TWIND

Twinning for an Offshore Wind Energy Partnership

Call identifier: H2020-WIDESPREAD-2018-2020

D4.3 –Technology action plan

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Lead beneficiary	TECNALIA
Authors List	Alberto Del Pozo, Germán Pérez
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1 INTRO AND EXECUTIVE SUMMARY

This report is the result of *Task 4.3 Action plans for technology capacitation* with the objective of defining scientific strategies for stepping up and stimulating scientific excellence and innovation capacity of WavEC but also for other Portuguese companies, in particular SMEs. The task is linked to different activities carried out during the project:

- Definition of the stakeholders' matrix, for the identification of companies interested in the offshore wind sector.
- Identification of technology gaps linked to the development of the offshore wind sector.
- Identification of funding opportunities to obtain an adequate technological baggage to participate in the sector.

All these activities, carried out in different tasks of the project, led to the definition of an action plan for different types of companies covering the whole supply chain.

The document has been divided into the following points:

- The current state of the offshore wind market and the medium-term objectives. Portugal and Spain have been taken as a reference because both countries are in an unfavourable starting situation compared to the rest of Europe. The reason for that is because they have very specific objectives that depend on a particular technology to be achieved (floating wind). In addition, they are neighbouring countries that can follow a similar path by sharing some points of the development plan.
- The main challenges to overcome and the existing technology gaps.
- Review of different actions in the implementation phase of an offshore wind farm, listing those considered as necessary and innovative to achieve the objectives and/or differentiate themselves from what currently exists in the sector.

As a result, companies are expected to participate in Portuguese and EU funded projects, as well as reinforce their position to achieve success in the offshore market. The focus was on Portuguese companies while taking into consideration the EU opportunities, with a special focus on the Iberian market.

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2 OFFSHORE WIND: CURRENT STATUS AND FUTURE OVERLOOK

As of the date of the present report and according to the latest information published by the Global Wind Energy Council (GWEC), the installed offshore wind capacity (cumulative and worldwide) reached 56 GW, of which 21.1 GW were installed in 2021 [1]:

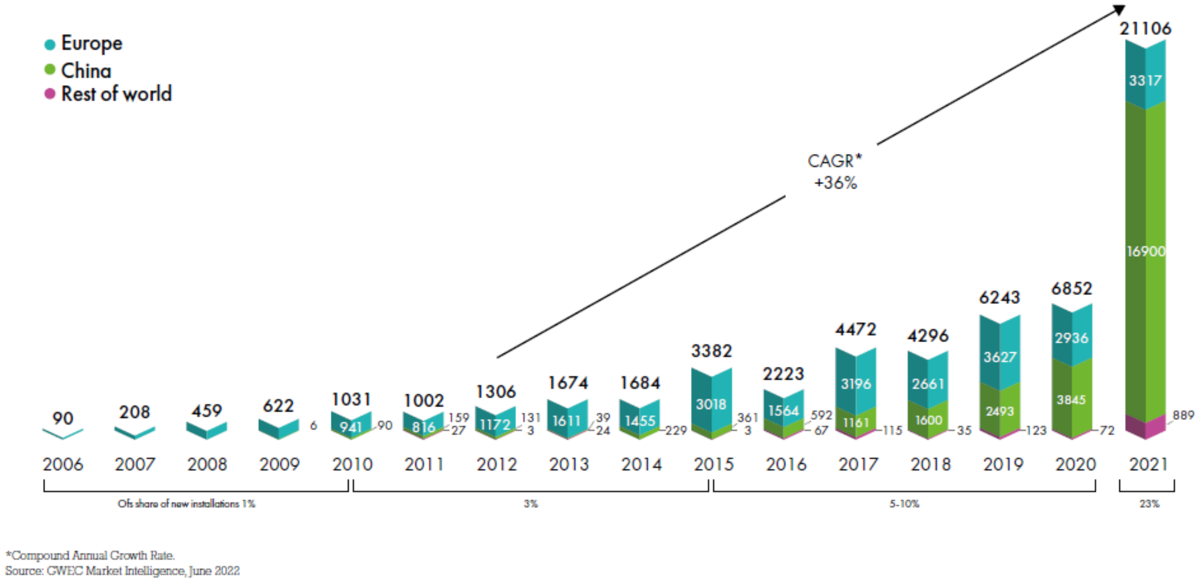

Figure 1: New offshore installations 2006-2021 (MW) [1].

The distribution of these offshore infrastructures, by country, can be seen in the following graph:

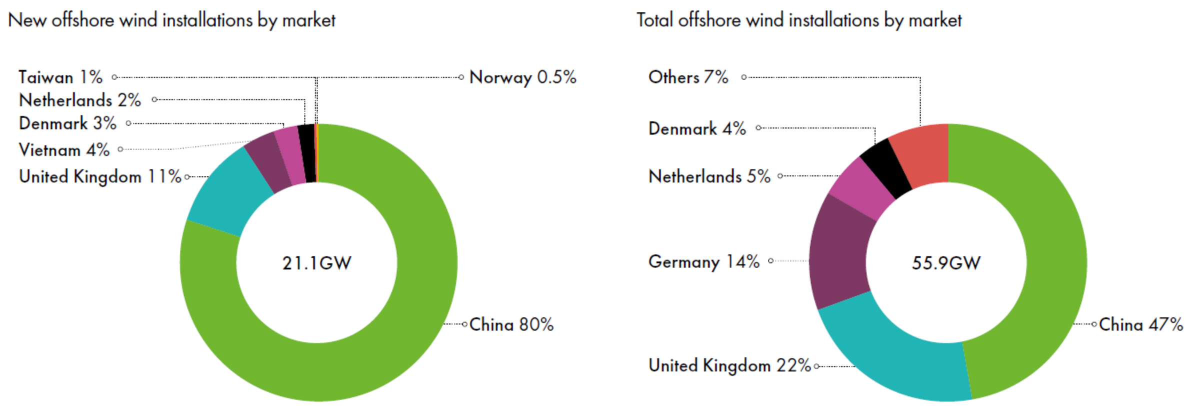

Figure 2: New offshore installations in 2021 (left) / Total offshore installations (right) [1].

As can be observed in the previous figures, the strength of the Iberian Peninsula in the total installed power is very marginal at the present time due, among other things, to the particularities of the coastal shoreline, which limits the use of bottom-fixed platforms.

[1] GWEC GLOBAL OFFSHORE WIND REPORT 2022. June 2022. www.gwec.net

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Portugal has a larger presence with 25 MW[2] in operation with floating platforms but Spain has only a few demonstrators and/or wind turbines located on the coast, albeit classified as offshore due to their situation [3].

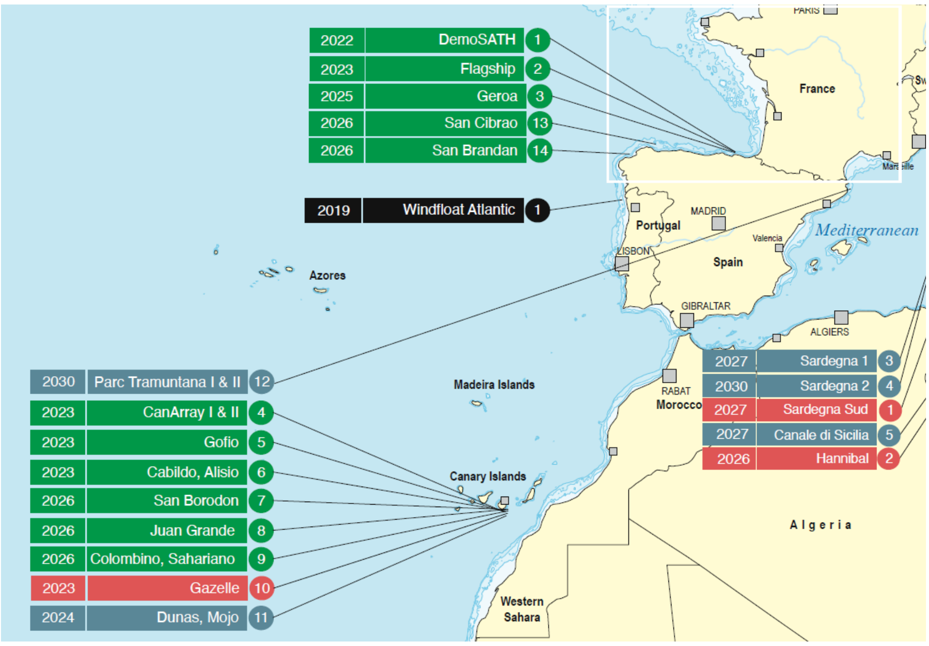

Figure 3: Wind projects in the Iberian Peninsula[4] .

The overall growth expectation, over a horizon of less than 10 years, according to the previously cited reports are as follows:

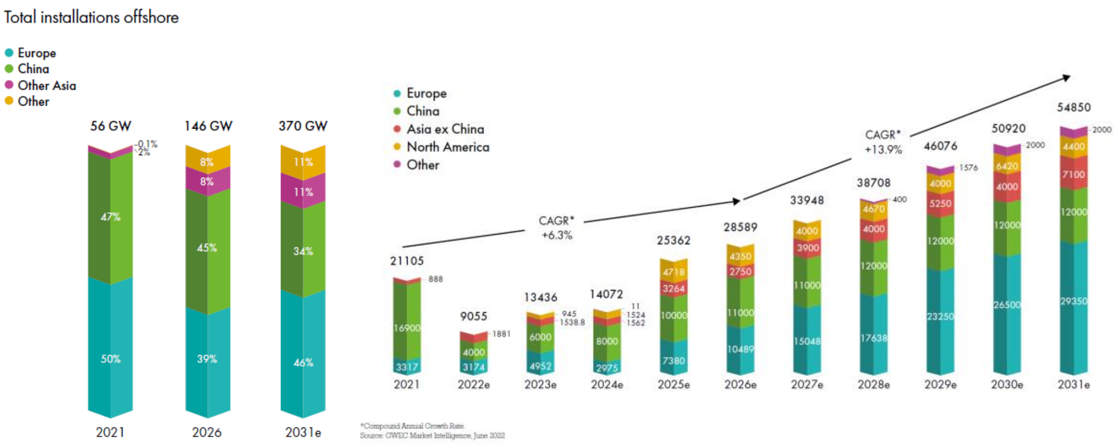

Figure 4: Overall growth approach up to 2031: cumulative (left) and year by year (right) [1].

[2] https://www.principlepower.com/projects/windfloat-atlantic
[3] https://www.thewindpower.net/windfarm_en_18520_gamesa-5mw-test-turbine.php
[4] https://questfwe.com/

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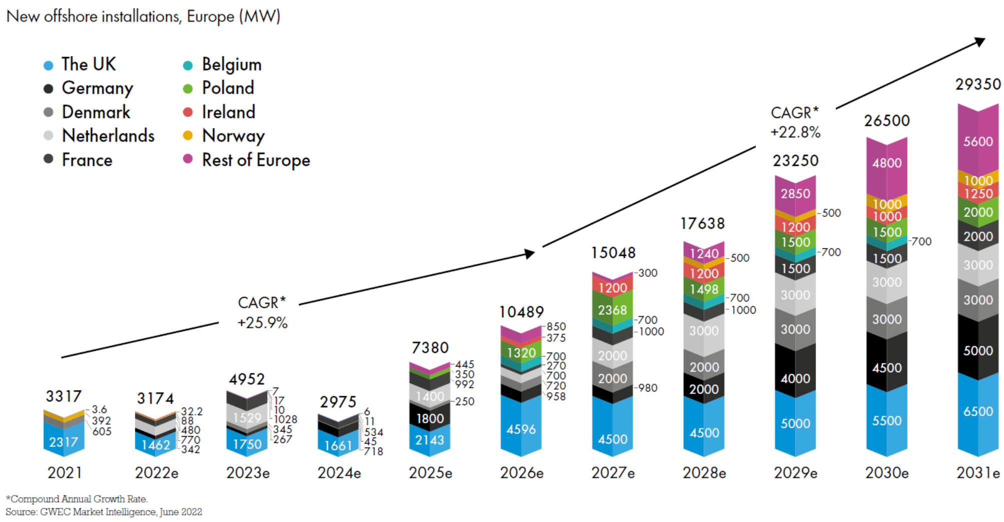

Figure 5: European expected growth up to 2031[1].

In the Figure 5, Portugal and Spain are under the cover of the "Rest of Europe" section, and to obtain some details about the growth strategies it is necessary to appeal to other sources of information:

- **Spain:** the plan is to develop between 1 GW and 3 GW of offshore wind capacity by 2030, according to the country's Ministry for the Ecological Transition and the Demographic Challenge[5]:

	2030 Targets	References 2030
Offshore wind energy	**1 – 3 GW**	5 – 30 GW floating globally. 7 GW floating at European level. 60 GW (fixed and floating) at European level.
Marine energy	**40 – 60 MW**	10 GW at global level. 1 GW at European level.

Figure 6: Targets by 2030 of the Roadmap for Offshore Wind and Marine energy in Spain[5].

- **Portugal:** according to the Portuguese of the Environment, Duarte Cordeiro, the initial plan to install between 6 to 8 GW has increased to 10 GW of offshore wind capacity for the following years [6].

The establishment of the Iberian market with the development of commercial offshore wind farms will provide an important experience to Portuguese companies to access the European market. For that purpose, the stakeholders' matrix developed during the TWIND project is a tool to identify the experience and interests of the companies and categorise them into the different stages of a

[5] https://www.idae.es/sites/default/files/documentos/idae/tecnologias/energias_renovables/eolica/EN_HR_EOLICA_MARINA-PDF_ACCESIBLE.pdf
[6] https://www.reuters.com/article/portugal-energy-wind-idAFL8N30S38I

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wind farm development, with different technology needs and gaps. It is available on the project's web site. The figure below shows the matrix.

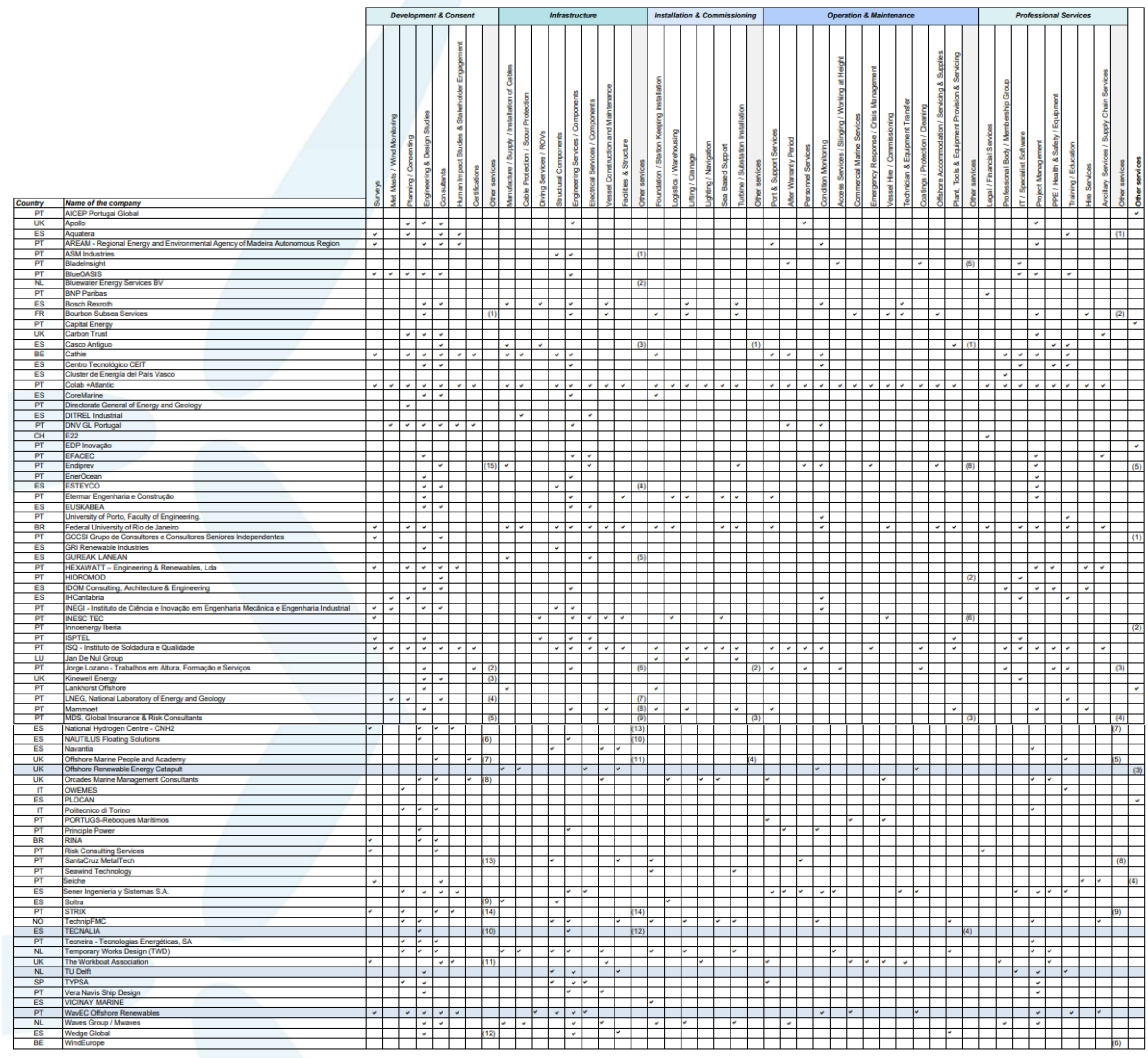

Figure 7: Stakeholders matrix developed during TWIND project.

A zoom for each of the categories, with the main information of the companies is available.

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3 IDENTIFIED CHALLENGES AND GAPS

One of the points to consider for the proper placement of an offshore wind farm, apart from the wind resource, is the site suitability. The considerable narrow continental shelf in the Peninsular area (and in the islands) is one of the reasons why the development of offshore wind power in Portugal and Spain is closely associated to the development of floating wind technology.

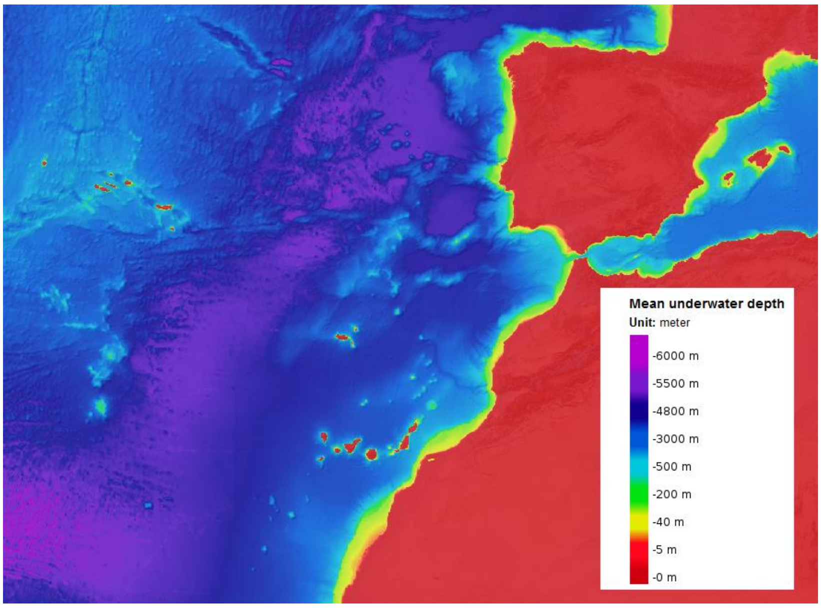

Figure 8: Mean water depth (m) [7].

At present, there are 113 MW of floating wind installed in Europe[8], which represent 0.2 % of the worldwide total offshore wind power and 0.4 % of the power installed in Europe.

The offshore wind potential for both regions, according to GWEC data, is about 131 GW for Portugal and 219 GW for Spain, mostly for floating platforms:

[7] https://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/mindmap_en.html
[8] https://windeurope.org/intelligence-platform/product/offshore-wind-energy-2022-mid-year-statistics/

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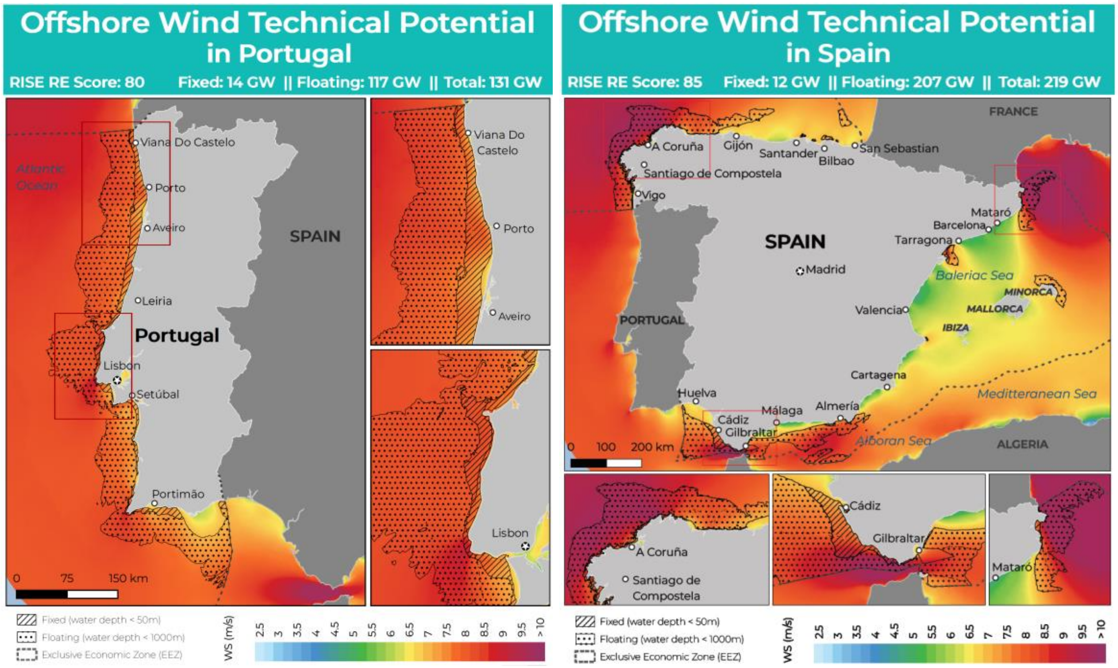

Figure 9: Offshore Wind Potential for Portugal[9] and Spain[10]

Portugal is well positioned for being one of the countries with floating wind already installed; there are Portuguese companies that took part in the development of that reduced scale wind farm, with enough background to take part in future commercial wind farms. Other companies, willing to enter the offshore sector, have a good example on how to become a relevant actor.

ETIP Wind, the European Technology and Innovation Platform on Wind Energy, together with the European wind industry, developed a roadmap[11] to provide technology solutions and research priorities that will drive the development of wind energy and help reduce costs across the supply chain. Offshore wind and particularly floating wind are the main focus of those priorities.

[9] https://gwec.net/wp-content/uploads/2021/06/Portugal_Offshore-Wind-Technical-Potential_GWEC-OREAC.pdf
[10] https://gwec.net/wp-content/uploads/2021/06/Spain_Offshore-Wind-Technical-Potential_GWEC-OREAC.pdf
[11] ETIPWind Roadmap, Roadmap | ETIPWind

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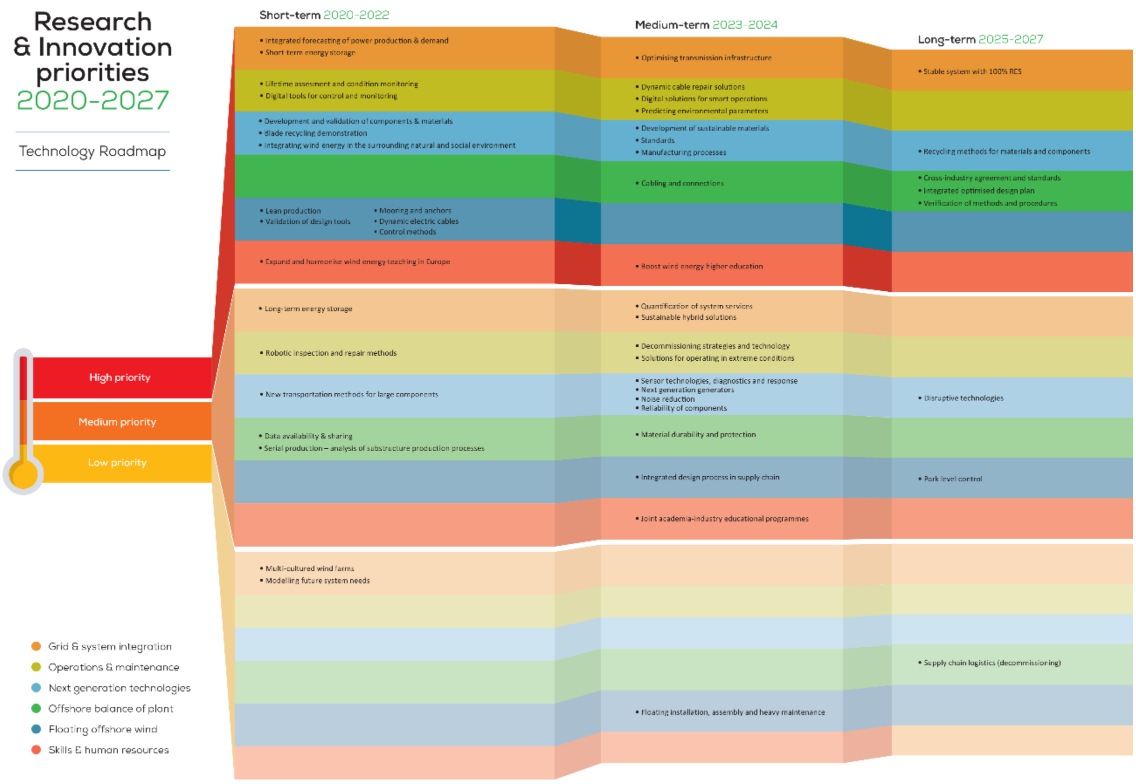

Figure 10: Research and Innovation priorities of the ETIPWind Roadmap[12].

Considering all those inputs, the results of the auctions -ScotWind, France - and the objectives of the EU countries, the main challenges and opportunities for the stakeholders can be categorised as:

- **Resource and site conditions:** Wind speeds and bathymetry are key parameters to determine the technical viability of a site.
- **Regulatory Framework:** the identification of proper areas with great potential, considering all the interferences and incompatibilities with other activities such as fishing, strategic spaces, environmentally protected areas, etc., is one of the first steps in the development of an offshore wind farm. Normally, this is performed by the Energy Department of each Country. If these spaces are not identified and published on time, there will be no developers able to bid and make use of them. Clarity and precise information during this process determine lead-time project development and cost reduction.
- **Onshore Grid connection:** grid capacity studies and access, connection prioritisation and planification for the development of new onshore grid infrastructures (to increase capacity) are important tasks for achieving established targets.

[12] ETIPWind Roadmap, Roadmap | ETIPWind

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- **Supply chain and Ports infrastructure:** Ports, industry capabilities and synergies among the involved parties are key factors for a techno-economic feasibility. The development of the floating wind sector in Europe will require a big number of manufacturing companies, supplying parts to be assembled in large ports.

- **Technology status:** in addition to the development of a cost-effective floating platform, it is also important to considerer the availability and degree of maturity of other elements such as moorings, anchors, dynamic cables and electrical connectors. The majority of those elements are frequently used in other energy sectors such as offshore Oil&Gas but it may be necessary to adapt them to the particularities and cost constraints of offshore wind.

- **Operation and Maintenance (O&M):** In general, the operation and maintenance of an offshore infrastructure is a real challenge, but if this infrastructure is located over a floating platform, there are additional uncertainties. It would be interesting to promote or develop new predictive maintenance techniques that minimise these uncertainties. It will be important to develop the means - access vessels, ROVs, drones… - and human resources - skilled technicians - to work in the floating wind farms which will be developed in Portugal and Spain. It is important to consider those O&M requirements during the planification stage of a wind farm, so that Portuguese - and Spanish - companies may have a good opportunity.

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4 TECHNOLOGY ACTION PLAN

With the information provided in the present and previous reports, the different working sessions and the information shared between different partners of the TWIND project - think tanks, workshops with stakeholders, funding opportunities - it is possible to list actions aimed at detecting opportunities for companies willing to enter or expand their business in the offshore wind sector.

4.1 Actions relating to resource and site conditions

Identifying areas with optimum wind resource, that do not interfere with other activities, that present good conditions (seabed composition, free of obstacles, etc.), evacuation routes, will require certain studies which in turn will be based on measurements and bathymetric campaigns carried out in the area.

Some required activities:

- Specialised Vessels and Remotely Operated Vehicles (ROVs) and their ancillary systems and scanning tools.
- Development of resource measuring infrastructure.
- Vision and image processing.
- GIS tools.
- Wind data analysis.
- Metocean data analysis.

This section could provide useful information for other working groups, such as:

- Information for site identification (Energy Department).
- Data for environmental studies.
- Data for energy forecast (economic energy plan).
- Weather conditions forecast for O&M.
- Data for floating platform selection/re-design (customization).
- Data for mooring/anchors selection.
- Data for cable engineering (route, armour, cable external protections).
- Data for installation: trenching method, cable laying speed, etc..

4.2 Administrative matters

In most cases, this entry is beyond the reach for an action plan for the companies, but it is possible that the Administration process require to carry out some of the tasks included in this section.

Government agencies should provide:

- Access to open sea test sites, which is critical to many developers in the absence of reliable field data from full scale devices.
- Support Research and Development (R&D) programs that combine knowledge and experience from areas such as offshore wind, oil and gas, and other offshore engineering sectors.
- Establish an international network of test facilities to avoid competition between infrastructures and to increase efficiency through complementary specialization.

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- Reduce administrative barriers to improve the deployment of offshore technologies.
- Offer collaboration with private investors and banks to improve financing.
- Accelerate regulatory and licensing processes.
- Coordinate an offshore electricity network strategy for a better integration of these structures.
- Develop translational and regional infrastructure programs covering ports, vessels, and other supply chain requirements for the large-scale deployment of offshore energy technologies.
- Provide financial incentives and risk mitigation to early-stage investors.

Companies with a consultancy profile may be their target.

4.3 Electrical infrastructure, Grid Capacity and Integration.

Big capacity Offshore Wind Farms normally require an onshore grid connection in voltage levels of 132 kV or higher. The operation of these infrastructures is usually under the Transmission System Operator (TSO) responsibility, as are the capacity studies, construction of new infrastructure for enhancement, reinforcement or modification. It is also possible that part of these operations may be subcontracted.

The uncertainty in the availability of the wind resource is another challenge to be resolved; the development of large-scale storage systems can support the integration of this energy resource. Green Hydrogen generation could take an important role on the use of offshore wind production when there's no demand. This would open a completely new sector, increasing the demand for renewables, and in particular for offshore wind generation. The EC and several countries like Portugal and Spain, are taking an important role lo lead the Green Hydrogen generation.

On the other hand, it will be necessary to carry out studies for grid integration and compliance with grid codes for new offshore wind farms approved.

Proposed activity plan:

- Grid Integration Studies: HVAC/HVDC transmission, Grid code requirements, Power Quality, protection elements specification and coordination.
- Communication studies for remote operation (owner and TSO), energy metering (owner and TSO), etc.
- Supervision and Monitoring.
- Network Security.
- Electrical Test for certification and commissioning.
- Storage Technology.
- Repowering of existing offshore wind farms.

Output for other working groups:

- Data for O&M.
- Gap identification for commercial equipment.

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4.4 Supply Chain and Infrastructures.

The current geopolitical situation causes supply chain breakdowns, especially at raw materials level; this leads to price increases and uncertainty in delivery times regardless of where the manufacturing points are located.

A close emplacement of ports, transport and manufacturing industries to the tendered areas will impact in several task such as inspection, manufacturing, installation and maintenance, as well as cost reduction. This proximity in services is not always possible, so it could be interesting to promote agreements not only on a local or regional level, but also on a national and international degree.

In many cases the available infrastructure and industry would require an adaptation to this new market, but the transition should be quicker if there is previous experience in sectors such as offshore Oil&Gas.

Proposed activity plan:

- Search for alternative or complementary supply sources to current ones.
- Identification of needs and the establishment of a list with available production means.
- Redesign or adaptation of existing means of production.
- Serial production: analysis of production processes.
- Collaboration, from the design phase, with the offshore wind technologist.
- New transportation methods for large components.
- Advanced manufacturing, with 3D printing techniques implementation.

Output for other working groups:

- Constrains for components design (i.e, floating platform dimensions limited by port capabilities).
- Resources availability for O&M.

4.5 Technology Development.

Many elements are involved in the construction of an offshore wind farm, from the wind turbine itself, the platform (fixed or floating), substation, inter-array and transmission cables and all the ancillary elements for each of them.

Most of these components are proven technologies, but others will require further development to reach an optimum degree of maturity and reliability. The use of new materials, new manufacturing and analysis techniques can help to achieve this.

In addition, it would be interesting to identify which elements are critical for the good performance of the whole package and focus efforts on them.

<u>Platform:</u> proposed activities to boost its development:

- Tools, combining hydrodynamic, aerodynamic and other influences, to develop a suitable designing for next generation turbines.
- Numerical modelling, computational fluid dynamics (CFD) and validation.
- Materials development.

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- Testing rig and in specific sites.

Wind Turbine: the objective will be focus on supporting design and testing of some components.

- Blade design and testing (fatigue), built-in sensors (fibres, etc).
- Drive trains test rig, from rotor to grid connection.
- Materials development.
- Wind tunnel test.

Moorings:

- Modelling and tool development of mooring systems optimized for offshore wind (nowadays adopted for the oil & gas sector).
- Testing (fatigue).
- Materials development.

Electrical:

- Transformers: new dielectric fluids, design to withstand acceleration and vibration cases, testing.
- Switchgear: new insulation medium for arc extinction.

Submarine cables:

- Modelling and tool development for the design and deployment of dynamic cables to extend life and reduce the risk of failure.
- Fatigue testing.
- Design of high-voltage (> 72.5 kV) dynamic cables.
- Develop Medium Voltage (>36 kV) and High Voltage connection and disconnection elements (improve installation and O&M stages). For both cable-cable and cable-turbine/platform connections.
- Develop new insulation materials: reduce ageing phenomenon, reduce electrical losses, mitigate or reduce the electrical treeing phenomenon.
- Develop new cable ancillary systems for new cable specifications (high voltage cables): bend restrictor, bend stiffener, buoyancy modules, protective armours.

Material Recycling: the used materials, apart from providing component improvements, should be environmentally friendly and easily recyclable.

Certification process: applied to all new development.

- Develop support documentation for the certification of new designs.
- Co-ordination with the different implementing standards.
- Risk assessment methodology.
- Standardisation of O&M mechanism.
- Test procedures.
- Project certification.

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4.6 Operation and Maintenance.

The main objective is to ensure that every element that belongs to the offshore wind farm is available as long as possible for energy production. This is mainly achieved by carrying out a careful monitoring during operation, verifying that everything is working properly and carrying out maintenance operations focused to reduce their deterioration or ageing.

Knowing in advance the state of the equipment will serve to planning adequately the intervention; in an offshore environment it is not always possible to access the infrastructure to inspect a faulty equipment, so corrective maintenance should be minimised where possible.

Preventive maintenance (based on operation time) could be applicable to some elements, especially if there are no other method to verify the status of the component.

Predictive maintenance, in most cases, will allow a right planification for the intervention and the necessary ancillary resources (not always available) with an adequate stock of spare parts. That is the reason why it is necessary to know in advance the condition of the major number of elements that are part of the offshore wind farm.

Activities required for this section:

- Analyse the feasibility and limitations of using new elements, such as drones for visual inspection.
- Exploring synergies with Oil&Gas sector.
- Specific staff training.
- Development of condition monitoring technologies such as improved sensing and data interrogation at a component level.
- Predicting environmental parameters.
- Solutions for operating in extreme conditions.
- Structural health monitoring technology development for blades, tower and nacelle coupled with advanced numerical modelling and CFD.
- Dynamic cable monitoring and modelling to predict and prevent future failures.

4.7 Funding opportunities

During the TWIND project, the partners shared with the stakeholders different funding opportunities, with the focus on EU calls which are a good framework to collaborate with other European companies and gain experience by developing R&D activities in different topics. Two workshops were held to explain the H2020 Green Deal call and the first topics of the HEU work programme 2021-2022. The new work programme, 23-24, includes some interesting topics related to offshore wind, all of them under Cluster 5, Climate Energy and Mobility call[13]:

[13] Cluster 5: Climate, Energy and Mobility (europa.eu)

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- HORIZON-CL5-2023-D3-01-05: Critical technologies for the offshore wind farm of the Future. Deadline 30 March 2023.
- HORIZON-CL5-2023-D3-02-15: Critical technologies to improve the lifetime, efficient decommissioning and increase the circularity of offshore and onshore wind energy systems. Deadline 05 September 2023.
- HORIZON-CL5-2024-D3-02-08: Minimisation of environmental, and optimisation of socio-economic impacts in the deployment, operation and decommissioning of offshore wind farms. Deadline 05 September 2024.
- HORIZON-CL5-2024-D3-02-09: Demonstrations of innovative floating wind concepts. Deadline 05 September 2024.

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5 FINAL REMARKS

One of the most relevant activities of the TWIND project was aimed at supporting the development of the supply chain for offshore wind in Portugal. During the project, companies with experience and/or interest in participating in different stages of the development of an offshore wind farm have been identified in the so-called stakeholders' matrix.

In parallel, work has been done on the identification of technology or service development needs in these different phases, focused on the Iberian market. For this, different activities have been organized such as think tank meetings or staff exchanges to discuss needs and future developments in different topics. In addition, financing programs have been identified that can help companies develop those capacities that the sector demands.

Four workshops were organized during the project, presenting financing opportunities at EU level, as well as the stakeholders' matrix.

The result has been a mapping of capacities, needs and potential players in the Portuguese offshore wind sector. This information is expected to help Portuguese companies to develop new technologies and services that allow them to reinforce their position to achieve success in the offshore market, not only to supply the Iberian market, but globally.

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