

WILLOW delivers breakthrough technologies for smarter and longer-lasting offshore wind farms

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Smart monitoring and predictive maintenance extend the lifetime of offshore wind farms

The project's final results were showcased to the wind energy sector at the WindEurope Technology Workshop in Rotterdam, highlighting new approaches to lifetime extension, predictive maintenance, cybersecurity, and health-aware wind farm operation.

After three years of research and innovation, the Horizon Europe project WILLOW *(Wholistic and Integrated Digital Tools for Extended Lifetime and Profitability of Offshore Wind Farms)* has delivered its final results. The project provides offshore wind operators with innovative digital tools and monitoring technologies to improve asset reliability, sustainability, and operational performance. These solutions also support data-driven lifetime extension and more cost-effective asset management.

Discover all the results of the WILLOW project

Would you like to learn more about the technologies and innovations developed within WILLOW? Discover the key research results on corrosion monitoring, cybersecurity, predictive maintenance, and smart wind farm management in the final publication.

Download the final publication

Available in English only

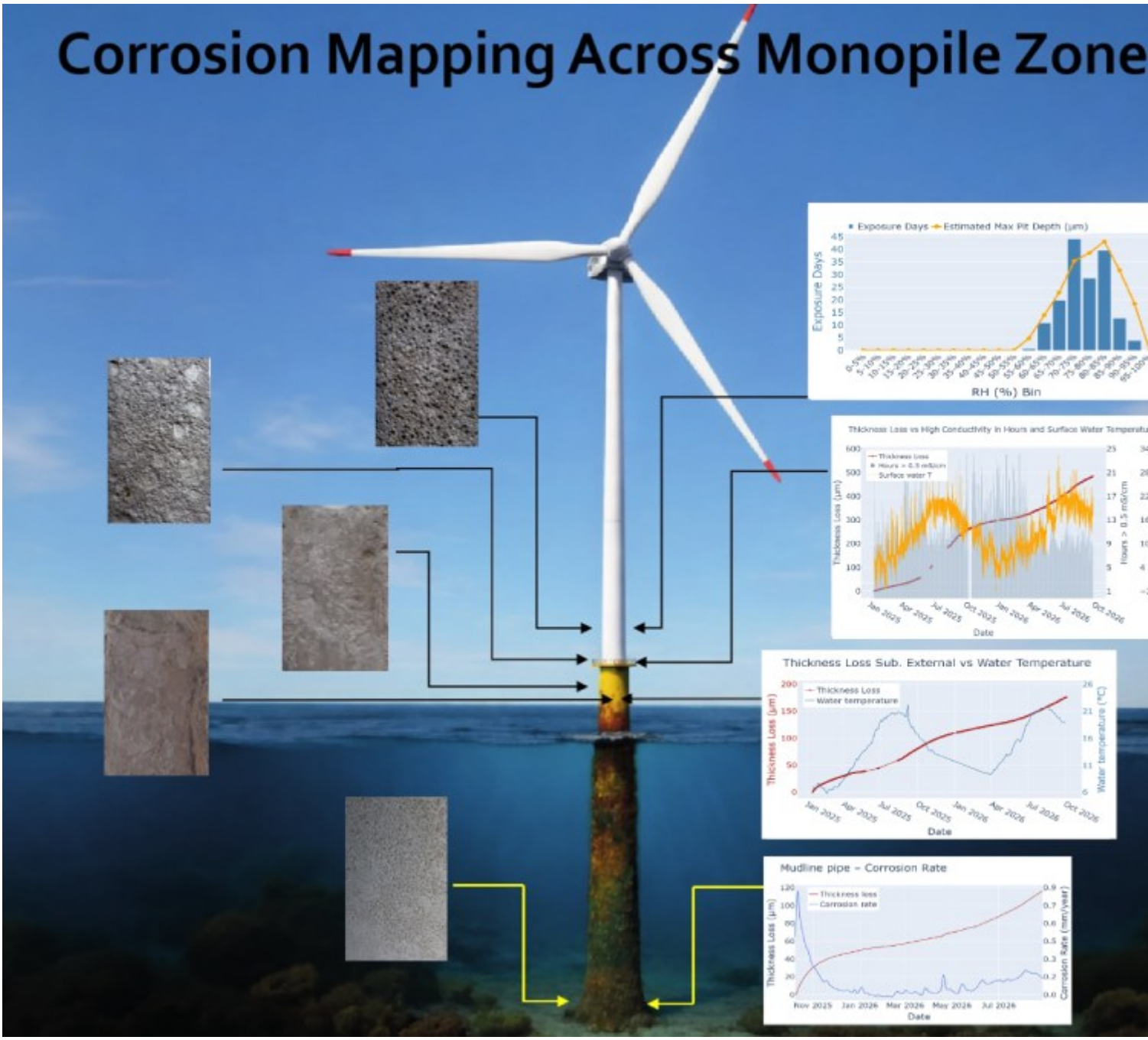


Figure 1 - As shown in the image above, both pitting and uniform corrosion occur on the monopile, and their severity depends strongly on the exposure zone.

Key innovations delivered by WILLOW

One of the project's major achievements has been the development of advanced monitoring technologies for corrosion and coating degradation, led by partners CEIT, Sirris, and C-CUBE. By combining ultrasonic sensing, electrochemical monitoring, and artificial intelligence, WILLOW has enabled earlier detection of degradation mechanisms and continuous condition monitoring of offshore structures.

The project also developed the Corrosion Condition Monitoring System (CCMS), allowing operators to move from periodic inspections to predictive maintenance strategies that support lifetime extension and reduce operational costs.

WILLOW has also strengthened the digital resilience of offshore wind farms by developing a comprehensive cybersecurity strategy for Internet of Things (IoT)-based monitoring systems. Led by CEIT, this work introduced secure-by-design architectures, advanced identity and access management mechanisms, privacy-preserving data processing, and intelligent threat detection capabilities. These developments provide operators with a secure foundation for the large-scale deployment of digital monitoring technologies across critical renewable energy infrastructure.

The project has also generated new insights into the environmental footprint of offshore wind farms. In collaboration with the Flanders Marine Institute (VLIZ), TSI successfully conducted a long-term underwater acoustic monitoring campaign at the Norther offshore wind farm in the North Sea. The resulting datasets improve our understanding of underwater noise generated by wind turbines. They will support future environmental impact assessments and the sustainable development of offshore wind energy.

A further key outcome of WILLOW has been the application of advanced data analytics and artificial intelligence to offshore wind asset management. VUB, 24SEA, and Flanders Make developed a scalable framework capable of transforming large volumes of operational, inspection, and monitoring data into actionable insights at wind farm level.

The resulting digital platform supports fatigue assessment, corrosion monitoring, anomaly detection, and lifetime prediction. This enables operators to make better-informed maintenance and operational decisions while reducing uncertainty and costs.

24SEA API
MONITORING OFFSHORE STRUCTURES

AI

Overview

ANNOTATIONS

Overview

Post

DATASIGNALS

Overview

SCADA

Acceleration

Inclination (INC)

Load (DEM + Bending Moments)

Fleet: norther 45

Fleetleaders 5

NRTA01

NRTA02

NRTA03

NRTA04

NRTB01

NRTB02

NRTB03

NRTB04

NRTC01

NRTC02

NRTC03

NRTC04

NRTD01

NRTD02

NRTD03

NRTD04

NRTE01

NRTE02

NRTE03

NRTE04

NRTF01

NRTF02

NRTF03

NRTF04

NRTG01

NRTG02

NRTG03

Location

NRTC01

DAILY AVAILABILITY

100.0%

DEM5 Scatter

Default context: turbulen

X axis Turbulence Intens



DEM5 and Mtn Time

DEM5 metrics and mean f



Figure 2 - Data platform for high-frequency sensor data (e.g. accelerations and SHM measurements) and SCADA data.

Finally, SINTEF led the development of innovative health-aware operational strategies that integrate information on the structural health of wind turbines into wind farm control systems.

Through the creation of a Smart Curtailment Tool and advanced lifetime consumption models, WILLOW demonstrated how curtailment strategies can be optimised to reduce structural fatigue while meeting grid requirements. These tools support a more balanced approach to energy production, asset integrity, and long-term wind farm profitability.

Transforming offshore wind operation and maintenance

Taken together, the results achieved within WILLOW demonstrate the potential of combining digitalisation, advanced monitoring technologies, and data-driven decision-making to transform offshore wind farm operation and maintenance.

By enabling earlier detection of degradation, improving asset lifetime assessment, strengthening cybersecurity, and supporting more sustainable operational strategies, the project provides the offshore wind sector with practical tools to increase reliability, reduce costs, and maximise the value of existing and future assets.

As offshore wind continues to play a central role in Europe's energy transition, the technologies and methodologies developed by WILLOW offer a solid foundation for safer, smarter, and more sustainable wind farm management.

About the project

WILLOW *(Wholistic and Integrated Digital Tools for Extended Lifetime and Profitability of Offshore Wind Farms)* is a Horizon Europe-funded project coordinated by CEIT. The consortium comprises 12 partners from five European countries.

More information

Sirris

Sirris is the collective centre for and by the technology industry in Belgium. It helps companies accelerate technological innovation, from idea to implementation. Sirris brings

together expertise in product development, advanced manufacturing, digitalisation, automation, circularity, and industrial testing and demonstration environments. This expertise contributes to the industrialisation of construction and renovation processes by making new solutions manufacturable, reproducible, and scalable. In this way, Sirris strengthens the links between technological innovation, industrial applicability, value chain development, and market-oriented implementation. As a neutral innovation partner, Sirris bridges the gap between research, businesses, and industrial applications in the construction and renovation sector.

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C-Cube International bv

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