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Global Expert Mission
Japan & South Korea Floating Offshore Wind 2019

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Welcome

This report provides an overview of the findings from the Innovate UK Global Expert Mission to South Korea and Japan on floating offshore wind (floating OSW). During this mission, a delegation consisting of government representatives and industry experts travelled to the cities of Ulsan and Seoul in South Korea and to Tokyo in Japan to meet key stakeholders from the South Korean and Japanese OSW markets.

The report is split into two sections – South Korea and Japan – as the markets within each country have their own characteristics and present a different level of opportunities for collaboration. The findings from the mission are presented in three sections:

- OSW market landscape
- Floating OSW landscape
- Potential areas for collaboration.

SOUTH KOREA	
DATE: 25-26 FEBRUARY 2019	
LOCATIONS: ULSAN, SEOUL	
UK MISSION DELEGATES: • Crown Estate Scotland (CES) • Department for Business, Energy and Industrial Strategy (BEIS) • EDPR • Green Investment Group (GIG) • Innogy • Innovate UK • Knowledge Transfer Network (KTN) • Offshore Renewable Energy Catapult (ORE Catapult) • Scottish Development International (SDI)	KEY SOUTH KOREAN STAKEHOLDERS: Public sector stakeholders • Government of City of Ulsan • Korean Energy Agency (KEA) • University of Ulsan Industrial stakeholders • ACE E&T • Blue Wind Engineering • Hyundai Heavy Industries (Hyundai) • Ulsan Technopark

JAPAN	
DATE: 27 FEBRUARY – 1 MARCH 2019	
LOCATION: TOKYO	
UK MISSION DELEGATES: As above, plus • Acacia Renewables (part of Green Investment Group)	KEY JAPANESE STAKEHOLDERS: Government stakeholders • Ministry of Economy, Trade and Industry (METI) • New Energy and Industrial Technology Development Organization (NEDO) Industrial stakeholders • Hitachi Zosen Corporation (Hitachi) • Japan Marine United Corp • Marubeni Corporation (Marubeni) • Mitsubishi Corporation (Mitsubishi) • Mitsui E&S (Mitsui) • TODA Corporation

The objectives of the mission were as follows:

Gather market insight and build foresight on the South Korean and Japanese floating OSW sector.	Identify benefits and synergies between the UK, South Korea and Japan in floating OSW to create commercial opportunities and support the growth of the sector.	Identify technology and business priorities which could be built upon and supported to make the UK "Partner of Choice" with Japan and South Korea in order to progress the global floating OSW sector.
Identify collaboration models with South Korean/Japanese stakeholders in floating OSW.	Set groundwork for early dialogue between South Korean/Japanese floating OSW stakeholders and UK stakeholders and the business community to catalyse future internationalisation opportunities.	Align innovation policy direction and unlock barriers for future international partnerships.

The mission was timed to build on a growing level of interest in the UK in floating OSW, driven by a number of key events:

- The successful operational year of the Hywind Project, the first commercial floating OSW project in the UK (commissioned late 2017).
- The upcoming Scotwind seabed leasing round, within which 60% of sites are expected to require floating type foundations.
- The release of the OSW sector deal in March 2019, which lays out plans for OSW in the UK to 2030 and beyond, securing the progression of the industry.

Japan and South Korea were both selected for this mission on floating OSW as they have:

1. A requirement for floating OSW for deep water OSW development, due to limited shallow water off their coastlines.
2. Demonstrated interest in the sector, through the development of demonstration projects.

2. South Korea

2.1 South Korea Market Landscape

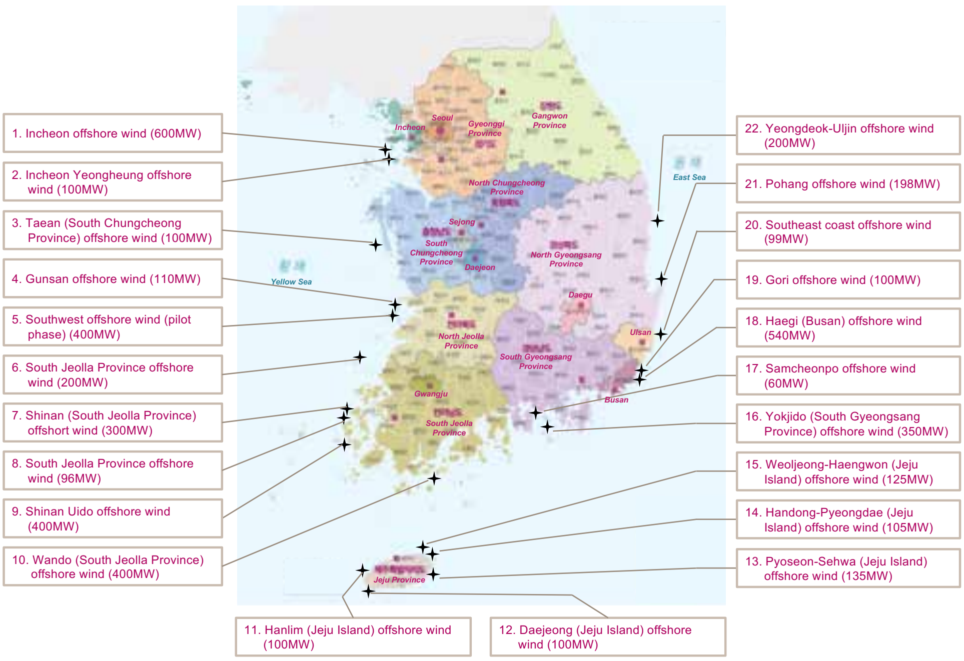
2.1.1 Market size

The South Korean OSW market is in the early stages of development but is growing rapidly. The first commercial OSW farm opened in late 2017 (30 MW capacity)[1]. Prior to this, South Korea had 8 MW of existing demonstration turbines. There is one additional farm under construction (60 MW). This places Korea substantially behind key European OSW markets; however, ambitious targets are in place for market growth.

The figure below shows 22 of the projects in development or pre-development – totalling 4.8 GW. Since this map was drawn, another four sites have been announced off Ulsan, and another four are allegedly under development but not yet announced.

South Korean OSW is still a fledgling industry, with less than 0.04 GW installed. However, the government target of 12 GW by 2030 has the potential to drive the growth of a substantial market, on a par with strong European markets such as the Netherlands.

Offshore wind farms in the pipeline



(Source: http://www.localsegye.co.kr/news/newsview.php?ncode=1065602766260462)

[1] https://www.offshorewind.biz/2017/11/17/south-koreas-first-commercial-offshore-wind-farm-goes-live/

2.1.2 National targets

The Renewable Energy 2030 Implementation Plan sets out an ambitious target from the South Korean Government to build 12 GW of installed capacity by 2030. There are no specific targets for floating OSW.

2.1.3 Key drivers for OSW development in South Korea

The key drivers for the development of OSW in South Korea are outlined in Figure 1.

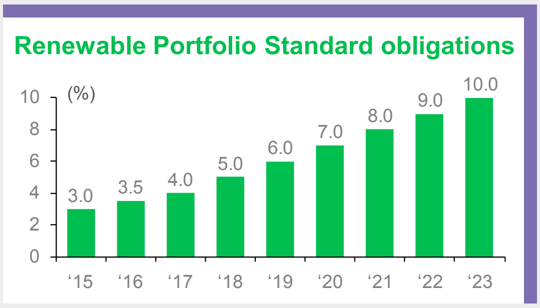
1. Jobs and economic development	Economic development appears to be a primary driver at the national and the regional level. OSW is seen as a way to re-stimulate South Korea's declining shipbuilding industry, where more than 100,000 jobs have been lost over the last five years. The conflict between lowering the cost of energy and building a local supply chain is still a controversial issue between industry and government. However, there are no binding local content rules.
2. Energy security	South Korea is one of the world's top five fossil fuel importers and therefore relies heavily on tanker shipments of crude oil and liquefied natural gas (LNG) to meet its energy needs. The import costs and energy security concerns are driving a move towards renewable energy, including OSW. There is limited opportunity for onshore wind development due to topographical constraints and lack of public acceptance. Therefore, OSW is a preferred solution. Furthermore, South Korea has scaled back its plans for nuclear power in the wake of Japan's Fukushima disaster and issues around nuclear safety certification in 2012.
3. Carbon reduction	In July 2018, the South Korean Government announced objectives to ensure carbon emissions will peak around 2020. This is in line with the Paris Agreement targets (domestic target is to reach 32.5% emissions reduction by 2030).[2] However, the government is still supporting the development of a substantial number of coal power plants in the country.

Figure 1: Key drivers for OSW deployment in South Korea

[2] https://climateactiontracker.org/countries/south-korea/

2.1.4 Key policies and mechanisms supporting OSW in South Korea

Listed in the following table are the key mechanisms implemented by the South Korean Government.

MECHANISM	SUPPORTING POLICY/SCHEME
Clear commitment to OSW by South Korean Government	8th Basic Plan for Electricity Supply and Demand Unveiled in late 2017, the plan aims to create a more balanced fuel portfolio to moderate reliance on nuclear and fossil fuel imports. It also includes greater demand-side management and energy efficiency initiatives. Renewable Energy 2030 Implementation Plan (RE3020) RE2030 outlines how the government aims to increase the level of renewable energy capacity from the current levels of 6% to 20% of total power generation by 2030. The plan aims to support the deployment of large-scale renewable energy projects (including OSW) and drive cost reduction through economies of scale. It outlines targets of creating 65,000 jobs in renewables between 2018 and 2022, reflecting the strong drivers for economic development through OSW.
Enforced renewables obligation on developers	Renewable Portfolio Standard (RPS) Scheme The RPS scheme is the primary scheme for supporting OSW development in South Korea. It forces organisations who own generating facilities with a capacity greater than 500 MW to produce at least 5% of their power from renewable sources, similar to the UK's historical ROC scheme. This minimum proportion is set to gradually increase to 10% by 2023, as shown below. Power generators are awarded Renewable Energy Certificates for every 1 MWh produced. Failure to comply with the RPS results in a financial penalty corresponding to 150% of the mean Renewable Energy Certificate (REC) price for that year. Energy companies can meet the RPS requirements by purchasing RECs. RECs are weighted depending on the location of the windfarm.  Source: http://www.asiawind.org/wp-content/uploads/2018/09/06-WOOD-MACKENZIE-LIEW.pdf South Korea shifted from a Feed in Tariff (FIT) scheme to the RPS scheme in 2012, primarily to drive cost reduction and encourage competition.
Financial incentive mechanisms	**Renewable Support Regulations** In addition to the RPS scheme, "Renewable Support Regulations" are in place. Loans may be handed out for installing renewable energy facilities under the Renewable Energy Act. Sums of up to KRW10 billion may be granted and paid back over 10 years. Repayments can be deferred for five years.

The impact of international relations with North Korea on OSW

Several South Korean stakeholders mentioned the issues around the proximity of some OSW sites to the border with North Korea. While the impact on security will need to be carefully reviewed as part of the development process, it was not perceived to be a significant barrier to development.

Can South Korea deliver its targets?

Despite strong government targets and a high level of ambition within the South Korean OSW industry, engagement during the mission indicates that there are still substantial barriers to meeting targets and building a substantial OSW industry within the country.

The primary issue is a lack of clear process for delivery of OSW to back up the ambitious targets in the country. Globally we have seen a lack of clarity around the development process deterring investment in the market, and it has been a key issue that has slowed the initial growth of other potentially strong markets, including China and the US.

Areas that were highlighted during discussions, that may cause issues include:

- A lack of mechanisms for constructive engagement with key stakeholders such as the fishing industry and residents.
- A lack of clarity over leasing and consenting responsibility within government and regional agencies and potential conflict between the agencies involved.

In addition, strong lobbying groups in both the fishing and O&G sector and local communities close to the development sites have the potential to derail the delivery of the targets. Real concern around these was evident during the mission.

2.2 The South Korean Floating OSW Landscape

The South Korean floating OSW market is still embryonic. The market is at least 5-10 years away from a first commercial deployment. It is, therefore, misleading to draw distinctions between the market and R&D landscape as separate activities. This section of the report provides an overview of the sector addressing both R&D activities and longer-term ambitions.

The South Korean floating OSW market is still in the early demonstration phase and is 5-10 years away from commercial deployment but the drivers and ambition for a long-term floating OSW market are clear.

2.2.1 The need for floating OSW

Conditions are very variable throughout the country, and therefore, a range of technologies will be needed if the OSW industry in South Korea develops as planned. Conditions are as follows:

Water depth	East Coast: >60 m West Coast: <10-60 m
Ground conditions	Seabed conditions in South Korea are variable and challenging. More challenging areas include hard basalt in the south and estuarine silt in the north.
Wind regime	6-8 m/s at 80 m above sea level – lower typical wind speeds than the UK 3-4 typhoons per year with wind speeds +50 m/s.
Distance from shore	Average distance from shore is approximately 10 km – significantly closer inshore than UK projects under development.

As outlined in the table and illustrated in Figure 2, the west coast has the potential for a significant fixed-bottom OSW development relatively close to shore. However, on the east coast, the depth of water increases rapidly to >60 m. If development in this region is to progress, floating OSW technology will be required.

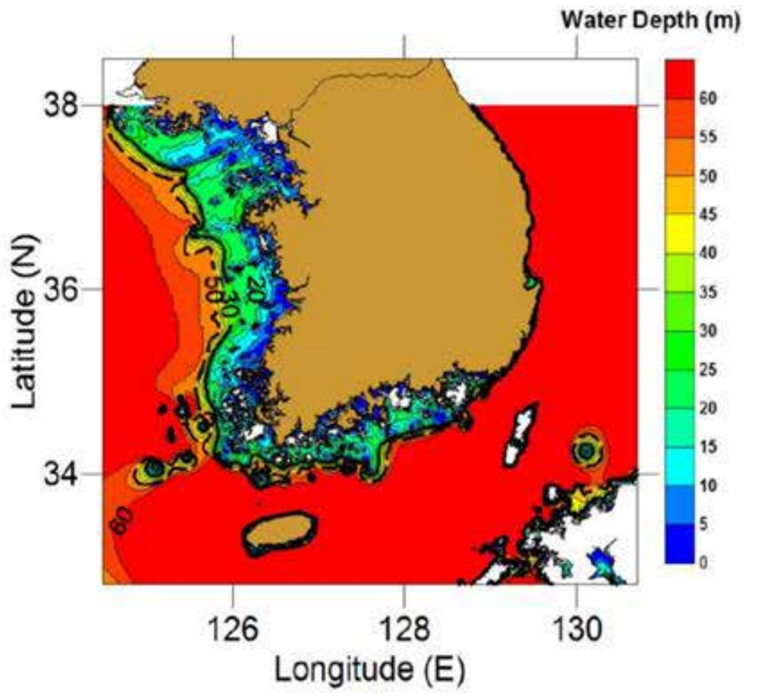


Figure 2: Water depths in South Korea

2.2.2 Floating OSW technology development and deployment in South Korea

The following table outlines the level of deployment or interest in the key technology elements in South Korea and how these compare to activities in floating OSW in the UK.

	Deployment/interest in South Korea	Comparison to the UK	Similarity of focus
FLOATING STRUCTURE	On the missions, significant interest was shown in both semi-subs and spar buoys. Tension Leg Platforms (TLPs) were noticeably not mentioned by stakeholders. The deployed 750 kW demonstration turbine uses semi-sub technology, but it is not certain this will be the preferred technology moving forward. Feedback was that there are pros and cons of both but, generally, there is a preference towards spar technology, despite higher installation costs. It is considered to be more economical to make better use of the local medium-sized shipbuilders compared to semi-subs, which they consider require a major shipbuilding outfit to deliver.	Unlike the UK, South Korea has a domestic floating platform developer with technology at concept demonstration stage; a large heavy industry base showing interest in the sector and a firm plan, with funding, for commercialisation of floating platform technology. There is a higher level of interest in spar buoys in South Korea than in the UK, where, despite Hywind being installed, spars are not seen as the primary technology for deployment in UK waters. This is due to constraints in port facilities, local supply chain opportunities, and concerns about spar buoy installation methods.	MEDIUM
TURBINES	Unlike in Europe, floating OSW consortia in South Korea are developing both the floating platform and the turbine. This has technical merits, allowing full integration of the turbine and the floating elements, and optimisation of structure and performance in a dynamic environment. However, it runs the risk of becoming a market barrier for three reasons: 1. Turbine size: The turbine manufacturers are not yet capable of delivering European-scale OSW turbines (>5 MW). This has significant cost implications. 2. Cost of development: Developing a turbine from scratch is expensive, compared to adapting an existing model. 3. Technical risk: Investors may be unwilling to accept the combined technical risk of a floating foundation and a turbine from a turbine manufacturer with a limited track record.	Within the UK there are no established domestic wind turbine manufacturers, so the UK is not actively developing turbines for the floating market. In addition, floating OSW developers to date have exclusively focused on the development of the platform and infrastructure, allowing the large turbine manufacturers to supply slightly adapted existing turbine models for floating demonstrators and projects.	LOW
BALANCE OF PLANT	Evidence presented to the mission suggests that the focus of activities in South Korea is very much on the platform and turbine development, and to date, little effort has been put into the mooring systems and electrical balance of plant. Three types of anchoring system were highlighted as of interest during the mission. These were: drag anchor, drive pile and suction pile. A general preference was shown for the suction pile as it was suitable for all seabed types. A range of dynamic cabling options were discussed, including: free-hanging quaternary, lazy wave, steep wave, lazy S, steep S and plant wave. Lazy wave was identified as the preferred solution at present by ECE E&T but deployment is at an early stage.	Within the UK, much of the development activity has been focused on BOP, such as dynamic cabling and mooring systems. The industry is not yet mature enough to have established strong technology trends, but the challenges faced by both the South Korean and UK industries are likely to be similar.	MEDIUM
Standard practice in installation and O&M methodologies has not yet been established in either South Korea or the UK due to immaturity of the market. Arguably the UK appears to be further ahead in its thinking on these issues and development work is ongoing, while evidence from the mission suggests that South Korea is less focused in this area.			

2.2.3 Ulsan – The hub of floating OSW in South Korea

Virtually all the floating OSW development in South Korea is focused in and around the city of Ulsan, in the southwest of the country. Ulsan is trying to position itself as the lead area for floating OSW in South Korea, and so far, it is succeeding. The South Korean Government is investing a total of KRW352.5 billion in the development of an OSW cluster in the city, as part of the Innovation Cities Development Plan. Ulsan has a strong heavy industrial manufacturing base, particularly in shipbuilding, and substantial ports, which makes it well-suited for developing a floating OSW supply chain. It has also suffered heavily from South Korea's declining shipbuilding industry, and therefore, there is strong local support for initiatives that promote economic development in the region.

Ulsan presented to the mission a strong roadmap from the installed 750 kW demonstration turbine to the development of full-scale commercial farms. There appears to be strong practical support for this roadmap from both city government, academia and industry, with Track 1 being driven by local government and the city council and Track 2 being driven by industry. More details of this roadmap are shown below.

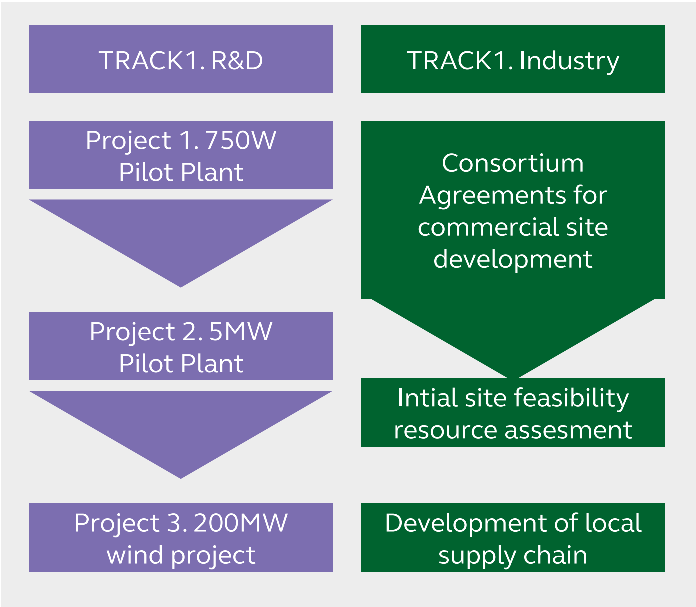


Figure 3: An overview of Ulsan City's floating OSW two track roadmap.

TRACK 1 R&D	
PROJECT 1 750 KW PILOT PLANT	The primary activity within Project 1 is the development and deployment of South Korea's first floating OSW turbine. The project to develop the 750 kW machine began in 2016, and it will enter testing this year. It is part of a KRW16 million (around $14 million) project between the University of Ulsan, Mastek Heavy Industries Co and Seho Engineering Co – the Shin-Gori Pilot Project (see case study).
PROJECT 2 5 MW PILOT PLANT	Project 2 consists of the development of a 5 MW floating pilot turbine built off the coast at Ulsan. It is being developed by a consortium of 10 organisations, including AC E&T (who are leading), Hyundai and Unison. This project was started in 2018 and is expected to be complete by 2020. There is also the potential for a smaller prototype site of 3-6 turbines before full commercial deployment. Work is ongoing on environmental impact assessment, cost estimation and project certification, grid and electrical design and the development of the 5 MW floating OSW system.
PROJECT 3 200 MW OSW PROJECT	The final stage of the R&D track is the development of a 200 MW floating OSW farm off the coast of Ulsan. This will be combined with the development of an OSW supply chain cluster around the local port facilities. There is strong support, and KRW590 billion has been set aside by the regional and national government for this activity. The initial feasibility study is underway and due to end in May 2020, including environmental impact and wind resource assessment. The proposed site is 58 km offshore and has a water depth of 150 m. It will use local oil and gas infrastructure to support OSW farm BOP infrastructure. The plan is to install a pilot plant in 2023.

TRACK 2 COMMERCIAL DEVELOPMENT

In order to deliver full commercial floating OSW farms, the City of Ulsan has signed MOUs for the development of commercial sites, in a waste dumping site off the coast of Ulsan. The ambition is to build over 1 GW of floating OSW farms. No timeline for development has been set.

The MOUs are believed to be with:

- Royal Dutch Shell and CoensHexicon, a joint venture between Hexicon AB and Coens, a Korean integrated service provider.
- SK E&S (a South Korean-based energy partner) and CIP.
- GIG and KF Wind (South Korean floating OSW developer), who are working with Principle Power on the project.
- Equinor and Korean National Oil Corporation.
- EDPR-Aker.

Under these MOUs, the companies are looking at the commercial and technical feasibility of sites and the potential development of a local supply chain. The MOUs indicate a level of interest in development of floating in South Korea by European developers and investors but all activity is speculative.

Notably, there is existing decommissioned oil and gas infrastructure on the site, which is hoped can be exploited by any windfarms in the area, for instance, using existing platforms for sub-stations.

Case study: Shin-Gori Pilot Project

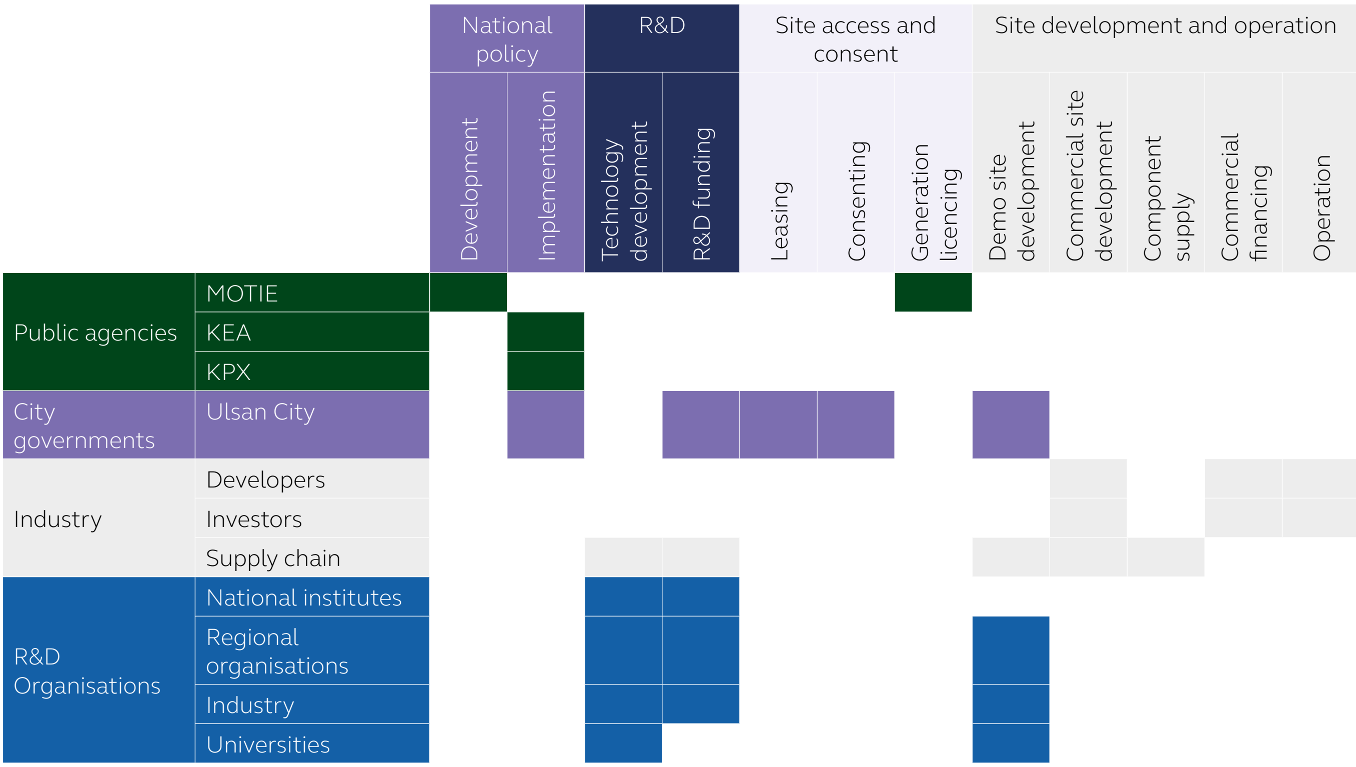
The Shin-Gori Pilot Project is South Korea's first floating OSW project and is a flagship programme for Ulsan City. The pilot project started development in 2016 and is due to be commissioned in summer 2019. The project is expected to be fully completed in 2020.

The demonstrator system represents the first step in Ulsan's wider floating OSW technology development roadmap and is a significant step in the initiation of South Korea's floating OSW sector. It is being developed by a consortium of the University of Ulsan, Mastek Heavy Industries Co, and Seho Engineering Co. The 750 MW turbine is being installed in 50 m deep water and is a semi-sub design. It was assembled quayside and towed out to the site and installed. Its foundation weight was stated as 110 tonnes. The technology is similar to that being developed by a number of manufacturers in Europe. Notably, unlike most European projects, the turbine itself was developed as part of the project; European projects have typically adapted existing established turbine models.

2.2.4 Floating OSW stakeholders

At present, given the immaturity of the floating OSW sector in South Korea (and globally), it is not possible to differentiate between commercial deployment stakeholders and R&D stakeholders. Therefore, both are included in the stakeholder review outlined in this section.

A summary of the roles of the key stakeholders are shown below:



<table>
<tr><th colspan="3">Public agencies engaged in OSW deployment</th></tr>
<tr><td rowspan="6">State-level agencies</td><th colspan="2">Ministry of Trade, Industry and Energy (MOTIE)</th></tr>
<tr><td colspan="2">MOTIE has responsibility for the development of commerce, investment, industry and energy. Part of its role is the development and implementation of policies relating to the energy sector. Notably for OSW this includes:
• Development of electricity policies
• Issuing generation licences
• Approving grid charges
• OSW construction approval.

MOTIE develops the basic plan for the promotion of renewable energy every five years. This includes setting targets for the ratio of renewable energy power generated to the total amount of power generated.</td></tr>
<tr><th>Korea Energy Agency (KEA)</th><th>KPX</th></tr>
<tr><td>KEA is a ministry under MOTIE. It implements national energy policies for energy efficiency improvement, renewable energy and climate change mitigation. The New and Renewable Energy Center (NREC) is a division of KEA. It supports renewable energy businesses and ensures renewables obligations are met. Importantly, it oversees the issuing of RECs under the RPS scheme. They are also active in technology certification and support with the development and standardisation of testing methods and facilities.</td><td>KPX, an agency under MOTIE. It operates the trade market for renewable energy certificates (RECs). All power generation must be dispatched through KPX with a few exceptions and KPX facilitates the bidding, metering, settlements and monitoring of electricity[3].</td></tr>
<tr><th colspan="2">Consenting authorities</th></tr>
<tr><td colspan="2">Two national agencies are also key to the consenting process for OSW:
• The Ministry of National Defence
• The Ministry of Oceans and Fisheries.</td></tr>
<tr><td rowspan="2">Regional and local agencies</td><th colspan="2">City governments</th></tr>
<tr><td colspan="2">For floating OSW, the most relevant city government is the City Government of Ulsan. The city is supporting the development of floating OSW through several initiatives including:
• Identifying areas for lease
• Consenting sites for development
• Local supply chain development and support including development of infrastructure and facilities
• R&D funding for technology development and commercialisation.</td></tr>
</table>

[3] https://gettingthedealthrough.com/area/99/jurisdiction/35/renewable-energy-korea/

INDUSTRY	
Developers	**Project investors**
There are three key types of developers in South Korea: 1. State-owned utilities 2. Large private sector companies (represent 90% of active developers at present) 3. Small developers. The larger private sector companies are both domestic and international developers. Although, in general, the large global developers are less active in the region than other Asian markets. Interest in the floating OSW market is somewhat behind the fixed-bottom sector, but it also attracts interest from overseas developers, notably Equinor and EDPR who have formally expressed an interest in the region. The nature of domestic developers is variable, with a range of large corporations dabbling in the sector to establish a presence. These are both energy supply companies, investment houses and supply chain companies looking to test the waters in South Korea. Demonstration projects are being developed by public bodies, in particular, Ulsan City, in conjunction with industrial partners.	Floating OSW in South Korea is starting to attract both domestic and international investors keen to get a first mover advantage in an emerging market. At this point, the levels of investment appear to be relatively low, to cover initial site feasibility costs. Investors known to be showing interest in floating OSW in South Korea include CIP and GIG. There are also a number of industrial investors including Shell, Aker. SK E&S and the Korean National Oil Corporation which have formally expressed interest.

Supply Chain

Industry in South Korea is dominated by the large industry corporations or chaebol. These organisations have a wide range of capabilities and a strong focus on manufacturing and export. They are hugely politically influential. The dominance of the chaebol and other large corporations means there is less of an ecosystem of innovative SMEs than found in Europe.

Manufacturing and supply are huge drivers for South Korea OSW development. As a result, a key factor in the progression of the floating OSW industry in South Korea is the degree of interest from chaebols in supplying the sector. An industry that relies heavily on imports is unlikely to receive the support it requires to be successful in the country.

OSW turbine manufacturers

Turbine supply in South Korea is an area of potential conflict between developers and government ambitions. There is an emerging local supply chain for OSW turbines. South Korean OSW turbine manufacturers include:

Manufacturer	Largest turbine demonstrated
Doosan	5.5 MW (8 MW in development)
Unison	4.2 MW (demonstrated 2018) also supplied 750 kW for Ulsan floating OSW demonstrator)
Hyosung Heavy Industries	5 MW (demonstrated 2014)
Hanjin	2.5 MW

Ulsan University, like some European manufacturers, is in the process of developing a 12 MW turbine. However, it is still in concept stage. Hyundai Heavy Industries took a 5.5 MW turbine to demonstration phase but has since pulled back from active turbine development and supply.

In South Korea, there is a strong focus on economic benefit that can be obtained from turbine supply. The UK has moved away from this approach, as turbine capital cost only makes up a third of the potential economic benefit from an OSW farm. The development and deployment of locally-developed turbines is being strongly encouraged by the South Korean Government through funding programmes and political pressure. However, the technology is much less advanced than is available from European suppliers and larger turbines are not available. Therefore, the use of local turbines could potentially significantly increase the cost of project development in the region and reduce investor interest. Significantly, European OSW turbine suppliers need to be certified by the KEA to be installed in South Korea, and currently none are.

Unlike all European floating platform developers, most potential South Koreans are developing or have developed their own turbines and are aiming to provide an integrated turbine and platform system. Technically, there are significant benefits to this, as it allows optimisation of the structure and turbine performance, but it increases technology risk. This approach reflects the dominance of the large, industrial companies, with a wide range of capabilities that dominate the industrial sector in South Korea.

Floating structure suppliers

South Korea has several organisations developing floating structures, and capability exists within its broader industrial sector for more to emerge. During the mission, the following floating structure suppliers were identified:

- University of Ulsan – The consortium led by the University of Ulsan is the only floating structure supplier in South Korea to have delivered a structure (only 750 kW).
- Hyundai Heavy Industry – There is interest from other industrial players around Ulsan, in developing and manufacturing floating platforms, most notably Hyundai Heavy Industries (see case study).

In addition, the presence of two European platform suppliers was observed:

- Hexicon – A Swedish floating platform developer. As part of a consortium, it has signed an MOU with the City of Ulsan to look at feasibility of floating OSW development in South Korea.
- Hywind – Active in the country with its spar buoy concept, supported by its parent company, Equinor.

Balance of plant

Evidence from the mission suggests that while South Korea is well-placed for large-scale fabrication of floating structures, there is limited domestic capability for electrical BOP, or mooring and anchoring systems. This was stated as an area where they would look to Europe for supply.

Installation and O&M contractors

Due to the immaturity of the industry, there is a limited local supply chain for installation and O&M and a lack of appropriate vessels was stated as a major issue by a number of stakeholders during the mission. However, Doosan has been developing capabilities in this area and the local shipbuilding industry would be capable of delivering vessels when needed.

Specialist support services	There is a limited number of domestic specialist support services, due to the immaturity of the industry. Most of the established UK-based technical consultancies have low-level activity in South Korea.
Utilities	Korea Electric Power Corporation (KEPCO) is the largest and most influential electricity utility in South Korea. It is responsible for the generation, transmission and distribution of electricity in South Korea as well as for 93% of Korea's electricity generation, including wind power. KEPCO also invests significantly in R&D including OSW.

Case study: Hyundai Heavy Industries

The delegation visited Hyundai Heavy Industries (Hyundai) at its Ulsan site. The site consists of ten very large scale dry docks with the supporting infrastructure, which covers a significant part of the Ulsan coastline.

Hyundai has a history of activity in the OSW sector, primarily in the domestic market. It has developed and demonstrated a 5.5 MW turbine, but recently pulled out of turbine supply.

Hyundai's activities in floating OSW sector are being lead by Hyundai Heavy Industries Offshore and Engineering Division. Its primary engagement with the floating OSW sector is its engagement in Ulsan's 5 MW OSW demonstrator project. In 2017 Hyundai signed an MOU with Atlantis, which included floating OSW platform development. This was noticeably not mentioned during the meeting, despite information being in the public domain, so it is not clear if this is progressing.

Hyundai representatives stated during the meeting that they are looking for a small success to prove floating OSW technology, and then they expect the market to take off. At this point, Hyundai will make firm plans for its participation in the sector. In the long term, Hyundai is expecting to be an EPCI player.

In general, Hyundai is maintaining a low-level of activity in floating OSW, with a view to being well-placed when a more concrete market emerges. Hyundai is confident it can deliver a floating turbine system, when needed, based on its extensive experience of floating O&G platforms; from what was observed during the mission, this appears to be the case. Areas outlined by Hyundai where it may require support included: dynamic cabling, sub-sea installation, and cost analysis of floating OSW.

2.2.5 Key barriers to delivery of floating OSW development in South Korea

The government has high ambitions for OSW in South Korea and interest in the sector is growing fast. However, there are a few issues that may slow development and prevent its 12 GW target being met. These are outlined below:

Lack of coordination on consenting and leasing	This is a general issue facing all OSW development in South Korea. The consenting process is complicated and opaque. It requires the cooperation of four, often conflicting authorities: local government, Ministry of Oceans and Fisheries, local authorities and the Ministry of National Defence. Criteria for acceptance or rejection are not clear.
Local turbine supply	At present there is considerable political pressure to use local turbine suppliers. Forcing the use of local turbines, while potentially beneficial in the long term, will potentially damage the planned projects in three ways: 1. Cost of turbines – South Korean turbines are typically 10-15% more expensive compared to similar turbines in Europe. 2. Size of turbines – The largest turbines available from domestic suppliers in South Korea are around 5 MW. This compares to around 10 MW in Europe. Falling costs for OSW in Europe have been driven by increasing turbine sizes. Until a South Korean turbine manufacturer can reliably produce a larger turbine, these cost benefits cannot be realised. 3. Increase project technology risk – South Korean turbines do not have the same track record as European-developed turbines. These increase both project risk and cost of investment.
Cost of floating OSW	Globally the cost of floating OSW is significantly higher than fixed-bottom OSW. As a less mature technology, it is much earlier on the cost reduction curve. Commercial developers will favour development of cheaper fixed-bottom sites before floating sites, with a commitment to the development of floating sites only becoming firm when fixed-bottom sites become significantly constrained. Costs are expected to fall significantly as mass deployment is achieved, but it is likely to need additional support from governments to overcome this initial barrier.
Local acceptance	Throughout the mission, concerns were raised about objections to OSW farms both from residents and, perhaps more significantly, from the fishing community which is a strong lobbying group in South Korea. Regulators and developers were keen to understand how local objectors were managed in the UK.

2.2.6 South Korean floating OSW R&D landscape

South Korea has a strong focus on R&D and is amongst the top spenders on R&D as a percentage of GDP in the world (ranked second by OECD in 2015). There is great emphasis on R&D into manufacturing rather than driving future technology trends[4]. Floating OSW R&D has been very much driven at regional level by the City of Ulsan and industrial partners in the region, as discussed in section 2.2.3.

The table below outlines the key stakeholders which are involved in floating OSW R&D or could be significant in supporting the growth of interest in this sector.

National institutes	Korea Institute for the Advancement of Technology (KIAT)	Korea Institute of Science and Technology (KIST)	Korea Institute of Energy Research (KIER)
	KIAT is a quasi-governmental organisation that reports to MOTIE. It is similar in function to Innovate UK and is the primary public R&D funding organisation in South Korea.	KIST is a public research institute based in Seoul. It has a wide-reaching international partnership scheme and a European centre in Germany. Its remit covers a wide range of areas from green cities to neuroscience.	KIER is an R&D organisation that focuses on energy technology R&D, including wind energy. It is partially government- and partially commercially-funded.
Regional organisations	Technoparks		
	Technoparks are incubator-type organisations that provide a supportive, subsidised environment for local industries and start-ups. The parks are a national initiative but are operated by local government. Of particular note for floating OSW is Ulsan Technopark, which is active in supporting the growth of the sector in the region.		
Industry	Large industrials		SMEs
	South Korean industry is dominated by chaebols and other large corporations, and the vast majority of applied R&D carried out in South Korea is delivered within these organisations. Most of these corporations have internal R&D institutes. For example, Hyundai has a corporate research centre which includes an offshore systems research institute and an energy systems research institute. In addition, it has business division research institutes in marine and energy systems. At present, it has a low level of activity in floating OSW in Hyundai. KEPCO, the largest utility also has a substantial R&D programme focusing on OSW technology and deployment.		Little evidence of innovation with SMEs was presented during the mission. This aligns with dominance of the large corporations. However, efforts are being made, through the Technopark initiative to support the growth of innovative SMEs in the country as this has been recognised as a development risk for the country.
Universities	Ulsan University has a significant amount of early stage floating OSW concept design and is also heavily involved in the Ulsan demonstration projects (see case study). No evidence was present of significant activity in any other universities in South Korea.		

Other than the University of Ulsan wave tank (see case study) no other testing sites were discussed during the mission.

However, wind component testing facilities are believed to be available in the Gyeongnam, led by the Korean Institute of Technology, and in Jeonnam. These are suitable for the current generation of South Korean OSW turbines but are unlikely to be suitable, with their facilities, for larger European scale >10 MW OSW turbines[5].

The key demonstration sites for floating OSW are based in Ulsan and are outlined in section 2.2.3.

[4] https://www.ft.com/content/99450bd8-ba71-11e7-bff8-f9946607a6ba
[5] More information can be found at: http://www.energy.or.kr/renew_eng/new/bed.aspx

Case study: University of Ulsan

The University of Ulsan is leading much of the research into floating OSW in South Korea. It has a range of R&D programmes on floating OSW, from early TRL academic programmes to leading the deployment of demonstrator turbines off the coast of Ulsan. It is also active in international projects and floating OSW standard development. It is leading the taskforce developing the IEC's international standards on floating OSW turbines.

Key areas of R&D being carried out at the university include:

- development and testing on a range of technologies including semi-subs, spar buoys and cone buoys
- development of in-house floating OSW system analysis codes
- development of autonomous-SOV for O&M on floating OSW farms
- floating positioning systems
- floating OSW ship refuelling stations
- OSW turbine development.

Alongside general engineering labs, the University of Ulsan also has a large wave tank (30 m × 20 m × 2.5 m). The tank was built in 1998 and has been used extensively for floating OSW concept model testing.

2.2.7 R&D Funding landscape

Limited information was provided to the mission about funding for R&D as the relevant funding stakeholders were not engaged. However, it is believed there are three key sources of funding of R&D in South Korea:

LEVEL OF SPEND

INDUSTRY	In 2017 around three-quarters of funding for R&D in South Korea came from industry sources.
KIAT	KIAT reports to MOTIE and is the primary public R&D funder in South Korea. It is not known how funding is allocated or distributed.
CITY GOVERNMENTS	City governments have budget to support local R&D organisations that promote economic development in their region.

Funding for floating OSW R&D seems to have come primarily from the Ulsan City Government, with some central government funding towards large demonstrator costs. No evidence was presented of any strategic programmes of funding aimed at floating OSW.

2.2.8 Focus of South Korea floating OSW R&D sector

During the mission, the following were highlighted as areas of R&D activity on floating OSW.

	Focus areas		Activity level	Level of capability in South Korea compared to UK
Technology development	Turbine development		High	Higher
	Floating platform development	Spar buoys	High	Same
		Semi-subs		
		Cone buoys		
	Design tools for floating systems		Medium	Same
	Installation technology		Medium	Same
	Mooring systems		Medium	Lower
	Dynamic cabling		Low	Lower
	O&M technology (ROVs, monitoring)		Low	Lower
	Future floating system concept – energy islands		Low	Same
Enabling R&D	Wildlife impact and monitoring		Medium	Lower
	Port optimisation		Medium	Higher
	Cost reduction strategies		Medium	Lower
	Understanding local benefit		Medium	Lower
	Stakeholder management		Medium	Lower
	O&M Strategies		Low	Lower
	Technology demonstration and performance monitoring		Low	Lower

2.3 Conclusion on the South Korean Floating OSW Market

The South Korean OSW sector is still in its early stages. The government has big ambitions for the development of the sector, which is reflected in strong targets and good financial incentives for OSW. This is driven primarily by the perceived economic benefit of OSW in areas with a declining shipbuilding industry.

The 12 GW deployment target has led to growing international interest in the South Korean OSW sector from both developers and investors. However, there are substantial barriers to achieving the target, mainly the lack of clarity and consistency on the consenting and leasing process and strong local stakeholder objections. As it stands, it is difficult to see South Korea meeting its target.

No commercial-scale floating OSW farms have been deployed in the country, so the market appears to be slightly less advanced than the UK. However, South Korea is progressing its activities in floating OSW and has the strong industrial base required to build the supply chain in the region.

Almost all floating OSW activities in South Korea are being driven from the City of Ulsan. The city has developed – and is successfully deploying – a very clear roadmap for demonstration and delivery of floating OSW. While not without its challenges, progress to date has been good, and there is clearly a high level of buy-in from both public stakeholders and relevant industrial players at all levels.

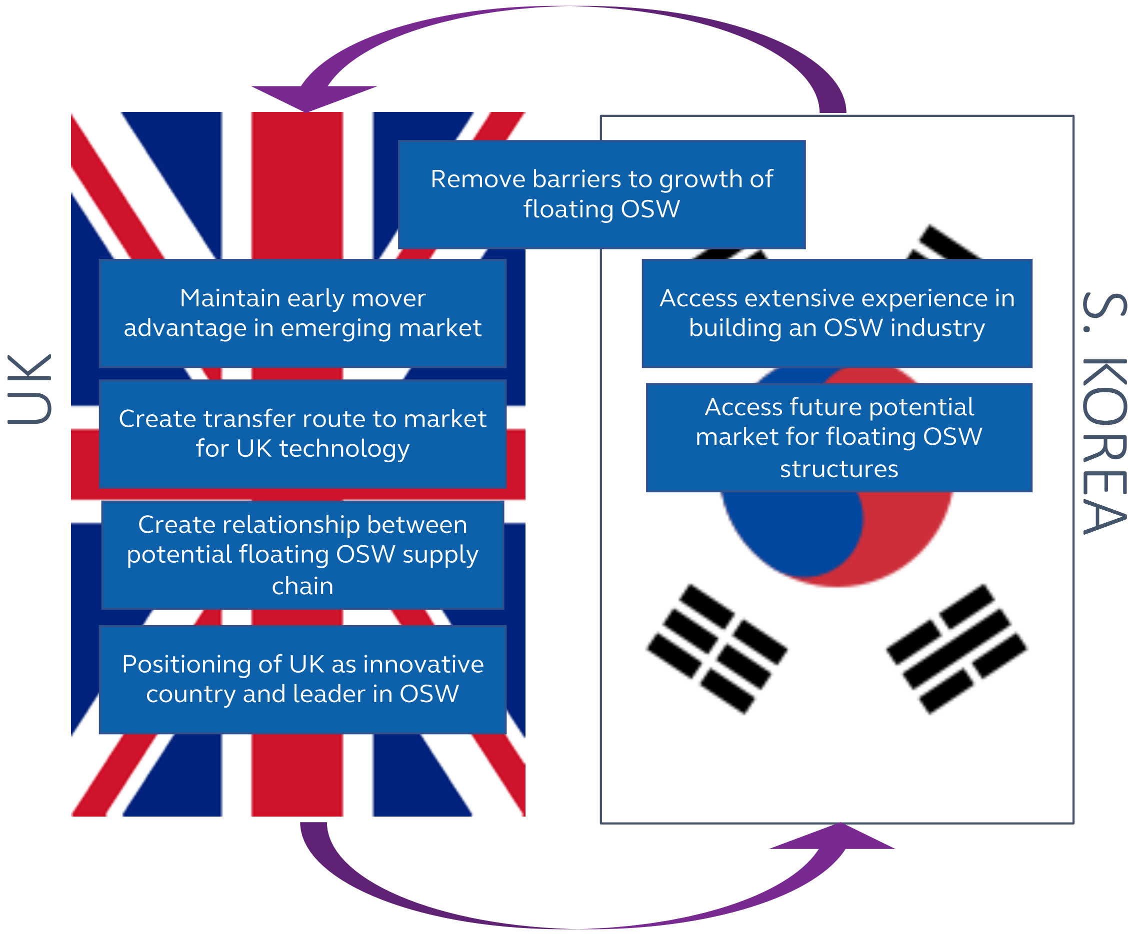
While the South Korean OSW market is far less developed than the UK's, South Korea and the UK are at a broadly similar stage in terms of development. The UK has addressed many of the challenges around process and regulation for OSW that is being faced by South Korea, but the technical and environmental challenges faced by both industries are very similar.

2.4 Potential for Collaboration between South Korea and UK on Floating OSW

This section of the report examines the benefits, opportunities and mechanisms for collaboration with South Korea on floating OSW R&D.

2.4.1Potential benefits of collaboration

The key benefits of collaboration with South Korea are outlined in the figure below.



How South Korea and the UK can share mutual benefit from collaboration

Remove barriers to floating OSW deployment
Both the UK and South Korean floating OSW markets are in their infancy. Both countries need to take significant commercial, policy and technology steps before floating OSW is a viable and investable alternative to fixed-bottom OSW. There are two main ways collaboration between the UK and South Korea can remove barriers to floating OSW development and move both industries forward: 1. Information and data sharing – by sharing the information gained from demonstrators and through R&D, the growth of the sector can be expedited in both countries. Of particular importance is creating a global track record for floating OSW, to give investors and governments the confidence that the technology is technically and commercially viable. 2. Pooling resources and capabilities to address key sector challenges – many of the barriers to floating OSW are common between the UK and South Korean floating OSW sectors. The opportunity exists to pool resources and capabilities to solve these common issues, which are highlighted in the section overleaf.

Why the UK can benefit from collaboration with South Korea

Maintain early mover advantage in emerging market
Direct opportunities for UK companies and innovators in South Korea are limited due to the immaturity of the market and the significant barriers in place for market development. However, at some point, South Korea is likely to have a large OSW market. The immaturity of the market means that other countries, such as Denmark and Germany, have not made the same effort to build formal relationships in the sector as in other emerging markets such as China, the US and Taiwan. This provides an opportunity for the UK to gain a first-mover advantage and build strong relationships that can be converted to preferential access to opportunities as the market emerges.

Create a transfer route to market for UK technologies into floating OSW
South Korea has a substantial industrial base that can supply much of what is needed for floating OSW from its shipbuilding and offshore structures industry, but it lacks specialist expertise in some areas, particularly sub-sea operations. There is an opportunity to bring UK-based innovative companies, especially oil and gas companies, to South Korea to address key issues in the emerging floating OSW market, creating a later route to export.

Create relationships between potential OSW supply chain
The floating OSW supply chain is still being developed globally. Despite some countries having a strong industrial base, no single country is likely to have the companies to provide the range of products and services needed to produce a commercially-viable floating OSW supply chain. While this is potentially an export opportunity for the UK, as outlined above, it is also an opportunity for the UK to gain access to the technology and suppliers needed to bring costs of floating OSW down in the UK. In particular, the UK could benefit from the shipbuilding and large-scale fabrication expertise of the large industrial corporations in South Korea. Not only do building supply chain relationships have potential to expedite the UK floating OSW sector, ensuring the technology required is available at a reasonable cost, it also has the potential to create inward investment opportunities. Early R&D collaboration can be used to create the relationships that are needed between the UK and South Korea to explore more firm opportunities for supply, when they arise.

Positioning of UK as innovative country and leader in OSW
The floating OSW sector represents the cutting edge of innovation in the OSW sector. A demonstration of capability and interest in this sector, sends a clear message to South Korea (and other countries) that the UK is looking to maintain its global leadership position in OSW innovation.

Why South Korea is keen to collaborate with the UK

Access extensive experience in building an OSW industry
As discussed, the South Korean OSW market is immature and still has a lot of policy and technical challenges to be addressed. The South Korean stakeholders are looking to build relationships with the UK to understand how the UK overcame these barriers in order to stimulate their domestic market.

Access future potential market for floating OSW structures
South Korean stakeholders recognise that they have world-class capabilities in the design and manufacture of ships and offshore structures that can be transferred to floating OSW. The UK represents one of the most promising early markets for floating OSW globally. Collaboration with the UK at this stage could create opportunities for export or joint ventures within the UK market, as it emerges. Access to the UK market and key stakeholders can be facilitated through collaborative R&D activities.

2.4.2 Synergies

The UK is substantially ahead of South Korea in establishing and deploying an OSW market. However, South Korea and the UK are in a similar position in terms of market development of floating OSW. Neither country has yet achieved full scale (<100 MW) commercial deployment. The UK is ahead in terms of deployment, with a small-scale commercial farm in operation, but South Korea has a clearer route to full-scale commercial demonstration through its Ulsan projects.

Figure 4 below illustrates the steps required to bring OSW technology to market in South Korea and highlights the areas where the UK and South Korea have complementary strengths. South Korea has the finance needed for both R&D and project development. It also has much of the technical know-how for the transition to floating wind and a strong plan for development of demonstration facilities and some world-class test facilities. The UK could bring its extensive experience in deploying OSW to any collaborative technology development programme, which is lacking in South Korea. It also has complementary test facilities and technical knowledge that could support activities floating OSW in the country.

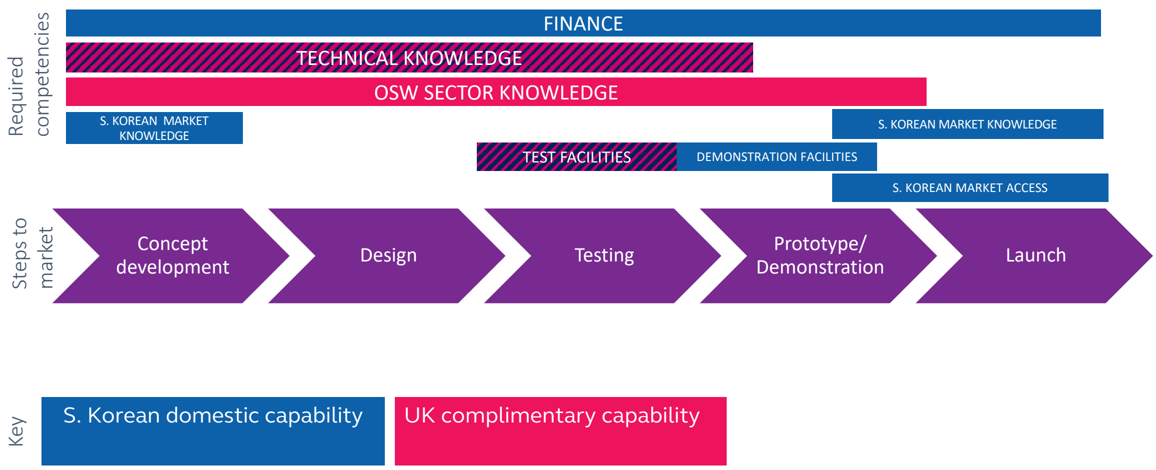


Figure 4: Summary of the UK and South Korea strengths in delivering OSW technology to market

2.4.2.1 Synergies in delivery mechanisms

The primary mechanism for delivery of applied innovation in floating OSW appears to be through government-funded turbine system demonstration programmes, delivered by selected consortia of relevant domestic industry and academia. It is not clear how consortium members are selected, but there was no indication that this was through open competition. The presence of Ulsan Technopark at the mission meetings also suggests that incubation services are available for smaller innovative companies in the sector.

It should be noted that the national-level R&D funding and delivery organisations were not present during the mission, so there was limited visibility of mechanisms used by these bodies. However, there is evidence of a track record of competitive calls for technology funding in the energy sector in South Korea through schemes like Mission Innovation[6].

This large-scale publicly-funded demonstration approach is different to the UK, which focuses on specific technology issues such as mooring or installation. Both approaches have value: the former allows the industry to build a track record, building stakeholder confidence; the latter uses resources efficiently to solve key challenges.

[6] See http://mission-innovation.net/2018/08/27/new-call-for-international-energy-joint-rd-projects-launched-by-south-korea/

2.4.2.2 Existing mechanisms for collaboration between South Korea and the UK

There is no precedent for collaboration between South Korea and the UK on OSW but there is an existing, if limited, track record of collaboration between the two countries on energy innovation. Wider bilateral trade agreements are in place, but do not specifically focus on R&D.

UK/South Korea Policy Exchange Seminar

The mission coincided with a UK/South Korea Policy Exchange Seminar coordinated by RenewableUK.

This event brought together South Korean and UK OSW stakeholders aiming to share the UK's experience in building an OSW industry with South Korea.

UK-South Korea Smart Energy Innovation Collaboration

The UK-South Korea Smart Energy Innovation[7] was launched in 2018. The competition had a value of £6 million and allowed UK companies to apply for funding for smart energy solutions in collaboration with South Korean companies. The funding was provided by BEIS, MOTIE and the Korean Institute of Energy Technology Evaluation and Planning (KETEP).

MOU with Korean Trade-Investment Promotion Agency (KOTRA)

In October 2018, a bilateral trade and investment MOU was signed between South Korea and the UK. This was aimed at ensuring ongoing partnership with South Korea post-Brexit, and a commitment to continue to work closely in developing collaborative business opportunities after the UK has left the EU. It is not known what agreements will be in place post-Brexit, but it is expected a trade deal will be reached.

[7] For more information see https://ktn-uk.co.uk/events/webinar-briefing-uksouth-korea-bilateral-collaboration-on-smart-energy-innovation

2.4.3 Areas of technical synergy in floating OSW

Shown below are potential areas for collaboration between the UK and South Korea.

	Focus areas	Potential for collaboration	Korea Institute of Energy Research (KIER)
Floating OSW technology	Mooring systems	High	Highlighted by South Korean industrial and public sector stakeholders as areas for collaboration. There is a lack of capability in South Korea, which corresponds well with the capabilities within the UK oil and gas sector.
	Dynamic cable systems	High	
	Installation technology and methodology	Medium	Reducing the complexity and cost of both installation and O&M is a common technology challenge in all floating OSW markets. Installation and O&M methodologies are very technology-dependent. If different platform technologies become dominant in the UK and South Korea (e.g. the UK adopts TLP and South Korea adopts spar buoys), the opportunity for collaboration will be reduced.
	Technology for improved O&M	Medium	
	Floating platform development	Low	There is extensive work being carried out in South Korea on floating platform development. Stakeholders are confident these can be delivered by South Korean companies without support.
Removing consenting barriers	Monitoring and managing impact on fishing industry	High	Both the UK and South Korea consenting bodies need to understand how floating OSW will impact the fishing industry and how this can be mitigated. Sharing data and studies could be beneficial to both countries.
	Marine mammal avoidance and monitoring	High	Both the UK and South Korean consenting bodies need to understand how floating OSW will impact marine mammals, compared to fixed-bottom OSW, and how any impact can be mitigated. Sharing data and studies on this could be beneficial to both countries.
	Managing local stakeholder objections	Medium	South Korean stakeholders are interested in learning how the UK manages objections from local stakeholders. The UK can share best practice in this area, but it is not an area for collaborative R&D.
	Radar impact mitigation	Low	OSW radar interference was raised as an area of concern in South Korea. The UK has extensive capabilities in this area, but collaboration in this area may cause concerns about national security, a sensitive issue in the region.
Developing markets and policy	Cost reduction strategies	High	Both the UK and South Korea need to drive down the cost of floating OSW in order to create a viable market. Capabilities from the UK in O&M and OSW operation and South Korea's experience in manufacturing large offshore structures are both hugely valuable in this process.
	Port capability studies	Medium	There may be some benefit in sharing best practice on portside infrastructure development, but it is likely to be fairly technology and site-specific.
	O&M strategies	Medium	There is stated interest from South Korean stakeholders in working with the UK on O&M strategies for floating OSW. This is a key challenge for the sector. However, many of the associated challenges are likely to be technology and site-specific. If mutual challenges can be found, both countries could benefit from activities in this area. South Korea's activities are, at present, mainly focused on the development of infrastructure. Focus on O&M is likely to happen once the technology concepts are proven.
	Local economic benefit evaluation	Medium	South Korea is interested in learning how the UK maximises economic benefit from OSW. There may also be lessons the UK can learn from South Korea on building an industrial base.

2.4.4 Key South Korean stakeholders for collaboration on OSW

The following table summarises the likely key stakeholders for any UK/South Korean collaboration in floating OSW and the level of interest shown.

Stakeholder		Level of interest in collaboration
National institutes	In South Korea, at present, there appears to be only a low level of interest in floating OSW within the national institutes. However, they are included in this list, as if a national level bilateral programme is to be pursued, these organisations are likely to be key funding and delivery agents. Interest in the sector within the institutes may increase, given the ambitious targets set by the government and the expected growth in the sector. A watching brief should be kept.	NONE OBSERVED
Ulsan City	Ulsan City is driving the floating OSW agenda in South Korea and supporting both R&D and demonstration of floating OSW technology. It should be considered a high-potential delivery partner for B2B collaboration.	HIGH
Ulsan University	Ulsan University is leading academic activities in floating OSW. It is actively pursuing international collaboration on floating OSW and should be considered a preferred academic research partner. It is keen to collaborate with the UK in some way but did not suggest mechanisms.	MEDIUM
Large corporations	As discussed, larger South Korean corporations will be the delivery vehicle for floating OSW in the country. They are also likely to be the primary funding mechanism for relevant R&D. Hyundai is based in Ulsan and is active in the floating OSW demonstration in the region. After positive initial engagement during the mission, it appears to be a potential partner for collaboration. It expressed an interest in collaboration with the UK oil and gas sector in key areas (particularly BOP and O&M issues).	MEDIUM

2.4.5 Barriers for collaboration

The key barriers to forming beneficial collaboration with South Korea are listed below.

Lack of maturity in South Korean OSW market	The main focus of activities is in establishing an OSW sector, rather than developing innovative solutions. There are enough fixed-bottom OSW sites in South Korea to allow the market to get established, and this is where the limited resources and capabilities in the country are being spent. Therefore, accessing resources needed for projects focusing on longer-term technology and commercial floating OSW challenges may prove to be a barrier to bilateral collaboration.
Lack of confidence in the South Korean OSW sector	There is still significant uncertainty about the potential size and rate of growth of the floating OSW sector in South Korea. Other Asian OSW markets, such as China and Taiwan, appear to have less market uncertainty and therefore are more attractive to innovative companies in the UK looking to invest in the region. It may be difficult to attract interest from companies looking to invest in collaborative R&D in South Korea, with a view to establishing a market presence.
Lack of confidence in potential floating OSW sector	In both the UK and South Korea there is a lack of confidence that floating OSW can achieve price parity with fixed-bottom OSW. Therefore, deep water sites may remain uneconomical to develop. This reduces the level of interest in investing in and supporting floating OSW.
Cultural differences	With most international collaborations, cultural barriers can hinder successful working relationships. Challenges likely to be experienced by UK companies looking to collaborate with South Korea include: • Lack of knowledge about South Korea – South Korea is a very unfamiliar country to many people in the UK. Most people are unaware of how to do business in South Korea and may be intimidated by the prospect of engaging with the country. • Language barriers – very few UK people speak Korean. While the level of English in the country appears to be moderate, translators were needed for most meetings. • Quick deal culture – unlike much of Asia, South Korean culture drives business stakeholders to look for a quick deal or result and then move on. Floating OSW is unlikely to produce quick results in South Korea; therefore, it may be difficult to sustain the interest of South Korean stakeholders within a long-term collaboration environment.

3. Japan

3.1 Japanese Market Landscape

3.1.1 Market size

The Japanese OSW industry is in its infancy, compared to Europe. No sizeable windfarms are in place, with only small-scale R&D or demonstration turbines operational. Notably this includes the Fukushima FORWARD floating demonstration project. By the beginning of 2019, just over 20 MW of OSW projects had been built in Japan. Higher figures have been quoted (up to 71 MW), but these include shoreline projects which are not considered to be fully offshore.

The Japanese OSW market is still very small, with only 20 MW installed. However, recent improvements in the development process mean that rapid growth in the sector is expected.

While the market is small, a clear roadmap and process for development are in place to increase the installed capacity over the coming decades.

There are around 5.4 GW of projects in the planning system. The figure below gives an indication of the current and planned OSW projects as of February 2018. They are clustered around the northwest, southwest and central east of the country.

	Installed		Under EIA	
Ocean	Goto (Floating)	2 MW	Tsugaru (3 areas)	1000 MW 500 MW 480 MW
	Fukushima (Floating)	14 MW	Happo-Noshiro	180 MW
	Choshi	2.4 MW	North Akita	455 MW
			Yuri-honjo	1000 MW
			Mutsu Bay (2 areas)	800 MW 80 MW
			Yasuoka	60 MW
			Enoshima	240 MW
			Sakiyama (floating)	22 MW
Port area	Kitakyushu	2 MW	Ishikari	104 MW
			Mutsuogawara Bay	80 MW
			Noshiro Port	100 MW
			Akita Port	70 MW
			Kitakyushu Port	220 MW
Total	Installed: 20.4 MW		Under EIA: 5391 MW	

In addition to those presented above, other projects in the pipeline include Ørsted and Tepco's joint plans to expand the Chosi site.

3.1.2 National targets

In 2018 the government set a target of 1.7% of energy generated from wind power by 2030. This would equate to 10 GW of OSW. The target has been widely criticised for being unambitious. Much higher targets are in place for both hydroelectric and solar generation (see Figure 5).

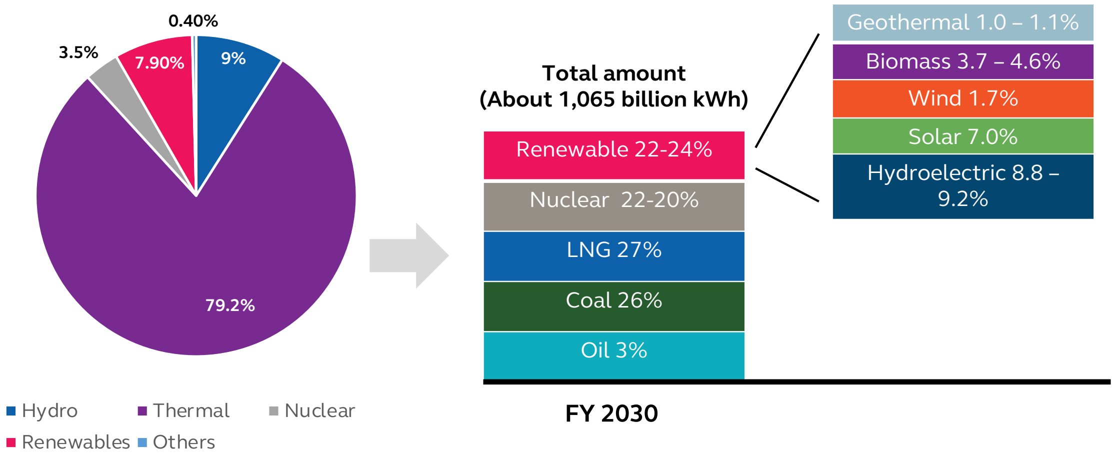


Figure 5: Sources of electricity generated in FY2017 and target composition of power sources FY2030

The 1.7% (10 GW) target is expected to be broken down into 6 GW fixed-bottom and 4 GW floating OSW as shown in the figure opposite.

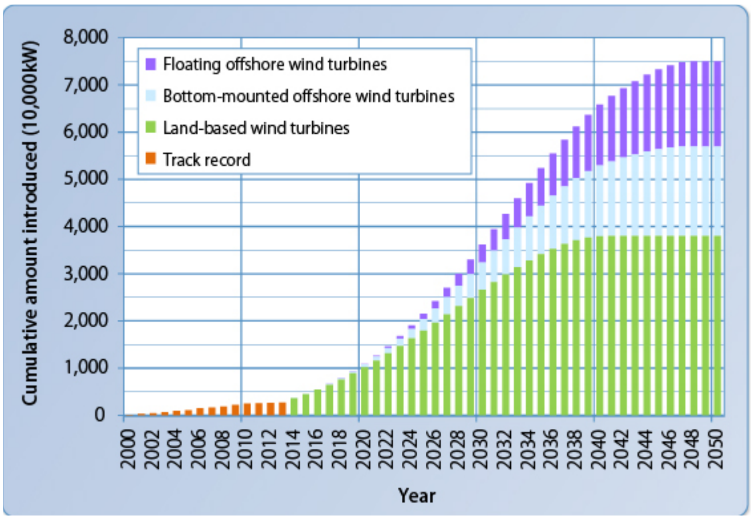


Figure 6: JWPA Wind capacity projections

By 2050 the Japanese Wind Power Association (JWPA) believes Japan can deliver around 10% of energy generated from OSW, but this is an aspiration rather than a firm target.

3.1.3 Key drivers for OSW development in Japan

The key drivers for the development of OSW in Japan are outlined in Figure 7.

PRIORITY

1. Safety	The accident at the Fukushima Daiichi Nuclear Power Station in 2011, increased interest in non-nuclear generation to "safer" forms of energy generation, including OSW. Safety has been highlighted as the most import pillar of the 5th Strategic Energy Plan. However, it is expected that nuclear generation will increase again to 2011 levels over the next decade.
2. Energy security	The reduction in the nuclear programme, following Fukushima, has led to increasing demand for imported fossil fuels from the Middle East in recent years. Japan is now the largest importer of LNG in the world and use is increasing. The share of LNG in Japan's energy mix rose from 28% in 2010 to 39% in 2017. This is seen as an unsustainable position, and there is a desire to reduce reliance on these imports. As outlined previously, the drive to increase OSW is a small part of a wider programme to support a range of renewables.
3. Carbon reduction	Environmental impact is outlined as one of the four pillars of the 5th Strategic Energy Plan. This includes carbon reduction. Japan's Nationally Determined Contribution (NDC) to the Paris Agreement is to reduce greenhouse gas emissions by 26% from 2013 to 2030. Renewable energy, including OSW is part of this drive. This is mainly driven by the recent move away from nuclear to fossil fuels.
4. Jobs and economic development	Initial activity in OSW, particularly in the Fukushima region was driven by local economic regeneration after the tsunami in 2011 when many coastal industries were decimated. OSW was seen as an immediate way of bringing industrial development back to the region. However, although there was some mention of economic benefit by stakeholders during the mission, there did not appear to be the same level of emphasis as seen in other emerging OSW regions such as South Korea, China and the US.

Figure 7: Key drivers for OSW deployment in Japan

Figure 7: Key drivers for OSW deployment in Japan

3.1.4 Key policies and mechanisms supporting OSW in Japan

Listed below are the key mechanisms implemented by the Japanese Government.

MECHANISM	SUPPORTING POLICY/SCHEME
Clear commitment to OSW by Japanese government	5th Strategic Energy Plan The 5th Strategic Energy Plan was issued in 2018 and presents the basis of Japan's energy policy towards 2030 and further onwards to 2050. Up to 2030, the plan aims to develop an optimal energy mix, based on four pillars. **Strategic Energy Plans Four Pillars '3E's + S'** Safety Energy Security Economic Efficiency Environmental Impact The plan to 2050, focuses on energy transitions and decarbonisation. The plan addresses renewable energy in two main ways: • Reaffirmation of a commitment to a target of 22-24% of generation from renewable energy sources by 2030. It should be noted that only 1.7% of this is expected to be wind energy. • Supporting the development of world-leading technology required to promoting OSW power generation.
Financial incentive mechanisms	Feed in Tariff Scheme for Renewable Energy Japan initiated its Feed in Tariff (FIT) in 2012 replacing the previous RPS scheme. This provides a guaranteed fixed cost for energy generated from renewable energy. The purchase price is re-examined each year but has been consistent at ¥36/kWh (equivalent to approximately £0.25/kWh) between 2017 and 2019. This represents a very generous Feed in Tariff and should stimulate growth of the industry in Japan. A contract for OSW is awarded for 20 years. The scheme was amended in 2017 so generation projects require a grid connection and appropriate construction, operation and decommissioning plans to be in place before FITs are approved.
Provide clarity of process of OSW development	Act of Promotion of Utilisation of Sea Areas in Development of Power Generation Using Maritime Renewable Energy Resources This Act sets out to remove several of the key barriers to development of OSW in Japan. It: • Allows windfarm operators to lease selected sites for 30 years (previously sea areas could only be occupied for 3-5 years). • Promotes the use of territorial waters as opposed to port/harbour areas for the development of renewable energy. This is important, as ports and harbours are covered by local development legislation but only account for 1.5% of Japanese territorial water. • Sets out "Promotion Zones" where OSW development can be undertaken. • Establishes guidelines for the tender process for leasing of the projects within the Promotion Zones. • Outlines the process by which tenderers will compete to secure development rights in the zones. The first round of bidding under the new legislation is expected to take place in spring/summer 2019.

Can Japan deliver its targets?

Prior to 2018, the Japanese OSW sector had been struggling to get established due to lack of development process and clarity on financial support mechanisms. However, the long-awaited Act of Promotion of Utilisation of Sea Areas in Development of Power Generation Using Maritime Renewable Energy Resources (the OSW Act), sets out very clearly the route for OSW project development in Japan. Japan's 10 GW target for OSW is relatively modest compared to other emerging OSW markets but does give a clear go-ahead to the industry.

The new legislation combined with a generous FIT support scheme means that the key barriers to OSW development have been removed. It is therefore likely that development of the OSW sector will accelerate over the next decade and could potentially meet the proposed targets. However, two key barriers present concerns to OSW stakeholders in Japan:

- Grid connection remains inadequate for large scale OSW.
- Powerful stakeholders, particularly the fishing industry, still have the ability to prevent windfarms being developed.

These are outlined in more detail in section 3.2.4. It is yet to be seen if the relatively modest targets are strong enough to attract significant international interest, but early indication suggests that they may be.

3.2 The Japanese Floating OSW Landscape

While still in its early stages, the Japanese floating OSW market is one of the most advanced in the world. It has three floating demonstration projects operational: Fukushima (14 MW), Chosi (2.4 MW) and Goto (2 MW), and a further 22 MW project in planning (Sakiyama).

All stakeholders engaged by the mission acknowledged that Japan will have a floating OSW market. Estimates of when floating OSW will be first commercially deployed varied from 2020 through to 2030.

The need for floating OSW for the Japanese market, and Japan's leading position, is recognised by the Japanese Government. As a result, the need for investment in the technology is outlined in the 2018 Act promoting OSW development in the country. Industrial stakeholders also acknowledge the need for floating OSW. However, estimates of when it will be commercially viable range from 2020 through to 2030.

After an initial flurry of activity in floating OSW in Japan, following the Fukushima disaster of 2011 the level of activity took a downturn, partly due to the perceived lack of success of the Fukushima demonstrator, and partly due to overall challenges with OSW development in the country. However, recent legislation has reinvigorated the Japanese OSW sector. While the sector is focused on securing the fixed-bottom OSW market, there is a strong recognition that to grow the industry to the 2050 targets, floating OSW needs to be developed. There is also a recognition amongst key stakeholders that Japan can capitalise on its position as a market and technology leader in this area.

3.2.1 The need for floating OSW

The OSW environmental conditions in Japan are as follows:

Water depth	Very deep waters close to shore. 80% of OSW resources are located at a depth greater than 100 m.
Wind regime	The wind regime varies from 6.5-8.5 m/s at 80 m, with the highest wind speeds being achieved in the north of the country. This is lower than those typically seen in the UK. Japan experiences regular typhoons, in summer and early autumn, typically over 20 per year.
Distance from shore	Most windfarms built to date are less than 5 km offshore, with the exception of the Fukushima FORWARD floating demonstration project, which is 16 km offshore. The five “port” projects under development will also be close inshore. Those labelled “General Area” development are less than 20 km offshore. This near-shore development is impacting issues around stakeholder engagement, which has largely been overcome in Europe as windfarms have moved further offshore.
Other notable conditions	Japan experiences regular earthquakes. This can impact OSW farms in two ways: • During an earthquake, the seabed experiences liquefaction, which turns the ground fluid. • Earthquakes can cause tsunamis, which can damage OSW farms.

The conditions in Japan lend themsleves favourably to floating OSW. The rapid increase in water depth to >60 m to the east of the country means there are limited shallow water development sites, driving the need for floating OSW.

In addition, floating OSW technology could overcome some of the challenges around earthquakes and tsunami resilience in Japan. Gravity-based floating foundations should be less affected by liquefaction than monopiles. Floating OSW also allows building in deeper water, which can be less impacted by tsunamis than development on the coastal shelves.

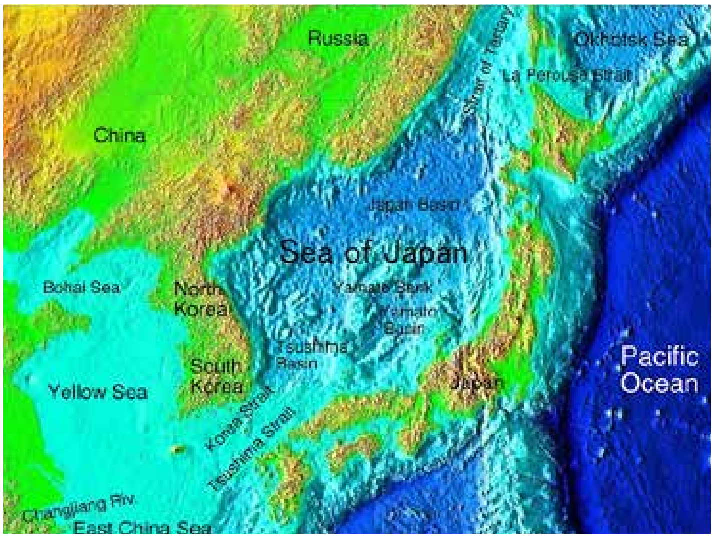


Figure 8: Water depths in Japan

3.2.2 Floating OSW technology development and deployment in Japan

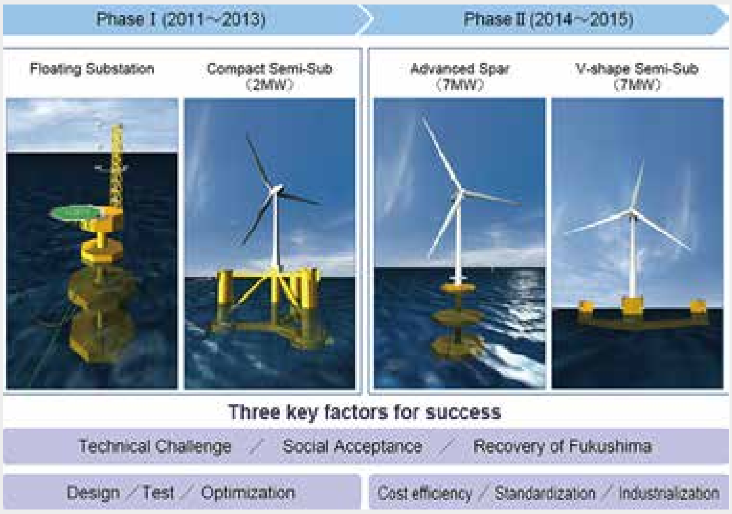
The following table outlines the level of deployment or interest in the key technology elements in South Korea and how these compare to activities in floating OSW in the UK.

	Deployment/interest in Japan	Comparison to the UK	Similarity of focus
FLOATING STRUCTURE	A range of floating structure technologies have been demonstrated or are under development in Japan, including: • Hybrid spar • V-shape semi-subs • Compact semi-subs. There appears to be no activity on Tension Leg Platform (TLP) systems. Both concrete/steel structure and pure steel structures are under development. To date most platforms have been developed to support non-specific downwind turbines, but the use of downwind turbines is not expected to continue. The early hybrid spars that were installed have developed a significant track record (90% utilisation for over seven years). However, Japan lacks the deep-water ports needed for economic spar installation, therefore other technologies may become more dominant moving forward.	Japan and the UK have very similar approaches and requirements for floating platforms. Both Japan and the UK: • Have started development by progressing and demonstrating spar buoys but there are questions about the viability of large-scale deployment in the country, lack of deep-water ports. • Are considering semi-subs as an alternative to spar buoys. • Are developing turbine-agnostic platforms that can be used with any turbine models. TLP solutions are not being considered in Japan at the moment. This is possibly because they do not offer the same resistance to earthquakes and tsunamis offered by the other technologies.	HIGH
TURBINES	Unlike other emerging OSW markets, Japan does not have a significant domestic supply chain for turbines and therefore does not appear to be driving any specific turbine technology. Stakeholders understand the need for >10 MW scale turbines to reduce costs, and there is a drive to scale up platform design to accommodate larger turbines. Floating OSW demonstrators are currently at 2-7 MW. TODA and other organisations have used downwind turbines to date on their floating structures. These are no longer available at OSW scale since Hitachi pulled out of the sector. This will have a significant impact on the platform design moving forward.	The UK also does not have a significant domestic supply chain for turbines, therefore remains turbine-agnostic. The Hywind site uses 6 MW Siemens turbines. The planned Kincardine site is expected to use the 9.5 MW Vestas turbine, which is on a par with fixed-bottom sites in the UK but ahead of Japan in terms of turbine size. The UK is not working on platforms for downwind turbines. Under current circumstances, it is unlikely that Japan will take this route forward.	MEDIUM
BALANCE OF PLANT	Japan United Marine developed a floating sub-station for use in Fukushima, using the advanced spar concept. Quaternary mooring chains were used at Fukushima, but general opinion of stakeholders seems to be that this solution was over engineered and expensive, so a new approach is needed. There is little interest in HVDC as the projects are all close to shore.	The UK has no direct experience in developing floating OSW sub-stations, although this is technology that will be needed as the floating OSW progresses. The Hywind project has an onshore sub-station. There is interest in HVDC cables for floating OSW in the UK as sites will be located far from shore so can benefit from this technology.	MEDIUM

Case study: Fukushima FORWARD floating demonstration project

The Fukushima FORWARD floating demonstration project is often considered globally as a flagship project for floating OSW development. However, this contrasts hugely to the attitudes to the project in Japan encountered during the mission.

The initial phase of the project was 100% funded by METI. The primary aim was to demonstrate a route to economic regeneration in the Fukushima region following the tsunami in 2011 and to demonstrate a proactive move away from nuclear energy, following the nuclear accident in the region. The project installed three floating turbines and a floating sub-station, using a variety of floating OSW technologies.



Many large Japanese industrial companies were involved in the development of the site. The consortium comprises:
- Furukawa Electric Corporation
- Hitachi Ltd
- Japan Marine United Corporation (substation)
- Marubeni Corporation (project integrator)
- Mitsubishi Corporation, Mitsubishi Heavy Industries
- Mitsui Engineering & Shipbuilding
- Mizuho information & Research
- Nippon Steel & Sumitomo Metal Corporation, Ltd
- Shimizu Corporation
- TODO Corporation
- University of Tokyo (technical advisor)

Fukushima FORWARD is not considered a success for two reasons:
- **Performance** – MHI stated that the capacity factor of their MHI 7 MW turbine on the site is less than 5%. As a result, the turbine is going to be decommissioned. This poor performance is due to the failure of the innovative hydraulic drive train system. Mitsui's installation was more successful with a 32% capacity factor.
- **Cost** – While the question of cost was raised a number of times on the mission, no one was prepared to give indicative costs for the Fukushima project. However, all stakeholders indicated that costs were very high, and several orders of magnitude above what they need to be, despite considering the early stage of technology development.

The general opinion was that the Fukushima project was not well thought-out and was initiated with only a short-term, economic regeneration objective in mind. As a result, sadly, it appears the demonstration project has done more harm than good to attitudes to the floating OSW sector in Japan. The judgement on the project seems a little harsh given that, while not cost effective, it has demonstrated the viability of some key floating OSW technologies. However, in Japan, stakeholder engagement suggests it has potentially set back the development of the industry by several years.

3.2.3 Japanese floating OSW stakeholders

As with South Korea, the immaturity of the floating OSW sector in Japan (and globally), means that it is not possible to differentiate between commercial deployment stakeholders and R&D stakeholders. This is reflected in the stakeholders outlined in this section.

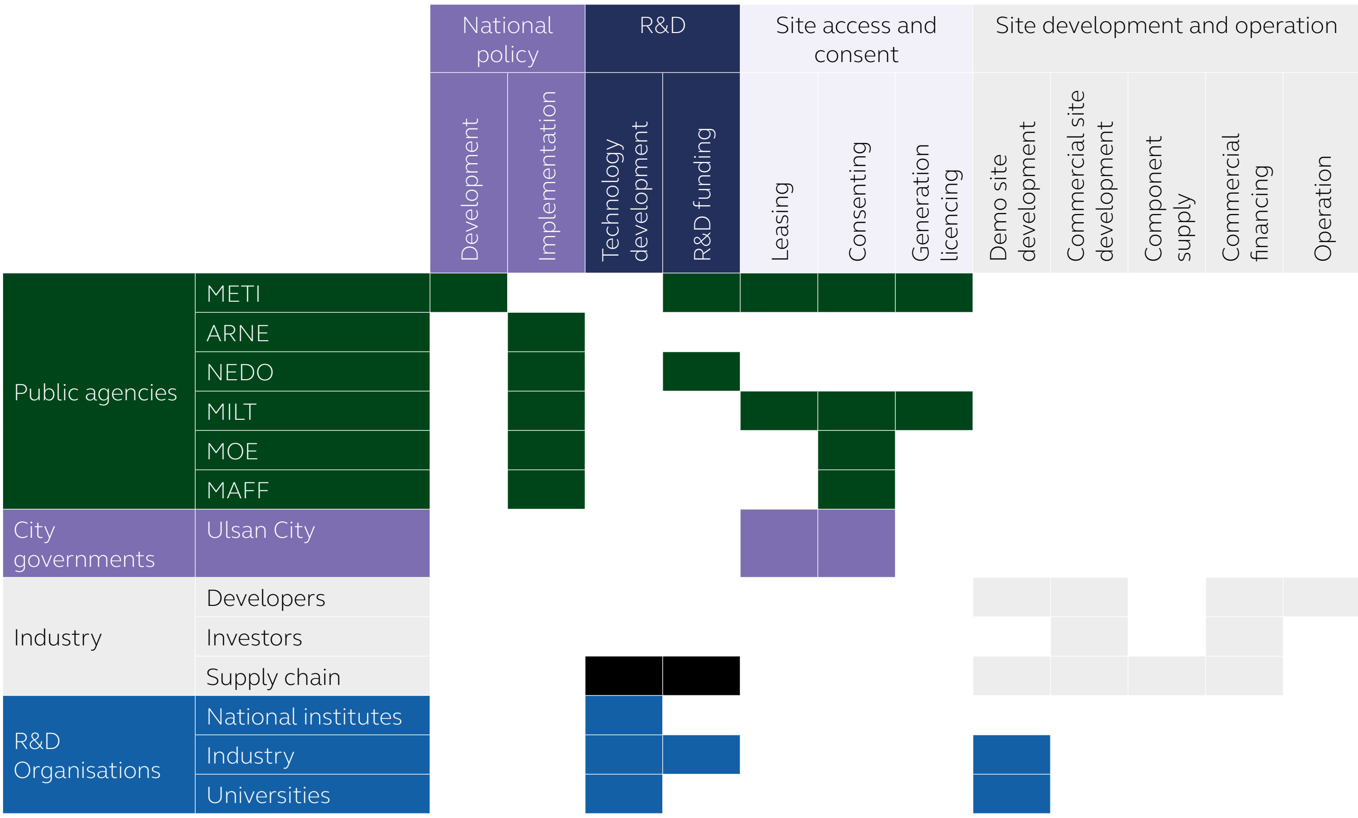


Figure 9: Roles of stakeholders within the Japanese floating OSW sector

The following tables show the stakeholders relevant to floating OSW development in Japan.

Public agencies engaged in OSW deployment		
Policy	Ministry for Economy Trade and Industry (METI)	METI is the primary agency that supports energy policy in Japan. Its role is to develop the Japanese economy through supporting industry and building trade relationships. It has a wide range of policy responsibilities, including energy. Within METI there are a number of departments relevant to OSW including the Electricity and Gas Market Surveillance Commission and ANRE. It can be considered as comparable to BEIS. METI is the most influential government stakeholder. Three key roles: • Certification of the PPAs and grid connection agreements that allow OSW developments to progress • Designation of Promotion Areas for OSW development • Coordination of auction for the allocation of sites. Historically METI's activities have been focused on PV and solar and more recently on hydrogen and CCS, but they stated to the mission that OSW is of high interest.
	Agency for Natural Resources And Energy (ANRE)	Part of METI, ANRE has responsibility for developing and implementing Japan's policies regarding energy and natural resources.
	New Energy and Industrial Tech-nology Development Organisation (NEDO)	See R&D stakeholders section below.
	Ministry of Land, Infrastructure, Tour-ism and Transport (MILT)	Government ministry involved in the setting of Promotion Zones. MILT has responsibility for several relevant areas including transport and shipping, and the coastguard. It also has a role in the coordination of auctions for development sites.
	Ministry of the Environment	The MOE sets the process for and reviews the environmental impact of development sites.
	Ministry of Agriculture, Forestry and Fisheries (MAFF)	A cabinet-level ministry responsible for, amongst other things, the Japanese fishing industry. It is heavily influential in designating Promotion Zones and ensuring consent is provided.
Regional and local agencies	City governments	Municipal governments have authority over projects in "Port and Harbour" areas. They act as mediators, ensuring stakeholders are aligned and have responsibility for consenting. Mayors of relevant municipal areas and governors of prefectures are also statutory consultants when designating promotional zones.

INDUSTRY

Developers	Project Investors
The level of interest from both domestic and international developers has increased significantly since the beginning of 2018. Ørsted, EDPR and Equinor have increased their level of activity in Japan to explore opportunities in the more favourable climate. Local developers such as Hitachi Zosen and Mitsui are also acquiring development rights in the region. Due to the immaturity of the floating OSW sector in Japan, the role of pure developer is not widespread. Most of the floating OSW development is being carried out by potential technology providers or supply chain companies, as most projects under development are demonstrators or pre-commercial, and there is no clear route to large-scale commercial projects. This development is often through large consortiums of key elements of the supply chain. This is likely to change as the industry become more established.	There is significant interest from Japanese investors in OSW both in Europe and Japan. Companies like Marubeni and Mitsubishi have been investing heavily in Europe and are starting to focus their attention back on their domestic markets. While they are primarily investors, they also play an active role in the development and operation of sites. Floating OSW projects are some way from being bankable for mainstream investors. The majority of investment in the floating OSW technology comes from companies looking to demonstrate technology, potential supply chain companies and the government.

Supply Chain

In general, there is a push for local supply, although it was noticeably lower on the agenda than other emerging OSW markets in Asia and the US. The Japanese have been stung by the PV market, where high FIT tariffs have been offered but almost all the equipment required for development has been imported, therefore showing very little local economic benefit. Industry, in particular, is keen that this is not repeated in OSW. However, the balance between cost and economic benefit is also realised and cost is likely to play the greatest factor in this development of the Japanese supply chain.

<table>
<tr><td>Wind turbine manufacturers</td><td>Hitachi was the only Japanese company with a viable product for the OSW sector, but in 2019 it announced it would stop production and focus its OSW activities on O&M and services provision, and supply through its partner Enercon.

MHI Vestas is partly owned by Mitsubishi Heavy Industries (MHI). However, the technology and manufacturing facilities come from the Vestas side, with MHI providing financial backing. It is therefore inaccurate to characterise MHI Vestas as a Japanese company.

It can be assumed that, for the foreseeable future, Japan will need to import turbines to develop the OSW industry. The new legislation brought in, in 2018 has caused an increase in interest from European turbine manufacturers, most notably MHI Vestas and Siemens.</td></tr>
<tr><td>Floating structure suppliers</td><td rowspan="4">The supply chain in Japan is dominated by large industrial companies such as Japan Marine United Corp, Hitachi, Mitsui E&S, MHI and TODA. These large, integrated companies can provide a range of integrated services to the sector, including:
- Technology and project investment
- Structural and systems design and engineering
- Design and supply of electrical infrastructure
- Design and fabrication of large offshore structures
- Offshore construction and installation
- Offshore maintenance.

It can be assumed that, if the large industrials were to engage fully in the sector, they would be able to dominate the Japanese supply chain and provide turnkey solutions for the floating OSW lifecycle. TODA has stated this as its intent for the Japanese and international markets. For export, there is an option to transport floating structures manufactured in Japan to other Asian markets. However, local manufacturing would be needed in Europe or US to exploit these markets.

Most activity by the large industrials has focused on the Fukushima FORWARD floating demonstration project. There has been limited activity following this project. Most appear to be keeping a watching brief or a low level of activity in the area.

More specialist European supply companies appear to be making an impact in Japan. In particular, those identified during the mission were IDEOL, a French floating platform supplier, which has engaged in a number of the demonstration projects and Wood, a Scottish-based consultancy and LIDAR supplier.</td></tr>
<tr><td>Balance of plant</td></tr>
<tr><td>Installation and O&M contractors</td></tr>
<tr><td>Specialist support services</td></tr>
</table>

Case study: Mitsubishi Corporation Power

The Mitsubishi Corporation Ltd (Mitsubushi) is the largest trading and investment firm in Japan. It has more than 77,000 employees in the parent company and its subsidiaries. The power section of the business covers a wide range of activities including generation asset development and operation, electricity retail and trading. It carries out OSW development through its Diamond Generating subsidiary. To date it has a stake in four OSW projects in three European countries:

- UK – Moray Firth (950 MW)
- Belgium – Norther (370 MW)
- Netherlands
    - Luchterduinen (129 MW)
    - Borselle 34 (737 MW)

Mitsubishi is expanding its operations in renewables and has a strong interest in growing its OSW portfolio both in Europe and Asia. Representatives engaged by the mission recognised the need for floating OSW in Japan (by 2020 in their opinion). Mitsubishi was engaged in the Fukushima FORWARD floating demonstration project, but has not been actively developing R&D in floating OSW since. However, representatives expressed a keen appetite for collaboration with OEMs, government and other elements of industry to progress the sector.

3.2.4 Key barriers to delivery of floating OSW development in Japan

A number of substantial barriers to development in OSW in Japan have been removed in the last six months allowing the sector to move forward. A slow, fragmented consenting and planning regime and lack of clear energy policy (post-Fukushima incident) have been cited as reasons for the slow start to the Japanese OSW industry. However, the OSW Act in 2018 has set out a clear strategy and process, including outlining development zones (see section 3.2.3). This is building industry confidence and provides a clear and expedited path to development.

Despite this progress, there are still significant barriers to rapid growth of the Japanese OSW market and there was clearly still some frustration amongst industrial stakeholders about efforts to remove these remaining barriers. The key remaining barriers identified during the mission are outlined below.

Stakeholder	Lack of stakeholder acceptance impacts the development of OSW in two key ways: • General government support – to date, solar has received more focus and a higher level of support than wind in Japan. This has its roots in concerns about public acceptance of wind. Solar is seen as more acceptable and less environmentally damaging. • Specific inability to gain consent – stakeholder issues can prevent consent being given at specific sites. The group that causes most concern to the OSW industry is the fishing lobby. It is a very powerful lobbying group in Japan and still has the ability to block windfarms. This is of particular concern for floating OSW as it is likely to have a greater impact on fishing areas than fixed, since it will need a much larger exclusion zone. A group has been set up to coordinate interaction between key stakeholders, but it is not yet clear how effective this will be.
Costs	METI stated that the Japanese Government is not likely to be able to meet the very high FIT level to 2030. Cost reductions will be needed, and FIT levels will need to be reduced. This is a particular challenge for floating OSW where costs are still significantly higher than fixed-bottom.
Environmental conditions	Deep water, typhoons, lightning strikes, strong ocean currents, and the risk of earthquakes and tsunamis create some significant challenges for Japan over and above the issues encountered in Europe. R&D work is being carried out, and it is thought that floating OSW may have increased resilience against some of these conditions.
Grid availability and costs	The grid network is unsuitable for transmission of renewable energy, especially in the region of Tohoku (where fixed-bottom is feasible), which has no remaining capacity. The grid is operated by independent power companies. These regional utilities have their own agenda, and to date have been very focused on large scale nuclear and thermal generation. Within these utilities there is little appetite for making the changes needed to accept more variable and offshore generation onto the grid. Efforts are being made to change this, both through improved coordination and through the new "Connect and Manage" scheme, aimed at making better use of existing grid infrastructure. As a result, changes to capacity calculations have freed up 374 MW of grid capacity, but this is not enough to support large scale OSW development.
Facilities for assembly and manufacture	Stakeholders highlighted the lack of port infrastructure large enough for the assembly of floating OSW structures in Japan. This was a challenge for Fukushima, where the devices needed to be towed a significant distance before being partially assembled close to site. Significant investment may be needed to realise economic benefit from manufacturing and servicing floating devices.

3.2.5 Japanese floating OSW R&D landscape

Activity in floating OSW R&D peaked in Japan between 2011 and 2015 during the delivery of the Fukushima project. They have since declined, particularly amongst industrial stakeholders. However, with new emphasis being put on OSW following the change in legislation in 2018, it is likely that the level of activity will increase moving forward.

The floating OSW stakeholder landscape appears to be relatively simple in Japan, with METI providing funding for a limited number of university research projects and NEDO providing funding to large corporations to deliver floating OSW development and demonstration. Other R&D delivery organisations are likely to become involved if interest in the sector increases. The following organisations have been active in supporting or delivering floating OSW R&D in Japan or have the potential to do so in the future.

National institutes	New Energy and Industrial Technology Development (NEDO)	
	NEDO was established to promote the development of new energy technologies to increase energy diversification. It supports R&D in energy technologies, including OSW and industrial technology, often bringing together a consortium of industrial partners to deliver projects. It supports technology from concept development through to demonstration and commercialisation. It is, in many ways, comparable to Innovate UK. NEDO is involved in a floating OSW project. In August 2018 NEDO pulled together a consortium to demonstrate a 3 MW floating OSW turbine in the Port of Kitakyushu. NEDO has a wider range of technology development collaborations globally, including one in heat pumps in the UK but none are listed for OSW. However, representatives stated to the mission that they have had engagement with Innovate UK and ORE Catapult.	
Regional organisations	There was no visibility or mention of regional R&D organisations during the mission. It is not known if this was due to the mission engagement strategy or because there are not significant regional R&D bodies.	
Industry	Industry	SMEs
	Large corporations have been the primary delivery mechanism for floating OSW R&D in Japan to date. They have been instrumental in developing the Fukushima FORWARD floating demonstration programme, which represents the majority of floating OSW R&D efforts in Japan. However, it would be unwise to use this as an indicator of their commitment to R&D in the sector. The majority of activities have been fully- or majority-funded by public funds. There is also likely to have been significant political pressure on companies to be seen to be supporting government economic generation efforts at Fukushima. The level of effort from industry has significantly reduced since that time.	There was little evidence gathered during the mission of SMEs being active in the floating OSW sector. It appears, from evidence presented, to be heavily dominated by large corporations. NEDO does work extensively with SMEs in other sectors and collaborative R&D programmes could be used to engage SMEs in the sector.
Universities	University of Tokyo – Department of Civil Engineering The University of Tokyo is running a project to develop a floating OSW system. The project aims to: • Establish design methodology for floating OSW for Japanese conditions (particularly typhoons, earthquakes and tsunamis) • Development of O&M methodology • Economic evaluation of floating OSW. The university was also part of the Fukushima OSW consortium. The university was not available for discussions during the mission. University of Kyoto The University of Kyoto leads a joint research project with TODA Corporation for the development of a 2 MW demonstration turbine at Goto City.	

During the mission and subsequent research, no dedicated OSW or floating OSW component testing facilities were identified. However, Japan has been proactive in developing floating OSW demonstration programmes. Two of the key demonstration projects in Japan are:

- Fukushima FORWARD – See case study in section 3.2.2
- Kitakyushu project – In August 2018, NEDO announced it was supporting a consortium to demonstrate a new floating turbine. The consortium consisted of: Marubeni, Hitz, Glocal, Eco Power, Tokyo University, Kyuden Mirai Energy. The turbine being used is a 3 MW supplied by German company Aerodyn and it is being floated on a platform from French company IDEOL. The turbine is now installed and being commissioned. The project will run until 2022.
- Goto City Demonstration site – In 2013 a 2 MW floating turbine was installed off the coast of Kabashima, Goto City, by the TODA corporation, in collaboration with Kyoto University.

3.2.6 R&D Funding landscape

In 2014 Japan was the world's third most R&D-intensive country, spending 3.59% of GDP on it. There is a target to increase this to 4% (the equivalent of around $246 billion) by 2020. Much of the R&D spend in Japan comes from industry with 20% of the top global R&D spenders located in Japan[8].

To date, the majority of R&D spend in floating OSW in Japan appears to have come from the public sector, mostly to deliver large fully-funded demonstration programmes. The public sector R&D funding routes in Japan are outlined in the figure below. The majority of funding for OSW R&D comes either from NEDO, or for larger initiatives, such as the Fukushima FORWARD floating demonstration project, the funding came directly from METI.

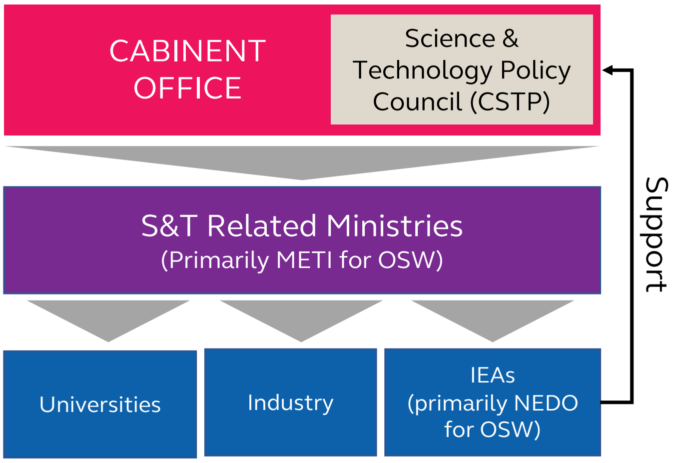


Figure 10: Structure of public funding support in Japan

3.2.7 Focus of Japanese floating OSW R&D sector

During the mission, the following were highlighted as areas of R&D activity on floating OSW.

	Focus areas		Activity level	Level of capability in South Korea compared to UK
Floating OSW technology	Wind turbines		Low	Same
	Floating platform development	Spar buoys Semi-subs	High	Higher
	Dynamic cabling		Low	Lower
	O&M technology (ROVs, monitoring)		Low	Lower
	Installation technology		Low	Lower
	Turbine/platform interface		High	Same
	Mooring systems		Low	Lower
Enabling R&D	Wildlife impact and monitoring		High	Lower
	Port optimisation		Low	Higher
	Cost reduction strategies		High	Lower
	Stakeholder management		High	Lower
	O&M Strategies		Low	Lower
	Tech demonstration and performance monitoring		High	Lower
	O&M Strategies		Low	Lower
	Technology demonstration and performance monitoring		Low	Lower

[8] Innovate UK, Future Cities Catapult – Japan Country Overview and Innovation Ecosystems.

3.3 Conclusion on the Japanese Floating OSW Market

In 2018, the Japanese Government brought in legislation that promotes OSW development in the country. This is expected to mark a changing point in the Japanese OSW sector. The targets set by the government are modest, with the focus of energy policy remaining on solar. However, the new legislation removes several key barriers to OSW development, particularly around consenting and site allocation. There is a very strong FIT to create a strong market pull. These combined have been enough to re-stimulate interest in the market.

In the mid-term, the Japanese OSW market is likely to become heavily reliant on floating OSW, due to deep water conditions and the frequency of earthquakes. This is recognised by all stakeholders in industry and government. However, there is a significant amount of fixed OSW capacity that is likely to be built first before the floating OSW market takes off.

This puts Japan in a similar situation to the UK, although Japan lacks the background experience and capability in fixed OSW on which to build its industry. While the need for floating OSW is acknowledged, there is some scepticism amongst stakeholders as to the cost-effectiveness of the technology. This has been primarily caused by the perceived lack of success of the Fukushima demonstration project.

As a result, Japan is looking to Europe to assess the way forward for floating OSW, and as confidence in other floating OSW markets grows, Japanese interest in the sector is likely to follow.

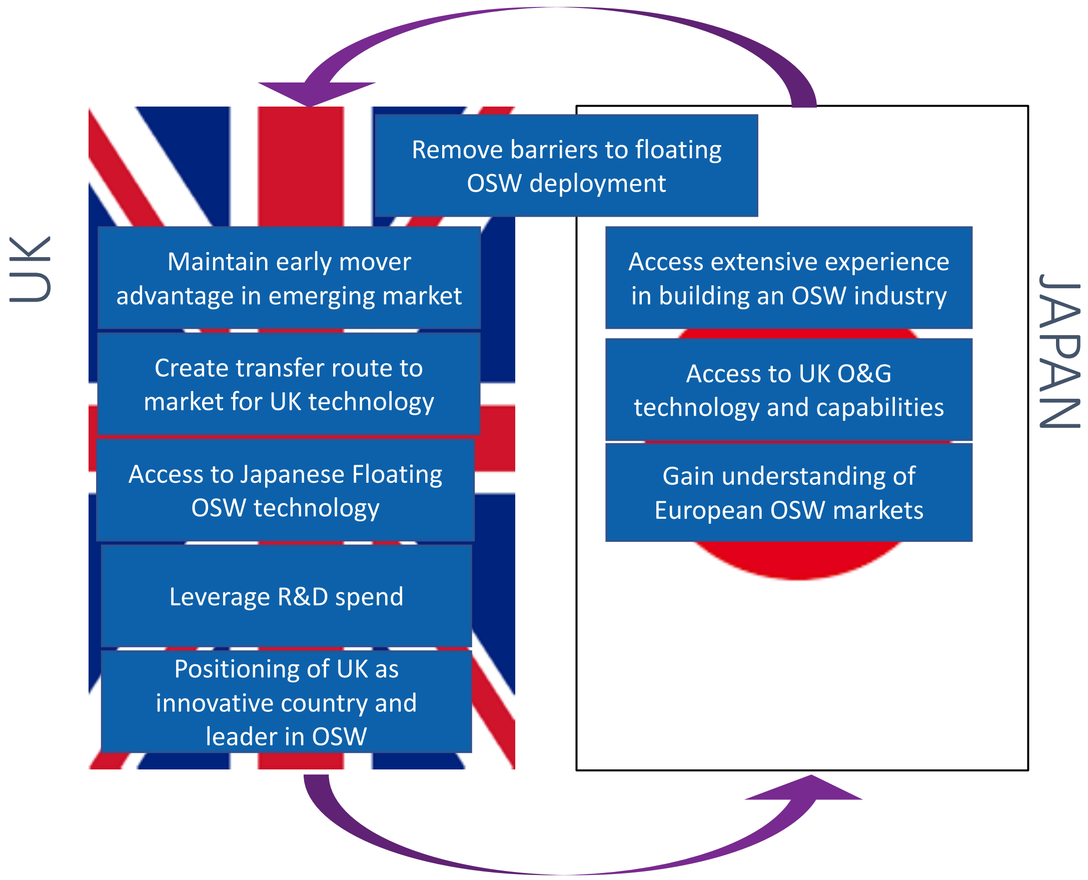
Despite current challenges, it is likely that, over the next two decades, Japan will become a leading market for floating OSW.

3.4 Potential for collaboration between Japan and the UK

This section of the report examines the benefits, opportunities and mechanisms for collaboration with Japan on floating OSW R&D.

3.4.1 Potential benefits of collaboration

The key benefits of collaboration with Japan are outlined in the figure below.



How Japan and the UK can share mutual benefit from collaboration

Remove barriers to floating OSW deployment

Neither Japan nor the UK has an established floating OSW industry, but both recognise the importance of the technology to deliver mid-term OSW targets. Both countries have clear policy and process to deliver OSW, but floating OSW raises some additional challenges in terms of cost, installation, O&M, structural design, manufacturing and environmental impact that have not been addressed by the fixed-bottom wind sector. Stakeholders in the government, investors and the supply chain need to be provided with reassurance that these have been addressed before the market can significantly progress.

Like South Korea, there are two main ways that collaboration between the UK and Japan can remove these barriers to floating OSW development and grow industry confidence.

1. By sharing the information gained from demonstrators and through R&D, the growth of the sector can be expedited in both countries. Of particular importance, is creating a global track record for floating OSW, to give investors and government's confidence that the technology is technically and commercially viable.

2. Pooling resources and capabilities can expedite the development of solutions for many of the barriers to floating OSW that are common between the UK and Japanese floating OSW sectors.

Why the UK can benefit from collaboration with Japan

Maintain early mover advantage in emerging market

The Japanese OSW market is still in its very early stages; however, the changes in legislation in 2018 mean that it is expected to grow rapidly over the next decade. This should produce opportunities for UK companies to export to the region. As the upturn in the market is recent, the country has not, historically, attracted significant attention from the international OSW community. As such, the UK can be considered to have an early mover advantage into a potentially exciting market. This is likely to change rapidly, but there is a short-term opportunity to capitalise on initial relationships to consolidate the UK's position as a preferred partner for OSW in Japan.

Create transfer route to market for UK technologies into floating OSW

Unlike in many Asian emerging markets, Japanese stakeholders recognise it has limited capacity in some key sectors of the floating OSW supply chain, particularly large-scale fabrication and offshore operations. It recognises that in these areas, it will need to import technology and services. There is, therefore, an opportunity to bring UK-based innovative companies, and in particular, oil and gas companies to Japan to address key issues in the emerging floating OSW market, creating a later route to export.

Access to Japanese floating OSW technology

The primary barrier to floating OSW deployment in the UK is cost. Finding the most cost-effective technology has to be a global priority for the sector. Japan has developed and tested more floating OSW concepts than the UK and has large industrial corporations with the ability to further develop and refine these concepts. The elements of the technology solution that are needed to allow the UK floating OSW sector to become commercially viable could come from Japan.

Positioning of UK as innovative country and leader in OSW

The floating OSW sector represents cutting-edge innovation in the OSW sector. A demonstration of capability and interest in this sector sends a clear message to Japan (and other countries) that the UK is looking to maintain its global leadership position in OSW innovation.

Why Japan is keen to collaborate with the UK

Access extensive experience in building an OSW industry

While the Japanese Government has made significant steps in removing key barriers to OSW deployment in the country, some barriers, particularly around stakeholder acceptance and cost remain. Japanese stakeholders are looking to build relationships in order to understand how the UK overcame these barriers to establishing a market.

Access to UK O&G technology and capability

As outlined above, Japanese stakeholders recognise that there are gaps in their national capability around offshore and sub-sea operations, due to a lack of domestic oil and gas market. They recognise this capability is available in the UK and has the potential to play a useful role in the development of the floating OSW sector in Japan.

Gain understanding of European markets

Japanese investors are very keen to get a foothold into European markets in order to gain understanding and identify/create future investment opportunities.

3.4.2 Synergies

The UK and Japanese floating OSW sectors are at a similar stage of development. Both countries have large scale demonstration/pilot projects in water. Both countries have requirements and interest in further developing the sector but lack a firm roadmap or strategy for development, although the UK is in the process of establishing one as part of the recent Offshore Wind Sector Deal.

The UK has an advantage over Japan, as it has two decades of OSW deployment experience, which can inform the development of its floating OSW sector. Japan has not yet had the chance to acquire this.

However, Japan can provide much of the expertise and facilities needed in order to bring new floating OSW technologies to the market. These are illustrated in figure 11 and include; finance for both technology and project development, a good level of technical knowledge and world-class demonstration facilities. The UK has core skills in OSW which complement Japan's gaps in expertise and facilities, including complementary technical knowledge, the experience of OSW deployment and good test facilities.

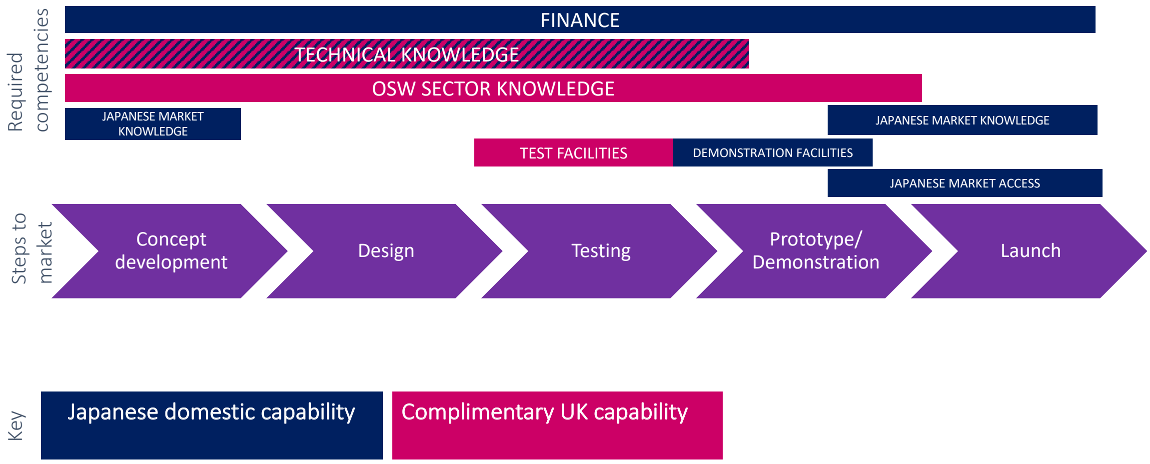


Figure 11: Summary of the UK's and Japan's strengths in delivering OSW technology into the Japanese market

In general, there are many synergies between Japan and the UK, including administrative systems, funding availability and market size. The market and support mechanisms appear relatively straightforward, compared with other emerging OSW markets. This makes the UK an attractive collaboration partner and should make it relatively straightforward to establish collaboration if both parties are committed to the process.

3.4.2.1 Synergies in delivery mechanisms

There are many similarities in innovation delivery mechanisms in the UK and Japan. NEDO, like Innovate UK, typically delivers competitive innovation calls for a business-led consortium to deliver solutions to specific technology challenges. Like the UK, Japan has a growing commitment to multilateral collaboration, through schemes such as Mission Innovation and the H2020 programme.

Like the UK, larger funds are occasionally provided, either by NEDO or METI, for specific one-off projects delivered by industry, such as floating OSW demonstrators. Funding and support are available for international collaborative initiatives, delivered through the Office of International Affairs.

3.4.2.2 Existing mechanisms for innovation collaboration between Japan and the UK

Japan and the UK are global strategic partners. In the period 2012-2016, the UK was Japan's second largest trading partner within Europe after Germany. The UK ranks as fourth amongst Japan's R&D partners, with almost 15,000 co-authored papers published between 2010 and 2014.

To date, there has been minimal direct OSW collaboration. However, there is a strong track record of collaboration in other sectors and at industrial strategy level. Some examples of the key existing initiatives to promote collaboration between Japan and the UK in science and technology are outlined below. There are no initiatives directly related to OSW at present.

Industrial policy dialogue

There has been a concerted effort to align Japanese and UK industrial strategy. The first step to delivering this was the Industrial Policy Dialogue in December 2017. The aim was to develop a platform on which to collaborate on shared challenges.

The meeting identified areas for further collaboration in five key areas; space, aviation, energy and climate change, advanced manufacturing and the bio-economy. A second meeting was held in December 2018. This led to the development of the Energy and Climate Working Group.

Energy and Climate Working Group

The Energy and Climate Working Group meets annually to discuss opportunities for mutually beneficial collaboration between Japan and the UK on energy and clean tech innovation. To date, discussions have focused on CCS and hydrogen, but no firm plans have been developed.

ESRC-AHRC UK-Japan SSH connection call

Launched in 2018, the call aims to improve connectivity between research communities, across social sciences and humanities. It funds researchers to build relationships and identify potential areas for collaboration, with a view to developing shared research agendas.

The programme is being supported by UKRI in the UK, which is providing £1.5 million in funding.

ESRC-AHRC UK-Japan SSH connection call

This call is aimed at supporting collaborative research projects between Japan and the UK in life sciences and environmental sciences. It encourages joint sharing of facilities and knowledge sharing.

UKRI is the coordinating authority for this call and is providing £5.2 million in funding.

3.4.3 Areas of technical synergy in floating OSW

METI stated that it was looking towards Europe to find policy and technology solutions for floating OSW in Japan in four areas:

1. Creation of system to de-risk projects.
2. Improving technology – turbine size, infrastructure.
3. Development of a sustainable supply chain.
4. Improve construction and operation methods.

Potential areas for collaboration between the UK and Japan are shown below.

	Focus areas	Potential for collaboration	Reason for rating
Floating OSW technology	Mooring systems and anchoring	High	Mooring, anchoring, and cabling systems were all recognised as key challenges in the UK and Japanese floating OSW markets. The UK brings extensive relevant sub-sea operational experience into any collaboration which could be usefully combined with data from the demonstration projects in Japan.
	Dynamic cable systems	High	
	Installation technology and methodology	High	Reducing the complexity and cost of both installation and O&M is a common technology challenge in all floating OSW markets. Installation and O&M methodologies are very technology-dependent but the requirements for these systems are expected to be similar in Japan and the UK. Japan is keen to work with the UK on sub-sea robots for floating OSW maintenance.
	Technology for improved O&M	High	
	Impact on turbine performance	Medium	Japanese stakeholders expressed an interest in sharing data to understand how attachment to a moving platform affects the long-term performance of turbines. This is a useful subject for both markets; however data may be hard to obtain in the UK as, unlike Japan, projects to date have not been publicly funded.
Removing consenting barriers	Floating platform development	Low	There has been extensive work in Japan to develop and demonstrate platform concepts, more so than in the UK, but the UK has transferrable skills that they could bring into a collaboration. Pooling resources to bring to market a concept that could be mass-produced at a reasonable cost would benefit both countries. However, there is confidence in Japan that the industry can deliver the platforms so there may be limited interest in collaboration.
	Monitoring and managing impact on fishing industry	High	Management of the fishing industry is a key concern for Japanese OSW stakeholder. It is likely to become a growing issue in the UK as it transitions to floating OSW. Both the UK and Japanese consenting bodies need to understand how floating OSW will impact the fishing industry and how any impact can be mitigated. Sharing data and studies on this could be beneficial to both countries.
	Marine mammal avoidance and monitoring	High	Both the UK and Japanese consenting bodies need to understand how floating OSW will impact marine mammals, compared to fixed-bottom wind, and how any impact can be mitigated. Sharing data and studies on this could be beneficial to both countries.
	Managing local stakeholder objections	Medium	Japanese stakeholders stated an interest in understanding how the UK engages with local stakeholders. The UK can share best practice in this area, but it not an area for collaborative R&D programmes.
Developing markets and policy	Cost-reduction strategies	High	Both the UK and Japan need to drive down the cost of floating OSW, in order to create a viable market and ensure stakeholder support. Identifying routes to cost reduction and developing frameworks for monitoring would be valuable.
	O&M strategies	Medium	Improved O&M strategies will be one of the key factors in reducing costs. Sharing learning and development of these strategies, and sharing experience on demonstrator projects would be beneficial to both parties.

3.4.4 Barriers for collaboration

The barriers to collaboration with stakeholders in Japan appear to be low. Some barriers remain and these are outlined below. Given the enthusiasm for collaboration from NEDO, none of these appear to be show-stoppers.

Lack of commitment to floating OSW from Japanese Government	The Japanese Government has not made any strong commitment to floating OSW to date. However, there appears to be ground level support from NEDO and the industrial base, which should allow collaboration to be initiated.
Negative perception of floating OSW in Japan	As discussed, floating OSW has had negative publicity following the high cost and technical issues at the Fukushima FORWARD floating demonstration project. This has damaged stakeholder confidence in the commercial viability of the floating OSW sector. This could impact the level of support that can be received for floating OSW collaboration.
Cultural differences	There are significant cultural and language challenges for UK organisations working in Japan. The formality of proceedings and the correct process must be observed, and it can take a significant amount of time to build the relationship and trust needed to create close collaboration. However, the UK has a track record of successful working with Japan on innovation, supported effectively by the Embassy and international trade organisations. This is, therefore, not considered to be an insurmountable barrier.

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