Workshop conclusions wind energy R&I priorities to 2030

WindEurope

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Introduction

In the last decade wind energy changed from a niche technology to an full-fledged industrial sector providing clean, competitive and reliable energy. The EU is the global leader in wind energy technology, but international competition in wind energy has intensified in recent years. For Europe to cement its domestic leadership in wind energy in the next decade, it will need to continuously invest in cutting edge technologies that will drive down the costs of wind energy and facilitate the integration of clean affordable wind generated electricity in the energy system.

The wind energy sector strongly feels the next EU Multiannual Financial Framework should ensure that research and innovation policy and other funding instruments, in particular for energy and transport infrastructure, continue to drive the transition to a decarbonised energy system. The EU's industrial policy should stay focused on innovation, digitalisation and decarbonisation. ETIPWind organised a workshop on 21 february to collect feedback from the sector and to support policy-makers with up-to-date information on research priorities.

Figure 1. Picture collage from the 21 February Research & Innovation workshop.

ETIPWind Research & Innovation workshop. Defining wind sector priorities to 2030

1 Workshop scope and format

1.1 Background and scope

In the last few years the wind energy sector transformed into a major EU industrial sector. Continuous efforts in Research and Innovation (R&I) was one of the key drivers in that process, with the wind energy industry spending some 5% of their turnover on R&I. This is well above the EU average of 2% and demonstrates the sector's commitment to innovation and cutting-edge science.

These industry efforts, coupled with targeted EU support, have made the European Union (EU) the global leader in wind energy technology. Still, an EU-wide approach to foster research and innovation will be needed for the EU to retain its leading position in the next decade. Even more so in light of the increasing competition from Asia and the United States on the global market.

To support future EU policies on research and innovation, ETIPWind organised a workshop for the wind energy sector to design a vision of where the sector as a whole is heading to. Guidance on this vision was provided by the ETIPWind Advisory Group, which identified 3 key objectives for the sector for 2030:

1. Retaining EU technology leadership in the global market;
2. Towards wind energy being competitive in a merchant price world;
3. Providing 30% of power demand by 2030.

The workshop took place in Brussels, Belgium on 21 February at the Thon Hotel Bristol Stephanie situated at the Avenue Louise 91-93. Participation was open to the entire wind energy community as well as to stakeholders from other sectors.

The aim of the workshop is to establish a long term R&I perspective and to identify the key challenges and opportunities ahead. Having a clear understanding and upfront look on the major trends and developments expected in the next decade will help to align EU policies and support mechanisms with the needs and challenges of the sector. This exercise will help the sector in delivering a clear message on what the key challenges ahead are and how they can be mitigated. The workshop findings, summarised in this report, will be a key input to the updated ETIPWind Strategic Research and Innovation Agenda (SRIA).

1.2 Format

In consultation with the ETIPWind Steering Committee, the secretariat created a skeleton structure for the workshop based on the discussions at the Advisory Group. The Advisory Group identified 7 thematic priorities:

1 Grid and System integration;

2 Digitalisation & cyber security;

3 Development of innovative storage techniques;

4 Innovative solutions for reducing OPEX;

5 Floating wind technology;

6 Wind energy as a driver for electrification;

7 Disruptive Turbine Technology research.

These 7 priorities were then molded into three separate tracks that reflected the priorities presented by the Advisory Group and retained a certain similarity with the "five pillars of research & innovation for wind energy" that is the cornerstone of the 2016 Strategic Research & Innovation Agenda. The three tracks were *Technology*, *Energy system* and *Offshore wind*. Each track consisted of two break-out sessions different R&I themes. Participants were asked to indicate their preferred break-out session in advance via an online survey.

Skeleton structure of the workshop			
	Track 1: technology	**Track 2: Energy system**	**Track 3: Offshore wind**
Morning session	Next generation technology	Grids & system integration	Offshore balance of plant
Afternoon session	Operations & maintenance	Electrification	Floating wind

Table 1. Skeleton structure of the workshop.

1.3 Attendance

75 representatives from the industry, research community and academia attended the event. A detailed list of participants can be found in the annexes. Upon their request some participants are not included in the participant list.

Figure 2. group photo of the participants of the 21 february workshop.

2 Content of the workshop

Aidan Cronin, chair of the ETIPWind Steering Committee, opened the workshop with a brief presentation on the ETIPWind platform, its key members and the scope of the discussions. The secretariat then gave a brief presentation on the broader process of defining R&I priorities and on the structure and expected outcomes from the workshop. Both presentations

Hanne Wigum, manager of renewable technology at Statoil, gave a key-note presentation on the challenges and R&I needs for the offshore wind sector in particular. The presentation was followed by a short discussion between her and Aidan Cronin on how to drive innovation in wind energy. The floor was then opened to the audience for questions.

After this, the crowd split into three different groups to attend the various breakout sessions. Three sessions, one of each track, were held in the morning. The remaining three were held in the afternoon. For the afternoon sessions, participants were free to switch tracks. Every session had two rapporteurs as shown in table 1 below.

During the break-out sessions participants were asked to first come up with a list of challenges for the sector. In a second step, they were asked to macth those challenges with the three strategic obectives, provided by the ETIPWind Advisory Group. Thirdly, the participants then defined the top priorities and developed R&I pathways to overcome the challenges. After the workshop, all participants were given the opportunity to rank the top priorities developed in the various break-outs.

Rapporteurs			
Track 1	Next Generation Technologies	Peter Eecen (ECN)	Martin Knops (ZF Wind Power)
	Operations & Maintenance	Lars Landberg (DNV GL)	Agnar Gudmundsson (Vestas)
Track 2	Grids & System integration	Adrian Timbus (ABB)	Hannele Holttinen (VTT)
	Electrification	Mattias Andersson (DTU)	Andree Altmikus (Enercon)
Track 3	Offshore balance of plant	John Olav Tande (Sintef)	Jørn S. Holm (Ørsted)
	Floating wind	Hanne Wiggum (Statoil)	John Olav Tande (Sintef)

Table 2. List of rapporteurs for the break-out session.

2.1 Track 1: Technology

2.1.1 Next generation Technologies

Moderated by Peter Eecen (ECN) and Martin Knops (ZF Wind Power).

The session leaders divided the participants in five groups. Each group was given a number of minutes to come up with three to five research and innovation challenges. The session leaders, seated in group 5, collected and consolidated all the input. A list of fifteen topics was compiled:

1. Digitization and big data for data driven design and operation methods;
2. Meteorological conditions – better understanding and prediction of site conditions;
3. Next generation components and materials, towers and support structures.
4. Improved control (e.g. feedforward control);
5. High fidelity design models & reliable software;
6. Development of human resources;
7. Smart, real-time turbines – light design, optimisation against cube law;
8. Reliability and predictability: next generation test and validation methods;
9. Multi-disciplinary optimisation and system engineering including all aspects;
10. Aero-acoustics – design of a silent turbine;
11. Radical developments (e.g. large-scale floating turbines, floating vertical axis turbines, airborn wind);
12. Design and development of cost competitive 20-30MW turbines;
13. Interaction with the environment (e.g. bat and bird scare system) – multi-functional use of space;
14. Automated robotics – robotisation;
15. Manufacturing technology – better, faster, more accurate production methods.

Additional topics such as the creation of synergies between offshore wind and other sectors (fishery, oil & gas) and health & safety (fire prevention) were added in comments received after the workshop.

The group then developed six priorities in more details in so-called R&I pathways. These priorities were seen as matching most with the objectives laid out by the ETIPWind Advisory Group. The priorities were ranked by the participants via an online vote held after the workshop. The six priorities can be found in table 3.

	Challenge	Targets	Expected Outcomes

1	Next generation components, materials, towers and support structures.	• Development of non-steel materials, composite materials and/or innovative steel concepts to be used in tower design with the aim of making towers lighter.
		• Design and development of reliable components such as bearings and generators for large turbines (more than 10 MW).
		• Analysis of the cost effectiveness of:
		  ○ new protection materials to battle leading edge erosion; versus
		  ○ increased robotisation of maintenance operations.
		• Development of new glass recipes and/or hybrid materials for new blade design.
			• Extended lifetime of wind turbine.
			• Reduce carbon footprint of wind energy manufacturing industry.
			• Increase economic margin.

2	Development and validation of high fidelity models. "*digitalisation creates opportunities to develop and design tools driven by high definition/resolution sensors*."	• Development of high fidelity tools on both wind turbine and wind power plant level. • Determining the level of uncertainties in the tools and of the input gathered. • Making full-scale instrumented turbines available for the creation of datasets for validation of models and tools. • Models should cover challenges outside / between the turbines, i.e. turbulence, wakes, waves, currents, etc., as well as those directly involving the turbine(s).	• Reducing the Levelised Cost of Energy (LCOE) of wind energy by new wind turbine and wind park layout designs.
3	Design of real time smart turbine.	• Development of a "sensor suite" to create a fully smart turbine. • Development of intelligent, multi-purpose sensor modules to give real time metadata outputs on the performance, condition, structural health of the asset as well as of the external conditions surrounding the wind turbine. • Active and passive flow control to alleviate loads on the blades.	• Reduce LCOE and costs of integration in the system. • The data gathered of smart turbines will open up for new possibilities for innovations.

4	Data driven design and operation methods.	• Create common structures to share and access data from:
		  ○ Designs;
		  ○ Operations:
		  ○ Measurement campaigns:
		  ○ Experiments.
		• Develop ways to maximally exploit available data (e.g. machine learning).
		• Establish clear rules and procedures for what will be public or private data.
		• Create sustainable models for data maintenance and payment for the use of data (e.g. government incentives).
			• Better planning, optimisation and operation.
			• Reduced LCOE by more accurate design.
			• Cost reduction by adapting O&M strategies to the current state of art.

5	Fundamental research into radical and/or disruptive innovations.	• Preparation by 2025-2030 of the theoretical and practical foundations for radical innovative technological developments that could transform the wind energy sector. Potential topics include:
		  ○ Development of models of multi-rotor wind turbines;
		  ○ Upscaling of airborne wind energy systems;
		  ○ Development of models of a 20-30-50 MW wind turbines.
			• Demonstration project of alternative multirotor turbine designs by 2025.
			• Scaling-up of existing multirotor designs.

6	Human Resources (HR).	• Create a sustainable and solid European HR base (e.g. by including a special track on system engineering in classical curricula). • Provide extra attraction toward women to choose for the wind energy sector.	• Have sufficient specialists and skilled labour available for wind energy.

Table 3. Next generation technology R&I priorities.

2.1.2 O&M

Moderated By Lars Landberg (DNV GL) and Agnar Gudmundsson (Vestas Wind Systems A/S).

The session leaders divided the participants in three subgroups. Each group was given a number of minutes to come up with research and innovation challenges. The session leaders, seated in group 5, collected and consolidated all the input. Following list of topics was compiled:

- Synthetic sensors (i.e. multi-disciplinary sensors that monitor several elements at the same time). This will improving wind turbine operations and also aid development of a so-called “digital ocean” (or Smart Ocean) by monitoring ocean operations from seafloor to water surface. It entails a focus on smart foundations and mooring and is strongly linked to the topic of predictive maintenance;
- Intelligent and predictive maintenance with a long term perspective. Big data tools for predictive maintenance are needed to analyse the integrated data from the turbine designers and the windfarm operators, as well as the feedback loops among them. Example: integrating a digital twin on a real time basis;
- Discover maintenance strategies, needs and actions on wind farm level to extend lifetime and long term commercial value. Looking at lifetime extension beyond 50 years. A holistic approach is needed (technical, digital, HR and all other aspects). With damages from cable failure being a big part of the operational costs, underwater systems incl. foundation, mooring and cables are a priority;
- Drone applications for O&M, including underwater drones/autonomous underwater vessels (AUVs), to improve maintenance of the turbine, foundation and mooring system;
- Image recognition system for underwater operations;
- Intelligent wind turbine control. Prognostics, analysis of sensor data, situation & conditions awareness, LIDAR applications, integration of all data into smart decision-making systems;
- Smart wind farm control systems: control of the turbine, foundation and mooring with a standardised open interface. Looking at wind farms from a systemic point of view. See the wind farm a single system;
- Close the gap between tolerance management and structuring. Better selection of the parameters to measure the performance;
- Remote sensing methods – smart turbine, smart foundations and mooring that don’t need inspection.

The group then developed four priorities in more details in so-called R&I pathways. These priorities were seen as matching most with the objectives laid out by the ETIPWind Advisory Group. The priorities were ranked by the participants via an online vote held after the workshop. The priorities can be found in the table 4.

	Challenge	Target	Expected Outcome
1	Predictive maintenance	• Development of new and better sensors. • Creation of new data-analysis tools. • Development of new holistic monitoring tools. • New tests to improve understanding of materials and mechanics.	• Reducing LCOE by decreasing turbine downtime, lowering cascade failures, greater utilisation of the components and better O&M planning strategies. • Increase digitalisation of wind energy assets to improve EU's competitive advantage.
2	From smart turbine to smart wind farm.	Target 1: Operations • Maximise the lifetime of assets by analysing the cost-effectiveness of key components. For some components it could be cheaper to replace them rather than to design robust models (e.g. blades). Target 2: Maintenance • Autonomous solutions for O&M to reduce human interactions.	• Increase value of wind energy by extending lifetime of assets. • New regulatory framework for warranty agreements
3	Lifetime extension.	• Upfront design. • Retrofitting (foundation is the limiting factor). • Development of a holistic approach (technical, digital, HR and all other aspects) to lifetime extension; • Cables (transmission and mooring) are a weak point in wind farm design.	• Increase value of wind energy by extending lifetime of assets. • Avoid shutdowns.
4	Awareness of the environment: external & internal conditions.	• Development of smart virtual sensors. • Development of synthetic, multi-disciplinary sensors. • Design of remote sensing strategies (e.g. LIDAR systems). • Design of smart wind farm control system.	• Intelligent wind turbine control.

Table 4. Operations & maintenance R&I priorities.

2.2 Track 2: Energy System

2.2.1 Grids & System integration

Moderated by Adrian Timbus (ABB) and Hannele Holttinen (VTT).

The moderators split the group into two subgroups. Each subgroup held a free flowing discussion on the various challenges and possibilities for wind energy with regard to the integration of large shares of variable renewable energy into the European grid. In addition they also discussed the benefits of wind energy as a distributed power source.

The subgroups then joined together again to identify and further develop the most pressing R&I challenges. They can be found in table 5. The group identified following benefits of investing in R&I that will facilitate the integration of wind energy into the European energy system:

- Accommodating more renewables in the energy mix will decrease emissions across the EU, most notably that of carbon.
- Distributed power generation will provide more and secure power supply in case of extreme weather events and other extreme events (e.g. terrorism).
- Increased shares of renewables allow the EU to be more energy independent.
- Retaining the EU's competitive advantage. Now the EU still has an advantage in technology and infrastructure vis-à-vis other regions. This leadership needs to be strengthened to remain competitive.

	Challenge	Target	Outcomes
1	Hybrids and storage.	Target 1: Storage • Development of new storage solutions. • Analysis of the benefits of distributed vs. centralised (bulk) storage. • Integration of storage solutions. • Regulation facilitating storage + wind systems. Target 2: Hybrids • Analysis of cost effectiveness of the various hybrid combinations. • Grid code compliance - new ways to fulfil compliance with hybrid systems. • Optimisation of balance of plant of hybrid systems.	• Demonstration of hybrid systems showing value for different markets and services (e.g. ancillary services).
2	Markets and Ancillary Services. *"Demonstrating grid support provision by wind power. Wind power generation can be the backbone of the energy system because of its distributed nature."*	Target 1: Ancillary services • Development of new controls with digitalisation. • Assessment of grid support provision (like curtailments/extra ramping) on asset lifetime. Target 2: Promoting distributed intelligence • Virtual power plant. • Redesign of regulatory framework (market design, tax rule etc.) and other barriers to enable better use of distributed resources. • Prognostics of wind, PV and demand response. Target 3: System stability • System modelling. • Harmonics from offshore. • Improving power quality. • Cybersecurity.	• Demonstration of Ancillary Services: ○ Virtual inertia; ○ Islanding; black start; and ○ Grid forming converters. • Demonstration of system stability value of wind power plants. • Develop digital resilience both internally (wind power plant level) and externally (energy system.

3	Flexibility, balancing & markets.	Target: Demonstrating system value of wind energy • Develop ways to increase electricity demand from flexible sources during surplus generation, via electrification (heat, transport). • Flexibility for balancing: value/cost sharing of system costs, fair cost allocation for flexibility. • Develop new communication channels between power generators and grid operators. • Harmonisation of data across the energy system. • Improve resource forecasting (not just wind).	• Improved digital controls. • Reduced occurrence of negative prices for wind energy. • Modelling balance of grid (geographical /locational also wind energy possibilities of flexibility and grid support). • Smart grid, demand response, electric vehicles and consumer behavior. • New storage solutions for hybrid projects (both onshore and offshore).
4	Grid expansion.	• New resource assessment of wind in remote areas (linked to planning). • Remote areas and offshore spatial planning (regulatory issues).	• Enlargement of the EU grid to encompass new areas suitable for wind power production.

Table 5. Grids & system integration R&I priorities.

2.2.2 Electrification

Moderated by Mattias Andersson (DTU) and Andree Altmikus (Enercon).

The group split into 2 subgroups each tackling some of the identified challenges. The groups focused more on getting a clear understanding of what electrification could mean for the wind energy sector. Instead of identifying research and innovation priorities, they came up with a set of key questions that need to be answered by the wind energy community to take a leading role in the ongoing electrification of the EU's energy system.

	Question	Target	Outcomes
1	What do we need to know?	• Anticipate load changes (e.g. new transportation habits or manufacturing technologies). • Location research: maybe moving power production from where the wind blows to where additional power is needed or to where load can be delayed until wind power is present. • Develop strategies for increase in load or load switching, primarily at times of low demand. • Analysis of a) feeding into the grid versus b) feeding directly into consumer friendly units (batteries & local storage, power-to-gas, charging stations…). • Analysis of what services wind turbines can offer to other machines. • Research the use of block chain technology for wind power production. "Wind turbines as the smartphones of the energy system".	• Better understanding of the customer's needs. • Implementation of greener systems. • Development of a prototype and demonstration project with new, large energy consumers.
2	How to increase load? *"Wind needs to prove it is the best possible partner for electrification."*	What will other sectors expect from us? • Clear and typical production pattern from wind is needed to allow for use in production/electrolysis processes. • Excellent communication on and harmonsiation of power forecasting (based on meteo forecasting) and demand forecasting (e.g. electric vehicles will put a strain on the system if their use is not well synchronised with variable power production). • Digitalisation of wind energy is critical to allow for electrification, because of the need for integration/data sharing procedures. • New concept of transmission lines (e.g. battery to battery using digital lines). • Internet of electricity.	• Creation of new business opportunities (e.g. wind companies becoming energy companies). • Increased sector coupling with electromechanical sector. • Increase electrical demand. • Increase variability of demand (flexible load > flexible demand). • Remove hidden costs borne by TSOs.

3	Electrification & Grids.	• Develop new technical and funding models.
		  ○ EU innovates through synergies;
		  ○ Asia innovates through scale (and is willing to try and fail);
		  ○ Africa innovates through necessity (micro grids, off grid operations etc.).
			• Establish the landscape of the most important players in electrifying the energy system.
			• Promoting wind as the first choice option for new electricity generation.

Table 6. Key research questions on electrification.

2.3 Track 3: Offshore wind

2.3.1 Offshore balance of plant

The group was split into three subgroups by the moderators. Each group was given some pre-identified challenges and topics to develop. The groups were free to add other challenges or research topics to the pre-selected ones. After the mini break-outs, the groups then decided on the five main R&I challenges. The groups then developed the challenges separately. The moderators then collected and consolidated the received input.

	Challenge	Target	Outcomes
1	Bigger turbines put a strain on foundations, substructures and supply chain.	Target 1: foundations. • Analysis of which foundations are best suited to support bigger turbines. Identified foundations are: sackets, BGS, suction buckets and floating. (Monopiles are expected to go "out of fashion" by 2030 due to increased "deep water" (more than 60m) projects). • Analysis of modular foundations. • Analysis of the crossover point between the viability of bottom fixed versus floating wind systems, including shallow waters. • Develop the basic understanding of foundations (monopiles, jackets, suction buckets, others) and soil interaction behavior for optimization. Target 2: substructures. • Develop new and efficient methods and technologies for multi-use substructures (i.e. for various depths). Particularly the development of floating concepts. Target 3: supply chain. • Development of larger components, vessels, port infrastructure, etc. suited to handle 10+ MW wind turbines.	• Small demonstration projects to proof foundation concepts and point out economic and technical relevance. • Numerical tools and lab testing to describe and evaluate new concepts. • New radical designs for deep sea (50-100m) substructures.

2	Optimal offshore grid design.	Target 1: offshore power transmission.
		• Analysis of re-using common components versus the one-size-fits-all principle.
		• Analysis of DC connections.
		  ○ DC creep resilience;
		  ○ Solutions on DC within the wind farm (i.e. move the sub-station converter).
		• Cables.
		  ○ Automated offshore cable repair;
		  ○ Inter-cable lay-out (DC without substations or AC or low frequencies).
		• Questioning the substation.
		  ○ Substation in the foundation, floating, semi-submersible or completely gone?
		Target 2: material research for new dynamic HV subsea cable technology.
		• HVDC (software & control systems)
		• Explore the options with the AC and crossover points between HV and AC.
		• Analyse low frequencies and 50 hertz options.
			• Secure reliable offshore transmission and reduced grid congestion issues.
			• Develop new materials for insulation and mechanical integrity of dynamic subsea HV cables.
			• New cable concepts and materials suited to DC.
			• Reduce curtailment by load switching (maybe on site via synergies with other sectors).

3	Floating vessels for installation of larger turbines and foundations.	Target: reduce installation and O&M costs. • For deeper waters, floating vessels for installation and O&M is very important to reduce costs. The bottom fixed industry, could be the first mover.	• Development of innovative vessels for floating installation and O&M.
4	Macro level European grid.	Target: increase cross border compatibility of offshore infrastructure. • Creating synergies in interconnecting the grid.	• Establishment of a cross-border research project to

		• Analyse DC connections costs, avoid the bottle neck of offshore expansion.	share best practices.
5	Decommissioning and repowering.	Target: secure wildlife and environment. • Define the process and the solutions to ensure the same or increased biodiversity during operations and after decommissioning. • Analysis of how repowering can be done in a more efficient and harmonised way.	• Study on standarisation and harmonization of repowering regulation. • Development of environmental friendly solutions for offshore wind farms.

Table 7. Offshore balance of plant R&I priorities.

2.3.2 Floating wind

The group was split into three subgroups by the moderators. Each group was given some pre-identified challenges and topics to develop. The groups were free to add other challenges or research topics to the pre-selected ones. After the mini break-outs, the groups then decided on the five main R&I challenges. The groups then developed the challenges separately. The moderators then collected and consolidated the received input.

	Challenge	Target	Outcomes
1	Holistic floating wind turbine system design.	Target 1: Streamline and select high value design concepts ready for optimisation. • Analysis of existing design tools and gap analysis. • Unified and integrated design analysis tools to enable system-level studies: wind, wave and soil interaction. • Analysis of wind farm effects on turbines. • Development of standarised templates for floating foundations. • Optimisation of entire system design. Target 2: develop new, innovative and efficient mooring and anchoring technology and systems. • New materials for mooring & anchoring. • New installation techniques (e.g. development of autonomous underwater vessels). • Develop shallow-water mooring techniques. • New models and proof of concept of innovative solutions such as turbine control to reduce mooring/anchoring loads.	• Optimised design and system dynamics of floating wind power plants, including mooring systems, electricity collection system, installation etc. • Improved tools and knowledge for optimal wind turbine and wind power plant design. • Reduce LCOE of floating wind power plants.
2	Preparing floating wind for market uptake and wide scale deployment.	Target: establishing a competition for testing of market deployment and upscaling possibilities. • Develop models, case studies and market assessments on best logistic systems for large scale deployment installation and operation of floating wind farms in various markets. • Need for full size test site with export cables.	• Identification of opportunities to maximise value creation across stakeholder groups. • Increased proof of economic viability of floating systems.
3	Establishing a supportive regulatory framework for floating wind power plants	Target: identify barriers to supporting floating wind farm concepts. • Analysis of bottlenecks. • Develop a clear pathway to operational and commercially viable floating wind farms.	• Levering support from Member States to support floating wind farm projects.
4	Development of stable supply chain.	Target: development of a floating wind supply chain including installation capabilities. • Installation of floating wind in mass numbers requires a well-adapted supply chain. • Modularity in installation could be key concept in reducing the strains on supply chain. • Increasing robotics and automation • Increasing reliability of hoisting systems.	• Development of new floating access systems. • Development of alternative support structures. • Secure health and safety procedures for floating wind.

5	Develop sectoral synergies to increase profitability of floating design concepts	Target: decrease downtime and curtailment.
		• Develop new multi-use system operation techniques (wind-diesel/gas-energy storage) to increase load for offshore wind.
		• Combine/adapt floating wind with/to:
		  ○ Ocean fish farms (water treatment);
		  ○ Power-to-x
		  ○ Oil & gas.
			• Reduced CO_2 and other emissions.
			• Increased sustainability of otherwise polluting economic activities.
			• Increased economic viability of floating wind.

Table 8. Floating wind R&I priorities.

ETIP Wind

EUROPEAN TECHNOLOGY & INNOVATION PLATFORM ON WIND ENERGY

ANNEX 1

Participant list

Tender project number: PP-03041-2014
EC contract 2015/RTD/OP-03041-2014

Participants List

ETIPWind Research & Innovation workshop. Defining wind sector priorities to 2030.

21 February 2018, Thon Hotel Bristol Stephanie, Av. Louise 91-93, Brussels

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Country Manager Belgium, D'Appolonia Belgium NV
56) Uwe Ritschel
Professor, University of Rostock
57) Javier Sanz
Renewable Energies Thematic Leader, INNOENERGY
58) Matthijs Soede
Research Policy Officer, European Commission
59) John Olav Tande
Chief scientist, SINTEF
60) Jan Tessmer
Coordinator Wind Energy Research, DLR - German Aerospace Center
61) Adrian Timbus
Technology and Solutions Manager, ABB
62) Alexander Vandenberghe
Project manager, WindEurope
63) Marcel van Duijvendijk
General Manager, Wind Engineering Solutions
64) Mathieu van Gehuchten
Director, WattElse

65) Tim Van Keulen

Solutions Manager, VBMS

66) Natasja Wanders

Business Manager, IPS Powerful People

67) Hanne Wigum

Head of Renewable Technology R&D, Statoil

68) César Yanes

Engineer, Iberdrola Renovables

69) Alexandre Ziegler

Energy consultant, WattElse

70) Udo Zillmann

Secretary General, Airborne Wind Europe

EUROPEAN TECHNOLOGY & INNOVATION PLATFORM ON WIND ENERGY

Annex 2
PowerPoint presentations

ETIP Wind

EUROPEAN TECHNOLOGY & INNOVATION
PLATFORM ON **WIND ENERGY**

Presentation of ETIPWind

Aidan Cronin
Chair of the Steering Committee

etipwind.eu

21 February 2018

What are ETIPs?

"…European Technology Platforms are **industry-led stakeholder fora** recognised by the European Commission as key actors in driving innovation, knowledge transfer and European competitiveness. These platforms **develop research and innovation agendas and roadmaps for action at EU and national level to be supported by both private and public funding.** They mobilise stakeholders to **deliver on agreed priorities** and share information across the EU."

EUROPEAN TECHNOLOGY & INNOVATION PLATFORM ON WIND ENERGY

WHO

is involved in ETIPWind ?

Turbine Manufacturers

Utilities and developers

Universities, research institutes and consultants

Supply chain

Secretariat

etipwind.eu

Geographical spread

ETIP Wind

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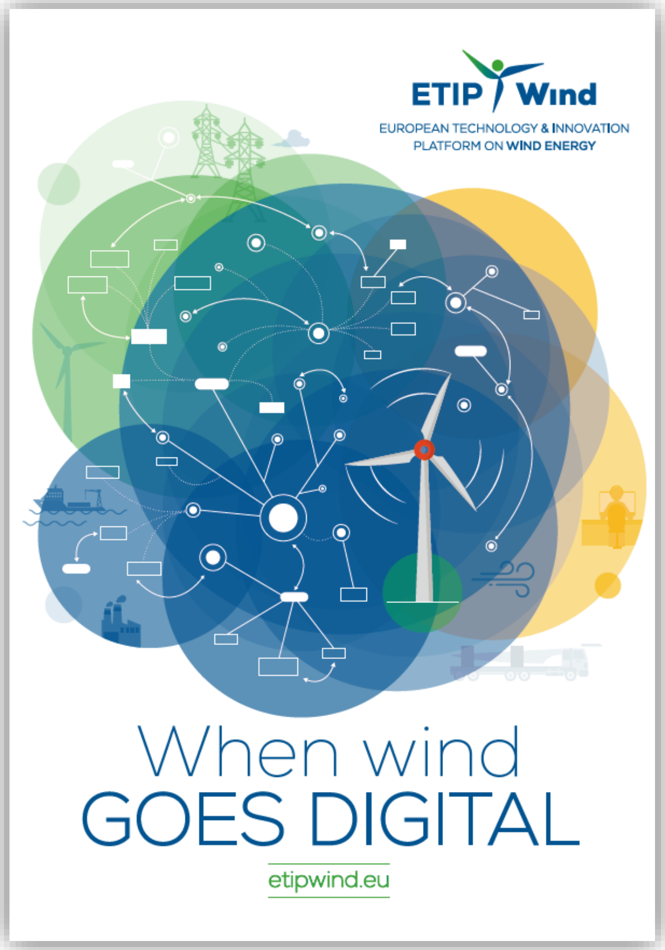
EUROPEAN TECHNOLOGY & INNOVATION PLATFORM ON WIND ENERGY

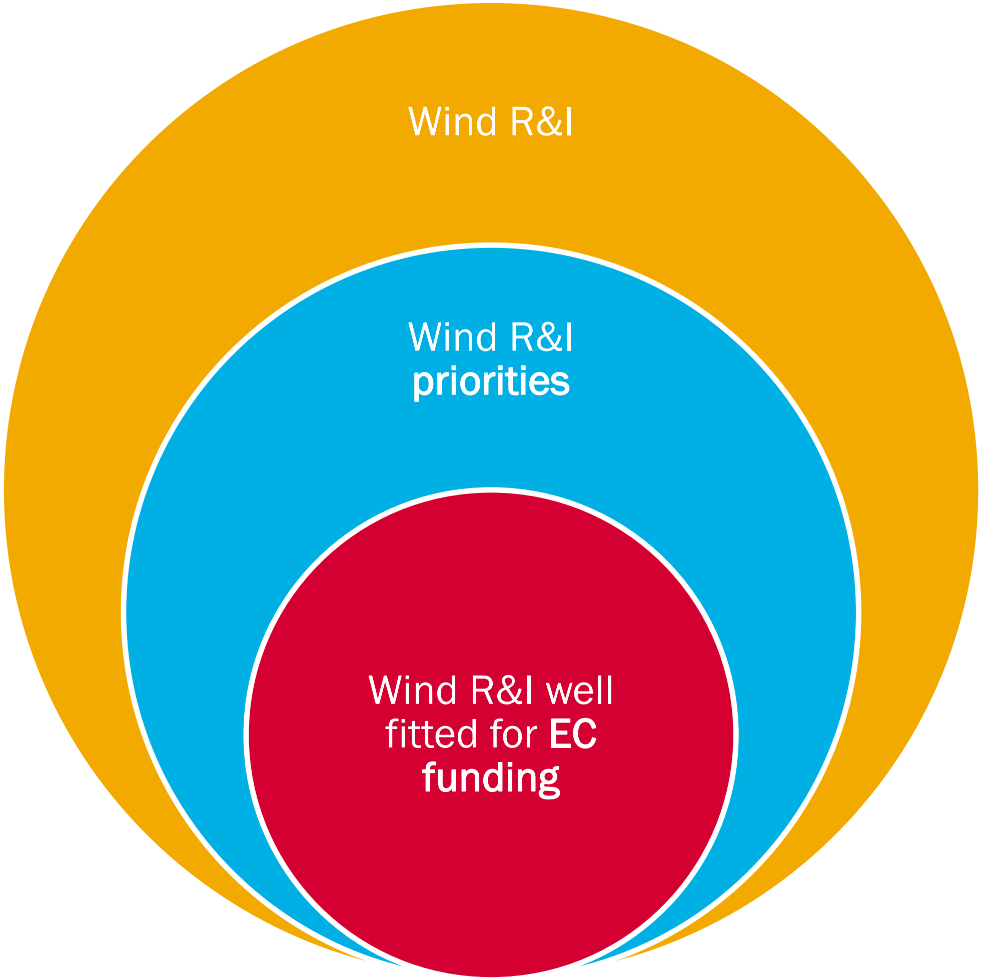
WHAT

Does ETIPWind do?

ETIPWind publications



Scope of the discussion



ETIP Wind

ETIP Wind

etipwind.eu/sria

European Commission

5 Pillars of research and innovation for wind energy

Grids systems, integration and infrastructure

Developing wind energy capabilities to fit in a grid with significant shares of renewable energy.

Operation and maintenance

More and further enhanced sensors enabling more reliable and efficient operation and maintenance of turbines, improving yields and optimising lifetime.

Industrialisation

Developing the value chain and facilitating the interaction between stakeholders notably through standardisation to achieve economies of scale and faster production.

Offshore balance of plant

Exploring new areas for offshore wind and making it competitive with conventional generation through the improvement of substructures and foundations, site access, offshore grid infrastructure, assembly and installation.

Next generation technologies

Consolidating the scientific base for wind research and enabling pioneering research to lead to breakthroughs.

From R&I to deployment

Adapting markets and policies for optimal integration of renewables, integrating wind turbines into their natural surroundings, ensuring public engagement and acceptance and deploying human resources.

Thank You!

#ETIPWind

ETIP Wind

EUROPEAN TECHNOLOGY & INNOVATION PLATFORM ON **WIND ENERGY**

Defining R&I priorities – What has been achieved so far?

Alexander Vandenberghe
Content Coordinator

etipwind.eu

21 February 2018

History of Strategic Research Agendas

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EWEA Strategic Research Agenda (2005)

Policy Background

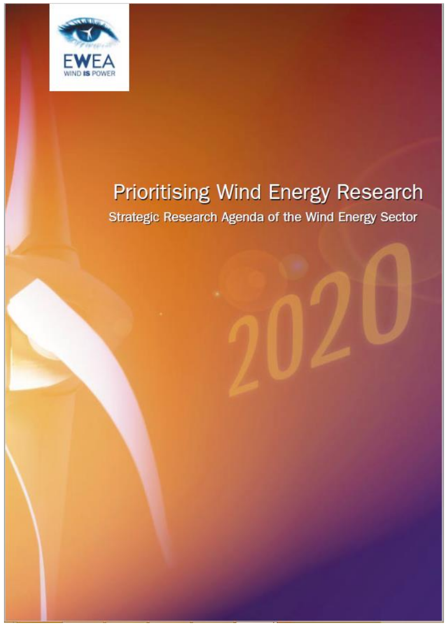
- Launch of FP7 (2007 – 2013).

Timeframe

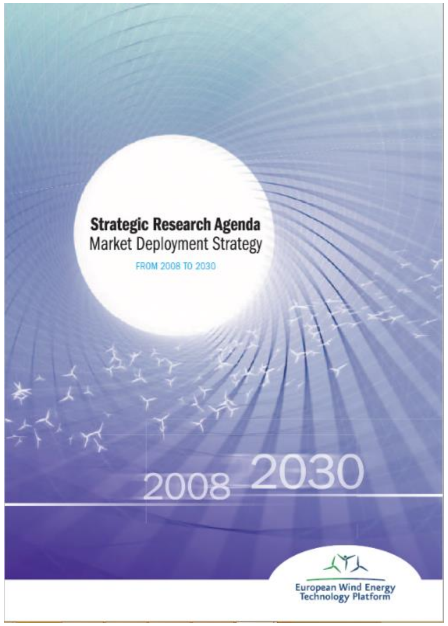
- Medium-long term: 2010 – 2020.

Messages

- Collaborative R&D on EU level needed (public & private);
- Highlighting EU value of wind energy research.



TPWind Strategic Research Agenda (2008)



Policy Background:

- FP7 Work programmes
- European Wind Initiative (2010-2020)

Timeframe

- Long Term: 2030 – 2050

Messages

- Public and private R&D funds to wind energy are needed to reach the EU’s renewable energy targets

TPWind Strategic Research Agenda (2014)

Policy Background:

- Implementation of the European Wind Initiative;
- Prolongation of the SET Plan;

Timeframe

- Medium-long term: 2030.

Messages

- Coordination of public and private R&D funds to maximise the sector's development.

ETIPWind Strategic Research & Innovation Agenda (2016)

Policy Objective:

- H2020 work programme ‘18-’20.

Timeframe:

- Short term: 2020.

Messages

- Collaboration on EU level is critical for the industry to retain its technological leadership & competitive edge.

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European Commission

5 Pillars of research and innovation for wind energy

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ETIPWind Strategic Research & Innovation Agenda (2018)

Policy Objective:

- FP9.

Timeframe:

- Medium term: 2020-2030.

Messages

- *your input here*

Defining R&I priorities - the process

1. Workshop on R&I priorities
    - Starting from a blank canvas
2. Consolidation of strategic priorities (March – April)
    - Comparison with 2014 & 2016 SRIA
    - Matching with EU policies
3. Writing of the SRIA (May – July)
    - “adding meat to the bones”
4. Publication @ Global Wind Summit (September)

What is the aim of the workshop?

Defining the outline for the new SRIA

- Identify key challenges and drivers
- Define pathways to reach the sector’s 2030 objectives
  - Medium term R&I needs (2020-2030);
  - Precise topics suitable for collaboration.

What is the aim of the next SRIA?

Provide a clear message for Framework Programme 9

- Where do we want to go?
- Why do we want to go there? (EU added value)
- How do we get there?
- What are the obstacles along the way?

Highlight the importance of wind energy to the EU;

- Reaching of clean energy targets;
- Global technological leadership;
- Local economic impact.

Workshop Agenda

Time	Track 1	Track 2	Track 3
10:00	REGISTRATION & WELCOME COFFEE		
10:20	OPENING ADDRESS *Introduction to ETIPWind* Aidan Cronin, Chair of the ETIPWind Steering Committee		
10:35	WHAT HAS BEEN ACHIEVED SO FAR? *Presenting the 2016 Strategic Research & Innovation Agenda* ETIPWind Secretariat		
10:50	WHAT ARE THE MAIN CHALLENGES TO TACKLE? Hanne Wigum, Head of Renewable Technology R&D – Statoil		
11:10	HOW TO DRIVE INNOVATION IN WIND ENERGY? Open discussion – (moderator Hanne Wigum – Statoil)		
11:25	BREAK-OUT SESSIONS Move to break-out rooms		
11:30	TRACK 1: TECHNOLOGY	TRACK 2: ENERGY SYSTEM	TRACK 3: OFFSHORE WIND
	Next Gen. Technologies • Data-driven design (turbine, tower etc.) • Real-time data tools • New materials	Grid & System Integration • Energy Management Systems • Digitalisation • Ancillary services • Hybrid systems • Storage	Offshore Balance of Plant • Offshore grid design • Substation design • Reliable transmission
13:00	LUNCH BREAK		
14:00	TRACK 1: TECHNOLOGY	TRACK 2: ENERGY SYSTEM	TRACK 3: OFFSHORE WIND
	Operations & Maintenance • Robotics • Intelligent control • Lifetime extension • Digitalisation	Electrification • Transport • Heating & cooling • Power-to-X	Floating Wind • Floating vs. fixed crossover point • Design concepts • Installation
15:30	COFFEE BREAK		
15:45	CONSOLIDATION WORKSHOP: FINDINGS & NEXT STEPS Panel discussion with track leaders (moderator Aidan Cronin – ETIPWind chair)		
17:00	RECEPTION		

Break-out structure

<table>
<tr><th colspan="5">Research Theme</th></tr>
<tr><td colspan="5">Identify and ranking of R&I challenges
(15 minutes)</td></tr>
<tr><td>1.1</td><td>1.2</td><td>1.3</td><td>1.4</td><td>1.5</td></tr>
<tr><td colspan="5">How will they contribute to the overall objectives
(10 minutes)</td></tr>
<tr><td>Towards wind competitive in a merchant price world</td><td colspan="2">Providing 30% of electricity demand by 2030</td><td colspan="2">Retaining EU leadership in the global market</td></tr>
<tr><td>• A
• B
• C</td><td colspan="2">• A
• B
• C</td><td colspan="2">• A
• B
• C</td></tr>
<tr><td colspan="5">Development of R&I action pathways
(15-20 minutes per challenge - depending on number of challenges)</td></tr>
<tr><td colspan="5">1. Define targets/expected outcomes
2. What (technical challenges & solutions)
3. When (milestones & timeline)
4. Who (what stkeholders to be involved)
5. Why (highlight EU and societal relevance)</td></tr>
<tr><td colspan="5">Consolidation and wrap-up
(5 minutes)</td></tr>
</table>

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EUROPEAN TECHNOLOGY & INNOVATION PLATFORM ON WIND ENERGY

Annex 3
Break-out findings

EUROPEAN TECHNOLOGY & INNOVATION PLATFORM ON WIND ENERGY

Track 2
Grids & system integration

Grid & System Integration - introduction

- Energy Management Systems
- Digitalisation
- Ancillary services
- Hybrid systems
- Storage

- Flexibility, stability/inertia, markets

Workshop agenda

- identify challenges
  - ranking to choose 3-5
- contribution to general objectives
  - Towards wind competitive in a merchant price world
  - Providing 30% of electricity demand by 2030
  - Retaining EU leadership in the global market
- discussion on R&I action pathways

1. Define targets/expected outcomes
2. What (technical challenges & solutions)
3. When (milestones & timeline)
4. Who (what stakeholders to be involved)
5. Why (highlight EU and societal relevance)

Goal: scope of challenge and benefits of tackling it
WHAT - WHY - IMPACT

Stability of power system / Ancillary Services

- Demonstrating capabilities
  - virtual inertia
  - island mode, black start, grid forming converters
  - new controls with digitalization, also lifetime impacts of curtailments etc
- AS provision in markets, cost compensation
- Distributed intelligence /digitalisation
  - virtual power plants, regulatory, prognostics of wind/PV, DR,
- Extreme events resilience
- Stability: system modelling also harmonics from offshore, power quality

FLEXIBILITY/BALANCING, MARKETS

- System value of wind /negative prices
- Value/cost sharing, fair cost allocation for flexibility
- Forecasting, also resource, also other than wind
- Modelling balance of grid geographical/locational also wind
  - integration/data/control capabilities/system wide
- System operator challenges, demo, trust from wind being part of system
- Smart grids, DR, EVs, consumer behavior also for storage investments

Storages / Hybrids

- Storages
  - integration, storage development, regulation for use of storages (by also grid operators etc)
  - distributed/centralized storages
- Hybrids:
  - cost effective/combination
  - grid code compliance
  - value for different markets/services
  - optimising balance of plant

Grid expansion

- remote areas and offshore special planning, regulatory
- resource assessment of wind linked with planning

Benefit to Europe

- Accommodating more wind /carbon neutral targets
- Improving security of supply
- Global leadership
  - developing system friendly wind power and
  - knowlegde of integration and system operation with high shares of wind

ETIP Wind

EUROPEAN TECHNOLOGY & INNOVATION PLATFORM ON WIND ENERGY

Track 3
Offshore Balance of plant

BoP - Group 2

A) Consider research project to take into account compatibility between countries: Macrolevel European grid. To avoid the bottle neck of offshore expansion & to learn from each-other.

Challenge: Macrolevel European grid.

To look for synergies in interconnecting the grid.

DC connections – costs (protected market)

BoP - Group 2

B) **Which fixed foundation type would you like to have in the future to cope with larger turbines (frequencies)?**

Challenge: Monopiles won't be used anymore (mainly North Sea with shallow water). Not for deeper water, (up to 60 meters), Jackets even BGS.

Goal:_Point out what would be relevant economically and technically.

Who:_Technology developers – engennerries consultancy – start- ups – installations companies (vessels to be handle the larger foundations). – owner operators.

Remark: Relative framework to be harmonised in EU.

Design guidelines – greater data on soil. – O&M on land.

BoP - Group 2

C) **Which type of Electrical architecture we would like to have in the park? To remove the sub-station**

Intercable lay-out (DC without substations or AC or low frequencies).

HVDC (softwares & control systems) is a challenge technically. Lack of consistence.

Explore also other solutions on DC within the wind farm. (to move the sub-station converter). Or to remove the sub-station

Explore the options with the AC and cross points between HV and AC.

Explore

- Reliable transmission:
- HVDC is digital, software. MMC technologies.
- Switched gears for HVDC:
- Low frequencies options.
- Explore the 50 hertz options
- or more HVDC solutions

BoP - Group 3

A: Challenge: Floating vessels for installation of larger turbines, foundations, cables, substations

Why: For deeper waters, floating installation and O&M is very important to be able to do – also for the bottom fixed industry, which could pave the way

What: Development of vessels for floating installation and O&M

When: Now

Who: Vessel designers; Contractors

BoP - Group 3

B: Challenge: To develop the basic understanding of foundations and soil interaction behaviour for optimisation

Why: With larger turbines, there is a need to develop larger, optimised foundations – and in new soil types in the rest of the world

What: Monopiles, Jackets, Suction buckets, others

When: Now

Who: Industry and academia

BoP - Group 3

C: Challenge: To reduce cost for development of larger offshore wind turbines and the supply chain that follows with the requirement for larger components, vessels, harbours, etc..

Why: Supply chain development is expensive

What: How can the supply chain development be made cheaper? Can we utilize the European supply chain development experience in the in the rest of the world?

When: Now

Who: ?

BoP - Group 3

D: Challenge: There is an increasing congestion of the grid as more offshore wind is produced and added into the system.

Why: There is a need for solutions that can help both offshore wind farms and the system handle this challenge

What: ?

When: Now

Who: Technology developers; Wind farm owners; System operators;

BoP - Group 3

E: Decommissioning and Repowering: What is the process, what are the solutions, and how do we ensure the same or increased biodiversity during both operation and after decommissioning?

Why: The environment should not be harmed

What: There is a need for cheap environmental solutions. There is also a need to understand how repowering can take place in an efficient way

When: 5-10 years

Who: Authorities; Developers;

BoP – Group 3

Other aspects:

Health and Safety and Environment should be considered across all aspects off offshore wind

Offshore BoP: Foundations, Soil, Scour, Marine

- **Title: Site characterization for improved design basis**
- **Specific Challenge**: Improve design basis for offshore wind farms and provide better measurement methodology and modelling systems for characterization of **met-ocean and soil conditions**.
- **Scope**: Multiscale environmental modeling; Met-ocean measurement methods; Ground model development
- **Expected impact:** Improved design basis for offshore wind farms; Better measurement and modelling systems for site characterization; 5 -10 % reduction of LCoE
- **TRL: NA**
- **Time needed: 4 years**
- **Budget needed: 10 MEUR**

Offshore BoP: Electrical systems

Electrical systems

- **Title: Electrical infrastructure**
- **Specific Challenge**: Develop tools and technologies for reliable and cost efficient grid connection of large offshore wind farms and clusters of wind farms
- **Scope**: Component modeling for electrical stress and interaction analysis; Collection and transmission system design tools and application analysis; Lab testing of new technologies
- **Expected impact:** Frequency-dependent component models for predicting overvoltage and harmonics; Tools for system level electrical design; Extended HVAC transmission; 5-10 % reduction in LCoE
- **TRL: 2-4**
- **Time needed: 4 years**
- **Budget needed: 10 MEUR**

Offshore BoP: Electrical systems

Electrical systems

- **Title: Material research for new sustainable cable technology**
- **Specific Challenge**: Develop / identify new materials for insulation and mechanical integrity of subsea cables, both inter array and exports.
- **Scope**: Material research; Collection and transmission system design tools and application analysis; Lab testing of new technologies
- **Expected impact:** Environmental sustainable materials, less damages during installation and operation, Extended HVAC transmission; 5-10 % reduction in LCoE
- **TRL: 2-4-6**
- **Time needed: 4 years**
- **Budget needed: 10 MEUR**

Offshore BoP: Installation

- **Title: Design analysis of support structures, transportation and installation (holistic approach)**
- **Specific Challenge**: Develop new and efficient methods and technologies to support innovations in design and installation of offshore wind turbine foundations and structures
- **Scope**: Integrated design assessment and optimization of substructures and foundations; Loads and response modelling; Transport and installation
- **Expected impact:** Best practice for integrated design and optimization of substructures; Reduced uncertainties in analyses; Optimize logistics for transport & installation; 5-10 % reduction of LCoE
- **TRL: 2-4**
- **Time needed: 4 years**
- **Budget needed: 10 MEUR**

Offshore BoP: Asset management

- **Title: Asset management of Offshore BoP components / condition monitoring / failure mechanisms**
- **Specific Challenge**: Develop new methods, tools, and advanced technologies for operational control and maintenance for large offshore wind farms.
- **Scope**: Model-based RT control algorithms for minimizing LCoE; Health monitoring and inspection systems; Optimal logistics & maintenance
- **Expected impact:** Methods for model-based wind farm control; Sensors and numerical models for health monitoring; Improved access systems and decision support models for maintenance planning; 5 % reduction in LCoE
- **TRL: 3-5**
- **Time needed: 4 years**
- **Budget needed: 10 MEUR**
-

Offshore BoP: Open access data

- **Title: offshore wind farm for research and innovation**
- **Specific Challenge**: Provide open access to data and pronounced opportunities to carry out test and measurement campaigns. Industry platform providing open data, integrating this into existing business and research, ensuring feedback loops.
- **Scope**: Mechanical structural loads and vibrations; Materials properties and degradation; Monitoring, communication and control systems; Electrical systems and grid interactions; Operation and maintenance; Met-ocean conditions and fluid dynamics; Health, safety and environment. The exact scope will depend on the agreements that can be made with industry on open access, e.g. it can be limited to some very specific measurement campaigns.
- **Expected impact:** An internationally unique platform for research and innovation that will contribute significantly to value creation and cost reductions for offshore wind energy.
- **TRL: 2-5, possibly also higher, pending on scope**
- **Time needed: 4 years**
- **Budget needed:** the budget shall be for the cost related to the agreed measurements or tests, including access costs, costs for preparing measurements/tests and for the administration of these, e.g. cleaning of data and storage in database.

Offshore BoP: System engineering

- **1. Title: Systems Engineering of Wind Power Plants**
- 2. **Specific Challenge**: Optimize the design and system dynamics of wind power plants and plant clusters, considering the relevant physical processes (e.g. turbines, grid, atmosphere) and stakeholders (e.g. manufacturers, plant owner/operators, grid operators, landowners)
- 3. **Scope**: Unified dynamic analysis tools to enable systems-level studies; Model validation with measurements at operating plants; International optimization competitions through IEA Wind Task 37
- 4. **Expected impact:** Improved tools and knowledge for optimal wind turbine and power plant design; Identify opportunities to maximize value creation across stakeholder groups; Increased profitability
- **5. TRL: NA**
- **6. Time needed: 4 years**
- **7. Budget needed: 10 MEUR**

ETIP Wind

EUROPEAN TECHNOLOGY & INNOVATION PLATFORM ON WIND ENERGY

Track 3
Floating wind

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Floating wind: holistic design

- **Title: Holistic floating turbine system design**
- **Specific Challenge**: Optimize the design and system dynamics of floating wind power plants, considering mooring system, el collection system, installation, etc.
- **Scope**: Unified integrated design analysis tools to enable systems-level studies; wind, wave, soil interaction; optimization of whole system
- **Expected impact:** Improved tools and knowledge for optimal wind turbine and power plant design; Identify opportunities to maximize value creation across stakeholder groups; Increased profitability
- **TRL: 2-4**
- **Time needed: 4 years**
- **Budget needed: 10 MEUR**

Floating wind: new dynamic HV subsea cable

- **Title: Material research for new dynamic HV subsea cable technology**
- **Specific Challenge**: Develop / identify new materials for insulation and mechanical integrity of dynamic subsea HV cables
- **Scope**: Material research; Lab testing of new technologies
- **Expected impact:** enable large floating wind farm with dynamic HV subsea cable
- **TRL: 2-4-6**
- **Time needed: 4 years**
- **Budget needed: 10 MEUR**

Floating wind: logistics

- **Title: Logistics of development, installation and operation of large scale floating wind for various markets**
- **Specific Challenge**: Develop / identify the best logistic system for large scale development, installation and operation of floating wind for various markets
- **Scope**: Develop model, case studies, market assessment
- **Expected impact:**
- **TRL: 2-4-6**
- **Time needed: 4 years**
- **Budget needed: 10 MEUR**

Floating wind: substructures for various depths

- **Title: Substructures for various depths**
- **Specific Challenge**: Develop new and efficient methods and technologies for substructures for various depths
- **Scope**: Describe and evaluate new concepts by numerical tools and lab testing
- **Expected impact:** New substructures for 50-100 m water depth. Radical new design concepts.
- **TRL: 2-4/5**
- **Time needed: 4 years**
- **Budget needed: 10 MEUR**

Floating wind: mooring and anchoring

- **Title: Mooring and anchoring system**
- **Specific Challenge**: Develop new and efficient mooring and anchoring technology and systems. New innovative concepts
- **Scope**: Models and concepts, e.g. use turbine control to reduce mooring/anchoring loads. New materials for mooring and anchoring. Installation.
- **Expected impact:** Radical new design concepts. Lower LCoE.
- **TRL: 2-4/5**
- **Time needed: 4 years**
- **Budget needed: 10 MEUR**

Floating wind: multiuse

- **Title: Multiuse of floating wind to increase synergies and profits**
- **Specific Challenge**: system operation (wind-diesel/gas-energy storage)
- **Scope**: Combine / adapt floating wind with ocean fish farms; power to x; supply to oil and gas platforms
- **Expected impact:** reduce CO_2 emissions from ocean fish farms, oil & gas platforms, etc
- **TRL: 1-5-9**
- **Time needed: 4 years**
- **Budget needed:**
-

Floating wind

- **Floating vs fixed crossover**
- Comparison of floating foundation concepts and respective impacts, e.g. on environment in order to point out the future best-practice
    - Mitigation of environmental impact; Multi-use – concepts with aquaculture
- Floating wind in shallow waters – where is the crossover point to fixed foundations – what is shallow waters in that sense?
- **Maintenance & Installation**
- Modularity in installations of floating wind turbines
- Mooring systems for shallow waters
- Installation of mass numbers of floating wind is hindered by the whole value chain – identification of bottlenecks in the value chain (logistics, installation etc.)
- **Design concepts**
- Modularity of wind turbines // Scaling – limitation of turbine size?
- Standardised modular templates for floating foundations
-

Floating wind

- Get supply chain in order, harbor space, series production
  - Target: development of supply chain, including harbor development and installation capabilities
  - Outcome: series production and cost reduction
- Floating to floating access and hoisting
  - Target: development access system + increase reliability or increase automation and robotics to reduce human intervention
  - Outcome: save accessibility – avoid access by humans
- Dynamic power cable connection
  - Target: assess reliability electrical connection- develop innovative connection – develop underwater plug
  - Outcome: reliable cable connections

Floating wind

- Lightweight, affordable support structures, integrated design to carry large turbines – moving to shallower water, Stability for floating structures in extreme conditions
  - Target: accurate integral design tools, integrated design, sharing information among supply chain (use turbine info for design of floater)
  - Target 2: create demonstration project for creation of open access datasets
  - Outcome: Lightweight, affordable support structure design
- Specific design of turbines for floating wind (control, components, reliability, acceptability criteria)
  - Target: get site data
  - Outcome:
- Track towards commercialization – is a standardized approached necessary or do we need site-specific design
  - Target: identify barriers, identify a location for a demonstration floating wind farm, convince a government to sponsor the first demonstration project.
  - Outcome: a clear path towards commercialization is defined and the bottlenecks identified leading to commercially operated wind farms

–

Floating wind

- Wind / wave movement interaction
- Installation
- Harbors / floating harbors
- Special turbine for floating operation, e.g. for horizontal transport
- Competition on floating concepts like Carbon Trust did for bottom fixed to narrow down viable concepts
- Mooring and anchoring system
- HSE
- Revisit standards for cost optimized design
- Lifetime corrosion
- Power to x (floating data storage)
- Strong international competition; important for Europe to be in the lead
- Combination with storage for far offshore to reduce required transmission capacity

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Thank You!

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