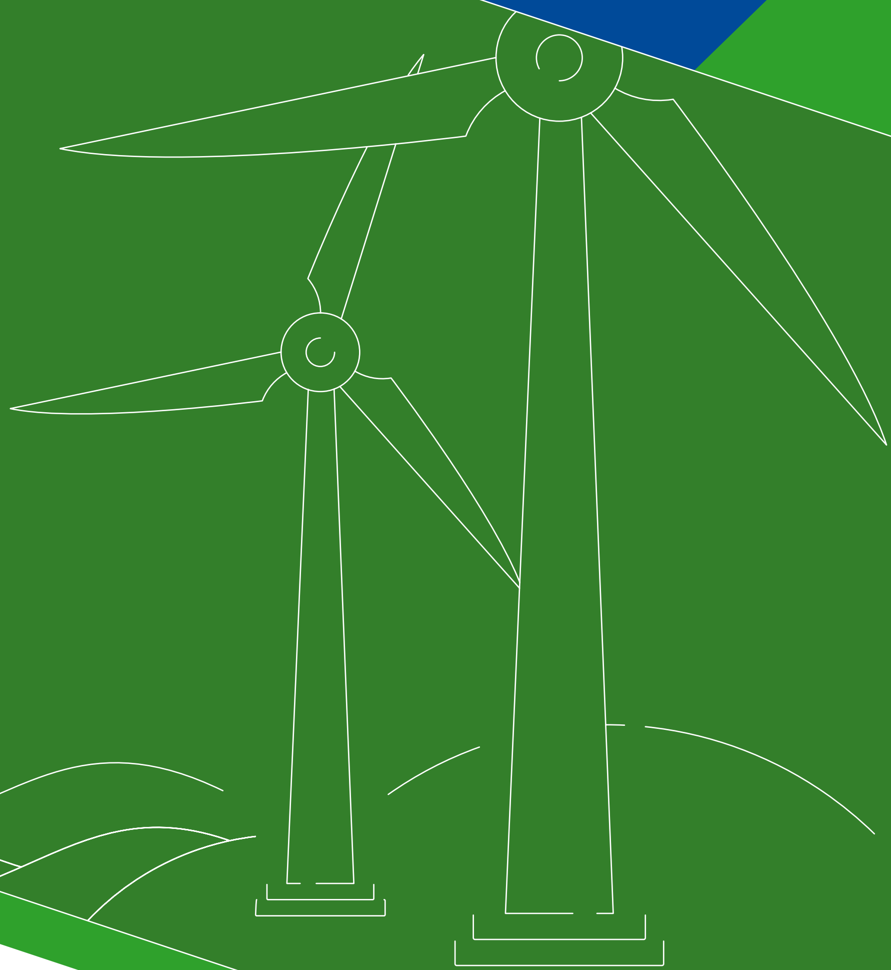

ETIPWind Roadmap

Offshore balance of plant

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ETIP Wind
EUROPEAN TECHNOLOGY & INNOVATION PLATFORM ON WIND ENERGY

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Offshore balance of plant

The sector's push towards developing offshore wind is driven by two considerations. Firstly, there are better wind conditions at sea. The winds are stronger and the air is denser. Secondly, going offshore also allows for larger turbines to be installed and run more operative hours. Whilst cost are higher to develop offshore, offshore wind farms deliver green bulk power and present good value for money. In recent years the sector has seen significant cost reductions from 150 €/MWh to 65 €/MWh or less.[1]

The balance of plant cost is the most challenging of problems and consists of offshore foundations, cabling and transformer platforms. In addition, it is linked to the optimisation of support ports and fit-for-purpose installation and cabling vessels. Balance of plant can account for as much as 50% of the offshore wind farm cost and is one of the most difficult areas to yield cost savings.

Offshore wind costs are higher than onshore in large part due to the high cost of offshore foundations, the hostile maritime environment and the scale. Not only are the turbines significantly larger and heavier, the wind farms themselves are also bigger. The average nominal capacity of an offshore wind farm increased from 79.6 MW in 2007 to 561 MW in 2018. This poses significant challenges with regard to logistics, installation and maintenance.

Challenge 1

Installing large volumes offshore

In offshore wind, size matters. Offshore wind turbines installed today are already the largest rotating machines in the world and the sector continues to develop bigger turbines, with 12-15 MW turbines due to reach the market in the next decade. These larger and heavier wind turbines require more space, deeper draughts and stronger installation vessels and cranes. The current stock of installation vessels is unable to install the designed 15 MW turbines. Innovative concepts and designs are needed to develop next generation vessels able to lift over 1,000 tonnes.

Cabling is essential to the success of offshore wind. Without solid electrical infrastructure, offshore wind farms are rendered idle. Cable faults cause prolonged disconnections that result in significant loss of production and revenue and often it takes weeks to repair. Cable faults affect both the inter-array cables connecting the turbines and the export cable from the wind farm to the grid connection point onshore.

Twisting, overloading and erosion of the seabed cover are some of the main causes of cable failures. The latter causes the cables to sway in ocean currents creating unforeseen loads to the already connected cables. Better methods to test the integrity of cables post-production, post-transportation and post-installation are needed to limit faults and avoid high repair costs.

Challenge 2

Common methodology for integrated offshore wind farm design and development

To reach large-scale commercialisation, the industry has identified several potential bottlenecks in the supply chain that could hinder offshore wind development in the coming years. The major issues relate to ports infrastructure requirements for serial production, dynamic export cables, and auxiliary equipment to withstand electric loads, as well as O&M technology.

The wind industry and its supply chain should develop logistics models for offshore wind and identify common installation technologies and manufacturing requirements. Bigger vessels, with cranes able to lift heavier components, will alter the existing logistic flow for assembly and installation of wind turbines.

In addition, standardisation in foundation systems will facilitate offshore wind development. Common junction boxes to ease and standardise termination of inter-array cables will significantly ease installation. This would avoid costly faults and allow the same foundation systems to be used by different manufacturers, enlarging the market for the European supply chain. R&I should help find new solutions and set better standards for corrosion protection for jacket foundations.

Wider regulatory requirements

Offshore wind farms are multi-billion euro projects and such investments require extensive and careful planning throughout the entire supply chain. A stable market outlook will be essential to unlock further investment in technology and R&I, skill development and jobs. Policymakers can improve investment clarity by:

- Integrating ambitious deployment plans for offshore wind to 2030 and beyond in their National Energy and Climate Plans;
- Stepping up cooperation in maritime spatial planning, cumulative environmental impact assessments and offshore grid connections (including interconnectors and hybrid projects);
- Coordinating the timeline of tenders across the various sea basins; and
- Increasing investments in port infrastructure and the maritime supply chain.

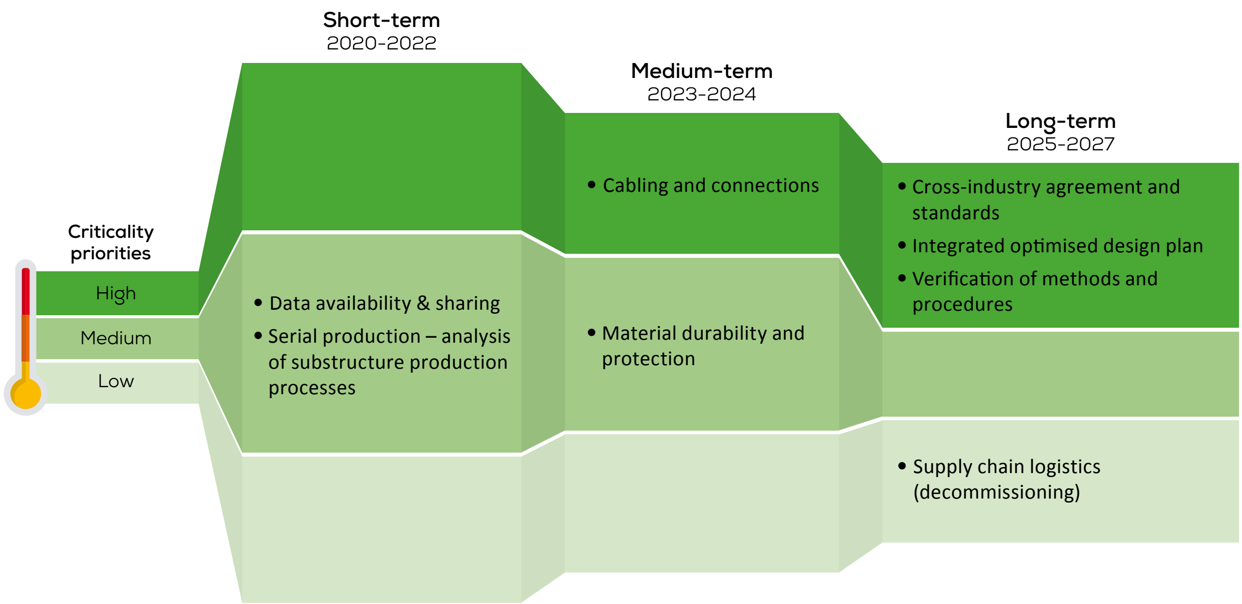

Figure 1 Research & Innovation action areas for offshore balance of plant

Challenge 1.1

Installing large volumes offshore

Serial production – analysis of substructure production processes	Short-term	Medium priority

Description and scope

Today most, if not all, offshore wind projects use custom-made foundations. Developing a North Sea standard for monopiles, piling procedures and gravity foundations will have a significant impact on cost reductions for offshore wind.

Recommended research actions

- Drive innovative processes to reduce multicity of designs to a few that use common components.
- Produce a catalogue of alternatives.
- Get approval for new solutions.

Milestones

- Common designs to be presented by 2022.
- Designs to be approved by 2024.

Challenge 1.2

Installing large volumes offshore

Cabling and connections	Medium-term	High priority

Description and scope

Cables are the most pivotal and weakest link in transferring offshore wind power to the grid. If the cable fails, power production drops and this affects the economic value of offshore wind. Most cable failures are due to one of the following 5 major causes: fatigue due to erosion of the support sand; failure of cable structure; damage from incorrect installation; manufacturing problems; and damage from ship anchors. There is a need for a new generation of high tensile light cables for floating offshore units. There is also a need to develop lead-free High Voltage Direct Current (HVDC) and High Voltage Alternating Current (HVAC) cables using new sealant technologies.

Recommended research actions

- Develop cables resistant to strain when support sand is washed away. Sensorise cables to warn of this in advance.
- Optimise materials and structure of cables to make them fit for purpose and reduce the high price.
- Develop automated repair systems for large array and export cables.
- Develop a new cable suitable for floating wind farm connection.
- Develop audio/optical-based ship monitoring and damage system to pre-warn and prevent damage and/or identify culprit of damage.
- Develop lead free HVDC and HVAC cables using non-metallic seals.

Milestones

- Develop new cable technology to reduce failures by 90 % by 2024.
- Develop new floating-ready cable technologies by 2024.
- Develop lead-free cables by 2024.

Challenge 1.3

Installing large volumes offshore

Material durability and protection	Medium-term	Medium priority

Description and scope

Foundation materials degrade, corrode and require frequent monitoring and maintenance. There is potential to find alternative materials that are better in terms of costs, tensile strength (e.g. that can maintain their integrity and self-heal when deficiencies occur), light weighting, easiness to manufacture, environmental emissions or improved environmental performance. Potential cost reduction from this element are material cost or damage resistance that would decrease maintenance cost.

Corrosion protections are generally applied on the outside and in some cases in the inner part of the structure. The best technique for corrosion protection is yet to be found.

Recommended research actions

- Investigation into system reliability, operational procedures and requirements for air ventilation/water exchange to validate corrosion protection.

Milestones

- Improved prediction performance of validation models for corrosion.
- Development of new corrosion protection measures.

Challenge 1.4

Installing large volumes offshore

Cross-industry agreement and standards	Long-term	High priority

Description and scope

Cross-industry agreement and the standardisation of manufactured parts can reduce cost through numerous channels. By allowing the manufacturing supply chain to produce standard parts, they can optimise manufacturing and reduce cost/lead time of components.

It also could reduce design time as 'off-the -shelf' components can be selected and utilised (no need for bespoke design and analysis each time for each component). The use of standardised nodes (joints) can be a key driver to cost/quality/time for manufacturing of jacket structures, and also encourage a process automation by using robotics.

Standards used in industry have been conservative as learning from the industry have been fed back into designs to limited extent. Foundation design are affected by the applied turbulence model. Further development in models (e.g. turbulence models) defined in the standards have potential to improve foundation designs and reduce the Levelised Cost of Energy (LCoE).

This becomes imperative as larger machines are deployed into deeper waters, and fundamental for floating machines. Key challenges are non-technical but related to confidentiality between original equipment manufacturers (OEMs) and structural designers and owner operators.

Recommended research actions

- Standardisation of transition piece for monopiles and jackets.

Milestones

- Industry agreement on common nodes (joints) by 2022.
- Standardised production of jacket foundations by 2024.
- Improved prediction performance of design models.

Challenge 1.5

Installing large volumes offshore

Supply chain logistics (decommissioning)	Long-term	Low priority

Description and scope

Current end-of-use management strategies and technologies are underdeveloped or still absent. New equipment needs to be developed to enable decommissioning and resource recovery. Dismantling and transporting installations can be costly and current techniques require vessels that are both expensive and short in supply in order to facilitate the work.

New vessels need to be developed to facilitate transport of decommissioned components. Cables present a further challenge as it is currently assumed that they will be left on the seabed, regardless their value. Suitable locations for storage and deconstruction/ remanufacturing of components is another pressing issue.

Recommended research actions

- Operating without cranes to provide useful technical export expertise.
- Identification of necessary equipment and locations for storage and remanufacturing of components.
- Solutions for direct reuse of materials from concept stage upwards.

Milestones

- Development of new and sustainable offshore wind decommissioning technologies that do not require heavy lifting cranes.
- Development of floating platforms to prepare material recycling.

Challenge 2.1

Common methodology for integrated offshore wind farm design and development

Data availability & sharing	Short-term	Medium priority

Description and scope

In every economic sector, expert use of data becomes increasingly important for cost optimisation and further technology development. For offshore wind there is a wealth of operational data that is currently underused. It could be used to improve post-event analysis and to forecast future trends.

The level of data utilisation is varied within the industry, providing the opportunity for innovation and collaboration between offshore wind stakeholders. Operational data is closely linked to core technology of the manufacturers.

Protection of Intellectual Property often prevents manufacturers from sharing their data, despite the fact that they all acknowledge that better data management and analysis will help drive the sector forward.

A clear set of policy incentives and quantified benefits would help alleviate industry concerns and create a more open and collaborative approach to harness the full potential of digitalisation.

Recommended research actions

- Create common taxonomies between turbine types and mapping alarms to specific turbine components.
- Design optimisation and design validation.
- Lifetime assessment of components.
- Quantify benefits to incentivise data-sharing activities.
- Cross-sector study to find the best examples of data sharing in other sectors (e.g. Oil & Gas asset management).

Milestones

- Standardisation of monopile monitoring.
- Creation of anonymised platform to enhance data sharing.
- Lifetime common data and information platform.

Challenge 2.2

Common methodology for integrated offshore wind farm design and development

Integrated optimised design plan	Long-term	High priority

Description and scope

The balance of plant (BOP) can account for about half the development costs, so long-term optimisations will play a major part in reducing overall costs of offshore wind. A key challenge to optimising balance of plant operations is analysing the interaction of the various elements in an integrated manner.

This means taking a holistic approach to analysing technical elements such as substructure design, grid connection, site conditions (e.g. wind and wave modelling) and coupling it with wider economic and environmental effects. At the same time, the assessed lifetime of the entire wind park (and not just the individual turbines and other components) needs to be accounted for in the design process, since operation and decommission significantly influence the initial optimal design.

Recommended research actions

- Coupling analyses of substructure and uncertainties of site-conditions (wind, wave, and soil).
- Combined modelling of technical and economic aspects.
- Incorporation of grid models.
- Integration of later lifetime phases (e.g. operation) in the design process.

Milestones

- Probabilistic, integrated design tool for structure and site-conditions by 2025.
- Consideration of (micro-)economic effects, risks, insurances, etc. in the technical design by 2025.
- Lifetime integrating design tool to evaluate operation and decommissioning aspects already in the design phase.
- Consideration of macroeconomic effects and the complete power grid by 2035.

Challenge 2.3

Common methodology for integrated offshore wind farm design and development

Verification of methods and procedures	Long-term	High priority

Description and scope

Design and analysis of modern offshore wind energy converters rely on numerical methods and computational procedures that are employed to estimate the very complex coupled dynamic behaviour coming from the existing multiple interactions among structure, fluids, electrical systems and controls.

On the one hand, models with several degrees of fidelity are available to study phenomena at different time and space scales. On the other, time-affordable solutions are essential to embed such methods and procedures into the design and optimisation loops. However, verifications and validations are required to warrant the accuracy of the virtual predictions made.

Recommended research actions

- Model vs. model and model vs. data comparisons for components and whole system.
- Well-founded definition of verification and validation procedures.
- Model enhancements by means of data integration.
- Model update, model calibration and system virtualisation.
- Development of a large open-access data bank for validation purposes.

Milestones

- Well-founded protocols for model verification and validation by 2025.
- Model and data driven numerical methods and computational procedures by 2025.
- Efficient consideration of properties degradation and permanent effects conditions by 2030.
- Model- and data-based virtualisation by 2035.

References

1 ETIPWind, *Strategic Research & Innovation Agenda*, 2018

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