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CIOS LEP CORNWALL & ISLES OF SCILLY LOCAL ENTERPRISE PARTNERSHIP

CATAPULT Offshore Renewable Energy

Supply chain report

BENEFITS OF FLOATING OFFSHORE WIND TO WALES AND THE SOUTH WEST

CONTENTS

FLOATING WIND INDUSTRY BACKGROUND

There is significant opportunity for floating offshore wind in UK waters, including the Celtic Sea covering waters around Wales and the South West of England. However, the pilot floating offshore wind projects deployed in Scotland to date have had limited contribution from the UK supply chain, with major fabrication and installation works being undertaken in Spain and Norway.

This report investigates how the industries surrounding the Celtic Sea can maximise local content. Under the UK's Industrial Strategy and Clean Growth Strategy, there is an increasing need to demonstrate that public funding of energy generation is giving value to UK taxpayers and energy consumers. Currently the UK supply chain for fixed bottom offshore wind is achieving 48% of the lifetime value of projects[1] . The Sector Deal, between the government and the sector, agreed in March 2019 sets a target of achieving 60% UK content by 2030, including an emphasis on increasing the UK share of capital expenditure ("capex") beyond 29%. This kind of supply chain development, which the region is seeking to encourage, will be critical to the sector delivering on its commitments.

Deployment and UK content targets by region or country within the UK are not specified in the Sector Deal. However, in order to implement the Deal successfully, the sector proposes capitalising on naturally existing clusters and providing sector leadership to create more opportunities for investment and growth in local economies. The sector is committed to continuing to invest in projects that will benefit local communities in the regions in which they operate.

1. *https://c.ymcdn.com/sites/www.renewableuk.com/resource/resmgr/publications/Offshore_Wind_Investment_V4.pdf*

1 INTRODUCTION

1.1 AIMS AND OBJECTIVES OF THIS REPORT

There is an opportunity to develop a local supply chain for Wales and the Greater South West region that is well equipped to provide the foundation for, and then benefit from, the long-term opportunities associated with the build-out of floating offshore wind in Wales, the Greater South West region and nationally.

The purpose of this report is to articulate the benefits to Wales and the South West in realising this ambition of developing and deploying a number of pre-commercial floating offshore wind projects in the mid to late 2020s, increasing in size from 32MW at Wave Hub to 90MW at Pembrokeshire Development Zone (PDZ) or equivalent site, then a 300MW project and a 500MW project.

This report defines a vision for floating offshore wind in Wales and the South West, evaluates supply chain areas that build on existing capabilities in the region and analyses what developments and investment are needed to achieve the vision.

We will make recommendations to maximise opportunities for local companies to grow with the industry, based on evidence and lessons learned from the global bottom-fixed offshore wind sector.

1.2 RESOURCE POTENTIAL

The Celtic Sea surrounding Wales and the South West has high average wind speeds, typically above 8 metres per second in water depths of 50 metres and above. Bristol based consultancy ITP Energised have undertaken a resource assessment of the potential for floating offshore wind capacity that could be deployed in the Irish and UK waters of the Celtic Sea for Simply Blue Energy[2].

Using GIS mapping to identify constraints, consenting issues and suitable environmental conditions, they identified ten potential zones for development as shown in ***Figure 1***. These zones have average wind speeds exceeding 10 metres per second. The Wave Hub test site and Pembrokeshire Demonstration Zone are indicated on the map as stars.

Taking account of further grid, environmental and technical constraints, ITP Energised suggest that between 15 – 50GW of the 150-250 GW total floating offshore wind capacity could realistically be developed in the Celtic Sea region between the UK and Ireland.

It is important to note that these zones are presented as one possibility of high potential areas for future offshore wind development. They have not been endorsed by The Crown Estate, who will conduct their own exercise ahead of any future seabed leasing rounds.

2. Assessment of the floating offshore wind potential in the Irish and UK waters of the Celtic Sea, Simply Blue Energy, 2019

This detailed work has not been done further up the coast along the North and Central Welsh coast, though there is additional potential for floating wind in parts of the Irish Sea in Welsh waters. ***Figure 2*** highlights the wind speed in areas of the seabed with water depth above 60 metres, however no further refinement according to exclusion areas has been performed.

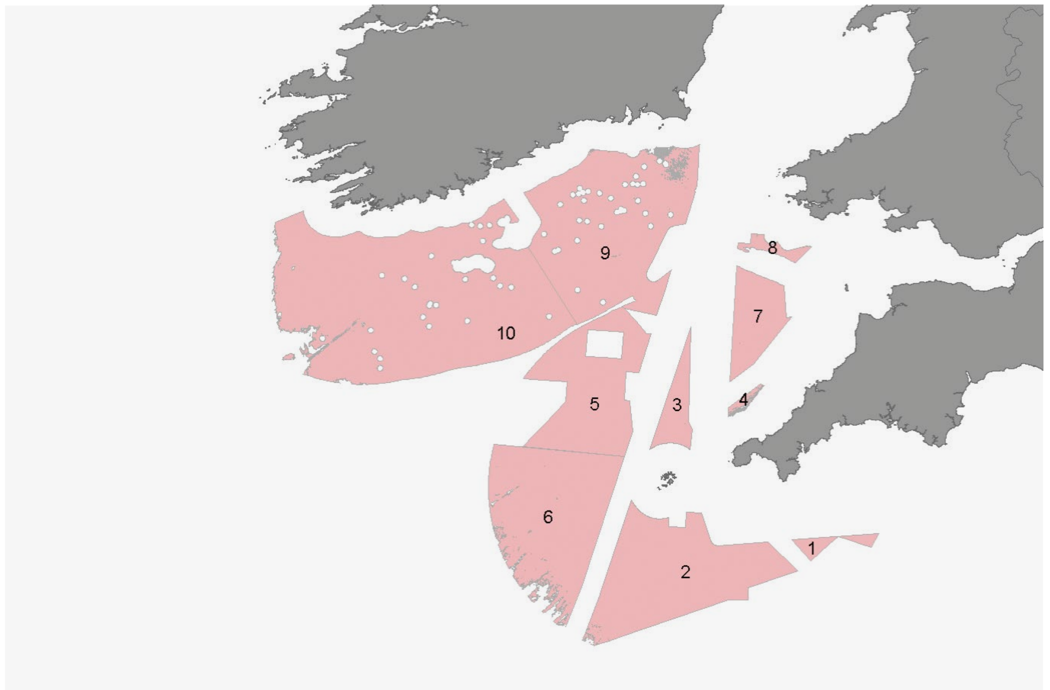

Figure 1: *Potential zones of floating wind development as identified by ITP Energised*

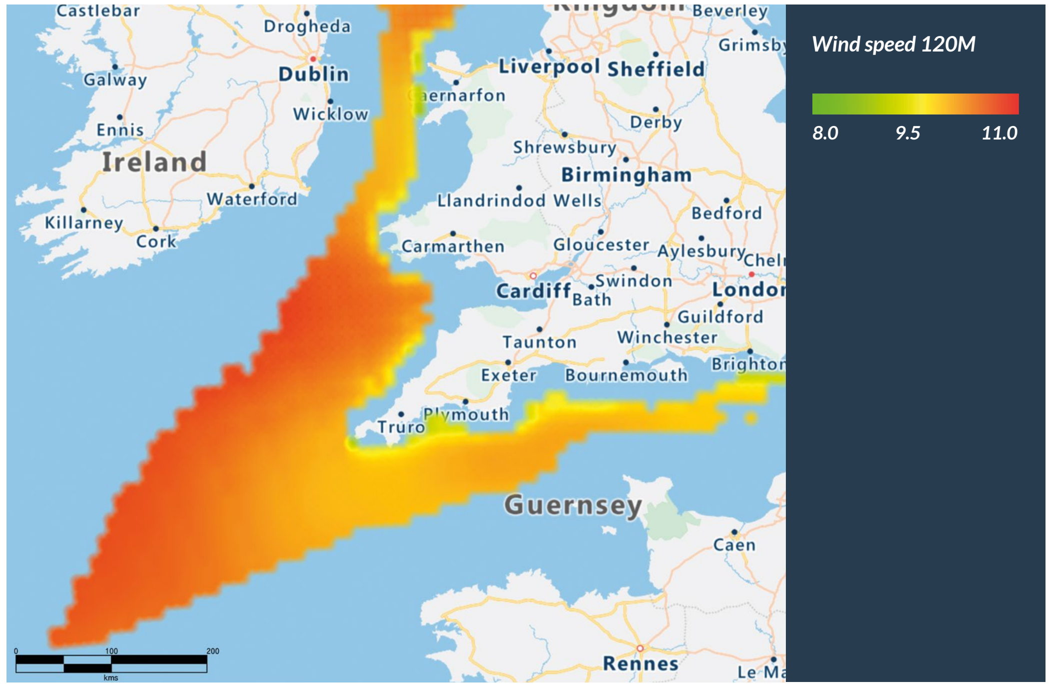

Figure 2: *Wind speed in waters around Wales and the South West*

2 FLOATING WIND PROJECTS IN THE CELTIC SEA

2.1 FLOATING WIND SITES IN WALES AND THE SOUTH WEST

Wales and the South West benefit from two designated development zones and access to deep water, high wind sites as a pipeline of future projects. This provides opportunities for the supply chain to prove their capability on smaller projects before investing in larger facilities to support commercial scale sites.

To analyse the potential economic growth this could induce in the region, a series of projects have been modelled with the site parameters shown in ***Table 1***.

These projects are:

- Wave Hub is a purpose-built grid connected test site capable of connecting 32MW capacity via an armoured cable with a single tail connecting each turbine to a subsea socket, or up to 48MW with upgrades. It is located 16 kilometres off the north coast of Cornwall and is undergoing an update to the consent to include floating wind. The seabed lease is active with 15 years remaining.
- Pembrokeshire Development Zone (PDZ) is located off the south Pembrokeshire coast and comprises a 90-kilometre squared area of seabed with water depths of between 50-62 metres. It is located between 15-21 kilometres offshore and the existing seabed lease is for wave energy. Discussions are ongoing with The Crown Estate to enable floating wind technology to be deployed at the site as well as wave energy. The Crown Estate retains an open-door policy for developments up to 100 MW.
- A 300MW site is modelled, 40 kilometres off the south coast of Pembrokeshire. The area has excellent wind resources in deep water offshore locations, suitable for floating wind power.
- A 500MW site is modelled 60 kilometres west from Cornwall, again noted as an area of high wind speeds and suitable water depths.

Floating wind turbine technology will mirror developments in fixed bottom wind. Paramount to this is the expectation that future projects will be using larger turbines. The turbines in Table 1 have been chosen as indicative of the technology expected to be available over the next decade, with 15MW turbines for the project being installed in 2029/2030, which are expected be the standard turbine rating by the late 2020s.

Project Description		Wave Hub	PDZ	300MW Site	500MW Site
Expected commissioning year		2023/24	2025/26	2027/28	2029/30
Project Capacity	***MW***	32	90	300	500
Turbine Rating	***MW***	8	10	12	15
Number of turbines		4	9	25	33
Water Depth	***m***	50 - 58	50 - 62	100	100
Distance from shore	***Km***	16	15	40	60

Table 1: *Regional floating wind projects*

2.2 FLOATING WIND SUPPLY CHAIN REQUIREMENTS

As the projects increase in size, fabrication moves from being bespoke pieces to requiring assembly line style methods beyond the current capability and scale of the regional supply for some components.

To build this capability, the region will need to invest in facilities to retain a large share of supply chain, as well as unlocking the opportunity to export these skills to projects in Ireland and further afield. Key supply chain requirements are outlined in ***Table 2*** [3].

Key Metrics		Wave Hub	PDZ	300MW Site	500MW Site
Tonnes of steel	***tonnes***	9,926	24,089	78,767	126,044
Metres of array cables	***metres***	4,400	135,900	60,118	79,355
Metres of chain/mooring	***metres***	6,294	14,067	51,064	67,405
Equivalent mass of mooring chain	***tonnes***	3,842	10,210	22,994	30,352
Number of anchors		12	27	75	99
Approximate mass of anchors (Total Array)	***tonnes***	252	540	1,463	1,931
Crane capacity required (onshore or offshore)	***tonnes***	550	700	700	700
Port-side assembly time	***days***	12	15	45	63
Installation vessel days	***vessel days***	373	603	990	1,185

Table 2: *Key supply chain requirements*

2.3 FLOATING WIND COST REDUCTION

Floating wind has made significant advances in recent years and is set to become a major contributor to global offshore wind capacity over the coming decades. However, there is currently no clear route to market for floating wind.

The options are to compete with bottom-fixed projects for a Contract for Difference (CfD) auction or find a private offtaker willing to pay a premium on their electricity to support the development of floating wind. Costs are expected to reduce on a 'per kilowatt' basis with project size and associated global industry maturity, as demonstrated in ***Table 3***. The supply chain will need time and investment to scale up to commercial scale projects and without a visible pipeline of projects, it will be difficult for the industry to achieve the costs anticipated in this assessment.

The series of projects in the region will see cost reduce in the following ways:

- Development costs are reduced for the Wave Hub and PDZ sites because the sites are expected to be pre-consented with a good understanding of the seabed and metocean conditions. Project developers will still need to undertake engineering design and project planning.
- The Wave Hub site is grid connected, with a connection available offshore for turbines to hook up to. The project at PDZ is expected to connect directly from individual array cables to onshore infrastructure without an offshore substation or higher voltage export cable. This adds additional cost to the PDZ site that pushes the capex higher than WaveHub.
- The anchor costs appear higher for the 8MW turbines at Wave Hub as the larger 10MW designs for subsequent turbines require relatively less anchoring mass 'per kW' than the turbines at Wave Hub.

3. *These values have been estimated using internal ORE Catapult bottom-up project modelling using the parameters outlined in Table 1 for a generic floating wind foundation*

- While 8MW turbines are modelled as being used at Wave Hub, wind turbine costs are expected to increase at PDZ when the project makes use of 10MW turbines new to the market. Turbine costs are then expected to reduce as the technology matures. Balance of plant costs have an associated cost reduction on a 'per kW' scale due to the larger turbines.
- Costs with a high fixed component, including installation vessels, electrical infrastructure and ports see a cost benefit with the larger projects as the fixed cost element is shared across a larger site.
- Operating costs, which are driven by the cost of accessing the site, also see a reduction in cost as the project capacity increases due to high fixed vessel costs and onshore facilities which benefit from larger sites. Floating sites are also expected to benefit from innovation driving cost reduction in fixed bottom offshore wind site, such as increasing automation and use of remote inspection. Regulatory and grid charges are included in 'other opex' along with operating insurance.

Capex		Wave Hub	PDZ	300MW Site	500MW Site
Development and Consenting	£/kW	95	94	209	124
Substructure	£/kW	1,368	1,142	1,011	879
Wind turbine	£/kW	1,280	1,200	1,100	1,000
Anchors	£/kW	55	45	32	26
Mooring lines	£/kW	63	95	95	92
Array Cables	£/kW	21	227	22	19
Electrical infrastructure	£/kW	-	190	573	364
Ports & Logistics	£/kW	55	67	30	21
Vessels and subsea engineering	£/kW	379	928	251	198
Other Capex	£/kW	513	561	396	320
Total Capex	£/kW	3,829	4,549	3,719	3,043
Opex		**Wave Hub**	**PDZ**	**300MW Site**	**500MW Site**
O&M offshore activities	£/kW/year	45	31	27	23
O&M onshore activities	£/kW/year	30	11	5	3
Other Opex	£/kW/year	44	44	43	42
Total Opex	£/kW/year	119	86	74	68
Decommissioning		**Wave Hub**	**PDZ**	**300MW Site**	**500MW Site**
Decommissioning	£/kW	345	173	74	51

Table 3: Project costs

Levelised Cost of Energy		Wave Hub	PDZ	300MW Site	500MW Site
LCOE (2012 real pre-tax)	(£/MWh)	123	120	80	64

Table 4: Levelised Cost of Energy

Analysis has been carried out on each key supply chain segment to understand the value that each category represents and how existing skills can be drawn upon to maximise the local content of projects in the region. The idea of planning the series of four projects in sequence gives local supply chain an opportunity to grow and mature as the projects grow in size. By showing capability in small projects, companies will be more confident and more able to access finance to invest in facilities required to win larger contracts.

3 REGIONAL SUPPLY CHAIN ASSESSMENT

The following section provides a detailed supply chain assessment for each cost area covering skills in the Wales and South West region, potential value and potential exportability.

3.1 DEVELOPMENT COSTS

Project development covers all early spend in a project, making up around 5% of capital spend. The main areas covered here are: Project development, certification, consultancy services (design, environmental, legal) and surveys.

3.1.1 Areas of existing strength

Figure 3: Project development supply chain capability in the region

Figure 3 shows the range of companies in the region with skills in project development and associated services. There are several established onshore and offshore wind project developers with transferable skills to floating wind. Cornwall Light and Power, REG wind power, RES and Vattenfall all have a base in the region. The benefit of a project developer established in the region is the use of local professional services: Accounting, legal, HR, IT roles, in addition to direct project development roles, both during construction and through the operating life of the project. It is unlikely that a project developer from outside of the area will set up or grow these departments locally to a project otherwise. It also increases the likelihood of locally based engineering and consultancy services being used.

Project developers often prefer in-house resources, especially in project management, but outsourcing is used wherever specialist advice is needed. There are more than twenty environmental consulting services, including Aquatera, MarineSpace and Cornwall Environmental Consultants with expertise in marine environmental impact assessments as well as several international engineering consultancies with offices in the region, including Ramboll, Atkins, Arup, Buro Happold and Mott Macdonald who all have experience in offshore wind, particularly structural design and resource modelling. There are also many smaller local engineering consultancies with skills across design areas, particularly in mooring and anchor design.

The region has a particular strength in the number of surveying companies in the region. Extensive surveying is done during site development and construction, as well as further surveys over the life of the site. A number of autonomous vessels have been developed in the region, including Thales, Seiche and Unmanned Survey Solutions (USS) which will play a significant role in future wind farms.

Fugro is a global company with significant experience in marine site investigation, pile drilling and foundation design for numerous global offshore wind projects. They have an office in Falmouth with over forty years of local geotechnical knowledge well suited to providing consultancy services during early project development. The team in Cornwall also provide site investigation and surveying expertise, operating drilling equipment and crew out of Falmouth. Data analysis, and wider foundation design, is currently done elsewhere in the UK but they are looking to bring expertise to the region. The wider UK team (Portchester office) also provides floating lidar and weather buoys, with several currently stationed off the coast of Cornwall.

3.1.2 Potential value for regional projects

The region already has the vast majority of skills to support project development. As outlined in ***Table 5***, we expect the region can capture 43% - 52% of project development spend, through local companies providing surveying, engineering design and other development services.

In RenewableUK's 2017 report[4] 'Offshore Wind Industry Investment in the UK', they ascertain that the average UK content of project development for projects that took final investment decision between 2010 and 2015 was 73% versus 57% for projects prior to that. If a project developer with a significant presence in the region takes on a project, we expect that the region can capture 75 - 80% of local project development spend for a project.

Development, regional spend (%)	Wave Hub	PDZ	300MW Site	500MW Site
Project development, Engineering & Certification	40%	40%	45%	50%
Geophysical & Geotechnical Surveys	70%	70%	80%	80%
Met station (LIDAR)			0%	0%
Development Total	**43%**	**43%**	**50%**	**52%**

Table 5: *Regional spend in development*

3.1.3 Potential for export

As design spend during development is largely desk-based, there is a big opportunity to export industry-specific skills developed in this area globally, particularly floating specific expertise where there is less experience available.

Ireland has existing strengths in engineering skills and will be self-sufficient in many areas of project development. Surveying will be very exportable to projects around the UK and Ireland. Companies such as Fugro and Longitude Engineering will also be well placed to provide structural design for specialist areas such as mooring line and anchor system design where there is limited experience. For a commercial project in the Irish part of the Celtic Sea, the region is expected to capture 15% of development costs if surveying companies from the region are used and some engineering expertise.

4. *www.renewableuk.com/resource/resmgr/publications/Offshore_Wind_Investment_V4.pdf*

3.2 SUBSTRUCTURE DESIGN AND FABRICATION

Substructure design and fabrication makes up 25 - 30% of capex spend. It is a labour and material intensive part of the supply chain and, dependent on suitable assembly yard access in the region, can provide a significant opportunity for jobs and manufacturing in the region. Serial manufacture of large units requires fabrication facilities with large laydown areas, high weight bearing quayside with good access and cranage.

A number of technology developers are emerging as leaders in the design of floating substructures - Principle Power with the WindFloat steel semi sub design and IDEOL's Floatgen concrete semi sub for example. There are no active technology developers in the region that have produced scale devices and it is likely that an established substructure design will be used in this series of projects.

Most project developers in the UK will contract a single engineering, procurement and construction (EPC) contractor who will subcontract to specialist companies for different areas of project scope. There is currently no established EPC contractor in the region who could readily undertake this role for a commercial scale floating wind project. The progression of projects from four turbines at Wave Hub to 33 turbines on a 500MW site brings an opportunity for a company, or consortium, to undertake manufacturing and installation contracts with increasing magnitude. This could be a game changer for the industry, representing a move from tier two suppliers to tier one global leaders.

When contracting for substructure fabrication tenders, several factors are assessed:

- **Cost of supply** – Attractive cost and comparable on a like-for-like basis with other bids.
- **Quality of supply** – Track record, quality management certificates, assessment of current facilities and skills to deliver the required scope and any upgrades or investments required in production or logistics.
- **On-time delivery** - Assess quality of supplier's supply chain and risks with transportation and logistics (distance, weather).
- **Warranties** - Ability of supplier to warrant % of contract value for a number of years.
- **Financial strength** - Ability to provide Parent Company Guarantee (PCG) or other underwriting to cover contract value or estimated value of potential losses from failed delivery, which can be greater.

Jacket components, similar to those required for semisub manufacture (tubulars, anodes, etc.), are not currently manufactured in the UK. Local yards are mainly used for assembly of the lower and upper sections, painting of top sections, and mating of these before load-out.

3.2.1 Fabrication Facility Requirements

The key processes, facilities and equipment required for a generic semisub or barge design floating substructure is shown here in order to illustrate how Wales and the South West region's capabilities map to current manufacturing requirements. This also provides a view on where there may be opportunities for improvements or changes to current processes to better suit facilities and expertise available or being developed in the UK.

The basic process for manufacture is shown in ***Table 6***. All facilities may be co-located or spread over a number of highly specialised locations. Where all facilities are not co-located, additional steps for transit of goods between locations is required. This will typically require SPMTs (Self-propelled modular transporters) for movement around the site and barges for transport between sites. Final delivery is made at the wind farm construction port either FAS (free alongside ship) or FOB (free onboard).

Process	Materials	Equipment/Personnel	Facilities
Steel plate goods inward	Processed steel	Cranes	Quayside / Storage
Steel plate rolling	Steel plate	Rolling equipment Production line personnel	Large indoor
Tube longitudinal welding	Rolled steel tubes	Welders / Robotic welding	Large indoor
Quality control		QA personnel (internal)	
Assembly	Structure sections	Cranes Welders / Robotic welding	Large indoor/ Quayside Storage
Quality control		QA personnel (external)	
Coating of structure	Completed structure Spray coatings	Crane Coating personnel	Large indoor

Table 6: *Substructure fabrication facility process*

Table 7 shows criteria for constructing and assembling floating wind substructures, taken from the US Bureau of Ocean Management study[5] "Determining the Infrastructure Needs to Support Offshore Floating Wind and Marine Hydrokinetic Facilities on the Pacific West Coast and Hawaii", with the units converted to metric.

Primary Criteria	
Navigation channel width	Spar: <60m Semi sub: 100m TLP: 91-137m
Navigation channel depth	8.5m minimum, some devices may require more depth
Skilled Labour and Manufacturing	Significant skilled labour pool required
Area	~20 hectares
Road/Rail	Highway connection required. Rail preferred.
Secondary Criteria	
Max vessel length	~143m
Air draft	46m
Min Berth depth	8.5m
Throughput capacity	30+ structures a year
Max Vessel draft	11.6m
Number of deep draft berths	1-Minimum, 2- ideal
Crane	~500-1000 ton
Dry dock and shipyard	Dry dock may be preferred. Width/length varies by technology Spar: ~91m length Semi-Sub: ~53m width TLP: ~53-70m width
Other equipment	Forklifts, crawler cranes, cherry pickers
Quayside bearing capacity	5 ton/square m
Berth length	175m
Max vessel length	143m

Table 7: *Substructure fabrication facility requirements*

5. *https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Pacific-Region/Studies/BOEM-2016-011.pdf*

3.2.2 Areas of existing strength

Figure 4: Substructure manufacturing supply chain capability in the region

Secondary steel stands out as an area of manufacturing that can readily be met within the region. As presented in *Figure 4*, 24 companies, largely clustered in South Wales and several in Cornwall, have been identified as having potential expertise in serial manufacturing parts such as boat landings, external access ladders, external and internal work platforms and corrosion protection systems. Secondary steel amounts to at least 4% of substructure fabrication spend on a project, or around £400,000 per structure.

Tata steel produce two million tonnes of steel coils a year in their steel production plant in Port Talbot. This can be used by fabricators for secondary steelwork for offshore wind structures. Steel coils can undergo further processing in Corby to be formed into tubulars that can be used to make chain. Whilst they see secondary steel and chain as potential growth markets for their product, they do not produce steel plate, which is the main product for offshore wind towers and substructures. Steel plate is produced by Liberty Steel in Scotland and is also commonly imported from other European countries, namely Spain and Poland.

A&P Falmouth have extensive experience in ship repair, which naturally transfers to the skills required for construction and repair of large floating wind substructures. Using the series of growing projects, A&P group is confident that they would be able to train more staff and scale their operations to meet secondary steel contracts for projects in the Celtic Sea.

To serial manufacture entire substructures at the port, A&P group would need significant additional financial backing to increase the height and lifting capacity of onsite cranes to enable portside lifting without the need for rented vessel cranage and extend the length of their quayside to accommodate the substructures that are likely to be more than sixty metres long. A site currently occupied by redundant buildings has been identified that could be redeveloped for new engineering workshops (approximately 9,000 square metres), if demand arises for on-site fabrication.

Pembroke Dock also have a background in ship repair. Mainstay Marine has been based in Pembroke Dock for over thirty years. They have fabricated a number of wave and tidal devices as well as designed and built wind farm support vessels, workboats and passenger vessels. Similar to A&P group, these skills could be transferred to the maintenance, fabrication and assembly of floating wind substructures. The Swansea Bay region are looking at structures that could support consortium of supply chain to bid up a tier.

REGIONAL SUPPLY CHAIN ASSESSMENT

Gibbs General Engineering, based at the Port of Mostyn, is a steel fabrication yard with suitable facilities to supplying secondary steel and similar components for offshore wind projects.

As well as acting as a project developer, RES has experience in the engineering, construction and operation of onshore and offshore wind farms. Coupled with an experienced fabricator with the right facilities, this could form an ideal joint partnership to provide EPC contracting services to projects.

3.2.3 Potential value for regional projects

It is expected that the region can capture 10% of substructure design and manufacturing spend for a Wave Hub project. Without significant public financial support for portside infrastructure to enable growth beyond current plans, we expect that the level of local content will remain at 10% for future projects. This is assuming the region will support 60% of design spend and 4% of manufacturing spend to produce secondary steel in the region.

For substructure manufacture in particular, the series of projects could enable both engineering and commercial learning through scaling up. Investment in serial production across a number of sites will be critical to enable commercial scale manufacture and this takes time to consent and develop the port to integrate new facilities. This is discussed further in section 3.7.

3.2.4 Potential for export

There is an opportunity for companies in the region to produce secondary steel for projects elsewhere in the Celtic Sea, particularly if ports in Wales or the South West are used for turbine assembly. This could include both the production of steel and fabrication into secondary steelworks. If a regionally based EPC builds its expertise through increasingly large projects, there is significant prospect for that company to act in the same capacity for projects in the Irish region of the Celtic Sea.

It is unlikely that secondary steel manufacturing will be exported further afield.

3.3 WIND TURBINE

The wind turbine (nacelle, blades & tower) makes up around 30% of capex spend and tends to be dominated by large established companies, such as Siemens Gamesa, MHI Vestas and GE. This means it is unlikely for the local supply chain to capture significant scope in the short to medium term. The nacelle is usually assembled at the original equipment manufacturer (OEM) facilities and blade manufacturing facilities exist elsewhere in the UK.

3.3.1 Areas of existing strength

There are several existing suppliers of gearboxes and generators and bearing manufacturers that may be able to replace parts in turbines once out of their warranty periods. However, there is no existing offshore wind turbine manufacturing in the region.

3.3.2 Potential value for regional projects

During construction there is limited opportunity for regional companies to supply projects. We do not expect any local content in this category. However, there may be more opportunity for smaller components to repair and replace parts during the operating life of the assets, which are categorised under operating costs, but are highlighted here in *Figure 5*.

Figure 5: *Wind turbine supply chain capability in the region*

3.3.3 Potential for export

It is unlikely that the region will export products or skills in this area.

REGIONAL SUPPLY CHAIN ASSESSMENT

3.4 ANCHORS

Anchors makes up around 1% of capex spend. Their use in commercial scale floating wind farms will require a step up in the manufacture of anchors to serve the industry. Vryhof anchors, manufactured in Rotterdam, were used in the Hywind Scotland project. Companies including Bruce Anchors and Isleburn Limited have production facilities elsewhere in the UK, however expected demand is higher than current manufacturing capability.

The preference for the type of anchors used in a project is driven by the type of structure going in the water and the seabed properties at the site.

- Drag embedded anchors used together with catenary mooring systems use chain mass on the seabed. This system relies on sufficient mass to hold the structure in place, so they would require additional clump weights if used at shallower floating sites such as Wave Hub and PDZ. Drag embedded anchors require sand or shale seabed to embed into the ground when acting in tension. Drag embedded anchors are generally the cheapest option, however they are unsuitable for shared mooring lines, so the cost may balance out for commercial sites.
- Suction anchors apply a vacuum into the seabed ground to exert horizontal and semi vertical resistance to movement. They work best in soft clays. This requires ROVs on site during installation and additional vessels, which can make them the most expensive choice in many situations.
- Piled anchors work best in harder ground and perform best with taut or semi-taut lines. Both suction and piled anchors are suitable for shared mooring lines in large arrays.

3.4.1 Areas of existing strength

There are four companies identified in the region with capability to manufacture anchors. Faun Trackway in North Wales are manufacturing gravity anchors for the Orbital 02 floating tidal device. A further three companies specialise in installation of drilled and grouted, or driven seabed anchor piles.

Acteon Group provides products and services through a range of operating companies to support subsea projects through the life of the site. Several subsidiaries are based the region. Large Diameter Drilling provide marine foundation solutions. They have the capability to drill piles for floating structures up to 8 metres deep using a 500 Nm drill rig. Their sister company Core Grouting Services, based in Cork, provides the grout for these operations. This group of companies are already exporting globally and would be ready to contract for a commercial scale project in the Celtic Sea immediately.

Fugro has recently launched the Fugro Vertical Boring Machine, a new drill designed to maximise efficiency of foundation drilling operations in deep water, which would be suitable for anchoring solutions in hard seabed conditions. Satellite positioning software for the drilling operations is managed from Fugro's Norwegian office, however the drilling equipment and crew are managed out of Falmouth, as for surveying.

3.4.2 Potential value for regional projects

The seabed conditions[6] expected at each of the reference sites are shown in *Table 8*. In the waters around Wave Hub and the 500MW site, the seabed is hard and will likely require piled anchors. For PDZ and the 300MW site, the seabed is expected to be sandy, which is more suitable for drag embedded anchors or suction bucket anchors. If a local company wins the contract for Wave Hub and continues to grow their facilities, there is no reason that piled anchors for the 500MW site and further commercial scale projects cannot be manufactured locally at a competitive price. It is less likely that the region will capture contracts for suction anchors which would still be suitable for a hard seabed. Drag embedded anchors are not expected to be manufactured in the region without significant investment from a newly established company and no companies have been identified to move into this space.

6. ICES Celtic Seas Ecoregion - Figure 7 was used to inform seabed conditions in each site. https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/CelticSeasEcoregion_EcosystemOverview.pdf

Figure 6: *Anchor supply chain capability in the region*

The region is expected to capture all direct equipment spend for the projects that use drilled anchor solutions but none of the spend for the projects using drag embedded anchors. However, anchor installation will require a main vessel contractor from outside the region, with locally sourced installation equipment potentially used to drill into the seabed.

	Wave Hub	PDZ	300MW Site	500MW Site
Seabed Conditions	Rock or hard substrate	Sand to muddy sand	Sand to muddy sand	Rock or hard substrate
Suitable anchor solution	Piled/drilled anchoring	Drag embedded	Drag embedded	Piled/drilled anchoring

Table 8: *Seabed conditions at modelled sites*

3.4.3 Potential for export

Most Irish floating wind sites identified are located in sandy and sediment seabed conditions so it is expected that limited export opportunities will come through anchors as they are likely to use drag embedded solutions.

3.5 MOORING LINES

Mooring lines makes up around 4% of capex spend. Their use in commercial scale floating wind farms will require a step up in the manufacture of mooring lines to serve the industry and there is not as yet a stand-out facility in the UK for this. As noted in Table 2, a 500MW site will require upwards of 45,000 tonnes of chain, which means any chain fabrication facility will need to be located in close proximity to the sea, most probably within existing or new port facilities.

As outlined in section 3.4, chain uses its mass to provide additional stiffness to the system. This is appropriate for shallow to medium sites. In deeper waters, the mass of mooring line is prohibitive, both in the lifting capacity required during installation and the forces pulling the structure below sea level. Two large global manufacturers of large diameter chain have ceased production this year, bringing global manufacturing capacity down by around 20%. The largest chain manufacturer in Europe

currently is Vicinay Cardenas who have capacity to manufacture around 35,000 tonnes a year in Spain. This is enough to manufacture chain for a single 800MW project each year.

Synthetic rope is likely to become the preferred option for deeper water sites. Rope manufacturing currently has lower manufacturing capacity globally than chain. The process is labour intensive; splicing is currently required at each end of a mooring line production and takes two days of labour, which could a significant bottleneck for waters in the range of 50 to 200 metres which are expected around the UK. Mechanical processes are in development that would speed up this production process and reduce the cost. This process is also required at the ends of lines, which makes the current method expensive and laborious for shallower floating sites. Lankhorst ropes have capacity to produce a few hundred mooring lines a year. They are currently the largest producer globally, with facilities in Portugal and Brazil that are currently underutilised so it is unlikely new manufacturers will enter the market in the Wales and South West region soon.

3.5.1 Areas of existing strength

We have not found any existing manufacturers of mooring lines in the region. However, there is significant skill in the region associated with the design of mooring systems, as stated in section 3.1.1. this includes University of Exeter and Longitude Engineering.

3.5.2 Potential value for regional projects

Offspring International, who work with Asian Star Anchor Chain, has expressed an interest in setting up chain manufacturing facilities in South Wales. They would have capacity to manufacture 30,000 tonnes of chain a year to meet demand both in oil and gas and the growing floating wind industry. It would require a site with 10 hectares for factory and laydown area with access to a harbour and up to 500 tonne lifting capability and could employ 100 to 130 local employees.

To make this investment worthwhile, the company needs assurance of a project pipeline that meets requirement for 30,000 tonnes a year for a minimum of five years, and visibility of sustained demand beyond that. As shown in Table 2, the series of Celtic Array projects sums to 88,000 tonnes. Clear sight of two additional 500MW floating wind projects in Europe would give the company a project pipeline large enough to consider this investment opportunity. This would also bring additional steel manufacturing requirement that could be produced locally by Tata Steel.

In the base case, no mooring line spend is assumed within the region. This increases to 100% in the high case which assumes mooring line facilities are set up.

3.5.3 Potential for export

If a manufacturing centre was set up in the region, there could be significant export potential to projects across Europe and the East Coast of the USA. Otherwise, we do not expect the region to export products or skills in this area.

3.6 ELECTRICAL INFRASTRUCTURE & CABLES

Electrical infrastructure makes up 13 – 20% of capex. For Wave Hub, the offshore cables and onshore substation have already been installed. PDZ will similarly connect directly to onshore infrastructure, however these costs will be borne by the project developer. More extensive infrastructure is required for the larger projects, covering switchgears, converters, reactive power compensation and earthing systems in the offshore substation as well as additional onshore infrastructure.

Floating turbines use dynamic cables to flexibly connect to the substation. Dynamic cables are available at the sizes required for array cabling (e.g. 33kV), but dynamic cables large enough for export to shore (e.g. 220kV and higher) are still in development and expected to be available in three to five years.

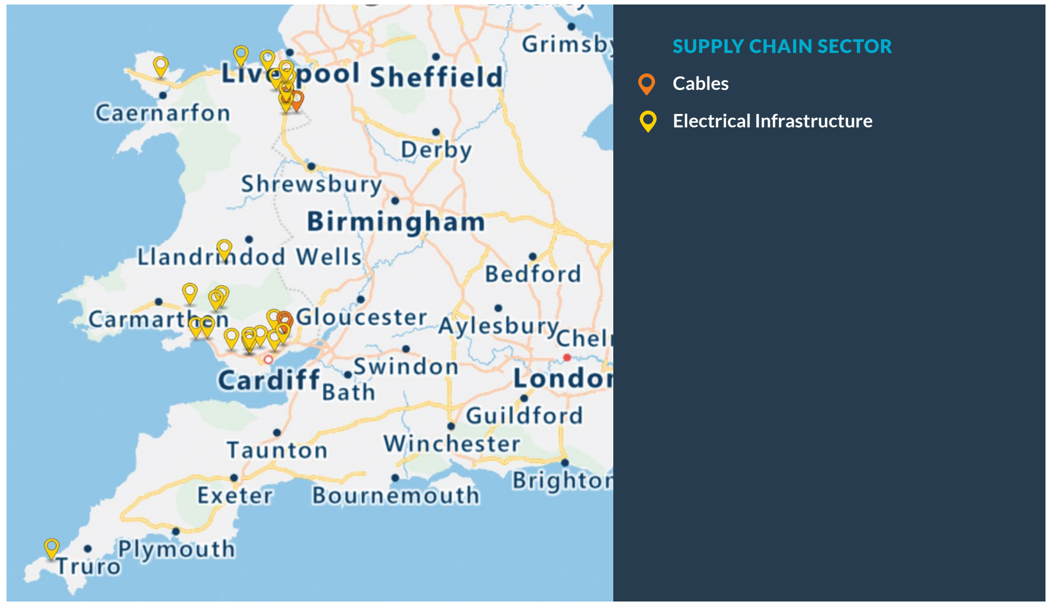

Figure 7: Electrical infrastructure supply chain capability in the region

3.6.1 Areas of existing strength

There are many established onshore electrical contractors clustered in north and south Wales, as shown in *Figure 7*. Earthing Solutions, based near Cardiff are established in electricity distribution and transmission, including for existing renewable energy sites.

Prysmian Group, an established cable supplier with bases in Wrexham and Aberdare, stands out as having the ability and experience to supply cables to floating wind projects, both within the region and exporting more widely. The Wrexham facility, which manufactures submarine cable cores, currently employs 309 people across 3 shifts. Prysmian Powerlink Services is the subsidiary of the parent company that specialises in offshore wind, which is managed globally. They will be providing the cable system for Kincardine Floating Offshore Wind Farm, covering both dynamic and static cable sections, however the cables for that project will be produced in plants in Spain and Norway.

Prysmian Group is producing array cable cores of three different sizes for Hornsea Two. The cable cores are being produced in Wrexham using raw materials from across Europe. The cores are then shipped to Norway to be formed as cables. Based on this large contract, Prysmian Group has upgraded its Wrexham facility to become the first UK facility to manufacture submarine array cable cores. Depending on cable design (insulation type, resistance required), Wrexham may be able to produce cables end to end. High Voltage cable accessories such as cable joints and terminations are produced in Hampshire.

Hornsea Two will use bespoke cable designs for the contract. It is expected that orders for cables at a floating wind test site (such as Wave Hub or PDZ) will use 'off the shelf' products. Commercial scale orders may use more bespoke products.

There are also three other identified cable manufacturers in the region with capability in onshore cables. There is no supplier in the region for export cables.

3.6.2 Potential value for regional projects

Presented in *Table 9*, we expect that all onshore electrical infrastructure can be manufactured within the region. The offshore substation is likely to be manufactured elsewhere in the UK, possibly with a small amount of assembly and final commissioning in the region. The design and contract management of cables is expected to be captured within the region, however the manufacture will be done elsewhere in Europe.

REGIONAL SUPPLY CHAIN ASSESSMENT

Electrical Infrastructure, regional spend (%)	Wave Hub	PDZ	300MW Site	500MW Site
Array Cables	20%	20%	50%	50%
Offshore Substation			5%	5%
Export Cable			0%	0%
Onshore Substation		100%	100%	100%
Electrical Total	20%	56%	36%	36%

Table 9: *Regional spend in electrical infrastructure*

Prysmian Group would be immediately ready to supply cables for a commercial scale project. With additional private investment, Prysmian Group may extend their Welsh facilities to manufacture all dynamic array cables. Assuming this to be the case, the region could capture the majority of array cable spend as well as onshore infrastructure costs.

In addition, if investment is made to expand fabrication facilities in the region, the topside of the offshore substructure could be undertaken, bringing additional economic value and jobs.

Combined, these investments would result in around 75% of electrical infrastructure spend within the region. This is used as the high case.

3.6.3 Potential for export

Prysmian Group already exports cables manufactured in Wrexham to the Middle East and Hong Kong. The company sees the plant as one of its core facilities and intends to continue to invest in it based on market demand for cables. There is a big opportunity for Prysmian to supply cables throughout the Irish and Celtic Sea and further afield.

Based on fabrication facilities, there is an opportunity for substation topsides for projects elsewhere in the Celtic Sea to be assembled and/or manufactured in the region.

3.7 PORTS AND LOGISTICS

Although ports and logistics only make up around 1% of capex spend, suitable and well-located facilities are important to all areas of assembly, installation and operations. It is important for the launch to take place within a reasonable proximity to site. Weather forecasts are more accurate within 72 hours and this is taken as an absolute maximum distance that is permissible so even if manufacturing is done elsewhere, final assembly to attach the turbine and tower to the substructure will likely be undertaken by ports in the region.

Different types of substructures have different port requirements, however local port capability is likely to influence substructure design choices. Semisubmersibles, barges and TLP's require appropriate slipways, floating quays or dry docks for full assembly and launch, with semisubmersibles and barges also requiring large quayside areas (up to 80m x 80m). Spars require extensive quayside draft or a deep-water sheltered area for turbine mating (similar to Hywind Scotland being mated off Norway and towed to Scotland) and are less likely to be used in the Celtic Sea.

A port looking to take on the final assembly and staging of floating wind projects will need access to a large laydown area to store nacelles, blades, towers, mooring and anchor systems before deployment at site. Mooring lines and anchors require a large space with nearby access to water but do not need particularly high lifting capability. There is potential to use drums to store synthetic rope, which would require less space. For turbine assembly, a port will need a lifting capacity of 675 tonnes for the nacelle, the heaviest lifting operation. Mobile cranes with sufficient lifting and reach capability are limited in global availability and could cost as much as £14 million to mobilise as it is transported in sections and needs to be assembled for use.

After turbine assembly in port, touch-up work takes five to six hours, including bolt tensioning checks, electrical circuits and safety system checks carried out by technicians.

3.7.1 Turbine Assembly port requirements

Table 10 shows criteria for constructing and assembling floating wind substructures, taken from the US Bureau of Ocean Management study "Determining the Infrastructure Needs to Support Offshore Floating Wind and Marine Hydrokinetic Facilities on the Pacific West Coast and Hawaii". The process is labour intensive and requires skilled technicians to carry out the work.

Primary Criteria	Semi-sub	Spar	TLP	Comments
Navigation channel width	100-135m	60-90m	90-135m	If berthed quayside, device must have 30m minimum offset from navigation channel.
Navigation channel depth	10-12m (conceptual)	6-9m if assembled at sea. 90m if assembled in protected waters.	10-12m	
Air Draft	Unlimited	Unlimited	Unlimited	
Area	4-6ha minimum 20-40ha ideal	4-6ha minimum 20-40ha ideal	4-6ha minimum 20-40ha ideal	Assembly only. Depends on size of wind farm
Secondary Criteria	**Semi-sub**	**Spar**	**TLP**	**Comments**
Quayside bearing capacity	~5 tonnes/m^2	~5 tonnes/m^2	~5 tonnes/m^2	
Crane	1000 ton	1000 ton	1000 ton	
Road/Rail Access	Highway connection required. Rail preferred.	Highway connection required. Rail preferred.	Highway connection required. Rail preferred.	
Max vessel length	~143m vessel	~143m vessel	~143m vessel	
Max vessel draft	11.9m (conceptual)	7.6m (min), 11.9m (ideal)	Not available?	
Number of deep draft berths	1-2	1-2	1-2	Deep draft > 7.6m
Other equipment	Specialized equipment, Forklifts, crawler cranes, cherry pickers, SPMT or marine railway.	Component manoeuvring requires specialized equipment.		
Dry dock use and width	May be assembled in dry dock of at least 50m width. May also be assembled quayside.	Demonstration project did not use dry dock.	~45-75m width. May also be assembled quayside.	

Table 10: Turbine assembly facility requirements

7. https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Pacific-Region/Studies/BOEM-2016-011.pdf

3.7.2 Areas of existing strength

Figure 8: Ports and logistics supply chain capability in the region

Several ports in the region are expected to have the necessary facilities to service floating turbines in the future. As shown in *Figure 8*, these are spread across the regional coast.

Port of Milford Haven

The Port of Milford Haven is the UK's largest energy port. It is actively diversifying its interests and has a keen focus on floating wind. Milford Haven Port Authority (MHPA) has worked with different floating wind technology developers to ensure the port is made suitable for deploying large floating wind arrays.

The Pembroke Dock Marine area is currently seeking £21million investment from the Swansea Bay City Deal and £7 million from the Welsh European Funding Office alongside private investment to redevelop Quay Four at Pembroke Dock. This will create 20,000 square metres of open plan fabrication and laydown areas and widen the slipway to up to 65 metres. Berthing for workboats will be extended to 100 metres. With local interest in developing hydrogen facilities, the port is prepared for future vessel innovation. Quay One has a crane strip fifteen metres back from the water, capable of lifting 300 tonnes, more than the mass of any turbine components that would be lifted during O&M. However additional lifting would be leased for turbine assembly.

The port could act as a one stop shop for fabrication, assembly and O&M, bringing in nearby facilities and third-party engineering services to support large commercial-scale floating wind projects when required. Traditionally oil and gas companies such as Ledowood, Altrad and Birwelco USA who have diversified marine renewable into their portfolio are based near the port. If the project pipeline opportunity increases sufficiently to warrant further future investment, the port could develop an additional laydown area, possibly through the repurposing of the offshore jetty at Hobbs Point. This would cost upwards of £20 million and would enable the port to store blades and nacelles longer term ahead of commissioning.

Some floating wind substructure designs exceed the width of the slipway or the 11-metre water depth at the toe of the slipway, which adds challenges to on-land substructure fabrication. The sheltered waterway makes on-water commissioning feasible.

Port of Milford Haven see a big opportunity in O&M to support project offices and ongoing engineering activity over the life of projects.

A&P Falmouth

As mentioned in section 3.2.2, A&P Falmouth have extensive experience in ship repair and see floating wind in the region as a significant opportunity. As with several other growing industries, final assembly of floating turbines will require longer berthing and deep-water access. A&P Group have undertaken a feasibility study as part of the Enterprise Zone initiative and this has recognised the importance of developing sufficient construction areas and deep water access for floating wind construction and assembly and the need for this to be built out prior to the installation of the 300MW site.
To move these plans forward, A&P group will need public financial support alongside private investment. To date, the plans are integrated with wider Cornwall Council investment into the Marine Hub Cornwall Enterprise Zone[8] industry deal and maritime south west initiatives. This covers development at Hayle Harbour, Falmouth Docks and Tolvaddon.

Assuming the plans of their feasibility study go ahead, A&P Falmouth will be well placed to also act as a final assembly port for substructures. They have the in-house capability to manufacture secondary steel and will have sufficient space to store anchors, mooring lines and cables, as well as turbine components during construction.

Port of Mostyn

The Port of Mostyn is situated in north Wales and has extensive experience in fixed bottom wind, operating as a base for offshore wind farm construction and offshore wind farm support services for seven projects to date. The tidal range at the port is 8.5 metres with an average water depth of 9 metres at spring tides. Dredging 4 metres would give a water depth up to 12 metres at spring tides, suitable for most non-spar floating wind substructure designs.

The port has three established O&M bases to service Gwynt-y-Mor, North Hoyle and Rhyl Flats wind farms. It has also supported the construction of seven fixed bottom offshore wind farm projects, using cranes with lifting capacities up to 1,300 tonnes to discharge and reload turbine components. This capacity would be sufficient for the turbine component mass expected for 15MW turbines. The port has extensive (75 acres) lay-down and storage land adjacent to 310 metres of riverside quays, suitable for the laydown of projects before assembly and warehousing and workshop facilities are also available for indoor storage of electrical and hydraulic components.

Other ports in the region with potential to employ in the floating wind include:

- Holyhead in North Wales have potential to grow skills in installation and operation. These are situated close to Barrow in Furness and involved in the North Wales supply chain cluster.
- Devonport dock-yard, currently managed by Babcock on behalf of the Ministry of Defence.
- Appledore in Devon, which was recently closed but may be reopening for shipbuilding purposes.
- Newlyn harbour, which has the potential to function as a crew base during operations. It is the closest in Cornwall to the Celtic Sea.
- Par harbour, which has limited access but a large laydown area that could be especially suitable for blade staging
- Plymouth Harbour, a sheltered port with a number of smaller docks and wharf areas for minerals, ferries and autonomous vessels - Devonport to the west (RN & Babcock) Cattewater to the East (Cattewater Harbour Commissioners, Victoria Wharf, James Fisher). The whole of Plymouth Sound is under control of Queens Harbour Master (RN)

3.7.3 Potential value for regional projects

There is a high number of ports in the region and it is likely that several will be required to provide the laydown area and range of skills needed during turbine commissioning. Port of Milford Haven is already gearing up to act as an O&M base for projects in the Irish and Celtic Seas and similar skills can be found at a smaller level across a number of ports in Devon and Cornwall.

8. https://marinehubcornwall.co.uk/our-four-plus-points/infrastructure/enterprise-zone

Due to the nature of the operations and value in using local facilities, we anticipate that 70% of ports and logistics spend is expected to be captured in the region for all projects. Lifting facilities are still expected to be rented in the base case and this will need to be brought in from elsewhere.

3.7.4 Potential for export

Ports on the east coast of Ireland, most notably Dublin Port, are very busy with little capacity to take a role in offshore wind deployment. Irish project developers may seek to use other well positioned ports. Whilst Belfast is well placed for North Sea and Irish Sea development, Milford Haven and Falmouth are best placed for offshore wind development in the Celtic Sea and the southern part of the Irish Sea. For offshore wind, UK ports are expected to be used for the first projects with possible development of Shannon and Cork thereafter.

3.8 VESSELS AND SUBSEA ENGINEERING

Installation costs, largely driven by vessel costs, make up around 8% of Wave Hub development, 5% for PDZ and 3% for commercial projects. This is due to the high fixed cost of leasing installation vessels. During development, survey vessels provide information on geotechnical and geophysical properties of the site. Large vessels or anchor handlers equipped with specialist equipment are then used to pre-install anchors and mooring lines; Anchor handlers are primarily used for towing devices to site; and specialist cable laying vessels install both array and export cables, although installation methods for dynamic cables, such as those used for floating wind substructures, are still being developed. During construction and operating phases, crew transfer vessels (CTVs) bring personnel to site for commissioning and maintenance tasks. For the commercial scale sites which are further from shore, a service operations vessel (SOV) may be stationed on site long-term to act as a base for offshore personnel. Helicopters may also be used in certain circumstances.

3.8.1 Areas of existing strength

There is an active marine industry already operating in Wales and the South West. 34 companies have been identified as having skills in the sector: 28 vessel operators and 6 subsea engineering companies. There are clusters in the south of Cornwall, north of Wales and Pembrokeshire, as shown in ***Figure 9***. The majority operate fleets of small vessels suitable for a wide range of uses that could cover towing, crew transfer, surveying and some heavy lifts in shallow water.

Vessel companies with experience working in offshore wind include:

- Keynvor MorLift, managed out of Falmouth, Cornwall, operate vessels, heavy lift floating crane and ROVs suitable for many areas of construction and operation.
- Leask Marine, with a base in Pembroke Dock, have been contracted on many of Europe's offshore wind farms for anchor handling, towing, diving support and wider uses.
- Quinquari Marine in Pembrokeshire have provided RHIBs and CTVs to existing wind farms in the UK.
- Turbine Transfers, based in Holyhead, have provided a range of offshore support vessels and service vessels to existing wind farms in the UK.
- Pangeotek, based in Cornwall, have extensive experience in offshore drilling, including installation of piled foundations for bridge supports, similar to operations required to pile anchors.
- James Fisher Marine Services, based in Falmouth, have experience and expertise in all areas of offshore operations for wind farms, as well as management systems for marine planning that have been used on many offshore wind sites to date.
- Prysmian Powerlink Services own their own cable installation vessels, which are headquartered in Chelmsford, Essex, though crew are from across the UK.
- Manor Renewables operate CTVs and provide offshore auxiliary power supplies (diesel gen sets onto transition pieces) based at Portland, Dorset.
- The Fugro team in Cornwall provide a range of marine installation services and manage a fleet of

REGIONAL SUPPLY CHAIN ASSESSMENT

Figure 9: *Vessel supply chain capability in the region*

  ten jack-up vessels equipped with lifting capacities up to 230 tonnes, capable of operating in water depths of up to 30 metres.
- LM Handling, part of the Acteon Group described in section 3.4.1 and based in Cornwall, provide quick latch lifting equipment for turbine installation. They use third party vessels for either portside or onsite installations and would be immediately ready to bid for work on commercial scale projects.

Innovation is changing the way vessels are being used offshore. There are a number of companies in the region with expertise in remotely operated vessels (ROVs) and autonomous surface vessels (ASVs) which are expected to see increasing use in wind farm operations for remote inspections and transfers. This includes Thales and MSubs for ROVs and Saab and Rovco for ROVs.

For the 500MW site, which is located 60km from shore, the site operator may decide to use a service operating vessel (SOV) during maintenance periods to host crew on site for a period of time and avoid a daily three-hour commute to site. There is capability in the region for ship builders to design and construct a vessel with this type of specification. Companies with these skills include Mainstay Marine, Jack Gifford, Solis Engineering, Pelagic Design, Morlek Engineering, Whiskerstay and Toms & Sons. This could provide additional opportunities to bring jobs to the region.

As the use of SOVs grows in the offshore wind industry, there is an additional opportunity for companies such as A&P group or Mainstay Marine, both described in section 3.2.2, to repurpose vessels as SOVs, and service them over their operating life.

3.8.2 Potential value for regional projects

A large proportion of vessel and subsea engineering spend during construction is expected to be captured in the region for all projects. This is shown in ***Table 11***. During the operating life of projects, regional vessels are expected to be suitable for most operations unless on site heavy lift capability is required.

The series of projects will allow sufficient time for vessel owners to invest in additional small vessels if they need to grow their fleet for larger projects.

Vessel operation, regional spend (%)	Wave Hub	PDZ	300MW Site	500MW Site
Anchors & Mooring lines installation	50%	50%	50%	50%
Turbine assembly, towing and hook-up	50%	50%	50%	50%
Array Cable installation	100%	100%	100%	100%
Offshore Substation Installation			100%	100%
Offshore export cable Installation			100%	100%
Vessel Operation Average	62%	92%	87%	88%

Table 11: *Regional spend in vessel operations*

3.8.3 Potential for export

There is a good opportunity to use Port of Milford Haven as a base for Irish projects and it can be expected that anchor handlers associated with the port may be used to tow devices to site.

3.9 OPERATING AND MAINTENANCE COSTS

Operating costs make up 20% to 30% of the levelised cost of a project. Over the operating life of the site, activity is focused on inspecting and maintaining the integrity of the assets and responding to faults or repairs required. During the initial period of operation, a wind farm may be primarily serviced by the wind turbine supplier. After this warranty period, it is common for operators to play a larger role in contracting for different on-site and off-site activity. A nearby site office will host in-house teams and contractors, giving an opportunity for long term local employment.

Much of the routine inspection and proactive maintenance will be very similar to bottom-fixed offshore wind, including increasing use of drone inspection and autonomous systems. Major repairs may take place by towing devices back to a port rather than the use of on-site heavy lift vessels, both to enable operations in more accessible sites with milder weather conditions.

3.9.1 Areas of existing strength

Mersey Maritime and Innogy Renewables UK have partnered to promote the 'Offshore Energy Alliance' (OEA), a supply chain cluster spanning North West England and North Wales. It aims to further increase benefits to coastal communities by providing support for local businesses, raising awareness of upcoming opportunities in the sector and helping to further innovation, skills and diversity efforts amongst the industries.

Specialist control equipment is used for platform health monitoring, fire suppression, navigation lights, AIS and communications. These can be provided and managed by a number of companies with a base in the region including Feritech Global Limited and Fred Olsen Group.

As detailed in section 3.7, several ports are well placed to act as operating and maintenance (O&M) hubs for the industry.

Mostech Energy Services Ltd was set up in 2013 by the Port of Mostyn to provide wind turbine technicians for repairs, maintenance and statutory inspections. They already support several offshore wind farms in the UK in both construction and operating phases. This places the Port of Mostyn well as an O&M hub for projects in the Irish Sea and north Celtic Sea.

Oftech wind provide offshore services including foundation, cathode and coating inspection and repair, general electrical and mechanical work and safety inspections. They have worked in the industry for several years.

REGIONAL SUPPLY CHAIN ASSESSMENT

For future support to surveillance, operations & maintenance activities, Newquay Airport and West Wales Airport have an Airspace Change Proposal approved for segregated airspace to provide a unique environment in which to safely operate unmanned air vehicles Beyond Line of Site and Plymouth SMART Sound operates as a launch point for autonomous surface vessels.

Over the operating life of floating wind assets, A&P group have facilities suitable for spares holding and are interested in moving into structural maintenance of offshore turbines based on their deep understanding of vessel repair. They also manage a towage fleet which can be used to move structures around Falmouth harbour during major repair campaigns. This could be scaled up to provide towage facilities to site in the future.

3.9.2 Potential value for regional projects

Local hubs have grown in Hull, East Anglia and Barrow-in-Furness to service local sites, so it is natural to assume that a local hub will grow in the vicinity of projects near South Wales in Pembroke and the South West.

Table 12 presents the regional content in each area of operating expenditure. Offshore activities will largely be managed by the turbine OEM in the first phase of operations. Balance of plant maintenance will likely be undertaken by locally based contractors. As much of the spend is on site, contractors that can be available and responsive to other site operations are valuable. This means locally based companies can play a significant role. Major replacement parts are expected to use OEMs, which may be required to come from outside the region. The Centre for Advanced Batch Manufacture in Swansea produces state of the art metal 3D printing on one off or small batch basis, which could provide certain bespoke components. Swansea University also has heavy duty metal 3D printers. 3D Kernow, based in Cornwall, currently has resin printers, supported by ERDF funding.

Onshore activity is expected to be higher at 70% local spend. New local roles will be created by the site operator at a local site office bringing people into the region. Associated professional services are expected to remain elsewhere.

Other opex covers insurance, Crown Estate seabed leasing charges and National Grid use of system charges. The regulatory charges go to centrally managed organisations elsewhere in the UK and are unlikely to be captured within the region directly.

The 2017 RenewableUK report[9] into UK content in UK offshore wind found that operating expenditure includes 75% UK content. If 'other opex' was assumed to be 100%, consistent with the RenewableUK methodology for UK content, this would bring the regional value to around 80%.

O&M, regional spend (%)	Wave Hub	PDZ	300MW Site	500MW Site
O&M offshore activities	50%	50%	50%	50%
O&M onshore activities	90%	90%	90%	90%
Other Opex	0%	0%	0%	0%
Total O&M	41%	29%	23%	23%

Table 12: *Regional spend in operations and maintenance*

3.9.3 Potential for export

Ireland expects to develop its own skills for O&M support services, however UK ports may still be used for bigger operations.

9. *www.renewableuk.com/resource/resmgr/publications/Offshore_Wind_Investment_V4.pdf*

3.10 TEST FACILITIES IN WALES AND THE SOUTH WEST

Although academic research hubs and testing facilities do not usually feed directly into the supply chain of commercial scale projects, they are invaluable in developing and proving new products and services that the supply chain may then take forward to the market.

The Wales and South West region is home to a number of world class test facilities where pre-commissioning and O&M activities can be demonstrated. This may attract supply chain companies to the region for testing and, combined with the stepping stones of projects, this may encourage new companies to base themselves in the region long term.

Relevant testing facilities are listed below:

- A&P chain testing facility
- University of Exeter Dynamic Marine Component (DMaC) test facility
- University of Exeter South West Mooring Test facility
- University of Plymouth COAST test facility (replicating wave, wind and tidal)
- University of Plymouth Electron Microscopy Centre (materials analysis)
- SMART Sound – ASV test range
- Swansea University – SEACAMS involvement with Bangor
- Marine Energy Test Area in Pembroke Dock
- Marine Energy Engineering Centre of Excellence (MEECE)
- Marine Business Technology Centre in Plymouth
- Wave Hub Limited – Being reconsented for FOW

4 DEVELOPING THE INDUSTRY

Based on the regional supply chain assessment, we have estimated the local supply chain capture in each area as a percentage of total spend.

This is shown in ***Table 13***. The weighted average percentage of capex being spent within the region is 20 – 25% with notably high capture in vessels, ports and drilled anchors.

Percentage of regional spend on regional projects (%)	Wave Hub (2023/24)	PDZ (2025/26)	300MW Site (2027/28)	500MW Site (2029/30)
Development and Consenting	43%	43%	50%	52%
Substructure	10%	10%	10%	10%
Wind turbine	0%	0%	0%	0%
Anchors	100%	0%	0%	100%
Mooring lines	0%	0%	0%	0%
Electrical infrastructure	20%	56%	36%	36%
Ports & Logistics	70%	70%	70%	70%
Vessels and subsea engineering	62%	92%	87%	88%
Other Capex	30%	39%	29%	28%
Total Capex	**17%**	**32%**	**21%**	**20%**
Opex	**Wave Hub**	**PDZ**	**300MW Site**	**500MW Site**
Major & minor repairs	50%	50%	50%	50%
O&M onshore facilities	90%	90%	90%	90%
Other Opex	0%	0%	0%	0%
Total Opex	**41%**	**29%**	**24%**	**24%**
Decommissioning	**Wave Hub**	**PDZ**	**300MW Site**	**500MW Site**
Decommissioning	65%	65%	65%	65%

Table 13: *Proportion of local spend in UK Celtic Sea projects*

Table 14 shows the direct value to the region of spend in each cost area for the series of four projects. Vessels, electrical infrastructure and substructures stand out as being of significant value to the region. This is despite only a small proportion of substructure spend being captured in the base case.

Direct value of regional spend (£m)		Wave Hub	PDZ	300MW Site	500MW Site
Development and Consenting	£m	1	4	31	32
Substructure	£m	5	11	31	45
Wind turbine	£m	-	-	-	-
Anchors	£m	2	-	-	13
Mooring lines	£m	-	-	-	-
Electrical infrastructure	£m	0.1	21	64	68
Ports & Logistics	£m	1	4	6	7
Vessels and subsea engineering	£m	8	77	65	87
Other Capex	£m	5	15	34	45
Total Capex	£m	21	131	232	298
Opex		**Wave Hub**	**PDZ**	**300MW Site**	**500MW Site**
O&M offshore activities	£m /year	0.7	1.4	4.0	5.8
O&M onshore activities	£m /year	0.9	0.9	1.3	1.5
Other Opex	£m /year	-	-	-	-
Total Opex	£m /year	1.6	2.3	5.3	7.3
Decommissioning		**Wave Hub**	**PDZ**	**300MW Site**	**500MW Site**
Decommissioning	£m	8	12	17	19

Table 14: Value of direct spend local project spend in supply chain

Table 15 shows the number of direct jobs related to project activity in each cost area for the series of four projects. Project development, electrical infrastructure and vessels stand out as bringing a significant number of jobs to the region. O&M will bring a smaller but long-term number of direct jobs to the region.

Direct jobs in region		Wave Hub	PDZ	300MW Site	500MW Site
Development and Consenting		9	24	206	212
Substructure		15	34	101	146
Wind turbine		-	-	-	-
Anchors		4	-	-	29
Mooring lines		-	-	-	-
Electrical infrastructure		1	116	352	373
Ports & Logistics		6	19	28	33
Vessels and subsea engineering		34	348	297	394
Other Capex		22	66	149	194
Total Capex		89	607	1,132	1,381
Opex		**Wave Hub**	**PDZ**	**300MW Site**	**500MW Site**
O&M offshore activities	Per year	3	6	18	26
O&M onshore activities	Per year	4	4	6	7
Other Opex	Per year	-	-	-	-
Total Opex	Per year	7	10	24	33
Decommissioning		**Wave Hub**	**PDZ**	**300MW Site**	**500MW Site**
Decommissioning		36	51	73	84

Table 15: Direct jobs involved in UK Celtic Sea projects

4.1 HIGH CASE

If all of the highlighted opportunities discussed in section 3 are pursued, the region is capable of capturing a more significant proportion of spend in regional projects, projects elsewhere in the Celtic Sea and further afield.

This includes:

- Locally managed project developer with professional services and project development team based in the region, taking local content up to around 75%.
- Construction of a chain manufacturing facility in South Wales in the mid-2020s, which can provide mooring lines for projects in Celtic Sea, elsewhere and Europe and potentially exported as far as the east coast of the USA.
- Expansion of Prysmian Group's cable manufacturing plants in Wales to produce dynamic cables.
- Use of port facilities to fabricate substructure in the region rather than just final assembly and possibly secondary steel, taking substructure fabrication up to 70% for the commercial projects.

Based on this additional infrastructure, the region could attract an additional £561 million in capital investment through the series of four projects alone, as shown in Table 16. There will be additional benefit to future projects in the region as well as an uplift in export potential, both across the Celtic Sea, and in the case of cables and mooring lines globally.

Direct value of regional spend (£m) – High Case		Wave Hub	PDZ	300MW Site	500MW Site
Development and Consenting	£m	2	6	47	47
Substructure	£m	5	11	209	303
Wind turbine	£m	-	-	-	-
Anchors	£m	2	-	-	13
Mooring lines	£m	-	-	28	46
Electrical infrastructure	£m	0.1	21	67	73
Ports & Logistics	£m	1	4	6	7
Vessels and subsea engineering	£m	8	77	65	87
Other Capex	£m	5	15	34	45
Total Capex	£m	22	134	457	630
Opex		**Wave Hub**	**PDZ**	**300MW Site**	**500MW Site**
O&M offshore activities	Per year	0.7	1.4	4.0	6.7
O&M onshore activities	Per year	0.9	0.9	1.3	2.1
Other Opex	Per year	-	-	-	-
Total Opex	£m /year	1.6	2.3	5.3	8.8
Decommissioning		**Wave Hub**	**PDZ**	**300MW Site**	**500MW Site**
Decommissioning	£m	8	12	17	19

Table 16: Value of direct spend local project spend in supply chain - High Case

5 EXPORT MARKET ANALYSIS

In June 2019, Ireland's Department of Communications, Climate Action and Environment (DCCAE) published the Climate Action Plan, which includes an ambition to connect at least 3.5GW of offshore wind to the electricity grid by 2030.

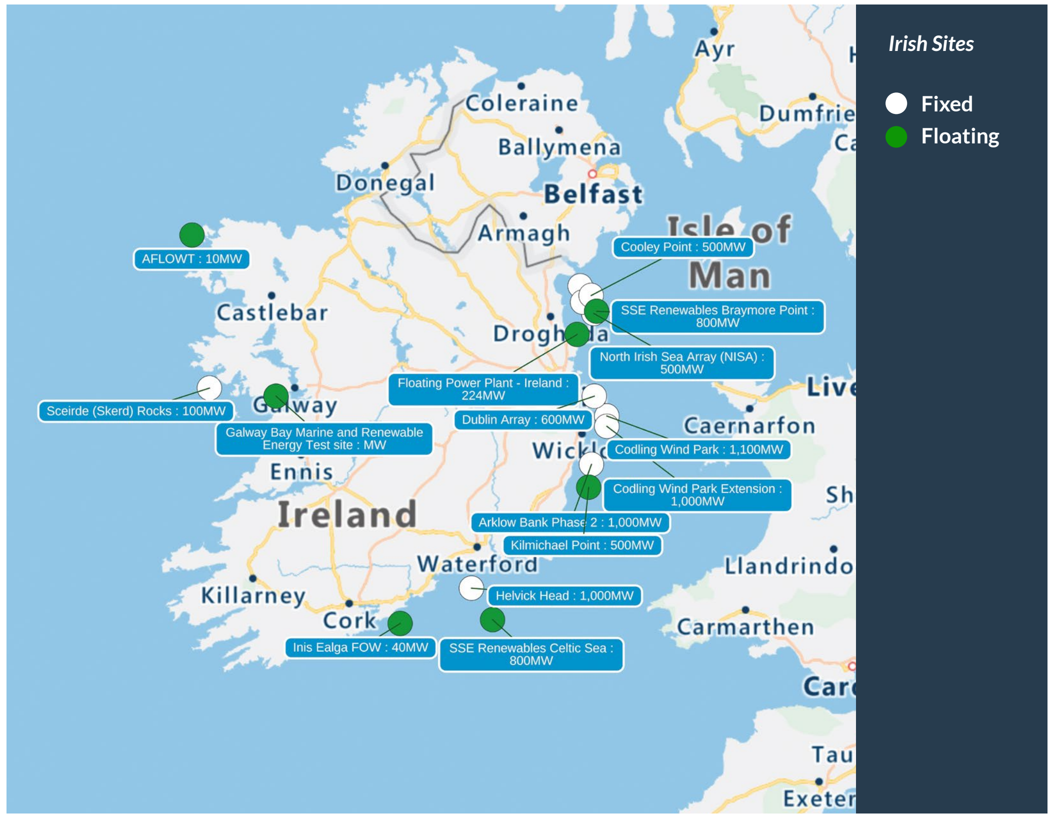

Figure 10: Irish offshore wind sites in development

Ireland currently has 10.2GW of offshore wind in stages of development from early planning to consented sites, of which 3.6GW is in the Celtic Sea and 1.3GW are at least partially in water depths above 55m. Potential floating wind sites are marked in green in *Figure 10*. It is expected that by the late 2020s, the focus will move to floating wind to meet deployment targets.

Ireland has several project developers based in the country and skills in pre-cast concrete, engineering and software. There is an opportunity to form partnerships with Irish companies through Enterprise Ireland as part of a wider supply chain development in the region.

Based on the analysis done in section 3, *Table 17* shows the level of supply chain activity the region could expect to capture for commercial scale projects in the Irish side of the Celtic Sea.

Direct value of export (£m)		% regional content	500MW Site (2028)	1000MW Site (2030)
Development and Consenting	£m	15%	16	19
Substructure	£m	4%	18	31
Wind turbine	£m	-	-	-
Anchors	£m	-	-	-
Mooring lines	£m	-	-	-
Array Cables	£m	50%	6	10
Electrical infrastructure	£m	-		
Ports & Logistics	£m	25%	3	4
Vessels and subsea engineering	£m	10%	13	20
Other Capex	£m	3%	6	10
Total Capex	£m	**3%**	**60**	**93**
Opex		**% regional content**	**500MW Site (2028)**	**1000MW Site (2030)**
O&M offshore activities	£m/year	20%	3	5
O&M onshore activities	£m/year	5%	0.1	0.2
Other Opex	£m/year	0%	-	-
Total Opex	£m/year	**14%**	**3**	**6**
Decommissioning	£m	7%	4	5

Table 17: Export value to Irish Celtic Sea projects

Globally, over 100GW is anticipated to be deployed by 2050 (*Figure 11*). Much of this deployment is expected to be after 2030 and in countries with limited experience in floating wind to date, which poses an excellent opportunity for the region to export its skills even more widely.

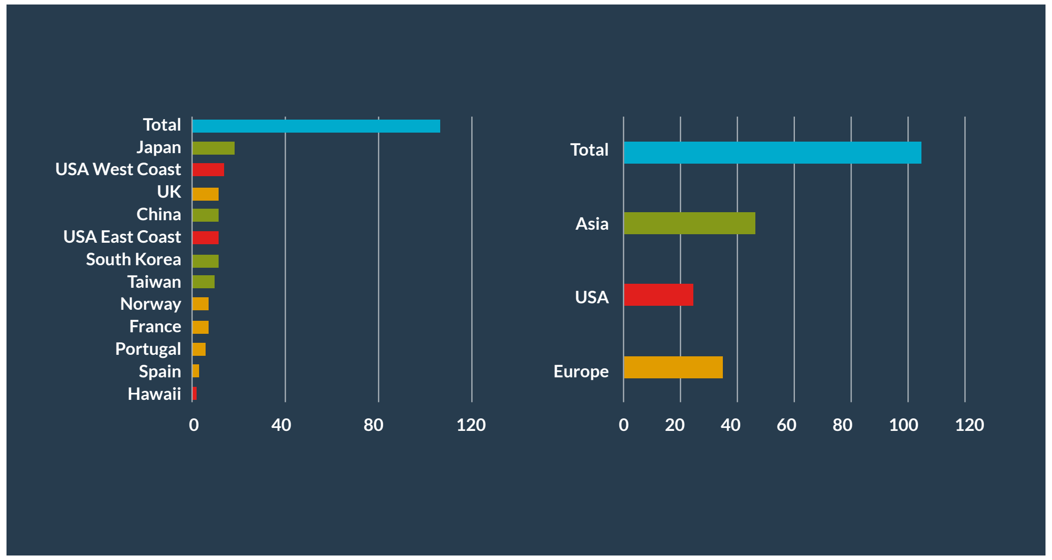

Figure 11: Potential 2050 floating wind deployment by country and region

6 VISION FOR FLOATING WIND IN WALES AND THE SOUTH WEST

There are several further areas where a secure pipeline of projects could trigger private investment to bring jobs and activity to the region: Wales and the South West has a number of existing areas of strength, where companies could bid into a commercial project immediately.

- Surveying companies, engineering design consultancies and environmental impact assessment businesses are successfully operating in the region and are ready to feed into the early stage project development for future floating wind in the region.
- Several portside fabrication yards have the skills to provide secondary steel for projects. Ports will need minimal intervention to act as staging points for installation.
- Driven or piled anchors foundations could be designed and installed using local companies.
- Prysmian Group already produces some cable parts in Wales which are used in offshore wind projects across Europe.
- Long term vessel maintenance is available in the region.
- Projects will require an operations base, preferably based near a port local to the offshore wind farm site generating new jobs.

There are several further areas where a secure pipeline of projects could trigger private investment to bring jobs and activity to the region:

- A greater proportion of substructure fabrication and turbine assembly could be accommodated at ports in the region with public financial support.
- Prysmian Group has suggested they may further invest in their Welsh facilities if demand increases, which could enable end to end cable production in the region.
- Offspring International would be interested in setting up chain manufacturing facilities in South Wales given a pipeline of at least 2GW in Europe. This could use locally produced steel.
- Smaller investments are likely in autonomous O&M for the wind farms of the future, relevant to both bottom fixed and floating wind sites. This is further enabled by the research and testing facilities in the region.

Table 18 highlights these areas of strength for the region and areas where there is potential that requires further support.

Supply Chain Area		Existing Capability	Potential Capability	Potential with investment	Export Potential	Comments
Development	Project Developers	✗	✓	N/A	✓	Limited
	Surveying Companies	✓	✓	N/A	✓	Several skilled companies exist
	Engineering Design Services	✓	✓	N/A	✓	Several skilled companies exist in a range of areas
Engineering, Procurement and Construction	EPC contractor	✗	✗	✓	✓	Skilled companies need public investment to expand facilities
Substructure	Steel manufacture	✗	✗	✓	✓	Steel for secondary steel and chain is available. No offshore wind steel plate manufacture
	Substructure fabrication	✗	✗	✓	✓	Skilled companies need public investment to expand facilities
	Suitable fabrication facilities	✗	✗	✓	✓	Skilled companies need public investment to expand facilities
	Secondary steel	✓	✓	N/A	✓	Several skilled companies exist
Anchors	Drag embedded	✗	✗	✗	✗	No interested party identified
	Suction anchors	✗	✗	✗	✗	No interested party identified
	Piled/drilled	✓	✓	N/A	✓	Several skilled companies exist
Mooring Lines	Chain	✗	✓	N/A	✓	Interested party if sufficient project pipeline and attractive terms
	Synthetic	✗	✗	✗	✗	No interested party identified
Wind Turbine	Blades	✗	✗	✗	✗	Unlikely to attract OEM given proximity to existing UK bases
	Tower	✗	✗	✗	✗	Requires similar skill set to substructure fabrication
	Nacelle	✗	✗	✗	✗	Unlikely to attract OEM given proximity to existing EU bases
Electrical Infrastructure	Array cables	✓	✓	N/A	✓	One skilled company exist
	Export cables	✗	✓	N/A	✓	Interested party already in region if sufficient project pipeline
	Offshore Substation	✗	✗	✗	✗	Requires similar skill set to substructure fabrication. No identified party interested
	Onshore Substation	✓	✓	N/A	LIMITED	Several skilled companies exist
Ports & Logistics	Turbine assembly	✗	✗	✓	✓	Skilled companies need public investment to expand facilities
	Installation staging	✓	✓	✓	✓	Export to Irish projects in Celtic Sea
Vessels	AHVs for turbine installation	✗	✓	N/A	✓	Several skilled companies exist
	Mobile cranes	✗	✗	N/A	✗	No interested party identified
	Cable installation vessels	✓	✓	N/A	✓	Several skilled companies exist
	CTVs	✓	✓	N/A	✓	Several skilled companies exist
	Vessel maintenance	✓	✓	N/A	✓	Several skilled companies and ports exist
O&M	Offshore activities	✓/✗	✓/✗	N/A	LIMITED	Offshore roles will be specialist and often use OEM personnel brought in for tasks. Wider roles may be locally based
	Onshore activities	✓/✗	✓	N/A	✗	Some existing skills; Project operator will create a base near site and fill gaps

Table 18: Summary of regional capability for floating wind

6.1 RECOMMENDATIONS

The recommendations presented here are intended to address the financial, commercial and technical challenges identified in the regional supply chain assessment in section 3. These recommendations build on existing strengths in order to allow companies to gain a larger share of this growing market.

1. Early engagement with project developers

The supply chain must be encouraged to engage at the earliest opportunity with project developers to understand requirements and schedule to inform investment in facilities, skills and capability.

2. Public investment in port infrastructure

Substructure fabrication and wind turbine manufacturing are the two largest capital cost areas for a floating wind project. Combined, they make up nearly half of the lifetime cost of floating offshore wind projects. However, the requirement for very large-scale investment in manufacturing infrastructure means this part of construction is generally centralised to several established facilities in Europe.

Whilst it is unlikely that wind turbine components will be manufactured within the region, there is an opportunity to develop existing port infrastructure to provide the capability required to perform this task. There is an additional challenge in that enabling this work could cost upwards of £30million per port, which is not commercially viable for short construction runs (i.e. 20-30 foundations over 5 -10 years) without public intervention. Port production facilities are currently ineligible for state aid which further complicates the issue, as the sector would greatly benefit from significant public investment and may make sense for a series of projects in both the Celtic and Irish Seas.

3. A clearer route to market

There are several commercial risks that lie outside of the control of stakeholders in the region. The most significant is the current lack of a direct route to market for the projects outlined in this study. A form of revenue support will be necessary, ideally from 2020 to see a series of floating wind projects in the Celtic Sea.

4. Support growth of an EPC in the region

There is currently no established EPC in the region who could readily undertake this role for a commercial scale floating wind project. The progression of projects from four turbines at Wave Hub to 33 turbines on a 500MW site brings an opportunity for a company, or consortium, to undertake manufacturing and installation contracts of increasing magnitude. This has the most potential to bring significant value to the region, both for local projects and exporting more widely.

5. Strengthen regional networking

The Celtic Sea alliance provides an ongoing opportunity for the establishing industry to engage with suppliers in the region interested in operating in the sector. Consistent with recommendation 1, there should be a focus on early engagement to bring suppliers on the journey from development projects to being ready to bid in for work on commercial projects.

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