FLOATING WIND JOINT INDUSTRY PROGRAMME

Fabrication, infrastructure and logistics

Project summary

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Contents

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Cover image courtesy of Alistair Morris, taken at Galloper Wind Farm.

Introduction

To date, floating offshore wind (FOW) projects have been deployed at small demonstration and pre-commercial scale capacity, much smaller than current bottom-fixed offshore wind farms, which have now exceeded 1 GW in project capacity. The current FOW pipeline shows that commercial sized floating farms will be in development over the next decade, bringing challenges to fabrication, infrastructure, and logistics. Constraints to effective deployment may include facilities for steel and concrete fabrication; port facilities for assembly and storage; launching facilities; transport of large equipment; and local content requirements.

This Fabrication, Infrastructure and Logistics (FIL) project delivered by Arup for the Floating Wind Joint Industry Programme (JIP) built upon previous projects to further understand the key fabrication, infrastructure, and logistical constraints towards building large-scale floating wind farms and to ensure that these infrastructure constraints do not prevent floating offshore wind deployment. The project objective was to understand the common infrastructure requirements for floating offshore wind projects in order that port authorities can understand investment requirements, and developers and fabricators have a framework for port selection.

This summary report outlines the project's key findings based on the objectives and highlights future requirements or needs for the industry.

Study objectives

1. Understand common infrastructure, fabrication and logistical constraints towards building large scale floating wind projects;
2. To provide port authorities with a clearer view of investment requirements;
3. To provide developers and fabricators with a framework for port selection;
4. Understand the restrictions infrastructure requirements may have on realising floating wind potential.

Figure 1: FloatHOME project, courtesy of Principle Power.

Methodology

The project methodology sought to build up an impression of logistics, infrastructure and supply chain needs for commercial scale deployment options for floating offshore wind across the regions of Asia, America and Europe.

Six key scenarios were defined to cover a broad range of substructure types, mooring systems and logistical options that factored in the availability and cost of materials, marshalling and integration infrastructure, and offshore site constraints. The 6 scenarios were defined as:

1. International substructure fabrication
2. Localised steel semi-submersible/ suspended weight spar
3. Localised concrete semi-submersible
4. Regional steel spar-buoy offshore
5. Localised concrete barge
6. Localised Steel Tension Leg Platform (TLP) nearshore integration

The study concluded that in order to support the 6 different scenarios and various permutations, there would likely be differing infrastructure requirements for the fabrication and critical marshalling integration roles, resulting in 27 different facility functions being considered; 19 for fabrication (across substructures, anchors, moorings, cables and Wind Turbine Generator (WTG) and 8 for the marshalling roles.

Some of the key assumptions made whilst investigating these six scenarios were:

- Anchors and mooring chains were transported (from fabrication to marshalling) on general cargo vessels and barges.
- For steel manufacturing, both international steel component manufacture and localised assembly, as well as local fabrication, scenarios were assessed.
- Concrete fabrication, focused on localised markets, with both pre-cast fabrication and slip forming.
- Option of both WTG integration at the quay, as well as away from the quay with a jack-up vessel considered.

Crucially, the project also engaged a selection of key stakeholders across the industry and wider supply chain around the themes of Capital Expenditure (CAPeX) reduction, local content and fabrication programme.

Key findings

1 **Collaborative action is required to ensure effective investment in national port infrastructure.**

- There are multiple infrastructure facilities required to successfully deliver commercial scale FOW projects across the mooring, anchoring, cabling, and substructure installations. This offers opportunities for smaller ports located in prime windfarm development zones.
- National strategic investment plans for port infrastructure could help overcome demand for port facilities.
- Collaboration across the industry, with governments, port authorities, supply chains, and developers is required to highlight bottlenecks and explore new opportunities such as clusters and hubs.
- There may be limitations around the available in-country infrastructure for larger-scale fabrication, WTG marshalling and WTG integration activities. These limitations could be mitigated with the development of national and regional support schemes.

2 **Substructure assembly areas require critical infrastructure investment including significant capabilities and capacity.**

- There is currently limited land area at most port facilities to carry out serial component production and final assembly of substructures, with access to necessary heavy lift quay space for both steel and concrete.
- Modelling of scenarios determined that at least 2 final assembly locations are required in key geographies to be able to meet a typical demand of 50 units within 2 years.
- These facilities will likely need an area of 18-24 Ha and require significant component storage space to maintain continuous mass production.
- Past 45 units, the land area of the marshalling port stops being the limiting factor, which instead becomes weather windows for transport and installation (T&I).
- To unlock increased capacity, there will need to be either an expansion of multiple existing facilities in geographical locations, or the development of bespoke port facilities to enable efficient delivery of commercial scale FOW projects.

3 **Significant investment is required for wet-storage areas to aid commercial deployment of foundations.**

- Many installation scenarios require significant wet storage capacity. This could be split across fabrication or marshalling facilities, or nearby sheltered waters, either afloat (requiring a large anchorage area) or grounded (may require permitting) depending on suitable draft seabed conditions.

- Wet storage requires sufficient water depth to allow the flexible movement of substructures in and out of position. The area required could be reduced when deploying substructures capable of ballasting and grounding.
- Variety in substructure design and the relative temporary nature of wet storage makes investment decisions challenging.
- Ports without any suitable wet storage may be required to create offshore anchoring, utilise existing structures or work with neighbouring ports of harbours.

4 **Selection of the installation campaign strategy will be dependent on scenario fabrication, launching and integration rates.**

- FOW integration can be carried out within the port but is exposed to a discord between the fabrication, launching, and installation rate.
- This discord, coupled with the high costs of integration equipment, means that maintaining the utilisation of equipment could be challenging.
- Effective wet storage of units could maintain a continued utilisation of on-shore ringer cranes or near-shore jack-up vessels for integration, where wet storage capacity then becomes the limiting factor. The key will be to balance the total number of foundations stored versus the installation rate.
- Multiple integration deployment campaigns split across projects into the northern and southern hemispheres could ensure consistent mobilisation, though with additional transport costs.
- Integration of spar-buoy floaters is more analogous to fixed offshore wind, where a single campaign of continuous deployment is feasible, and met-ocean conditions will instead be the limiting factor.

5 **Demand for FOW substructure fabrication rates outweighs current capabilities in certain markets. An international roadmap could help manage demand, utilizing multiple fabricators both nationally and internationally.**

- Reaching the required maturity and rate of fabrication is likely to take several years through multiple projects. There is a significant discrepancy between the market ambitions and the existing fabrication capability of the industry, as shown in Figure 2.
- Splitting fabrication contracts into two or more manageable substructure procurement packages would reduce the risk of delays. Formalised alliances or joint ventures may ease the demand.
- The demand for steel fabrication will outstrip the trained skilled workforce. Concrete requires a lower-skilled workforce, making it a better option in some scenarios. There is little incentive for steel ship-building facilities, with a reliable revenue stream, to pivot towards substructure fabrication.

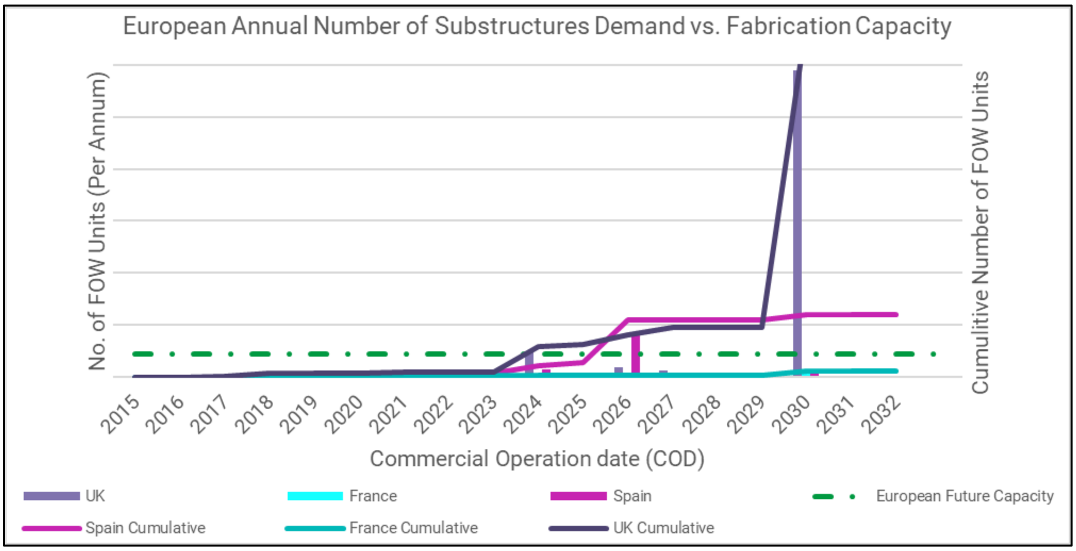


Figure 2: The European potential fabrication capacity vs demand. 2 fabrication facilities were assessed as part of this study.

Industry needs and innovations

1 **Developing specialist semi-submersible barges that can increase launch efficiency.**

There are currently a limited number of semi-submersible heavy load carriers suited for the launching of substructures.

The challenge with semi-submersible heavy load carriers is that they were designed for transportation of other vessels, caissons and are not suited to wider more symmetrical structures such as FOW barges, or semi-submersibles. This current method of transportation is reaching its limits, with the large overhang makes transporting these structures difficult. Figure 3 shows the semi-sub structure for a 9.5 MW rated turbine, and as footprints will increase for larger turbines, this shows the current transport restrictions.

Figure 3: Kincardine semi-submersible foundation transport overhand, courtesy of Boskalis.

2 Initiating whole-life carbon considerations of floating offshore wind substructures.

In order to improve the whole-life carbon of the FOW substructures the following 3 areas were identified as areas for further development:

- **Low Carbon Solutions:** The quality of recycled steel, green steel and lower carbon concrete is currently limited. Substructure designers will rely on scientific research developments to implement alternative materials in the future.
- **Carbon-intensive Transportation:** The nature of the vessels used, and the high impact of their emissions will continue to be closely considered by bodies such as the IMO and there will be a future modal shift to cleaner fuels. There needs to be development of low-carbon fuel solutions from these key vessels to enable the industry to minimise the impact in the near and longer term.
- **Substructure towing efficiencies:** There are likely to be challenges with the lack of larger Anchor Handling Tug Vessel (AHT) availability, a potential bottleneck as demand for tow-out of substructures increases; investment in larger AHTs will be required for more efficient installation.

3 Further development of technology and tools to improve the mooring and hook-up operation offshore.

Reducing the operational time for hook-up could significantly impact the overall assembly schedule, both by reducing the process time, but also by reducing risk factors for the required weather window to carry out hook-up operations.

Areas of development where the manufacturing schedule could be improved are:

- Alternative connection points such as pinned connections.
- Partial pre-assembly of the mooring elements with the substructure.
- Use of a mixture of permanent and temporary mooring elements.

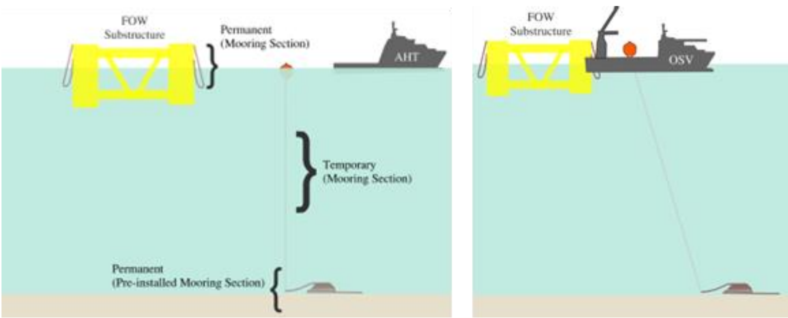


Figure 4: Potential temporary and permanent mooring interfacing, delivered for the FIL project by Arup.

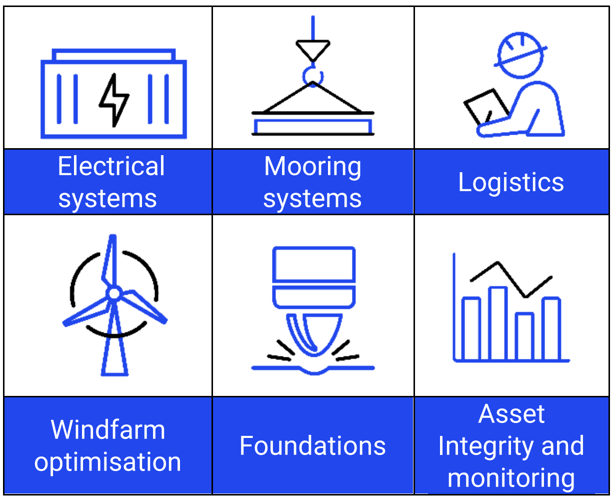
ABOUT THE FLOATING WIND JIP

The Floating Wind Joint Industry Project (Floating Wind JIP) is a collaborative research and development (R&D) initiative between the Carbon Trust and 17 leading international offshore wind developers: bp, EDF Renouvables, EnBW, Equinor, Kyuden Mirai Energy, Ørsted, Ocean Winds, Parkwind, RWE Renewables, ScottishPower Renewables, Shell, Skyborn Renewables, SSE Renewables, TEPCO, Tohoku Electric Power Company, Total Energies and Vattenfall.

The primary objective of the Floating Wind JIP is to overcome technical challenges and advance opportunities for commercial scale floating wind. Since its formation in 2016, the programme scope has evolved from feasibility studies to specific challenges focusing on:

- Large scale deployment
- Industrialisation
- De-risking technology challenges
- Identifying innovative solutions
- Cost reduction

This Fabrication, Infrastructure and Logistics (FIL) study was delivered under Stage 2 Phase V of the floating wind JIP. Contrasting to previous phases, the Floating Wind JIP partners decided to publish individual project reports for Phase V due to an increased number of projects with different durations. The summary reports for previous Stage 2 phases can be found here: Phase I, Phase II, Phase III and Phase IV.



Research areas

The Floating Wind JIP identified six research areas where further understanding and advancement is required to reach full commercialisation of floating offshore wind projects.

These research areas are explored through different Carbon Trust research mechanisms such as common R&D projects, Discretionary Projects and Industry Competitions.

ABOUT THE CARBON TRUST

Who we are

Our mission is to accelerate the move to a decarbonised future. We are your expert guide to turn your climate ambition into impact.

We have been climate pioneers for more than 20 years, partnering with leading businesses, governments and financial institutions to drive positive climate action. To date, our 400 experts globally have helped set 200+ science-based targets and guided 3,000+ organisations and cities across five continents on their route to Net Zero.

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