Master class – Probabilistic Design and Assessment for Offshore Wind Turbines

Date: 25–26/02/2027

Location: Brussels, U-residence VUB Campus Etterbeek

Abstract

Offshore wind turbines and their support structures are still designed with large safety margins to cover uncertainties in loads, material properties, models and inspection. Probabilistic design makes these uncertainties explicit, allowing structures and components to be designed to an acceptable reliability level rather than by conservatism alone. The workshop is aimed at engineers and researchers who want to understand, and apply, the reliability basis behind the design standards in the IEC 61400 series. Participants will learn the probabilistic models, target reliability levels, and how direct probabilistic assessment can support a leaner design when informed by site-specific data, or monitoring results. Theory is combined with illustrative examples and discussion of cases, along with an operator's perspective on how measured data from operating wind farms supports design and lifetime extension decisions.

The workshop is organized in the framework of the DLC:X.X project (January 2026 – December 2027) [https://www.bluecluster.eu/projects/dlcxx]. DLC:X.X aims to make offshore wind support structures more cost-effective without compromising reliability. It develops a probabilistic design and fatigue-life management framework that explicitly incorporates structural health monitoring data and active load control, and extends the design load case table to reflect future grid and market conditions, including revenue-driven ("offensive") and load-reducing ("defensive") power setpoints. Project partners are Vrije Universiteit Brussel, Ghent University and Aalborg University, supported by VLAIO, with an Industrial Advisory Board of Otary RS, Elicio, JERA Nex bp, Jan De Nul, ENGIE Laborelec, 24SEA, Siemens Energy, Vestas Wind System A/S and Vattenfall A/S.

Speakers

Prof. John Dalsgaard Sørensen (Aalborg University): John Dalsgaard Sørensen is a Professor in the Department of the Built Environment, Aalborg University, and Head of the Risk, Resilience, Safety, and Sustainability of Systems research group. His research focuses on structural reliability, probabilistic design, and reliability- and risk-based planning of operation and maintenance, particularly for wind turbines and offshore structures. He contributes extensively to international standardization, including the IEC 61400 series, the Eurocodes, and ISO standards. He served as convenor for the development of IEC TS 61400-9 on probabilistic design measures for wind turbines.

Prof. Jannie Sønderkær Nielsen (Aalborg University): Jannie Sønderkær Nielsen is an Associate Professor in the Department of the Built Environment, Aalborg University. Her research focuses on structural reliability and probabilistic, risk-based design and assessment, particularly for offshore wind turbines. She works on target reliability levels, lifetime extension, and the use of monitoring data to inform decisions about structures in service. She contributed to the development of IEC TS 61400-9 as a member of its project team and as a subgroup leader.

Prof. Pablo G. Morato (Aalborg University): Pablo G. Morato is an Assistant Professor in the Department of the Built Environment at Aalborg University. His research focuses on advancing computational methods for reliability analysis and decision-making under uncertainty to support the design, operation, and management of complex engineering systems in the built environment. Motivated by the computational challenges posed by real-world applications, he develops scalable multi-agent reinforcement learning algorithms. His work includes predictive maintenance and stochastic control methods for offshore wind energy components and systems, integrating probabilistic modeling, data-driven inference, and optimization to identify effective risk-informed sequential decisions.

Michael Sandholm Jepsen (Vattenfall): Michael Sandholm Jepsen is the Technical Authority for Support Structure Integrity at Vattenfall. His work focuses on support structure integrity, digitalization, and data-driven asset integrity management. With more than 15 years of experience in offshore energy, he works at the intersection of structural engineering, monitoring systems, and digital twin methodologies, supporting the safe, cost-effective lifetime extension of offshore assets.

Agenda

Day 1 – Thursday 25 February 2027 (full day)

Introduction to Uncertainty Modelling, Reliability in Decision-making

Speakers: Prof. John Dalsgaard Sørensen, Prof. Jannie Sønderkær Nielsen, Prof. Pablo G. Morato (Aalborg University)

- Introduction
- Uncertainty modelling (Strength, loads, lifetimes, model uncertainty, …)
- Estimation of failure probability by FORM, SORM and simulation
- Design load cases in IEC 61400 – probabilistic modelling
- Classical reliability of mechanical and electrical components (failure rates)
- System reliability – Time-variant reliability – Inverse FORM in IEC 61400
- Partial safety factor calibration and target reliability in IEC 61400 and DNV standards
- Risk analysis, predictive maintenance, monitoring and lifecycle decision-making
- Throughout the day, examples will be shown and cases will be discussed with the participants.

Day 2 – Friday 26 February 2027 (half a day)

Probabilistic Design and Assessment for Offshore Wind Turbines – Part I

Speaker: Michael Sandholm Jepsen (Vattenfall)

- Need: Managing structural risk throughout the asset lifecycle
- Paradigm Shift: From reactive to proactive asset management
- Foundation: Establishing confidence in structural health monitoring and data-driven assessments
- Opportunity: Reducing uncertainty through monitoring, observations and operational experience
- Capability: Understanding actual structural performance through Digital Twins
- Enabler: Structural reliability for risk-informed decision-making
- Showcases: Reassessment, lifetime extension and fleet surveillance
- Future: Closing the loop between design and operation

Probabilistic Design and Assessment for Offshore Wind Turbines – Part II

Speaker: Prof. John Dalsgaard Sørensen (Aalborg University)

- Background for partial safety factors in IEC 61400-1 ed. 4
- Probabilistic design of wind turbines following IEC 61400-1, IEC 61400-9 and IEC 61400-8
- Data-driven probabilistic assessment of existing offshore wind support structures

Day 2 is expected to finish around 14:00.