Challenges and solutions to deploying floating offshore wind power in Japan

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Executive Summary

IRENA and GWEC have pointed out that to remain on track to meet the 1.5°C target of the Paris Agreement, 500 GW of global offshore wind installations will be needed by 2030. This is around eightfold of cumulative offshore wind energy capacity installed globally in 2022, which amounted to 63.2 GW.

Japan announced its target to introduce 30-45 GW of offshore wind power by 2040 in its Green Growth Strategy. In order to achieve this target, Japan needs to accelerate the process of project approval and open up more sea areas for project development, given the lead time required for development.

Japan has limited territorial land area and shallow waters up to 50-60 meters deep that are suitable for bottom-fixed offshore wind turbines. However, it is surrounded by large bodies of water whose area, including its territorial waters and Exclusive Economic Zone (EEZ), is the sixth largest in the world. Therefore, floating offshore wind power is a promising technology for Japan.

A bill to amend the Marine Renewable Energy Act so that the sea area for offshore wind power development can be extended to the EEZ has been compiled after long discussions and is expected to be submitted to the Diet. This will enable Japan to deploy large amounts of offshore wind power and the demonstration of Japan's intentions to construct wind farms in its EEZ will be a decisive step toward the development of the floating offshore wind power market in Japan.

Offshore wind power development in the EEZ

The United Nations Convention on the Law of the Sea (UNCLOS) acknowledges that coastal States may exercise sovereign rights over the exploration, exploitation, conservation, and management of natural resources and other economic activities, such as the production of wind or tidal power in their EEZs. In Europe, many countries such as Germany and the UK have developed maritime spatial plans (MSPs) which include areas designated for offshore wind power in their EEZs. A number of wind farms are already under development or in operation in the EEZ.

All States enjoy the right of navigation and overflight and the laying of submarine cables and pipelines within any EEZ. Given that neighboring countries having announced or currently constructing wind farm projects in their EEZs, it is becoming increasingly urgent for Japan to develop projects in its EEZ as early as possible. Japan should demonstrate its intention to build wind farms in its EEZ by formulating a maritime spatial plan based on both scientific data and stakeholder engagement. However, given the time required for developing such national plans, the government could formulate a concrete roadmap to achieve its offshore wind power targets and map out zones for project development.

Stakeholder coordination in the EEZ

It is important to secure the understanding of different stakeholders when constructing wind farms in the EEZ or establishing safety zones around them. In Japan, the fisheries sector will be among the most important stakeholders. In the Japanese EEZ, "offshore fisheries" are conducted with permits and licenses issued by prefectural governors and "distant water fisheries" are conducted with those issued by the Minister of Agriculture, Forestry and Fishery. However, target parties, often large private companies, that operate in the target area are difficult to identify compared to coastal fishery rights-based fisheries. Furthermore, the

stakeholders are not always based in the coastal area close to the target sea area, but can be distributed across Japan, thus often not sharing the interests or visions of local stakeholders.

Project operators can establish safety zones around wind turbines during construction or operation. The approach to allowing fishing vessels into wind farm areas varies among different countries. Even when vessels are allowed to enter an area, some fishing methods are difficult to implement. Depending on the sea area, target fish species and fishing methods differ, as well as the vessel size and geographic extent of the fishing ground; and therefore, it is difficult to predict the impact that wind farms will have on fisheries.

The call for early floating offshore wind project development

Floating offshore wind power generation has already entered the commercialization stage, mainly in Europe. However, compared to onshore wind power and bottom-fixed offshore wind power, there are fewer examples of its installation; and therefore, there are not only technological challenges but also engineering and cost issues pertaining to the relevant infrastructure and installation.

Many floating offshore wind power technologies are still in the development stage. While demonstration projects are necessary to establish the technology, the floating offshore wind power demonstration projects currently considered in Japan are too small in scale to attract foreign wind turbine manufacturers. This is because the manpower and costs required for the front-end engineering and design (FEED) of a small pilot project are not so different from what is needed in a full-fledged project. In order to advance floating offshore wind power in Japan, it is essential to offer foreign wind turbine manufacturers a clear picture that Japan has a huge and promising market. Therefore, in addition to technology demonstrations, real full-scale projects should be launched based on established technology. With announcements of GW-scale projects, floating offshore wind power is shifting from the technology-push phase to the market-pull phase.

Domestic supply chain development as a part of Japan’s industrial strategy.

The invasion of Ukraine by Russia has renewed awareness of the importance of energy and economic security. Excessive dependence on a particular country for products raises concerns about risks to stable supply in the event of supply chain disruption. When wind turbines are supplied by a certain manufacturer or when their maintenance services are provided by a particular company, they will risk suspension of the remote monitoring system, and consequently massive power outages. If they are controlled remotely by a foreign wind turbine manufacturer, they will risk suspension that will be difficult to recover in the event of war or other contingencies. Therefore, it is important to build a domestic supply chain and develop and secure the human resources and infrastructure to support domestic production and operation and maintenance.

The Japanese government needs to demonstrate its commitment to promoting floating offshore wind power not only to foreign companies but also domestic companies and thus enhance the presence of domestic players in the market in terms of both quantity and quality. Domestic companies need to be convinced that the government is determined to promote floating offshore wind power as a major pillar of its industrial development policy.

The supply chain for floating offshore wind power includes study and design, port development, manufacturing wind turbines, floating foundations and other equipment, shipping equipment and components, assembly and installation of turbines and transmission lines (submarine cables), operation and maintenance, and decommissioning. Japan lacks the experience in the offshore oil and gas operations that many North Sea countries possess and currently has no domestic manufacturing base for wind blades and thus must rely on overseas manufacturers for wind turbines. Yet, there are many Japanese companies with individual elemental technologies in the supply chain. Japan bears the potential to take the lead in building a supply chain for floating offshore wind power by tapping on the technologies that it excels in, such as shipbuilding, submarine cable technology, carbon fiber reinforced plastics (CFRP), and marine civil engineering. However, it needs to grasp the momentum.

Japan's offshore wind industry needs to improve and reduce the cost of current technologies, and at the same time explore new technologies to solve challenges unique to Japan, such as land constraints related to manufacturing and transporting equipment. It is important to support and foster startups that develop emerging technologies with completely new concepts.

It is essential from an economic and energy security perspective that most of the supply chain be covered domestically, Stronger incentives should be provided for building factories and supply chains in Japan to encourage domestic manufacturing and procurement.

It is also important to enhance recycling and reuse efforts. Not all components of a floating offshore wind power turbine can be recycled or reused; and therefore, recycling and reuse will not solve all supply chain issues. However, it will help retain critical resources within Japan and reduce imports, thus contributing to enhancing economic and energy security. For example, recycling neodymium magnets in Japan will prevent the outflow of the rare metals, or domestic goods, contained in these products, and thus reduce imports. In addition to technological development, economic support measures, and regulations, it will be important to draw a picture in which venous industries, especially recycling, contributes to the promotion of domestic industry and the economy.

A new energy system harnessing offshore wind power

Strategic planning by the national government with the strong support and coordination from local governments will be essential not only to promote the development of a domestic supply chain for floating offshore wind power but also to optimize the energy system.

Grid connection is a critical element of future offshore wind power development. Japan's transmission grid expansion and reinforcement plan takes future offshore wind power development into consideration. However, in the longer term, there remains a possibility that there will not be enough grid capacity to accommodate all offshore wind power. Therefore, converting electricity derived from offshore wind to hydrogen is an ideal option for fully utilizing offshore wind power.

There are existing studies and pilot projects for hydrogen production using offshore wind power in Europe, especially in countries facing the North Sea, such as the United Kingdom, Germany. The development of both offshore and onshore electricity transmission lines, hydrogen pipelines, and/or other means to deliver hydrogen will be critical to integrating offshore wind power into the energy system. Japan seeks to build several hydrogen/ammonia hubs to facilitate the scaling up of domestic hydrogen/ammonia demand and hydrogen/ammonia infrastructure is a key component of hub development. Synergy with such hydrogen/ammonia hubs should be considered in the system design of integrating offshore wind power into the onshore energy system as this will reduce the overall infrastructure construction cost.

When there are infrastructure constraints to transmit wind power to other parts of Japan, relocating energy demand to regions with abundant offshore wind resources could also be a solution for integrating offshore wind into the future energy system., Regions with large offshore wind resources may also be attractive to potential off takers of clean energy. For example, data centers could be potential consumers of clean electricity and green hydrogen), and direct reduced iron (DRI) production will use great amounts of green hydrogen. This can also lead to the fostering of local industries and prevent the offshoring of domestic industries, given that the power generation cost from offshore wind is competitive enough to attract clean energy end-users.

Participatory decision-making

The amendment bill for the Marine Renewable Energy Act will introduce a two-step procedure for selecting offshore wind power projects in the EEZ. In the first phase, developers granted a preliminary permit by the government will initiate coordination with fishermen groups and other interested parties. Such consultations should involve not only those with obvious interests but a wide range of stakeholders, including local community and parties of bilateral fishery agreements. Furthermore, a framework to ensure fairness should also be established.

Today, the Japanese government designates Promotion Zones, Promising Zones and Preparation Zones for offshore wind based on discussions with local stakeholders in a committee often comprising representatives of local interest groups. Individual negotiations are often conducted by the project developer, as contribution to the local economy is included in the evaluation criteria. However, stakeholders will be difficult to identify in the EEZ and negotiations are likely to become more challenging.

Stakeholder engagement covering a wide range of parties and individuals is important for all parties to foster a sense of ownership for individual projects, and in the long run, maritime spatial plans. In the Netherlands, the development of the North Sea Agreement demonstrated the importance of not only having top-level conversations but to engage stakeholders of different levels.

Japan lacks a participatory process for decision-making that is required by law in many countries. Open discussion supported by science-based information will make outcomes more acceptable across different parties. Maritime spatial planning will require consultations with and consensus among a wide range of stakeholders, including different interest parties as well as local people and businesses spread across extensive coastal areas. There is an urgent need for a participatory decision-making process to be developed in Japan. Such processes should be led by a government organization such as the Cabinet Office or a newly established government organization that can cover inter-ministerial topics.

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Acronyms

ANRE: Agency for Natural Resources and Energy, METI

BEIS: Department for Business, Energy & Industrial Strategy (United Kingdom)

BSH: German Federal Maritime and Hydrographic Agency

BMJ: German Federal Maritime and Hydrographic Agency

DBJ: Development Bank of Japan

EEZ: Exclusive Economic Zone

GWEC: Global Wind Energy Council

IEA: International Energy Agency

IRENA: International Renewable Energy Agency

JETRO: Japan External Trade Organization

METI: Ministry of Economy, Trade and Industry

MLIT: Ministry of Land, Infrastructure, Transport and Tourism

MSP: Maritime Spatial Planning

NEDO: New Energy and Industrial Technology Development Organization

NREL: National Renewable Energy Laboratory

OCCTO: Organization for Cross-regional Coordination of Transmission Operators

*Unless otherwise stated, all web-based material has been last accessed on February 28, 2024.

1 Policy overview of offshore wind power

1.1 Offshore wind power trends and targets

Offshore wind power holds great potential in increasing the world's share of renewable energy. According to ESMAP (2019)[1] and IEA (2019)[2] there are over 71,000 GW and 120,000 GW, respectively, of technically extractable offshore wind resources globally. IRENA and GWEC (2023)[3] points out that to remain on track to meet the 1.5°C target of the Paris Agreement, 500 GW of global offshore wind installations will be needed by 2030. This is around eightfold of cumulative offshore wind energy capacity installed globally in 2022, which amounted to 63.2 GW[4]. The installed capacity needed in 2050 will be almost forty-fold, or 2,465 GW.

In 2022, China accounted for almost half of total installed offshore wind capacity, which was almost equivalent to total installed capacity across Europe, where the UK had the largest share, followed by Germany and the Netherlands. Japan's installed capacity stood at 61MW in 2022. (Figure 1-1)

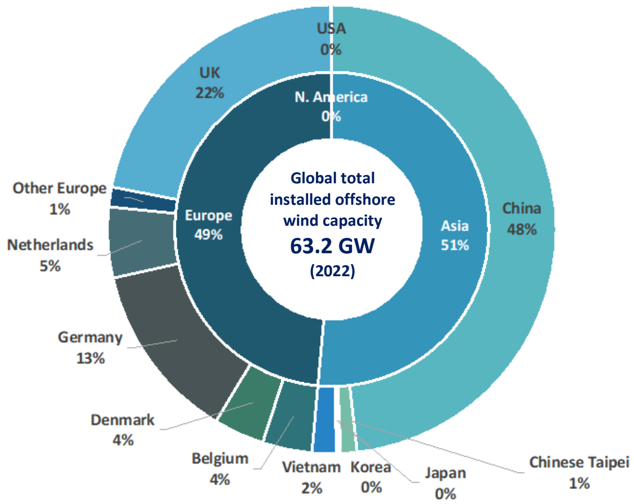

FIGURE 1-1 SHARE OF GLOBAL CUMULATIVE INSTALLED CAPACITY OF OFFSHORE WIND (2022)

Source: IRENA Renewable capacity statistics 2023

In June 2021, the Japanese government launched the Green Growth Strategy[5], in which it positioned offshore wind power as one of the fourteen key industrial fields where future growth is expected and set out the targets of introducing 10 GW of offshore wind power by 2030 and 30-45 GW, including floating offshore

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1 ESMAP (2021), *Energy Sector Management Assistance Program Annual Report 2021*, International Bank for Reconstruction and Development / The World Bank https://documents1.worldbank.org/curated/en/615511640189474271/pdf/Energy-Sector-Management-Assistance-Program-ESMAP-Annual-Report-2021.pdf

2 IEA (2019), *Offshore Wind Outlook 2019: World Energy Outlook Special Report,* https://iea.blob.core.windows.net/assets/495ab264-4ddf-4b68-b9c0-514295ff40a7/Offshore_Wind_Outlook_2019.pdf

3 IRENA and GWEC (2023), *Enabling frameworks for offshore wind scaleup: Innovations in permitting*, International Renewable Energy Agency, https://mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net/-/media/Files/IRENA/Agency/Publication/2023/Sep/IRENA_GWEC_Enabling_frameworks_offshore_wind_2023.pdf

4 IRENA (2023), *Renewable capacity statistics 2023,* https://mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net/-/media/Files/IRENA/Agency/Publication/2023/Mar/IRENA_RE_Capacity_Statistics_2023.pdf

5 Cabinet Secretariat, et al (2021), "Green Growth Strategy", https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/ggs_full_en1013.pdf

wind, by 2040, based on the first "Vision for the Offshore Wind Industry[6]." This will be achieved by to designating promotion zones accounting for approximately 1GW of offshore wind power every year for 10 consecutive years (See 1.2).

Japan's target is modest in comparison with both its Asian neighbors and other countries across the world (Table 1-1), considering the total area of its territorial seas and Exclusive Economic Zone (EEZ), which together is the sixth largest in the world (see Chapter 4). Japan has the technical potential of generating more than 9,000 TWh per year[7]. Given that its electric power demand in 2022 was around 870 TWh, Japan can produce ten times its demand with offshore wind power.

TABLE 1-1 COMPARISON OF GOVERNMENT TARGETS FOR OFFSHORE WIND POWER DEPLOYMENT

Region/country	Targets		Name of policy*4	Year announced
	Offshore wind	Floating offshore		
Japan	2030 10 GW 2040 30-45 GW		Green Growth Strategy	2021
Korea	2034: 20.1 GW*1		Fifth Basic Plan for New and Renewable Energy	2020
Taiwan	2040: 40-55 GW		2050 Net-Zero Emissions Roadmap	2022
Vietnam	2030: 6 GW 2050: 70-91.5 GW		Eighth National Power Development Plan (PDP8)	2023
European Union	2030: 111 GW*2 2050: 317 GW		Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Delivering on the EU Offshore Renewable Energy Ambitions	2023
Denmark	2030: 14 GW 2050: 35 GW		Wind Pledges - European Wind Power Action THE DECLARATION OF ENERGY MINISTERS on The North Sea as a Green Power Plant of Europe	2023 2022
Germany	2030: 30 GW 2035: 40 GW 2045: 70 GW		Wind Energy at Sea Act (WindSeeG)	2022
Netherlands	2031: 21 GW 2040: 50 GW 2050: 70 GW		Wind Pledges - European Wind Power Action	2023
United Kingdom	2030: 50GW	2030: 5GW	British Energy Security Strategy	2022
Ireland	2030: 7GW 2040: 15-20GW 2050: 37GW	2030: 2GW*3	Offshore Energy Programme	2023
Norway	2040 30GW		Government press release	2022
United States	2030: 30GW	2035: 15GW	Government press releases	2021, 2022

Source: compiled by authors based on various sources

Notes:
*1: Calculated based on target for wind power and target share for offshore wind power.
*2: Target for offshore renewable energy and includes ocean energy.
*3: Offshore renewables dedicated to green hydrogen production.
*4: Sources for each policy are as follows:
Korea： MOTIE (December 29, 2020, press release), "Fifth Basic Plan for New and Renewable Energy", https://www.motie.go.kr/kor/article/ATCL3f49a5a8c/163676/
Taiwan： Climate Change Administration (2022), "Phased Goals and Actions Toward Net-Zero Transition", https://www.english-climatetalks.tw/_files/ugd/5e0d7e_5813cf454e2f48ba88b6b5823c8ac60e.pdf
Vietnam： Government of Vietnam (2023), "National Electricity Development Plan For 2021-2030 (Eight National Power Development Plan", https://thuvienphapluat.vn/van-ban/Thuong-mai/Quyet-dinh-500-QD-TTg-2023-Quy-hoach-phat-trien-dien-luc-quoc-gia-2021-2030-tam-nhin-2050-566461.aspx

[6] Public-Private Council on Enhancement of Industrial Competitiveness for Offshore Wind Power Generation (2020), "Vision for Offshore Wind Industry", https://www.enecho.meti.go.jp/category/saving_and_new/saiene/yojo_furyoku/dl/vision/vision_first_en.pdf

[7] IEA (2019), *op. cit.*

EU： European Commission (2023), “Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Delivering on The EU Offshore Renewable Energy Ambitions”,
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023DC0668&qid=1702455230867；
Denmark： European Commission (2023), “Wind Pledges - European Wind Power Action”,
https://energy.ec.europa.eu/document/download/ff9911eb-4f53-497b-a6a6-84a64feeea60_en;
“THE DECLARATION OF ENERGY MINISTERS on The North Sea as the Green Power Plant of Europe”(May 2022),
https://kefm.dk/Media/637884570050166016/Declaration%20of%20Energy%20Ministers%20(002).pdf
Germany： BMJ (German Federal Ministry of Justice) (2023), “Offshore Wind Energy Act (WindSeeG)”, https://www.gesetze-im-internet.de/windseeg/WindSeeG.pdf
The Netherlands： European Commission (2023), op. cit.
UK： GOV.UK (2022), “British Energy Security Strategy”, https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy
Ireland： Government of Ireland (2023), “Accelerating Ireland’s Offshore Energy Programme Policy Statement on the Framework for Phase Two Offshore Wind”, https://assets.gov.ie/249823/bbd8b13c-73cd-46d4-9902-533fbf03d7fe.pdf
Norway： Government.no (May 11, 2022, press release), “Ambitious offshore wind initiative,”
https://www.regjeringen.no/en/aktuelt/ambitious-offshore-wind-power-initiative/id2912297/
US： 2030 target: The White House (March 20, 2021, press release) “FACT SHEET: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs”, https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/； 2035 target for floating offshore wind： The White House (September 15, 2022, press release), “FACT SHEET: Biden-Harris Administration Announces New Actions to Expand U.S. Offshore Wind Energy”, https://www.whitehouse.gov/briefing-room/statements-releases/2022/09/15/fact-sheet-biden-harris-administration-announces-new-actions-to-expand-u-s-offshore-wind-energy/

1.2 Japan’s offshore wind power policy

In Japan, the “Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities (Marine Renewable Energy Act)[8]” was enacted in 2018 to ensure that developers can occupy sea areas for offshore wind power generation for a maximum of 30 years. The Act also establishes a framework for local coordination through councils with relevant stakeholders, including fishermen, vessel operators, and other parties who use the sea area.

The Marine Renewable Energy Act defines categories of suitable sites for offshore wind power generation according to their stage of progress made: “preparatory zones,” “promising zones,” and “promotion zones.”[9] Preparation zones are designated based on the local willingness to commercialize offshore wind power projects. These areas are promoted to “promising zones” if they meet certain requirements provided in the Guidelines for Designation of Promotional Areas, such as the possibility of establishing a council which meets with the prefectural government and local officials to discuss the implementation of offshore wind power generation. If agreement is reached, the area is designated as a “promotion zone” for which public tenders are held. Tenders are designed so that bidders can receive a maximum of 240 points divided evenly between the proposed supply price (120 points) and the strength of the proposed business feasibility plan (120 points).

So far, two rounds have been held to select developers for promotion zones. In May 2021, the developer for the sea area off the coast of Goto City, Nagasaki Prefecture was chosen. Then in December 2021, the results were announced for the first tender for projects totaling 1.67 GW in three promotion zones in Akita and Chiba prefectures. As consortiums led by one developer swept the board, the rules were revised for Round 2, which selected developers for 3 additional promotion zones in Akita, Niigata and Nagasaki prefectures. The new rules give a higher evaluation score to operators that submit earlier start-up dates and set a 1 GW-limit on the bids that one consortium can win in one auction.

[8] Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities (Act No. 89 of 2018), https://www.japaneselawtranslation.go.jp/en/laws/view/3580
[9] As of October 2023, 10 promotions zones, 9 promising zones, and 8 preparatory zones have been designated.

The Green Growth Strategy aims to bring fixed-bottom offshore wind prices to 8-9 JPY/KWh in 2030-2035. As presented in Table 1-2, the supply price of fixed-bottom offshore wind power is already declining below this level[10].

TABLE 1-2 AUCTION RESULTS OF ROUND 1 & 2

Round	Area	Winning bidder consortium members	Output (MW)	Price (JPY/kWh)	Commencement year	Supply price points	Feasibility points
1	Offshore Noshiro City, Mitane Town, Oga City, Akita Prefecture	Mitsubishi Energy Solutions, Mitsubishi Corporation, CTech	480	13.26	Dec 2028	120	88
	Offshore Yuri-honjo City, Akita Prefecture	Mitsubishi Energy Solutions, Mitsubishi Corporation, Venti Japan, CTech	820	11.99	Dec 2030	120	82
	Offshore Choshi City, Chiba Prefecture	Mitsubishi Energy Solutions, Mitsubishi Corporation, CTech	390	16.49	Sep 2028	120	91
2	Offshore Oga City, Katagami City, and Akita City, Akita Prefecture	JERA, J-Power, Itochu, Tohoku Electric Power	315	3	Jun 2028	120	120
	Offshore Murakami City and Tainai City, Niigata Prefecture	Mitsui & Co., RWE Offshore Wind Japan	684	3	Jun 2029	120	120
	Offshore Enoshima, Saikai City, Nagasaki Prefecture	Sumitomo Corporation, TEPCO Renewable Power	420	22.18	Aug 2029	120	101

Source: compiled by authors based on METI (January 2024)[11]

In addition, the Ministry of Economy, Trade and Industry (METI) and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) have established a "centralized approach" in which the government and local governments are involved from the initial stages of project formation to conduct surveys more quickly and efficiently. Under the centralized approach, the Japan Organization for Metals and Energy Security (JOGMEC) conducts surveys on wind conditions and seabed characteristics for the basic design of offshore wind power generation. Stakeholder consent is required for studies to be conducted under this approach.

Furthermore, up to 85 billion yen will be spent for Phase 2 of the Green Innovation Fund to conduct demonstrations of the integrated use of elemental technologies in floating offshore wind power systems. Four areas have been selected for these demonstrations.

[10] However, it should be noted that the actual supply price will be determined under a Power Purchase Agreement (PPA).

[11] ANRE (January 2024), "About Wind Power" (Document 1 delivered at the 92th meeting of the Procurement Price Calculation Committee (January 16, 2024)), https://www.meti.go.jp/shingikai/santeii/pdf/092_01_00.pdf

1.3 Floating offshore wind power development

Conventional fixed-bottom offshore wind turbines that are secured to the sea floor are limited to water depths up to 50-60 meters. However, 80 percent of the world's offshore wind power potential lies in waters deeper than 60 m[12], where floating foundation technologies are required. The UK and other European countries have led floating offshore development to date (Figure 1-2).

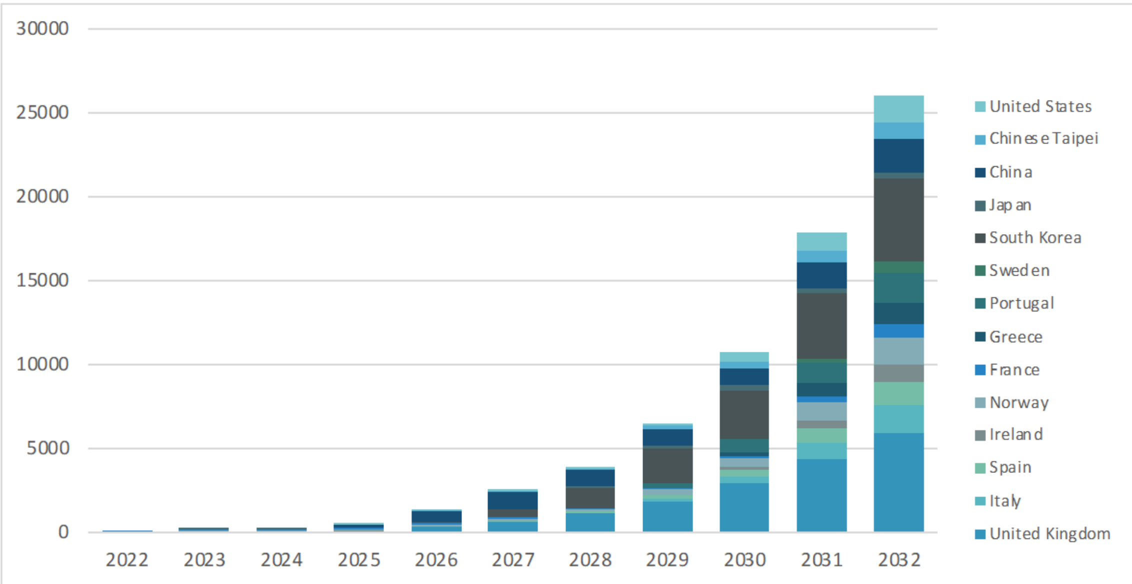

FIGURE 1-2 CUMULATIVE FLOATING OFFSHORE WIND POWER INSTALLATIONS OUTLOOK

Source: compiled by authors based on GWEC (2023), p.107

Note: Figures for 2023 and beyond are based on expected new floating wind installations.

Japan's technical offshore wind power potential is located in deep waters even in areas within 10 km of its coastline[13]; and therefore, floating platform technologies will be required in order to harness most of its potential. While it is urgent for Japan to develop these technologies and bring costs down, the government target for offshore wind power does not include an explicit figure for floating offshore wind. While four candidate demonstration areas have been chosen under Phase 2 of the Green Innovation Fund, each area will only accommodate 10-90 MW, which amounts to less than 6 turbines[14].

A bill to amend the Marine Renewable Energy Act so that the sea area for offshore wind power development can be extended to the Exclusive Economic Zone (EEZ)[15] is expected to be submitted to the Diet and the government has announce a call for public comments at the time of writing[16]. The amendment, based on

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[12] GWEC (2023), *Global Offshore Wind Report*, https://gwec.net/wp-content/uploads/2023/08/GWEC-Global-Offshore-Wind-Report-2023.pdf

[13] Hiroshi Nagai, Tatsuya Ikegaya, Masaharu Itoh, Toru Nakao (2010), "Offshore Wind Power Potentials in Japanese Coastal Waters," *Journal of JWEA* Vol.34, No.1, https://www.jstage.jst.go.jp/article/jwea/34/1/34_103/_pdf

[14] METI (October 3, 2023, press release), "Designation of Promotion Areas under the Renewable Energy Sea Area Utilization Law, Areas Subject to Central Approach Studies and Candidate Areas for GI Fund (Floating Offshore Wind Demonstration)," https://www.meti.go.jp/press/2023/10/20231003002/20231003002.html

[15] An Exclusive Economic Zone (EEZ) is an area of the ocean, generally extending beyond a nation's territorial seas to no more than 200 nautical miles (around 370 km) from the coast of a state, within which a coastal nation has jurisdiction over both living and nonliving resources. (See Chapter 4)

[16] Public comments will be received via the government portal site from February 9 through 22, 2024.

discussions at the joint government committee meeting in January 2024[17], will introduce a two-step procedure for selecting offshore wind power projects in the EEZ, similar to those implemented in the U.K., U.S., and Australia.

Under the proposed scheme, potential project developers can select a project site in the larger "feasible sea area" designated by the government with consideration of fisheries and defense radars and apply with a draft zone map and draft plan for the installation of wind turbines and related facilities. Based on survey results and stakeholder coordination, the developer will submit the adjusted project plan and map to the government for evaluation. Permits will be issued to developers that meet the evaluation criteria. (Figure 1-3)

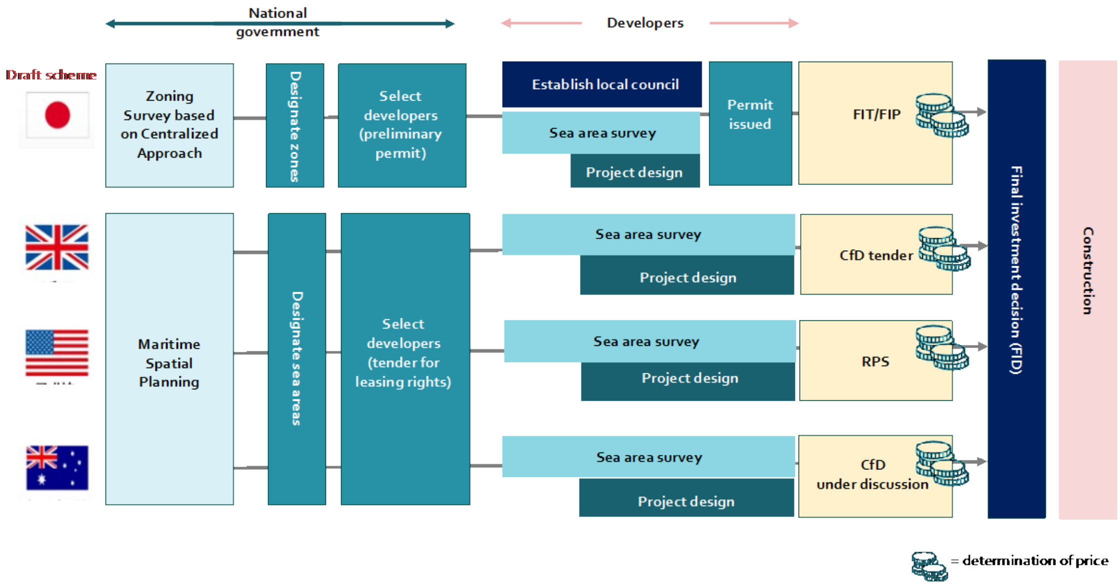

FIGURE 1-3 TWO-STEP PROCEDURE FOR PROJECT SELECTION IN THE EEZ

Source: adapted by authors based on material from 22nd Joint meeting of the Working Group on Promoting Offshore Wind Power Generation

Some European countries, including the U.K., Norway, Germany, the Netherlands, Denmark and Germany, already have offshore wind power projects in their EEZs in operation or in the pipeline.

In the U.S., where two-thirds of the offshore wind potential exists in waters unsuitable fixed-bottom wind turbine foundations, the Floating Offshore Wind Energy Shot seeks to reduce the cost of floating offshore wind energy in deep waters by more than 70% to $45 per megawatt-hour by 2035.[18]

In Asia, China has several fixed-bottom offshore wind power projects under construction in its EEZ. Korea also has a number of projects planned in its EEZ, many of which are floating offshore wind power projects. In April 2023, the Ulsan Floating Offshore Wind Association was launched with a membership comprising the Ulsan Chamber of Commerce and Industry (UCCI) and five floating offshore wind power consortiums to build an offshore wind power ecosystem in Ulsan[19]. Taiwan is amending its Renewable Energy Development Act to

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[17] 22nd Joint meeting of the Working Group on Promoting Offshore Wind Power Generation (Subcommittee on Mass Introduction of Renewable Energy and Next-Generation Electricity Networks, Committee on Energy Efficiency and Renewable Energy, Advisory Committee for Natural Resources and Energy, METI) and the Subcommittee for Promoting Offshore Wind Power Generation (Environment Committee, Harbor Committee, Transport Policies Council, MLIT) (January 26, 2024) https://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/yojo_furyoku/022.html

[18] U.S. DOE website, "Floating Offshore Wind ShotTM: Unlocking the Power of Floating Offshore Wind Energy," https://www.energy.gov/sites/default/files/2022-09/floating-offshore-wind-shot-fact-sheet.pdf

[19] Korea Floating Wind (April 5, 2023, press release), "Ulsan Floating Offshore Wind Association officially launched with KF Wind," https://koreafloatingwind.kr/ulsan-floating-offshore-wind-association-officially-launched-with-kf-wind-3333

allow the construction of wind farms beyond its territorial seas[20].

[20] Bureau of Energy, Ministry of Economic Affairs (July 12, 2023), "The Draft Amendment to Renewable Energy Development Act Passes Third Legislative Reading, Adding Regulations on "Solar Panel Installation on Buildings" and the "Chapter for Geothermal Energy", https://www.moea.gov.tw/MNS/english/news/News.aspx?kind=6&menu_id=176&news_id=110545

2 Technical barriers to massive offshore wind deployment

Japan has limited land area, with vast mountain coverage, which limits the installation of wind farms on land, but offshore wind power is a promising technology for large-scale deployment in Japan as it is surrounded by ocean. In particular, Japan's territorial waters and exclusive economic zones (EEZ) together have the sixth largest area in the world, and studies have shown that if the EEZ is included, Japan's offshore wind power potential could reach 500-900 GW[21][22]. Yet, even in waters within 10 km of the coastline, much of Japan's territorial sea is deeper than 50-60 m[23], exceeding the depth suitable for bottom-fixed offshore wind turbines. The EEZ is even deeper; and therefore, floating offshore wind technology is needed. This technology involves keeping a floating foundation in position using a mooring system.

Floating offshore wind power generation has already entered the commercialization stage in Europe and other countries. However, compared to onshore wind power and bottom-fixed offshore wind power, there are fewer examples of its installation; and therefore, there are not only technological challenges but also engineering and cost issues pertaining to the relevant infrastructure and installation.

A floating wind farm comprises wind turbines, floating platforms, mooring cables/anchors, electric power cables, substations, and other components. This section summarizes the challenges and promising solutions for major components.

2.1 Technological challenges of floating offshore wind power

2.1.1 Floating foundations and wind turbines

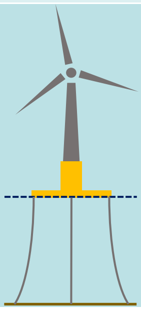
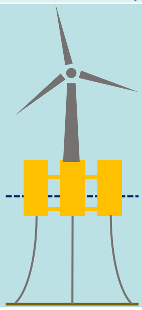
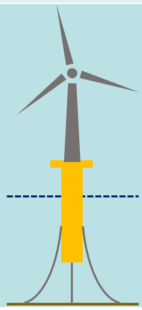
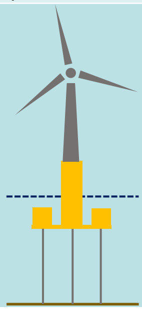
For floating offshore wind power, the current mainstream structure consists of a horizontal axis wind turbine mounted on a floating foundation. Although floating wind turbines need to be designed to take wave and surge motion into account, horizontal-axis wind turbines are often applied because they are widely used in both onshore and fixed-bottom offshore wind power generation systems. There are four main types of floating foundations technologies: barge, semi-submersible, spar, and tension leg platform (TLP). Table 2-1 provides an overview of the features, advantages, and disadvantages of each type of floating foundation.

[21] Renewable Energy Institute (2023), "[Analysis Report] Japan's Offshore Wind Power Potential: Territorial Sea and Exclusive Economic Zone", https://www.renewable-ei.org/en/activities/reports/20231219.php

[22] EX Research Institute, Asia Air Survey (2020), "Report on the Commissioned Work for the Development and Publication of Basic Zoning Information on Renewable Energy in Fiscal Year 2019", Ministry of the Environment, https://www.renewable-energy-potential.env.go.jp/RenewableEnergy/report/r01.html

[23] Nagai et al (2010), *op. cit.*

Table 2-1 Comparison of mainstream floating foundations

	Barge	Semi-submersible	Spar	TLP
Features	Mainly a flat-bottomed pontoon with a wind turbine. Usually anchored to the seafloor with catenary mooring lines. The large surface area in contact with the water provides stability.	An improved version of the barge type. The floating foundation is submerged to a given draught.	A cylinder most of the weight is placed at the lowest possible point to provide stability. .	A type of mooring in which a tension mooring line connects a forced semi-submerged buoyant body to the seabed and uses the tension force generated by the forced buoyancy to moor the vessel.
Advantages	Suitable for mass production.	Many suitable locations.	Simple design and thus easy to manufacture.	Compact installation and thus limited seafloor area needed for mooring.
Disadvantages	Large turbulence	Complex structure	Difficult to install in shallow waters. Larger turbines will require longer cylinders, posing challenges for manufacturing, transport and installation. Deep draught will make maintenance challenging.	High costs for mooring, etc.
Applicable waters	Relatively susceptible to waves, it is suitable for installation in calm waters.	With the majority of the floating structure submerged in water, less susceptible to waves, and thus suitable for offshore installation.	Less susceptible to waves due to small penetration area in water surface, and thus applicable in offshore areas with severe wave and surge conditions	Not suitable for soft seafloors.
Applicable depths	50-100m	50-100m	Over 100m	Over 100m
Projects (Japan)	Off the coast of Kitakyushu City (Fukuoka)[24]	Fukushima Floating Offshore Wind Farm Demonstration Project (Fukushima)	Sakiyama 2MW Floating Offshore Wind Turbine (Goto City, Nagasaki)	Low-Cost Technology Verification Project for TLP-type Floating Offshore Wind Power Generation
Projects (overseas)	EolMed (France)	Valorous (UK) EFGL (France)	Hywind Tampen, (Norway), Hywind Scotland (Scotland)	Provence Grand Large (France)
Domestic developers		Hitachi Zosen, Japan Marine United, Tokyo Gas	Toda Corporation, TEPCO RP	Mitsui Ocean Development Co.
Concept diagram				

Source : compiled by authors based on NEDO(2018)[25], Zhao (2021)[26], and other corporate sources as indicated

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24 NEDO (May 24, 2019, press release), "NEDO Holds Opening Ceremony in Kitakyushu City to Commemorate Start of Demonstration Operations for Floating Offshore Wind Power Generation System", https://www.nedo.go.jp/english/news/whatsnew_00142.html

25 NEDO (2018), *Floating offshore wind power technology guidebook*, https://www.nedo.go.jp/library/fuuryoku_guidebook.html

26 Jian Zhao (2021), "Commercialization of floating offshore wind power speeds up in Europe: expectations are also high in Japan, which aspires to deploy up to 45 GW of offshore wind power by 2040" (Mitsui & Co. Global Strategic Studies Institute Monthly Report), https://www.mitsui.com/mgssi/en/report/detail/__icsFiles/afieldfile/2021/08/18/2107t_zhao_e.pdf

Notes:
*1 Corporate sources are as follows:
Off the cost of Kitakyushu： NEDO (May 24, 2019, press release), “NEDO Holds Opening Ceremony in Kitakyushu City to Commemorate Start of Demonstration Operations for Floating Offshore Wind Power Generation System”, https://www.nedo.go.jp/english/news/whatsnew_00142.html
Fukushima Offshore Wind Farm： Fukushima Offshore Wind Consortium website, http://www.fukushima-forward.jp/english/index.html)
Sakiyama 2MW Floating Offshore Wind Turbine: Toda Corporation website, "Sakiyama 2MW Floating Offshore Wind Turbine," https://www.toda.co.jp/business/ecology/special/pdf/sakiyama2mw_e.pdf
Low cost technology verification project: Mitsui Ocean Development, Inc. (January 21, 2022, press release), “Adoption of the Low-Cost Technology Verification Project for TLP-type Floating Offshore Wind Power Generation”, https://www.modec.com/jp/news/2022/20220121_pr_TLP_OffshoreWindTurbines.html
*2 Corporate sources are as follow:
EolMed: EOLMED website, “EOLMED Floating wind energy in Western France”, https://eolmed.qair.energy/en/
Valorous: Blue Gem Wind website,“Valorous: An early commercial project in the Celtic Sea”, https://www.bluegemwind.com/our-projects/valorous/
EFGL: EFGLwebsite, “The PPI Float” https://info-efgl.fr/le-projet/le-flotteur-ppi-eiffage/
Hywind Tampen: Equinorwebsite, “Hywind Tampen”, https://www.equinor.com/energy/hywind-tampen
Hywind Scotland: Equinor website, “Hywind Scotland”, https://www.equinor.com/energy/hywind-scotland
Provence Grand Large: Prysmian Group (n.d.) “Provence Grand Large”, *Insight*, https://www.prysmiangroup.com/en/insight/projects/provence-grand-large

The development of floating offshore wind power has been actively promoted in the United Kingdom and other countries. It is necessary to determine the most appropriate type of floating foundation, taking into account the water depth, seabed features, environmental conditions, social conditions such as fisheries, and the frequency of earthquakes and tsunamis of each ocean area.

In 2021, the top five wind turbine suppliers in the world, including both onshore and offshore wind power, were Vestas (Norway, 17.7%), Goldwind (China, 11.8%), Siemens Gamesa (Spain, 9.7%), Envision (China, 8.6%), and GE Renewable Energy (U.S., 8.5%), collectively accounting for over half of the global market.[27] Thus, due in part to the limited number of manufacturers that can supply wind turbines, offshore wind construction often involves different suppliers for wind turbines and floating foundations. For example, at the Hywind Scotland floating offshore wind farm off the coast of Scotland which began commercial operation in 2017 as the world's first floating offshore wind farm, the main operator is Equinor (then Statoil), with Siemens Gamesa supplying the wind turbines, the foundation, Aibel supporting the engineering and procurement of the foundations, towers, and mooring systems, and Navantia-Windar manufacturing the floating foundation.[28]

Currently, there are no large-scale wind turbine manufacturers in Japan and therefore, Japan needs to rely on foreign manufacturers for wind turbines in developing offshore wind power. While international competition may make it difficult to develop a domestic wind turbine industry in the future, as the world’s third largest shipbuilder, Japan has a strong foundation in shipbuilding technology and excellent quality control[29], and can thus strategically foster domestic companies that specialize in this field to lead both domestic and overseas markets. However, it should be noted that competition in the floating foundation market is also expected to intensify in the future, as new technologies are being developed outside of Japan;

[27] GWEC (2022), “Global Wind Development Market Supply Side Data 2021”, https://gwec.net/wind-turbine-suppliers-see-record-year-for-deliveries-despite-supply-chain-and-market-pressures/

[28] JETRO Research Department, London Office (June 2023), “Study on Offshore Wind Supply Chain Trends in the UK - Part 1: General Discussion: Supply Chain”, https://www.jetro.go.jp/ext_images/_Reports/01/80a7a99f692a5876/20230010_02.pdf

[29] Public-Private Council for Enhancing the Industrial Competitiveness of Offshore Wind and NEDO (April 1, 2021), "Technology Development Roadmap for Enhancing the Industrial Competitiveness of Offshore Wind", https://www.enecho.meti.go.jp/category/saving_and_new/saiene/yojo_furyoku/dl/roadmap/roadmap20210401.pdf (accessed in January 2024)

for example, Gazelle Wind Power[30] is developing floating structures with a dynamic mooring system that responds to waves so that the platform can move horizontally and vertically to minimize tilting.

2.1.2 Mooring systems

Steel anchor chains are currently often used for offshore mooring systems. However, in Japan's surrounding waters and EEZ, the water is deeper, thus increasing the weight of mooring cables. This makes their manufacturing and transportation challenging. This issue is being addressed by considering the possibility of using synthetic fiber cables[31]. Synthetic fiber cables are lightweight and can be reeled, reducing the size of offshore wind vessels and the space required for cargo handling. Synthetic fibers have different physical properties, including water resistance, elongation, and strength, depending on the material used; and therefore, it is necessary to select the material in accordance with the conditions of use. Japanese manufacturers already have experience supplying synthetic fibers for mooring cables for floating offshore wind in the U.K.[32]. Furthermore, in Japan, a hybrid mooring system using both steel chains and synthetic fiber ropes is being tested off the coast of Akita.[33]

Floating offshore wind turbines also have significant mooring costs on the seafloor in deep water. Therefore, not only developing materials but also the new mooring system is being considered. Several studies have concluded that the introduction of a shared mooring system, in which mooring ropes and anchors are shared among multiple wind turbines, not only reduces the number of components required, but also saves installation costs, thus leading to reduced mooring costs[34],[35]. Equinor's Hywind Tampen project adopts a shared anchor system using 19 anchors for the mooring of 11 wind turbines, demonstrating a significant reduction compared to Hywind Scotland, which follows a conventional design that uses 15 anchors for 5 wind turbines.

2.1.3 Transmission lines

Floating offshore wind farms tend to be located further offshore than fixed-bottom systems, and the longer distance poses a challenge in terms of power transmission. In the case of 230 kV alternating current (AC) cables, the transmission distance will be limited to 30-50 km due to the large transmission loss caused by the distance. With direct current (DC) cables, there is less loss over long distances and cables can be made thinner than in the case of AC cables. However, the substations will need to be larger, thus increasing the associated costs.

Major technical challenges in floating offshore wind power transmission cables are installing them at large depths and handling turbulence. Based on experience with conventional submarine power cables, installation at depths of up to around 300 m is feasible. Currently, cables that can be laid in deep waters of 1500 m below water level are under development for floating offshore wind power systems in waters with greater water

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[30] Gazelle Wind Power website, https://gazellewindpower.com/what-we-do/technology/ (accessed in January 2024)

[31] Toshiki Nakajo (2021), "Designing Mooring Systems with Synthetic Fiber Cables for Floating Offshore Wind Power", (Institute of Maritime, Port and Aeronautical Technology, Research Presentation) https://www.mpat.go.jp/pdf/202112_2.pdf ,

[32] Wind Journal (March 6, 2023), " World's first! Synthetic fiber cables are used for TLP type floating offshore wind power generation. Reduce costs by reducing weight", https://windjournal.jp/115617/#

[33] Japan Marine United (August 30, 2022, press release) “Scale Model Testing for Hybrid Mooring for the GI Fund Project "Development of Technology and Construction Technologies for Semi-Submersible Floating and Hybrid Mooring Systems,” https://www.jmuc.co.jp/news/assets/windfarm_scalemodel_20220830.pdf

[34] Hang Xu et al (2024), “Shared mooring systems for offshore floating wind farms: A review,” Energy Reviews Volume 3, Issue 1, March 2024, https://www.sciencedirect.com/science/article/pii/S2772970223000500

[35] NREL (2022), “Shared Mooring Systems for Deep-Water Floating Wind Farms: Final Report” prepared for National Offshore Wind Research and Development Consortium, https://nationaloffshorewind.org/wp-content/uploads/142869_Final-Report.pdf

depth[36] along with dynamic cables that can withstand dynamic motion caused by waves and tidal currents[37]. Efforts are also being made to improve the manufacturability and cost and facilitate the installation of submarine power cables[38].

A Japanese company[39] leads the world in submarine DC cable manufacturing by developing unique materials; and therefore, Japan promises to have an advantage in this area.

2.1.4 Emerging technologies

New types of wind power generation are being developed in order to find solutions to various technological obstacles. Many of these new approaches are being made by startups. In onshore wind, Challenergy (Japan) is developing a “Magnus Vertical Axis Wind Turbine (VAWT)”[40] that can actively respond to changes in wind speed and direction and utilizes the "Magnus effect[41]" generated from the rotation of a cylinder instead of a propeller. Vortex Bladeless (Spain)[42] has developed and commercialized a bladeless wind turbine that harnesses vortex-induced vibration[43].

In the field of offshore wind power, startups such as World Wide Wind (Norway)[44] and Albatross Technology Inc. (Japan)[45] are developing vertical-axis floating offshore wind turbines. Both models feature simple structures that do not require dedicated vessels for installation and thus facilitate offshore installation.

World Wide Wind’s Counter-Rotating Vertical Axis Turbine (CRVT) has an upper and lower turbine vertically set up that counterrotate, thus increasing the power generated. Furthermore, the lower wake turbulence reduces the impact on other wind turbines located downstream; and therefore, the distance between turbines can be reduced.

The wind turbine blades of Albatross Technology’s floating axis wind turbine (FAWT) can be manufactured in lengthwise sections with the same cross-sectional shape, which enables mass production using an automated continuous manufacturing process. Additionally, this design eliminates the need for large-scale manufacturing factories and facilitates transport. Therefore, it is suitable for production and transport in Japan, where limited land and accessible roads make it difficult to secure manufacturing yards and transport. Albatross Technology has signed a joint research agreement with J-Power, TEPCO, Chubu Electric Power, and Kawasaki Kisen Kaisha in May 2023, and the Development Bank of Japan (DBJ) invested in the project in

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[36] Ryosuke Kuwahara et al. (2022), " Technological Trends, Development Tasks and Initiatives for Submarine Power Cable Systems: Contribution to the Achievement of SDGs", *Furukawa Electric Jiho* No. 141, April 2022, https://www.furukawa.co.jp/rd/review/fj141/fj141_08.pdf

[37] Ryota Taninoki et al. (2017), “Dynamic Cable System for Floating Offshore Wind Power Generation,” *SEI Technical Review*, No. 190, January 2017, https://sei.co.jp/technology/tr/bn190/pdf/190-09.pdf

[38] Yukito Ida, et al. (2022),"Characteristics of Water Tree in Submarine Cable (Wet-Design) for Offshore Wind Power Generation" *Sumitomo Electric Technical Review* No. 200, January 2022, https://sumitomoelectric.com/jp/sites/japan/files/2022-01/download_documents/J200-07.pdf

[39] Sumitomo Electric Industries, Ltd. website, "DC Submarine Cable." https://sumitomoelectric.com/jp/products/submarine-cable

[40] Challenergy website, https://challenergy.com/en/

[41] The “Magnus effect” is a physical phenomenon in which rotating an object exerts a force perpendicular to the wind direction

[42] Vortex Bladeless website, https://vortexbladeless.com/

[43] “Vortex-induced vibration” is a phenomenon caused by the vibration of cylinders exposed to wind. When the natural frequency of the cylinder and the frequency of the air vortex generated by the wind hitting the cylinder match, resonance is caused and the amplitude increases.

[44] World Wide Wind website, https://worldwidewind.no/pages/technology

[45] Albatross Technology, Inc. website: https://www.albatross-technology.com/

December 2023, acknowledging the cost reductions expected from eliminating the need for large vessels and domestic procurement of blade materials[46].

These technologies are yet to be fully developed[47] and a variety of issues must be resolved through pilot demonstrations before they can be scaled up and commercialized. Yet, there are examples of emerging companies entering the market; Hexicon, a company specializing in offshore wind power founded in 2009 was awarded a project at TwinHub (U.K) that will use its "TwinWind" technology which mounts two wind turbines on one floating foundation[48]. It will be important to take prompt actions to welcome new technologies with a spirit of trial and error and to develop a policy instrument to help support them.

2.2 Developing industrial strategies

As indicated in 2.1.1, the development of floating offshore wind power has significantly more components, including floating foundations and mooring cables, and thus involves a vast number of stakeholders compared to onshore and fixed-bottom offshore wind. There are many Japanese companies related to these components. Related industries common with onshore wind and fixed-bottom offshore wind includes carbon fiber reinforced plastic (CFRP) manufacturers for turbine blades, generator manufacturers, and the iron and steel industry for steel towers. For floating structures, Japan can exert its strength in the following industries: the shipbuilding and construction industries; for mooring cables, the steel industry and chemical industry, including manufacturers of synthetic fibers; for submarine cables, the electric wire manufacturing industry; and for assembly and installation, the shipbuilding, construction, and marine civil engineering industries.

Although Japan currently has no large-scale wind turbine manufacturers, there is potential for floating offshore wind power-oriented industrial development led by other industries. Furthermore, as indicated in 2.1.4., startups are developing technologies based on new concepts. The Netherlands, Spain, and Taiwan also have no wind turbine manufacturers, but are nevertheless developing strategies to seize global market share while domestically promoting their offshore wind power through developing base ports for offshore wind power and fostering and promoting peripheral industries[49]. This may serve as a reference for promoting floating offshore wind power in Japan.

The Japanese government, in its Working Group of Experts for the Realization of GX[50], has also stated its intention to “to ensure predictability for operators and promote domestic and foreign investment by setting up targets specifically for floating offshore wind power.” A concrete industrial strategy focused on floating offshore wind power is called for.

2.3 Conclusions

Given Japan’s limited land space and large EEZ, floating offshore wind power is a promising renewable energy source. Many floating offshore wind power technologies are still in the development stage compared

46 DBJ (December 6, 2023, press release), “Investment in Albatross Technology, Inc.-Supporting the development of ‘floating axis wind turbines,’ a new option for floating offshore wind turbines”, https://www.dbj.jp/topics/dbj_news/2023/html/20231206_204574.html

47 These floating offshore wind turbines are small-scale, and some concepts use aluminum instead of steel for the towers and wood for the floating structures. Aluminum is easier to recycle than steel, despite possible issues regarding the strength of the material. Using domestic wood could contribute to building a domestic supply (see Chapter 3).

48 Searade Maritime News (July 8, 2022), "Hexicon wins 15-year package for Celtic Sea floating wind project," https://www.setrade-maritime.com/offshore/hexicon-wins-15-year-package-celtic-sea-floating-wind-project

49 Tetsuro Nagata (2019), “Strategies for Countries without Wind Turbine Manufacturers,” Research Project on Renewable Energy Economics No. 139 (August 1, 2019), Graduate School of Economics, Kyoto University, https://www.econ.kyoto-u.ac.jp/renewable_energy/stage2/contents/column0139.html

50 Cabinet Secretariat GX Office (2023), “Investment Strategies by Field (5)” material delivered at the Fifth Meeting of the Expert Working Group for the Realization of GX (December 7, 2023), https://www.cas.go.jp/jp/seisaku/gx_jikkou_kaigi/senmonka_wg/index.html

to those of bottom-fixed offshore wind power. Japan bears the potential to take the lead in building a supply chain for floating offshore wind power by tapping on the technologies that it excels in, such as shipbuilding and submarine cable technology. However, it needs to grasp the momentum.

While demonstration projects are necessary to establish the technology, the floating offshore wind power demonstration projects currently considered, including the Green Innovation Fund Phase 2 (floating offshore wind pilots)[51] are too small in scale to attract foreign wind turbine manufacturers, who are developing projects over 300-500MW[52]. In order to advance floating offshore wind power in Japan, it is essential to offer foreign wind turbine manufacturers a clear picture that Japan has a huge and promising market. Therefore, in addition to technology demonstrations, real full-scale projects should be launched based on established technology. In fact, with announcements of GW-scale projects overseas, floating offshore wind power is shifting from the technology-push phase to the market-pull phase. In parallel with development of real large-scale projects led by foreign wind turbine manufacturers, it is important, based on the experiences gained and lessons learnt through the development, to foster the domestic related industry to establish domestic production and supply chain, which will be addressed in the next chapter.

[51] METI (October 3, 2023, press release), *op. cit.*

[52] Based on interviews with domestic offshore wind power stakeholders. Regardless of the project scale, the manpower and costs required for the front-end engineering and design (FEED) are not so different; and therefore, smaller projects are less cost efficient and are less attractive.

3 Supply chain challenges and solutions

3.1 Security issues

The invasion of Ukraine by Russia has renewed awareness of the importance of energy and economic security. China currently accounts for more than half of the global wind turbine production[53]. Chinese-manufactured wind turbines can be more attractive when cost is prioritized. However, excessive dependence on a particular country for products raises concerns about risks to stable supply in the event of supply chain disruption.

There are other security challenges. While the operation and maintenance (O&M) of solar power systems can be conducted by parties other than the panel manufacturer, wind farms often depend on wind turbine manufacturers for maintenance and other services[54]. When wind turbines are supplied by a certain manufacturer or when their maintenance services are provided by a particular company, they will risk suspension of the remote monitoring system, and consequently massive power outages[55]. Furthermore, if they are controlled remotely by a foreign wind turbine manufacturer, they will risk suspension that will be difficult to recover in the event of war or other contingencies. The risk level will be particularly high in the case of large-scale offshore wind farms; and therefore, careful consideration is called for when relying on foreign manufacturers for the O&M of wind farms. In addition, the installation of wind turbines by a foreign manufacturer would also offer them the opportunity to survey the seafloor of Japan's waters, which could lead to defense-related issues.

While economics is an important factor in deploying offshore wind power, the energy and economic security perspective must not be forgotten in light of the issues discussed above. While it is currently difficult to build a supply chain consisting entirely of domestically produced goods, the ratio of domestically produced goods should be increased as much as possible to address the security challenge. The U.S. has placed restrictions on Chinese solar PV imports and the tax incentives of the Inflation Reduction Act (IRA) are designed to promote internal production[56]. With a target to achieve a 60% domestic procurement ratio by 2040[57], the Japanese offshore wind power industry is currently building the foundations and nacelles for fixed-bottom offshore wind power, as well as the vessels needed for construction and O&M[58]. The Japanese government is also aiming to establish a domestic manufacturing supply chain through the GX Supply Chain Establishment Support Project[59].

It is also important to develop and secure the human resources essential for domestic manufacturing. The Japanese government is also providing support for the creation of curricula and the development of training

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[53] GWEC (2022), *op. cit.*

[54] Kunihiko Toda and Shoko Takaragawa (2021), "Offshore Wind Power Projects in Japan - Points to Consider in Light of Differences with Europe", *Sompo Japan RM Report* 221, November 22, 2021, https://image.sompo-rc.co.jp/reports/r221.pdf

[55] For example, in Europe, major wind turbine makers Enercon and Nordex, as well as Deutsche Windtechnik AG, a company specializing in the maintenance of wind turbines have experienced cyber-attacks.（WSJ Pro (April 25, 2022), "European Wind-Energy Sector Hit in Wave of Hacks", https://www.wsj.com/articles/european-wind-energy-sector-hit-in-wave-of-hacks-11650879000）

[56] JETRO (April 3, 2023), "Import Restrictions on Chinese Products Create Headwind for Tight U.S. PV Supply and Demand (Part 2)," *JETRO Area Report*, https://www.jetro.go.jp/biz/areareports/2023/f21b8789fbc9baa0.html (accessed in January 2024)

[57] Public-Private Council on Enhancement of Industrial Competitiveness for Offshore Wind Power Generation (2020) *op. cit.*

[58] ANRE (September 8, 2023), "Next-Generation Technologies Related to Renewable Energy," Document 1 delivered at the 54th meeting of the Subcommittee on Mass Introduction of Renewable Energy and Next-Generation Electricity Networks, Committee on Energy Efficiency and Renewable Energy/Subcommittee of Electricity and Gas Industry, Advisory Committee for Natural Resources and Energy, METI, https://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/pdf/054_01_00.pdf)

[59] METI (September 4, 2023), "GX Support Measures Expenses" (List of presentation materials for METI FY2024 budget request), https://www.meti.go.jp/main/yosangaisan/fy2024/pr/gx/keisan_gx_01.pdf,"

facilities for training engineers and specialized workers for the offshore wind power industry[60]. Given that engineers are currently concentrated in fixed-bottom type, human resource development for the floating offshore wind power type is also called for in the future. Such human resource development projects will also contribute to reskilling workers from existing industries that may decline in the path towards decarbonization.

Thus, it is commendable that individual support for the establishment of a domestic manufacturing supply chain is being promoted in Japan. On the other hand, even if domestic production costs more than overseas production, it is important for the Japanese government to consider the benefits that the promotion of domestic offshore wind power-related industries will bring to the Japanese economy. Enhancing the domestic supply chain will not only create jobs and contribute to economic growth but reduce the impact of global supply constraints that may occur due to increased global demand. In this regard, it is important that the Japanese government formulate a detailed industrial strategy, addressing offshore wind power as an important pillar of its economic and industrial policy, in addition to achieving cost reductions in offshore wind power as part of its energy policy.

3.2 Materials and recycling

Recycling and reuse of decommissioned materials and components is also an important factor in increasing the share of domestic production and strengthening the domestic supply chain. For some time now, concerns have been raised regarding the mass disposal of solar and wind power generation, and the need for recycling and reuse has been pointed out in light of properly disposing industrial waste[61,62]. A supply chain with enhanced domestic recycling and reuse can contribute not only to the development of a circular economy and the enhancement of sustainability through the reduction of industrial waste load, but also to security. In particular, preventing the outflow of critical minerals and key materials, including rare earths, will contribute to a stable supply. In the following subsections, we will discuss the current status, challenges, and future prospects of recycling and reuse technologies for key components of wind power generation.

3.2.1 Turbine blades

Glass fiber reinforced plastics (GFRP) have conventionally been used for turbine blades, but as blades become larger in size, stiff carbon fiber reinforced plastics (CFRP) have become mainstream in order to avoid the risk of blade damage from collisions with the tower due to wind-induced blade deflection[63]. CFRP is widely used in aircrafts, automobiles, industrial equipment, and daily necessities. While it is mostly treated as industrial waste after used and sent to landfills, there are efforts to recycle CFRP in Japan [64],[65],[66]. There are a variety of CFRP recycling methods, but most involve removing CFRP resin by pyrolysis or chemical decomposition, from which only carbon fiber is recovered. It is difficult to reuse CFRP for its original application because CFRP is cut into smaller pieces in an earlier process and cannot be restored to its original length, and because the mechanical properties of recycled CFRP can be more diversified than that of unused materials.

60 ANRE (September 8, 2023), *op. cit.*

61 MRI (2015), "Report on the Commissioned Work for the FY 2014 Pilot Study on the Promotion of Recycling Used Renewable Energy Facilities" (FY2014 project Commissioned by the Ministry of the Environment) https://www.env.go.jp/content/900535821.pdf

62 ANRE (July 24, 2018), "Massive waste solar panels in 2040? Renewable waste issues", https://www.enecho.meti.go.jp/about/special/johoteikyo/taiyoukouhaiki.html

63 Note that CFRP is used for turbine blade girders, but GFRP is also used for blade surfaces.

64 Toru Kamo (2018), "Current Status and Challenges of Recycling Carbon Fiber Reinforced Plastics (CFRP)" *Journal of the Japan Society of Material Cycles and Waste Management*, Vol. 29, No. 2, pp. 133- 141, https://www.jstage.jst.go.jp/article/mcwmr/29/2/29_133 /_pdf

65 International Aircraft Development Fund (2018), "Reuse Technology for Recycled Carbon Fiber", Aircraft International Development Fund [Explanatory Overview 2022-4], http://www.iadf.or.jp/document/pdf/2022-4.pdf)

66 Toray website, "Recycling", https://www.cf-composites.toray/ja/aboutus/sustainability/recycling.html)

Therefore, at present, recycled CFRP is mostly used for concrete reinforcement or in injection molded or press-molded products.

Outside of Japan, there are a number of initiatives dedicated to the recycling of wind turbine blades as a measure to address waste from the future replacement of components of the rapidly expanding wind turbine fleet[67]. For example, GE Renewable Energy has partnered with Veolia North America to utilize recycled blades for cement production[68]. Vestas has also established a method to chemically break down epoxy resin, a substance that was believed to be impossible to reuse, into virgin-grade materials, thus opening a path to “blade-to-blade” recycling[69]. In Denmark, the wind power industry and recycling companies have jointly established the DecomBlades[70] to reuse wind turbine blades that have been decommissioned after reaching the end of their operational life.

Although "blade to blade" recycling is currently difficult for some materials, advancements have been seen in various efforts, including technology development: and therefore, future trends in the recycling field needs to be closely followed.

3.2.2 Towers

Since towers are made of steel, they can be fed into electric furnaces as scrap after use to manufacture new products, but it is said that the problem of impurities in the tower paint and other materials makes it difficult to transform them into products that meet the quality standards required for offshore wind towers. On the other hand, in recent years, there have been efforts[71],[72] to produce high-grade steel in electric furnaces, and if quality can be ensured through future technological development, there is a possibility that the steel could be reused for offshore wind towers. If this happens, an intra-regional circulation of steel will be formed with offshore wind power bases at the core, contributing to a stable supply of materials and strengthening security.

3.2.3 Rare metals

Neodymium magnets are often used as permanent magnets in wind power generators. The production of neodymium, a rare metal, and neodymium magnets is highly dependent on China. The Ministry of Economy, Trade and Industry's "Policy on Initiatives to Secure a Stable Supplies of Permanent Magnets"[73] states the need to strengthen neodymium magnet manufacturing facilities and recycling facilities in Japan. The policy sets the goal of securing production capacity to meet domestic demand expected in 2030 for manufacturing and doubling the recycling capacity from 2020 levels in 2030. In addition, Japan aims to develop neodymium magnet alternatives and neodymium magnets that can halve the amount of neodymium used within the next five years.

Various rare metal recovery technologies are under development in Japan, I'MSEP has developed a selective recovery process for recovering rare earth metals from neodymium magnets by molten salt electrolysis, thus

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[67] Wind Europe (February 12, 2020), “Circular Economy: Blade recycling is a top priority for the wind industry” https://windeurope.org/newsroom/news/blade-recycling-a-top-priority-for-the-wind-industry

[68] GE (December 8, 2020, press release), “GE Renewable Energy Announces US Blade Recycling Contract with Veolia,” https://www.ge.com/news/press-releases/ge-renewable-energy-announces-us-blade-recycling-contract-with-veolia)

[69] Vestas (February 8, 2023, press release), “Vestas unveils circularity solution to end landfill for turbine blades,” https://www.vestas.com/en/media/company-news/2023/vestas-unveils-circularity-solution-to-end-landfill-for-c3710818

[70] DecomBlades website, https://decomblades.dk/

[71] Denki Shimbun (October 4, 2019), “Carbon-free steel manufacturing with technological innovations in electric furnaces” https://www.denkishimbun.com/sp/45183

[72] Japan Metal Bulletin (May 30, 2022), “JFE Metal to produce high-quality metal in electric furnace: capital investment in Sendai for mass production” https://www.japanmetal.com/news-t20220530118316.html

[73] METI (January 19, 2023), “Policy on initiatives to secure stable supplies of permanent magnets” https://www.meti.go.jp/policy/economy/economic_security/magnet/magnet_hoshin.pdf

avoiding the conventional high-temperature pretreatment at more than 1000°C and the large consumption of acid and alkali[74]. CMC Technology Development also possesses technologies for the recovery, separation, and refinement of neodymium and dysprosium from neodymium magnet scrap[75]. Furthermore, awarded an international demonstration project funded by NEDO, Suzuki Shokai seeks to use AI technologies to classify used motors based on image analysis, recover rare metals such as neodymium, and recycle them to a reusable grade in Thailand[76].

3.2.4 Challenges in recycling and reusing wind turbines

As mentioned above, technological development is underway to recycle wind turbine components, but at present “turbine to turbine” recycling is difficult. However, future technological development may increase the possibility of reusing wind turbine components. Furthermore, even if "turbine to turbine" recycling is difficult, recycling turbines for other applications will contribute to security from a macro perspective. In particular, floating offshore wind turbines involve more components, including floating foundations and mooring lines, than onshore wind turbines or bottom-fixed offshore wind turbines, and thus more materials; therefore, and it is important to pursue the possibility of recycling each element with a view to the future large-scale introduction of floating offshore wind turbines.

Institutional considerations for the promotion of recycling may include the introduction of environmentally friendly design based on recyclability and the inclusion of recycling efforts as an evaluation point in the criteria for selecting of offshore wind power project operators. Furthermore, from a recycling perspective, it may also be necessary to change the structure of floating offshore wind power facilities. If we aim to establish a domestic flow of manufacturing, use, disposal, transportation, and recycling, the unique solution for Japan may be to pursue mass production and recyclability by downsizing and introducing sub-assembly manufacturing (see 2.1.4), rather than following the global trend of building larger wind turbines.

It is also important to address recycling as an opportunity not only to enhance economic security but also to contribute to Japanese industry and economy. To this end, specific strategies should be developed for industrial promotion policies that promote not only the arterial industry, but also the venous industry based on recycling. For example, for neodymium magnets, used generators and motors are currently exported and recycled in Thailand for economic efficiency, but a strategy to develop domestic industry by establishing a system to domestically circulate these materials is also required.

3.3 Infrastructure-related challenges

Floating platforms are key to developing floating offshore wind power. Western oil majors can utilize the offshore platform-related technology and know-how acquired in drilling oil and natural gas fields offshore to date in the development of floating offshore wind and substations. New floating offshore wind platforms are also being developed[77]. Although Japan lacks offshore platform-related technologies, it possesses shipbuilding and engineering technologies that can serve as the basis of platform technologies, and it is important to build on these strengths to these to quickly enhance its technological capabilities in this field.

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[74] I’MSEP website “Recycling rare metal, rare earths” http://www.imsep.co.jp/recycle_rare_earth_element/

[75] CMC Technology Development Co., Ltd. website, http://www.cmctd.co.jp

[76] Japan Metal Daily (November 6, 2023), “Suzuki Shokai, Hokkaido’s major metal recycling business initiates development of neodymium recycling technologies: Awarding of NEDO funds to establish a rational manufacturing process harnessing AI technologies,” https://news.yahoo.co.jp/articles/88e2fbaea06964a5064d1a0e91c5f2689accf4a0 (accessed January 2024)

[77] For example, Gazelle Wind Power (aforementioned) and Tugdock, a developer of road-transportable floating dry docks, have signed a Memorandum of Understanding to jointly develop a modular offshore wind assembly system, that is expected to dramatically drive down costs and increase production of floating offshore wind farms .(Gazelle Wind Power (December 21, 2023 press release), “Gazelle Wind Power And Tugdock Work Together to Reduce Cost of Floating Offshore Wind Platform”, https:// gazellewindpower.com/2023/12/gazelle-wind-power-and-tugdock-work-together-to-reduce-cost-of-floating-offshore-wind-platform

Using foreign Self Elevating Platform (SEP) vessels for floating offshore wind power construction will involve supply-demand balance issues. Growing global demand will make it difficult to stably secure SEP vessels; and therefore, it is essential to promote domestic production. It is significant that Shimizu Corporation and Japan Marine United have manufactured one of the world's largest SEP vessels[78].

As for offshore wind power base ports, the Port of Esbiau in Denmark is well known as a base port for offshore wind power generation in the Baltic Sea. The Port of Esbiau has attracted industries in the construction, operation, and maintenance of offshore wind power, creating approximately 8,000 jobs and thus contributing to regional revitalization[79]. In Scotland, a government-commissioned study identified five ports as potential offshore wind base ports based on factors including location and cost and designated the Port of Inverness and Cromarty Firth[80] as a Green Freeport[81] which focuses on floating offshore wind farms[82].

NREL also focused on the importance of domestic supply chain that can supply 4–6 GW of projects per year to achieve its target to deploy 30GW of offshore wind power in 2030. It concluded that half of the U.S. offshore wind energy projects in the pipeline are at risk of being delayed beyond 2030 because of limited port and vessel infrastructure.[83]

Plans are underway across Japan to develop Carbon Neutral Ports (CNP) to decarbonize ports and adjacent areas through receiving imported low-carbon hydrogen and ammonia. On the other hand, no specific infrastructure plans related to offshore wind power have been announced at potential CNPs located within "promotion zones" under the Marine Renewable Energy Act, even if they have been designated base ports under the revised Port and Harbor Law. It has also been announced that future decisions on the designation of new base ports will be based on the status of offshore wind power project development, maximizing the use of already designated base ports and responding to increased needs for the designation of base ports. However, port development is said to require five years; and therefore, late decisions may delay the development of offshore wind power projects. It is worthwhile to specifically consider the efficiency of building new energy and industrial infrastructure by linking CNP development plans with offshore wind base port development plans. This point is discussed in Chapter 5.

3.4 Operation and maintenance

Operation and maintenance (O&M) costs are said to account for 30- 40% of the total cost of the entire fixed-bottom offshore wind supply chain[84]. Naturally, the reduction of O&M costs is called for, but at the same time, if domestic operators can assume O&M, it will contribute to the development of the domestic industry. As indicated in 3.1, the Japanese government is providing support for the training of skilled personnel specializing in the construction and maintenance of offshore wind power facilities. For example, in one of its subsidized projects, NYK Line has been implementing educational programs for specialized workers and developing training facilities in order to strengthen the operational scheme and human resource development for crew

[78] Shimizu Corporation (October 6, 2022, press release) "Shimizu's "BLUE WIND", World's Largest Class SEP Vessel Completes — She Will be Used in March 2023 Following Various Tests and Training for Engineers and Crew —," https://www.shimz.co.jp/en/company/about/news-release/2022/2022046.html

[79] Public-Private Council on Enhancement of Industrial Competitiveness for Offshore Wind Power Generation (2020), *op. cit.*

[80] Inverness and Cromarty Firth Green Freeport website, https://greenfreeport.scot/about/

[81] A Green Freeport is a large special economic zone with the key policy objectives of job creation, promoting decarbonization and a just transition to a net zero economy, establishing hubs for global trade and investment, and fostering an innovative environment. Companies that locate there will benefit from tax and other incentives. Two ports have been designated as of January 2024.

[82] Ironside Farrar (2021), "Port Enhancements for Offshore Wind: An Assessment of Current and Future Marshalling and Assembly Capacity in Scottish ports", Scottish Enterprise, Highlands & Islands Enterprise, Crown Estate Scotland, https://www.evaluationsonline.org.uk/evaluations/Documents.do?action=download&id=987&ui=basic (accessed in January 2024)

[83] NREL (2023), *A Supply Chain Road Map for Offshore Wind Energy in the United States,* https://www.nrel.gov/docs/fy23osti/84710.pdf

[84] Toshiki Nakajo (2021), *op. cit.*

transport vessels (CTV) that carry maintenance workers ¥ to and from the sites[85]. A number of other private companies are also engaged in offshore wind power O&M services[86],[87],[88].

From the viewpoint of contributing to the local economy, local fishermen can also be employed to transport offshore wind project personnel to offshore sites[89]. Furthermore, a CTV order was made to a domestic shipbuilder with the intention of activating the domestic shipbuilding and related industries in relation with the offshore wind industry[90].

3.5 Conclusions

The supply chain for floating offshore wind, includes study and design, port development, manufacturing wind turbines, floating foundations and other equipment, shipping equipment and components, assembly and installation of turbines and transmission lines (submarine cables), operation and maintenance, and decommissioning. Japan has no domestic manufacturing base for wind blades and lacks the experience in the offshore oil and gas operations that many North Sea countries possess. Yet, there are many Japanese companies with individual elemental technologies along the supply chain.

It is essential from an economic and energy security perspective that most of the supply chain be covered domestically, while improving and reducing the cost of current technologies, and at the same time exploring new technologies to solve challenges unique to Japan, such as land constraints related to manufacturing and transporting equipment. Stronger incentives should be provided for building factories and supply chains in Japan to encourage domestic manufacturing and procurement.

It is also important to enhance recycling and reuse efforts. Not all components of a floating offshore wind power turbine can be recycled or reused; and therefore, recycling and reuse will not solve all supply chain issues. However, it will help retain critical resources within Japan and reduce imports, thus contributing to enhancing economic and energy security. In addition to technological development, economic support measures, and regulations, it will be important to draw a picture in which venous industries, especially recycling, contributes to the promotion of domestic industry and the economy.

In order to promote the development of floating offshore wind power in Japan and to increase the involvement of domestic players, the Japanese floating offshore wind power market must be more attractive not only to foreign companies but also to domestic companies, as indicated in Chapter 2. This will require a clear demonstration by the government that it is committed to promoting floating offshore wind as a major pillar of its industrial development policy. The expansion of offshore wind power to the Exclusive Economic Zone (EEZ) is expected to demonstrate the large scale and attractiveness of the Japanese offshore wind power

85 ANRE (September 8, 2023), *op. cit.*

86 JFE Engineering Corporation website, “O&M (Operation and Maintenance) Services”, https://www.jfe-eng.co.jp/products/life/owp03.html

87 Nittetsu Engineering Corporation (January 18, 2023), “Establishment of O&M Service Implementation Scheme for Offshore Wind Power Facilities with Fukada Salvage Construction”, https://www.eng.nipponsteel.com/news/2023/20230118.html

88 Mitsubishi HC Capital Corporation and Horizon Ocean Management Corporation (September 8, 2023, press release), “Mitsubishi HC Capital and Horizon Ocean Management Agree on Business Alliance to Stabilize and Streamline O&M Operations in Domestic Offshore Wind Power Business”, https://www.mitsubishi-hc-capital.com/investors/library/pressrelease/pdf/2023090801.pdf

89 ANRE (2022) “Case Studies of Measures to Promote Regional and Fishery Development through Offshore Wind Power Generation,” Document 6 distributed at the 2nd meeting of the Council for Offshore Oga City, Katagami City, and Akita City, Akita Prefecture (held on May 10, 2022), https://www.enecho.meti.go.jp/category/saving_and_new/saiene/yojo_furyoku/dl/kyougi/akita_oga/02_docs06.pdf

90 NYK (February 20, 2024, press release), “First CTV for offshore wind power made to a domestic shipbuilder: contributing to the deployment of sustainable energy and activation of the shipbuilding industry”, https://prtimes.jp/main/html/rd/p/000000085.000120868.html

market. In the next chapter, we will summarize the challenges of floating offshore wind development in the EEZ and provide some policy recommendations.

4 Discussions on developing offshore wind power in the Exclusive Economic Zone

In order to achieve the target of introducing 30-45 GW of offshore wind power by 2040, Japan needs to accelerate the process of project approval and open up more sea areas for project development, given the lead time required for development. Given the limited sea area suitable for fixed-bottom offshore wind power in its territorial sea, Japan has started considering expanding offshore wind development into its Exclusive Economic Zone (EEZ), whose area is the sixth largest in the world.

Table 4-1 Area of territorial seas and Exclusive Economic Zones (EEZ)

	Territorial seas + EEZ (million km^2)	Percentage relative to total land area	Total land area (million km^2)
U.S.A.	7.62	80%	9.63
Australia	7.01	90%	7.69
Indonesia	5.41	290%	1.90
New Zealand	4.83	1790%	0.27
Canada	4.70	50%	9.98
Japan	4.47	1180%	0.38

Source: METI (2023) [91]

Offshore wind power in the EEZ will be less exposed to NIMBY (not-in-my-backyard) issues compared to other variable renewable energy, such as onshore wind and solar power, but may involve conflict with other sectors such as fisheries and national security and also require consideration of compliance with international law, as discussed below.

4.1 Compliance with international law

4.1.1 Right to produce electricity in the EEZ

Under the United Nations Convention on the Law of the Sea (UNCLOS) Article 56, paragraph 1(a), offshore wind power generation is included in “other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds.” The coastal State has sovereign rights over such activities. Coastal states also have the exclusive right to construct and to authorize and regulate the construction, operation and use of artificial islands and installations and structures for the purposes provided for in Article 56 and other economic purposes in the EEZs.[92] Therefore, the coastal State has exclusive rights over its wind farm, provided floating wind power generation facilities are defined to be “installations and structure” under Article 60.

UNCLOS does not expressly determine the legal status of a floating wind power generation facility. While fixed offshore wind are unarguably artificial installations, floating offshore wind, which sit on floating foundations that are moored or anchored to the seabed, can also be interpreted to be “ships” due to their mobility. Indeed, some countries such as Norway allow for the registration of floating devices other than

[91] METI (2023), “Next-generation technologies for renewable energy” (Document 1 delivered at the 57th meeting of the Subcommittee on Mass Introduction of Renewable Energy and Next-Generation Electricity Networks), https://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/pdf/057_01_00.pdf

[92] UNCLOS Article 60 (1) (a)-(b)

ships[93] and the registration of the research floating wind turbine "Unitech Zephyros" under the Norwegian Ordinary Ship Register (NOR) is the first example of such registration[94]. Japanese domestic law (Electric Business Act, Law No. 170, 1964) also defines floating offshore wind farms as "special vessels" regulated under the Ship Safety Law (Law No. 11, 1933). If wind power generation facilities are to be defined as ships, the flag state would have jurisdictional rights. When the coastal state is not the flag state, this could potentially pose a threat to national security.

4.1.2 Electricity transmission rights

Article 79 of UNCLOS confirms "the right of the coastal State to establish conditions for cables or pipelines entering its territory or territorial sea, or its jurisdiction over cables and pipelines constructed or used in connection with the exploration of its continental shelf or exploitation of its resources or the operations of artificial islands, installations and structures under its jurisdiction" (Article 79 (4)). Yet, "all States are entitled to lay submarine cables and pipelines on the continental shelf" (Article 79 (1)), which poses a challenge for the coastal State when transmission lines or pipeline operated by another state already exists in its EEZ. In such cases, the coastal State will need to "have due regard to cables or pipelines already in position" (Article 79 (5)).

Conflict may be avoided if the coastal State had a maritime spatial plan that reserves a sea area for resource exploitation by the coastal State or for environmental conservation purposes. Germany has formulated a maritime spatial plan that covers its EEZ[95], where most of its offshore wind farms are located. The plan, originally formulated in 2009 and revised in 2021, ensures the transport of power generated in the EEZ to suitable transition points on the boundary of the territorial sea. Cable corridors are allocated in the maritime spatial plan but if submarine cables for the transport of power generated in the EEZ cannot run parallel to existing structures, they can cross priority areas for shipping by the shortest route possible. Germany's maritime spatial plan recognizes that although a single cable bears very little potential for conflict, the planned expansion of offshore wind energy will lead to an increase in the number of power cables, triggering the need for regulation.

4.1.3 Establishing safety zones

UNCLOS provides that coastal States may establish safety zones that do not exceed a distance of 500 m around offshore installations to ensure the safety of users of the marine environment and of the installations. This is most relevant during the construction phase; and there seems to be agreement among countries on this.

Germany's Offshore Wind Energy Act (WindSEEG 2017)[96] provides for the setting up of safety zones around the facilities in the EEZ (Section 53). The safety zone established for Hywind Borkum Riffgrund 3, Germany's largest offshore wind power project, is unique as the distance of 500 m is measured from the outer boundary of the wind farm. Whether or not establishing safety zones measured from the outer boundary of a group of turbines, thereby closing the entire wind farm area to other vessels, is acceptable may be debated in the future.

Some other examples of safety zone practices in different countries are presented in Table 4-2. It should be noted that not all of the wind farms described are located in the EEZ.

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[93] Section 33 of the Maritime Code allows for the registration of floating devices other than ships in the Norwegian Ordinary Ship Register. (Peter Aall Simonsen & Sveinung Rostad (June 15, 2020), "What security options are available for lenders to offshore wind projects?", *Lexology*, https://www.lexology.com/commentary/energy-natural-resources/norway/advokatfirmaet-simonsen-vogt-wiig-as/what-security-options-are-available-for-lenders-to-offshore-wind-projects#Floating)

[94] Siren Skalstad Ellensen, Alexander Severence, Andreas Helle (March 28, 2023), "Security when financing offshore wind projects in Norway", *DLA Piper,* https://norway.dlapiper.com/en/news/security-when-financing-offshore-wind-projects-norway-0

[95] BSH (2009)

[96] Offshore Wind Energy Act (WindSEEG 2017), http://www.gesetze-im-internet.de/windseeg/#download=1

TABLE 4-2 EXAMPLES OF SAFETY ZONE PRACTICES IN SELECTED COUNTRIES

	Hywind	Dogger Bank A	Borssele	Borkum Riffgrund 3	Vineyard Wind
Country	Scotland, UK	UK	Netherlands	Germany	U.S.A
Foundation type	Floating	Fixed bottom	Fixed bottom & floating	Fixed bottom	Fixed bottom
Total capacity	30 MW	1.2 GW	1.5 GW	913 MW	800 MW
Nominal output per turbine	6 MW	13 MW	8-9.5 MW	11 MW	13 MW
Distance from shore	22 km	131 km	24 km	70km	15 km
Depth	95-120 m	18-63 m	16-38 m	28-34 m	37-49 m
Safety Zone	500 m of construction works both in the turbine deployment area and along the export cable route. [97]	Rolling 500 m safety zones established around each wind farm structure and/or their foundations during construction. 50m safety zones established around any wind farm structure which is either partially completed or constructed but not yet commissioned. 500m safety zones around all 'major maintenance' being undertaken around a wind farm structure, as denoted by the presence of a major maintenance vessel. [98]	50 m distance to turbine poles and 500 distance of transformation stations, 500m safety zone around windfarm area. Closed to shipping through the wind farms; vessels with a length of up to 45 m may pass solely through the corridor. [99]	500 m around the wind farms, measured from the outer boundary. Navigation on shipping routes that are of importance to international shipping will not be affected by the safety zone. [100]	500 m from the center point of installations, temporarily during construction [101]

Source: compiled by authors based on various sources

4.1.4 Consideration of fishery rights

UNCLOS recognizes the sovereign rights of coastal States for the purpose of exploring and exploiting, conserving and managing fishery resources. Therefore, wind farms constructed in the EEZ should not give rise to any conflict with fisheries of other countries unless there are bilateral agreements in place. However, coordination with domestic stakeholders is likely to be challenging. This will be further elaborated in section 4.3.

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[97] Statoil (2015), "Hywind Scotland Pilot Park Project Environmental Statement" https://marine.gov.scot/sites/default/files/hywind.pdf

[98] BEIS (May 24, 2022), "Safety Zone Application – Dogger Bank A Offshore Wind Farm Decision Letter", https://assets.publishing.service.gov.uk/media/62ac59008fa8f5356fade931/dogger-bank-a-safety-zone-application-decision-letter-24052022.pdfFo

[99] Noordzeeloket, "Code of conduct for safe passage through the Borssele Wind Farm Pass", https://www.noordzeeloket.nl

[100] BSH (2023), "Notices to Mariners: Official Maritime Publication", Volume 154, https://www2.bsh.de/daten/NFS/NfS2023/nfs-heft08-2023.pdf

[101] Coast Guard (2023), "Safety Zone; Vineyard Wind 1 Wind Farm Project Area, Outer Continental Shelf, Lease OCS-A 0501, Offshore Massachusetts, Atlantic Ocean" (Temporary final rule), https://www.federalregister.gov/documents/2023/06/30/2023-14073/safety-zone-vineyard-wind-1-wind-farm-project-area-outer-continental-shelf-lease-ocs-a-0501-offshore

4.2 Discussions in the Japanese government

In January 2023, the Cabinet Office compiled a report[102] by a group of experts focusing on six major aspects to be considered in relation to how they are defined under the United Nations Convention on the Law of the Sea (UNCLOS) and their consistency with domestic law, with a view to implementing offshore wind power generation in the EEZ. The main points of the report are summarized in Table 4-3.

TABLE 4-3 MAJOR CONCLUSIONS OF THE CABINET OFFICE WORKING GROUP

Item of consideration	Relevant UNCLOS articles *1	Relevant domestic laws	Conclusions
Legal status of offshore wind power facilities under international law	§56, §60, §91, §92	Ship Act; Electric Business Act	Given that the Ship Act (Law No. 46, 1906) does not define offshore wind power generation facilities as "ships," offshore wind power generation facilities installed in a given area for economic purposes should be considered to be "installations and structures" under UNCLOS.
Scope of sovereign rights and jurisdiction	§56, §60	Act on Exclusive Economic Zone and Continental Shelf	If the necessary procedures are stipulated under domestic law, a coastal State may permit, supervise, collect reports on, and conduct on-site inspections of exploration and development activities and occupancy of offshore wind farms during the construction, operation, and dismantling phases as part of exercising their sovereign rights and jurisdiction in the EEZ.
Setting safety zones	§60 (4)-(7)	Act on Establishment of Safety Zone Pertaining to Structures at Sea, etc.	A safety zone may be established around an offshore wind farm in the EEZ in accordance with the "Act on Establishment of Safety Zone Pertaining to Structures at Sea, etc." within an area not exceeding 500 meters from the outer edge of the offshore wind farm. Due notice shall be given on the extent of the safety zone
Reasonable consideration of the rights of other states: freedom of navigation and freedom to lay submarine electric cables and pipelines	§56, §58, §60, §79, §90	-	Freedom of navigation: it can be said that reasonable consideration has been given by notifying the location of the wind farm and extent of the safety zone when established, in addition to mapping the location on nautical charts. Freedom to lay submarine electric cables and pipelines: it would be appropriate to take measures such as keeping a certain distance between cables to prevent abrasion.
Environmental Impact Assessment	§1, §192, §194, §204, §205, §206	Electric Business Act; Environmental Impact Assessment Act	EIA should be implemented by taking the necessary domestic measures and applying domestic laws and regulation based on the "Law Concerning Exclusive Economic Zone and Continental Shelf", while taking into account discussions in the international community and national implementation by other countries. It should be noted that while the Electric Business Act holds the prefectural government responsible for EIA, there are no prefectural governments with jurisdiction over EEZs; and therefore, new regulations will need to be considered.
Requirement of prior notification and announcement to relevant countries	N.A.	N.A.	The government should appropriately determine whether or not prior notification is necessary as well as the scope of such notification, taking into consideration practices by other countries.

Source: Compiled by authors based on Cabinet Office (2023)

Notes:
*1 The subtitles of each article are as follows: Article 56: Rights, jurisdiction and duties of the coastal State in the exclusive economic zone; Article 1: Use of terms and scope; Article 58: Rights and duties of other States in the exclusive economic zone; Article 60: Artificial islands, installations and structures in the exclusive economic zone; Article 79: Submarine cables and pipelines

102 Cabinet Office, (2023), "Report of the Working Group on Issues Related to International Law Pertaining to the Implementation of Offshore Wind Power in the Exclusive Economic Zone", January 31, 2023, https://www8.cao.go.jp/ocean/policies/energy/pdf/torimatome.pdf

on the continental shelf; Article 90: Right of Navigation; Article 192: General obligation; Article 194: Measures to prevent, reduce and control pollution of the marine environment; Article 204: Monitoring of the risks or effects of pollution; Article 205: Publication of reports; Article 206: Assessment of potential effects of activities

The Ministry of the Environment has also started to study the environmental impact assessment system for wind power generation, including ensuring environmental considerations in EEZs, in the Central Environment Council.

4.3 Conflict with other sectors

4.3.1 Potential conflict with fisheries in Japan

In Japan, offshore fishing in the EEZ is conducted with permits and licenses from prefectural governors or from the Minister of Agriculture, Forestry and Fishery as described in Table 4-4. The Act on the Exercise of Sovereign Rights in Relation to Fishing, etc. in the Exclusive Economic Zone regulates fishing by foreign vessels in Japan's EEZ. Bilateral fisheries agreements with Korea and China allow these neighboring countries to enter Japan's EEZ for fishery purposes.

TABLE 4-4 FISHERY CATEGORIES IN JAPAN

	Coastal fisheries	Offshore fisheries	Distant water fisheries
Sea area	Coastal areas	Coastal areas to 200 nautical miles (25 approx. 370 km)	200 nautical miles to High Seas
Target species	Horse mackerel, mackerel, octopus, cuttlefish, shrimp, kelp, etc.	Mackerel, sardines, pacific saury, shrimp, crab, etc.	Tuna, bonito, cuttlefish, cod, etc.
Fishing methods	Diversity of local methods (Fixed net, small-scale bottom trawl fishing, drift net, gillnet, angling, etc.)	Offshore bottom trawl net, large to medium-sized drift net, nearshore single-line bonito fishing, etc.	Tuna longline fishing, trawl fishing, single-line bonito fishing, etc.
Duration	Mainly day trips	1 day – 1 month	50 days to 1 year
Characteristics	Accounts for more than 80% of fishermen in Japan	Use of 20～200 t vessels Accounts for more than half of nationwide catch.	20～30 ship crews
Licensing	Fishery right-based fisheries (Governor grants fishery cooperatives, individuals, or legal entities exclusive rights to conduct coastal fisheries or aquaculture)	Governor-licensed fisheries (Governor permits fisheries conducted in the offshore area off prefectural coasts)	Minister-licensed fisheries (Fishery conducted across several prefectures or in overseas waters)

Source: compiled by author based various sources

It is important to gain the understanding of different stakeholders when constructing wind farms in the EEZ or establishing safety zones around them. In Japan, the fisheries sector will be among the most important stakeholders, but target parties, often large private companies, that operate in the target area are difficult to identify compared to fishery rights-based fisheries. Furthermore, the stakeholders are not always based in the coastal area close to the target sea area, but can be distributed across Japan, thus often not sharing the interests or visions of local stakeholders.

While it is difficult to identify the location of operations in minister-licensed fisheries because of the vast area of operation, it is possible to acquire navigational data from fishing vessels because it is mandatory for them to be equipped with devices that can acquire navigational data and to keep these devices constantly in operation. On the other hand, operations for governor-licensed fisheries do not cover as vast an area but are difficult to locate as many fishing vessels are not equipped with the aforementioned equipment.

4.3.2 Conflict with security interests

Wind turbines may interfere with radars because their large towers and moving blades may reflect or obstruct electromagnetic waves. This could affect weather monitoring, forecasting and warning systems, military target tracking systems and aviation control. Therefore, careful consideration and consultation is called for when siting wind turbines. There are ongoing studies on how to mitigate such impacts.

In Japan, a large portion of its EEZ borders critical national security waters of South Korea and China, which may limit access for wind power operators.

4.3.3 Approaches taken in other countries

In all countries, national security or military use is a national interest that is prioritized over other uses, but countries take different approaches towards fisheries, as provided in Table 4-5.

TABLE 4-5 RULES FOR FISHERIES IN WIND FARM AREAS IN SELECTED COUNTRIES

	Scotland	UK	Netherlands	Germany	U.S.A.
Rules for fisheries	Existing fishing sites are safeguarded if possible. In the pre-commission phase and 20-year operational phase of the Project, fisheries are restricted from the 7.5 km^2 occupied by the turbines and their mooring system	Fishing is given priority.	Fishing has access to all areas, but national interest activities have priority.	Interference with fisheries shall be avoided as much as possible	Fishing is not restricted within windfarms.
Examples of major commercial fisheries	Turbine deployment area: Norway lobster, squid, scallop dredging (export cable corridor Export cable corridor: scallop dredging, crab and lobster (creels), mackerel (hand lining)	Various fisheries, with vessels registered in the UK, Denmark and the Netherlands accounting for 93% of surveillance sightings between 2002 and 2011[103].	Cutter fishing, shrimp fishing, gillnet fishing	Cod, flatfish, saithe, North Sea crab	Lobster, crab, black sea bass, etc.

Source: compiled by author based various sources

In the UK, the Dogger Bank Wind Farm, keeps mariners informed, providing weekly notices of operations and notices on their website[104]. While fishing is not restricted within wind farms in the UK, studies have found that fishing activity within offshore wind farm (OWF) boundaries has changed, primarily because fishermen are fearful of fishing gear becoming entrapped by seabed obstacles such as cables. However, fishing was found to co-exist with offshore wind farms by some fishermen who operated demersal trawl gear in cable-free corridors.[105] This kind of experience could be extended to other fishermen.

[103] Brown & May Marine (2014), "Environmental Statement Chapter 15 Appendix A Commercial Fisheries Technical Report" https://doggerbank.com/wp-content/uploads/2021/11/ES-Chapter-15-Appendix-A-Commercial-Fisheries-Technical-Report_Part1.pdf

[104] Dogger Bank Wind Farm website "Mariners and fisheries" https://doggerbank.com/mariners-fisheries/

[105] Gray, M., Stromberg, PL., Rodmell, D., (2016),"Changes to fishing practices around the UK as a result of the development of offshore windfarms – Phase I (Revised)" Crown Estate, https://www.thecrownestate.co.uk/media/2600/final-published-ow-fishing-revised-aug-2016-clean.pdf

Information on fisheries is not included on the spatial development strategy map of the Netherlands' "North Sea Programme 2022-2027"[106], as in principle, fisheries have access to all areas of the Dutch part of the North Sea, except where there are restrictive measures, such as safety zones, in place. The Dutch maritime spatial plan seeks to explore co-use of the limited sea area. It notes that the space available for certain fishing methods like trawl fishing will continue to decrease as a result of the expansion of nature conservation areas and wind farms. The transition to sustainable fishing practices, including a shift to aquaculture and passive fishing, is also listed as a national interest. Yet, there is limited space available for passive fishing activities in a wind farm zone; and therefore, spaces are allocated through registration.

Salerno et al (2019)[107] points out that while experiences in countries like the U.K. and the Netherlands have proven that fishing with fixed gear, such as pots, within offshore wind farms do not pose significant challenges and commercial fishing has thus successfully continued, it can be difficult to use the European experience to predict the effects that offshore wind farms may have on other fisheries. This is due to variations in fish species and fishing methods (as presented in Table 4-5), as well as the size and geographic expanse of fishing vessels.

Wind turbine arrays can be arranged to accommodate different fisheries, but this could compromise the cost efficiency of a wind farm. An example is the decision made by the U.S. Bureau of Ocean Energy Management (BOEM) in 2021 to permit Vineyard Wind – a grid layout of 62 turbines spaces at 1-nautical mile (nm) intervals. The original plan had 0.9-nm intervals, but commercial fishermen had advocated the inclusion of 4-nm-wide vessel transit lanes to ensure safe navigation and to enable the use of certain types of fishing gear[108]. BOEM pointed out that vessel transit lanes would increase congestion and reduce the economic benefits of the windfarm. The project remains exposed to four lawsuits arguing that the BOEM failed to adequately evaluate the project's potential impact of local fishermen and marine mammals[109].

The variation of fish species and fishing methods, differences in diets and the economic dependence on fisheries, among other factors make it difficult for countries to take a common approach to fisheries. Therefore, countries need to find solutions tailored to their circumstances. It is also crucial to explore ways to co-use the limited maritime space with wide stakeholder participation, as discussed in the following subsections.

4.4 Maritime Spatial Planning

Maritime Spatial Planning (MSP) is a public process of allocating the use of marine areas, balancing demands for development with the need to protect the environment. It brings together multiple users of the ocean to make informed and coordinated decisions about how to rationally use marine resources in an efficient, safe, and sustainable way.

Some countries have been engaged in maritime spatial planning for more than a decade. The UK[110] and Scotland[111] provide frameworks for formulating Marine Plans that extend to the EEZ and taking decisions affecting the marine environment that support multiuse of marine space, including commercial fisheries. In Europe, the EU Directive for maritime spatial planning (2014/89/EU) obliges all EU coastal states to establish maritime spatial planning plans by 2021. The maritime spatial plans of Germany and the Netherlands extend

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[106] Government of the Netherlands (2022), North Sea Programme 2022-2027, https://www.noordzeeloket.nl/publish/pages/201299/north-sea-programme-2022-2027.pdf

[107] Jennifer Salerno, A. Krieger, M. Smead, L. Veas (2019), Supporting National Environmental Policy Act Documentation for Offshore Wind Energy Development Related to Navigation, Washington (DC): U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2019-011, 89p, https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Renewable-Energy/BOEM-2019-011.pdf

[108] National Fisherman (May 18, 2021), "Vineyard Wind decision shows questions remain of economic, environmental impact," https://www.nationalfisherman.com/northeast/vineyard-wind-decision-shows-questions-remain-of-economic-environmental-impact

[109] Kaitlyn Vu (2023), "Turbines in Trouble: The Controversy Behind Vineyard Wind & Offshore Wind in Massachusetts", *Harvard Political Review*, https://harvardpolitics.com/turbines-in-trouble/

[110] UK Parliament (2011), The UK Marine Policy Statement

[111] Scottish Government (2015), Scotland's National Marine Plan (Edinburgh)

to the EEZ. With many projects in the EEZ already in the pipeline, these examples provide good reference for Japan.

4.4.1 UK

The Marine and Coastal Access Act 2009 (Parliament of the United Kingdom, 2009) introduces spatial planning for the British marine area, which includes the territorial seas and offshore area adjacent to the UK, the area of sea designated as the UK EEZ the continental shelf. The Fishery Limits Act (Parliament of the United Kingdom, 1976) identifies fishing areas currently extending to 200 nm from the baseline.

UK has also established a Renewable Energy Zone (REZ) under the Energy Act 2004 beyond the limits of the UK territorial sea, in which the UK can exercise rights over the production of energy from water or winds. The REZ is similar in function and extent to an EEZ. UK criminal and civil law are also applicable to the REZ, where the UK Government issues licenses to wind farm developers, etc.

4.4.2 Germany

Germany formulated the Spatial Plan for the German Exclusive Economic Zone in the North Sea and Baltic Sea in 2009 (and last amended it in 2021). Its legal basis is the Federal Spatiall Planning Act (ROG), which was extended to the EEZ in 2004 (and last amended in 2017). The new plan coordinates the various uses in the EEZ, comprising shipping, offshore wind energy, cables, pipelines, raw material extraction, fisheries, research and defense. It reserves areas for individual uses, thus helping to minimize conflicts.

The areas and sites designated In the 2021 Maritime Spatial Plan as priority and reservation areas for offshore wind energy are said to be able to accommodate a total of 43 GW of offshore wind turbines, sufficiently covering the target of reaching 40 GW in 2035.[112] As of December 2021, Germany had 27 wind farms in the EEZ in operation, under construction or in preparation, collectively amounting to a total capacity of totaling around 8.87GW. Twenty of these wind farms are located in a priority zone designated in its maritime spatial plan. In the designated priority areas for wind energy, the extraction of wind energy is given priority over all other spatially uses. The interests of fishing and defense are to be taken into account in the planning, with co-use as a possibility for a better balance of interests.

4.4.3 Netherlands

The Netherlands adopted its first Maritime Spatial Plan, the North Sea Policy Document in 2009. The North Sea Programme 2022-2027[113] is the Netherlands' third maritime spatial plan, covering the Netherlands' territorial sea and EEZ. Seeking to achieve the right social balance in the spatial development of the North Sea, program describes the policy for strengthening the ecosystem, the transition to sustainable food supply, the transition to sustainable energy provision, maritime transport, and a sustainable blue economy. The North Sea Programme 2022-2027 describes newly designated offshore wind farm zones and "search areas" to be considered for wind energy beyond 2030, collectively amounting to 34 GW.

4.5 Public participation in marine policy development

In many European countries, it is becoming common practice to develop policies based on wide public participation to obtain public understanding through open discussion and maritime spatial planning is not an exception. The marine spatial plans mentioned above are outcomes of participatory processes. Many overseas

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[112] BSH (2023) "Maritime spatial-relevant developments in the German Exclusive Economic Zone in the North Sea and the Baltic Sea: Annual Report 2021"
https://www.bsh.de/EN/TOPICS/Offshore/Maritime_spatial_planning/_Anlagen/Downloads/Jahresbericht_AWZ_2021_EN.pdf

[113] Government of the Netherlands (2022), *op. cit.*

participatory processes engaging a wider range of stakeholders have successfully resulted in policies based on wide consensus.

In Japan, after the government designates a "promising zone," a council is established for consultation among relevant parties and facilitation of local coordination. This is not as extensive a process as many practices in Europe. The following subsections offer an overview of participatory processes supporting maritime spatial planning in selected European countries and some insight in the lessons learned in the context of decision-making in marine spatial planning in Japan.

4.5.1 UK

In the UK, a Marine Plan is formulated following a 12-step process with stakeholder engagement during each step (Figure 4-1).

FIGURE 4-1 MARINE PLANNING PROCESS IN THE UK

Source: adapted by authors based on GOV.UK website[114]

A Statement of Public Participation (SPP) is required for each marine plan area under the Marine and Coastal Access Act 2009. It helps ensure that the marine planning process is transparent, and that stakeholders understand how they can be involved and can influence a marine plan's development. All draft SPPs are subject to public consultation before they are submitted to the Secretary of State for approval to publish, after which the marine planning process is formally commenced in the relevant marine plan area. Different channels, such as meetings, bespoke workshops, consultation events, stakeholder events, digital tools (social media, webinar, websites, videos and animations, blogs, etc.) and direct access (consultations, email, newsletters, questionnaires, etc.). The stakeholders engaged include not only different interest groups but also bordering nations and administrations, coastal partnerships, delivery partners, local communities, the general public, government departments, industry representative groups, local and other public authorities, and non-governmental organizations.

4.5.2 Germany

Germany's Maritime Spatial Plan 2021 came into force after an extensive revision process pursuant to Section 9 Paragraph 1 of the Federal Spatial Planning Act (ROG). In the initial stage, public authorities were given the opportunity to provide information on any plans and measures they intended to take in the EEZ or

[114] Marine Management Organization (June 11, 2014), "Guidance: Marine planning and development", https://www.gov.uk/guidance/marine-plans-development#agree-how-and-when-interested-people-will-be-involved

had already taken, as well as on the time schedule for their implementation. Then, following various thematic workshops and expert discussions conducted by BSH (German Federal Maritime and Hydrographic Agency) on shipping, nature conservation, fisheries, underwater cultural heritage, defense and raw material extraction, national and international consultations were held. (Figure 4-2)

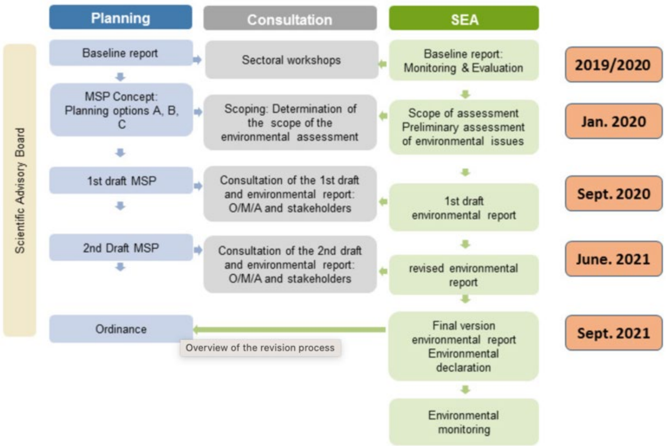

FIGURE 4-2 REVISION PROCESS OF THE MARITIME SPATIAL PLAN

Source: BSH website[115]

4.5.3 Netherlands

Numerous civil society organizers called upon the national government to formulate a joint North Sea Agreement, a set of Agreements between the Dutch government and stakeholders through to 2030 with a future vision on the development of wind energy in the long term. The North Sea Consultation (NZO) was established by the Physical Environment Consultative Council (OFL), and the Agreement was signed in June 2020. The document includes agreements on the designation and protection of areas, the designation of wind farm zones, the plotting and combined use of wind farms, additional nature areas, fishery in marine nature areas, installations and objects, and oil and gas production. Although the NZO attempted to take all stakeholder considerations into account, it remains unsigned by the Dutch Fishermen's Association and VissNed, a producer organization. Based on the North Sea Agreement, the NZO has formally been launched in 2021 as a permanent consultative body of stakeholders with seats kept open for these fisheries representatives.

Hatenboer, et. al (2023)[116] points out that division within the fisheries sector, among different fisheries organizations, over modes of interest representation made it unable to ratify the North Sea Agreement. Widely differing views existed about the maximum number of closed areas that could be accepted as well as about the fleet transition and decommissioning scheme. Support for an agreement by sectoral leaders does not always represent the majority of members but this is often not visible from the outside. This challenge could be faced in Japan where discussions are often conducted among high-level stakeholder representatives.

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[115] BSH website, "Maritime Spatial Plan 2021", https://www.bsh.de/EN/TOPICS/Offshore/Maritime_spatial_planning/Maritime_Spatial_Plan_2021/maritime-spatial-plan-2021_node.html

[116] C. Hatenboer, C. van den Berg, R. Holzhacker (2023) "The Dutch fisheries sector and the North Sea Accord: Unpacking stakeholder participation in multi-levelled marine governance" *Marine Policy* Vol. 147, https://www.sciencedirect.com/science/article/pii/S0308597X22004110

4.6 Conclusions

Given that UNCLOS acknowledges that coastal States may exercise sovereign rights over exploration, exploitation, conservation, and management of natural resources and other economic activities, such as the production of wind or tidal power, many countries like Germany and the UK have developed maritime spatial plans, which include areas designated for offshore wind power. Given that all States enjoy the right of navigation and overflight and the laying of submarine cables and pipelines within any EEZ; and therefore, it is important for Japan to announce its intentions to construct wind power farms in its EEZ. This can be done by formulating a maritime spatial plan based on both scientific data and stakeholder engagement. Yet, given that maritime spatial planning will require time, it will also be essential for the government to promote and announce early project development by formulating a concrete roadmap to achieve its offshore wind power deployment targets.

Negotiations with stakeholders, including not only Japanese fishermen but also parties of bilateral fishery agreements should be initiated promptly. Today, the Japanese government designates Promotion Zones, Promising Zones and Preparation Zones for offshore wind power based on discussions with local stakeholders, often representatives of local interest groups. Individual negotiations are often conducted by the project developer, as contribution to the local economy is included in the evaluation criteria. However, stakeholders will be difficult to identify in the EEZ and negotiations are likely to become more challenging.

The engagement of a wide range of stakeholders in designing these plans is important to ensure fairness and for parties to foster a sense of ownership for not only the plan itself but for individual projects. The lessons learned in the Netherlands are an example of the consequences to be faced when there is an internal conflict of views within a stakeholder group. It demonstrates the significance of not limiting coordination activities to the top level and ensuring stakeholder dialogue at all levels.

Japan lacks a participatory process for decision-making that is required by law in many countries. Open discussions supported by science-based information will make outcomes more acceptable across different parties. Maritime spatial planning will require consultations with and consensus among a wide range of stakeholders, including the fishing community, as well as local people and businesses spread across extensive coastal areas. There is an urgent need for a participatory decision-making process to be developed in Japan. Such processes should be led by a government organization that can cover inter-ministerial topics, such as the Cabinet Office or a newly established organization dedicated to participatory processes.

5 Exploring the development of local industrial hubs

5.1 Grid integration of offshore wind power

Grid connection is an important issue for the future development of offshore wind power. In Japan, the grid capacity available for new renewable power connection is becoming increasingly limited. Curtailment of renewable power generation occurs in all service areas except in that of Tokyo Electric Power Company (TEPCO). In the short term, to facilitate offshore wind development, new offshore wind projects can be connected to the grid under the “Grid Securing Scheme”. The detailed design of the Grid Securing Scheme is now under discussion[117]. Under the Grid Securing Scheme, utility companies will provide connection for new offshore wind projects under the “non-firm” connection rule. Under the “non-firm” connection rule, a new power generation plant can be connected to the grid even if there is no spare grid capacity, on the condition that its output will be the first in line to be curtailed without compensation in the event of grid congestion.

Given that the frequency and amount of curtailment under the “non-firm” connection rule is difficult to predict, the bankability of a project subject to the “non-firm” connection rule may be undermined. Changing the grid utilization rules from “first-come-first-served” to rules based on the carbon intensity and power generation cost of each power plant can help improve the bankability of not only offshore wind power projects but also all new renewable power projects without having an impact on grid stability.

In the longer term, further expansion and reinforcement of transmission capacity, especially inter-regional transmission connection capacity, is needed. The Organization for Cross-regional Coordination of Transmission Operators (OCCTO) has released a Master Plan for the future transmission grid network system[118]. Expected future offshore wind power installations were also considered in the development of the master plan. However, the future inter-regional transmission capacity under construction and in planning is around 10 GW (Figure 5-1) and may not be enough to accommodate future offshore wind power projects. In addition to the further expansion of inter-regional transmission lines, transporting offshore wind power resources in other forms such as hydrogen, or relocating energy demand to places with abundant offshore wind power potential can also be solutions to overcome grid capacity constraints.

[117] ANRE and MLIT (June 2023), “Review of the grid securing scheme” (Document 1 delivered at the 19th Joint meeting of the Working Group on Promoting Offshore Wind Power Generation (Subcommittee on Mass Introduction of Renewable Energy and Next-Generation Electricity Networks, Committee on Energy Efficiency and Renewable Energy, Advisory Committee for Natural Resources and Energy, METI) and the Subcommittee for Promoting Offshore Wind Power Generation (Environment Committee, Harbor Committee, Transport Policies Council, MLIT) (June 16, 2023)
https://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/yojo_furyoku/pdf/019_01_00.pdf

[118] OCCTO (2023), *Long-term Plan for Cross-regional Grid (Master Plan of Cross-regional Transmission Grid)*, https://www.occto.or.jp/kouikikeitou/chokihoushin/files/chokihoushin_23_01_01.pdf

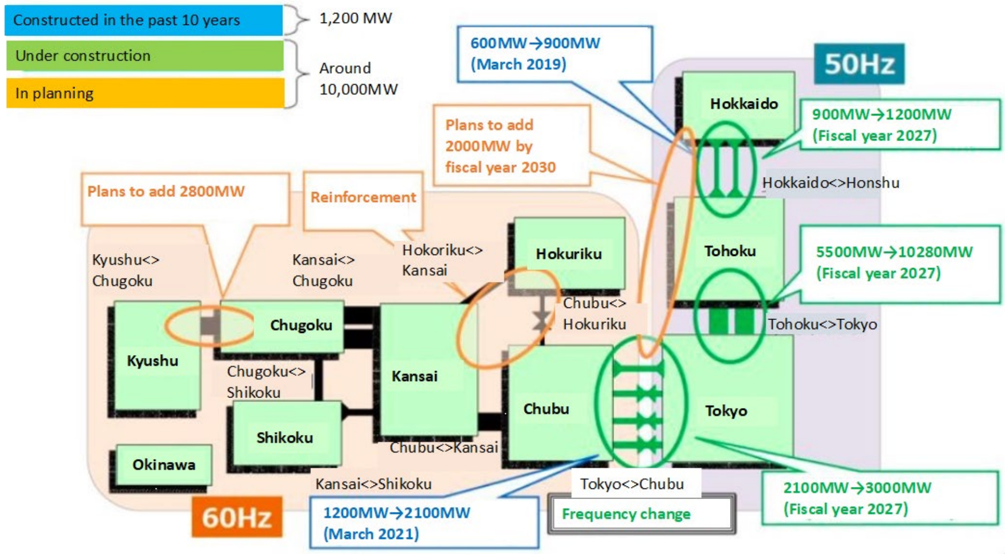

FIGURE 5-1 FUTURE TRANSMISSION NETWORK REINFORCEMENT PLAN

Source: ANRE (February 2023)[119]

5.2 Converting offshore wind power to other energy carriers

Considering the imbalance between offshore wind power potential and grid constraints, measures can be taken to fully utilize energy from offshore wind. An example is using it in other forms such as hydrogen. In the future, if the generation cost of offshore wind power becomes low enough, using offshore wind power for local green hydrogen production can be more economic than using electricity from the grid, since transmission and distribution costs will not be needed. Furthermore, when offshore wind power generation costs are reduced, green hydrogen produced from local offshore wind power can also be competitive against imported green hydrogen as hydrogen carrier conversion/reconversion costs and costs associated with long-distance transportation and storage of hydrogen can be avoided. Yet, it should be noted that costs related to transporting hydrogen by pipeline from the offshore hydrogen production site to coastal area will be added to the total hydrogen supply cost.

Hydrogen production using offshore wind power is being promoted especially in Europe where offshore wind development is more advanced. For example, the Westküste 100[120] project in Germany, uses electricity from an offshore wind farm and solar PV to produce green hydrogen, which is used to produces synthetic fuels with CO_2 captured from a nearby cement factory. In this project, green hydrogen is produced using electricity from an existing offshore wind project that already has transmission lines in place to deliver electricity onshore and the hydrogen production facility is in the coastal area.

There are also offshore wind power projects dedicated to hydrogen production under development. For example, in the United Kingdom, the Deepwater Offshore Local Production of Hydrogen (DOLPHYN) project plans to use a dedicated floating offshore wind farm to produce hydrogen. The project examined several design options for the floating offshore wind power generation and electrolysis system. According to the cost analysis, the hydrogen supply cost (including production and transportation costs) is lowest in the case with a semi-submersible floating offshore wind platform with a hydrogen export pipeline to the shore (“Case 1” in

[119] ANRE (February 2023), “Next-generation electric power system” (Document 3 delivered at the 49th meeting of the Subcommittee on Mass Introduction of Renewable Energy and Next-Generation Electricity Networks (February 9, 2023), https://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/pdf/049_03_00.pdf

[120] Westküste 100 website, https://www.westkueste100.de/

Figure 5-2). In this case, hydrogen production facilities (desalination unit and electrolyzer) are integrated on each floating offshore wind platform. [121]

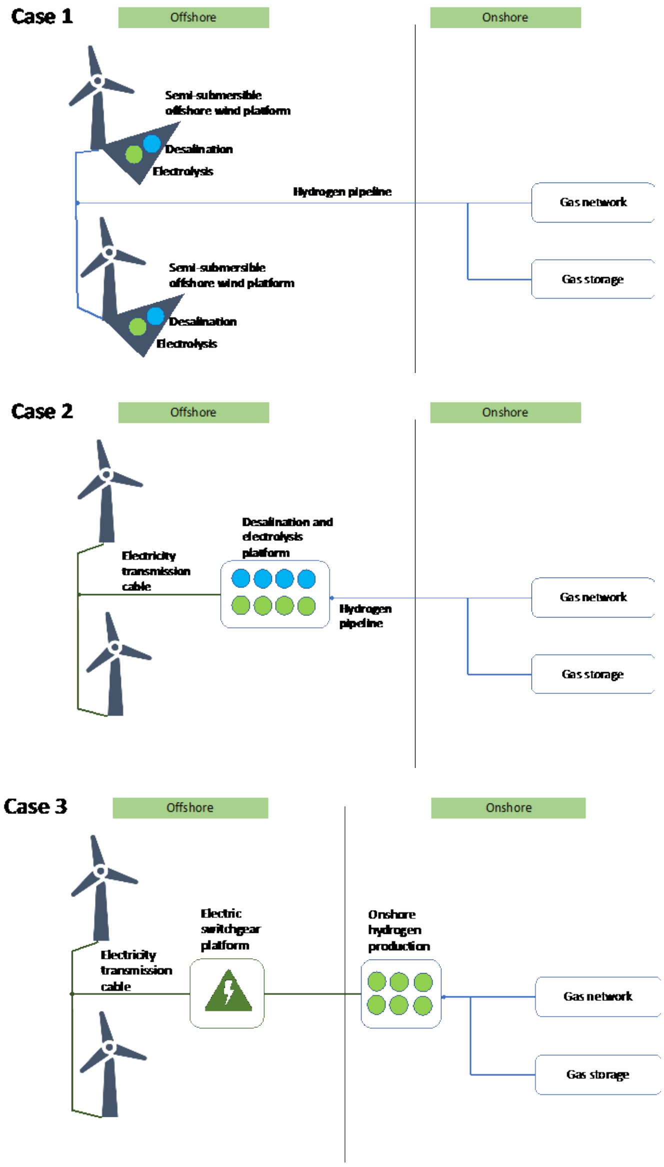

FIGURE 5-2 CASES OF SYSTEM DESIGN EXAMINED IN THE DOLPHYN PROJECT STUDY

Source: depicted by authors based on ERM (2019)

Furthermore, companies from North Sea countries are developing offshore wind power and hydrogen production projects such as the North Sea Wind Power Hub (NSWPH) project. The NSWPH project aims to build several offshore wind energy supply hubs in the North Sea that produce both electricity and. The NSWPH consortium comprises utility companies, including Gasunie, Energinet, and TenneT. The consortium examines the optimal system design for integrating offshore wind power into the energy system, supplying both electricity and hydrogen to countries in the North Sea region in the most efficient way. The study[122] found

[121] ERM (2019), *Dolphyn Hydrogen Phase-1 Final Report* (Submitted to Department for Business, Energy & Industrial Strategy, United Kingdom), https://assets.publishing.service.gov.uk/media/5e4ab9be40f0b677c1344ec8/Phase_1_-_ERM_-_Dolphyn.pdf

[122] NSWPH (2022), "Grid-integrated Offshore Power-to-Gas Discussion Paper #1", https://northseawindpowerhub.eu/knowledge/nswph-discussion-paper-on-grid-integrated-offshore-power-to-gas

that, rather than dedicating all the offshore wind power to offshore hydrogen production, or to export all the electricity to the onshore power grid, a hybrid grid-integrated Power to Gas (PtG) system, that for example produces hydrogen, can harvest the maximum offshore wind power and integrate it into the energy system. The hybrid grid-integrated PtG system will initially supply electricity to the onshore electricity grid and use the surplus electricity that could not be absorbed by the grid for offshore hydrogen production. The hydrogen will be exported to coastal regions via hydrogen pipeline.

5.3 Infrastructure

Transmission lines and hydrogen delivery measures are of great importance in delivering the electricity or hydrogen from offshore wind farms to end users. The transmission and delivery infrastructure comprises two parts: offshore transmission and delivery infrastructure (to export energy generated from offshore facilities to shore), and onshore transmission and delivery networks.

5.3.1 Offshore transmission and delivery infrastructures

Current submarine transmission line or oil/gas pipeline technologies are already mature and have been used in many projects. Most current submarine electricity transmission cables are in Europe, with some projects also in North America and Asia (Table 5-1). According to current projects, the depth of submarine electricity transmission cables can reach as deep as 1,600 m.

Onshore hydrogen pipelines are established technology. Although submarine hydrogen pipelines do not yet exist, experience from submarine oil/gas pipelines can be used in building submarine hydrogen pipelines. Furthermore, some oil/gas pipelines can be repurposed for hydrogen transport in some cases. Currently, submarine oil/gas pipelines are found mainly in the U.S. Gulf of Mexico, West Africa, Brazil, and Northern Europe. According to Mark J. Kaiser & Siddhartha Narra (2019)[123], the U.S. Gulf of Mexico is one of the most developed regions in the oil and gas industry and there are around 21,872 miles (35,200 km) of active oil and gas pipelines of which about 9,462 miles (15,228 km) are underwater in depths of more than 400ft (122 m). Gas pipelines can be installed in waters as deep as 2,000 m[124].

Table 5-1 Examples of Submarine Electricity Transmission Cables

Electricity Transmission Cable	Voltage	Length	Max. Depth	Operation Year
NorNed (Norway-Netherlands)	±450kV (DC)	580 km	410 m *1	2008
NordLink (Norway – Germany)	±525kV (DC)	623 km *2	410 m	2021
SA.PE.I (Mainland Italy – Sardinia)	±500kV (DC)	435 km	1640 m	-
ELMED (Italy – Tunisia)	500kV (DC)	220 km *3	800 m	To be completed by 2028*4
Kitahon HVDC Link (Japan/ Hokkaido-Honshu)	±250kV (DC)	167 km (submarine cable: 42km)	300 m	Latest cable expansion in 2014
Maritime Link (Canada)	±200kV (DC)	170 km	470 m	2017

Source: compiled by authors based on various sources*5

Notes:
*1: 420 km of cable in shallow waters (up to 50m) and 160 km of cable in depth of up to 410 m;

[123] Mark J. Kaiser & Siddhartha Narra (2019), "U.S. Gulf of Mexico pipeline activity statistics, trends and correlations", *Ships and Offshore Structures*, 14:1, 1-22, https://www.tandfonline.com/doi/abs/10.1080/17445302.2018.1472517

[124] TechnipFMC (August 23, 2013 press release), "Technip to lay the world's deepest gas pipeline, for Shell in the Gulf of Mexico", https://www.technipfmc.com/en/investors/archives/technip/press-releases/technip-to-lay-the-world-s-deepest-gas-pipeline-for-shell-in-the-gulf-of-mexico/

*2: 516 km of submarine cable;
*3: 200 km undersea;
*4: Procurement phase started in 2023. In 2023, the World Bank Loan to Tunisia was approved and EU Grant, signed.
*5: Jan-Erik Skog et. al. (2006)[125], T&D World (2008)[126], Magnus Callavik and Ola Hansson (2015)[127], KfW[128], Terna Diving Energy[129], ELMEDProject[130], J-Power (2021)[131], Nexans (2018)[132], Hitachi Energy[133]

5.3.2 Onshore transmission and delivery infrastructures

To deliver clean electricity or hydrogen to end users, onshore transmission and delivery infrastructures are also essential. As aforementioned, Japan has already developed a Master Plan for future transmission network expansion and reinforcement. The future electricity supply from offshore wind was also considered in the development of the Master Plan.

Europe already has plans to develop a Europe-wide hydrogen pipeline network, most of which will comprise repurposed natural gas pipelines, but there are no such plans in Japan yet. Main hydrogen delivery measures in Japan are currently high pressure compressed hydrogen trailers and liquefied hydrogen tank trucks. At the early stage of market scaleup, when hydrogen consumption is still small, such delivery measures can be used for distribution to hydrogen end users, such as hydrogen refueling stations. However, for larger volumes of concentrated hydrogen demand, hydrogen pipelines are more efficient. In the longer term, when the hydrogen market is more developed, the installation of hydrogen pipeline networks in regions with high hydrogen demand could be considered.

5.4 Synergy with local/regional hydrogen hubs

To develop and expand the domestic market for hydrogen and its derivatives, the Japanese government is considering building several hydrogen hubs in Japan. Some of the cost will be supported by the government. An important criterion for the selection of potential hub locations is the potential demand for hydrogen and its derivatives. The hubs will have large-scale hydrogen users, such as hydrogen- and ammonia-fired thermal power plants, refineries, and large industrial users. There will be hydrogen pipelines for hydrogen delivery as well as ports with import facilities for hydrogen and its derivatives. In the future, if offshore wind-powered hydrogen production sites can be well planned to take advantage of infrastructure synergy and supply hydrogen to the hydrogen hubs, the total cost for infrastructure buildup may be reduced (Figure 5-3).

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[125] Jan-Erik Skog, Kees Koreman, Bo Pääjärvi, & Thomas Andersröd (2006), "The Norned HVDC cable link–A power transmission highway between Norway and The Netherlands," *ENERGEX 2006*, https://library.e.abb.com/public/f3a6c2afe601d185c125718e002e3823/THE%20NORNED%20HVDC%20CABLE%20LINK.pdf

[126] T&D World (May 9, 2008), "NorNed, the Longest Electricity Cable in the World, is Operational", https://www.tdworld.com/overhead-transmission/article/20956052/norned-the-longest-electricity-cable-in-the-world-is-operational

[127] Magnus Callavik and Ola Hansson (2015), "NORDLINK Pioneering VSC-HVDC interconnector between Norway and Germany", (White Paper from ABB), https://library.e.abb.com/public/aaa99cf7067cd258c1257e0d002c9a7b/Nordlink%20White%20Paper%20from%20ABB.pdf

[128] KfW website, "Green electricity from Norway", https://www.kfw.de/stories/environment/renewable-energy/nordlink/

[129] Terna Diving Energy website, "SA.PE.I", https://www.terna.it/en/projects/sapei

[130] ELMEDProject website, https://elmedproject.com/#:~:text=The%20power%20line%20will%20run,along%20the%20Strait%20of%20Sicily.

[131] J-Power (2021), "Study group for the development of long-distance submarine DC power transmission: Inter-regional interconnection by submarine DC transmission" (Document 6 distributed at the 1st meeting of the Study group for the development of long-distance submarine DC power transmission), https://www.meti.go.jp/shingikai/energy_environment/chokyori_kaitei/pdf/001_06_00.pdf

[132] Nexans (February 18, 2018, press release), "Nexans Delivered North America's Longest Submarine Cable to Provide Cleaner Energy to Eastern Canada", https://www.nexans.com/en/newsroom/news/details/2018/01/Nexans-Delivered-North-America-Longest-Submarine-Cable-to-Provide-Cleaner-Energy-to-Eastern-Canada.html

[133] Hitachi Energy website "Maritime Link", https://www.hitachienergy.com/about-us/customer-success-stories/maritime-link

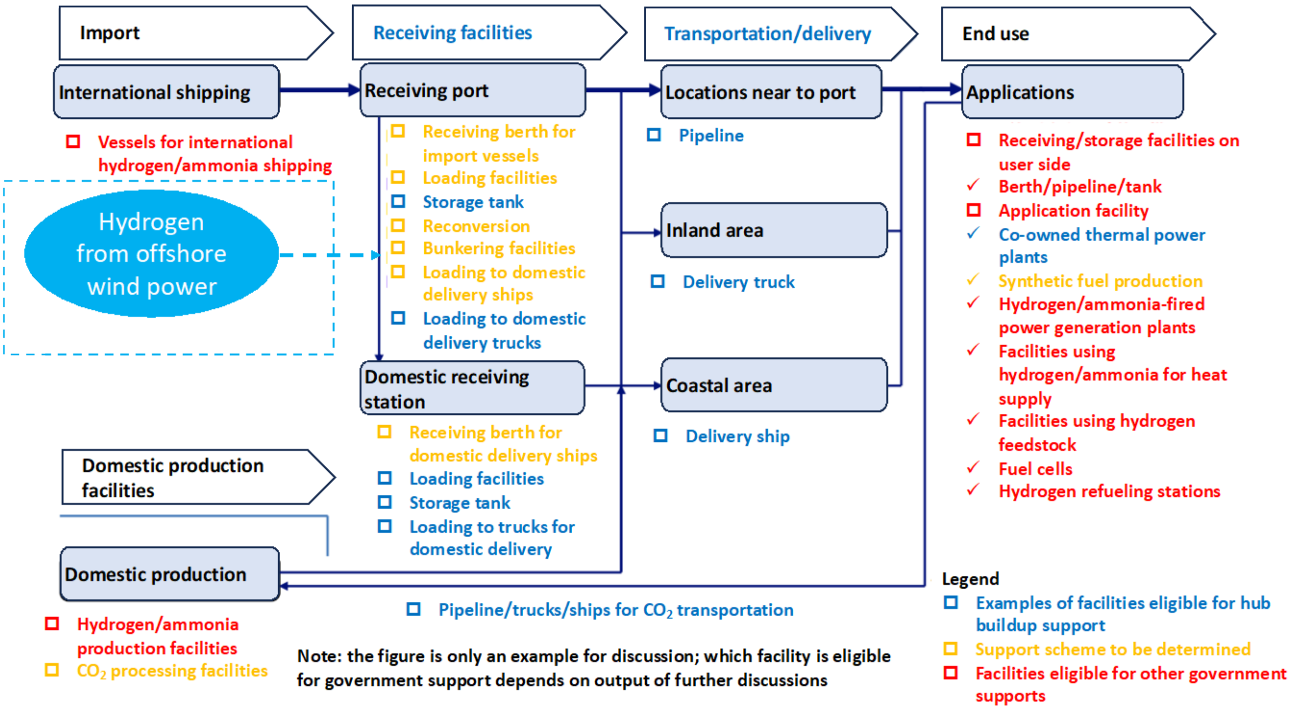

FIGURE 5-3 IMAGE OF HOW OFFSHORE WIND POWER CAN BE INTEGRATED INTO THE HYDROGEN HUBS UNDER DISCUSSION IN JAPAN

Source: Compiled by authors based on METI[134]

5.5 Relocation of energy

In the longer term, to fully utilize the offshore wind potential, demand side measures should be considered in addition to those on the energy supply side. With the growing demand for green products and stricter regulations regarding the carbon footprint of products, industry users are increasingly in need of low-cost clean energy supplies. In the longer term, even when offshore wind power generation costs can be significantly lowered, the cost of power transmission will need to be considered, and if hydrogen is produced from the wind-derived electricity, the cost of hydrogen transport should also be included. Therefore, the distance of power transmission or hydrogen transport should be minimized for the highest cost efficiency. In that sense, increasing local energy demand by shifting energy consumers to such areas with abundant offshore wind potential, such as Hokkaido, can be a solution for optimizing future energy supply and demand, as huge investment in new energy infrastructure, such as pipelines and transmission lines to distant demand centers can be avoided.

Potential energy end users in areas with high potential for offshore wind power include industries related to the offshore wind supply chain, such as wind turbine manufacturers, equipment suppliers, assembly companies, and recycling companies, as described in Chapter 3. In addition, industries with enormous needs for low-cost clean electricity or hydrogen can also create new energy demand. Some examples are data centers consuming large amounts of electricity and steel manufacturing plants with large demand for high temperature heat.

Further advances in digitalization will make data centers one of the top electricity consumers in the future. Data center providers and operators, such as major IT companies, are increasingly sourcing their electricity supply from clean energy sources, mainly renewable energies. Data centers require Uninterruptible Power

[134] METI (December 2023), *Interim Report of Joint Meeting of Hydrogen Policy Subcommittee and Ammonia and Low Carbon Fuels Subcommittee*, https://www.meti.go.jp/shingikai/enecho/shoene_shinene/suiso_seisaku/pdf/007_02_00.pdf

Supply (UPS), which requires backup generators in case of power outage. Microsoft is testing the use of hydrogen fuel cells as the backup generator of its data centers[135]. In the future, the offshore wind power system will be able provide both clean electricity and fuels (e.g. green hydrogen) for backup generators supporting the data center.

The iron and steel industry is a so-called "hard-to-abate (difficult to decarbonize by clean electricity)" industry. An effective decarbonization solution is Direct Reduced Iron (DRI) production using hydrogen as the reducing agent and as fuel to provide high temperature heat. The production of 1 ton of crude steel using the DRI process requires 45~55 kg of hydrogen (Hydrogen Europe[136]). For a typical steel plant with 4 million tons of crude steel production per year, the annual hydrogen demand is 180,000~220,000 tons. According to IEA (2019)[137], 10GW of offshore wind can produce around 1 million tons of hydrogen per year. To provide green hydrogen to a steel plant producing 4 million tons annually, around 1.8~2.2GW offshore wind is needed. Offshore wind farms can also provide clean electricity to local steel manufacturers using electric arc furnaces, which can process recycled steel scraps from both onshore and offshore wind power plants, thus contributing to the local circular economy.

End users such as data centers or industrial users can directly purchase electricity or hydrogen from local offshore wind power generators. The Feed-in-Premium (FIP) scheme was adopted for Round 2 of offshore wind power tenders which was held in December 2023[138]; and therefore, wind power operators have chosen to directly sign Power Purchase Agreements (PPA) with end users.

Amid the race to decarbonize industry and the entire energy demand, locations with an abundant supply of low-cost clean energy can be more attractive to industries. Provided that the cost of offshore wind power can be significantly reduced in Japan in the long term, shifting existing industrial energy demand to and siting new industrial energy demand in regions with large offshore wind power potential but limited transmission capacity is a solution for efficient energy use. Industrial relocation will be accompanied by a population shift of workers and their families, and thus can lead to the revitalization of local economy. Therefore, relocating energy demand to new energy hubs could be considered as a long-term industrial strategy. This will require a long-term multidimensional approach. Now, as we stand at the beginning of the energy transition, comprehensive discussions should be initiated on how we envision energy, local economy, and industry issues.

5.6 Conclusions

Grid connection is a critical part of future offshore wind power development. Japan's the transmission grid expansion and reinforcement plan takes future offshore wind power development into consideration. However, in the longer term, there remains a possibility that there will not be enough grid capacity to accommodate all offshore wind power. Therefore, converting electricity derived from offshore wind to hydrogen is an ideal option for fully utilizing offshore wind power and optimizing the energy system.

There are existing studies and pilot projects for hydrogen production using offshore wind power in Europe, especially in countries facing the North Sea, such as the United Kingdom and Germany. To integrate offshore wind power into the energy system, infrastructure development, including both offshore and onshore electricity transmission lines, hydrogen pipelines, and/or other means to transport hydrogen, is of great

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135 Microsoft (July 28, 2022, press release), "Hydrogen fuel cells could provide emission free backup power at datacenters, Microsoft says", https://news.microsoft.com/source/features/sustainability/hydrogen-fuel-cells-could-provide-emission-free-backup-power-at-datacenters-microsoft-says/

136 Hydrogen Europe (2020), *Green Hydrogen Investment and Support Report*, p. 19 https://h2fcp.org/system/files/cafcp_members/2%20Hydrogen-Europe_Green-Hydrogen-Recovery-Report_final.pdf, (cited from Hybrit, Fossil free Steel, summary of findings from HYBRIT pre-feasibility study 2016-2017 Assessment of hydrogen direct reduction for fossil-free steelmaking, Valentin Vogl, Max Åhman, Lars J. *Nilsson Journal of Cleaner Production* 203 (2018) 736-745)

137 IEA (2019), "Offshore Wind Outlook 2019", page 56, https://iea.blob.core.windows.net/assets/495ab264-4ddf-4b68-b9c0-514295ff40a7/Offshore_Wind_Outlook_2019.pdf

138 ANRE (November 2023), "Guidelines on call for proposals based on Marine Renewable Energy Act" (Document delivered at the 89th meeting of the Procurement Price Calculation Committee), https://www.meti.go.jp/shingikai/santeii/pdf/089_01_00.pdf

importance. Japan seeks to build several hydrogen/ammonia hubs to facilitate the scaling up of domestic hydrogen/ammonia demand; and hydrogen/ammonia infrastructure is a key component of hub development. Synergy with such hydrogen/ammonia hubs should be considered in the system design of integrating offshore wind power into the onshore energy system as this will reduce the overall infrastructure construction cost.

Relocating energy demand to regions with abundant offshore wind resources is another solution for optimizing the integration of offshore wind into the future energy system. In addition to industries along the offshore wind supply chain, regions with large offshore wind resources can also accommodate potential off-takers of clean energy. For example, data centers are potential consumers of clean electricity and green hydrogen), and direct reduced iron (DRI) production will use great amounts of green hydrogen. When there are infrastructure constraints to transmit wind power to other parts of Japan, relocating energy demand to close to coastal areas that can supply the offshore wind power can help avoid large investments for new infrastructure. This can also lead to the fostering of local industries and prevent the offshoring of domestic industries.

The precondition for such energy demand relocation is that the power generation cost from offshore wind is low enough to attract clean energy end-users. Strategic planning by the national government with the strong support and coordination from local governments will be essential to promote the relocation of energy demand.

6 Conclusions and recommendations

Japan has limited territorial land area and shallow waters suitable for bottom-fixed offshore wind turbines. However, it is surrounded by large bodies of water whose area, including its territorial waters and Exclusive Economic Zone, is the sixth largest in the world. Therefore, floating offshore wind power is a promising technology for Japan. A bill to amend the Marine Renewable Energy Act so that the sea area for offshore wind power development can be extended to the Exclusive Economic Zone (EEZ) has been compiled after long discussions and is expected to be submitted to the Diet. This will enable Japan to deploy large amounts of wind power and the demonstration of Japan's intentions to construct wind farms in its EEZ will be a decisive step toward the development of the floating offshore wind power market in Japan. Yet, there is an urgent need for Japan to accelerate the development of projects in its EEZ as neighboring China and Korea are already developing large-scale offshore wind power projects in their EEZs.

Accelerate offshore wind power development in the EEZ.

The United Nations Convention on the Law of the Sea (UNCLOS) acknowledges that coastal States may exercise sovereign rights over exploration, exploitation, conservation, and management of natural resources and other economic activities, such as the production of wind or tidal power in their EEZ. In Europe, many countries including Germany and the UK have developed maritime spatial plans (MSPs) which include areas designated for offshore wind power in their EEZs. A number of wind farms are already under development or in operation in the EEZ.

All States enjoy the right of navigation and overflight and the laying of submarine cables and pipelines within any EEZ. Given that neighboring countries having announced or currently constructing wind farm projects in their EEZs, it is becoming increasingly urgent for Japan to develop projects in its EEZ as early as possible. Japan should demonstrate its intention to build wind farms in its EEZ by formulating a maritime spatial plan based on both scientific data and stakeholder engagement. However, given the time required for developing such national plans, the government could formulate a concrete roadmap to achieve its offshore wind power targets and map out zones for project development.

Promote the early development of real full-scale floating wind power projects.

Many floating offshore wind power technologies are still in the development stage compared to those of bottom-fixed offshore wind power. Japan bears the potential to take the lead in building a supply chain for floating offshore wind power by tapping on the technologies that it excels in, such as shipbuilding and submarine cable technology. However, it needs to grasp the momentum.

While demonstration projects are necessary to establish the technology, the floating offshore wind power demonstration projects currently considered are too small in scale to attract foreign wind turbine manufacturers as the manpower and costs required for the front-end engineering and design (FEED) of a small pilot project are not so different from what is needed in a full-fledged project. In order to advance floating offshore wind power in Japan, it is essential to offer foreign wind turbine manufacturers a clear picture that Japan has a huge and promising market. Therefore, in addition to technology demonstrations, real full-scale projects should be launched based on established technology. With announcements of GW-scale projects, floating offshore wind power is shifting from the technology-push phase to the market-pull phase.

Promote domestic supply chain development for offshore wind power as a part of Japan's industrial strategy.

The Japanese government needs to demonstrate its commitment to promoting floating offshore wind power not only to foreign companies but also domestic companies and thus increase domestic players in the market. Domestic companies need to be convinced that the government is determined to promote floating offshore wind power as a major pillar of its industrial development policy.

The supply chain for floating offshore solutions, includes study and design, port development, manufacturing wind turbines, floating foundations and other equipment, shipping equipment and components, assembly and installation of turbines and transmission lines (submarine cables), etc., operation and maintenance, and decommissioning. Japan has no domestic manufacturing base for wind blades and lacks the experience in the offshore oil and gas operations that many North Sea countries possess. Yet, there are many Japanese companies with individual elemental technologies in the supply chain.

It is essential from an economic and energy security perspective that most of the supply chain be covered domestically, while improving and reducing the cost of current technologies, and at the same time exploring new technologies to solve challenges unique to Japan, such as land constraints related to manufacturing and transporting equipment. Stronger incentives should be provided for building factories and supply chains in Japan to encourage domestic manufacturing and procurement.

It is also important to enhance recycling and reuse efforts. Not all components of a floating offshore wind power turbine can be recycled or reused; and therefore, recycling and reuse will not solve all supply chain issues. However, it will help retain critical resources within Japan and reduce imports, thus contributing to enhancing economic and energy security. In addition to technological development, economic support measures, and regulations, it will be important to draw a picture in which venous industries, especially recycling, contributes to the promotion of domestic industry and the economy.

Create a new energy system harnessing offshore wind power

Strategic planning by the national government with the strong support and coordination from local governments will be essential not only to promote the development of a domestic supply chain for floating offshore wind power but also to optimize the energy system.

Grid connection is a critical element of future offshore wind power development. Japan's the transmission grid expansion and reinforcement plan takes future offshore wind power development into consideration. However, in the longer term, there remains a possibility that there will not be enough grid capacity to accommodate all offshore wind power. Therefore, converting electricity derived from offshore wind to hydrogen is an ideal option for fully utilizing offshore wind power.

There are existing studies and pilot projects for hydrogen production using offshore wind power in Europe, especially in counties facing the North Sea, such as United Kingdom, Germany. To integrate offshore wind power into the energy system, infrastructure development, including both offshore and onshore electricity transmission lines, hydrogen pipelines, and/or other means to deliver hydrogen, is significant. Japan seeks to build several hydrogen/ammonia hubs to facilitate the scaling up of domestic hydrogen/ammonia demand and hydrogen/ammonia infrastructure is a key component of hub development. Synergy with such hydrogen/ammonia hubs should be considered in the system design of integrating offshore wind power into the onshore energy system as this will reduce the overall infrastructure construction cost.

Relocating energy demand to regions with abundant offshore wind resources is another solution for optimizing the integration of offshore wind into the future energy system., Regions with large offshore wind resources can also accommodate potential off takers of clean energy. For example, data centers are potential consumers of clean electricity and green hydrogen), and direct reduced iron (DRI) production will use great amounts of green hydrogen. When there are infrastructure constraints to transmit wind power to other parts of Japan, relocating energy demand to close to coastal areas that can supply the offshore wind power can help avoid large investments for new infrastructure. This can also lead to the fostering of local industries and prevent the offshoring of domestic industries, given that the power generation cost from offshore wind is competitive enough to attract clean energy end-users.

Establish a participatory decision-making process.

The amendment bill for Marine Renewable Energy Act will introduce a two-step procedure for selecting offshore wind power projects in the EEZ. In the first phase, developers granted a preliminary permit by the government will initiate coordination with fishermen groups and other interested parties. Such consultations should involve not only those with obvious interests but a wide range of stakeholders, including local community and parties of bilateral fishery agreements. Furthermore, a framework to ensure fairness should also be established.

Today, the Japanese government designates Promotion Zones, Promising Zones and Preparation Zones for offshore wind based on discussions with local stakeholders in a committee often comprising representatives of local interest groups. Individual negotiations are often conducted by the project developer, as contribution to the local economy is included in the evaluation criteria. However, stakeholders will be difficult to identify in the EEZ and negotiations are likely to become more challenging.

Stakeholder engagement covering a wide range of parties and individuals is important for all parties to foster a sense of ownership for individual projects, and in the long run, maritime spatial plans. Japan lacks a participatory process for decision-making that is required by law in many countries. Open discussion supported by science-based information will make outcomes more acceptable across different parties. Maritime spatial planning will require consultations with and consensus among a wide range of stakeholders, including different interest parties, as well as local people and businesses spread across extensive coastal areas. There is an urgent need for a participatory decision-making process to be developed in Japan. Such processes should be led by a government organization such as the Cabinet Office or a newly established government organization that can cover inter-ministerial topics.

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