UK STRATEGIC CAPABILITY ASSESSMENT OFFSHORE WIND FOUNDATIONS

ORE CATAPULT REPORT FOR THE OFFSHORE WIND GROWTH PARTNERSHIP

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Acknowledgement

This report has been prepared by ORE Catapult with input and feedback from a range of organisations and individuals. ORE Catapult would like to acknowledge and thank all respondents and consultees for their valuable contributions.

Consultees for this study are listed in Appendix 1.

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Offshore Wind Growth Partnership

The Offshore Wind Growth Partnership (OWGP) is a long-term business transformation programme that promotes closer collaboration across the supply chain, implements structured productivity improvement programmes and facilitates shared growth opportunities between developers and the supply chain.

In order to identify the areas of greatest potential for UK growth in the offshore wind sector, OWGP is carrying out a series of Strategic Capability Assessments. This report is the first in this series and aims to assess the benefits and barriers for growth in the UK offshore wind foundations sector.

Future Strategic Capability Assessments will be carried out in other areas such as turbines, installation, electrical infrastructure and O&M.

Contents

1 Executive Summary

This report was commissioned by the Offshore Wind Growth Partnership (OWGP) as the first in a series of Strategic Capability Assessments that will be used to identify the areas of greatest potential for UK growth in the offshore wind sector. Foundations are a major component of an offshore wind farm and account for just under 10% of the lifetime costs of a wind farm. Future reports will consider the capability and opportunities in other significant areas such as turbines, installation, electrical infrastructure and O&M.

This report focuses on the capability of the UK offshore wind foundations sector and is based on wide consultation with developers, fabricators and EPCI contractors. Due to the significant scale of investment required for UK growth in the foundations sector (10s of £m for existing facility development through to 100s of £m for new facility development) it is essential that a coordinated approach is taken between industry and government.

1.1 Offshore Wind Foundations Market

The UK has over 8.5GW of operational offshore wind farms consisting of over 2,000 offshore wind turbines. In terms of foundations, 90% of the installed turbines use monopile foundations with the remaining 10% being jacket foundations.

As deployment ramps up towards the 2030 target of between 30GW and 40GW, sites will be developed in deeper waters and jackets are expected to increase share to 22% compared to 78% for monopiles. Beyond 2030, it is expected that floating foundations will become cost-competitive and be used on the majority of UK projects.

We estimate the market from 2020 to 2030 for as yet uncontracted fabrication of UK foundations to be worth £3.9bn for monopile foundations and £1.6bn for jacket foundations. Over the period from 2030 to 2050, we expect the UK foundations market to be worth £1bn for monopiles, £1.5bn for jackets and £9.7bn for floating foundations. **Recommendation 1 is for OWGP to track developments in foundations technology to ensure investments are future-proofed.**

1.2 Monopiles

There are currently no UK-based suppliers of monopiles of the size required (up to 11m diameter and growing to 14m diameter by the mid-2020's) for offshore wind turbines.

Annual Europe-wide monopile demand in the 2020's is estimated at 514,000 tonnes compared to a current European capacity of approximately 500,000 tonnes. This clear demand coupled with the fact that monopile production is highly automated with a similar cost base across Europe suggests there are opportunities new monopile fabrication facilities in the UK. **Recommendation 2 is for DIT and SDI to explore the potential for a new monopile production facility in the UK.**

1.3 Jackets

There has been a clear trend in jacket fabrication of contracts being awarded to companies distant from the UK. All 30 jackets for the Ormonde windfarm in 2011 were fabricated by BiFab in Scotland, jacket contracts for UK projects in 2018 were split 50/50 between the UK and Europe, but for projects in 2019 to 2022, only 18% of jackets have been contracted to UK fabricators. There has been a migration from the UK firstly to Europe and more recently to the Middle East and Asia in an ongoing push for further cost reduction.

Industry feedback highlights obstacles to awarding fabrication contracts to UK companies; these obstacles relate mainly to cost and financial risk. UK-fabricated transition pieces and jackets can be 10-15% more expensive than the most competitive prices achievable in the market. This means that, even with some cost reduction, UK fabricators in jackets particularly, are currently likely only to win a small share of contracts (i.e. the buyer will incur 10-15% premium on only a portion of the overall contract) – as is currently being seen.

In general, the products are delivered to time, quality and budget but there have been instances of jacket contracts being finished by alternative contractors at short notice due to the original contractor not fulfilling requirements. Buyers price-in the risk based on the track record of the contractor and if unchecked this will count against UK companies which have under-performed in the past. These factors are increasingly important as UK strike prices have been driven to all-time low levels. **Recommendation 3 is for Fabricators to work with OWGP and government agencies to publicise improvements in order to enhance their reputation and reduce perceived risk.**

1.4 Port Infrastructure

The best in class fabrication facilities for monopiles and jackets are sited at large ports, with excellent logistics, including efficient goods in and goods out routes and processes for movement of thousands of tonnes of raw materials and finished goods. This is critical to maintaining the most competitive pricing. The UK has no equivalent to Esbjerg (Denmark), Rotterdam (Netherlands) or Rostock (Germany). **Recommendation 4 is for national and regional government agencies to work with port owners to unlock investment for port upgrades.**

1.5 Finance

Fabricators often struggle to access financing for improvements, especially without a committed pipeline of work to justify the level of investment required. UK Export Finance can provide support for firms which export or are building export capability. **Recommendation 5 is for OWGP to work with UK Export Finance along with government agencies to publicise finance available to UK companies.**

1.6 Recommendations

1. OWGP should work closely with industry to track technological developments in foundations in order to ensure any investment in foundation manufacturing capability is future-proofed and to

identify new opportunities. As wind farms are developed in more challenging site conditions, there may be a need to bring new foundation types to the market.

2. Department for International Trade (DIT) in collaboration with Scottish Development International (SDI) to conduct a detailed feasibility study into establishing a monopile production facility in the UK, which should include: identification of an appropriate site; attracting investment from an existing fabricator; investigating state of the art technologies transferable from other industries for production lines and paint halls.

3. To enhance the reputation of UK jacket fabricators, national and local government together with OWGP should work with fabricators on recently-awarded contracts to document and publicise the new processes and techniques being employed compared to previous contracts in order to quantify the positive impact of learning from experience and to show the route to the next round of improvements in quality and budget management.

4. Government agencies should work with port owners to try to unlock investment in port upgrades, both as an essential element underlying a new monopile facility and for existing jacket and transition piece locations, where efficient logistics can reduce costs.

5. OWGP should work with UK Export Finance, with support from other government agencies, to publicise as widely as possibly the credit finance available to UK companies for domestic as well as export projects (provided exporting is a part of their business).

2 Introduction

2.1 UK Offshore Wind Sector Deal

In March 2019, the UK Government and UK offshore wind industry agreed a Sector Deal[1], which secures offshore wind's position at the heart of the future UK energy mix as a large scale, low carbon form of electricity. Sector deals aim to create significant opportunities to boost productivity, employment, innovation and skills. To date sector deals have been agreed with the aerospace, artificial intelligence, automotive, construction, creative industries, life sciences, nuclear, offshore wind and rail industries.

The offshore wind sector deal sets out ambitious 2030 targets for the industry to be a global leader and maximise its advantages for the UK and includes a number of industry targets:

1. Deliver 30 GW of installed capacity.
2. Increase UK content[2] from 48% in 2016 to 60% by 2030, including increases in the capital expenditure phase
3. Support 27,000 jobs by 2030, with the majority of these in coastal communities
4. Increase representation of women in the offshore wind workforce to at least a third.
5. Increase exports fivefold to £2.6bn per year.

2.2 The Offshore Wind Growth Partnership

A number of initiatives have been put in place to support delivery of these targets. This includes the Offshore Wind Growth Partnership (OWGP), which will support UK supply chain companies to enter and fully exploit this growing market. The OWGP has a crucial role to play in delivering Sector Deal targets, particularly enabling the growth in UK content and exports, while seeking to achieve an appropriate geographic and demographic spread of economic benefits and jobs. In order to target the resource and funding being made available, the OWGP is undertaking Strategic Capability Assessments on each key area of the UK offshore wind supply chain.

2.3 Strategic Capability Assessments

Strategic Capability Assessments (SCA) are designed to benchmark elements of the UK supply chain against the best in class in order to identify strengths, weaknesses, opportunities and threats for UK businesses in the domestic and global export markets.

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[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/786279/BEIS_Offshore_Wind_sector_deal_print_ready.pdf

[2] A Guide to Measuring the UK Content of Offshore Wind Farms is available at https://cdn.ymaws.com/www.renewableuk.com/resource/resmgr/publications/guides/guide_to_measuring_uk_conten.pdf

This approach has been applied in the nuclear and aerospace sectors. The results have been to transform these industries in the UK into world-class, high value adding sectors.

The offshore wind supply chain areas identified for SCA's include:

- Foundation supply
- Array cable supply
- Installation
- Offshore substation supply
- Export cable supply
- Operations and Maintenance (O&M)

This report documents the findings of the Foundations Supply SCA conducted between July 2019 and October 2019.

3 Methodology

The approach applied to each SCA follows a similar methodology but is tailored to the requirements of the supply chain area under assessment. The methodology for the Foundations Supply SCA is outlined in this section.

- Define the scope of the supply chain segment under assessment
    - Foundation types – offshore wind turbine and offshore substation
    - Scope of supply – primary and secondary material, transition piece, assembly, coatings
- Assess the market opportunity
    - Current and future market volumes and value
    - Key geographies
- Industry requirements – what does good look like from buyers' perspective
    - Identify offshore wind foundation buyers
    - Establish procurement criteria
- Analyse the most successful suppliers
    - Identify which suppliers have won contracts
    - Analyse cost structures, capacities, capabilities and logistics
- Analyse capabilities of UK supply chain companies
    - Identify existing and potential UK suppliers
    - Analyse cost structures, capacities, capabilities and logistics
- Benchmark UK companies against most successful companies
    - Cost structure
    - Capacity
    - Capabilities
    - Logistics
- Identify actions to increase success of UK companies in the segment

4 Scope of Assessment

4.1 Study Scope

This UK Offshore Wind Strategic Capability Assessment covers the following UK supply chain elements for turbine foundations.

Jacket	Monopile
Primary steel	Primary steel
Secondary steel	Secondary steel
Piles / Suction buckets	Transition Piece
Assembly	

Table 1: Scope of assessment

The market opportunity, industry requirements, most successful suppliers and UK supply chain companies will be assessed in each of these elements.

The study has also considered floating wind and solicited input on the prospects for other types of foundations (e.g. gravity-based). However, the majority of feedback from respondents indicates that monopile and jacket foundations are expected to dominate the market out to 2030 and so these foundation types are the focus for this report.

Figure 3: Transition pieces (source: EEW)

Figure 1: Jackets (source: Smulders)

Figure 2: Monopile (source: Boskalis)

4.2 Future Trends in Foundation Design

As noted above, the foundations market is currently dominated by monopiles, with jackets being the second most common foundation type deployed. Other foundations deployed to date include concrete gravity-base, suction piles, jacket variants and various floating designs. The growing pace of offshore wind deployment will drive projects to be developed in more challenging conditions (eg. deeper waters, challenging seabed, further from shore) and this has implications for the optimum foundations for each site. The overall feedback through this study is that industry respondents expect monopiles and jackets to continue to dominate the market throughout the 2020's at least.

In addition to floating wind designs, there are various alternative bottom-fixed designs in development, including modular suction bucket, pre-stressed concrete jacket and tetra-base. For new foundations to gain a significant market share requires supply costs to be in line with those for existing solutions or to enable sites which could not otherwise be constructed – even then the overall project economics must be competitive. Our expectation is that offshore wind will continue to be built out using monopiles wherever possible, due to their now almost commoditised nature, and jackets. It is possible that new designs will gain market share if they can be manufactured competitively using existing fabrication facilities or low-cost greenfield facilities, with enough volume contracted; we expect these foundations would be produced by the existing supply chain rather than giving rise to a new fabrication base.

5 Offshore Wind Market Context

5.1 Global Offshore Wind Turbine Foundation Market

The global offshore wind market is forecast to increase from 22GW deployed as of June 2019 to as much as 228GW by 2030 and 1,000GW by 2050 according to IRENA's latest offshore wind outlook[3]. The deployment forecasts we have used for this study apply discounts to these forecasts (which are roughly double previous forecasts released by IRENA and Bloomberg New Energy Finance), to reach 187GW by 2030 and 907GW by 2050. The global deployment forecast underlying our market assumptions is shown in Figure 4.

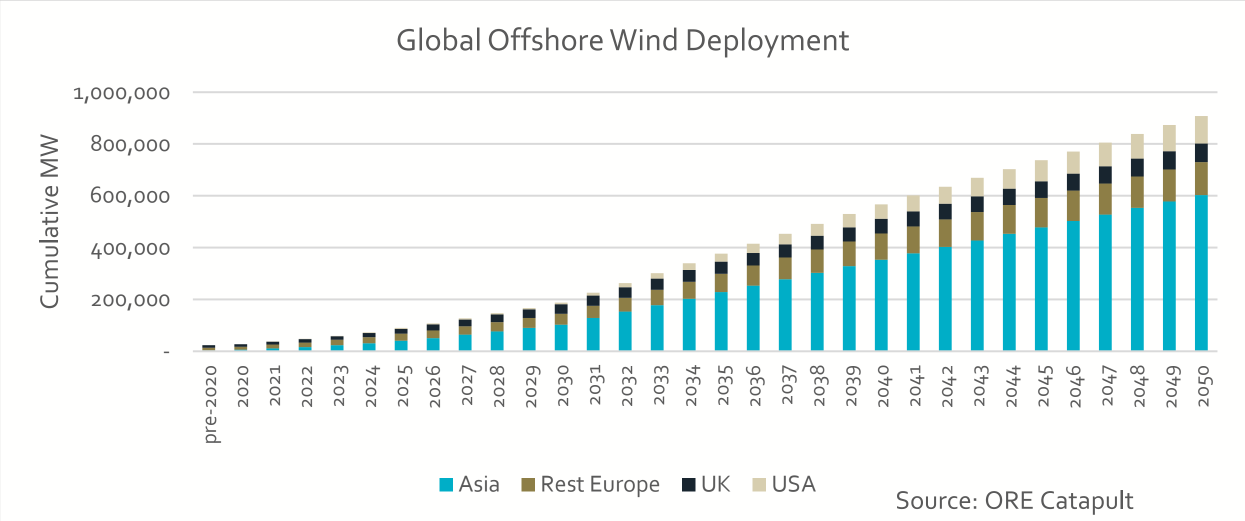


Figure 5: Global offshore wind deployment 2000 – 2050 (MW)

Assuming turbine rating increases steadily from an average of 7MW installed in 2018 to 12MW in 2025, 15MW by 2030 and 20MW in the 2030's, we estimate that approximately 14,000 offshore wind turbines and foundations will be installed between 2020 and 2030 and a further 42,000 turbines and foundations will be installed between 2031 and 2050.

Monopiles are expected to continue to dominate the market out to 2030, with projects being selected mainly based on ability to construct at lowest cost.

Based on this, we estimate **9,800 turbine monopiles, 3,500 turbine jackets and 400 floating foundations** to be contracted between 2020 and 2030, representing **average annual demand of 980 for monopiles, 350 for jackets and 100 for floating foundations (over 2027-2030 for floating)**. Our forecast by foundation type to 2050 is shown in Figure 6.

[3] IRENA Current Status and Outlook for Offshore Wind 2019
https://www.researchgate.net/publication/334509799_Current_Status_and_Outlook_for_Offshore_Wind

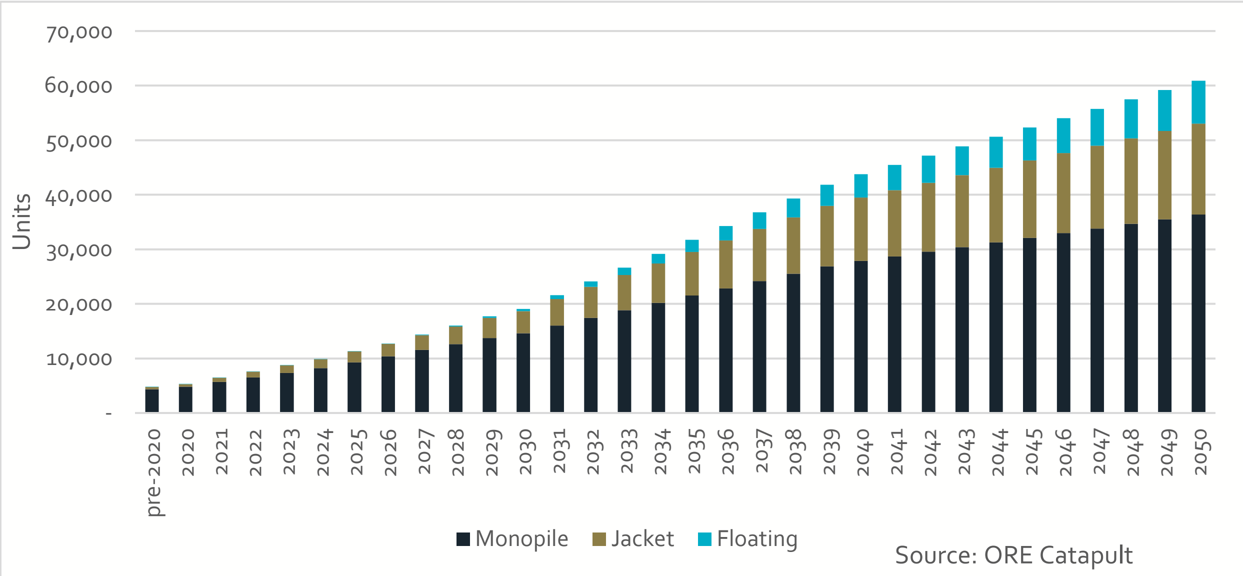


Figure 6: Global deployment (number of units) by foundation type

5.2 UK Offshore Wind Turbine Foundations Market

Under the Sector Deal, the UK offshore wind industry is aiming for 30GW installed by 2030. Recent political announcements suggest a target of at least 40GW will be adopted. Given the time required to consent and construct sites, we have estimated 37GW could be installed in the UK by 2030. Beyond this, our forecast adopts the Committee on Climate Change estimate of 75GW required by 2050[4].

Of the 37GW by 2030, the supply contracts for approximately 14GW have already been fulfilled or contracted. This leaves supply contracts for up to 23GW of projects still to be awarded (including the 5.5GW recently awarded under Allocation Round 3). We estimate this 23GW to represent 1,850 turbines (and foundations) with capacities ranging between 10MW and 15MW.

While these projects are being developed in many cases in deeper waters than previously, ever-larger monopiles are being considered beyond 50m water depth and so we expect monopiles to account for 78% of demand to 2030. Based on this, we estimate for the UK **1,500 turbine monopiles** (2,000,000 tonnes of monopiles, 830,000 tonnes of TP's and 100,000 tonnes of secondary steel) **and 350 turbine jackets** (390,000 tonnes of jackets, 170,000 tonnes of piles and 38,000 tonnes of secondary steel), to be contracted between 2020 and 2030.

It is possible that commercial-scale floating wind projects could be installed in the UK by 2030, particularly with a higher deployment target. However, the route to market is currently unclear, with no support in place outside of the Allocation Round competitive auction process. The applicability of monopile and jacket fabrication methods and facilities to floating wind foundations is considered in this report.

[4] https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

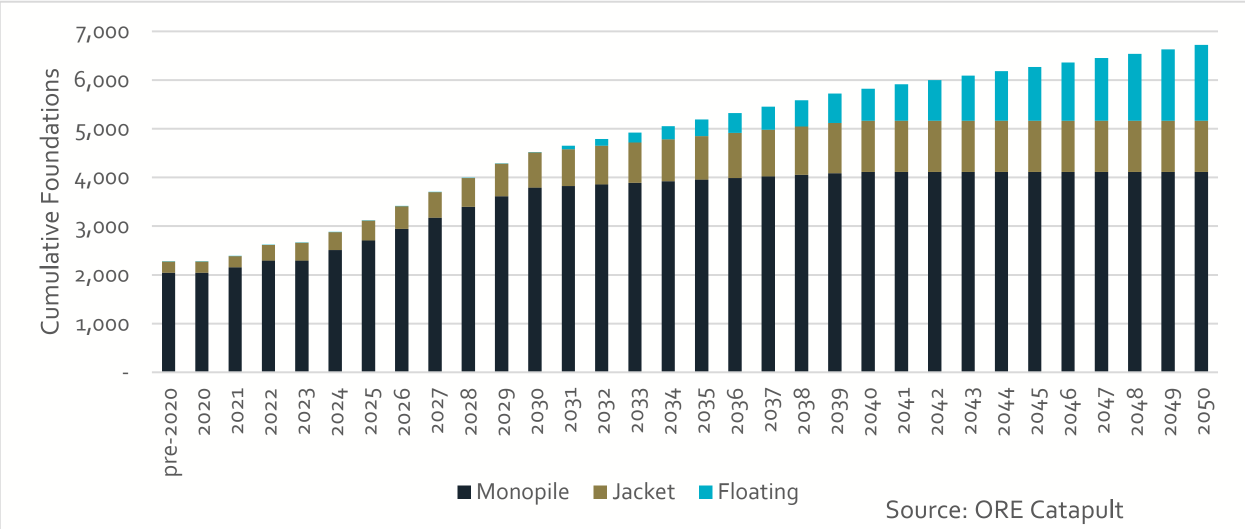


Figure 7: UK Foundations Market Forecast by Foundation Type

5.2.1 UK Market Value

The estimated value of the UK (uncontracted) offshore wind turbine foundations market to 2030 is £5.5bn, consisting of **£3.9bn for monopiles and TP's and £1.6bn for jackets and piles**. Beyond 2030, we estimate the cumulative UK market values for 2031 to 2050 to be £1bn for monopiles, £1.5bn for jackets and piles and £9.7bn for floating foundations.

5.2.2 Value Breakdown

In broad terms, the value in monopile foundations can be viewed as 60% in the monopile and 40% in the TP and secondary steel; for jackets the value is roughly 70% in the jacket and 30% in the piles and secondary steel (SS). Our estimated UK annual market value breakdown is as shown in Table 2.

Value breakdown £m	2024	2025	2026	2027	2028	2029	2030	Grand Total
Jacket structure	-	120	184	183	226	224	204	**1,142**
Jacket piles & SS	-	44	68	68	84	84	73	**421**
Jacket total	-	164	252	251	310	308	277	**1,563**
Monopile	340	311	360	357	332	329	319	**2,349**
Monopile TP & SS	233	214	248	247	230	228	202	**1,602**
Monopile total	5743	525	608	604	562	557	521	**3,951**

Table 2: Estimate UK Value Breakdown by Foundation Type

The UK market to 2030 for transition pieces, secondary steel, pin piles and suction buckets is estimated to be worth a total of £2bn, compared to the market for primary structures of £3.5bn.

5.3 Key Players in the UK Turbine Foundations Market to Date

Our analysis of available data on foundation contract awards has identified the following trends in the organisations successful in winning work for UK offshore wind projects.

5.3.1 Monopiles

As monopiles have increased in size, the market has been dominated by SIF, and more recently by EEW. Tees Alliance Group (TAG) was awarded the monopile contract for Humber Gateway (first power 2015). It went into administration in 2014, and since then no monopiles have been made in the UK.

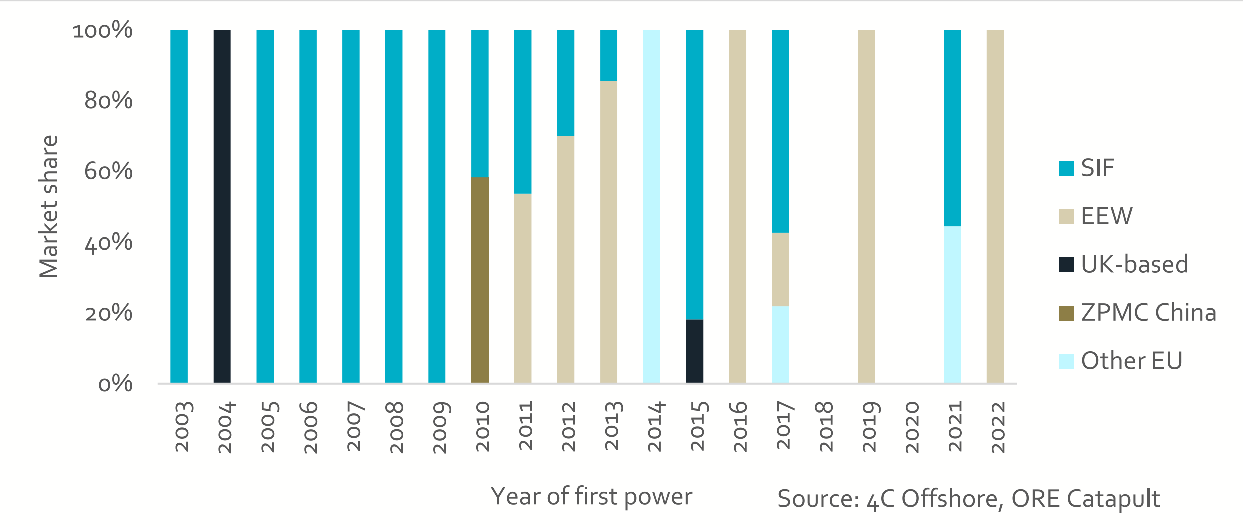
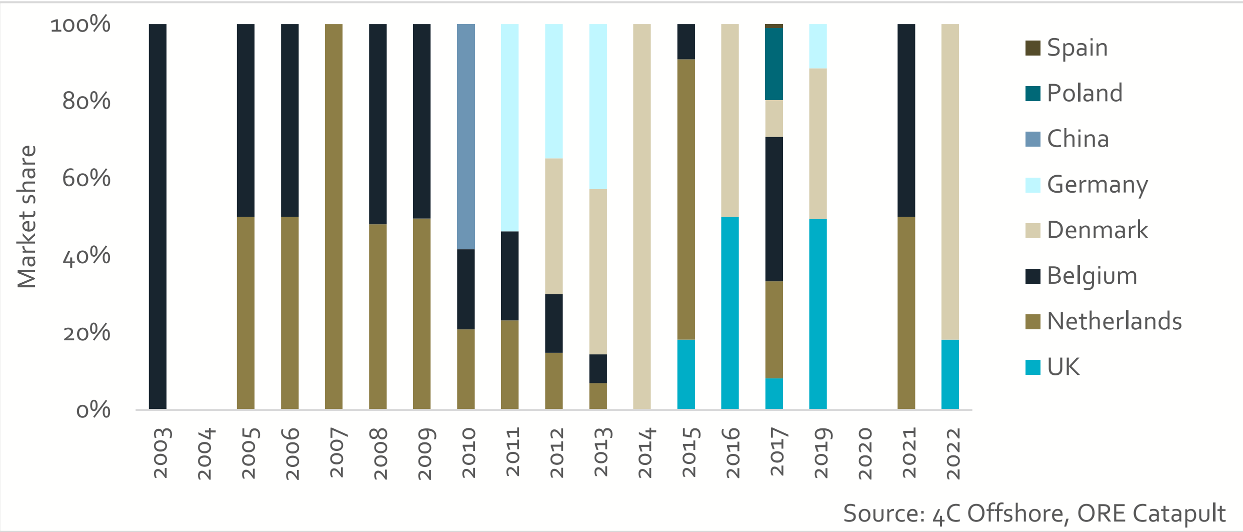


Figure 8: Monopile suppliers for UK projects 2003 – 2022

5.3.2 Transition Pieces

Transition pieces for the UK market have mostly come from European yards in Belgium, Denmark, the Netherlands and Germany. The UK's position improved with the founding of EEW OSB in 2014, which



has won contracts to supply TP's for the Burbo Bank and Walney extensions, and Hornsea Projects One & Two and complements the pre-existing UK offering in this area.

5.3.3 Jackets

The UK's track record for manufacturing jacket structures for offshore oil & gas facilities has transferred to the offshore wind sector. However, as turbines and foundations have become larger, and cost-pressure increased, the trend has been for more procurement of jackets from overseas, with a migration from UK to mainland Europe and then the UAE and Indonesia.

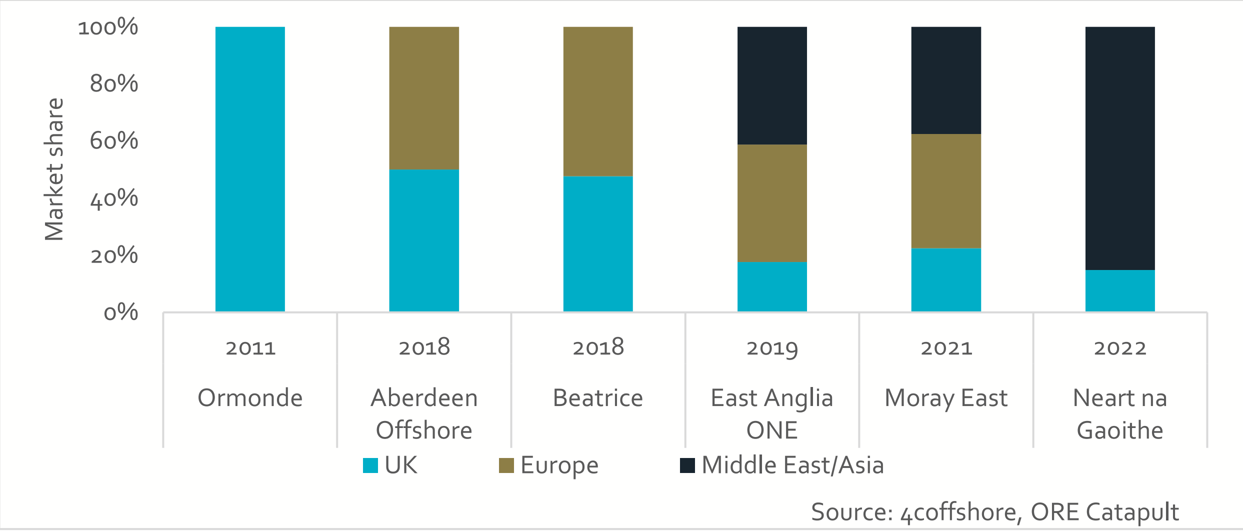


Figure 10: Jacket suppliers for UK projects 2011 - 2022

5.4 Market Opportunity Summary

Global demand for turbine foundations is set to grow to around 1,400 units per year, including 300 per year for the UK and 250 for the rest of Europe by the middle of the 2020's. This represents markets valued as shown in Table 3, with UK jackets and piles worth a cumulative £1.56bn and UK monopiles with TP's worth £3.9bn for projects as yet uncontracted out to 2030.

Type	Element	UK	Rest of Europe	Rest of World
		£bn	£bn	£bn
Jacket	Jacket	1.1	1.2	6.0
	Piles and SS	0.4	0.5	2.2
Monopile	Monopile	2.3	1.8	7.3
	TP and SS	1.6	1.3	5.0
Floating	Floater	-	0.7	1.2
	SS	-	0.1	0.1

Table 3: Estimate Cumulative Values for Projects To Be Contracted to 2030

From 2030 to 2050, we estimate the UK monopile market to be worth £586m for monopiles and £372m for TP's and secondary steel; and the UK jacket market to be worth £1.1bn for jackets and £406m for piles and secondary steel; over this period, as floating wind becomes much more prominent, we value the UK floating foundations market at £8.7bn for the main structures and £920m for secondary steel.

6 Offshore Wind Industry Requirements

Engagement with the buyers of offshore wind foundations (project developers and EPCI (Engineering, Procurement, Construction and Installation) contractors) shows that assessment of contract tenders focuses on:

Cost of supply

- Not always lowest bidder awarded contract as factors outlined below are at least as important
- Includes an exercise in ensuring tenders are compared on like-for-like scope coverage

Quality of supply

- Track record (previous first-hand positive experience with the supplier is very important)
- Quality management certification (ISO's etc)
- Site visits (especially if the supplier is new to the buying organisation)
- Assessment of current facilities and skills to deliver the required scope and any upgrades or investments required in production or logistics

On-time delivery

- Assess quality of supplier's supply chain
- Assess risks with transportation and logistics (distance, weather)
- Assess ability of contractor to manage interface risks with related work packages (e.g. transport and installation, secondary steel)

Warranties

- Ability of supplier to warrant % of contract value for a number of years (varies from 2-7 years)

Financial strength

- Ability to provide a bond covering performance, delivery and defects, amounting to an agreed % of the overall contract value or, in some cases cover the value of potential losses from failed delivery, which can be greater than the contract value[5]

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[5] In some case, this has been cited by suppliers as a major obstacle as they may lack the balance sheet or parent company support or access to credit required; some developers have advised they understand this issue and try to take a sensible approach which does not price suppliers out of the tender, but also need to apply standard T&C's determined at a corporate level so have limited room for manoeuvre.

- Ability to provide Parent Company Guarantee (PCG) to provide comfort that the contract can be delivered even in the event of difficulties

It is worth noting that UK offshore wind projects are currently constructed and operated under the Contracts for Difference (CfD) scheme. The project developer must adhere to strict milestones, with the 15-year CfD period for each phase beginning by designated commissioning dates regardless of the full required installed capacity being installed (i.e. some or all of the capacity could receive less than 15 years of CfD support if delivered late); further, if the CfD "long-stop" date is missed then the Low Carbon Contracts Company (LCCC) has the right to terminate the CfD contract altogether. The effect on the project economics of not meeting these milestones means project developers require maximum comfort that its supply chain has the ability to deliver to the required schedule.

7 Offshore Wind Foundation Manufacturing Processes

The key processes, facilities and equipment required for the most widely used foundations are shown here in order to illustrate how UK capabilities map to current manufacturing requirements. This also provides a view on where there may be opportunities for improvements or changes to current processes to better suit facilities and expertise available or being developed in the UK.

7.1 Monopile Manufacture

The basic process for monopile manufacture is shown in Table 4. All facilities may be co-located or spread over a number of highly specialised locations. Where all facilities are not co-located, additional steps for transit of goods between locations will be required. This will typically require SPMTs (Self-propelled modular transporters) for movement around the site and barges for transport between sites; road transport is generally not suitable for movement of wide diameter cans and long monopile sections. Final delivery is made at the wind farm construction port either FAS (free alongside ship) or FOB (free onboard).

Process	Materials	Equipment/Personnel	Facilities
Steel plate goods inward	N/A	Cranes	Quayside Storage
Steel plate rolling	Steel plate	Rolling equipment Production line personnel	Large indoor, allowing 12m diameter
Can longitudinal welding	Rolled steel cans	Welders Robotic welding	Large indoor, allowing up to 14m diameter
Quality control		QA personnel (internal)	
Monopile structure circumferential welding	Completed cans	Robotic welding Support personnel	Large indoor, allowing up to 14m diameter
Quality control		QA personnel (external)	
Coating of monopile section above seabed	Completed monopile Spray coatings	Crane Coating personnel	Large indoor, allowing up to 14m diameter

Table 4: Monopile fabrication process

7.2 Jacket Manufacture

The basic process for jacket fabrication is similar to that of monopiles, as shown in Table 5. The key differences between the two are that jacket fabrication will generally require buying in made-to-measure steel tubulars and requires; i) more storage space, ii) more welding and iii) an indoor crane for up-righting and gradual assembly. Jackets are also more difficult to fabricate as a serial process. As with monopile manufacture, facilities may be co-located or spread over a number of highly specialised locations, with additional steps required for transit of goods (i.e. via SPMTs around site and barges between sites). Some offshore wind jacket foundations[6] have been fabricated in two sections; i) a larger, lower section consisting of rolled tubes welded together as the main frame and support trusses and, ii) a transition piece connected to a smaller, upper section of welded tubes. In other cases, the platform and transition piece might be welded to the full jacket structure at the final assembly stage. Again, final delivery is made at the wind farm construction port either FAS or FOB.

Process	Materials	Equipment/Personnel	Facilities
Steel tubes goods inward	N/A	Cranes	Quayside / Storage
Tube longitudinal welding	Rolled steel tubes	Welders / Robotic welding	Large indoor
Lower jacket assembly (outer legs, trusses, feet)	Completed tubes	Cranes Welders / Robotic welding	Large indoor
Quality control		QA personnel (internal)	
Transition piece (with upper jacket if applicable) inward	N/A	Cranes	Quayside Storage
Jacket assembly	Jacket sections	Cranes Welders / Robotic welding	Large indoor/ Quayside
Quality control		QA personnel (external)	
Coating of jacket	Completed jacket Spray coatings	Crane Coating personnel	Large indoor

Table 5: Jacket fabrication process

[6] Beatrice Offshore Wind Farm. Contractor: Smulders.

7.3 Transition Piece Manufacture

A transition piece connects the tower of the offshore wind turbine to the foundation. In the case of monopile foundations, the transition piece is primarily a large steel can with secondary steel component attached. Transition pieces for jacket foundations also consist of large steel cans but have a smaller depth than that of monopiles, due to the fact that more of the primary structure is visible above water level. Fabrication of monopile transition pieces is typically undertaken at a different facility to the primary structure due to large storage space required.

7.4 Secondary Steel Manufacture

Foundations of any type require internal and external secondary steel components to be manufactured and welded to the primary structure. Examples of these components include suspended internal platforms (SIP's), boat landing systems, access ladders and railings. Welding to the primary structure can take place during the final assembly stage, which makes secondary steel components suitable for fabrication at or near the construction port, even if the facilities do not have the capacity to manufacture full primary structures. In other cases, secondary steel components will be included in the scope for transition piece manufacture. Secondary steel fabrication is labour-intensive, with labour forming roughly 60% of the final fabricated cost.

7.5 Jacket Piles Manufacture

Jacket foundations can be secured in place using piles drilled or hammered into the seabed, with the jacket legs fitting in to the piles and being grouted into place. The fabrication process of the jacket piles themselves is similar to that of monopiles, but on a smaller scale, roughly 2.5m diameter depending on overall design requirements. The jacket piles can be manufactured in the same facility as the jacket structure, or elsewhere as a separate scope of work.

7.6 Suction Bucket Manufacture

An alternative to using pin piles to secure a jacket structure to the seabed is the use of suction buckets, also known as suction piles or suction anchors. Suction buckets are open-ended steel cans attached (via welding) to each corner of the structure. Suction buckets work by creating a pressure difference between the inside of the bucket (after water has been pumped out) and the water surrounding it, thereby reducing the need for mechanical force during installation. The diameter of the suction bucket can is much larger than the steel tubes making up the primary jacket structure. Therefore, fabrication of the suction bucket takes place at a different facility (i.e. with large steel rolling equipment), with welding to the main structure taking place at the final assembly stage. The use of suction buckets has the potential to reduce the overall installed cost of a piled jacket foundation due to reduced piling requirements and removing the need for grouting.

8 Global Offshore Wind Foundations Supply Chain

8.1 Global Supply Chain Overview (excluding UK-domiciled companies)

The supply chain for offshore wind foundations is becoming increasingly global in nature. Key fabrication bases in Denmark, Germany, the Netherlands and the UK are facing increased competition from fabricators in Spain, the Middle East and Far East. This increased competition currently applies mainly in jacket supply, but it is likely that recent entrants (and/or further new entrants) to the offshore wind foundations supply chain will expand their offerings to monopiles and transition pieces at some point.

These companies operate out of state of the art facilities which are well aligned with the success factors highlighted in Table 7.

Key supply chain players are as follows:

Current Suppliers	Location(s)	Monopile	Transition Piece	Jacket	Secondary Steel
Bladt Industries	Aalborg (DK)		✔	✔	
EEW	Rostock (DE)	✔			
	Teesside (UK)		✔		
Lamprell	Jebel Ali (UAE)			✔	
Navantia	Fene (ES)			✔	
Sif	Rotterdam (NL)	✔			
Eiffage Smulders	Hoboken (BE)		✔	✔	
	Vlissingen (NL)			✔	
	Spomasz (PL)				✔
	Newcastle (UK)			✔	
Steelwind	Nordenham (DE)	✔	✔		
ST3	Szczecin (PL)		✔	✔	✔
ZPMC	Shanghai (CN)	✔	✔	✔	✔
New Entrants	**Location(s)**	**Monopile**	**Transition Piece**	**Jacket**	**Secondary Steel**
Haizea Wind Group	Bilbao (ES)	✔	✔		
Saipem	Karimun (IDN)			✔	
Windar	Aviles (ES)	✔		✔	

Table 6: Key global supply chain players

These supply chain bases are shown in Figure 11.

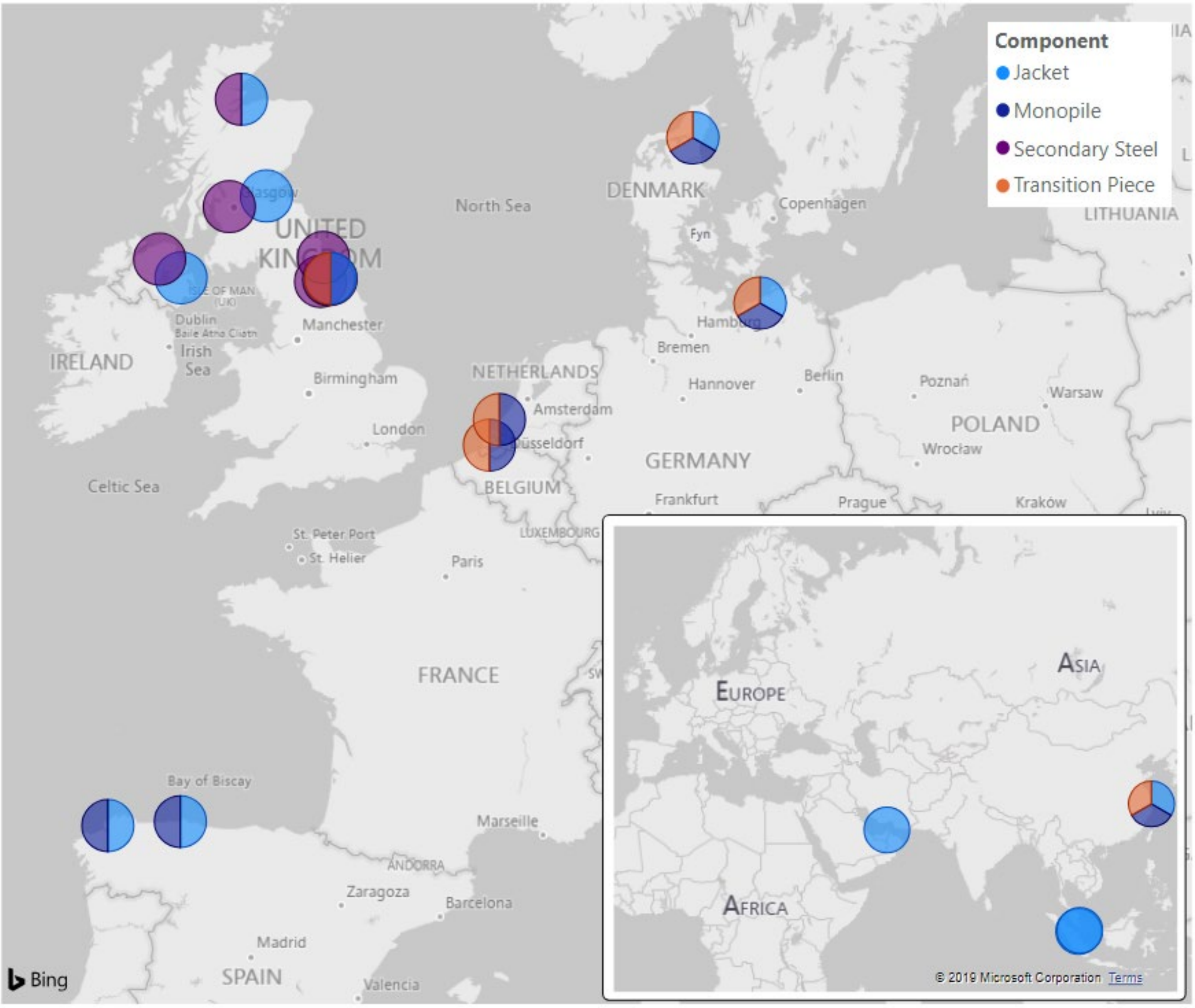

Figure 11: supply chain bases

8.2 Business Models

Many facilities are focussed on a specific scope of work, e.g. monopile, TP, jacket. This allows each site to be optimised and to leverage on local advantages (e.g. access to particular skills, low-cost labour, low-cost land, specialist supply chain, logistics hubs, trade routes). In order to be able to provide the customer's full scope requirement, the two most common approaches are:

Operate a number of complementary facilities, e.g. Smulders fabricates jacket lower part in Wallsend, top part in Hoboken, secondary steel in Spomasz and currently carries out final assembly at Wallsend using the on-site ring crane; EEW fabricates monopiles in Rostock and TP's in Teesside (EEW OSB).

Partner with other organisations, e.g. Sif and Smulders have formed joint ventures to supply monopiles and TP's into various projects; EEW OSB may produce the external cans for TP's and buy in the internal components from other local suppliers.

8.3 Success Factors

Engagement with fabricators has identified the following factors as critical to profitable delivery of offshore wind foundations to market requirements.

Factor	Monopile	Transition Piece	Jacket	Pin Piles	Secondary Steel
Large-diameter steel bending	✔	✔			
Large covered halls	✔		✔	✔	
Semi-automated paint shop	✔	✔	✔		
Large, strong quayside	✔	✔	✔		
Fixed and mobile cranes	✔	✔	✔		
Efficient logistics routes	✔	✔	✔	✔	✔
Automated/robotic welding	✔	✔		✔	
Skilled labour	✔	✔	✔	✔	✔
Continuous work programme	✔	✔	✔	✔	✔
Financial strength	✔	✔	✔	✔	✔

Table 7: Success factors for offshore wind foundation fabrication

8.4 Monopile Supply

The most successful companies in monopile supply to date are Sif, Steelwind, Bladt and EEW. The key success factors identified for these companies are:

- Large rolling hall able to accommodate structures up to 120m in length
- Ability to bend steel to produce large diameter cans
- Robotic welding for longitudinal and circumferential welds
- On-site, semi-automated, paint shop
- Access to large, strong quayside (for goods in and loadout of finished products)
- Mix of fixed and mobile cranes
- Flat surface for efficient movement of heavy goods around site
- Ability to attract and retain skilled labour

Fabrication limits for the leading players are shown in Table 8.

Organisation	Max diameter	Max thickness	Max length	Max mass
EEW	12m	76mm	120m	1,500te
Sif	11m	250mm	120m	2,000te
Steelwind	11m	150mm	120m	2,400te

Table 8: Fabrication limits

8.5 Monopile Transition Piece and Secondary Steel Supply

The most successful companies in transition piece supply to date are Sif, Steelwind, Bladt, EEW and Smulders. The key success factors identified for these companies are:

- Ability to bend steel to produce large diameter cans
- Robotic welding for longitudinal and circumferential welds
- On-site, semi-automated, paint shop
- Access to large, strong quayside (for goods in and loadout of finished products)
- Mix of fixed and mobile cranes
- Flat surface for efficient movement of heavy goods around site
- Ability to attract and retain skilled labour at the right rates to conduct and manage technical and labour-intensive welding

Transition piece fabrication can be undertaken at a single facility or the scope may be split between fabrication of the large external can and supply of the more complex internal work, including platforms, stairways, handrails, etc. The key success factors for TP internals have been identified as:

- Ability to work across diverse industries, to withstand cyclical contract awards
- Ability to attract and retain skilled labour
- Relationships with primary steel fabricators
- Automated manufacturing processes

8.6 Jacket supply

Jackets are fabricated or assembled in the UK by Smulders, BiFab, and (until recently) Harland and Wolff. Overseas, the major fabrication yards are owned by Bladt, Windar Renovables, Navantia, Kvaerner, Lamprell and now Saipem. The key success factors identified for these companies are:

- Large yard space to allow for serial production
- Port access for efficient load-out
- Mixed cranes (including ring) and/or skid beams to reduce lifting
- Scaffolding to reduce working at height
- Ability to attract and retain skilled labour
- Low personnel costs to manage technical and labour-intensive welding

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

9 UK Offshore Wind Foundations Supply Chain

9.1 Summary of UK Capability

- At present, there are no existing facilities in the UK where the current (>7m) and future size (>12m) of monopiles can be fabricated.
- Three UK fabricators currently have the ability to fabricate jackets, although only two (BiFab and Smulders) are pursuing this as a business line.
- Four companies have capability to produce pin piles and steel tubulars as components for jackets.
- Four companies have the ability to fabricate suction buckets, with one company actively pursuing this as a line of business.
- Four companies are able to act as main contractor for transition pieces (as they have capacity to roll the heavy outer cans) and can call on a combination of a large number of different UK companies to fabricate the internal and external secondary steel.
- Six companies have the necessary size facilities and are equipped to act as final assembly yard for jacket foundations (and potentially for some floating foundations).

9.2 UK Supply Chain Assessment

We have assessed the UK supply chain for jackets (including pin piles; suction buckets are excluded as there is insufficient track record) and for monopile TP (monopiles themselves are excluded as there is no current UK monopile producer) and secondary steel against the factors identified as most important to the buyers of foundations. The "technical" criteria are assessed here separately for the different foundation types, while the wider commercial and financial elements are covered separately in the following section of this report.

9.2.1 Jackets and pin piles

Cost of supply: High UK labour costs relative to those in low-cost economies, poor site infrastructure (ground conditions and on-site conditions (in some cases) and vessel access for goods in and out) and sub-optimal processes are the key drivers for higher UK fabrication costs; even allowing for higher transportation costs, overseas fabrication is generally the lower-cost option and, in many cases, by a significant margin (a net saving of 10-15%, taking transportation into account, has been quoted repeatedly in discussions with both buyers and supply chain companies).

Quality of supply: Overall, the quality of UK-fabricated jackets compares well against those supplied from elsewhere. There have been recent high-profile cases of significant re-working required on jackets fabricated overseas causing delays and resulting in large financial losses for the fabricator. However, there have also been cases of contracts awarded to UK fabricators being placed with alternative suppliers in order to fulfil contractual requirements.

On-time delivery: UK companies have a mixed track record. The majority of projects have been successfully delivered on time and on budget. However, there have also been examples of companies not being able to deliver to scope, time or budget. With track record being so crucial, any failures create significant barriers to convincing buyers that similar issues will not re-occur. Between the 2 active UK-based jacket fabricators identified, a total jacket output of ~50 complete jackets per year could be made in the UK.

9.2.2 Transition pieces and secondary steel

Cost of supply: Based on input from buyers and from supply chain companies, TP's and secondary steelwork from the UK are more expensive than the lowest cost available. However, in a number of cases, the quality of product makes the TP and associated secondary steel a natural fit for UK supply and can justify the extra cost – though this is not always the case and we have also received feedback that cost can be the deciding factor.

Quality of supply: UK TP's are as high quality as TP's from any other source. There are a number of relatively small UK companies which, in collaboration with partners, can provide all of the secondary steel requirements

On-time delivery: Buyers' schedules for TP delivery are becoming increasingly demanding as overall cost reduction means an even greater push for minimising vessel waiting time and getting to first power as soon as possible. The scopes for the large TP can and the secondary steel can be delivered by the same organisation or split between two or more. Splitting the scope can help with hitting the required schedule but requires additional co-ordination. UK companies are delivering on-time and no issues have been flagged.

9.3 Key Strengths / Advantages

9.3.1 Precision engineering

Design specifications for offshore wind components are precise, with a high degree of accuracy required to pass inspections. The UK's history of ship-building and oil & gas fabrication are being leveraged to meet these requirements, particularly regarding complex welding techniques. This applies across all foundation types, with welding of various jointing angles in jackets and precision integration of secondary steel with the transition piece outer can.

9.3.2 Quality finishing

The ability to provide products requiring minimal reworking is an important element in keeping costs down for offshore wind projects. Experienced UK fabricators base their work programme and pricing on producing the appropriate quality, minimising the likelihood of cost over-runs.

9.3.3 Proximity to sites

A number of UK facilities are situated close to offshore wind projects, particularly those off the East of Scotland and North East of England. UK fabricators and assembly yards can benefit if the difference in fabrication cost can be reduced below the cost to ship products from overseas. These yards would benefit from improved port facilities in order to minimise logistics and handling costs and contribute to the cost reduction required.

9.4 UK Supply Chain Companies Highlighted In This Study

Company	Monopile	Jacket	Pin piles	Suction buckets	TP's	Secondary	Assembly
A&P Group			✔	✔		✔	✔
BiFab		✔	✔	✔		✔	✔
EEW Offshore Structures (Britain) Ltd			✔	✔	✔		✔
Global Energy Group		✔	✔	✔	✔	✔	✔
Smulders		✔			✔		✔
Wilton Engineering					✔	✔	
Adey Steel						✔	
Allerton Steel						✔	
Barrier Offshore						✔	
CTL Seal						✔	
Dales Marine Services							✔
FLI Structures						✔	
Francis Brown Limited						✔	
Hutchinson Engineering						✔	
Lionweld Kennedy						✔	
Marine Fabricators Ltd						✔	
Mech-Tool Engineering Ltd						✔	

Table 9: UK foundation supply chain companies

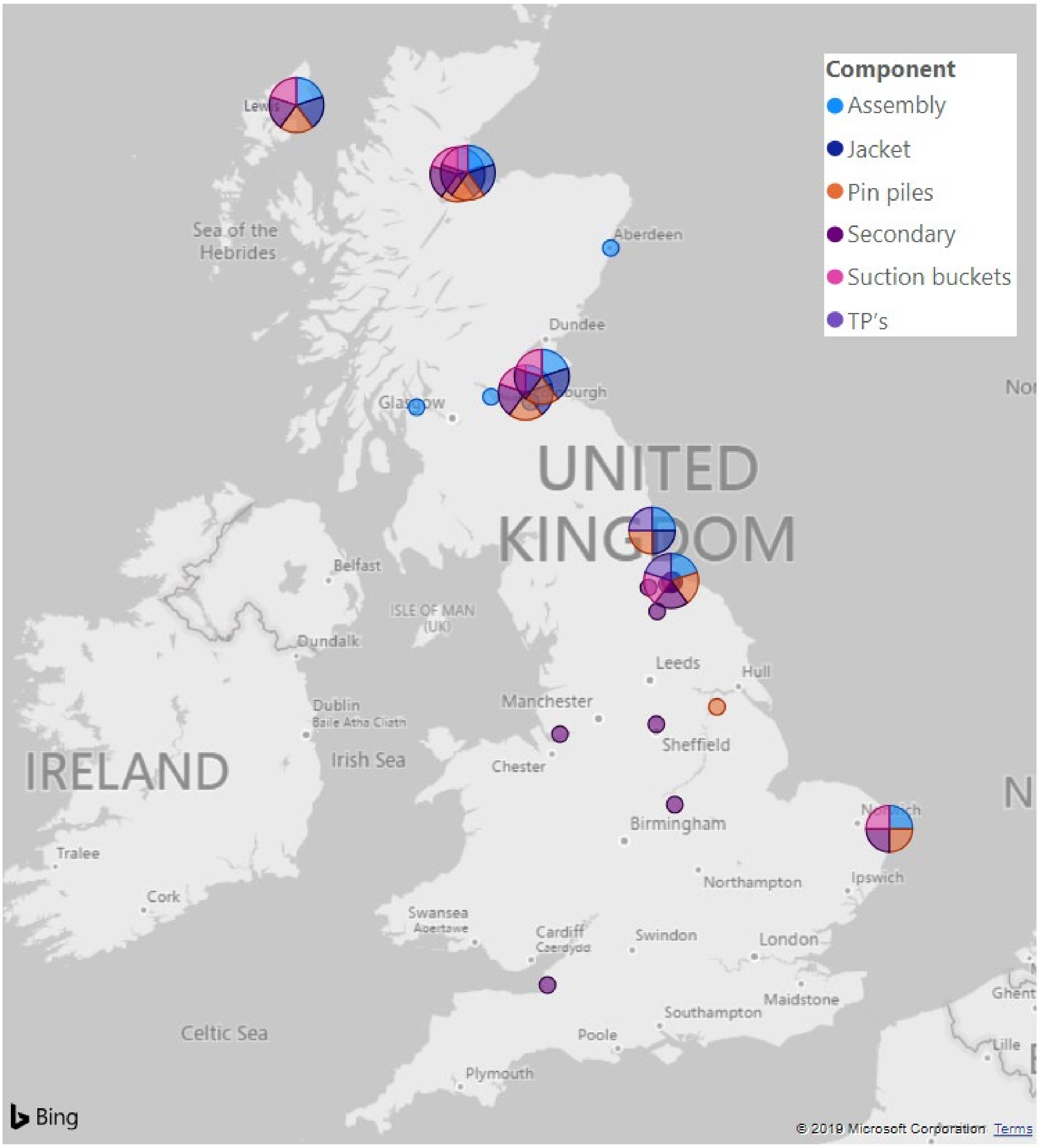

Figure 12: UK supply chain bases

10 Financial & Commercial Challenges & Opportunities

Discussions with the supply chain have highlighted several areas of financial risk which hinder contract awards or the ability to deliver projects.

10.1 Financing and penalties

10.1.1 Challenges

Parent Company Guarantees and Performance Bonds – Exact requirements vary between parties, but buyers (either project developers or Tier 1 / EPCI contractors) require suppliers to have a clean credit history in order to provide comfort that working capital requirements can be met during the performance of the contract. Some form of Parent Company Guarantee (PCG) or similar is usually required; depending on the supplier's history and group structure, this may not always be possible. A bond covering performance, delivery and defects, amounting to an agreed % of the overall contract value, is also normally required.

Penalty Clauses – Penalties in the form of liquidated damages or similar can (based on input from supply chain respondents) amount to a sum greater than the value of the contract due to taking into account the knock-on financial impact of failure to perform (e.g. programme delays); this can amount to more risk than the supplier can take on.

Lack of access to credit finance – In order to bid competitively for contracts, investments are required to improve fabrication yards in the UK. The owners of these yards often struggle to access financing for improvements, especially without a committed pipeline of work to justify the level of investment required. UK Export Finance can provide support for firms which export or are building export capability – this support is up to 80% of value required where a commercial bank is willing to back 20%.

10.1.2 Opportunities

Increasing demand for foundations – Risk or perceived risk is the major factor when considering financial guarantees and penalties. The pool of contracts has been relatively small in comparison to the capacity of the supply chain, which has allowed developers and EPCI contractors to push financial risks down to the supply chain. A rapid growth in demand for foundations (from the Sector Deal, and projects globally) may shift the balance of power back towards the supply chain.

Developer/Tier 1 and supply chain collaboration – A short-term solution to reducing the burden of financial guarantees would be for suppliers to work in closer collaboration with developers. Keeping the buyers up to speed with progress and developments may reduce the requirement for onerous guarantees.

UK Export Finance (UKEF) – Changes in UK Export Finance to broaden the areas of support would be welcomed by the supply chain. Some steps already in motion include extending support for the supply chain of exporting companies, and a General Export Facility to cover general costs of exports, and not just specific project costs. Supporting domestic suppliers to win contracts for UK projects will increase their ability to export. Increasing support for companies in this position would increase UK content and export potential.

10.2 Commercial Aspects

10.2.1 Challenges

Resourcing – With slim margins common in offshore wind, suppliers can struggle to provide resources for in-depth business development and market research. UK suppliers may lose out if they are not able to identify and leverage opportunities. This applies especially to smaller companies (where resource is often scarce) involved in secondary steelwork but can also apply to larger entities.

Commercial and contracting models – At present there is no UK-headquartered EPCI firm. Overseas EPCI's often already work with trusted partners and networks which may be outside of the UK.

Fragmented supply chain – With a somewhat fragmented supply chain in the UK, there is no one company able to offer the full scope for foundations (monopile with transition piece, or fully assembled jacket). Fabricators of large structures have their origins in oil & gas or shipbuilding and have been adapting existing facilities to suit the offshore wind market, but this does not overcome the fundamental difference between yards established for single unit or at best low-volume production and yards set-up for serial or volume production for projects requiring 50+ units delivered to tight project schedules. This is in contrast to a number of facilities in Europe which have been purpose-built for volume production and incorporate the most state of the art technology to ensure maximum efficiency, often as part of a wider offshore renewables supply chain infrastructure project. There is a lack of networks in place to be able to subcontract the full scope across diverse suppliers. UK companies are more likely to act as subcontractors to Tier 2 suppliers, providing secondary work or a subset of the overall order volume.

10.2.2 Opportunities

Greater visibility of project opportunities – Helping the supply chain to identify projects, both domestic and overseas, will increase the chances of contract awards, and allow companies to develop expertise. This may be facilitated by improving transparency of the tender/contract process in offshore wind. A centralised source of market intelligence, available to the UK supply chain at a low cost would be another option.

Consortium bidding – Closer collaboration between the supply chain and EPCI contractors, potentially via bidding as consortiums, could improve the UK's offering for the offshore wind sector. Work scopes for jackets, for example, could be split between suppliers to produce the full scope in the UK.

11 Monopile Challenges & Opportunities

A number of areas have been identified as challenges, but also potential sources of opportunity in monopile foundations:

- Monopile production
- Increasing or maintaining UK share of TP and secondary steel market

11.1 Monopile production

11.1.1 Challenges

There are currently no UK facilities capable of rolling large diameter cans of the thickness required for XL and XXL monopiles (over 10m diameter, 150-250mm thickness). Investment for a greenfield facility with the capability is likely to exceed £100m.

11.1.2 Opportunities

Monopile production – The dawn of XXL monopiles requiring diameters potentially up to 14m and monopile mass in excess of 2,000 tonnes will require significant investment from existing fabricators. Only Sif and Steelwind (based on the Netherlands and Germany) have been identified as being able to roll cans up to 11m diameter AND accommodate final structures in excess of 2,000te. Even these companies may require some upgrade to accommodate increasing monopile diameter and mass. Monopile manufacture is a highly automated process and has a very similar cost base in any region; cost advantages are achievable through efficient logistics into, throughout and out from, the facility – this makes choosing the right port-side location critical.

Our market forecasts estimate an average (as yet uncontracted) demand for 1,400,000 tonnes of monopiles per year from 2021 to 2030. Roughly 20% (290,000 tonnes per year) of this demand will be for UK projects and a further 16% (224,000 tonnes per year) for other European projects. Combined UK/Europe demand is set to be 514,000 tonnes per year. We estimate the current European monopile supply chain annual capacity at 500,000 tonnes per year and expect monopile fabrication capacity in China to be occupied with supplying Chinese projects. We therefore see an opportunity for an existing monopile fabricator (e.g. Bladt, EEW, Sif, Steelwind) or a new entrant to establish a facility through inward investment into the UK, provided the investment conditions and business case are right. Setting up operations in the heart of an established and growing market and providing local content makes strong strategic sense.

The anchoring of a primary monopile structure fabricator in the UK would have the following benefits:

- Increased rationale for the higher value transition piece and secondary steel work to be done in the UK

- It is possible that the industry will move to TP-less foundation designs at some point during the 2020's (i.e. turbine tower mated directly with monopile without the need for TP's) and so, without a monopile facility, there would be no TP market for UK companies to pursue and it would be difficult for the UK to even maintain its current market share of secondary steel in the type of foundation expected to continue to dominate the market
- The ability to produce large diameter cans will provide a base for UK fabrication of floating wind platforms in the future, extending the current likely offering from the components required for Tension Leg Platforms (TLP's) to encompass steel semisubmersible and spar foundations

Creation of such a facility would require significant port-side land and to be situated with easy access to UK-produced or imported steel slabs. The required investment would be in the region of £150m and strong buy-in from regional and national public bodies will be critical to providing the appropriate conditions for inward investment and making the right locations available.

If the facility is established by an operator headquartered overseas, this may well involve some or the majority of profit being sent abroad. However, this is a segment of the value chain in which UK companies cannot currently participate at all. It would also allow UK engineering in facility design and set-up, including employing the most advanced and innovative technology, as well as UK management and personnel during operations. The cost breakdown of monopiles (weighted roughly 80/20 towards machine costs (highly automated processes) and material costs compared to labour) favours UK expertise in design and process engineering.

11.2 Maintaining share of TP and secondary steel market

11.2.1 Challenges

Competition – We have identified 6 non-UK based companies which can produce TP's. As a relatively high-value (cost per tonne) component, there is a great deal of competition in the TP market. In some cases, a company which successfully wins a monopile supply contract will also produce the TP's using another facility

Cyclical nature of industry – This can impact all elements of the offshore wind supply chain. The cyclical pattern of auctions and contract awards makes it difficult for fabricators to keep on their workforce between projects. Re-hiring and re-training take time and money, and process efficiencies are lost. These all affect the margins for suppliers but can be offset by diversifying the sectors serviced from the same facility.

11.2.2 Opportunities

Multi-use facilities – We believe there is space in the market to enhance existing rolling capacity in the UK to be able to continue to produce large diameter cans for TP's and to produce suction buckets and turbine tower sections. Such a facility would also be suitable for producing components for the oil & gas and nuclear sectors. Unlike the monopile facility outlined above, which we expect would need to be a greenfield site, this facility could be an upgrade to existing rolling capacity.

12 Jackets Challenges & Opportunities

A number of areas have been identified as challenges, but also potential sources of opportunity in jacket foundations:

- Fabrication cost
- Site facilities and locations
- Continuity in production
- Provision of full fabrication scope

12.1 Fabrication Cost

12.1.1 Challenges

Labour costs - Jacket fabrication is labour-intensive, with many hours of manual welding required. The UK has high labour rates relative to those of overseas competitors (e.g. UAE, Indonesia), meaning the labour component of jacket manufacturing is key to winning contracts. The target price for a jacket varies between projects, depending on foundation size, revenue levels and overall package. General feedback from buyers and supply chain respondents to this study suggests UK fabricated jackets are 10-15% more expensive than the lowest cost alternative, even taking transportation costs into account. For a 1GW project consisting of 100 x 10MW turbines this could amount to roughly £40m. This issue of cost competition is not unique to the UK; feedback from developers and supply companies is that fabrication yards in mainland Europe are also finding it increasingly difficult to compete with the some of the low prices being offered by fabricators in Asia.

Retention of skilled labour – There are often gaps between orders, meaning that employers are not able to retain all the skilled labour hired for a job. Each new job must therefore carry some cost of hiring and allow time for a certain amount of learning on the first units produced, causing process inefficiencies – something which is minimised where the same teams are working continuously from one job to the next.

12.1.2 Opportunities

As highlighted, above, there is a significant gap between UK and overseas pricing. While we do not see any one big game-changer, there are a number of possible actions which, when combined, can narrow that gap. We do not expect these to make UK pricing directly competitive with the lowest-cost available, but could reduce sufficiently to allow UK fabricators to be more readily awarded a share of jackets for UK projects given the continuing practice of spreading fabrication contracts over a number of suppliers to mitigate against potential delays and bottlenecks.

Competitor performance – The existing gap between UK pricing and best alternative (net 10-15%) is significant. However, it is in the public domain that Lamprell recently wrote off US$80m (~£65m) relating to the contract for supplying 60 of the 102 East Anglia One jackets. The amount written off is in excess of 10-15% of the contract value and so, while the cost to the buyer is within budget, the true cost of delivery (ie. production plus transportation) is in line with pricing we would expect from the UK. It is **possible** therefore that other overseas fabricators will face similar issues and either raise prices or lose some of their appetite for the market. This **could** narrow the pricing gap which UK fabricators must bridge.

Automation - UK fabricators have advised that there are some limited options available to improve production efficiency through increased automation in existing welding stations. However, the payback period for any investment is likely to be greater than 10 years and the cost reduction potential is limited to less than 5%. Public funding into developing and implementing innovation automation solutions would reduce the private investment and enhance the commercial business for pursuing improved automated processes.

Improved working practices – Installing appropriate scaffolding can improve the health and safety of workers at height and provide cost reductions by allowing leaner processes. From discussions with fabricators, increasing flexibility in workers being able to perform a greater number of tasks could also lead to improved processes and efficiency.

Continuous production – Further cost reduction can be possible through enabling continuous production, which makes it easier to retain the best labour and maximise continuous learning by doing. This, however, requires a consistent order book, which is difficult to achieve with auction cycles and fierce competition in the supply chain.

12.2 Site facilities and locations

12.2.1 Challenges

Storage and load-out – Fabrication yards in the UK often lack onshore storage for final jacket structures ahead of load-out to barges or installation vessels. Where land is available, it may not have a suitable surface or load-bearing quality to move jacket structures.

Quayside water depth – Installation vessels are continuing to increase in size, which is putting pressure on the already stretched water depth limits for quayside load-outs. Some sites have short windows during high tide to complete load-outs, increasing the installation time and cost.

12.2.2 Opportunities

Site expansion – at least 2 fabrication sites based in Scotland (one of which is actively pursuing jackets as a line of business) have adjacent land which, we understand, is potentially available for industrial development. This could provide additional onshore storage space.

Port enhancements – in some locations, investment in breakwaters and/or dredging could increase quayside water depth and increase the weather windows for vessels accessing the quayside. This would be expensive, and a mix of public and private money would be required to be able to provide a return on the investment.

12.3 Continuity in production

12.3.1 Challenges

Cyclical nature of industry – This can impact all elements of the offshore wind supply chain. The cyclical pattern of auctions and contract awards makes it difficult for fabricators to keep on their workforce between projects. Re-hiring and re-training take time and money, and process efficiencies are lost. These all affect the margins for suppliers.

12.3.2 Opportunities

Diversification – For maximum efficiency, it is natural to pursue a strategy of focusing on a single product. However, in order to insulate against the peaks and troughs in any one industry, it is vital that fabricators can supply goods and services into other markets. Actively pursuing opportunities in the nuclear and oil & gas sectors, for example, can provide work requiring similar equipment set-up and skills base.

12.4 Provision of full fabrication scope

12.4.1 Challenges

Lack of one-stop shop –UK-based fabricators are not currently well-placed to provide a full jacket fabrication scope with maximum efficiency, with significant differences in the welding and lifting requirements for fabrication of the lower and upper sections. This makes it difficult for a buyer to award the fabrication scope to a UK company (although Smulders, for example, has been successful through delivering the full scope across multiple sites in mainland Europe and the UK).

12.4.2 Opportunities

Collaboration between fabricators - There is scope for UK fabricators to collaborate further than at present and provide more comprehensive offerings to the market. This would mean joint tendering or assigning a lead on tenders, combining scopes such as jacket fabrication, pin pile and/or suction bucket fabrication, and final assembly to deliver a full fabrication scope. This allows each facility to use its core capabilities and optimise these for further future success, rather than either being stretched to provide products on the margins of their abilities or offering a limited scope and being passed over in favour of a supplier offering a full package. (This opportunity is currently focused on jacket fabrication but would apply equally to monopiles and transition pieces if a UK monopile production facility were to be established.)

We forecast that, compared to monopiles, jackets will make up a smaller share of the foundations market globally and in the UK in the next decade. However, we have forecast the UK to require an average of 60 jackets per year (range of 35-70) from 2025 to 2030. This could be sufficient volume to sustain 2 UK-based fabricators if the jacket lower and upper sections are awarded as separate scopes, in addition to pin piles and/or suction buckets. However, companies with multiple yards around the UK and EU would need to be incentivised to cannibalise work from their European yards. Developers and EPCI firms would also need to be comfortable spreading the risk across multiple suppliers.

Collaboration with designers – There is potential for fabricators to work more closely with jacket designers earlier in the design stage. This would allow design to be optimised for the fabrication facilities rather than focusing on minimising steel content. Suggestions from respondents have included 3-legged jackets. This could give a slight improvement in the cost competitiveness of UK fabricators. However, barriers to this are:

- Designers not wishing to be tied to a particular fabricator as the ultimate buyer (EPCI or developer) may wish to award the contract elsewhere
- The amount of this cost saving alone is unlikely to be sufficient to offset the currently higher UK cost.

13 Recommendations

The recommendations presented here are intended to address the financial, commercial and technical challenges identified in key foundation fabrication scopes. These recommendations build on existing strengths in order to allow UK companies to gain a larger share of this growing market.

1. OWGP should work closely with industry to track technological developments in foundations in order to ensure any investment in foundation manufacturing capability is future-proofed and to identify new opportunities. As wind farms are developed in more challenging site conditions, there may be a need to bring new foundation types to the market.

2. The Department for International Trade (DIT) in collaboration with Scottish Development International (SDI) should conduct a detailed feasibility study for a UK monopile facility, which would broaden the UK scope of supply, anchor contracts for TP and secondary steel fabrication, insulate against TP-less foundations in future and pave the way for fabrication of floating foundations:

    - Identification of site with suitable acreage, access to strong quayside load-out facilities and access to skilled labour which can be developed in time for delivering units circa 2023
    - Identification of an inward investor, with a proven track record in monopile fabrication and planning to invest in new facilities
    - Detailed consultation with operators in other industries, such as automotive and nuclear, on innovative fabrication techniques, e.g. robotic and automated production lines, to ensure any new facility is at the leading edge of efficient monopile fabrication

3. To enhance the reputation of UK jacket fabricators, national and local government together with OWGP should work with fabricators on recently-awarded contracts:

    - Document and publicise the new processes and techniques being employed compared to previous contracts
    - Quantify the positive impact of learning from experience
    - Show the route to the next round of improvements in quality and budget management.

4. Government agencies should work with port owners to try to unlock investment in port upgrades, in order to improve logistics and reduce costs:

    - As an essential element underlying a new monopile facility
    - For existing jacket and transition piece locations, where efficient logistics can reduce costs.

5. OWGP should work with UK Export Finance, with support from other government agencies, to publicise as widely as possibly the credit finance available to UK companies for domestic as well as export projects (provided exporting is a part of their business).

Appendix 1 List of Consultees

A range of organisations have been consulted in the preparation of this report. Input was provided via a combination of written questionnaires, face-to-face meetings and telephone interviews.

Project Developers	EPCI
Equinor	DEME Group
Ørsted	Malaysia Marine & Heavy Engineering (MMHE)
ScottishPower Renewables	Seaway7
SSE	

Supply Chain	Other
A&P Group	Department for International Trade (DIT)
Atkins	Fife Council
Burntisland Fabrications (BiFab)	UK Export Finance (UKEF)
EEW-OSB	University of Strathclyde
Eiffage Smulders	Henrik Stiesdal
Global Energy Group	BVG Associates
Lionweld Kennedy	
MHI Vestas	
Osbit Ltd	
Tata Steel	
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