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Global Expert Mission US Offshore Wind 2018

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1. Welcome

Innovate UK's global missions programme is one of its most important tools to support the UK's Industrial Strategy's ambition for the UK to be the international partner of choice for science and innovation. Global collaborations are crucial in meeting the Industrial Strategy's Grand Challenges and will be further supported by the launch of a new International Research and Innovation Strategy.

Innovate UK's Global Expert Missions, led by Innovate UK's Knowledge Transfer Network, play an important role in building strategic partnerships, providing deep insight into the opportunities for UK innovation and shaping future programmes.

In this publication, we provide an overview of the findings from the Expert Mission to the US on offshore wind (OSW). During this mission, a delegation consisting of government representatives and industry experts travelled to New Jersey to meet key stakeholders from the emerging US OSW market.

DATE: 2-6 April 2018	LOCATION: Princeton, New Jersey
UK MISSION DELEGATES • Advent.re Ltd • Department for Business, Energy and Industry Strategy (BEIS) • Department for International Trade (DIT) • Innovate UK • James Fisher Marine Services • Knowledge Transfer Network (KTN) • Offshore Renewable Energy (ORE) Catapult • Science and Innovation Network (SIN) • Siemens Gamesa Renewable Energy Ltd	KEY US STAKEHOLDERS ENGAGED • Deepwater Wind • The Department of Energy (DoE) • GE Renewable Energy • Maryland state representatives (Department of Commerce and Energy Administration) • National Renewable Energy Laboratory (NREL) • New York State Energy Research and Development Agency (NYSERDA) • Ørsted • POWER-US • Pretti Strategies

The Expert Mission was timed to coincide with exciting developments in the US OSW market. These include:

1. An upsurge in interest in the potential of the US OSW markets

The last two years has seen a significant upturn in both global and domestic interest in the US OSW sector. This upsurge in interest has been driven by four key factors:

- Commissioning of Block Island Wind Farm, the US's first OSW farm, which came online in December 2016;
- Rapidly reducing costs of OSW deployment in Europe making OSW more cost-competitive against other energy sources;
- A downturn in oil and gas prices which has led to an increase in interest in diversifying into alternative energy sources by large oil and gas companies; and
- Increased adoption of carbon reduction targets across US coastal states.

2. Firm commitments to OSW from five key states

The increase in confidence in the ability of OSW technology to deliver a secure, low carbon energy source has prompted five states in the US to make specific policy commitments to procuring and supporting OSW during 2017-2018, totalling over 8 GW of capacity. There is also visible activity in OSW in eight other coastal US states.

The UK/US Treaty on Science and Innovation Cooperation

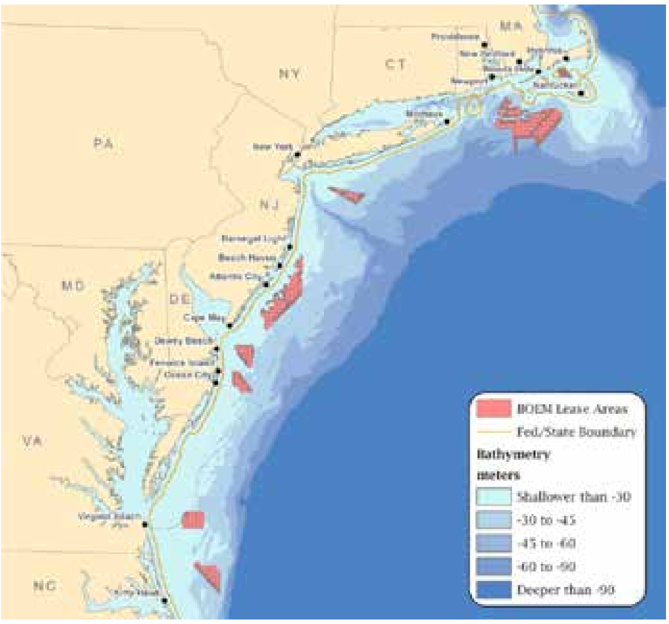
The timing of the Expert Mission also coincides well with the signing of a Science and Innovation Cooperation treaty between the UK and US in September 2017. It provides a high-level framework for science and technology collaboration, including support for any IP sharing arrangement between UK-US consortia.

2. US Market Landscape

2.1 Market Size

In December 2016 the US's first commercial OSW farm, Block Island Wind Farm, began generating off Rhode Island. Whilst only small, with a 30 MW capacity, it represents a significant milestone in the development of an OSW industry in the US. After a number of false starts over the last decade, there is growing confidence that Block Island represents the start of a much-anticipated boom in the US OSW market.

This is backed by the announcement of OSW-specific targets and incentive mechanisms by many Atlantic coastal states. Pacific states, namely California and Hawaii, are also seriously considering the prospect of future floating OSW projects.



Atlantic Outer Continental Shelf renewable energy leases.
Source: *BOEM 2018*

The increase in confidence in the market has been backed by the release of leases for OSW development sites, predominately by the Bureau of Offshore Energy Management (BOEM) and to a lesser extent by individual states. It has also led to the revitalisation of several projects that have failed to deliver to date, including Garden State and Empire Wind. Leasing rounds conducted to date, as well as those planned for 2018 and 2019, culminate in over 18 GW of capacity.

Although it is highly unlikely the total capacity of these leases will be constructed in the medium term, if at all, this huge figure gives an indication of the appetite for OSW in the US. In comparison, in 2017, Europe had a total installed OSW capacity of just over 15 GW.

The table below summarises the level of commitment to US wind.

US Commitment to OSW

Status	Capacity (MW)	States
Operational	30	RI
Commitment made to procurement by states (not including operational wind farms)	8,136	CT, MD, MA, NJ, NY
Leased/lease announced with no procurement commitment	16,461	MD, MA, NJ, NY, NC, OH, RI, TX, VA
Identified zones and unsolicited applications (no formal leasing process in place)	18,257	CA, HI, ME, MA, NJ, NY, SC

What OSW capacity will actually be delivered?
The figures in the tables above show a huge potential market waiting to happen; these figures are widely used in the US when discussing the buoyant market. However, it is important to be realistic about how many of these projects will progress to construction during the anticipated timeframe.

We know from experience in the UK that a significant number, potentially the majority, of the 16 GW of open leasing sites will not be developed. In the UK only 1.2% (400 MW) of the capacity leased since 2010 is currently generating, with 6% in construction. Lessons have been learnt during this process that the US can take on board, so the early stage of industry growth should be easier, but the percentage actually built can still be expected to be a fraction of that leased.

Whilst the 8.1 GW of state-procured capacity represents a firmer commitment, unforeseen barriers due to consenting and regulatory issues during project development are likely to cause delays in project delivery. There is also a potential risk to these projects from changes in political priorities.

Actual market predictions for the US market growth vary from a pessimistic 2.3 GW by 2026 by MAKE Consulting and 3-4 GW by 2030 by Bloomberg, to more optimistic 8.4 GW by 2030 by BVG Associates. These figures still represent a major ramp-up in OSW activities and the emergence of a major global market for OSW. The current influx of experienced European players in the US sector adds credibility to the optimism about market growth in the US that was lacking during early stage of the industry development.

2.2 Key Drivers for OSW Development in the US

OSW development is being driven by individual states and their priorities rather than through any federal policy. Supporting activity is in place at federal level through the BOEM and the Department of Energy, but this alone is not driving the industry. The drivers for OSW development in the US can be prioritised as Figure 1.

The drivers in the US are broadly the same as the UK, but are prioritised differently. The UK market is primarily driven by carbon reduction targets arising from legislation such as the Climate Change Act 2008, and from international commitments, such as the EU's signing and ratification of the Paris Agreement together with the associated Nationally Determined Contribution (NDC) for the EU bloc. Job creation and economic benefit are strong aspirations rather than key industry drivers.

Figure 1: Drivers for OSW industry development in the US

PRIORITY	Driver	Description
	1. Jobs and economic development	By far the biggest driver for states to support OSW development is jobs and economic development, with very high job creation targets being presented. For example, New York has stated that it hopes to get over 5,000 jobs from OSW by 2028, and Maryland is aiming for 7,000 jobs from their planned OSW developments.
	2. Reduction in carbon emissions	The secondary driver is carbon reduction. Many of the states promoting OSW have set ambitious carbon reduction targets through mechanisms such as the Regional Greenhouse Gas Incentive. These states see OSW as a part of the roadmap needed to meet these goals.
	3. Energy security (including CoE)	With ageing power plants in some states, there is a need for alternative energy sources and OSW is being considered as part of a stable generation portfolio.

Potential conflict: Local jobs vs. market stimulation?

The US OSW industry risks being caught between the strong drive for local jobs/economic benefit and the drive to grow the market rapidly and provide value to energy rate payers.

The fastest, lowest cost and lowest risk deployment option for the states developing OSW would be to import European developers and their experienced supply chains, potentially bringing key components from Europe. However, this could potentially severely limit the local economic benefit from OSW in the states and see political motivation for developing the industry diminish.

The most economically-beneficial option for the states would be to develop a US domestic supply chain for OSW; this is a widely-held aspiration. However, it is unlikely that the US domestic supply chain can build up or transition from existing markets in time to deliver the ambitious targets for development. The reality of this is already becoming evident as for some recent project tenders, no US companies bid for the key balance of plant (BOP) contracts. This option would either cause a pacing of industry growth, which is being encouraged by some US developers, or force developers to look to Europe for their supply chain.

In reality, to ensure a financially viable and politically supported long-term OSW industry in the US, a mechanism will need to be found to support both affordable market growth and local supply chain development. To deliver this, facilitation will be needed to ensure capabilities from Europe are transferred to support the growth of the potential domestic US supply chain. This can partially be achieved through inward investment in facilities. However, turbine manufacturers have articulated that they need around 100 turbines per year to warrant significant investment in facilities. Assuming that the average turbine size will be 10 MW and greater, as expected, the firm US market pipeline is not yet large enough to warrant this investment.

The UK opted for quick deployment and industry growth, as carbon emission reduction was the key driver, and this has led to dominance of mainland European players in the UK market and arguably limited the growth of a UK supply chain.

The balance found between these drivers is likely to be state-specific, depending on the mechanism for industry growth adopted. To date we have seen contracts being awarded to a mixture of European and domestic developers; this is expected to continue.

2.3 Key Policies Supporting OSW in the US

2.3.1 Regional Greenhouse Gas Initiative (RGGI)

The RGGI is the key policy driving clean technology deployment in each state where it has been adopted. There is correlation between states adopting the RGGI and adopting the Renewable Portfolio Standards (RPS). It places regional caps on the amount of CO_2 which can be emitted from fossil-fuelled power plants. Each region is allocated tradable CO_2 allowances.

RGGI auctions, where the state sells CO_2 allowances to generators, are run quarterly. Funds from these auctions are put towards clean energy and energy efficient initiatives including, in some states, RPS. Clearing prices have ranged from $1.86 to $7.50, with full results available at https://www.rggi.org/Auctions/Auction-Results/Prices-Volumes

2.3.2 Renewable Portfolio Standards (RPS)

RPSs are renewable energy production targets set by states and are the main mechanisms for driving and supporting renewables, including OSW. The state requires utilities to supply a given percentage of their total energy from renewable sources. Renewable energy generators are provided with Renewable Energy Certificates (RECs) for every unit of electricity sold and utilities are required to purchase these certificates in order to show compliance with the RPS. This is similar to the Renewables Obligations scheme in the United Kingdom.

States may treat varying renewable energy sources differently, for example by creating minimum or maximum production requirements from specific sources or by providing additional certificates to generators of specific sources.

Table 1 below shows the coastal states which are part of the RGGI or have implemented RPSs.

Table 1: US coastal states which are part of the RGGI or have implemented RPSs

State Regional Greenhouse Gas Initiatives and Renewable Portfolio Standard commitments			
State	**RGGI**	**RPS**	**RPS Standard** (electricity from renewable sources, unless otherwise stated)
California		●	50% by 2030
Connecticut	●	●	28% by 2020
Delaware	●	●	25% by 2025
Hawaii		●	100% by 2045
Maine	●	●	40% by 2017
Maryland	●	●	2.5% maximum for OSW
Massachusetts	●	●	15% by 2020 and an additional 1% each year following
New Hampshire	●		25.2% by 2025
New Jersey	●	●	24.4% by 2028. Executive order signed for NJ to re-join the RGGI programme. Expected to re-join by 2020
New York	●	●	RPS has expired. NY has adopted a Clean Energy Standard of 50% by 2030
North Carolina		●	Investor-owned utilities: 12.5% by 2021 Electric cooperatives, municipal utilities: 10% by 2018
Oregon		●	Large investor-owned utilities: 50% by 2040 Consumer-owned utilities: 5-25% by 2025 depending on size
Rhode Island	●	●	38.5% by 2035
South Carolina		●	2% by 2021
Virginia		●	15% of 2007 sales by 2025 (3 x multiplier for OSW)

2.4 Mechanisms for Supporting OSW in the US

State-level and federal-level mechanisms are in place to support the growth of the US OSW industry. Below are a few examples of mechanisms which help to increase the economic attractiveness of OSW investment and support the local supply chain, as outlined in Table 2.

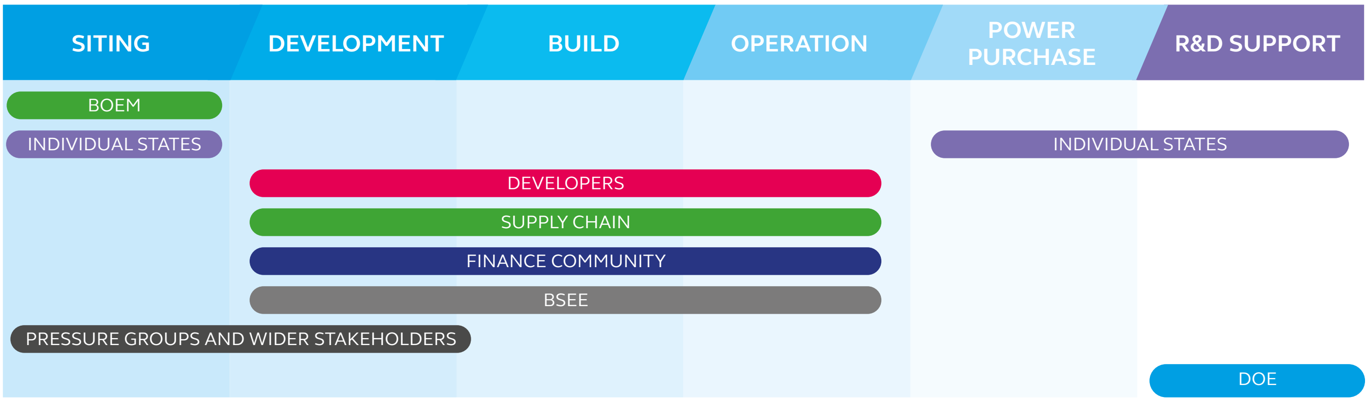
Table 2: Mechanisms for supporting OSW in the US *(Based on NREL: 2016 Offshore Wind Technologies Market Report)*

Mechanism		Example
Increased visibility and confidence in potential market size	**Renewable targets:** State-level policies indicating targets for renewable energy, or specifically OSW generation, provide confidence to developers and the local supply chain. These are often controlled through Renewable Energy Certificates. **Procurement contracts:** States committing to procurement of fixed amounts of OSW generation provide both market security and a known price for the OSW generation output.	• Massachusetts's H.4568 – Outlines a target for 1.6 GW of OSW capacity by 2027. • New York's Governor committed New York to procure 2.4 GW of OSW 2030. • New Jersey Wind Economic Development Act – the State Governor has signed an order allowing the New Jersey Board of Public Utilities to develop a programme of Offshore Wind Renewable Energy Credits and issue a solicitation for 1.1 GW of OSW capacity.
Providing access to development sites	Leasing seabed for development and issuing Requests for Proposals (RfP) for developing these sites provides a clear route for development of projects in these areas. New York has plans to acquire sites from BOEM, partially develop the sites and then re-issuing the leases, de-risking the sites for developers and investors. However, this has not yet been successfully implemented.	• BOEM has leased 16 sites, including 11 sites since the beginning of its renewable energy programme. More information on leases can be found at www.boem.gov/Lease-and-Grant-Information. • States are responsible for the leasing of sites within state waters and The Great Lakes. • Planned projects in state waters include Icebreaker and Fishermen's Energy Atlantic Offshore Wind Farm.
Financial incentive mechanisms	Financial incentive mechanisms reduce risks associated with the long-term revenues of OSW projects and increase the value of electricity from the projects. These usually take the form of monies relating to the amount of energy produced, such as REC or guaranteed energy prices, as state level or tax breaks at the federal level. Historically, the US has supported the wind industry primarily through the US Internal Revenue Service's production tax credit. However, it is currently being phased out and will expire in 2020. Unless these are revived, it is unlikely that many planned offshore projects will benefit from this support mechanism.	• New Jersey Wind Economic Development Act requires the New Jersey Board of Public Utilities to develop a programme of Offshore Wind RECs. • Maryland provides developers of the US Wind and Skipjack projects $131.93 per megawatt-hour (MWh) for a term of 20 years, in return for investment in local infrastructure. • US Internal Revenue Services' investment tax credit – a tax credit on the capital expenditure of a wind project. The percentage given is 30% for projects starting construction prior to 2020, with projects beginning in 2020 receiving 26% and 22% if built between 2021 and 2022.
Supply chain development Support	States directly provide financial, commercial, or technical assistance for developing businesses activities in the OSW sector.	• The Massachusetts Clean Energy Centre upgraded the New Bedford Marine Commerce Terminal for OSW activities. • In Maryland, grants are available for CAPEX spend and training for companies looking to break into OSW in the state.
Innovation support	Innovation support assists companies looking to generate new technologies and solutions by supporting R&D and demonstration. It typically takes the form of grants or access to facilities and expertise.	• Specific innovation support is discussed in more detail in section 3.

2.5 Offshore Wind Deployment Stakeholders

The following section provides an overview of key stakeholder groups who will influence the development of the OSW industry in the US. Different stakeholders are influential or active at different stages of the wind farm development and are summarised in Figure 2 below.

Figure 2: Key Offshore Wind stakeholders by development state



More detail on the stakeholders is provided below.

Federal agencies	**Department of Energy (DOE)**	**Bureau of Ocean Energy Management (BOEM)**	**Bureau of Safety and Environmental Enforcement (BSEE)**
	The DoE's main focus is on industry enabling, technology support and demonstration project development. They support OSW innovation by: • Supporting national laboratories, some of which are working in OSW • Demonstration project development • Direct funding for R&D (usually fairly early technology readiness level).	Part of the Department of Interior. Equivalent to the UK Crown Estate regarding offshore development. They manage operations in the US Outer Continental Shelf (OCS), identify sites, issue leases and easements for offshore development. BOEM works with federal, state and local governments to identify sites and support development through 14 renewable energy task forces.	BSEE is the sister organisation to BOEM. It is generally equivalent to the UK Health and Safety Executive and its role is to develop HSE standards and regulations for the energy industry and ensure they are met. Evidence to date suggests that the US stakeholders have not considered health and safety to the extent that might be expected at this point in the development of the sector.
	<u>Drivers to support OSW:</u> • Energy security • Cost of energy	<u>Drivers to support OSW:</u> • Income from leasing sites • Ensuring sustainable use of seabed	<u>Drivers to support OSW:</u> • Safety and environmental enforcement
Individual states	States drive the OSW agenda in the US. The role and level of commitment varies between states. The more proactive states work with BOEM to identify sites and provide cable easements through state waters (3 NM from shore). Some states are providing contracts for procurement of the energy generated (through PPAs) and Renewable Energy Certificates (RECs). New York is also planning to carry out some development work e.g. environmental assessment and offering bundled lease (bought from BOEM) and PPA packages. In a few cases (Block Island, the Aqua Ventus I and Atlantic City Wind Farm) the development sites are in state water so will be leased by the states. Activities in states are either driven through local economic or energy agencies. The more visibly active organisations include: • New York: New York State Energy Research and Development Authority (NYSERDA) • Massachusetts: Massachusetts Centre for Clean Energy (MassCEC) • Maryland: Maryland Energy Administration. States also provide direct incentives and support to companies for OSW supply investment in the region.		
	<u>Drivers to support OSW:</u> • Economic benefit to state • State clean energy targets • State energy security		

<table>
<tr><th>Industry</th><th>Developers</th><th>Supply chain</th><th>Investors</th></tr>
<tr><td></td><td>Developers carry out consenting, development and in some case operation of OSW projects. It is anticipated that the US OSW market will consist of:
• Smaller, less-experienced US-based OSW developers e.g. Deepwater Wind
• Large experienced European OSW developers e.g. Ørsted, Avangrid, Statoil
• Developers with US onshore wind developers looking to break into US OSW sector e.g. EDF RE, Innogy.</td><td>The OSW supply chain is extensive. However, primary suppliers include:
• Turbine manufacturers
• Balance of plant (BOP) suppliers e.g. cables, substation, etc.
• Installation contractors
• Operations and maintenance (O&M) contractors
• Technical support e.g. hydrographic surveys, environmental consultants.

These suppliers will support extensive secondary supply chains. For more information on supply chains see section 2.9.</td><td>Most OSW farms in the US will have external investors that are not active in developing the projects. For example, CIP (Copenhagen Investment Partners) and Canadian Pension Funds.

Bringing investors on-board during the early stage of the UK OSW industry was challenging and led to the government establishing the Green Investment Bank (GIB) to boost private investor confidence in the sector. However, lessons learnt from Europe and the involvement of experienced European players in the US market should provide a level of investor reassurance.</td></tr>
<tr><td></td><td><u>Key drivers to support OSW:</u>
• Financial returns from projects
• Development of OSW track record</td><td><u>Key drivers to support OSW:</u>
• Sales of products or services
• Ongoing revenue streams</td><td><u>Key drivers to support OSW:</u>
• Return on investment</td></tr>
<tr><td>Pressure groups and wider stakeholders</td><td colspan="2">Special interest organisations
Lobbying groups protecting their own interests can potential be a key blocker to the development of the industry as we have seen in the UK and at Cape Wind Farm. These groups can be highly influential and should not be underestimated. Special interest groups with a position on OSW include:
• Local community groups
• Fishermen
• Wildlife groups including the National Wildlife Federation
• Oil and gas lobby
• US military</td><td>OSW support/lobbying organisations
There are a range of Industry bodies and lobbying groups that support OSW development in the US, through lobbying, arranging events and convening working groups to address specific barriers to development. One of the most influential is the American Wind Energy Association (AWEA). Other groups include the Business Network or Offshore wind and US Offshore Collaboration.</td></tr>
</table>

2.6 State-by-State Overview

At present, the term US OSW market is somewhat misleading, as it is not a unified market with common drivers. It is more accurate to consider the US OSW market on a state-by-state basis. However, no single state has enough demand to be considered a market its own right. Each state has its own set of targets, procurement and incentive schemes.

Currently New York, Massachusetts, New Jersey, Connecticut and Maryland have, or are planning to put in place, procurement contracts for OSW and can be considered to be leading activities in the sector. The majority of Atlantic coastal states are supporting leasing rounds in state or federal waters off their coasts. Development in a few of the more passive states, such as Hawaii, is currently being driven by developers rather than through state programmes.

A summary of activity in the five states that have made firm commitments to OSW is shown on the following pages.

NEW YORK

Announced cumulative capacity to be leased by end of 2019: 1,890 MW

New York is, arguably, the most proactive state in supporting OSW. The Governor of New York has implemented a target of 2,400 MW of OSW to be procured by 2030 as part of its Clean Energy Standard targets of 50% of electricity from renewable sources.

New York, through NYSERDA, issued its New York State Offshore Wind Master Plan in January 2018 outlining:

- Suitable sites (identified in conjunction with BOEM)
- Expected economic benefits and job creation
- Potential procurement mechanisms
- Cost reduction pathways
- Infrastructure requirements
- Impact mitigation.

Its ambitious plans aim to create a $6 billion industry. Unlike other states, New York intends to take on the pre-lease activity directly from BOEM and has carried out initial development activities (environmental impact and securing grid connection), de-risking development of the sites for developers tendering for the sites. This is similar to the early stages of the development model carried out by the Dutch government.

Leasing areas and key projects

- A key project in the state is the 90 MW South Fork project, located 30 miles southeast of Mantouk which has been approved and is due to come online in 2022.
- Statoil signed a lease for a 1,000 MW site, Empire Wind, in December 2016, at a record bid of $42 million.
- Four identified leasing areas totalling 2,400 MW: Fairways North, Fairways South, Hudson North, and Hudson South. 800 MW is expected to be leased across two rounds in 2018 and 2019.

MASSACHUSETTS

Announced cumulative capacity to be leased by end of 2019: 4,100 MW

Massachusetts has had a high-profile difficult start to its ambitions to be a leading player in OSW in the US. What was expected to be the US's first commercial-scale OSW farm, Cape Wind, was cancelled in late 2017 due to overwhelming stakeholder opposition. However, the Governor of Massachusetts has mandated three regional utility firms to procure 1.6 GW of OSW by 2027. In May 2018, Massachusetts is due to award PPAs for up to 800 MW of OSW, which is hoped will kick-start the OSW market in the state. Recently Massachusetts has begun the process to increase its target to 5 GW of OSW. No target date has been set and the process is likely to take two years to pass into law.

Massachusetts has already invested heavily in the infrastructure needed to support the OSW sector, including a purpose-built 29-acre OSW port facility at New Bedford and a world-class OSW blade testing facility. Both are operated by the Massachusetts Clean Energy Centre (MassCEC).

Leasing areas and key projects

- Vineyard Wind (1,600 MW) and Bay State Wind (2,000 MW) secured leases from BOEM in 2015. PPA and transmission agreements are set to be established in May 2018.
- The tender process for two sites, OCS-A 0502 and OCS-A 0503, opened in April 2018. The site leases have an estimated capacity of 3,012 MW and 1,707 MW respectively.
- Gosnold and Martha's Vineyard are two other sites stated to have potential for OSW development.

NEW JERSEY

Announced cumulative capacity to be leased by end of 2019: 4,197 MW

New Jersey launched its first initiative in 2010; the Offshore Wind Economic Development Act (OWEDA) which unsuccessfully aimed to create 1.1 GW of OSW capacity. However, the New Jersey OSW sector was kick-started with the reissue of the (OWEDA) in January 2018 with a more ambitious target of 3.5 GW by 2030. Leases have been secured by developers for three projects which have a potential maximum capacity of over 4.1 GW, making New Jersey one of the largest OSW markets.

Leasing areas and key projects

- Fisherman's Atlantic City Windfarm is leased 24 MW site which has been significantly delayed due to missing a government funding deadline by failing to secure a PPA. A resubmitted application is expected mid-spring.
- US Wind Inc and Ørsted both secured leases for sites from BOEM in January 2016. The sites have a total capacity of over 4.1 GW.
- Garden State Offshore Energy is an offshore site with the potential installed capacity of 680 MW.

CONNECTICUT

Announced cumulative capacity to be leased by end of 2019: 200 MW

Connecticut's interest in OSW has been slow to start but it is gathering pace, making it a potential key future market. In early 2018, The Connecticut Department of Energy and Environmental Protection (DEEP) issued a request for proposal for 825 GWh of OSW per year. The winners of the RFP will be announced in June 2018 and need to start generating by December 2025.

Under the RfP, DEEP is seeking proposals from developers of qualified Class I OSW sources. The minimum nameplate capacity of the projects must be no less than 2 MW, which may include paired and co-located energy storage.

Leasing areas and key projects

- RFP winners expected to be announced in June 2020.

MARYLAND

Announced cumulative capacity to be leased by end of 2019: 625 MW

Maryland's Public Service Commission has signed off two OSW farms. The state is very focused on building supply chain capacity through OSW development and has mechanisms in place for this to happen. Maryland's offshore renewable energy credit gives developers of the US Wind and Skipjack projects $131.93 per megawatt-hour (MWh) for a term of 20 years. In return the developers must invest $76 million in steel manufacturing in Maryland, $39.6 million in port infrastructure upgrades, and $6 million in the Maryland Offshore Business Development Fund. The incentive was created in the Maryland Offshore Wind Energy Act of 2013.

The potential growth of the OSW sector in Maryland may be limited as there is a cap to at a maximum of 2.5% of the state's electricity coming from OSW.

Leasing areas and key projects

- US Wind Inc secured two neighbouring leases in Maryland. The development is expected to have a capacity of between 500-750 MW.

A summary of OSW activity in other states can be found in Appendix 2.

Great Lakes Projects

There is one project currently in development in The Great Lakes. The Icebreaker project in Lake Erie is a 21 MW project planned to finish construction in late 2020. The Great Lakes projects present a unique and niche set of challenges and are not specifically considered within this report.

2.7 US OSW Market Site Conditions and Technology

2.7.1 Site Conditions

One of the key reasons for US stakeholder interest in the UK market is the similarity in site conditions between the US east coast with the UK coast. The US west coast, however, has much deeper water, more akin to the west coast of Scotland, which is as yet undeveloped for OSW.

Site conditions	US Atlantic	US Pacific	Similarity between installed UK projects and US sites	
			Atlantic	Pacific
Ground conditions	The majority of the Atlantic Coast is home to coarse sand, with areas of fine sand, clay, and silts. Patches of boulders and cobble exist off the coast of Maine and Massachusetts.	In coastal areas there is predominately sand and gravel. Mud, clay and biogenic sediment become dominate further offshore.	High	High
Water depth	Most leased sites on the Atlantic coast have similar water depths to UK projects, approximately 10-60 m.	Waters depths along the US Pacific tend to fall off very quickly. If development of OSW projects in the Pacific is successful, it is likely the majority of these will be placed in deeper water than typical UK projects.	High	Low
Distance from shore	The distance from shore of east Atlantic Coast projects range from between 4-58 km. Most projects are between 20-45 km from shore.	As stated above, water depths along the US Pacific tend to fall off very quickly. The planned project by Principle Power is 8.1 km from shore. Developers will target near-shore developments initially until suitable sites are limited.	High	Low
Wind regime	Average wind speeds vary between 5.6-7.7 m/s at 10 m above mean sea level. Hurricanes and other extreme weather events are more likely in the US than in the UK.	Average wind speeds vary between 5.5-7.3 m/s at 10 m above mean sea level.	Medium	Medium

Floating wind in the US

The US OSW market has a much greater emphasis on floating wind than the UK. This is primarily driven by two key factors:

- **58% of US wind resource is in deep water** and is not accessible using fixed bottom technology. In addition, both California and Hawaii have aspirations in OSW, driven by their commitment to the RPS. The two Hawaiian development zones, Oahu North and South, have water depths ranging from 32 m to 1,298 m according to 4c Offshore. According to the same source, the area being considered for development in California by The Redwood Coast Energy Authority and Consortium has water depths of 102 m to 1645 m, thereby making the sites incompatible with fixed bottom wind technology.
- **Floating wind can be a differentiator for the US OSW supply chain.** There is a general recognition that Europe will lead the way on technology and supply for fixed bottom wind. However, there are no mass-produced solutions for floating wind so the opportunity to become sector leader still exists.

The Department of Energy has stated that it expects the cost of floating wind to be similar to fixed bottom wind by 2030 and a range of technology development and demonstration programmes are in place to support its deployment. The DoE recognises that, unlike most technologies, it cannot rely on importing floating technology from Europe and is heavily supporting R&D programmes in this area.

2.7.2 Technology and Operations and Maintenance (O&M) Strategies

The local site conditions, supply chain and technology maturity will drive the use of specific technologies for US sites, including a much higher level of interest in floating wind than is seen in the UK. A summary of technologies expected to be used is provided below.

Table 3: Technology and O&M strategy of US Offshore Wind sites

TECHNOLOGY				
Site-section	**US Atlantic**	**US Pacific**	**Similarity between installed UK projects and planned US sites**	
			Atlantic	**Pacific**
Foundations	Monopiles and jackets are suitable for the site conditions in the Atlantic. Monopiles are usually the most cost-effective option in shallow water, however Deepwater Wind favoured jackets in shallow water at Block Island to ensure a US supplier could be used.	Floating foundations will be required for projects on the US Pacific Coast. Floating OSW foundations are relatively immature compared to fixed bottom foundations.	High	Low
Turbines	Turbines will likely be 3-blade upwind turbines with direct drive or mid-speed gearboxes. Planned projects turbine capacity ranges between 5-10 MW. It is expected that 10 MW+ turbines will be used, similar to future European projects.	Likely to be 3-blade upwind turbines. Demonstrations of 6 MW floating turbines are being carried out. It is expected that turbines on most floating farms would be this size or larger.	High	Medium
Electrical BOP	US projects will likely use HVAC transmission systems as projects are being developed in isolation by individual developers, much like UK Round 1 and 2 projects.	Floating projects will require more novel transmission export technologies (floating offshore sub-stations and dynamic motion cables). This is an area of potential technological innovation for the US market.	High	High
INSTALLATION AND OPERATION STRATEGIES				
Installation	The installation for OSW turbines in the US is technically identical to the UK. The only key difference is that the Jones Act restricts movement of vessels so there is likely to be restrictions on vessel use. More information on the impact of the Jones Act can be found in section 2.9.	Installation of floating wind farms will depend on the floating technology adopted. In many cases, the turbines will be floated out of port and moored on site with the turbine pre-installed. This can be achieved using conventional tugs, freely available in the US. There is potential for a floating turbine to be classified as vessel under the Jones Act.	Medium	Low
O&M	It is too early to determine the operations and maintenance (O&M) strategies of specific windfarms, but strategies are typically driven by distance from a suitable port. It is expected that a combination of crew transfer vessels and service operation vessels will be used. CTVs and SOVs will need to be constructed in the US to be Jones Act compliant.	The O&M strategy will depend on the technology deployed but won't differ significantly from access vessels used for conventional bottom-fixed windfarms. The ability to change out major components for floating wind turbines is an issue, given the inability of jack-up vessels to operate in these water depths. This is a technology issue, rather than an industry-specific issue. The US could lead the way in developing novel methods for major component change-outs.	High	Medium

Drivers of Technology Choice

In Europe, finding the cheapest technology available or more cost-effective O&M strategy for a given site have been the only real drivers for technology choice. However, in the US there is a subtler interplay between costs and local content.

For example, whilst monopiles are the cheapest foundation type for shallow water and seabed conditions seen on the US East coast, there is a drive towards jackets as these can be more easily manufactured locally and are more familiar to the existing oil and gas supply chain that exist in the region. This boosts the opportunity to create local jobs, but adds costs to OSW projects. In 2016, Deepwater Wind used jackets at its Block Island site to enable Gulf Island Fabrications, a US fabricator, to make the foundations; in the depth of water at the site, monopiles would most likely have been a cheaper technology.

The US OSW has also demonstrated that it is prepared to use "behind the curve" technology in order to ensure local content. The US Wind Project opted to use a met mast for wind resource assessment, as this could be provided by the US supplier and be fabricated locally, rather than more advanced, lower cost technical solutions are available and widely used in Europe.

2.8 Key Barriers to Delivery of OSW in the US

As discussed, some the individual states in the US have set highly ambitious targets for the deployment of OSW. There are no significant physical or commercial barriers to the US developing a significant OSW industry. Stakeholder intervention or loss of support is likely to be the primary reason the industry may fail to deliver as hoped. Some key stakeholder barriers to market growth are listed below.

Strong intervention by local interest lobbying groups	Anti-wind interest groups can be incredibly powerful. In the short history of the US OSW industry we have already seen otherwise potentially viable OSW development sites fail due to either lobbying by local interest groups, for example Cape Wind, or through intervention by the military, such as in California. Much of the OSW development proposed is in areas which host a high level of wealthy and influential individuals who have power to oppose wind farms in their area.
Unrealistic expectations of supporting stakeholders	The expectations on what can achieved by the US OSW industry are enormously high, and there is a real risk that what can be achieved in the expected timeframe falls far short of these, both in terms of market size and local economic benefit. If these targets are not met, stakeholder motivation to grow the industry may wane, both from political stakeholders and in the potential supply chain, which could bring the industry to a standstill
Complex disjointed state level market	To date there has been no real coordination between states, and therefore the US OSW market development is not benefitting from the overall potential scale of the US market to the level it could. It is not, for instance, maximising potential inward investment of manufacturing facilities through a coordinated approach or addressing cost reduction through regional infrastructure sharing. Other issues with a state-level approach to national market include: • Complex and costly stakeholder management required to deliver projects. It is estimated that 70 stakeholders per state will need to be engaged to get an OSW project constructed. • Difficulty in getting the level of visibility of market direction, which is needed to secure investment in OSW.
Immaturity of market leading to high profile mistakes	The potential US OSW supply chain is on a steep learning curve. As such, there are likely to be mistakes. This can be mitigated to some extent through importing experience from Europe, but not all lessons will be taken on board. In addition, there is, perhaps, an attitude amongst some (not all) potential US OSW players that help from Europe is not needed and the US industry can "figure it out on its own". If major mistakes are made, such as significant environmental damage or major safety incidents, this will provide support for the anti-OSW lobbying groups, damage political support and discourage supply chain growth.
Levelised Cost of Energy (LCoE)	Ensuring projects can be delivered at an affordable cost needs to be considered a key challenge in any OSW market. Ultimately, the LCoE of OSW projects must become competitive with other generation types in the region. However, evidence suggests that cost is not going to be the primary barrier to the initial deployment of OSW in the US. The market appears willing to accept higher costs in return for additional benefits. The ongoing cost-reduction activities in Europe have also driven down the cost of OSW sufficiently that, even given the early inefficiencies expected in the immature US market, the technology appears much more commercially-attractive than at the start of the European market. Costs of US wind will naturally fall over time as the market matures and benefit is gained from the ongoing cost reduction programmes in Europe.

Conclusion: The US doesn't want to recreate the European market but does want to learn from it

There are many similarities between the UK and the potential US markets, particularly in terms of site conditions. As a result, there is strong push amongst US stakeholders to learn from Europe but there is also a strong push not to recreate the European market, particularly if it means importing European supply chains, to the detriment of local supply chain development. As discussed, the drivers for the US market are different. Notably:

- the market is driven at a state level not at federal level
- the key driver is job creation, particularly in manufacturing
- the West coast market is much deeper water, driving a much stronger move toward floating technology than is seen in the UK.

However, despite the general protectionist drive towards creating its own market, the US will need the experience and learning from Europe in order to deliver at the proposed scale in the proposed timeframe.

Projections for growth could potentially far outstrip the trajectory achieved in Europe in the same timescale and are highly ambitious. It is unlikely that the full potential will be realised, but the US represents a significant emerging market if stakeholders are well-managed and experienced European companies are allowed to take a key role.

CASE STUDY

Block Island Wind Farm – the pioneer of US OSW

Block Island is the first commercial OSW farm in the United States. The project is situated in the Atlantic Ocean off the coast of Rhode Island. It was developed by Deepwater Wind, a US OSW developer.

The project used five GE Haliade 150-6-MW turbines on jacket foundations. Construction began in 2014 and the project was fully operational by December 2016. The project equity is owned by Deepwater Wind, GE Financial Service and Citi.

The project provided a number of US contractors with their first work in OSW, including foundation manufacturer Gulf Island Fabrications.

The installation was carried out by European contractor Fred Olsen, in conjunction with Falcon Global, a US-based contractor. Whilst only small, Block Island is being heralded as a significant milestone in establishing a US OSW industry and has boosted confidence that the industry can deliver.

Figure 3: Block Island Offshore Wind Farm (Source: Smithsonian)

2.9 Supply Chain

There is currently a very limited OSW supply chain in the US. Due to the immaturity of the market, there are very few companies in the US which have had the opportunity to build up experience and a track record in the sector. The US has an established onshore wind supply chain, with over 500 manufacturing facilities supporting the industry in the US. It also supports an extensive existing offshore energy sector focusing on oil and gas. There are real synergies between these sectors and OSW that can potentially be exploited to build a regional OSW supply chain, but this is yet to happen as the US OSW industry is very much in its infancy.

2.9.1 Drivers of US Supply Chain Development

There are three key elements that will drive the direction of development for the US OSW supply chain:

1. Individual state drivers to create local jobs
   As mentioned earlier, the key driver for OSW development is jobs. All states will be pushing for development of a localised supply chain, either through diversification of existing companies or through attracting inward investment from large manufacturers. The states appear to be prepared to accept a higher cost in energy to do this, but when awarding energy procurement contracts typically 70-75% of the scoring is based on costs of energy and 25-30% on local economic benefit.

   As to be expected, the states are also offering significant financial incentives for companies looking to establish manufacturing facilities in their state. For example, New Jersey is offering up to $100 million to set up an OSW manufacturing facility in the state.

2. Developers driving down project costs
   Developers will also look to drive down costs on their projects, and this is likely to conflict with the drive to purchase locally. Local supply from the US is potentially more expensive than export from Europe as the European supply chain is more established and therefore:
   - Extensive work has been carried out to reduce manufacturing and transport costs.
   - Economies of scale can be applied as the supply chain is servicing a wider market.
   - The risk of using established suppliers is lower and this may be reflected in the cost of accessing finance for projects.

3. The ability of the US supply chain to ramp up in time for delivery
   The ability of the US supply chain to deliver the proposed 8 GW within the target timeframes may also drive purchasing strategies. The supply chain is starting from a very low base in terms of experience and relevant facilities and may not be able to grow in line with the rapid proposed project development.

Discussions during the mission suggest that the extent to which suppliers will support the development of a US supply chain is likely to depend heavily on whether the developer is an established European developer or a US developer and therefore, to what extent they have an existing established global supply network.

2.9.2 Expected Profiles of Key US Supply Chain Players

Developers	Three types of developers are active in the US market: • US developers: US developers are competing directly with experienced European developers for leases and power purchase agreements. [1]Deepwater Wind is the most active US developer. It developed Block Island and has secured leases for four other sites with the potential for over 1,800 MW of installed capacity. US Wind also has leases in Maryland and New Jersey. Apart from Deepwater Wind, US developers have no track record in developing OSW. • Experienced European developers: Ørsted, Iberdrola (through Avantgrid) and Statoil are all highly active in the US market and have obtained leases that are currently under development. • Joint development organisations: On some of their sites, Ørsted is partnering with US developers. For example, Ørsted and Dominion Energy are co-developing a 12 MW site in Virginia, with the potential for a further 2,000 MW of capacity. Ørsted is also collaborating with Eversource on Bay State Wind, a potential 2,000 MW site in Massachusetts, and operating as a sole developer of a 1,500 MW site (Ocean Wind).
Turbine manufacturers	Globally the OSW turbine market is dominated by Siemens and Vestas; together they make up over 80% of the installed global OSW capacity. It is, therefore, fully expected that they will be significant players in the US market, especially on projects developed by European developers. GE Wind has supplied turbines to the Block Water wind farm with its 6 MW machine. This machine is unlikely to be competitive in the wider US market as it is relatively small compared with Vestas' and Siemens' offerings. However, GE Wind is launching a 12 MW turbine due to be released in 2020 in time for the larger US projects. As a US manufacturer, with a large machine, GE could potentially be a significant threat to European manufacturers' efforts to dominate the US market. It should be noted that GE's 12 MW turbine is still in development and untested – this may delay access to the market.
Balance of plant (BOP) manufacturers	BOP manufacturing is one of the main opportunities for domestic US companies to develop an OSW capability as there is substantial overlap between the skills required for oil and gas fabrication and those needed for OSW structure fabrication. As we have observed in the UK, there are still significant barriers for oil and gas companies looking to transition into OSW, including meeting the OSW cost demands and mass production of very large structures. It is likely there will be partnerships established between European BOP manufacturers and fabrication yards in the US to allow European companies to access the US market and to support the US companies up the OSW learning curve. This is typified by the announcement in 2018 of a partnership between EEW, an established German foundation manufacturer, and Gulf Island Fabrications to supply large steel structures for OSW.
O&M contractors	There is a range of contracting arrangements for OSW O&M contracting. In many cases, the O&M is carried out by the turbine supplier, particularly during the warranty period, and there is no reason to expect this will be different in the US. Post warranty period, more experienced developers such as Ørsted will carry out their own O&M operation and subcontract specialist tasks. Less experienced operators will usually either extend their service contracts with the turbine manufacturers or bring in a third-party O&M contractor. Any O&M contractors are likely to be US-based and, because of the Jones Act, will require the use of US constructed and based vessels. The east cost of the US already has an established oil and gas O&M supply chain, which is likely to want to engage with the OSW industry. There is potential for partnerships between established European O&M contractors and US contractors, but this is one area which the US is taking a home-grown approach. In 2018, Fred Olsen and Falcon Global announced a partnership to carry out OSW installation in the US.
Lower tier manufacturers	There is extensive opportunity for the US to build domestic supply chains for a range of lower tier products and services. The main opportunity for US suppliers is unlikely to be turbine components but will include auxiliary systems, small-scale fabrication and specialist O&M products and services.
Expert services	A range of European consultancies have already established a presence in the US to support the growing US OSW market, including BVG Associates, DNV GL, Mott MacDonald and RCG. The appetite for understanding lessons learnt in Europe means that the barriers to entry for UK consultancies entering the US OSW market are low compared to other areas of the supply chain.

[1] Since the Expert Mission, Orsted has acquired Deepwater Wind in October 2018. (https://orsted.com/en/Company-Announcement-List/2018/10/1819975)

The Jones Act and Passenger Vessels Act

There is much discussion in the US OSW industry about the potential impact of the Jones Act on the development of the US OSW sector. The Jones Act regulates the carrying of merchandise between points in the US, commonly known as coastwise trade. It states that a vessel, with a few minor exceptions, may not transport merchandise between points in the US, either directly or via a foreign port, unless the vessel is wholly owned by US citizens, US flagged and built in the US.

The Passenger Vessel Services Act similarly restricts the transportation of passengers between points or places in the United States to vessels built in and owned by citizens of the United States.

The Jones Act and Passenger Vessel Act complicates the construction and O&M of OSW farms in the US because it generally requires components and technicians to be moved between a US port and towers attached to the seabed, which count as a port in the US. This means European purpose-built installation vessels cannot be used to build OSW farms.

The general opinion gathered during the mission was that the Jones Act has been in place since 1920 and exceptions have only been made for military or disaster relief purposes and therefore, it is unlikely that an exemption will be made for OSW. Solutions being considered by the US OSW industry include:

- **Manufacturing Jones Act-compliant installation vessels** – the first is due to be brought online in Autumn 2018.
- **Using non-specialist heavy lifting vessels** which potentially adds project risks.
- **At-sea transfer of components** from Jones Act-compliant vessels to European vessels, which is viable but adds cost and risk, in particular that of safety related to double handling at sea, to project delivery.
- **Shipping components from Europe**, which would be politically very unpopular.

O&M is likely to be carried out by Jones Act-compliant vessels. As the O&M strategies evolve, more specialist vessels will likely need to be built in the US, similar to Edda Passat, the first Service Operation Vessel (SOV) built in Spain, which commenced sea trials in Feb 2018 for Ørsted's Race Bank OSW farm in the UK.

Barriers to UK Companies Entering the US Supply Chain for OSW

Despite the clear benefits to the US OSW market from gaining experience from the European supply chain, there are significant barriers for UK companies hoping to break into the sector. These include:

- **Protectionism** – either through regulation such as the Jones Act, or through a general "buy American" attitude.
- **Job creation agenda** – UK companies will need to demonstrate how they will benefit the local economies and support developers' local content targets.
- **Complexity of the market** – significant effort is needed to understand the complexities of the US market and the myriad of influential stakeholders.
- **Market uncertainty** – the US OSW sector is still an emerging market and has no track record of delivery of projects, making any investment in the region speculative and high risk.

Partnering is one of the key mechanisms for overcoming the barriers to entering the US OSW sector – recent announcements such as the EEW/Gulf Island Fabrications and the Fred Olsen/Falcon Global partnerships demonstrate that some European companies are taking this approach. There is also a push by European developers such as Ørsted to bring in their existing supply chain and, to meet US local content requirement, facilitate partnerships between US and UK companies.

3. Research and Development Landscape

3.1 Overview

As to be expected, the OSW research and development (R&D) landscape in the US is still immature and represents a very small sector of the wider US R&D activities. However, there has been an increase in the number and types of organisations involved in OSW R&D in the US over the last 5-6 years, in line with an increased interest and confidence in the market sector. This has included the opening of two large OSW-specific testing facilities and the launching of federal- and state-level support programmes, including, in 2017, an announcement of $20.5 million funding from the Department of Energy for OSW innovation[2].

As an immature industry, R&D support programmes and activities in the US are heavily focused on developing the solutions needed to remove specific barriers to development of the US industry – for example, developing floating wind for deeper water, wildlife impact and hurricane protection. The key exception to this is the Department of Energy, which has a greater focus on more generic OSW cost reduction in the US market. The Department of Energy's focus on cost reduction is more in line with the UK's OSW R&D focus on cost reduction.

At present, academic organisations dominate the US OSW R&D landscape. These organisations are mostly building on expertise in onshore wind research or on oceanography and environmental capabilities. To date, there is little evidence of the established OSW industry investing significantly in R&D in the US. This is due to the maturity of the sector, and because the established European OSW supply chain has invested heavily in R&D expertise and facilities in Europe over the last fifteen years. The established OSW suppliers that were met during the mission showed little inclination to significantly increase R&D activities in the US.

The Department of Energy has been the main source of support for OSW innovation both through National Laboratories and through funding public and private institutions. Additionally, some of the states, including New York, Massachusetts, and Maryland, have put in place innovation support for local institutions with a view to both accelerating industry growth in their states but also to effect economic growth through R&D.

Understanding Innovation

Both in terms of semantics and activity, the focus of innovation within the US energy sector differs from the general understanding of the word in the UK.

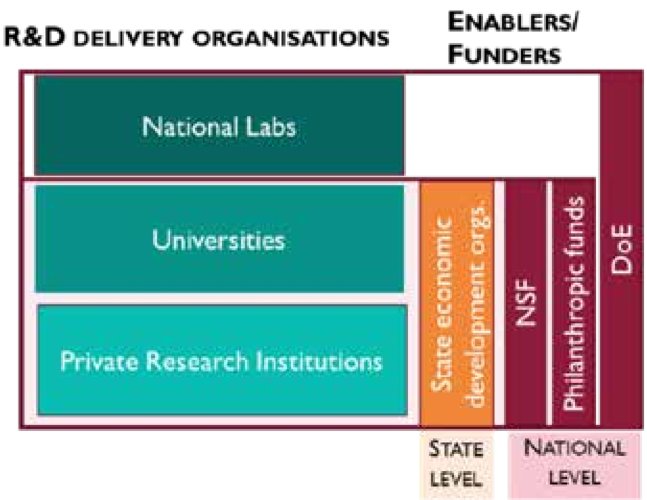
Innovation in the US context refers to earlier technology-readiness level (TRL) activity (1-4), whereas in the UK this is typically referred to as research, with innovation starting around TRL 4.

This is reflected in US federal- and state-level innovation support programmes which are widely available for early TRL work, compared with the support available for mid- and later-stage activities such as prototyping and demonstration. This is in contrast to the range of programmes in place to support later TRL activities in the UK.

3.2 Key Stakeholders

For the purpose of this report, stakeholders within the OSW R&D sector have been split between enablers, which support innovation through funding or programme initiation and facilitation, and delivery organisations, which deliver R&D in OSW. The seven key sets of stakeholders are summarised below.

Figure 4: An overview of key stakeholder in US OSW innovation



[2] The DOE has subsequently awarded the US18.5m research programme to the New York State Energy Research and Development Authority (NYSERDA) in June 2018. (https://www.energy.gov/eere/wind/articles/department-energy-announces-185-million-offshore-wind-research)

3.2.1 Key Enablers

The organisations below support innovation in OSW in the US either through funding, steering, and road-mapping or facilitating relevant R&D programmes.

DEPARTMENT OF ENERGY

The Department of Energy (DoE) facilitates innovation in the OSW through the Wind Energy Technologies Office (WETO) and through supporting and funding the National Laboratories. The DoE's total budget for its programme office, focusing on research into energy efficiency and renewables, is around $2.3 billion. In addition, National Laboratories and ARPA-E are provided with discretionary money. At present, only a small fraction of this goes towards supporting OSW. Their focus is on:

- **Technology development:** Supported through funding to National Laboratories and competitive technology programme.
- **Market acceleration:** Support through knowledge exchange, identifying barriers and mitigating steps.
- **Development of demonstration projects.**

The DoE also has a figurehead role to play in ensuring the world knows "the US is open to offshore wind". Its R&D support programmes are primarily focused on addressing US market-specific issues, including:

- Cost reduction in US projects.
- Mitigation of environmental impacts.
- Project installation and O&M in US waters.
- Supply chain development.
- Wind turbine hurricane survival.
- Floating wind.

The DoE also hosts the Advanced Research Projects Agency-Energy (ARPA-E). This looks at cutting-edge future technologies. It has set aside $8 million for two OSW-related projects: one on a 50 MW offshore turbine, the other for Electrohydrodynamic (EHD) turbine-less wind energy system.

Key Programmes

Competitive solicitation for OSW consortium

In December 2017, the DoE announced a $20 million funding call for a consortium to deliver innovation across key US-specific OSW industry challenges. For more information see section 3.4 Funding. More information on POWER-US, one of the key bidders, is also provided on page 23.

Demonstration site development

The DoE is supporting the Lake Erie Energy Development Corporation's Icebreaker Project in Cleveland and the University of Maine's New England Aqua Ventus. The DoE carried out project scoping and environmental assessment for these projects as well as providing $10.7 million to each project to date. The DoE is making another $40 million available to each of the projects as they progress.

STATE ECONOMIC DEVELOPMENT ORGANSISATIONS

It is unusual for individual states to fund renewables innovation programmes directly. However, a few of the states driving the development of the OSW sector have provided mechanisms though which innovation in OSW can be supported. During the mission, OSW innovation activities in New York, Maryland and Massachusetts were outlined and these are summarised below.

States actively supporting OSW innovation

MASSACHUSETTS	Massachusetts Clean Energy Centre's (MassCEC) primary role is economic development in the clean energy sector in Massachusetts. It has a secondary role in promoting the deployment of clean energy technology. As part of this, they have a remit to support Innovation Supply Chain development in the state. It has an annual operating budget of $30 million to invest in a range of clean energy initiatives, including supporting a 90 m wind turbine blade test facility. In addition to its own activities, it provides funding to Massachusetts-based R&D institutions working in OSW to match-fund federal funding. It is a lead member of the POWER US consortium.

NEW YORK	New York State supports the development of OSW through the New York State Energy Research and Development Agency (NYSERDA). NYSERDA is a public benefit corporation providing technical and market expertise and funding to reduce the state of New York's reliance on fossil fuels and create clean-energy jobs. NYSERDA has around 35 people working on innovation in across-energy technologies, of which four or five are on renewable energy. They have a budget for renewable energy research of around $5-$6 million. They do, on occasion, release funds for renewables R&D (including OSW) through a competitive process. They are expected to be leading a bid for the Department of Energy's $20.5 million funding call, but it is not possible to confirm until the winners are announced.
MARYLAND	The infrastructure for specific innovation support appears less developed in Maryland than in New York and Massachusetts. However, it is actively supporting its local universities to engage in research in OSW. In addition, there are incentive schemes in place for inward investment that could potentially support collaborative innovation in the state.

CalCEF

Whilst not a state-led activity, California hosts the California Clean Energy Fund (CalCEF) which acts as a coordinating body for roughly five key clean energy venture capital funds that operate in the state.

3.2.2 Key Research and Development Delivery Organisations

The stakeholders below play a key role in delivering OSW research and development (R&D) in the US.

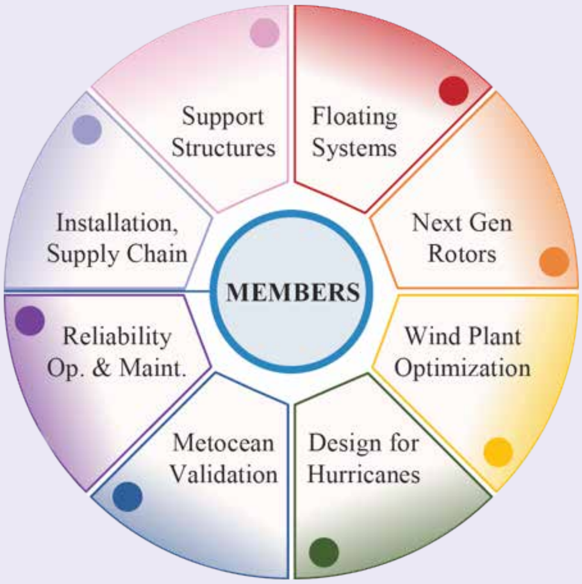
NATIONAL LABORATORIES	
The National Laboratories are a network of laboratories and technology centres that address energy and nuclear technology development and deployment. They are primarily funded by the DoE (up to 85%) and cover a full range of technology-readiness levels (TRLs) from basic research to testing and demonstration.	
National Laboratories active in OSW	
NATIONAL RENEWABLE ENERGY LABORATORY (NREL) **Colorado**	NREL is the primary research institution for OSW in the US. It is the only laboratory specialising solely in renewable energy. Approximately 50% of its funding comes from the DoE; the rest comes from industry, cross-laboratory collaboration, and other government departments such as BOEM. Its research focus is addressing US-specific barriers to OSW through technology development. This includes floating wind, freshwater ice, grid integration of renewable energy, aerodynamic modelling, and techno-economic studies. It has a range of specialist wind testing studies – these are outlined in section 4.2.
SANDIA **New Mexico, California**	Sandia has a long history of onshore wind development and has more recently started addressing the challenges facing OSW. Its research areas include: • Large Offshore Rotor Development • Floating Vertical Axis Wind Turbines • Modelling Codes for Simulating Offshore Wind Farms • Sediment Transport & Scour Analysis • Structural Health & Prognostics Management. Sandia's activities focus on reducing the technology risks associated with OSW power generation and to reduce the levelised cost of energy.
PACIFIC NORTH WEST **Washington**	A laboratory specialising in met ocean condition measurement and modelling and wildlife monitoring. It carries out a range of work on US coastal wind resource assessment and developed a tool for tracking bird and bat interaction with wind farms.
SAVANNAH RIVER **South Carolina**	A laboratory operated by the DoE Office of Environmental Management. It carries out studies on wave impact on OSW.

POWER-US

POWER-US is one of the consortia established to bid in the current competition for the $20.5 million DoE funding for OSW research and development. It is being co-ordinated by the Massachusetts Clean Energy Center (MassCEC). The funding is spread over four years but the winning consortium is expected to become a self-sustaining hub, coordinating and steering much of OSW research in the US, and therefore has the potential to be highly influential in OSW research and development in the US.

Whilst is it not within the remit of this report to speculate on which consortium may win the funding, the membership of POWER-US covers an impressive range of 15 leading US universities, 8 national and regional laboratories, 3 leading overseas OSW research and development institutions, 2 offshore turbine manufacturers and 6 US OSW developers. Members include, amongst others, MassCEC, NREL, DTU Ørsted and Deepwater Wind. It also incorporates most of the key OSW test and demonstration facilities in the US.

The programme would focus on eight technology working groups (see right) relating to OSW challenges for the US market.



Source: *POWERr-US*

The consortium is set up as a membership organisation with state membership ($1 million-per-year for 4 years) core industry member ($250 million-per-year for 4 years), member ($10k-per-year). **ORE Catapult and Durham University are both engaged as key international advisory members of the consortium.**

STATE UNIVERSITIES

A small number of departments have been set up in US universities to address issues related to OSW, mostly on US-specific issues. This is an emerging research sector in the US and most departments have been set up in the last five years and did not appear to be as developed as programmes in key universities in the UK. Activities carried out within the universities range from policy and economic analysis, through lab testing to full-scale offshore demonstration. Funding for academic activities comes from a combination of the DoE competitive funding, state funding and philanthropic organisations.

Universities known to be active in OSW research in the US

UNIVERSITY OF DELAWARE	The University of Delaware (UD) hosts a Wind Power Program, which conducts research, education, and outreach on wind power, with a focus on coastal and offshore wind. UD also hosts a Special Initiative on Offshore Wind, which is separate from the Wind Power Programme. It is funded by four philanthropic organisations and is focused on developing policy to support OSW, including capitalising on lessons learnt from Europe.
UNIVERSITY OF MASSACHUSETTS	UMass hosts the Massachusetts Research Partnership (MRP) for Offshore Wind. It is funded by MassCEC (for around $300k) and includes six MA academic and research institutions. MRP was established to prepare the national research agenda. UMass conducts a wide range of wind energy research within its Wind Energy Centre including work on controls, monitoring, data management, aerodynamics, and materials. UMAss Amherst is a key part of the POWER-US Consortium.
UNIVERSITY OF MAINE	The University of Maine is leading activities on the New England Aqua Venture Demonstration Project, a partially DoE-funded OSW demonstrator. The University of Maine also hosts the DeepCwind Consortium, a 30-member consortium funded by the DoE and NSF, amongst others, to develop floating wind for deep water.

Other universities known to be active in OSW research include:

- Florida International University
- Johns Hopkins University
- North Eastern University
- Oregon State University
- Stanford University
- Tufts University
- University of Maryland
- University of Texas

OTHER R&D INSTITUTIONS	
Other R&D institutions identified during the mission that are carrying out research into OSW in the US;	
WOODS HOLE OCEANOGRAPHIC INSTITUTION Massachusetts	Private non-profit research institution specialising in ocean monitoring and assessment. They have been carrying out research into environmental monitoring of OSW.
BIODIVERSITY RESEARCH INSTITUTE New York	Private non-project research institution specialising in the study of biodiversity. Actively researching the impact of OSW on wildlife.

Industry

There is little industry-led R&D activity in OSW in the US at present, and no evidence that this is likely to change in the immediate future. The European-based developers and turbine manufacturers have established R&D centres and partnerships in Europe and the indigenous supply chain is not yet mature enough to be focusing on R&D.

In addition, there appears to be little pressure from US stakeholders to site additional R&D capacity in the region. The stakeholder focus for attracting investment appears to be very much on manufacturing jobs.

Two exceptions to this were evident during the mission:
- GE has its global research base in New York, with 20-30 people working on OSW. However, the majority of OSW turbine R&D is still carried out in Europe where core expertise is readily available.
- The POWER-US consortium has a range of industry members and it is likely some of the other bidders also do. This appears to be strong platform for industry to start engaging with the emerging US OSW research sector.

3.3 Key Facilities

Despite the immaturity of the market, the US boasts a world-class portfolio of OSW R&D facilities that can rival most countries in Europe, including the UK. Some key facilities are outlined below.

NREL

NREL has over fifteen years of testing and validation of wind turbines, making it the most-experienced wind turbine test facility and team in the US. It is a DoE-funded National Laboratory based in Colorado. Facilities relevant to OSW include:
- Drive train testing up to 5 MW.
- Blade testing (load and accelerated life) up to 50 m blade length.
- Controllable Grid Interface for off-grid validation of turbine electronics.
- Structural testing labs.

The test facilities at NREL are too small for full-scale testing of turbine components but are useful for scale testing and research. They are also a key partner in the WTTC blade testing facility in Massachusetts, which has larger blade facilities.

CLEMSON UNIVERSITY WIND DRIVE TRAIN TEST FACILITIES

Clemson University hosts the US's largest wind turbine drive train test facilities. It has two test rigs capable of testing 7.5 MW and 15 MW. The facility opened in 2013 and cost $90 million, of which $45 million came from the DoE. In 2017, MHI-Vestas announced it would be using the Clemson facilities to test its newest 9.5 MW turbine drive train.

The facility also hosts Duke Energy's e-Grid, which is a 15 MW grid simulator capable of simulating any grid in the world.

WIND TECHNOLOGY TESTING CENTER (WTTC)

Hosted by MassCEC, the WTTC is the US's largest blade test facility. It is based in Massachusetts and can test blades up to 90 m in length. This compares to 100 m at ORE Catapult and current requirements from industry for 105 m blade testing.

The centre opened in 2011. NREL is a partner and brings its experience of testing to the centre.

NEW ENGLAND AQUA VENTUS 1

Aqua Ventus I, is a 12 MW floating wind demonstration project in 60-100 m water depth off Maine. The project will deploy two 6 MW turbines on a floating concrete semi-submersible design by the University of Maine. The project will be grid-connected.

It is being developed as part of the DoE Offshore Wind Advanced Technology Demonstration Project. The DoE provided $39.9 million with further funding available during construction phases. The total project cost is expected to be around $96 million.

Project partners include the University of Maine Advanced Structures and Composites Center, Emera, Cianbro and DCN.

Other relevant facilities are listed below. This list is not intended to be exhaustive but covers the facilities identified during the mission.

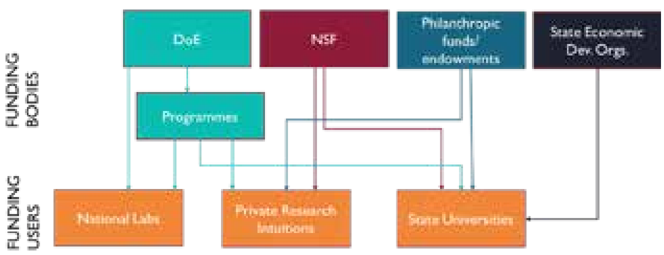
TESTING		
Operator	**Facility**	**Comment**
Florida International University	Wind tunnel	The FIU Wind Wall is a large wind tunnel capable of testing scale models of OSW structures. It can simulate hurricane conditions.
Oregon State University	Wave tanks	The Hindsdale Wave Lab is the largest wave flume basin in North America. Working on hurricane resistance in OSW structures.
University of Maine	Integrated wave/wind tanks	The Alfond W2 Ocean Engineering Lab is a 1:50-scale offshore model testing facility that can simulate wind and wave conditions for floating turbines.
Pacific North West (PNW)	Lidar Buoys	PNW have two buoy-mounted lidar to collect meteorological and oceanographic data, which relevant bodies can rent for met ocean studies.
DEMONSTRATION		
Lake Erie Energy Development Corporation	Icebreaker Project	A planned demonstration project consisting of six 3.45 MW direct-drive turbines on innovative bucket foundations eight miles off the coast of Cleveland in Lake Erie. Part of the DoE's Offshore Wind Advanced Technology Demonstration.
Virginia Electric and Power Company	Virginia Offshore Wind Technologies Advancement Project (VOWTAP)	In 2016, BOEM issued a wind energy research lease of Virginia, giving Virginia's state energy agency the right to pursue the Virginia Offshore Wind Technology Advancement Project (VOWTAP), a 12 MW OSW test facility to be located in federal waters.

3.4 Funding

There are three main funding sources available for OSW research and development in the US:

1. Federal funds
   a. Department of Energy – basic and applied research
   b. National Science Federation – basic research
2. State-level funding
3. Private philanthropic funds and private endowments

Figure 5: Summary of funding pathways for OSW in the US



At present the level of public and private funding available for OSW research in the US is low compared with other energy sectors. However, it is roughly comparable to the level of R&D spend on OSW in the UK. For example, Innovate UK spent around £15 milion per annum for the last five years, including grants for the operation of ORE Catapult, which is in the same ball park as the Department of Energy's expected spend on OSW programmes and relevant National Laboratories spend. There has been a general increase in the level of funding available for OSW R&D in the US over the last 2-3 years, both at state and federal level and to lesser extent from industry. This has been driven by increasing confidence in the viability of the US OSW industry, focus on job creation and the visibility of "steel in the water" at Block Island. It may be reasonably expected that funding will increase as the industry becomes more mature and established.

3.4.1 The Department of Energy

The Department of Energy (DoE) is the primary source of federal funding for OSW R&D in the US. Smaller amounts are provided by BOEM. To date, funding for OSW R&D has mainly been provided to the National Laboratories. In general, the level of funding available for R&D for renewables in the

US has remained stable in the change between the Trump and Obama administrations, with more of this funding being provided to OSW. However, the level of ongoing DoE funding is hard to predict as there is no underlying federal policy supporting the expenditure. The R&D budget for renewables has remained stable, primarily because it is set by Congress rather than President Trump's White House, which is less supportive of OSW, although the DoE reports to the White House.

In December 2017, the DoE announced a $20 million funding call for a consortium to deliver innovation across key US-specific OSW industry challenges. The programme runs for four years and needs to be match-funded by the consortium. The winning consortium will be able to prioritise how the funding is spent and will be able to issue funding for specific projects, to an extent taking over the historical role of the DoE. The DoE hopes the consortium will build on the seed funding and become a lead in OSW R&D in the US. The winner is expected to be announced in June 2018.

3.4.2 Other Funding Sources

NATIONAL SCIENCE FEDERATION (NSF)

The NSF is a government agency that supports fundamental research and education in all science and engineering. It primarily funds universities through competitive grants. It has funded a range of research programmes in OSW but not to the same extent as the DoE.

STATES

Some funding is available at state level to match-fund federal or private funding for research initiatives undertaken by state research institutions. The amounts and mechanism for issuing funding will vary by state. A good example of this is MassCEC providing some of the match funding to allow the POWER-US consortium to apply for DoE funding.

PRIVATE PHILANTHROPIC FUNDS

Some philanthropic funds will fund OSW research initiatives. For example, the University of Delaware Special initiative on OSW is supported by the Rockefeller Brothers Fund, New York Community Trust, John Merck Fund, and the Mertz Gilmore Fund. Universities and research institutions also have obtained direct funding from private endowments which are spent on research, potentially including OSW programmes.

3.5 Technical Focus and Strengths of US OSW R&D Sector

The following areas were identified during the mission as areas of focus for OSW innovation activities in the US. To provide some context for observed capabilities, a very broad comparison with UK capabilities in the areas has been provided. This is a qualitative assessment based on discussions during the mission and visible innovation programmes identified.

	Focus areas	Level of interest	Level of capability in US compared with UK
Optimising turbine and BOP design	Floating wind	High	Higher
	Fixed foundations and structures	Medium	Lower
	Next generation rotors	Medium	Similar
	CFD and wind farm aerodynamic modelling	Medium	Higher
	Blade and drive train testing design	Medium	Similar
Manufacturing and supply chain	Techno-economic modelling	High	Similar
	Supply chain transition	High	Lower
	Advanced manufacturing of wind turbines and BOP	Medium	Similar
	Advanced material for wind turbines	Medium	Similar
Site development	Wildlife impact monitoring and assessment	High	Lower
	Met ocean condition assessment	High	Similar

	Focus areas	Level of i nterest	Level of capability in US compared with UK
Installation	Installation of wind farms	Medium	Lower
Operational challenges	O&M operations (including HSE)	High	Lower
	Wind farm hurricane and storm survival	High	Higher
	Condition monitoring and diagnostics	Medium	Similar
	Freshwater ice survival	Low	Higher
Grid	Integration of OSW onto grid	Medium	Similar

4. Potential UK-US Collaboration on Offshore Wind

This section of the report examines the benefits, opportunities and mechanisms with the US on OSW R&D.

4.1 Potential Benefits of Collaboration

There are a range of potential benefits for collaboration for both the US and UK. These are summarised in Figure 6 below.

Figure 6: Potential benefits for OSW R&D collaboration

4.1.1 Why the US is Keen to Collaborate with the UK

Accelerate US OSW industry development

The US has very limited track record in deploying OSW, with only 30 MW capacity constructed. The states have set very ambitious targets for deployment of wind over the next decade which means the US must come up the OSW learning curve very fast. In order to deliver the proposed projected in a safe, timely and cost-effective manner, the US stakeholders are keen to understand lessons learnt from the UK's experience of subsidising, consenting, constructing and operative OSW farms. Through this, US stakeholder are hoping to avoid the mistakes made during the early stages of the European OSW industry and benefit from the significant achievements made in cost reduction.

Gain access to capabilities that will allow US firms to successfully enter OSW market

As discussed, in addition to growing a cost-effective market, the US is looking build economic benefit through a local supply chain. To do this state are looking to import expertise from the Europe to embed into the potential US OSW supply chain to allow US companies to position themselves to supply to the US OSW market as it grows.

4.2 Partnership Synergies

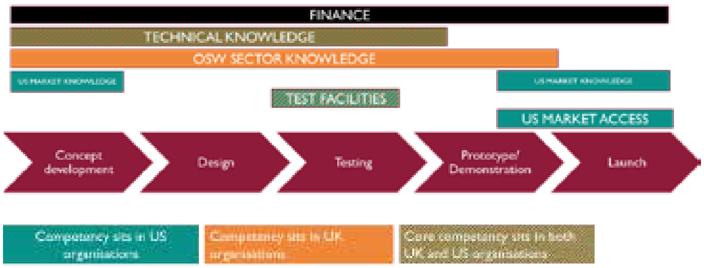
There is a strong synergy between what the UK can offer and what the US needs to accelerate and overcome barriers to delivery of a sustainable OSW market. The key barrier to deployment of innovation in the US is lack of "real-world" experience of deploying and operating OSW projects. This is where the UK's core capabilities in OSW lie.

The key barrier to UK companies deploying OSW innovation in the US is US market knowledge and market access. This is something that can be, to a large extent, provided by US companies or companies with a US base. Therefore, there is potential for the US and UK's capabilities to be used to complement each other to provide mutual benefit.

In addition, there is a high level of relevant technical expertise, in a range of relevant subjects, on both sides of the Atlantic that can be mutually shared support innovation in the OSW sector.

The diagram below shows the steps needed to bring innovation to the market and how the core capabilities of both the US and UK map against these requirements. It highlights areas where the UK can provide capabilities to the US innovators and vice versa and where there is overlap and therefore there is opportunity for co-development.

Figure 7: Synergies between US and UK linked to the capabilities needed to bring OSW innovation to the market



4.2.1 Technical Area Synergies

The potential technical areas for collaboration were assessed qualitatively, addressing all the areas that were identified as areas of R&D interest by US stakeholders during the mission. These are summarised in the table below.

Focus areas	Potential for collaboration	Reason for rating
Floating wind	High	There is a high level of interest in floating wind in the US and world-leading facilities. The UK can learn from US activities, whilst UK can provide general wind farm operation expertise.
Blade and drive train testing design	High	There is opportunity for mutual beneficial knowledge exchange based around the UK's and US's world-class facilities.
Techno-economic modelling	High	There is strong interest from the US in working with the UK to understand our techno-economic models and assumptions.
Advanced materials for wind turbines	High	High level of expertise in both countries. UK has world class expertise in composites for blades through NCC. The US also has strong capabilities.
Metocean condition assessment	High	Programmes running in ORE Catapult and US national laboratories on metocean assessment technology
O&M operations (including HSE)	High	UK has a high level of expertise and data which can be leveraged, one of the key offerings which makes the UK an attractive partner to the US.
Condition monitoring and diagnostics	High	UK has been pushing innovation in this area and brings real knowledge of the needs of monitoring. US has expertise from other sectors.
Integration of OSW onto grid	High	Good level of expertise on either side of the Atlantic. Potentially mutually beneficial topic for both countries. Individual states already looking to Europe for expertise on this.
Fixed foundations and structures	Medium	The UK has expertise to offer on this, but the US is likely to want to build on US capabilities in the oil and gas sector.
Next generation rotors	Medium	Some expertise on both sides but not a core skill set unique to the UK. More expertise sits in other European countries.
CFD and wind farm aerodynamic modelling	Medium	Good level of expertise in the UK. Strong level of expertise in the US and in Germany or Denmark. US has some facilities that the UK could benefit from accessing.
Supply chain transition	Medium	UK has some expertise, although limited success in this.
Advanced manufacturing of wind turbines and BOP	Medium	Turbine manufacturing is driven by the turbine manufacturers and without their buy-in it is a challenging area to develop. More opportunities around BOP, but there is limited expertise in the UK.
Wildlife impact monitoring and assessment	Medium	Best practice and technology can be shared but many issues will be US species-specific.
Installation of wind farms	Medium	UK has some expertise but much of the expertise sits in other European counties.
Freshwater ice survival	Low	No interest to UK, and UK has minimal expertise.
Wind farm hurricane and storm survival	Low	No benefit to UK, and UK has minimal expertise.

Appendix 1: Offshore Wind Projects

State	Project name	State	Capacity (MW)
Operational	Block Island	Rhode Island	30
Leased	Maryland US Wind Inc Offshore Wind Farm	Maryland	625*
	Skipjack	Maryland	120*
	Bay State Wind	Massachusetts	2000
	Vineyard Wind	Massachusetts	1600
	Deepwater 1.2	Massachusetts / Rhode Island	1000*
	US Wind	New Jersey	2226
	DONG Energy	New Jersey	1947
	Garden State Offshore Energy	New Jersey	680*
	Statoil Wind NY	New York	1000
	Deepwater 1 South Fork Project	New York	90*
	Avangrid Renewables	North Carolina	1485
	Icebreaker	Ohio	21
	Galveston Offshore Wind Farm	Texas	150
	Virginia Dominion 2	Virginia	1500
	Virginia Dominion 1	Virginia	500
	Virginia Demo (VOWTAP)	Virginia	12
Lease expected	Connecticut 1	Connecticut	200
	Unleased Area	Massachusetts	3009
	Unleased Area	Massachusetts	1710
	New York 1	New York	400
	New York 2	New York	400
	WEA Wilmington West (NC)	North Carolina	1623
	WEA Wilmington East (NC)	North Carolina	627
Identified zones and unsolicited applications	Trident Winds (Morro Bay) (CA)	California	765
	California - Potential Offshore Wind Energy	California	100
	AW Hawaii Wind (Oahu Northwest)	Hawaii	408
	AW Hawaii Wind (Oahu South)	Hawaii	408
	Progression Hawaii	Hawaii	400
	New England Aqua Ventus III	Maine	4508
	New England Aqua Ventus II	Maine	480
	New England Aqua Ventus I	Maine	12
	Martha's Vineyard Wind Energy Area	Massachusetts	234
	Gosnold Wind Energy	Massachusetts	153
	Fishermen's Energy Atlantic Offshore Wind Farm	New Jersey	24
	New York 3	New York	800
	New York 4	New York	800
	PNE Wind USA (Excelsior Wind Park) NY	New York	400
	Grand Stand	South Carolina	7623
	Cape Romaine	South Carolina	1887
	Charleston	South Carolina	432
	Winyah	South Carolina	423

*Lease capacity given as announced planned project capacity. Leased site may have space for additional projects.

Appendix 2: State-by-State Overview

(continued from section 2.6)

RHODE ISLAND

Announced cumulative capacity to be leased by end of 2019: 530 MW

Rhode Island hosts the only operation OSW farm in the US, Block Island Wind Farm. Deep Water, the Block Island developer, has ambitions for a further 1.0 GW project that spans across Rhode Island and Massachusetts.

Leasing areas and key projects

- Home to America's first OSW farm, Block Island.
- Lease in place for a 1.0 GW site that spans across Rhode Island and Massachusetts.

NORTH CAROLINA

Announced cumulative capacity to be leased by end of 2019: 3,735 MW

Avangrid Renewables is planning a 1.5 GW project sited 27 miles off the coast of North Carolina, after winning an offshore lease from BOEM. Two additional development areas of North Carolina are expected to be leased by BOEM in 2018. They cover 1,401 km^2 and 209 km^2 respectively.

Leasing areas and key projects

- 1.5 GW Avangrid Renewables project BOEM lease granted in 2017.
- BOEM lease auctions for WEA Wilmington East and West, totalling 2.25 GW, planned for 2018.

HAWAII

Announced cumulative capacity to be leased by end of 2019: 0 MW

Two sites surrounding the Hawaiian Island of Oahu have received unsolicited bids and Requests for Interests, but BOEM is still investigating their suitability for OSW leasing.

Hawaii has predominately deep water so would require floating turbine technology.

Leasing areas and key projects

- 621 km^2 Oahu North Area.
- 1341 km^2 Oahu South Area.

TEXAS

Announced cumulative capacity to be leased by end of 2019: 150 MW

There has been little OSW activity in Texas to date. In 2005 a lease in state waters was acquired. A met mast has been collecting data since 2007. An update in the 4C Offshore database in 2017 states that the project will go ahead once a PPA agreement is in place.

Leasing areas and key projects

- 150 MW Galveston Offshore Wind Farm.

CALIFORNIA

Announced cumulative capacity to be leased by end of 2019: 0 MW

California has strong carbon reduction targets with a 50% renewable electricity target by 2030 and it was anticipated that OSW would have a role in this. However, no leases have been issued yet and there are some significant challenges to overcome before the market can really take off in the state:

- Deep water – California has deep water, so any major wind farm developments will need to employ floating wind technology, which is still an immature technology.
- The US Navy has declared a large tranche of seabed earmarked for OSW as off-limits for development, confining development to the north of the state. This is currently under review.
- Permitting and consenting – stakeholders in California have a conservative approach to seabed development.

Due to these challenges, it is not expected that California will have any wind farms installed before 2025.

Leasing areas and key projects

- The Redwood Coast Energy Authority selected a consortium to develop a 100-150 MW site. A lease application is expected in 2018.
- A project in Morro Bay raised interest from Trident Wind and Statoil. Subject to BOEM studies, the project will go to a competitive auction.

MAINE

Announced cumulative capacity to be leased by end of 2019: 12 MW

Maine is actively pursuing floating OSW, as the Gulf of Maine has deep water. To this end, New England Aqua Ventus' phase one, a 12 MW floating site, has been consented off the coast of New England. The developer is hoping to develop the project further in three phases, including 480 MW in phase 2 and 4508 MW in phase 3.

The Maine Wind Energy Advisory Commission was established in January 2018 to study the economic impact of OSW farms and consider the need for leasing procedure specific to OSW projects. No permits related to OSW turbines can be submitted until the Commission's written report of findings and recommendations is published.

Leasing areas and key projects

- New England Aqua Ventus developers have ambitious aims for a total of 7.5 GW floating offshore. A pilot 12 MW site is planned for 2020.

VIRGINIA

Announced cumulative capacity to be leased by end of 2019: 2,012 MW

In 2017 Dominion Energy Virginia announce a partnership with Ørsted to develop the Virginia Offshore Wind Technology Advancement Project (VOWTAP), a 12 MW demonstration project consisting of two 6.0 MW turbines. The project is still in development. This the first phase of development by Dominion in Virginia that has the potential for another 2,000 MW, but this is at an early stage.

OSW activities in Virginia are coordinated by the Virginia Offshore Wind Development Authority.

Leasing areas and key projects

- Dominion has leased two site sites in Virginia, totalling 2,012 MW. Dominion has an agreement in place with Ørsted to develop a two-turbine 12 MW site, with the potential for further collaboration to develop the remaining capacity.

SOUTH CAROLINA

Announced cumulative capacity to be leased by end of 2019: 0 MW

A call for interest for four OSW development zones off South Carolina's coast was issued in 2015/16. Two developers responded and in 2016 these were reviewed by BOEM. However, little activity has been observed since.

Leasing areas and key projects

- Four development areas have been identified, although no evidence of progression since BOEM's review.
- Cape Romaine – 1800 GW.
- Charleston – 432 MW.
- Grand Strand – 7620 MW.
- Winyah – 423 MW.

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