DESIGN GUIDELINES FOR OFFSHORE WIND PORTS

PROPOSED TECHNICAL WORKING GROUP

TERMS OF REFERENCE

1. Historical Background Definition of the problem

The transition to renewable energy and the goal of energy independence highlights wind energy as a reliable and sustainable source of power. Offshore Wind (OW) plays a crucial role in achieving renewable energy targets. However, the deployment of large-scale OW projects—measured in gigawatts (GW)—requires ports to be upgraded or new ones to be developed. Currently, there is not enough port capacity to handle the expected increase in demand, which is a major challenge for the industry.

Different Impacts of Wind Energy on Ports

Onshore and offshore wind energy have different impacts on ports. For onshore wind, ports are used to move large components like turbine blades, towers, and nacelles from factories to locations near the wind farms. These components are oversized and require special equipment and logistics.

Offshore wind places greater demands on ports, and these demands depend on the type of technology used. Bottom-fixed (BF) offshore wind is commonly installed in shallow waters up to approximately 60m, like the North Sea, using structures such as monopiles, jackets, and Gravity-Based Structures (GBS). Ports serving BF projects serve primarily as marshalling hubs, where components are pre-assembled before being transported to installation sites.

Floating offshore wind is an emerging technology that allows wind farms to be installed in deeper waters, where most wind resources are located. This technology requires ports to handle larger components, such as floating platforms, and to provide more space for assembly and storage. Floating OW places even greater demands on port infrastructure compared to BF projects.

The Need for Port Development

Ports are essential for the deployment of OW projects. Without adequate port facilities, the ambitious renewable energy targets set by governments cannot be met. Expanding and upgrading ports is not only a logistical need but also an opportunity to create economic benefits, reduce environmental impacts, and support local communities.

Addressing the port capacity gap requires careful planning to meet the specific needs of offshore wind projects. Ensuring ports are ready for these challenges is critical to supporting the growth of wind energy and achieving a sustainable energy future.

OW Ports Variation from Conventional Ports

Offshore bottom-founded and floating wind ports vary significantly from conventional container, liquid, or bulk terminals in that:

- Offshore wind ports typically have significantly higher loads and use heavy lift equipment which is not common for typical breakbulk facilities.
- Facility production rate or transfer throughput for large components drives the layout for offshore wind.
    - Bottom-fixed wind facilities may be utilized for component fabrication or for material laydown, with the latter providing storage only with seasonal on and offloading of Ro-Ro transports driving layout.
    - Offshore floating wind projects typically require a more complicated infrastructure design that allows for high production rate fabrication, storage, and assembly of foundations components, and integration of Wind Turbine Generators (WTGs) onto the foundations. In effect, these facilities are more similar to shipyards than laydown yards. These activities may occur separately at multiple facilities. Floating wind integration sites may also be utilized for future major maintenance activities.
- Launching of offshore floating wind foundations and WTG integration may occur using various methods, each of which alters marine infrastructure needs.
- Due to the size of the elements involved, there are likely to be significant navigation challenges within existing river and port facilities. Channel width limitations for floating foundations in particular can be especially challenging in some existing ports.
- Facilities providing for operations and maintenance service vessels, including laydown for heavy equipment, are also required. These are likely smaller dedicated facilities established as close as possible to the wind farm.

2. Objectives

The objective of this working group is to provide guidelines to determine the specific demands that wind energy projects place on ports, with a focus on the progression from onshore to offshore wind. By reviewing the impact of these projects on port operations and infrastructure, the group aims to:

A. **Analyse Industry Singularities**: Identify and explain the unique requirements that offshore wind projects impose on ports. Define typical bottom-fixed and floating wind port functional requirements, including facilities used for:

- Manufacturing key components, such as:
    - Wind turbine components such as towers, blades, and nacelles
    - Monopiles, jackets, transition pieces, landings, etc. associated with fixed offshore wind foundations
    - Floating wind foundation subcomponents, including semi-submersible columns, trusses, or other modular construction and floating technologies: spar, semi-submersible, barge and Tension Leg Platforms (TLP).

    - Electrical substation platforms or floating substations
    - Cables, chains, anchors, or other major items
- Laydown yards used for temporary storage wind components
- Port yard for the marshalling of wind components for the execution of bottom-fixed projects.
- Assembly of floating foundations from major components and / or integration of Wind Turbine Generators (WTGs)
    - Major maintenance facilities where integrated floating foundations may be towed for repair or upgrade
- Operations and maintenance facilities used for Crew Transfer Vessels (CTV) or Service Operations Vessels (SOV)

B. **Provide Insights and Recommendations**: Offer practical insights and recommendations to guide future port developments, considering the entire lifecycle of offshore wind projects and the types of terminals needed, such as marshalling ports, assembly/manufacturing ports, WTG integration ports, O&M bases, and logistics hubs. Provide guidance for port layout and navigation related to the above facilities, including addressing functional flow to ensure high rates of production and utilization.

C. **Facilitate Knowledge Sharing for Emerging Technologies**: As floating offshore wind is still in its early stages, with limited data and mostly pilot or pre-commercial projects, the group will discuss how the sector is preparing for deployment and share general findings on the planning of future activities and terminal requirements.

D. **Document and Share Real Experiences**: Present real-world cases and gather data from current projects to draw general conclusions about the implications for ports.

By addressing these points, the working group aims to contribute to the understanding and development of port infrastructure that supports the growing wind energy sector, providing guidance to owners and designers of all types of bottom-fixed and floating offshore wind ports worldwide.

3. Earlier reports to be reviewed

There are numerous international reports developed that assess various ports or regions for use in offshore wind; however, there are no specific guidance documents for the design of offshore bottom-fixed or floating wind construction or servicing ports. A sampling of reports which may be reviewed as part of this working group include, but are not limited to, those listed below:

3.1. PIANC Reports

- PIANC WG11 Ferry Developments and Their Consequences for Ports, Recommendations for the Design and Operation of Port Facilities
- PIANC WG24 Criteria for Movements of Moored Vessels 1995
- PIANC WG34 Seismic Design Guidelines for Port Structures
- PIANC WG121 Harbour Approach Channels - Design Guidelines
- PIANC WG 150 - Sustainable Ports - A Guide for Port Authorities
- PIANC WG158 Masterplans for the Development of Existing Ports
- PIANC WG 161 - Interaction Between Offshore Wind Farms and Maritime Navigation.
- PIANC WG 213 – Design guidelines for marine multipurpose terminals.
- PIANC WG-235 Ship Dimensions and Data for Design of Marine Infrastructure

4. Scope of work

The working group will focus on understanding and addressing the specific requirements of ports in supporting offshore wind projects. The scope of work includes:

A. **Assessing the State of the Art**

- **Review of Publications and Current Practices**: Analyse existing literature, reports, and publicly available data on ports involved in wind energy projects.
- **Evolution of Wind Turbine Technology**: Study the increasing size and weight of wind turbine components and their implications for port infrastructure and logistics.
- **Offshore Wind Foundations**: Evaluate the requirements for bottom-fixed projects, including jackets, monopiles, and gravity-based structures.
- **Floating Offshore Wind**: Explore the types of floating technologies being developed and their specific demands on ports.

B. **Collection of Case Studies**

- Gather insights from real-world offshore wind ports by engaging with key stakeholders such as port authorities, terminal operators, service providers, technology developers, project cargo specialists, transport and installation (T&I) suppliers among others.

C. **Developing Guidelines and Recommendations**

- Identify and document the key requirements for designing or upgrading ports to support offshore wind projects.
    - Identify key infrastructure facility types for both bottom-fixed and floating wind. Highlight functional and operational similarities and

differences between facility types. Provide typical facility component size and live load capacity requirements

- Address the specific needs of ports during the lifecycle of a wind farm, including marshalling, assembly/manufacturing, WTG integration, operations and maintenance (O&M), and decommissioning activities.

- Provide practical recommendations to ensure ports are equipped to handle the unique demands of both bottom-fixed and floating offshore wind technologies.

    - Discuss facility layout impacts of:

        - Equipment and travel lanes

        - Laydown area sizing

        - Berth onloading / offloading, WTG integration for floating wind, and simultaneous operations

    - Discuss infrastructure needs and system design based on heavy equipment weights including berth, heavy lift areas, storage areas, and ground improvement

    - Identify navigational concerns for above facilities, including heavy lift transports and floating foundation towing

    - Identify infrastructure needs and layout for O&M facilities

The working group aims to provide practical insights and a framework for port development, assisting stakeholders in aligning infrastructure capabilities with the increasing demands of the offshore wind industry.

5. Intended product

A WG Report providing guidelines for offshore wind (OW) port design, including:

- **Industry Analysis:** An overview of the current state of the industry, evolving trends, and the role of ports in supporting the growth of both bottom-fixed and floating offshore wind projects.

- **Technical Guidance:** A comprehensive technical document offering detailed recommendations for designing and upgrading ports to meet the specific requirements of OW projects.

- **Lifecycle Considerations:** An in-depth exploration of port needs across the entire lifecycle of wind farms, covering marshalling, assembly, integration, operations, maintenance, and decommissioning activities.

6. Working Group membership

The working group seeks to include members with a diverse range of disciplines and expertise to comprehensively address the challenges of offshore wind (OW) port development. The desirable areas of knowledge and experience among the working group membership include:

A. **Port Authorities, Operators, and Concessionaires**

- Stakeholders with experience handling OW project-related traffic or those in the planning or development phase of OW-specific port facilities.

B. **Offshore Wind Developers**

- Developers with insights into project logistics, infrastructure demands, and trends driving the growth of the OW sector.

C. **Service Providers**

- Professionals with extensive experience in handling offshore wind breakbulk cargo, including WTG components such as tower sections, nacelles, blades, suction piles, and anchors.
- Specialists in project cargo, heavy lifting, and transporting large objects essential for OW projects.

D. **Fabrication and Assembly Facilities**

- Representatives from factories, shipyards, and other facilities involved in the fabrication and assembly of OW components, including WTG parts, station keeping system (SKS), floaters, foundations, inter array cable (IAC), etc.

E. **Transport and Installation Companies**

- Experts from T&I firms with practical experience delivering OW projects and managing the logistical and technical aspects of installation.

F. **Fleet Operators**

- Operators of specialized vessels, including jack-up vessels, semisubmersible barges, and heavy-lift vessels, that are critical to OW component transport and installation.

G. **Contractors and Engineering Firms**

- Contractors and Engineers with experience in designing and sizing ports tailored to the requirements of OW projects, considering the unique needs of bottom-fixed and floating technologies. Structural, coastal, geotechnical, mechanical, and electrical engineering, naval architecture, and port planner expertise will be required.

Other Potential Collaborators

The working group will also seek collaboration with external organizations to enrich its findings:

- **4C Offshore**: Accessing its comprehensive database on OW ports and projects.
- **Offshore Wind Ports Platform (WindEurope)**: Leveraging its network to connect with industry experts and share knowledge on OW port development.

This mix of expertise and collaboration is intended to provide a holistic approach to understanding and advancing OW port infrastructure development.

7. Target Audience

The working group's deliverables are designed for stakeholders and individuals with varying levels of expertise in offshore wind (OW) port development, including:

A. **Maritime Community**
   - Port authorities, operators, and concessionaires preparing for or managing OW-related activities.
   - Fleet operators and maritime logistics companies supporting the transport and installation of OW components.
   - Individuals and organizations within the broader maritime sector interested in understanding the impact of OW on ports, even if they lack direct experience with the industry.

B. **Offshore Wind Stakeholders**
   - OW developers, fabricators, and service providers seeking practical insights into port infrastructure and operational needs.
   - Engineering firms involved in designing or upgrading ports for OW projects.

C. **General Audience with Interest in OW Ports**
   - People interested in learning about the unique challenges and opportunities of OW ports, regardless of prior experience.
   - Students, educators, and professionals looking to expand their knowledge of this emerging field.

The goal is to provide accessible, practical insights that benefit both experienced professionals and newcomers interested in the intersection of maritime infrastructure and offshore wind development.

8. Relevance

8.1. Relevance to Countries in Transition

The guideline will aid countries in transition as they look to introduce offshore wind or to develop fabrication or manufacturing capability for offshore wind installations being developed internationally. The document will take advantage of the collective knowledge of the offshore wind ports in developed countries and major global stakeholders.

8.2. Climate Change and Adaptation

This working group supports climate change mitigation by helping develop the infrastructure needed for offshore wind (OW) projects. OW is a key part of reducing carbon emissions and dependence on fossil fuels. Proper port infrastructure is essential to the successful deployment of offshore wind farms and achieving global CO2 reduction targets.

Climate Change needs to be considered in the planning and design of coastal infrastructure and civil engineering projects. The final document will address these issues by providing, for example, guidelines for conducting risk assessments during the establishment of site conditions and in the Basis of Design.

The working group also focuses on the social and environmental aspects of port development. Port upgrades or new facilities should consider not only economic factors but also environmental impact and benefits for local communities, ensuring sustainable growth of the offshore wind industry.

8.3. Working with Nature

Working with Nature is not directly applicable to the proposed WG report.

8.4. UN Sustainable Development Goals

This working group will support the achievement of several United Nations Sustainable Development Goals (SDGs) by focusing on the development of offshore wind (OW) ports. Ports are essential to the supply chain for OW projects and play a crucial role in achieving these goals.

SDG 3: Good Health and Well-being Offshore wind energy helps reduce air pollution from fossil fuels, which can lead to respiratory illnesses and other health issues. By supporting the construction and operation of offshore wind farms, ports contribute to cleaner air and better public health.

SDG 7: Affordable and Clean Energy Offshore wind energy is an important renewable energy source, and ports are key to enabling its deployment. By facilitating the growth of offshore wind projects, ports contribute to making clean energy more accessible and affordable.

SDG 9: Industry, Innovation, and Infrastructure Developing and upgrading ports for offshore wind projects requires significant investment in infrastructure. Ports play a central role in supporting the offshore wind industry, providing space for manufacturing, assembly, and maintenance. By developing these ports, regions can attract businesses and create jobs, supporting industrial growth and innovation.

SDG 13: Climate Action Offshore wind energy helps reduce carbon emissions and mitigate climate change. Ports are vital in supporting OW projects by handling the logistics of transporting and installing wind turbines. By enabling the efficient deployment of OW farms, ports play an important role in reducing reliance on fossil fuels and supporting climate action efforts.

In conclusion, the working group is contributing to the achievement of these SDGs by supporting the development of offshore wind ports, which play a crucial role in advancing clean energy, tackling climate change, promoting industrial growth, alleviating poverty, and improving health.

9. References

9.1. Third-party Reports/Standards

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    - *Wind industry needs standardisation link*
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9.2. Ports in Operation and New Port Developments.

Active OW Ports/Terminals (non-exhaustive list)	New Port Developments to Follow (non-exhaustive list)
Ronne. Denmark.	Ferrol. Spain
Esbjerg. Denmark	Ardersier . UK
Cuxhaven. Germany	Port-La-Nouvelle. France.
Eemshaven. Netherlands.	Fos-sur-mer. DEOS Project. France.
Rotterdam. Netherlands	A Coruña (Langosteira). Green port project.
Green Port Hull (Humber Port). UK	Talbot. UK
Oostende. Belgium	New Jersey Wind Port. USA
Brest. France	Aberdeen, UK
Saint-Nazaire, France	Blyth, UK
Bilbao. Spain	Cromarty Firth Port, UK
Avilés. Spain	Kashima. Japan
Viana do Castelo. Portugal	Kitakyusyu. Japan
New Bedford Marine Commerce terminal. Massachusetts. USA.	Niigata. Japan
New London State Pier. Connecticut Port. USA	Aomori. Japan
Portsmouth Marine Terminal. Virginia Port. USA	Sakata. Japan
Taichung. Taiwan.	
Taipei. Taiwan.	
Akita. Japan	
Noshiro. Japan	