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Celtic Sea Blueprint

Review of options for securing value & managing deployment risk

Final Report to The Crown Estate
February 2024

Version Control

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A	Draft report for working group comment	09/23
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The project utilises Everoze's SCCA model developed for OWIC & OWGP, with GVA modelling provided by BiGGAR Economics. The model is owned by OWIC/OWGP with rights given to Everoze re. utilisation.

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Table of Contents

Images:

Icon design:	Sarah Chivers
Cover Image:	Kincardine windfarm, source: Principle Power
P.5 & p.34:	Provence Grand Large windfarm, source: SBM
P.6	BW Ideol Floatgen construction St-Nazaire, source: Mills
P.7	Stiesdal Floating Wind Demonstrator, source: Stiesdal
P.12 & p.17:	Kincardine windfarm, source: Boskalis
P24:	WindFloat Atlantic, source: Principle Power
P33:	Deep water jacket installation by the Saipem 7000, source: Seagreen Wind Energy

Introduction

This Celtic Sea Blueprint was commissioned by The Crown Estate (TCE) to help the offshore wind sector and supply chain determine minimum viable infrastructure required to deliver 4.5 GW of floating offshore wind in the Celtic Sea.

This report builds on recent work of Everoze and LumenEE to deliver a supply chain capability analysis (SCCA) to the Offshore Wind Industry Council and Offshore Wind Programme Board. We have utilised the expertise and modelling from this SCCA report, with additional investigation and team expertise to produce a Celtic Sea Blueprint for The Crown Estate.

The main output of this work is a *Celtic Sea Blueprint*: a one-page summary of infrastructure & supply chain requirements required for Celtic Sea build out. That summary is complemented by this slidepack report setting out the background methodology, and further details of the work. The one-pager for 4.5GW is set out in slide 8.

To support the analysis of infrastructure and supply chain requirements, this document sets out the methodology used to develop these figures, including supply chain assessment, economic analysis, scenario development and a review of opportunities for optimisation, plus accompanying literature review of previous work.

The main findings have been generated using the SCCA model (see methodology) and tested against a review of current regional, UK and global capacity to support delivery. In addition, the work looked at opportunities for optimisation to help overcome the risks inherent in a shortage of infrastructure and supply chain capacity. Particular focus was given to options for use of port infrastructure and supply chain as a route to mitigate (at least partly) some of the capacity risks identified in the report.

The document will be used as part of TCE’s stakeholder engagement activities with a view to informing dialogues between developers, the supply chain and broader Celtic Sea community, with the ultimate aim of de-risking the pipeline of projects originated by Celtic Sea Floating Offshore Wind Leasing Round 5 (‘Leasing Round 5’). TCE can play a supporting role in addressing barriers to deployment. Overall, the offshore wind sector and the supply chain will need to work alongside regional and national authorities to look at routes for overcoming constraints on in the Celtic Sea so that the overall opportunities and benefits highlighted in this report can be secured.

The Blueprint document was delivered by LumenEE & Associates with support from Everoze, BiGGAR Economics and Offshore Solutions Group.

Scrutiny and advice in support of the Celtic Sea Blueprint was provided by representatives of Exeter & Cardiff Metropolitan Universities. Professor Lars Johanning (Exeter University), Dr Jeanette Reis (Cardiff Metropolitan University) and Dr Rachel Mason-Jones (Cardiff Metropolitan University) all sat on the project working group and provided feedback during the process.

1. Main Findings

The Celtic Sea Blueprint sets out the *minimum* required infrastructure and supply chain for delivery of the proposed 4.5GW (based on three 1.5GW projects) Leasing Round 5. Slide 8 summaries these high-level quantities and is followed by 3 slides providing a further breakdown in terms of assumptions and requirements for (a) ports; (b) major components; and (c) vessels.

Within the Celtic Sea region are opportunities across a range of component, vessel and service areas. A number of regional ports can all potentially win work from assembly, integration, marshalling, O&M and wet storage activities. Local ports can potentially look to maximise value from floating offshore wind build out by ensuring available tugs and logistics support is in place to work alongside larger vessels.

Within the region there already exists strong capacity in several important areas, including opportunities to grow expertise in concrete platform production, building on available material supply for cement and aggregate, plus the Celsa facility in Cardiff which is the UK's primary rebar supplier. There has been significant investment in region around the construction of Hinkley Point C nuclear power station, meaning the region has expertise in complex steel and concrete structures.

A small number of secondary steel providers and fabricators also exist in the region who could supply steel elements into steel and concrete platforms. With port investment to support localised steel platform assembly, a strategy to build UK supply of primary and secondary components into these assembly bases becomes viable. There is also potential to build links with steel production within the region and work with this industry to grow its capacity to supply required types of steel, as well as to make use of this existing regional expertise and skills base.

At a national level, the UK has capability in areas such as blade and array cables supply, as well as engineering consultancy, subsea services and engineering. The UK has strong capability around anchors and moorings and can use this in particular to build expertise and supply chain presence. While much of this supply chain sits outside of the Celtic Sea, roll out of projects in the Celtic Sea will benefit from this existing UK expertise.

However, the UK also needs to recognise that for most major turbine components and shipping requirements, the UK market and Celtic Sea build out is set to be dependent on global supply.

Leasing Round 5 offers a route for the commercialisation of floating offshore wind, plus opportunities for the supply chain growth across the UK.

This Blueprint shows that delivery of a Celtic Sea 4.5GW programme will deliver into the UK £1.4 bn GVA and an average of 5,300 jobs through the development of necessary port infrastructure and the supply of critical components and vessel needs.

Important opportunities from Leasing Round 5 stem from investment into integration ports, assembly of platforms, plus marshalling for turbine components, cables, moorings and anchors. These investments will also support longer term success from future leasing rounds. Shown in this report are minimum requirements, which may grow depending on whether projects are delivered sequentially or concurrently, as well as if there is future work for these ports supporting other floating offshore wind projects.

However, this review has shown that there are capacity challenges at a local and national level that need to be addressed to unlock the GVA and job benefits from this deployment, with a number of risks remaining due to global capacity challenges.

Regional challenges come particularly from the lack of current port infrastructure. While some of these are being addressed – for example the lease requirement from The Crown Estate to support set up of integration ports – others also require focus. The establishment of regional and/or UK-wide ports that can support the assembly and manufacture of steel and/or concrete platforms is seen as a critical challenge/opportunity.

This Blueprint defines minimum infrastructure requirements. However, dependent on the pipeline and delivery, this infrastructure will likely be larger. This is particularly the case for port requirements. Activities such as integration, assembly and marshalling require large parcels of land. Whether these activities take place in one or multiple location will depend on port options and also the timeline of projects.

Within the region are ports that are looking closely at floating offshore wind as an opportunity, but they will need to see a clear business case to justify the significant investment required. These ports will need to have confidence they can secure sufficient activity to ensure a return on investment, meaning that rather than see investment in different activities at different locations we will see clustering of integration and assembly and potentially marshalling around a small number of primary regional ports. This result is broadly in the interest of projects, as larger sites are likely to be more cost effective and make management of logistical challenges easier. Project developers will also be working to build out a project quickly, meaning a preference for larger ports capable of handling multiple projects.

The Celtic Sea Blueprint calculates that the minimum port infrastructure requirement to support integration, assembly and marshalling is 25.5 ha. In addition, ports would need access to other land for port related activities and storage of equipment and materials, plus access to seasonal storage to act as a buffer to help manage delays in a construction programme. This minimum infrastructure would enable the three 1.5 GW to be delivered sequentially. However, market demand is likely to require overlapping deployment of projects meaning port space developed will almost certainly exceed this minimum space area.

In addition to space for assembly of floating platforms, a focus on securing assembly can be used to help bridge out and secure regional and UK based supply of components, provided that the UK is adept at process engineering and ensuring a rapid shift to volume component manufacture. Doing this will bring efficiencies that drive value and lower risk for projects, plus of course lead to additional port requirements.

At a national and global level there also exist a number of supply chain challenges, with demand greater than supply of some components and vessels. There is work at a national level (e.g. sector work on an Industrial Growth Plan) as well as at a global level needed to resolve these sector supply chain bottlenecks. However, these issues are hard to resolve.

The report also identifies the volume of components required. The delivery of Leasing Round 5 will require significant volumes of steel and/or concrete for floating platforms, plus materials for blades, towers and nacelles. While the supply chain around turbine supply is mature, the supply chain for the delivery of floating platforms needs to be built up.

While there will be challenges for the region and the UK, the opportunities relating to platform assembly as well as manufacturing of primary and secondary components, remains open and therefore still very much to play for. Regional expertise in concrete supply that has benefited from the construction of Hinkley Point C nuclear power station, can potentially be adapted for use in the floating offshore wind supply chain. The region also has significant steel production and fabrication expertise.

Finally, this Blueprint looks at optimisation options for the Celtic Sea that can help overcome installation constraints and supply chain bottlenecks. **The report identifies optimisation & coordination around wet storage, port integration, substation installation (jacket & topside lift) and O&M port set up as priorities for TCE, leaseholder and supply chain engagement.** Coordination around these five areas could deliver particularly high benefits to individual projects as well as to the overall deliverability of Leasing Round 5 and help improve the competitiveness of the regional and UK supply chain in comparison to suppliers outside of the UK.

Celtic Sea Blueprint requirements

Minimum infrastructure required to deliver 4.5 GW (three x 1.5GW projects) of floating offshore wind capacity in the Celtic Sea

Capital expenditure on the Celtic Sea 4.5GW programme will deliver £1.4 bn GVA to the UK, and 5,300 jobs on average over five years

25.5 ha

1.5+ ha per port
1 Integration port
Capacity Risk = High
Barrier to resolution = Medium

8 ha per port
1 x Assembly port with **2** assembly lines
CR = High
B2R = Medium

16 ha per port
1+ marshalling port
12 ha (turbines)
4 ha (mooring & anchors)
CR = High
B2R = Low

4+
Wet storage sites
CR = High
B2R = Medium

1+ bases
O&M bases, plus 1 MCR port
CR = High
B2R = Low

264
Offshore Wind Turbines
CR = Medium
B2R = Medium

264
Floating platforms
CR = High
B2R = Medium

3+
Substations
CR = Medium
B2R = Medium

41 km
Dynamic – interarray cables
CR = Medium
B2R = Medium

515 km
Static – interarray cables
CR = Low
B2R = Medium

1056
Anchors
CR = Low
B2R = Low

12+
Transhipment vessels
CR = Medium
B2R = Medium

3
Scour protection vessels
CR = Medium
B2R = Medium

6+
Support vessels
CR = Medium
B2R = Low

326 km
Export cables
CR = Medium
B2R = High

317 km
Total mooring line length
CR = Medium
B2R = Low

1056
Number of mooring lines

3+
Cable lay vessels
CR = Medium
B2R = High

6+
Anchor handlers
CR = Low
B2R = Low

3
Service operation vessels
CR = High
B2R = Medium

Defining capacity risk (CR)
High = no existing capacity or high constraints in market
Medium = some existing capacity and some constraints in market
Low = sufficient existing capacity and limited constraints in market

Defining barrier to resolution (B2R)
High = high inertia & low market influence or lack of options
Medium = some market influence and potential alternatives
Low = high sector control and/or solutions emerging

Celtic Sea Blueprint – minimum infrastructure requirements

1.5+ ha per port

1 x Integration port

It is assumed that each project will need to secure the services of an integration port. TCE has prioritised the establishment of suitable integration ports as a necessary first step for successful deployment of Celtic Sea projects. The SCCA model assumes permanent utilisation of an integration site across a construction programme including mobilisation and demobilisation. The SCCA assumes a 1.5GW project will need 900 days of integration port time (simplified to 30 units per year). This would require one port integrating 30 units per year, assuming load out of the platform using a semi-sub barge. To accommodate a minimum of 2 projects simultaneously the space area will need to be doubled to a minimum of 3ha. In addition, wider port land will be required for associated port activities.

It is assumed that the integration port could play a longer-term role as an MCR (main component repair) port used for tow-to-port activities when major repairs are required. **No suitable integration ports are present in the region, though a number have potential.**

8 ha per port

Assembly port with 2 assembly lines.

Platform assembly here means the bringing together of necessary components to assemble the completed floating offshore wind platforms (i.e. steel). The SCCA has assumed the use of 2 assembly lines per assembly port with average assembly time of 20 days per platform with additional time for mobilisation and demobilisation. In practice different platforms and port layouts will lead to different times needed for assembly (particularly concrete vs steel options). Assembly activities would ideally take place within the integration port to drive installation efficiencies. In addition, wider port land will be required for associated port activities to support assembly work. To assemble more than one project simultaneously will require double the port space. **No suitable assembly ports are present in the region or in the UK, though work at a UK level is underway to address this future demand.**

Additional space would be required to support steel platform fabrication and manufacturing activities. For concrete platform production an additional 6-9 ha would be required for batch plant and associated production requirements.

16 ha per port

Marshalling

Marshalling includes the storage of turbine components (nacelle, tower, blades) prior to integration of the turbine with platform at the integration port. It is assumed that marshalling of turbine components takes place in the same port as integration activities, though this need not be the case, with additional logistics. Assumes 12 ha for turbine components sufficient to store components for approx. 16 turbines, plus 4 ha for anchors and mooring lines. Opportunities exist for optimisation through proactive logistics strategies.

Marshalling of mooring and anchor elements can be done within the integration port or different ports depending on space availability. If marshalling is required for multiple projects simultaneously, significant additional space will be required. Mooring and anchors could potentially be marshalled in a common port facility arranged by an EPC or installer. Mooring and anchors need space for assembly of mooring spreads prior to installation. **Ports such as Mostyn have existing marshalling capability, but no ports in the immediate region are in place. However, a number have potential.**

4+

Wet storage sites

The exact volume requirement of wet storage locations and the number of anchorage 'slots' per location, and across multiple locations, is a complex calculation based on project scale, distances, schedules, frequency and related port infrastructure and capacities. The TS-FLOW© multi-developer industry JIP assumes that to support 4.5GW of activity and a construction/installation period spread over 6 years would require a minimum of 4 locations. Each location would require #20 anchorage slots, occupy a sea area of ~4km^2. 6 locations of potential suitability as standard sites and a further 8 smaller or restricted locations have been identified. Of these potential locations, which all require further and ongoing evaluation and technical assessment, only 2 could be within existing (or current planned extensions) statutory harbour areas (SHAs) with the remaining within 'open' waters under The Crown Estate control.

1-3 bases

O&M bases for routine maintenance, plus 1 MCR port

Industry will need access to O&M bases located close to projects, and there may be shared preference for a specific location, giving a minimum of 1 base. These locations are likely to be different to assembly, integration and marshalling ports as they need to be operational prior to Celtic Sea construction being completed. There are potential benefits to joint-hosting of O&M bases by ports but decisions on location will be made by individual developers. Modelling has assumed O&M bases will be for SOV support. There may be opportunities for shared provision of some O&M services including helicopters, back up CTVs and other periodic services (e.g. mooring anti-fouling). **No O&M bases exist in the region, though there are a number of ports with potential.**

Celtic Sea Blueprint – minimum component requirements

264
Turbines

Apart from blades the UK does not have access to domestic turbine supply. Celtic Sea deployment will depend on supply from the wider European supply chain. There are known supply chain pressures here, with production capacity below known demand, based on analysis of future offshore wind pipeline and growth. We have assumed utilisation of 17MW turbines within this analysis.

264
Floating platforms

No regional, UK or global supply chain yet exists for the supply of floating platforms at the scale needed for rounds such as Celtic Sea. However, work is underway across the sector to prepare for this future demand. The Celtic Sea deployment is likely to benefit from work underway as part of ScotWind, as well as early generation projects such as Erebus, Llŷr and White Cross to help embed a supply chain. Local supply chain opportunities exist for items such as secondary steel, rebar and concrete supply. Steel platforms need an assembly base and will utilise a global supply chain for different components. Concrete platforms need to be manufactured in situ and then brought to an integration site. Assembly/manufacture may take place outside of the region depending on port space and suitability.

41km
Dynamic – interarray cables

515km
Static – interarray cables

Floating offshore wind turbines require inter-array cables to connect individual turbines to the substation, including use of dynamic and static cable types. Calculations re. cable lengths are based on knowledge of proposed sites' water depth plus turbine spacings of 7.8D. UK suppliers of array cables are available.

326km
Export cables

Export cables are used to connect the substation to the main GB national grid. This study has modelled use of three radial export connections from each individual wind farm to substations at Alverdiscott/Pembroke. While work is underway to look at options for holistic network design, as there remain a variety of design options this study has utilised current standard practice to define supply chain needs.

3-9
Substations

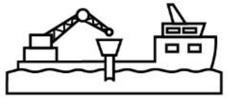
This study assumes use of HVAC substations on deep water jackets. Each wind farm will need 1 to 3 substations. The sector may choose HVDC but the supply chain and capacity is currently less developed, and no UK capability for HVDC substations currently exists. HVAC vs HVDC does not significantly impact on project assumptions re. quantities.

Substations will require installation using heavy lift vessels. There are currently market constraints owing to high demand for these vessels.

1056
Anchors & Mooring lines

For the Celtic Sea, our default mooring configuration is #4 mooring lines. A 'standard' mooring would be a combination of top chain, central fibre rope and bottom chain, though different developers may have different preferences. Anchors are modelled on DEA, but conditions may require piled or suction bucket. Anchors & mooring lines can be marshalled at different locations to other marshalling activities.

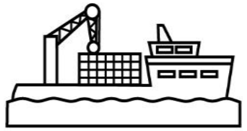
Celtic Sea Blueprint – minimum shipping requirements



3
Scour protection vessels

Project substations / export cable will require scour protection. The challenge for Celtic Sea FOW projects is the short time required for each vessel, meaning overall contract value will be low. Vessel availability due to high market demand is expected to be limited.

Vessel will need to come from global market

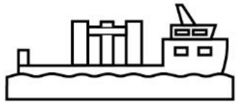


3-6
Cable lay vessels

Different vessels can be utilised for the export cable installation and array cable installation. Larger cable vessels are in high demand globally. However, there are potential options to mitigate some of this risk.

Lower water depths, project sizes and turbine distances may open up opportunity for smaller vessels to install array cables. Cable installation can be carried out well in advance of turbine integration to potentially mitigate against risks of vessel availability.

UK has some cable lay vessels but availability set by global market



12+
Transhipment vessels

Estimates based on (minimum) access to 1 heavy lift vessel, 2 tugs and 1 barge/semi submersible barge. Quantities likely to be above this minimum. Will depend on chosen installation strategy. Different vessels will be required for logistics needs during construction/installation. Specialist vessels within the market are available to shipment of turbine components to marshalling sites.

For platforms, an assembly strategy could mean use of heavy lift or barges to transfer components to final assembly site. Alternatively it may be that completed platforms are transported direct to wet storage/integration sites by heavy lift vessels. Ports active in FLOW work will need access to tugs, barges and semi-sub barge for movement of different components.

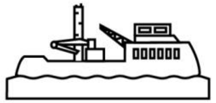
UK has capability in smaller vessels but dependent on global market for HLVs

6-12
Anchor handlers

Different anchor handlers will be needed for different parts of installation. Vessel choice will be dictated by installation strategies, but different strategies give wider options from available vessel fleet.

Larger anchor handlers with greater bollard pull (c.100 T) will be required for initial anchor and mooring installation. Smaller anchor handlers, working as multi-service vessels can be used for connection to turbine as part of installation.

Anchor vessel availability is less of an issue unless larger vessels specified. Any risks can be mitigated in part by installing anchors well ahead of turbine installation.



3
Service Operation Vessels

The study has worked on the assumption that Service Operation Vessels (SOVs) will be the main vessel for O&M services. Current SOVs on the market are designed for use in fixed offshore projects, so ships may evolve as floating O&M strategies become clearer. SOV vessels with deck space for working or limited anchor handling capabilities may be required. SOVs may be supplemented by flotels for offshore workers.

The Celtic Sea will also require vessels able to coordinate a regular programme of below water line maintenance focused on mooring and anchors, including clearance of biofouling.

Alongside SOVs there may be a need for CTVs and/or helicopters for rapid transport needs. As in oil and gas there is potential for these to be shared.

6+
Support Vessels

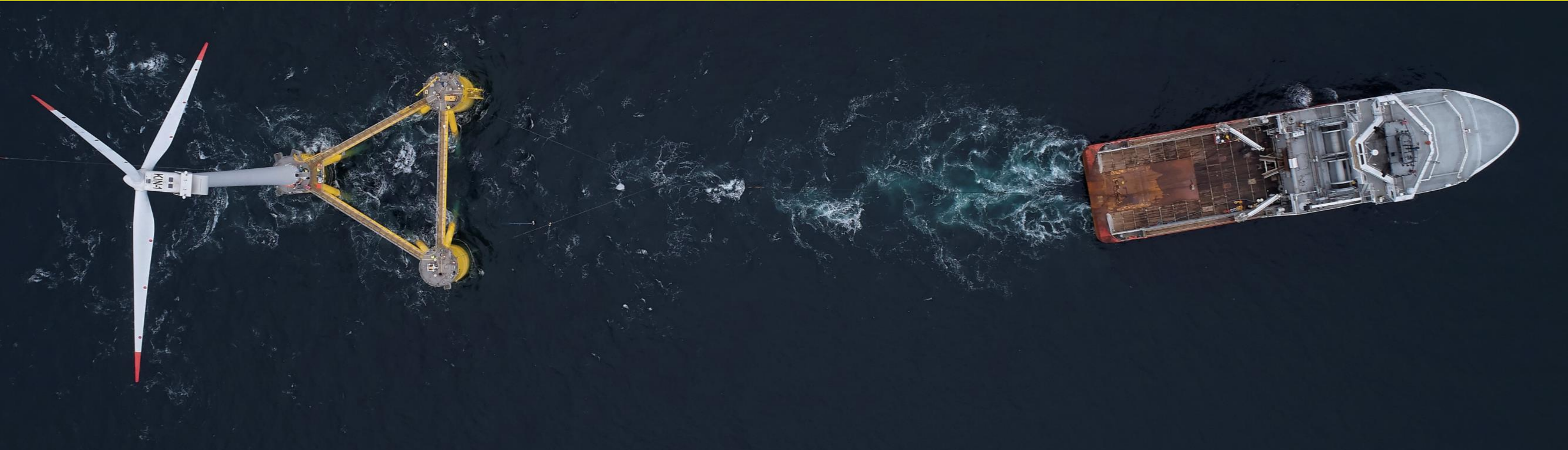
During the construction phase of Celtic Sea build out a range of vessels will be needed, including multi-service vessels (MSVs), workboats, guard vessels and barges alongside tugs and anchor handlers.

2. Methodology

This section sets out the approach used in developing the Celtic Sea Blueprint. The project aim was to define the minimum infrastructure and supply chain required to deliver 4.5GW of floating offshore wind in the Celtic Sea.

To do this the project team utilised Everoze's Supply Chain and Capability Analysis (SCCA) model, developing a pipeline of supply chain needs against a set of agreed reference projects. These results were sense-checked against available literature and Associate expertise. GVA and job analysis was carried out by BiGGAR Economics.

The capacity of the local, UK and global supply chain to support delivery of Celtic Sea was also assessed, and scenarios developed to help look at options for optimisation in deployment of Celtic Sea projects, to look at options to partly mitigate deployment risks.



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Methodology – stages of work

1. Applying Everoze's supply chain model

- The foundation for analysis for the Celtic Sea Blueprint is use of the Supply Chain Capability Analysis (SCCA) model. This model was developed by Everoze for OWGP & OWIC and contains detailed information on cost, quantity and supply chain requirements for offshore wind delivery, based on a series of offshore wind reference projects (see slide 18). The SCCA model has been adapted for use with a series of reference projects developed by the Blueprint working group. Two reference projects (one using steel platforms, one concrete) have been developed.

2. Review existing report literature and summarise findings

- The second phase of work was to analyse a series of agreed reports to look at what existing literature says re. key requirements for floating offshore wind delivery. Each of these reports was reviewed with relevant lessons brought out. A list of reports is set out in slide 21.
- Data and analytics gathered from the literature review was used to test information within the SCCA model. Consultant expertise from the working group was used to fill in remaining gaps so that we had (a) fully scoped reference projects and (b) full specifications for requirements of each reference project.

3. Calculate FTE & job years

- Partner BiGGAR Economics had worked with Everoze to develop the GVA and employment data within the SCCA. They led work to check figures, and also added additional information re. costings for different elements. Particular focus was looking at different shipping requirements suitable for the Celtic Sea, as well as adding information re. GVA related to wet storage.

4. Assess supply chain capacity

- The SCCA includes a capability review of the UK supply chain with approximately 2,000 companies with a UK presence catalogued against different parts of the offshore wind supply chain. Using this supply chain listing, this project looked to assess regional, UK and international capacity to deliver each of the 10 supply chain elements within the Celtic Sea Blueprint. This has been tested with the working group to identify gaps, particularly in terms of regional providers.
- Supply chain capacity was assessed using 2 metrics: **Market position** (outsider, foothold, domestic champion or export champion (based on SCCA methodology) and **Supply Chain Readiness Levels**. See next slide for further explanation.

5. Optimisation review

- A deployment scenario was developed by the working group to help test likely risks for Celtic Sea deployment.
- A matrix of potential optimisation options was developed, with a review for each Blueprint element. These were reviewed for practicality and likely impact to aiding delivery of the deployment scenario.

Assessing supply chain capacity & readiness

UK capability

The SCCA tracks UK capability in the supply chain. To do this it categorise UK based suppliers depending on their market position, UK footprint and growth potential. These are terms developed specifically for this project. This analysis has been used to support a review of capacity for the Celtic Sea Blueprint.

The supplier database in the SCCA Model was built through access to datasets from enterprise agencies, clusters, RenewableUK and sector specialist knowledge.

Market position

UK footprint

UK footprint was assessed as a broad company average based on the knowledge of our experts. It was not based on quantitative assessment.

- High – *Majority (80%+) of product / service supplied from the UK*
- Mid – *Product / service supplied from a mix of UK and abroad*
- Low – *Majority (80%+) of product / service supplied from abroad*

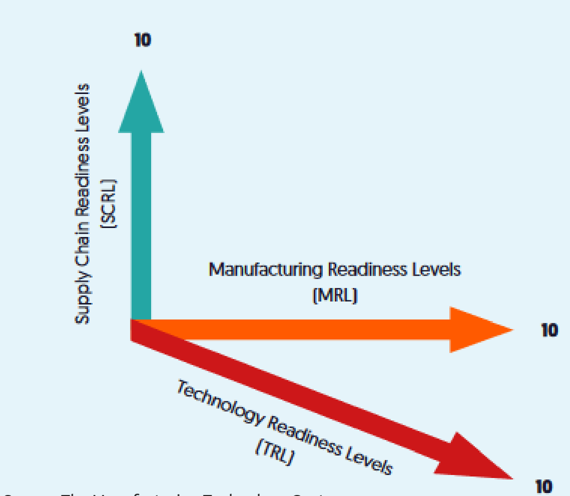
Growth potential

- High – *Company is expected to grow quicker than general market growth*
- Mid – *Company is expected to grow aligned to market growth*
- Low – *Company has low growth prospects below that of market growth*

Supply Chain Readiness Level

Whilst measurement systems exist for the measurement of the maturity of a particular technology, or a manufacturing process, it is also important to understand the maturity of supply chains and their ability to respond to and adopt innovation.

In the net zero economy, and particularly with a technology such as floating offshore wind, understanding the readiness of supply chain is important. Having a local, national and global supply chain able to respond to the demands of floating offshore wind as it rapidly scales will be important.



Source: The Manufacturing Technology Centre

The Supply Chain Readiness Level methodology has been developed by the Manufacturing Technology Centre

An SCRL is intended to "assesses the supply chain's readiness to industrialise Innovation and operate at world class standards". For the Celtic Sea Blueprint, the SCRL criteria were used to make a qualitative assessment of capacity against the four SCRL levels:

1. Awareness
2. Understanding
3. Advanced Practice
4. Expert Practice

Celtic Sea Blueprint reference projects

The starting point for our modelling work was to define two reference projects (RP01&2) that reflect the expected Celtic Sea projects.

Broadly these align with project specific elements set out by The Crown Estate in its July 2023 market update to potential bidders, but adjusted to align to 1.5GW project sizes.

Project specifications were developed using consultant knowledge plus testing and refinement with the Working Group. The high-level assumptions are shown here. The model also incorporates more detailed assumptions which enable detailed cost and quantity data to be produced.

This methodology is aligned to the use of reference projects in relevant work such as the Supply Chain Capability Analysis, Industrial Growth Plan and work being undertaken by the Floating Offshore Wind Taskforce, which either draw upon or are underpinned by Everoze's SCCA model. However, there are differences in reference projects relating to modelled water depths and distance from shore. These differences will mean changes to cable and mooring quantities. These differences do not impact on overall results.

Note: to allow reference project modelling, assumptions had to be made re. HVAC vs HVDC equipment. However, the Holistic Network Design process is still underway. This study should not be used to prejudge that work. Efforts have been made to ensure that supply chain requirements set out in this report relating to cable and electrical needs can be relied upon irrespective of final design configurations of HVDC or HVAC.

	RP01	**RP02**
Name	**CS Blueprint i**	**CS Blueprint ii**
Commercial Operations	2034	2034
Installed Capacity	1500 MW	1500 MW
Operational Lifetime	30	30
Site Parameters		
Water Depth	70	70
Soil Type	Sediment - Offshore circalittoral sand & coarse sediment	Sediment - Offshore circalittoral sand & coarse sediment
MetOcean	Harsh	Harsh
Offshore Cable	90 km	90 km
Onshore Export Cable Route Length	15 km	15 km
Wind Turbines		
Wind Turbine Capacity	17 MW	17 MW
Qty WTGs	88	88
Foundation		
Concept	Semi-Sub	Semi-Sub / Barge
Principal Material	Steel	Concrete
Moorings	Chain Catenary	Chain Catenary
Anchor	DEA	DEA
Array Cables		
Array Voltage	132 kV	132 kV
Configuration	Static and Dynamic	Static and Dynamic
Total length	185 km	185 km
Export System		
OSS Capacity Range	0.9-1.4GW	0.9-1.4GW
System Concept	HVAC	HVAC
Qty. OSS	1	1
OSS Foundation Type	Jacket	Jacket
Export Voltage	320 kV	320 kV
Port Requirements		
No of Assembly lines	2	2
Assembly site mobilisation (days)	56	56
Assembly site demobilisation (days)	28	28
FOWT – time to assemble 1st foundation (days)	40	40
FOWT – average foundation assembly time (days)	20	20

Calculating GVA for the Celtic Sea Blueprint

Estimate Spend

Spend is split by contract in line with SCCA Model's Work Breakdown Structure (WBS) – i.e. individual contract elements within an offshore wind farm.

Spend is equivalent to increased turnover in businesses.

Key Source: WBS

Sector Allocation

Each WBS contract is allocated a sector, or multiple sectors. Sectors are defined by SIC Codes.

This allows the economic impact of turnover in that industry to be estimated.

Sectors are allocated based on companies listed in WBS and description of impact.

Key Source: WBS

Direct GVA

The direct GVA of the increased turnover is estimated based on industry ratios for the appropriate sectors.

GVA is calculated by dividing the contract turnover by the turnover/GVA ratio for that sector.

Key Source: ONS UK Annual Business Survey

Direct Employment

The direct employment that is supported by each contract is estimated based on the turnover per job in that sector

Impacts are initially reported in years of employment and then converted to jobs based on contract length

Key Source: ONS UK Annual Business Survey

Indirect Impacts

Indirect impacts capture the jobs and GVA supported further down the supply chain.

Considers leakage and type of supplies purchased.

Multipliers are specific to each industry.

Applied to direct GVA and jobs.

Key Source: ONS Input Output Tables

Following completion of the establishment of the reference projects, BiGGAR Economics led a review of GVA, based on the existing model utilised within the SCCA. Figures were checked to ensure that changes to the reference projects were factored in. Additional data was added to ensure that GVA around wet storage and some vessel requirements were accurate.
The results of the GVA work are set out on Slide 23.

Note: The economic calculations also include estimates of staff costs and induced impacts for each contract area. However, these are not included in the reported impact figures. The reported figures focus on the direct and indirect (supply chain) impacts only to maintain consistency with the UK government's approach to CfD Supply Chain Plans and quantifying UK content for the UK Offshore Wind Sector Deal.

3. Supply Chain Capacity Review

The SCCA contains supply chain data on UK companies working in offshore wind, tracking experience in terms of project experience and projects awarded.

This dataset of 1,300 companies was used to test capacity in the local and UK market to support Celtic Sea deployment.

This data was supplemented by Working Group knowledge, particularly with local supply chain knowledge.

This data was supplemented by research from The Crown Estate on global capacity in the offshore wind market, as well as reports and analysis from WindEurope and the Global Wind Energy Council.

This capacity review sets out where the risks are greatest across the supply chain. As can be seen there are significant risks in the region in terms of available port provision. Some of these risks can be partly mitigated by wider UK capacity. However, at UK and global level there are also a number of high and medium risks relating to the supply of components and availability of vessels that add risk to successful deployment.

Celtic Sea Blueprint Capacity Review – how to use

The following information gives background to the review of risks and barriers in local, national and global port infrastructure, components and shipping needs

Defining capacity risk

To review capacity, a high, medium, low score was used. This is based on the following assessment:

High = no existing capacity or high constraints in market

Medium = some existing capacity and some constraints in market

Low = sufficient existing capacity and limited constraints in market

For example, there are no suitable ports in the Celtic Sea region for integration so this is assessed as a High Capacity Risk. This RAG rating are set out in the Blueprint one-page summaries (see slides 7 & 11).

Defining barrier to resolution

While reviewing capacity risk was useful in defining key deployment risks, it was seen as more helpful to look at barriers to resolution of these risks. So for each element reviewed, a High, Medium, Low score was given based on the following assessment:

High = high inertia & low market influence or lack of options

Medium = some market influence and potential alternatives

Low = high sector control and/or solutions emerging

Defining major risks & barriers

As risks and barriers can occur both locally, nationally and globally, an assessment was made of the location of the most significant risks/ barriers. The most significant risks/barriers are highlighted in bold on the following tables. For example, integration ports are judged a local risk as local integration will be needed, while an assembly port was judged a national risk/barrier as local production may not be necessary, but some national production is needed to capture economic benefits.

The result of this is that port risks/barriers tend to be defined primarily at the local level (except for assembly), components at global level (except for array cables), and shipping at global level (except for anchor handlers & support vessels).

Celtic Sea Blueprint Capacity Review - ports

	Local capacity					National capacity					Global capacity				
	Market Position	**Supply Chain Readiness Level**	**RAG - current capacity**	**RAG - barriers to resolution**	**Commentary**	**Market Position**	**Supply Chain Readiness Level**	**RAG - current capacity**	**RAG - barriers to resolution**	**Commentary**	**Market Position**	**Supply Chain Readiness Level**	**RAG - current capacity**	**RAG - barriers to resolution**	**Commentary**
Integration port	Outsider	2			**No current integration capacity, though active planning within ports, plus sector engagement. Port Talbot, Pembroke, Falmouth have potential facilities for integration. Seen as high risk, but medium barrier to resolution**	Foothold	2	NA	NA	Not relevant as integration activity needs to take place in region	Export	3	NA	NA	Not relevant as integration activity needs to take place in region
Assembly port	Outsider	2			No current assembly capacity. Need will depend on materials and platform specification (e.g. rolling vs use of "flat-pack" steel). Region has concrete expertise but no port facilities ready. Region has secondary steel capability, plus MPS as platform supplier. Plymouth, Bristol & Port Talbot offer options for assembly	Foothold	2			**No current capacity, though planning and investment being sought, particularly re. ScotWind, including supply chain coordination re. establishing larger facilities for volume manufacturing**	Foothold	3			Currently is low capability/capacity for volume platform assembly /manufacture.
Marshalling	Domestic champion	2			**No current marshalling capacity, though active planning within ports, plus sector engagement.** **Multiple ports could offer marshalling, particularly if marshalling of moorings, anchors done separately, and cables marshalled out of region.**	Domestic champion	3			UK has existing capability (on east coast & Irish Sea) and associated expertise. Dependent on local capacity may be need to marshal components further away – this requires sophisticated logistics	Export	3	NA	NA	Growing port demand for offshore wind activity creates port constraints in international markets. However, non-UK ports unsuitable for Celtic Seas integration due to distance
Wet storage	Outsider	1			**No current wet storage, though active port discussion and sector led JIP underway in region.** **Shortlist of ports identified and work underway to develop business model further. Current sector focus on providing 2 primary sites, with up to 2 secondary sites on standby**	Outsider	1			No current capacity, though sector JIP looking at options in different UK locations	Outsider	1	NA	NA	No wet storage capacity yet developed in other markets. As integration needs to take place in Celtic Seas in any case needs to be regionally based
O&M bases	Domestic Champion	2			**No current O&M bases, though active port discussion underway and multiple suitable locations. Port suitability depends on CTV vs SOV project decisions, plus 24 hr access requirements.** **Need to consider siting of MCR port location (ideally co-located with integration activities)**	Export champion	2			Strong UK capability and capacity, but expertise will generally need basing in region	Export	2	NA	NA	High O&M capability present in all mature offshore wind markets. Location of Celtic Sea means O&M activities need a local / regional focus. Potential options for integration with future Ireland market (which remains undeveloped)

Celtic Sea Blueprint Capacity Review – supply chain

	Local capacity					National capacity					Global capacity				
	Market Position	Supply Chain Readiness Level	RAG - current capacity	RAG - barriers to resolution	Commentary	Market Position	Supply Chain Readiness Level	RAG - current capacity	RAG - barriers to resolution	Commentary	Market Position	Supply Chain Readiness Level	RAG - current capacity	RAG - barriers to resolution	Commentary
Turbines	Outsider	2			No local capacity for production of any turbine major components	Export champion	4			UK capacity re. blades. Opportunities exist for towers within UK. Nacelles need to be imported. Current UK capacity in high demand due to pipeline volume.	Export	3			**High constraints on future turbine supply - particularly blades. Mix of UK and European provision re. blades. All other elements need to come from European market (and towers from global market)**
Platforms	Foothold	2			Opportunities for supply exist re. secondary steel supply for both steel & concrete platforms with strong local expertise, plus UK centre for rebar supply for concrete platforms. Marine Power Systems bringing platform to market	Foothold	2			No existing UK capacity but significant work underway to build up manufacturing capacity for platform supply.	Foothold	3			**Global supply chain for floating platforms not yet in place, though scale up and investment underway (source GWEC port review by LumenEE, 2023)**
Inter-array cables	Domestic champion	2			Some capacity at Prysmian in Wrexham. In addition, local capacity can be established for cable jointing work locally	Export champion	4			**UK capacity exists, but high market growth means high demand**	Export	3			Global supply chain in place, but high market demand
Export cables	Outsider	1			No local capacity for HVAC or HVDC, though is a potential regional link between X-Link project and potential establishment of manufacturing in SW Scotland.	Outsider	2			No current domestic export cable capacity, though strong market presence of JDR, plus Sumitomo plans in Scotland & XLinks exploring inward investment.	Outsider	1			**Market led by European manufacturers, but high market demand. Demand for HVDC cable types particularly acute.**
Substations /converter stations	Outsider	2			No local capacity for production of substations	Domestic champion	2			Siemens Energy has UK HVAC capacity, including working with Smulders to provide top sides. Available capacity does not meet demand. No UK HVDC capacity/capability	Export	2			**Market led by European manufacturers, plus imports from APAC.**

Celtic Sea Blueprint Capacity Review – vessels

	Local capacity					National capacity					Global capacity				
	Market Position	Supply Chain Readiness Level	RAG - current capacity	RAG - barriers to resolution	Commentary	Market Position	Supply Chain Readiness Level	RAG - current capacity	RAG - barriers to resolution	Commentary	Market Position	Supply Chain Readiness Level	RAG - current capacity	RAG - barriers to resolution	Commentary
Cable Lay Vessels	Outsider	1	Red	Red	**Expected to be brought in from outside region. Options to utilise wider vessel range for installation of dynamic cables**	Outsider	1	Amber	Red	Cable laying vessels need to be brought in from global market	Export	3	Amber	Red	**High demand for cable laying vessels due to global pipeline of projects**
Transhipment	Foothold	2	Red	Red	Some local capacity re. smaller shipping needs such as workboats, tugs, barges. These vessel types have lower barrier to entry	Domestic champion	2	Red	Red	UK reliant on global shipping fleet for heavy transport, but has capacity and expertise re. smaller elements - e.g. tugs, barges	Export	3	Amber	Amber	**Some heavy lift vessel capability present. Investment needed dependent on assembly strategies of global FLOW market.**
Anchor Handling & Tug Supply (AHTS)	Foothold	2	Amber	Amber	No local capacity for supply of Anchor Handers, but opportunity for local ports to ensure tug fleet able to support FOW logistics	Export champion	4	Green	Green	**UK has strong capacity and capability in anchor handlers. However, constraints exist for larger vessels**	Export	3	Green	Green	Reasonable availability of anchor handler vessels in market. Larger AHTS needed for initial anchor installation have higher supply constraints than smaller AHTS needed for final connection
Service Operation Vessels	Outsider	1	Red	Red	No local capacity for supply of SOVs	Domestic champion	4	Red	Amber	UK has been reliant on global supply, but recent success of North Star in provision of Dogger Bank SOV demonstrates growing capacity. Ship construction remains abroad	Export	1	Red	Amber	**High demand for new SOVs in global offshore wind market creating constraints in supply**
Scour protection vessels	Outsider	1	Red	Red	No local capacity for supply of Scour protection vessels	Foothold	2	Red	Red	UK reliant on global vessel fleet.	Export	2	Amber	Amber	**Celtic Sea has low needs for scour protection, so will have limited demand on market. Celtic Seas likely to utilise vessels between larger contracts, as contract value low due to number of installations required.**
Support Vessels	Foothold	2	Red	Red	Some local capacity for adaption into market, including supply of guard vessels and work boats	Domestic champion	3	Amber	Green	**General availability of construction support vessels, particularly if alternate construction strategies used, with focus on options of tugs, barges, as well as smaller work boats and anchor handlers**	Export		Amber	Green	General availability of construction support vessels, Exception to this is utilisation of heavy lift vessels for substation installation which are in high demand globally

Celtic Sea Blueprint Capacity Review – key findings

Local Capacity & constraints

Local capacity is expected to be utilised at a lower supply chain tier, with opportunities in a range of component, vessel and service areas. The highest risks relating to local capacity stem from port availability for construction, though there are several ports actively engaged with developers on port needs, with investment plans underway. Ports such as Port Talbot, Pembroke/Milford Haven, Bristol, Falmouth and Plymouth can all potentially win work from assembly, integration, marshalling & wet storage activities. Other local ports could support marshalling of smaller components, wet storage and O&M activities. The SW also brings strong shipping expertise that could be utilised in the development phase, as well as interest from shipyards like Appledore in low carbon propulsion systems. Local ports can potentially look to maximise value from FOW build out by ensuring available tugs and logistics support is in place to work alongside larger vessels.

With the region exists strong capacity in several important areas. An example is the supply chain that could support production of concrete platforms. There is available material supply for cement and aggregate, plus Celsa in Cardiff is the UK's primary rebar supplier. There has been significant investment in region around the construction of Hinkley Point C nuclear power station, meaning the region has expertise in high-skilled welding and concrete. This could be potentially used by floating offshore wind, though there could be competition for skills and resources depending on timeline of projects.

There also exist in region a number of secondary steel providers and fabricators who could supply steel elements into steel and concrete platforms. With port investment to support localised platform assembly, a strategy to build UK supply of primary and secondary components into these assembly bases becomes viable. There is also potential to build links with steel production within the region and work with this industry to grow its capacity to supply required types of steel, as well as to make use of this existing regional expertise and skills base.

National Capacity & constraints

The UK has capacity in areas such as blade and array cables supply, as well as engineering consultancy, subsea services and engineering. However, for most major components and shipping requirements, the UK market and Celtic Sea build out is set to be dependent on global supply. This creates challenges given the size of the UK market in proportion to the wider European offshore wind market. There are opportunities for the UK to invest and support platform manufacture, including volume manufacture of steel platform components, as well as to attract in concrete platform expertise. The UK has strong capability around anchors and moorings and can use this in particular to build expertise and supply chain. While much of this supply chain sits outside of the Celtic Sea, roll out of projects in the Celtic Sea will benefit from this existing UK expertise.

Global Capacity & constraints

Globally, but particularly in Europe, the offshore wind market faces a number of constraints. These are particularly acute in the supply of turbine components. Returns and profitability are currently impacting the ability of OEMs to invest and scale up production. There are insufficient blade, nacelle and tower plants to meet expected demand. Shipping remains a major constraint for offshore wind, though in floating offshore wind these constraints are generally less severe. However, this report identifies a number of potential areas of concern. Of particular concern are:

- **Cable vessels:** demand for cable laying is acute. While constraints re. export cable installation are significant, there are potential routes to look at alternative means of array cable installation, to avoid reliance on larger cable vessels.
- **Heavy lift crane vessels:** this project has assumed use of deep-water jackets for substations. Developers are likely to minimise numbers of substations to avoid the high costs of installation. However, appropriate crane vessels are expensive and in high demand. Dependent on construction periods, there may be value for individual projects to work together to coordinate jacket installation to better access vessels and secure better rates.
- **Scour protection vessels:** while project needs are small in comparison to fixed offshore wind, scour protection will be needed around substations for export cables. Small contract worth/volume may mean reliance on these vessels between larger contracts. It may be of value for developers to work to coordinate scour protection work (see heavy lift cranes above).

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Results of Blueprint GVA analysis

GVA analysis carried out for the Celtic Sea Blueprint shows that the capex (i.e. the construction phase) related to the delivery of a Celtic Sea 4.5GW programme will deliver into the UK £1.4 bn GVA and an average of 5,300 jobs across an assumed 5 year construction period. The analysis highlights a greater GVA benefit and jobs from utilisation of concrete vs steel platforms.

This GVA analysis assumed the deployment of 2x reference project RP01 (steel) and 1x reference project RP02 (concrete). GVA results for each project are shown below. The GVA impact under different combinations of project types (e.g. 2 concrete, 1 steel projects, or all steel or all concrete projects), can be easily calculated by multiplying the GVA analysis for the 2 different reference projects (see right).

Economic Impact in 4.5GW Scenario

(assumed total 5 year construction period)

Reference Project	Total GVA	Total Years of Employment	Average Jobs (over 5 years)
RP01a	£424 m	6,447	1,600
RP01b	£424 m	6,447	1,600
RP02	£535 m	8,226	2,100
Total (4.5GW)	£1,383 m	21,120	5,300

Economic Impact of different platform types

(assumed total 5 year construction period)

RP combination	Total GVA	Total Years of Employment	Average Jobs
3 x RP01 (steel)	£1,272 m	19,341	4,800
2 x RP01, 1 x RP02	£1,384 m	21,121	5,300
2 x RP02, 1 x RP01	£1,918 m	22,899	5,800
3 x RP02 (concrete)	£1,605 m	24,678	6,300

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4. Scenario work & optimisation opportunities

To test against different deployment risks (in addition to component supply constraints and vessel availability) a deployment scenario was developed.

This scenario was used to assess potential areas of optimisation as a means of addressing capacity constraints identified in this report.

Optimisations were prioritised in terms of practicality and impact. It looks clear that priority should be given to consideration of wet storage and integration capacity.

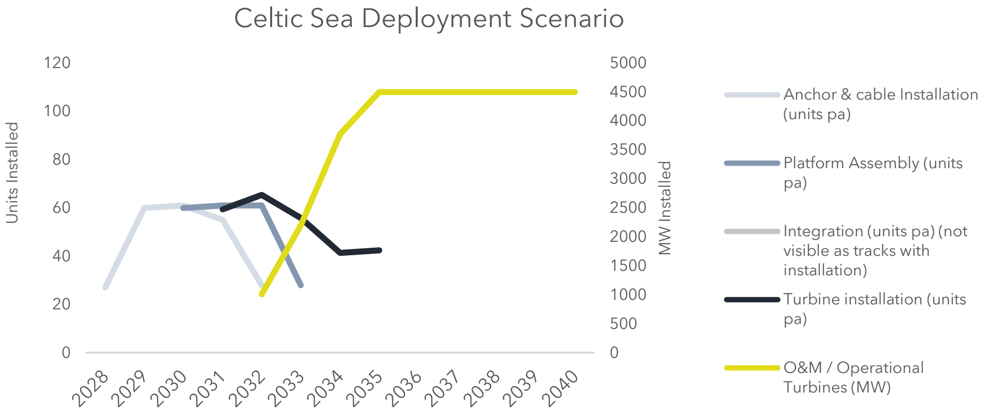
There are also options for coordination on other potential supply chain bottlenecks, including installation of deep water jackets and associated scour protection for required substations/ converter stations.

Celtic Sea Blueprint deployment scenario

To complement assessment of the SCCA model, a simplified deployment scenario was developed to help identify and test some of the risks and constraints that could impact on Celtic Sea deployment. This scenario was based on the deployment of 3 x 1.5GW projects. This scenario work was used to test impact on deployment due to installation delays (e.g. constrained weather windows), as well as constraints due to port integration capacity.

The scenario was based on projects being able to hit a modelled 2035 target date for installation. This deployment scenario was used to model options for shared port infrastructure use and shared supply chain. Note, risks to projects due to planning delays and in particular grid connection dates were excluded from scenarios.

Deployment Scenario	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CS1 Anchor & Cable Installation	30	30	30										
CS1 Platform Assembly		30	30	30									
CS1 Integration				32	32	23							
CS1 Installation				32	32	23							
CS1 Turbines needing O&M					32	65	88	88	88	88	88	88	88
CS2 Anchor & Cable Installation		30	30	30									
CS2 Platform Assembly			30	30	30								
CS2 Integration				32	32	23							
CS2 Installation				32	32	23							
CS2 Turbines needing O&M					32	65	88	88	88	88	88	88	88
CS3 Anchor & Cable Installation				30	30	30							
CS3 Platform Assembly					30	30	30						
CS3 Integration						9	41	38					
CS3 Installation						9	41	38					
CS3 Turbines needing O&M						0	9	50	88	88	88	88	88



Above is shown a basic Gantt charts for different parts of deployment, plus the shift into O&M activities. The scenario shows installation of number of units per project over different years. Colours (blue, red, green) denote the different 1.5GW projects. To the right, this deployment scenario is simply graphed out.

Interrogation of this deployment scenario demonstrates highlighted how constrained weather windows or constrained integration port capacity would impact deployment timelines. Problems at ports will lead to potential delays to production, potentially risking installation. Developers can manage this risk by building out cables, anchors and platforms ahead of need, but this will lengthen the construction schedule.

Constraints due to ports are likely to increase risks of different parts of the build being available on time, leading to higher logistics costs, as well as greater need for wet storage. Installation delays will mean delays at the end of the project. This can be particularly risky if port space is available for a limited time. The deployment scenario highlights the benefit of a 3-year installation window (vs 2-year) with anchor and cable installation activity being brought forwards to better mitigate deployment risk. However, earlier installation of anchors and cables creates some other deployment risks that need to be mitigated against. However, this early deployment necessitates projects being able to reach final investment decision FID quickly, so is impacted by the ability of the system operator to provide connection, plus the consents system to deliver approvals. Depending on the speed of this development timeline pre-FID, the 2035 target date used for this scenario would need to be pushed backwards.

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Optimisation Review – ports (1/2)

Supply Chain item	Options for Optimisation	Discussion	Risks to delivery re. non-optimisation vs benefits of optimisation	Practicality of optimisation	Practic-ality (1-5) 1= low	Impact	Impact (1-5) 1= low
Integration	Sites can potentially integrate 1x turbine and platform every 2 days. However, capacity depends on wider port factors and supply chain, as well as access to wet storage and/or installation site.	Logistics, crane arrangements etc. could still be managed in coordinated way or offered via port. Port may be able to run multiple production lines for separate developers but flex space requirements over time.	Lack of sufficient port infrastructure would mean risks re. hitting deployment windows. Biggest risk likely to be in ports not having sufficient time to complete integration, meaning projects delayed or penalties included	Medium	3.5	High risk of delay due to lack of port space, plus potential for delays to production of platforms	4
Assembly	Manufacturing of different elements for steel platforms will be done at multiple locations. These will need assembly, ideally near integration site. May be opportunities re. (a) logistics to move components and (b) cross sector backing for UK component manufacture to secure supply chain in UK facilities. Sites experience low productivity during mobilisation, initial learning and demobilisation. Concrete manufacturing different in that activities need to be done on a single site. There are advantages of local manufacturing, but heavy lift vessels can move platforms from other sites if sites not available.	Optimisation benefits likely to stem from collaboration between developers choosing concrete platforms. This would depend both on platform type and engineering company selected. But sector needs to bring large concrete engineering companies into sector, so may be opportunities for centralised concrete slip-forming facility. Are opportunities to utilise expertise gained around Hinkley Point C and supply chain there which will remain in place for Sizewell C build	Risks in assembly of steel platforms relate to use of multi port and complex logistics plus having sufficient space at ports to deal with project delays, particularly at installation. Wet storage provision key for ensuring smooth transition from assembly to integration phases	Medium	2	Platforms will rely on global supply chain. Are potential regional benefits re. collaboration around optimisation but these relate primarily to the supply chain	2
Marshalling & Loadout	Marshalling includes: turbine elements (blades, nacelles, towers) - provided by single OEM for each project. Likely to be different OEM providers in Celtic Sea and different EPCs/ installation contractors. anchors: smaller number of providers in UK / European market so may be options for coordination. Space requirements smaller than for turbines. seabed allows different anchor choices, so different projects may adopt different specifications mooring lines: different supply and technology options available. Depends on developer/platform preference as well as availability from supply chain. Space requirements smaller than for turbines.	Optimisation re. turbines potentially viable if OEMs/EPCs win consecutive or concurrent projects in Celtic Sea Options exist for sector coordination re. establishment of anchor/mooring line marshalling. Can also be further away than integration port.	Lower risks here, depending on technology choices of project. Some risk exists that individual projects seek to utilise nearby integration ports as marshalling locations for all components	Low (sector coordination re. OEMs marshalling unless contracts awarded to same OEM) High (sector coordination re. marshalling of anchor/mooring	3	Integration ports will tend to also act as marshalling ports. While there will be a big impact over integration activities, this seen as having a smaller impact on marshalling activities	2

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Optimisation Review – ports (2/2)

Supply Chain item	Options for Optimisation	Discussion	Risks to delivery re. non-optimisation vs benefits of optimisation	Practicality of optimisation	Practic-ality (1-5) 1= low	Impact	Impact (1-5) 1= low
Wet Storage	Shared wet storage space would mean less competition re. available location. No available storage so has to be created. Industry JIP underway. Need to establish commercial structures to underpin investment case so available ahead of need	Potential for individual projects to contract directly with ports to address own wet storage requirements. However, as sector needs unclear and will depend on reality of construction build out there are potential advantages for independent and/or shared provision.	Risks to delay in production of platforms will encourage earlier production and increase storage need. Risks to installation day also increases storage need. Risks relate to required provision which rests on actual deployment timescale of 4GW	High	4.5	Shortage of integration port space, plus risk of installation delays means need for wet storage. If correctly specified wet storage could provide space and equipment for some integration prep activities	4
O&M	Location of the 4 sites will mean available ports suited to O&M will be under consideration by each project. Options for shared infrastructure, particularly if SOV route utlised meaning port needs to accommodate larger vessels but only on intermittent (ie. regular but infrequent) basis	Limited port options will focus developer interest into a few ports. Also worth highlighting skills and training needs in region and options for coordination re. training programmes to prepare future technician workforce.	Risks relate primarily to availability of future workforce. Benefits would come from lower O&M costs through some shared infrastructure	High	4	There are a number of ports suitable for O&M so scarcity less of a challenge. There are some benefits of co-location, particularly if port infrastructure needs upgrading. However also requires sufficient size. Greater benefits seen around agreement on MCR (see integration)	2.5

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Optimisation Review – components (1/2)

Supply Chain item	Options for Optimisation	Discussion	Risks to delivery re. non-optimisation vs benefits of optimisation	Practicality of optimisation	Practic-ality (1-5) 1= low	Impact	Impact (1-5) 1= low
Turbines	Joint contracting / procurement of turbine would provide better incentives from OEM to (a) guarantee supply at required date and (b) offer better price. But cuts strongly across developer control of project	Turbines will come from different suppliers. Low opportunity for optimisation unless contract awards go to single supplier, but this will be known comparatively late in planning for deployment. May be early opportunities for optimisation around individual turbine sizes (i.e. what turbine size choices are being made) which could then drive opportunities for coordination and optimisation in other areas of supply chain	Are supply chain risks re. turbine supply due to shortage of OEM facilities. But 4.5GW pipeline insufficient to drive investment decisions, but could be used to get prioritisation of supply	Low	1	Ability to procure turbines across Celtic Sea could partly mitigate delivery risk	2
Platforms	Multiple platform types in market. Specification of same platform would create (a) clarity around deployment programme and (b) give clearer regional and UK supply opportunity. But cuts strongly across developer control of project and potentially limits innovation pathway	Hard to see developers working jointly re. procurement of a non-standardised item such as a platform, given low market knowledge and risks re. how this part of supply chain is commercialised. But there would be lesser benefits re. local supply chain. e.g. 4 x concrete contracts or 4 x steel contracts provides bigger opportunity (particularly around concrete). Furthermore, as SCCA report notes, clarity re. specification and requirements would better enable supply chain and port readiness	High risks relating to platforms as area of sector in need of commercialisation - particularly re. shift to volume production. Opportunities for collaboration seen as strongest around work to establish concrete supply chain in region. Developers may specify concrete if they (a) judge technology as preferred and (b) judge supply chain in region can help manage and reduce delivery risks.	Low: joint tendering/ specification re. provision of specific platform Low: sector agreement re. platform material (i.e. steel vs concrete Medium: sector work re. specification requirements to give earlier supply chain/infrastructure visibility Med/High: sector work re. support for supply chain readiness (once technology chosen). Seen as highest if are multiple projects choosing concrete for platforms	2	Foundation market is immature, so actions to collectively manage risk adding risk at this stage. There will be options for joint engagement with the supply chain for lower tier items.	1

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Optimisation Review – components (2/2)

Supply Chain item	Options for Optimisation	Discussion	Risks to delivery re. non-optimisation vs benefits of optimisation	Practicality of optimisation	Practic-ality (1-5) 1= low	Impact	Impact (1-5) 1= low
Inter-Array Cables	Shared contracting of cables and/or cable installation	Cables a commodity product with multiple suppliers. Some challenges exist re. supply chain availability, including around installation vessels	Some risks but lower risks in comparison to other delivery risks in projects. May be benefits if cable companies win multiple projects, but this also depends on timescale of different projects.	Low	1	May be options to look at lower tier items, including jointing, in coordination.	2.5
HVDC vs. HVAC	Sector utilisation of a holistic network design with shared connections	Sector soundings show that is no strong case for HVDC vs HVAC in terms of Celtic Sea based on distance and project size. So issues likely to relate to risk of delivery/cost.	DC options seen as higher risks due to larger supply chain constraints. But if developers have preference for DC options, then potential to collaborate to build demand and help inward investments into UK (e.g. XLinks)	Low. Decisions re. AC vs DC will be made on project basis, unless made by NG ESO	1	Hard to judge impact when HND process has yet to resolve	1.5
Substations and converter stations	SCCA model assumes 1GW reference projects will utilise substations for HVAC, while 1.5GW will utilise HVDC. May be opportunities for cooperation to stimulate supply chain – both jackets and topside production as well as transformer elements. Risks facing projects relate primarily to installation – mostly access to required heavy lift crane vessels, as well as access to scour protection vessels (see below)	Few substations needed, though individually are high value items. UK has some capability (only HVAC). Options exist for looking at future demand to not overwhelm UK supply chain as well as options for sharing installation vessels to better manage supply risks	Risks here relate to (a) coordination of contracts to maximise UK supply chain opportunity and (b) availability of installation vessels	Medium. Procurement difficult to coordinate, but some co-ordination would be needed if sector has appetite for UK content. Medium. Co-ordination re. installation vessels may be viable given risks of vessel availability	3	Supply chain constrained. UK has strong capability but limited capacity. Coordination re. engagement would allow supply chain better planning	4

Note: **export cables** have been excluded from this optimisation review, as scope depend on NG ESO and Ofgem and engagement with offshore wind sector on Holistic Network Design.

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Optimisation Review – vessels (1/2)

Supply Chain item	Options for Optimisation	Discussion	Risks to delivery re. non-optimisation vs benefits of optimisation	Practicality of optimisation	Practic-ality (1-5) 1= low	Impact	Impact (1-5) 1= low
Cable Lay Vessels	Options to share contracting of cable lay vessel. But this depends on construction timetable of projects. If there is no overlap there may be options to share vessels, but benefits of this likely to be limited	Depends primarily on construction timetable. Cable lay vessel will need to be contracted on a per project basis, with different installation contracts for array cables and export cables. Utilisation of vessels depends on project choices. Therefore export cable dependent on NG ESO decisions	Availability of cable lay vessels may be project risk. Depends on wider global activity more than Celtic Sea deployment, but if projects in Celtic Sea have overlapping construction timelines then different vessels will need to be specified	Low	1.5	Some opportunities to look at alternate provision re. array cable installation. May mitigate against vessel availability risk.	2
Transhipment	Multi-port strategies will necessitate movement of components both ahead of assembly, and as part of marshalling and then integration. May be opportunities for sharing of necessary logistics arrangements	SCCA work identified potential for logistics models to be in use in UK. So would need logistics provider in place which is then contracted across multiple projects. Could drive cost savings but this depends primarily on different project deployment timescales	Reliance on larger heavy lift vessels creates potential risk. May be need to book vessels for a period of time rather than specified journeys to ensure availability. Adds to cost and also lowers availability for wider market	Medium: highest opportunities likely to stem from movement of components within region, so could be benefit in provision of shared vessels	3	Shared logistics & in port facilities , particularly for smaller and local movement of items to minimise reliance on larger vessels could reduce bottlenecks.	3
Crew Transfer Vessels	Blueprint assumes sector O&M focus will be SOV. However, may be case for rapid transfer/access vehicles, including for emergency transport	O&G sector works on shared provision re. CTVs and helicopters. Strong safety case to have provision in place in Celtic Sea, plus cost benefit case for having this shared	High risks to sector if safety issues not addressed and risks mitigated	High - sector coordination around provision of rapid/emergency transport	4	Project modelling has looked at SOV options for O&M. May be opportunity for some shared CTV provision for rapid transit of equipment/personnel and emergency back up	1
Service Operations Vessels	See O&M port discussion above. Coordination likely to be around port infrastructure and shared use. Many be opportunities for shared SOV use on site, as projects will be in close proximity	Options for shared SOV will depend on developer decisions re. level of SOV need. But developers will need to have guaranteed level of access to SOV to ensure wind farm availability. Depending on what O&M strategy used, may be options for shared accommodation vessels at sea which link to different SOVs/CTVs	Low risks to projects from having unilateral provision of SOV/accommodation. Benefits stem from opportunity to share costs/infrastructure	High - shared port use Medium - shared use of accommodation vessels Low - shared SOV use	3.5	Supply chain constrained. UK has strong capability but limited capacity. Coordination re. engagement would allow supply chain better planning	1

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Optimisation Review – vessels (2/2)

Supply Chain item	Options for Optimisation	Discussion	Risks to delivery re. non-optimisation vs benefits of optimisation	Practicality of optimisation	Practic-ality (1-5) 1= low	Impact	Impact (1-5) 1= low
Scour Protection Vessels	Shared contracting of scour protection vessel(s)	Potential supply risks from vehicle fleet. Options for contracting of ships to provide scour protection. But this will depend primarily on synergies in construction timeline for different projects	Risks relate primarily to access to vessels when needed if are supply shortages	Low	3	Limited use of scour protection vessel, but shortage of vessel availability. Potential opportunities to coordinate installation of substation and scour protection	3
Anchor Handling and Tug Supply	Shared contracting of anchor handlers. UK wide supply chain benefits of coordination with vessel providers.	Will need different anchor handler types for anchor installation and turbine/platform hook up. In practice when project is in installation phase will be fully engaged so little practical benefit in sharing. However, there could be Anchor handler size will in part depend on developer specifications (e.g. size of mooring lines, type of mooring lines)	Are risks re. supply depending on project mooring specification decisions. These decisions may drive sector toward larger Anchor handlers which are in short supply.	Medium - benefits in sector discussion re. mooring requirements so that sector seeking to utilise smaller anchor handler vessels in Celtic Sea. Low - shared contracting of vessels seen as impractical	3	Shared logistics & in port facilities , particularly for smaller and local movement of items to minimise reliance on larger vessels could reduce bottlenecks.	3
Support Vessels	Shared contracting of construction vessels	Depends on type of vessels but in general when construction activity begins vessels will be fully utilised/need to be fully available. If projects are not delivered consecutively could be benefits in coordination	Low risks in market re. access of construction vessels, though this depends in part on installation route (e.g. will be potential need for large crane vessels for substation installation)	Depends on vessel type. Options seen as most viable include working with regional providers re. provision of guard vessels, and coordination with supply chain re. jacket installation.	2	General availability of workboats and need for focus on individual sites means will be little impact of optimisation of these vessels.	1

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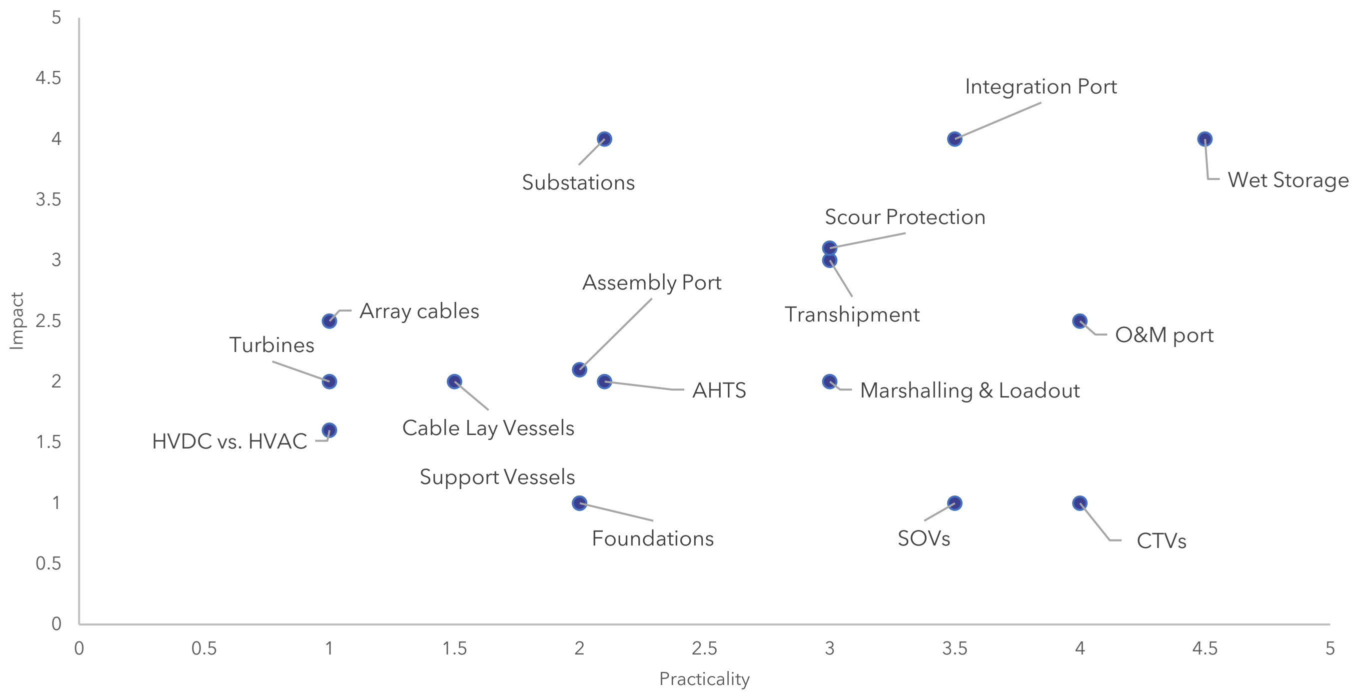
Optimisation Review – prioritisation

Assessment of options & priorities for Optimisation



Left is the assessment of optimisation options for the Blueprint. It shows areas where there are potential for high impact, mapped against practicality. It is recommended that the following priorities are considered:

Wet storage: The production of simple scenarios for this Blueprint work highlights the potential risks from misaligned construction schedules as well as weather risk. Projects cannot accurately predict precise wet storage needs (duration and volume). This risk could be better pooled, particularly as suitable sites are limited.

Integration port: TCE has requested bidders set out what actions they will take to support establishment of integration capacity in the region. Simple scenario analysis highlights this could be a potential deployment bottleneck, as this activity needs to take place locally. Looking at how projects can share integration capacity and in particular manage demobilisation from one project into mobilisation for a successor project could bring particular value

O&M: there are a number of suitable ports for local O&M bases, and investment may go further if pooled in fewer ports. Projects should also consider how to ensure there is a regional main component replacement (MCR) port in region over the longer term. Finally, there is scope for joint provision/contracting of items such as flotels, stand-by CTVs and helicopters to support O&M activities.

Jacket installation: Celtic Sea deployment is expected to rely on deep water jackets for substations/converter stations. This means deployment is reliant on access to heavy lift crane vessels and scour protection vessels. There would be efficiencies if this installation programme can be coordinated.

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6. Conclusion

This Celtic Sea Blueprint report for The Crown Estate sets out the minimum port infrastructure, supply chain and vessel requirements for a list of critical components. For a 4.5GW (3x1.5GW) deployment programme, the supply chain needs are significant with a number of capacity risks found at local, national and global level.

This report maps both the capacity of the regional, national and global supply chain today, and the “barriers to resolution” – i.e. the difficulty of putting required capacity in place. There is capacity within the Celtic Sea region, as well as across the UK that can be put in place, to help unlock the economic benefits flowing from Celtic Sea deployment.

This study identifies GVA benefits to the UK of £1.4bn across five years, with an average of 5,300 jobs. These benefits relate to the capital phase alone and covers captured GVA the UK can secure, not the overall project value. In addition, there are regional and UK opportunities relating to development and operation of these projects.

While there are regional activities needed to overcome gaps in capacity – primarily around ensuring regional ports are ready – at a UK level there are activities that can be undertaken to grow UK capacity. Sector effort on the forthcoming Industrial Growth Plan and other programmes can help to grow UK benefit *and* help the UK respond to global capacity gaps. However, it needs to be recognised that within the offshore wind supply chain exist capacity bottlenecks that need to be addressed on a global scale.

This study also identifies options for project coordination on utilisation of a number of different assets, including ports and vessels. For example, dependent on project timescales, there could be opportunities for coordination on key infrastructure such as substations and export cables plus associated requirements such as scour protection. There are clear market constraints on capacity relating to cabling installation, meaning developers could mitigate risks and potentially costs through coordination on installation ahead of individual project build out.

There is a need to grow port capacity in the region, but equally it will be important that this is used effectively, both to help ports make the business case needed to put infrastructure in place, and then to maximise its utilisation, particularly when projects are likely to seek to move forward together so need to build a partnership approach to make best use of this capacity. Opportunities for coordination exist in utilisation of integration, assembly, marshalling and O&M port facilities. Such an approach is better than individualised project deployment strategies that lead to investment in multiple sub-optimal facilities.

Annex. Literature Review

To support analysis of supply chain requirements, and also help add to evidence on local, UK and global capacity to support floating offshore wind deployment, a literature review was carried out.

This review looked at a number of recent studies, focused particularly on the UK, South West England and South Wales.

The following pages provide a summary of the key findings from these reports and relevance to Celtic Sea deployment and this blueprint. Reports reviewed were:

1. Guide to a Floating Offshore Wind Farm (2023)
2. Opportunity Study for the Heart of the SW (2022)
3. Strategic Infrastructure & Supply Chain Development (2022)
4. Industry Roadmap 2040 (2023)
5. Driving the Celtic Sea FLOW Opportunity (2022)
6. Floating Wind in Wales – Substructure & Port Review (2021)
7. Floating Substructures for Fabrication in Scotland (2020)
8. Manufacturing Concrete Floating Wind Foundations in Scotland (2021)
9. Dynamic cables and ancillary systems (2021)
10. Moorings and anchor systems (2021)
11. Concrete for Celtic Sea FLOW (2023)
12. Ports for offshore wind (2020)

1. Guide to a Floating Offshore Wind Farm

Date Published: 2023

Reporting to: ORE Catapult & TCE

Report by: BVG Associates

Scope

Component and lifecycle requirements of a modelled 450MW floating offshore wind project operational by 2028

Relevance to Blueprint?

Report provides detailed explanation of major component, infrastructure and installation requirements for an offshore wind farm to be delivered at end current decade.

Report information allowed corroboration of assumptions set out in SCCA Model, including assessment of vessel requirements.

Report provides useful benchmark to Celtic Sea Blueprint on port space requirements as follows:

Construction port requirements for a 450 MW project are typically:

- Between 15 and 20 ha suitable for lay down and pre-assembly of turbines
- Between 10 and 12 ha of wet storage
- Large areas of land are required due to the space taken when turbines are stored lying down on the ground.
- Sites with greater weather restrictions or for larger scale construction may require an additional lay-down area of up to 30 ha.

2. Opportunity Study for the Heart of the SW

Date Published: 2022

Reporting to: South West LEP, Devon CC

Report by: Regen

Scope

Review of strengths in Devon and Somerset including Plymouth and Torquay

Relevance to Blueprint?

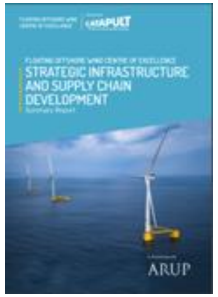
Report manages to be ambitious for the opportunity in floating offshore wind.

Report is clear headed as to regional capabilities and sets out practical steps to support growth of this existing capability.

Report focuses on maritime expertise, options for use of Appledore and Plymouth as hubs of activity/investment.

Report also identifies experience and initiatives established around Hinkley Point C Power Station construction that can be utilised including presence of high specification welding and concrete expertise & supply chain.

3. Strategic Infrastructure & Supply Chain Development



Date Published: 2022

Reporting to: Floating Wind Centre of Excellence

Report by: Arup

Scope

Assess capability, barriers and benefits of securing floating wind manufacture and assembly across three regions (Scotland, Celtic Sea and North East of England)

Undertakes business case analysis for port and manufacturing development and assesses GVA.

Relevance to Blueprint?

Report identifies barriers to securing port investment due to timescales of project delivery and mismatch between point when developers able to commit to ports after FID and the time required by ports to develop / prepare.

Report sets out for short, medium and long term deployment and makes recommendations around use of port clusters and scheme design for supporting strategic infrastructure between 2024 and 2028.

Note: report links can be found by clicking on report images.

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4. Industry Roadmap 2040

Date Published: 2023

Reporting to: RenewableUK / Floating Offshore Wind Taskforce

Report by: Royal Haskoning DHV

Scope

Review into UK Port Infrastructure required to unlock the UK's floating wind opportunity

Relevance to Blueprint?

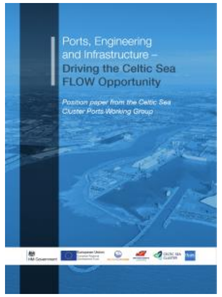
Report includes clear breakdown of different port requirements for parts of floating offshore wind lifecycle. Includes design and specification parameters, plus requirements in different regions including Celtic Sea.

Report includes brief summary of regional port capabilities. Celtic Sea will require 1-2 ports depending on low-high scenario. Low scenario will only deliver up to 3GW (high = up to 4.6GW). Therefore high scenario used for Blueprint analysis.

Defines requirements either 17 or 20MW turbines. Blueprint has used the 17MW assumptions for testing against the SCCA and reference project design.

Report highlights that 3 regional ports, with varying degrees of investment, could be developed to provide industrialised scale integration facilities to support FLOW deployment in the Celtic Sea. The key limitations of the existing port infrastructure are that sufficient quayside facilities and landside areas have yet to be developed.

5. Driving the Celtic Sea FLOW Opportunity



Date Published: 2022

Report Partners: HM Government, EU; Celtic Sea Power; British Ports Association, Celtic Sea Cluster, UK Major Ports Group

Report by: Celtic Sea Cluster Ports Working Group

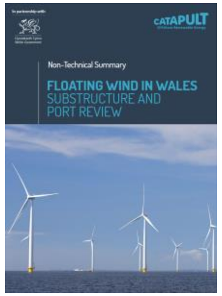
Scope

Sets out ports engineering and infrastructure case for floating offshore wind in the Celtic Sea, including steps to build a sustainable industry anchored in the Celtic Sea Region

Relevance to Blueprint?

Reviews port availability and suitability for Celtic Sea floating offshore wind deployment. Report notes that "We have combined quay space of around 30,000m with various loadings, depths of water alongside up 17m, combined laydown area of around 500ha and sheltered waters suitable for wet storage. This infrastructure is employed servicing our current customers. (Figures from OREC port study – SWFLOWA Application 2020.)"

6. Floating Wind in Wales – Substructure & Port Review



Date Published: 2021

Reporting to: Welsh Government

Report by: ORE Catapult

Scope

Report details how Welsh ports could play a significant role in building a sustainable future for Wales by unlocking opportunities for floating offshore wind within the Celtic Sea

Relevance to Blueprint?

Report highlights need for further strategic consideration and capital investment to unlock long-term potential. Key findings include the requirement to promote collaboration across our ports and to engage with both The Crown Estate and UK Government to create market certainty for the sector.

Note: report links can be found by clicking on report images.

7. Floating Substructures for Fabrication in Scotland

Date Published: 2020

Reporting to: FOW Centre of Excellence

Report by: ORE Catapult

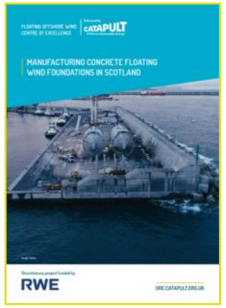
Scope

Review into opportunities for fabrication of floating platforms

Relevance to Blueprint?

While focused on specifics of Scottish market, including a review of ports and supply chain, report provides specifics on port capabilities and requirements, and highlights characteristics of main platforms coming to market.

8. Manufacturing Concrete Floating Wind Foundations in Scotland



Date Published: 2021

Reporting to: FOW Centre of Excellence

Report by: ORE Catapult

Scope

Review of requirements re. concrete floating substructures

Relevance to Blueprint?

Reviews Scottish capability and port capabilities and requirements, and highlights characteristics of main platforms coming to market. Highlights different requirements for concrete (vs steel) platforms

Highlights importance of calculating material requirements as proportion of existing supply chain. E.g. it estimates that 30% of aggregate production in Scotland would be taken up to support a baseline scenario of concrete substructures in Scotland. It also notes that only Celsa in Cardiff has rebar capacity to meet Scottish demand, and a concrete baseline scenario would take up 10% of Celsa capacity.

9. Dynamic cables and ancillary systems

Date Published: 2021

Reporting to: FOW Centre of Excellence

Report by: ORE Catapult

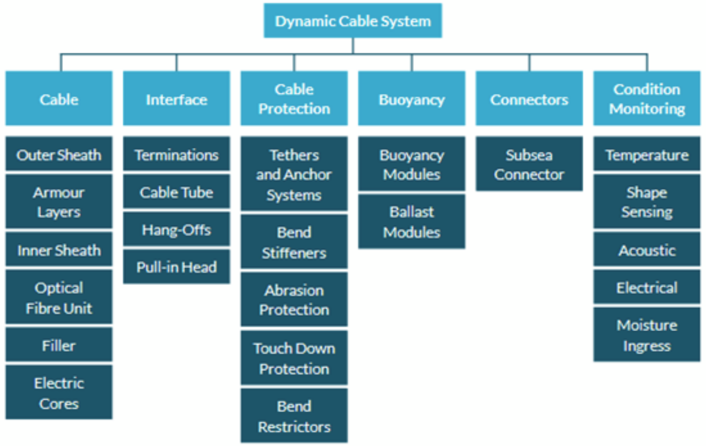
Scope

Review of market requirements, components and modelling of expected growth

Relevance to Blueprint?

Based on modelled turbine size and FLOW pipeline models high demand for cables and ancillary systems.

Report identifies main elements of a dynamic cable system and provides a taxonomy of components (below).



Note: report links can be found by clicking on report images.

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10. Moorings and anchor systems

Date Published: 2021

Reporting to: FOWCEx

Report by: ORE Catapult

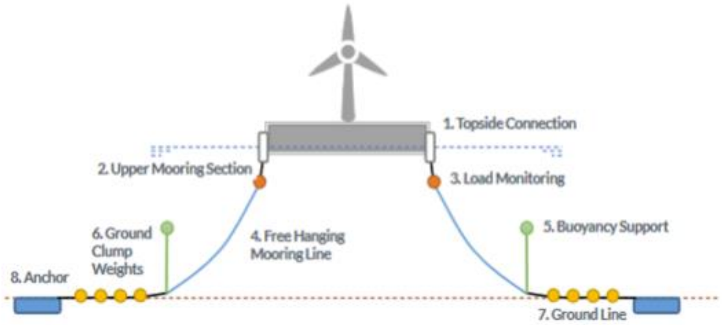
Scope

Review of market requirements, components and modelling of expected growth

Relevance to Blueprint?

Based on modelled turbine size and FLOW pipeline models high demand for mooring and systems.

Report identifies main elements of moorings and anchoring (below) and also provides a taxonomy of components.



11. Concrete for Celtic Sea FLOW & Missing Middle

Date Published: 2023 & 2024

Report by: Cornwall FLOW Accelerator

Scope

Concrete for Celtic Sea FLOW provides a review of supply chain and fit for concrete substructure development in the Celtic Sea

Relevance to Blueprint?

Identifies strong overlap between concrete substructure production and regional capability, including aggregate and cement materials supply and rebar production, plus local skills base and port suitability (see below).

The Cornwall FLOW Accelerator's Missing Middle Report was published after the literature review and supply chain capacity analysis had been conducted. The document is included here as it provides useful commentary on the Cornish supply chain and strategies for growing success in securing work from the Celtic Sea floating offshore wind pipeline.

12. Ports for offshore wind

Date Published: 2020

Reporting to: Arup

Report by: Crown Estate Scotland

Scope

Review of port capability and requirements for offshore wind development in Scotland

Relevance to Blueprint?

While focused on the (then forthcoming) ScotWind leasing round, the report provides a clear methodology for assessing port capability, and sets our clear criteria for port needs, including floating offshore wind demand for cables and ancillary systems.

Report identifies main elements of a dynamic cable system and provides a taxonomy of components (below).

Note: report links can be found by clicking on report images.

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