ETIPWind Roadmap

Operations & maintenance

ETIP Wind
EUROPEAN TECHNOLOGY & INNOVATION PLATFORM ON WIND ENERGY

etipwind.eu

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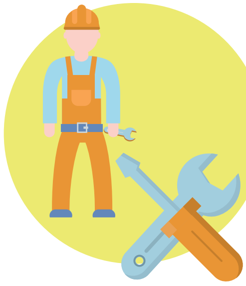

Operations & maintenance

Operations & maintenance (O&M) lies at the core of wind energy technologies. The O&M sector is a highly competitive arena for the wind energy industry. Next to the wind turbine manufacturers, there are now many specialised companies providing O&M services. This means that, for manufacturers, service contracts only make up between 15 and 20% of the annual revenues.[1] At the same time, it is estimated that operational costs for wind projects can account for up to 20% of the total budget.[2]

As such, technology development in O&M is mostly covered by the private sector. Still there needs to be more research in transversal areas such as automation, robotics and big data analytics. Cybersecurity will also grow in importance as the wind sector becomes increasingly reliant on digital technologies to communicate and integrate with other actors in the energy system.

In terms of operations, the focus for research and innovation should be on improving the overall performance of the technology at the lowest possible cost (seen from a lifetime point of view). With regard to maintenance, research should focus on improving condition monitoring and reducing manned interventions to a bare minimum (e.g. by enhancing automated repair methods).

Challenge 1

Optimising operations

Wind turbines are exposed to a wide variety of weather phenomena including extreme winds, lightning, frost and heat. These external conditions are highly variable and turbines are built to endure them all during their lifetime. However, due to these ever-changing external conditions, wind turbines experience a wide range of changing loads. These loads build up stress levels in key components such as blades and generators.

More accurate understanding of the stress levels in critical components is vital to ensure wind turbines operate at their optimum capacity. Better performance management will allow the asset to be operational for a longer period of time and increase the value of each MWh produced. To do so, operators will need to connect and aggregate real time data from the turbine components. The amount of data gathered for analysis will require new big data analytic techniques and solutions using the development of artificial intelligence.

Challenge 2

Increasing energy availability

Operating wind power plants is very different from operating conventional energy plants. Wind power plants often comprise multiple connected, yet independent assets that are geographically distributed. So wind operations come with a unique set of challenges, of which we underline two.

Firstly, unlike conventional power plants, wind turbines are often installed in more remote and less densely populated areas. This makes it often difficult to get the people, materials and components to the asset on time, especially when an unexpected error occurs. The sector's priority is to prevent unexpected failure modes, but research and innovation in digital solutions and remote sensing will help increase the active range of operations and maintenance personnel in case an error occurs.

Secondly, wind farm operators and portfolio managers also operate and maintain a large amount of assets compared to conventional power plant operators. More research into digital portfolio management systems will help ensure operators can optimise power production at fleet level rather than at individual turbine level. In addition, as more and more wind turbines assets are installed, operators will also need to develop comprehensive decommissioning strategies to deal with the number and variety of assets that will reach the end of their designed life in the coming years. Decommissioning strategies and technology need further development.

Wider regulatory requirements

Standardisation and harmonisation of regulatory requirements will simplify manufacturing, installation and operational procedures and bring additional cost reductions. This is especially true for the offshore wind sector. Based on the recommendations of the North Seas Energy Forum, the wind energy sector calls for:

- Standard recognition and/or harmonisation of certification standards for crew and technicians and the alignment of crew requirements;
- Standard definition, recognition and/or harmonisation of certification standards for waste maritime operations; and
- More flexible regulatory requirements for park layout to allow optimal yields. In particular, straight lines should be avoided.

As 20 GW of installed capacity will reach the end of its designed life by 2022, decommissioning and dismantling will become an essential part of the wind energy business.[3] To ensure safe and cost-effective decommissioning across Europe, we call for policymakers to:

- Standardise and align the requirements for wind farm developers across Europe with sector developments.

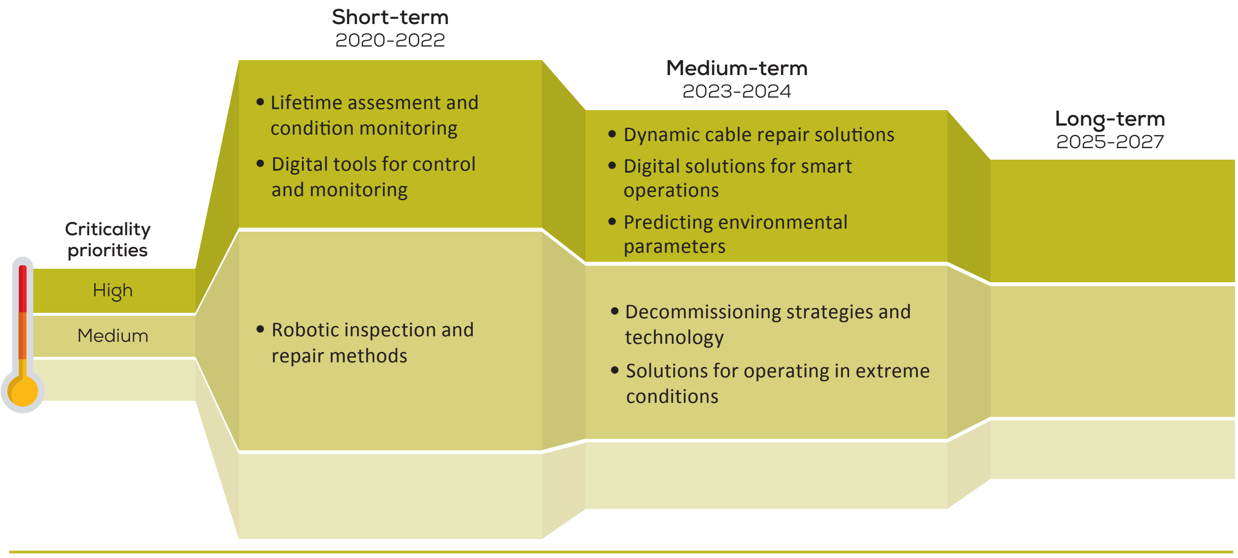

Figure 1 Research & Innovation action areas for operations & maintenance

Challenge 1.1

Optimising operations

Lifetime assessment and condition monitoring	Short-term	High priority

Description and scope

Predicting the remaining lifetime of wind energy assets will allow operators to make better informed decisions on whether to optimise or extend the remaining lifetime or to plan for decommissioning and recycling of the assets.

All critical components have to be assessed in order to make the best possible business decision. For some components (e.g. transformers), there are established common practices with regard to lifetime assessment/replacement. But for many others there is a clear need to establish better assessment protocols, the priority components are blades, foundations, anchor bolts.

Recommended research actions

- Industry assessment of instrumentation – identify what available instrumentation is not commonly used in the wind industry and which tools used need significant improvement.
- New instrumentation to assess actual condition of components, including models that can predict the lifetime of a component.
- Development of new measurement tools for shorter and more accurate site inspections.
- Development and validation of models' remaining lifetime per component and for full system assessments based on additional Condition Monitoring Systems data.
- Identification, development and assessment of new lifetime extension methods, including component replacement/repair and adjusting operational procedures.
- Development of comprehensive methodology to take optimal commercial decisions based on new digital architecture using big data analytics and machine learning.
- Development and validation of new models and standards to extrapolate data values from singular wind turbines to entire wind farms.

Milestones

- Comprehensive overview of lifetime assessment tools and instruments.
- Increased prediction performance of component lifetime assessment models.
- Increased use of machine learning in the wind industry.

Challenge 1.2

Optimising operations

Digital tools for control and monitoring	Short-term	High priority

Description and scope

Turbines have an increasingly data-driven approach, and to unblock all their potential they need to be supported by the most innovative digital tools for the control and monitoring of activities, (e.g. augmented reality, virtual reality, big data, artificial intelligence, etc.).

These tools could enable the optimisation of operational activities (and their management), making them safer, more efficient in terms of time and cost, and more easy to plan.

Recommended research actions

- Development of new digital tools for onsite operations;
- Development of new/improved digital tools for data collection, analysis and visualisation.

Milestones

- 'Digital twin' projects for prognosis of failures in main components and lifetime evaluation.

Challenge 1.3

Optimising operations

Digital solutions for smart operations	Medium-term	High priority

Description and scope

Digitalisation and the use of Artificial Intelligence (AI) will have a large impact on the wind energy industry and society at large. In order to fully benefit from this, it is necessary to:

- understand the technologies;
- investigate the possibilities;
- develop and demonstrate the solutions;
- understand the risks; and
- have methods for verifying these solutions.

It is important that the research carried out is generic in nature and easily generalisable. Finding the right digital solutions will bring a huge benefit to the European wind industry, with European players and assets potentially emerging as world leaders within this new field.

Recommended research actions

- Develop digital/AI solutions that significantly reduce costs of operations (followed by development and maintenance of onshore and offshore wind farms).
- Establishing a common research framework for evaluating the risks associated with digital/AI solutions, including cyber security aspects.
- Development and validation of models to verify the performance of digital/AI solutions.

Milestones

- Comprehensive technology maturity framework for digital/AI technologies applicable to wind energy.
- Through the use of digital/AI solutions the Levelised Cost of Energy (LCoE) of demonstrator wind farms (off- and onshore) has been significantly reduced.
- A risk framework for digital/AI solutions in wind energy.
- A verification framework for digital/AI solutions in wind energy.

Challenge 1.4

Optimising operations

Prediction of environmental parameters	Medium-term	High priority

Description and scope

The prediction of environmental parameters (wind and wave) has been an important research topic from the very start of the wind energy industry. As the turbines get bigger and taller and the wind farms get larger new issues and challenges arise (e.g. related to atmospheric boundaries) so that the topic still has continued relevance. The increase in the number and size of offshore wind farms has opened up a new field of wind-and-wave interaction. Understanding the environmental parameters will assist in the continuous drive to lowering the Levelised Cost of Energy (LCoE) on the pre-construction, construction as well as the operations side.

Recommended research actions

- Fundamental research in wind energy turbulence such as demonstration and validation models for out-of-boundary layer flow.
- Improved measurement devices and methods for all environmental parameters (e.g. wind and wave).
- Next generation models for environmental parameters (e.g. wind and wave).
- Prediction models for average quantities of environmental parameters, including the associated uncertainties.
- Models for the prediction of extreme values of environmental parameters, including the associated uncertainties.
- Research into the application of Artificial Intelligence (AI) in the prediction of environmental conditions.
- On-site experiments measuring all environmental parameters at a high temporal and spatial resolution.

Milestones

- New model for atmospheric turbulence.
- New measurement devices for environmental parameters developed.
- Next generation models for environmental parameters developed.
- Next generation models for extreme values of environmental parameters.

Challenge 1.5

Optimising operations

Solutions for operating in extreme conditions

Medium-term

Medium priority

Description and scope

Today wind turbines are forced to be stopped in cases of extreme conditions, at the cost of productivity and revenues. The technical challenge is to provide new/improved solutions for safely maintaining turbines in operation.

Recommended research actions

- Development of new/improved coatings (hydrophobic) for an anti-icing solution.
- Development of an improved and more reliable ice detection system.
- Development of a more efficient and cheaper de-icing system.
- Development of an improved control system able to manage unexpected loads due to extreme weather conditions.

Milestones

- In-field demonstrations.

Challenge 2.1

Increasing energy availability

Robotic inspection and repair methods	Short-term	Medium priority

Description and scope

Electronic inspection methods, like drones, robots and Automated Underwater Vehicles (AUV), started to be tested in wind activities because of the significant advantages that could provide in terms of efficiency and safety of operations. This services need to be completely validated/consolidated, in order to unlock their potential for new applications.

Recommended research actions

- Demonstration of testing methods to enhance understanding and knowledge about new applications of drones, robots and AUVs (not only for inspection, but also for coating, measuring, cleaning, repairing, etc).
- Development of new/improved models of drones, robots and AUVs, allowing more autonomy and flexibility of (remote) operations and inspections.
- Common European Regulation for the use of drones and AUVs.
- Development of tools/models for better integration on maintenance activities (i.e. artificial intelligence, image treatment, new sensors and capabilities, etc.).

Milestones

- Development of new applications (not only inspection) by 2020.
- Improved reliability of operations.
- Common European Regulation by 2020.

Challenge 2.2

Increasing energy availability

Decommissioning strategies and technology	Medium-term	Medium priority

Description and scope

As the wind industry matures, more and more assets are reaching their end of life. This means that research must be carried out to decommission the ageing assets as effectively, efficiently, and environmentally friendly as possible. Balancing these and many other factors is a challenge that needs research. Waste management, particularly of composite materials, should be addressed according to the recommendations stipulated in the chapter on next generation technologies.

The research will need to cover a wide variety of scientific disciplines including materials science, logistics, regulations, economy, structural engineering, circular economy, health, safety and environment and recycling. Lessons can be learned from the oil & gas sector regarding decommissioning of offshore platforms.

Recommended research actions

- Mapping of required scientific and technical disciplines within decommissioning technology.
- Development of decommissioning methods and procedures taking the required combination of scientific and technical disciplines into account.
- Development of decommissioning technologies for offshore wind. Including monopile extraction (e.g. over-pressure, vibro-extraction) and new cutting tools for subsea bed cutting.
- Formulation of decommissioning demonstration projects.
- Development of decommissioning vessels specifically suited to offshore wind, building on experiences from the oil & gas sector (e.g. lessons learned from "pioneering spirit" vessel).
- Development of economic model for full decommissioning project cycle, including a cost/benefit analysis.

Milestones

- Mapping of scientific and technical disciplines necessary for successful decommissioning.
- All-encompassing multi-discipline methods developed for decommissioning on- and offshore wind farms.
- Decommissioning methods demonstrated on two wind farms at their end of life.
- Economic model for decommissioning project cycle validated at demonstration wind farms.
- Results published in peer-reviewed journals.

Challenge 2.3

Increasing energy availability

Dynamic cables repair solutions	Medium-term	High priority

Description and scope

Dynamic cables for bottom-fixed turbines as an alternative to a Cable Protection System may introduce new lateral oscillation modes. Floating solutions introduce stress levels/modes normally of concern during installation (monitored).

There is currently a lack of monitoring cables after installation. This, combined with the dynamic movement in a number of planes/frequencies and the addition of longitudinal forces may lead to new types of failures (i.e. bird caging/screen damage).

The "new" cable dynamics and resulting failure modes for the above installations will require a new approach to design stage modelling, failure detection and repair methodologies which are yet to be understood.

Recommended research actions

- Repair methods for bottom-fixed dynamic cable failures.
- Create comprehensive overview of existing repair methodologies and concepts all Technology Readiness Levels (TRL) - cable-to-cable joint damages, intra-cable damages.
- Analyse advantages and disadvantages of systems to prevent damages, e.g. bend restrictors (limiting bending, increasing thermal insulation), adding "S" spring flexibility to rising cables.
- Floating wind has a set of specific challenges which are addressed in the section on floating offshore wind. It suffices to say that more research is needed to:
  - Improve understanding of dynamic cable failures. Dedicated analysis of which floater concept will increase stress and fatigue on dynamic cables.
  - Identify changes in failure modes, estimate impact on failure frequency and severity and anticipate the signals in Cable Management Systems (CMS) that would provide ad-hoc and predictive failure detection.

Milestones

- Map of available repair technologies and concepts of all Technology Readiness Levels by 2022.
- New damage prevention systems on the market by 2024.

References

1 ETIPWind analysis of financial statements.
2 Wind Turbine Condition Monitoring: State-of-the-Art Review, New Trends, and Future Challenges. Pierre Tchakoua, René Wamkeue, Mohand Ouhrouche, Fouad Slaoui-Hasnaoui, Tommy Andy Tameghe and Gabriel Ekemb. Energies 2014, 7, 2595-2630; doi:10.3390/en7042595.
3 Based on WindEurope market analysis.

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