is required (one million square meters). Is it possible to expand these ports in this way? It is important to shorten the period between the start of full-scale planning and the start of operation to speed up the recovery of funds, but this would require a large area (one million square meters). It will be fine until five years later, but Japan needs to plan for 10 years later as well.

Nagasaki, for example, is aiming for the style of the Humber region, including Hull. The Nagasaki Marine Industry Cluster Promotion Association was established in 2014 as a public-private-academia consortium, and the Nagasaki Ocean Academy was established in 2020 to develop human resources for the future of offshore wind power, a typical interdisciplinary field.[2, 12] At present, the Academy is for managers and engineers who are involved in project development and EPC contractors. There is an urgent need for courses to train engineers and technicians in the field, especially courses in safety management to obtain qualifications. As for research and development as well as innovation, Japan as a whole needs to further strengthen its capabilities. As a result, we would become able to provide consultant services to Asian countries.

Next, I will describe the development of the style of the Sing Da Harbor in Kaohsiung, Taiwan (Foundation structure continuous manufacturing factory style) and that of Taichung Port in Taiwan (blade factory style). Advanced European companies have an overarching view of the Asian market as a whole. They search for the optimal supply chain throughout Asia to reduce power generation costs, and advance collaboration with local companies to establish manufacturing bases. Their development will be dispersed throughout Taiwan, China, the Republic of Korea, and Japan. Items with a high price per weight will probably be transported from Europe, which is currently the most advanced region for the time being. However, items with a lower price per weight, such as piles, jackets, transition plates, blades, and towers, will be made in suitable locations in Asia. There will probably be a partnership base established in Japan. For the time being, we are waiting for monopile super-thick steel sheet bending manufacturing factories to be developed on a large scale in Japan. Bending machines for piles made by bending ultra-thick steel plates, as well as cranes and yards for constructing floating support structures, etc., require high capital investment, so they should be developed in anticipation of at least 20 years. From this perspective as well as others, Japan's long-term and stable renewable energy policy is important.

Because it is difficult to mass produce jackets and floating support structures in a short period of time like monopiles, they will be made with parallel manufacturing in multiple yards. Therefore, standardization of products, parts, and quality control is very important. In the case of Asia, where there are more islands, straits, and sometimes bridges than in the North Sea, tailor-made designs will be required for each project depending on the geographical location of the yard with capacity and transportation routes.

6. The Great Proposition: Cost Reduction and Technological Innovation

There was a period of time when Europe's offshore wind power industry suffered from high costs. In the decade between 2000 and 2010, the cost of offshore wind power in Europe more than doubled. The main reason for this was the increase in the cost of maintenance management as well as the costs of transmission cables and transformation to land as the farms moved further offshore, making them farther from land and in deeper water. It was the Offshore Wind Accelerator, a market pull project in the United Kingdom, that overcame this and brought the cost back to the original level over a period of 10 years.[16] As a result, the cost was reduced and the scale of offshore wind farms rapidly increased. In order for offshore wind power to grow significantly in Japan, it is necessary to increase the scale of farms. The following two points are important for realizing large-scale farms.

・In the case of Japan, maritime area possession and usage rights are still limited to

areas close to the shore, and the development of maritime areas that straddle multiple prefectures, much less Japan's territorial seas and EEZ, has not been considered on the legal front. It is necessary to improve the legal aspects of this as in Europe.

・The number of fishermen per maritime area in Japan is an order of magnitude larger than that in Europe, so a system that enables cooperation and collaboration with fishermen is necessary. At this time, considering the current situation where fishery resources are decreasing on a global scale, it is desirable to collaborate on the recovery of fishery resources.

7. Cooperation and collaboration with fishermen

Let's consider a different way of solving the problem from that in Europe. Fishery resources are decreasing on a global scale, and Japan is no exception. In 2018, the Fisheries Reform Act was enacted as the first fundamental reform in 70 years.[16] The Act changed the way resources are managed and abolished the order of use for maritime areas, opening the way for companies and others that are recognized as contributing to regional development to use the resources.

Given these changes, I will discuss how large-scale offshore wind farms are a great opportunity for fishermen to develop new businesses to raise fish and also to restore fishery resources. Firstly, there is offshore large-scale aquaculture. Japan's aquaculture industry has already used up all the suitable areas where the waves are calm, causing water pollution and red tides. In the future, we should expand to offshore areas where the tide can come in and raise healthier and tastier fish. However, to expand to offshore areas where the waves are large, automatic feeding systems and automatic ebb and flow systems are required, and this requires large-scale efforts. Finding the funding for this would thus be a challenge for the local fishermen. On the other hand, wind power companies are seeking the maritime area possession and usage rights with business potential. The offshore wind power business is massive, so the investment in large-scale offshore aquaculture would only be a small percentage of the total. However, the consent of local fishermen's associations is indispensable for maritime possession and usage rights, and the reality is that the inclinations of such associations determine a great extent about the maritime areas beyond. As shown in Figure 2, offshore wind power companies and local fishermen can cooperate to create new large-scale off-shore aquaculture business through cooperation with the fishery companies that are the current large-scale aquaculture operators and have experience and know-how.

However, this should not lead to an increase in the cost of offshore wind power projects. If the joint ventures are independently profitable and managed separately, they will not be a drag on the offshore wind projects, and large-scale offshore wind projects can be planned. The only concern is that the current act on the use of sea areas for renewable energy does not allow this kind of joint planning of the use of maritime areas by the private and public sectors. The Act of Promoting Utilization of Sea Areas in Development of Power Generation Facilities Using Maritime Renewable Energy Resources should be revised so that it does not hinder the search for new business models without compromising the public interest. This is one of the roles of the national government regarding cost reduction.

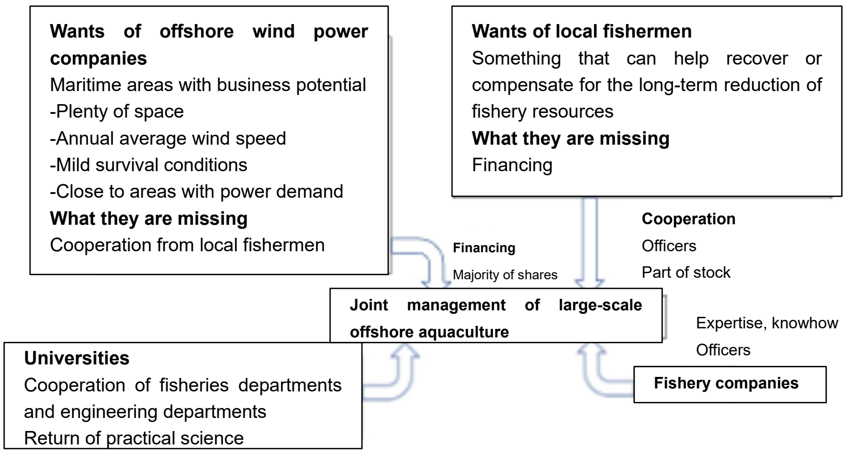

Fig. 2 Large-scale offshore aquaculture managed jointly by companies and local fishermen[19]

Next is projects for recovery of fishery resources. There is a long history of research on recovery of fishery resources. Since the conditions are different in each region, it is difficult to draw a general conclusion. However, the most prominent symptom of the gradual decline of resources is wie$hiwivxmjmgexmsr, which is the loss of spawning grounds and habitats for fish and shellfish due to the loss of seaweed beds. It is known that divalent iron ions, humic acid, fulvic acid, and sunlight are effective in preventing shore denudation.[18] In addition, these are effective for the reproduction of phytoplankton, which enriches the food chain pyramid of marine life connected with zooplankton and small fish. One of the reasons why countermeasures have not been taken in spite of this knowledge is the lack of a platform for fixed-point observation and the high cost of large-scale tests to demonstrate the effects. A large number of monopiles and support structures for offshore wind turbines could serve as platforms for fixed-point observations and large-scale demonstrations. It would be possible to monitor the concentration of iron ions with sensors and supply iron ions, humic acid, and fulvic acid to the algae beds grown on the monopiles and support structures. Iron ions can be obtained at a low cost. Humic acid and fulvic acid take more than 100 years to be produced from humus in nature, but it has been shown that they can be obtained inexpensively in 10 days by adding ingenuity to the urban human waste treatment process.[19] Furthermore, the support structures would encourage the upwelling of nutrient-rich deep water, which would increase the primary production of marine life and create new and better fishing grounds, a dream project. However, it is difficult to create a business model for this project because it is challenging to identify the beneficiaries. This is where the national and local governments would play roles. As the understanding of fishery cooperation and joint business creation related to offshore wind power increases, large-scale farms that cover the EEZ will be realized, and this could lead to cost reductions comparable to or even greater than those in Europe.

8. Instill democratic values in the people of developing countries with imposing political systems through ODA (soft and sharp power toward Asia)

Decarbonization of energy sources is a major issue not only in developed countries but also in developing countries. It is majorly significant for Japan to help developing countries establish renewable energy sources that they can install and maintain on their own. For this purpose, Japan's most successful ODA project, the "School for All" project that has been spread to 40,000 schools in Africa, can be used as a reference. It is the practice of creating a better learning environment for children through the collaboration of "everyone," meaning schools, local communities, and parents and guardians. In order to ensure the transparency of operations and to establish an active committee, it is important for residents, parents, and guardians to democratically elect committee members. School and community officials also cooperate together to improve school buildings. The government officials are in charge of monitoring and support.

Even before the School for All project, school management committees consisting of teachers, parents and guardians, and local residents were formed to ensure School Based Management (SBM). However, the concept of "school" remained psychologically distant for local residents, parents, and guardians in the community. In the School for All project, work was conducted to create a framework for collaboration among residents, teachers, and those responsible for school management, and it was decided to elect the members of the management committee through anonymous elections. The teachers, parents and guardians, and residents are now working on the project themselves, and it is clear that collaboration based on information-sharing and trust is essential for the collaboration in the project.

As for international cooperation in the use of marine renewable energy, the Tidal Stream Industry Energiser (TIGER) Project for 2019-2023 in the English Channel is a good reference. This is a bilateral cooperation project between the developed countries of the United Kingdom and France, but Japan should propose regional development cooperation in Asia through locally produced and consumed tidal stream power generation as cooperation between developed and developing countries. This style of small-scale local production for local consumption is more suitable for supporting developing countries.

In Indonesia, there are many suitable sites for tidal power generation, but the demand areas are far away and the scale is small because there are few villages, let alone factories, around the suitable sites. Parts, installation, and maintenance are the main roles of the local community. The first step would be to design a system for this to be done locally. With consideration of prioritizing local development before improving the scale and efficiency of the project, it would be a good project to instill democratic values in the people of developing countries with imposing political systems through ODA; in other words, to instill soft and sharp power in Asia. The problem of immature local economies is often seen as a negative factor, but in fact, joint development with local communities can be a favorable theme.

In addition to the strengthening of the soft and sharp power of democracy through economic promotion and decarbonization in Asia, the companies of the local production for local consumption projects within Japan that will be advanced concurrently with this project will better understand the perspectives of the local people, and the new projects involving collaboration utilizing maritime areas will enable large-scale farms in Japan as well as achieve cost reductions. This will be the strength of Japan's marine energy (offshore wind power) that the leading European countries do not have.

9. Conclusion

The key to the success or failure of offshore wind power projects is the tailor-made design for each project. The structure and mooring form of large structures, being made of concrete instead of steel, or bolted construction at the base port instead of dock construction, may be manufactured in a short period of time. The optimum value of a sea gauge of a floating structure varies from project to project. Optimal design of the entire project, in other words, “flexible engineering capability,” is the way to utilize the shipbuilding, civil engineering, and construction technologies that Japan has long cultivated.

Small-scale offshore renewable energy projects that are locally produced and locally consumed can be applied to the Asia region, which is facing the challenge of economic development as well as decarbonization. Through ODA, such projects will bring soft and sharp power to Asia by instilling democratic values in the people of developing countries with imposing political systems, and greatly contribute to regional security as well. This will also make it possible for Japan to develop its own large-scale offshore wind power generation and reduce costs.

References

(1) https://www.meti.go.jp/shingikai/energy_environment/yojo_furyoku/pdf/002_02_01.pdf
(2) International Energy Agency (IEA); World Energy Outlook 2020 (2020)
(3) IEA: Monthly OECD electricity statistics – data up to December 2019, Revised historical data (2020)
(4) Ministry of the Environment: Entrusted Work Concerning the Development and Basic Zoning Information Concerning Renewable Energies (FY2017)
(5) IEA “Offshore Wind Outlook 2019” (Sustainable Development Scenario)
(6) https://www.nedo.go.jp/fuusha/doc/20130627_06A.pdf
(7) https://www.cdit.or.jp/_userdata/53CDIT_s-42.pdf
(8) https://www.jkri.or.jp/PDF/2019/sogo_79ishimaru.pdf
(9) https://www.4coffshore.com/news/changhua-jackets-near-fabrication-completion-nid17100.html
(10) https://mhivestasoffshore.com/mhi-vestas-offshore-wind-inks-firm-orders-for-taiwan-projects/
(11) GWEC “Global Offshore Wind Report 2020”
(12) https://noa.nagasaki.jp/courses/280
(13) http://jwpa.cloud/
(14) http://www.oeaj.org/

(15) Carbon Trust: The Future Of Vessels For Offshore Wind, Fred Olsen Wind Carrier, 2014, London
(16) https://www.nhk.or.jp/kaisetsu-blog/100/311156.html
(17) http://www.nagasaki-u.ac.jp/ja/about/info/news/news2899.html
(18) sehigijutsusiryou.pdf (maff.go.jp)
(19) https://www.iist.nias.ac.jp/divisionalresearch#gsc.tab=0__