WESC 2023

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ACCEPTED MINI SYMPOSIA FULL DETAILS

Contents

Theme 1: Wind resource, metocean and extreme conditions

(Dual) Doppler Wind Radar for Wind Energy Applications

Gottschall J, Lange B, Hirth B, Schroeder J

Dual Doppler (DD) Radar technology enables measurement of the wind field on the scale of a typical large-scale wind farm with very high temporal and spatial resolution. Compared to currently used wind lidar technologies, DD Radar offers the ability to scan more than 10 times faster with a substantially larger maximum data range allowing for the simultaneous documentation of multi-scaled phenomena important to the wind energy community.
In this mini-symposium, we want to discuss the current state of the art of DD Radar in both research and industry applications so far. We encourage contributions from academic and industry users who have worked with the DD Radar technology and/or data and want to share their experiences and conclusions. Work on the advancement of the technology, data processing and analysis, measurement results, validation studies and applications for wind energy topics are equally welcome. The aim is to provide an overview over the current status and identify future research needs.
The session organizers will contribute with their view on the technology advancement (Texas Tech University) and an overview and first results of the publicly funded 'Windpark RADAR' project, which aims at validating and demonstrating DD Radar for wind energy applications (Fraunhofer IWE

Atmospheric drivers of blade leading edge erosion

Barthelme, R, **Pryor S**

Description of the role of hydrometeors (and other atmospheric parameters) in causing blade leading edge erosion. Discussion of advanced methods to quantify the atmospheric drivers of leading edge erosion including novel instrumentation, data from field campaigns, statistical and numerical modeling approaches are also welcome.

Atmospheric Icing on Wind Turbines

Özgen S, Ceyhan Yilmaz O, Croce A, Uzol O

Wind turbines suffer from considerable power losses because of atmospheric icing. Understanding these phenomena and developing high-fidelity experimental and numerical approaches for their prediction will help mitigate their adverse effects.
Wind farms are increasingly being located in regions where they are subject to atmospheric icing conditions. Extreme cold weather events due to climate change also threatens the energy supply. Icing has severe effects on aerodynamic performance of blades, fatigue loads and the safety of population. Power production losses due to icing can reach up to 20% of the yearly power production depending on geographical location and turbine size. Ice may result in structural imbalance, resulting in shorter turbine life and increased operational costs. Ice is a safety risk, as ice chunks are thrown to large distances, threatening the surrounding population. The role of critical parameters such as wind speed, temperature, liquid water content on ice shapes and sizes needs to be understood in order to tailor mitigation measures.

The Mini Symposium on Atmospheric Icing will gather scholars, researchers, wind turbine operators and manufacturers in a forum where latest developments in the field (and related fields including blade contamination and erosion) will be discussed and knowledge will be exchanged.

Bringing together offshore wind resource assessment and metocean technical aspects

Gottschall J, Cowan M, Jeans G, Gandoin R, Santos P

The rapid growth of offshore wind energy requires an integrated approach of wind resource assessment and metocean disciplines. These two communities have developed separately over the recent decades but have been increasingly coming together to perform the necessary design and engineering of modern offshore wind farms. This Mini-Symposia aims to provide a meeting point and a stage for discussion on the intersection between offshore wind resource and metocean technical aspects. Potential topics to be addressed are related to extreme conditions (wind, wave and currents), design requirements of offshore substructures, verification and validation of wind and wave models, model forecasting, metocean data applied to planning or operation and maintenance, among others. This Mini-Symposia proposal is connected with the Wind Resource Metocean (WRM) and the Wind Resource Assessment Group (WRAG) discussion platforms, where participants from both academia and industry openly share knowledge and network. Hence, we invite participants from those discussion groups and the research community to submit your work with new insights on metocean analysis applied to offshore wind farm planning.

IEA Wind Task 52: Replacing met masts and Accelerating offshore wind deployment

Gottschall J, Santos P

IEA Wind Task 52, building on the prior success with Task 32 on wind lidar, connects researchers and industry to develop the best and preferred wind measurement devices for the wind energy community. You can find more information about the Task at https://iea-wind.org/task52/.
This session showcases the Task's activities in estimating wind resource, metocean and extreme conditions based on lidar measurements in various terrains. We will present our goals, share our latest results, and tell you how you can get involved in our activities. But also presentations from parties who have not been involved in the Task so far are very welcome.
Note that there is also a second mini-symposium on Task 52, focusing on our two other task themes "Universal inflow characterisation" and "Connecting wind lidar".

Large wind farm wakes

Barthelme R, Pryor S

Focused on quantifying offshore and onshore wake development within and downstream of large wind farms using both numerical simulations and observations

Large-Scale Wind Farm Effects – is there an upper limit for installations?

Giebel G, Mann J, Göçmen T, Platis A

Wind farms keep getting larger, with the first GW size wind farms starting to produce power. Is there a physical upper limit for how large a wind farm can be?
There are several approaches to calculate the momentum transfer from the atmosphere to the wind farm for very large wind farms. Amongst other projects, in TRAIN2WIND, which is a PhD TRAINing school analysing enTRAINment in offshore WIND farms, this is done with a combination of computer models and experiments. The 13 PhD students are currently working on the preparation of the Lollex experiment, in Lolland, Denmark. The mini-symposium will report the measurements of the wind flow inside the Rødsand II wind farm from several lidars, UAS and satellite observations. The measurements will be used in conjunction with the computer modelling (LES and WRF), which was executed beforehand to find the best measurement strategy, and afterwards to model the measurement results.
Other research along the same lines is invited to contribute to this mini-symposium.

Minute-scale forecasting for wind power applications

Theuer F, Würth I

The share of wind energy to our overall electricity production has been increasing during the last years and is expected to further do so. The high volatility of the feed-in poses a challenge for grid stability and threatens power system security. To support the balancing of supply and demand typically power forecasts are applied. In this context, minute-scale forecasts are gaining importance. Recently, several methods to forecast wind speed and power in the minute-scale have been developed and applied. Statistical-time series models rely on deducing patterns from past observational data and extrapolate these relationships to predict future values. Remote sensing-based forecasts use upstream measurements from lidar or radar devices as preview data. Also, observer-based forecast that combine different data sources, e.g. lidar measurements and turbine operational data, have been explored recently. Forecasts based on physical models such as NWP models assimilate measurement data to adapt better to local changes in wind conditions.
In this mini-symposium we welcome contributions from everybody interested in minute-scale forecasting. The symposium aims at giving an update on the state-of-the-art in this area and will discuss advantages and disadvantages of the different forecasting methods regarding e.g. extreme event forecasting, forecast availability or computational time and cost.

Understanding the physics and aerodynamics of atmospheric flow for predicting wind power production and evaluating loads

Mann J, Méndez B, Watson S

As wind turbines grow bigger and taller, their rotors are increasing impacted by a greater range of turbulent atmospheric flow features, while airborne wind energy systems operate at even higher altitudes. This increasing atmospheric height of interest currently lays between the current numerical models at the microscale and the mesoscale. Further, the data integration of the models of these different altitudes is still scarce. Thus, there is a need for an improved understanding of atmospheric flow physics, particularly when predicting wind power production and designing wind energy technology components. This requires

knowledge concerning the inflow such as turbulence, veer and shear. However, parameters such as humidity, precipitation and particulates (e.g. sand) affect performance and loads and their characteristics need to be fully understood when considering component design, wind farm planning and O&M strategies. This mini-symposium will incorporate research into the use of observational data and modelling tools of various fidelities and how they are combined to better understand flow structures over a range of spatial and temporal scales. Presentations will show how model chains can be used to predict surface and airborne wind plant performance, estimate loads, and reduce uncertainty in the design and operation of wind energy generation systems.

Wind fields – highly resolved measurements, models and uncertainties

Peinke J, Cheng P, Heißelmann H

Wind fields are the essential energy resources for wind turbines determining the energy conversion process. Their turbulent content is challenging and important for many details of wind turbines and the energy conversion process. In particular, the growing size of wind turbines results in higher flexibility and requires knowledge of larger wind field areas. This demands for improvements of the knowledge about wind fields, including advanced measurements, the modeling of wind fields and the resulting uncertainties. These topics will be addressed within this mini-symposium.

Wind Resource Variability and Climate Change Impacts

Hahmann A, Dörenkämper M, Wohland J

Winds are one feature of the highly interconnected climate system, and climate changes may thus cause changes in wind energy potentials and generation characteristics. While the IPCC recently concluded that "Climate change will not substantially impact future wind resources and will not compromise the ability of wind energy to support low-carbon transitions" [IPCC, AR6], many aspects of the energy-climate interface remain insufficiently understood. In this mini-symposium, we invite contributions that explore the interface between climate and wind energy further, for instance, by addressing

- climate change impacts in site assessment applications
- uncertainties in climate change projections, as well as model/ensemble selection
- mechanisms and processes through which climate risk manifests for wind energy
- the role of bias correction in wind climate change assessments
- suitability and interpolation of climate model surface winds to relevant heights
- changes in the spatial or temporal variability and their effect on system integration
- the role of changes in land use to future wind resources
- climate change impacts on wind farm operations

[IPCC, AR6] Energy Systems. in Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

Theme 2: Wind resource, metocean and extreme conditions

AWAKEN—The American Wake Experiment

Hamilton N, Bodini N

Wake interactions are among the least understood physical processes in wind plants today, leading to unexpected power losses. New wind plant-scale observations are needed to further validate wind farm models, leading to improved layouts and operational strategies for existing and future wind plants. The American WAKE ExperimeNt (AWAKEN) campaign aims to collect meteorological data with an unprecedented fleet of remote sensing and in-situ instruments in the middle of the Southern Great Plains of the U.S., where the largest concentration of American wind farms and where a strong future growth is most likely. The AWAKEN international team includes researchers from national laboratories, academic institutions, and industry members, such as wind farm owners who wish to learn more about wake impacts within their wind farms and turbine manufacturers, who want to study turbine response in wind farm environments. The primary goal of the AWAKEN project is to gain an improved understanding of wind plant performance through observation and modeling concurrent with systematic validation of advanced wind plant modeling tools. The research community involved in the AWAKEN project is invited to submit abstracts to this minisymposium to present their preliminary results after the first 9 months of the field deployment activities.

Complex Wind Plant Physics

Churchfield M

The overarching topic of this minisymposium is wind-plant physics, but specifically does not include wind-plant controls as there is a minisymposium dedicated to that topic. The goal of this minisymposium is to present work that furthers our understanding of the complex physics and their interactions within a wind plant. These physics are not limited to flow physics but also include wind turbine/plant response and its feedback to the flow. Specific topics addressed may include, but are not limited to, large-scale wake interactions; wind-plant blockage; wind-plant-induced atmospheric gravity waves; and the effect of atmospheric turbulence and wakes on wind turbine performance, mechanical loads, and motion in large wind plants. Submissions may be based on experimental observations or simulated results generated by tools ranging from engineering tools to high-fidelity tools or a combination of these.

Full scale offshore wake model validation

Schlez W

Wind farm wake losses are an important source of uncertainty when planning (offshore) wind farms. Large wind farms and clusters of wind farms are increasingly impacted by internal wakes and external long distance wake effects.

New wake models of different levels of sophistication have recently been proposed. How do we quantify the resulting improvements in uncertainty in calculating wake losses? What fundamentally new flow features do they model, making use of the advanced physics? This mini-symposium discusses real world benchmarks and validation data that can be applied to test and improve the models.

Presentations are invited that

- compare different wake models against
- data from full scale (offshore) wind farms

The experimental data could consist of wind farm SCADA data, wind measurements, wind field measurements using remote sensing equipment. Of particular interest is full-scale data that has not yet been published, methodologies, models, variants, or comparisons of different wake modelling approaches.

Open Source Wind Farm Flow Model Libraries

Réthoré P, Fleming P, Jonas S

The intend of the Mini Symposia is to gather the developer and user community of open source wind farm flow models such as pyWake, FLORIS, Foxes.
The Mini Symposia will have 2 parts. The first part is addressed at the user community and focussed on presenting new scientific technical developments around those frameworks.
The second part will focus more on the developer community and address the standardisation of those tools to enable a better inter-connectivity between the different codes.

Optimal value-generation of wind energy systems through adaptive operational strategies

Meyer T, Requate N

In research on wind farm operation, a transition towards adaptive control strategies can be observed. A flexible response to market prices and operator demands is required, while achieving the best long-term value and usage. In addition, the maximum long-term benefit for environment and society is desired. This necessarily includes the perfect utilization of components, i.e. of their individual load bearing capacity. To achieve optimization of the overall system for long-term value, building blocks from different research directions are necessary and must be integrated with each other. This requires contributions from different research fields, which on the one hand include evaluation criteria and measures for long-term value, as well as forecasts of wind and market conditions. On the other hand, solutions for adaptive wind turbines and wind controllers are needed that consider goals beyond short-term performance maximization. In particular, this includes models for failure modes that can be influenced by operations and that affect long-term reliability. For long time periods, surrogate models are often necessary for this purpose. We'd like to discuss objectives, methods, and strategies for using adaptive operation to gain more value from each turbine based on research findings and ideas.

OWA GloBE: Building Industry Consensus on the Global Blockage Effect in Offshore Wind

Adams N

The Global Blockage Effect (GBE) is a complex, two-way interaction between a windfarm and the atmosphere. The turbines' cumulative thrust causes the approaching wind to decelerate, reducing the power captured by the windward turbines and causing flow accelerations elsewhere. Historically it was not

included in energy yield calculations, and was cited as a potential cause of disparities between pre- and post-construction yield estimates.

The Global Blockage Effect in Offshore Wind (OWA GloBE) project aims to build consensus around how GBE should be modelled and accounted for. The project is led by RWE and the Carbon Trust, and funded by ten of the leading offshore windfarm developers and the Crown Estate, with in-kind contributions from Vaisala and DTU and collaborations with projects run by Fraunhofer IWES (X-Wakes) and TNO (AFFABLE). It strives to achieve consensus by measuring the blockage effect at RWE's Nordsee Ost and Amrumbank West wind farms, and assembling a large consortium of industry experts (including many leading Lenders' Technical Advisors) to validate various blockage models and develop a shared understanding of the phenomenon, including remaining points of uncertainty or disagreement. In this symposium, various GloBE stakeholders will present their perspectives on measuring, modelling and accounting for blockage.

Wind Farm Flow Control research organized by IEA Wind Task 44

Fleming P, Eguinoa Erdozain I, Becker M, van Wingerden J, Bay C, Bottasso C, Latour M, Gocmen T, Simley E

Wind Farm Flow Control is an active field of research in which the control activities of individual turbines within a farm are coordinated. The benefit of this coordination can be energy capture maximization, minimizing wake-driven loads, or to supply market driven demands, to maximize the value of the energy produced to the electrical grid. This mini-symposia will feature multiple sessions covering topics related to the research of wind farm flow control. This includes, but is not exclusive to field validation campaigns, uncertainty quantification, beyond power maximization, wind farm control in complex terrain and wind tunnel testing.

Theme 3: Aerodynamics and aeroelasticity

Active Flow Control at Blade Scale

Braud C, Motofumi T, Deparday J

Increasing wind turbine life time, decreasing noise, increasing the energy production, developing remote O&M solutions for offshore wind turbines are all part of the major challenges that will be faced by wind turbine operators/manufacturers in the future. The development of active blades to tackle these problematics either globally (pitch control) or locally (flap, slap, active flow control etc ...) is a complex task that is only emerging and many important challenges remain, such as:
- identifying relevant flow phenomena to be controlled,
- developing and using effective sensors and actuators to detect and/or mitigate them,
- developing control strategies (feed-forward, feedback, model-free, model-based, machine learning…) regarding effectiveness, reliability and robustness for multi-MW turbines.

This mini-symposium is willing to gather all studies from experimental (field or wind tunnels tests or others), theoretical to simulated environments (wind tunnels, computational fluid mechanics, aero-elastic solvers…) dedicated to the improvement of active flow control at the blade scale.

Current state of the art and new developments in wind turbine aeroelasticity

Riziotis V

There are several occasions in which existing state-of-the-art comprehensive aeroelastic tools fail to reproduce the underlying physics of complicated aeroelastic phenomena and therefore they are unable to consistently reproduce the loads of the turbine. There are several recent developments on high fidelity wind turbine analysis which extend the use of CFD aerodynamics and nonlinear geometrically exact beam models to aeroelastic simulations with turbulent inflow, analyses of vortex induced phenomena at high operation angles of attack, aeroelastic simulations of unconventional blade geometries which cannot be accommodated in existing aeroelastic tools or aeroelastic analyses of mutually interacting turbines in offshore wind farms. The proposed symposium will also address new aeroelastic tailoring techniques and new developments (numerical and experimental) in aeroelastic blade shape morphing, in addition to CFD and advanced aeroelastic analyses.

Multidisciplinary Design of Wind Turbines

Zahle F

This mini-symposium focuses on multi-displinary design of wind turbines with focus on the rotor design, covering disciplines ranging from aerodynamics, aeroelasticity, aero-acoustics applied in a design optimization context. Multiple fidelities of modelling will be covered, ranging e.g. in aerodynamics from Blade Element Momentum to Computational Fluid Dynamics, again with focus how to apply these disciplines in an optimziation context. Focus areas are methods for computing gradients, solver robustness and multidisciplinary coupling.

Wind Turbine Blade Aerodynamic Measurements

Kelley C, Madsen H, Schepers G

This mini symposium will disseminate and discuss results of recent field tests that deployed aerodynamic measurements systems on operational wind turbines. Field deployments are challenged by characterizing the aerodynamics and pressure field for wind turbine blades operating in the natural environment. Presentations should address lessons learned overcoming measurement challenges such as lightning, dust, water, data transmission, and new sensor technologies. In this mini symposium, we will gather aerodynamics and measurement experts to present results and technology solutions to further validate aerodynamics models and wind turbine models. Researchers are also invited to share ongoing wind tunnel aerodynamic measurements that are testing technologies for future wind turbine blade applications.

Theme 4: Control strategies and acoustics

Control strategies for Acoustics

Bottasso C, Bertagnolio F

Noise emissions from wind turbines and wind farms are among the biggest concerns of the public towards on-shore wind energy deployment. The reduction of sound emissions has been a topic of great interest for both academia and the industry, leading to a considerable body of literature being produced in the field of wind turbine noise. In the present mini-symposium, we aim at providing a platform for sharing experience in the field of aeroacoustic noise control and mitigation. We encourage talks about noise generation such as serrations, brushes, porous trailing edge and boundary-layer manipulation, as well as tip noise mitigation, amplitude modulation and wind turbine operations for noise reduction, both in high- and low-frequency.

Environmental design and operation of wind turbines

Kölle K, Stærkebye Nørstebø V

More wind energy is needed to meet the ambitious targets of renewable energy. Future wind farms will have more turbines, larger wind turbines and will be installed in previously untouched areas. This will impact the environment not only during the construction period but also during the operation. An environmentally aware operation of wind turbines is obviously highly topical to protect the invaded ecosystems from irreversible damages.
This mini-symposium deals with the environmental impacts caused by the operation of wind turbines and their mitigation by adjustments of design and operational parameters. Contributions addressing both the analysis environmental impacts to pave the way for practical solutions as well as specific strategies for mitigation are welcome.

IEA Wind Task 52: Lidar-Assisted Control, Turbulence Estimation, and Digitalization

Schlipf D, Simley E, Clifton A

Wind lidar systems provide detailed information about what is most important in wind energy: the wind itself!

The new Task 52 connects researchers and industry to develop the best and preferred wind measurement devices for the wind energy community. It builds on prior successes with IEA Wind Task 32 on wind lidar, which ran for 10 years and finished at the end of 2021.

This session showcases the Task's activities in the areas of lidar-assisted wind turbine control, digitalization, and the estimation of turbulence intensity. We'll present our goals, explain how we work, share our latest results, and tell you how you can get involved in our activities. The session also includes presentations from researchers and engineers leveraging the Task's activities in these areas. You can find more information about the Task at https://iea-wind.org/task52/.

Power Electronics Control for Wind energy systems

Campos-Gaona D

Power electronics play a crucial role in improving the generation and transmission of wind energy. As wind farms become larger and more widespread in power networks, new control challenges for its associated power electronics have arisen, for example, improving fault ride-through capabilities of wind turbines and wind farms, stable power delivery in weak grids, damping of resonances and grid forming capabilities, among others. Furthermore, the HVDC links of distant offshore wind farms rely on advanced power electronic control to deliver bulk power to the AC network. These mini-symposia offer researchers and industry the opportunity to present and discuss the latest advances in electronic power control for wind power systems.

Smart operation control technologies for offshore wind farms

Stephansen A, Kvamsdal T

China is now the world's largest offshore wind industry, while Norway is the pioneer and leader when it comes to floating offshore wind. In this minisymposium we will investigate how research can contribute to substantial cost reductions through a four step approach: 1) improving methods for nowcasting for the incoming wind field, 2) using reduced order modelling techniques for tracking wake flow within the wind farm, 3) building a holistic wind farm model which includes stochastic descriptions of uncertain inputs and states, and 4) developing a model-predictive wind farm controller. The aim is not necessarily to optimize the energy production of the wind farm, as the profitability may also increase by limiting the wear and tear of the turbines. We will also compare the difference in approach by the two countries and the interaction with the industry. As Norway is about to open up their coastal waters for their first large scale offshore wind farms and China is further expanding their developments, we will also discuss the challenges faced by the industry to fulfill the political ambitions in both countries.

Theme 5: Structures, structural integrity, materials

Advanced design of support structures-load assessment, structural reliability, and computer-aided optimisation

Muskulus M

Support structures have to be designed safely and economically, in the face of uncertainties regarding fatigue resistance, actual site condition and future environmental loads. Traditional approaches to deal with these challenges and to make the design problem manageable include the use of codified safety factors, target reliability indices, the statistical extrapolation of ultimate loads, and the lumping of load cases. Due to well-known limitations inherent in these approaches there is a potential for more economical designs by using advanced approaches.

The aim of this mini-symposium us to bring together the latest ideas and research supporting such advanced design of support structures, for example in the form of computational and methodological advances that allow for more accurate or more efficient structural assessments. Topics to be considered include load simulation and structural verification, uncertainty quantification, reliability-based design

optimisation, risk-based design (e.g. optimisation of the compromise between structural strength and inspection costs), the use of statistics and machine learning to improve the design process, and other advances.

The focus is on methodologies and novel approaches for designing better support structures, but case studies and work related to design standards is also welcome.

Structural and mechanical sub-systems of multi-MW turbines: Recent advances and innovations in design, load modelling and dynamic monitoring

Kazemi Amiri A M

Current and foreseeable high demand on wind energy supply have forced the turbine design to be considerably upscaled and further pushed into harsher and more remote environment. Wind energy systems are growing in size and power rating, and undergoing more severe loading conditions. Thus, design innovations as well as further improved modelling and monitoring of dynamic behaviour of turbine components are becoming more crucial to address. These are pivotal to ensure lifetime structural integrity and enable cost reduction for the sub-systems such as support structure, composite blade and drivetrain, both at the manufacturing phase and over the system life.

This mini-symposium aims to gather the experts from industry and academia to contribute to responding to the above needs. The mini-symposium covers the topics from innovative design approaches and improved turbine load and dynamic response analysis methods, to novel techniques for instrumentation and minoring of components dynamics. The submission subjects include but are not limited to:

- Design innovations and structural optimisation of support structure, blade and drivetrain in onshore, and fixed and floating offshore wind
- Structural design improvements and modification of joints and connections in turbine support structure, blade and geared/directly-driven drivetrains
- Offshore wind design guidelines/standards and potential for lifetime extension
- High fidelity turbine aeroelastic modelling and validation assisted by data fusion
- Novel instrumentation methods and load/response measurement techniques for blades, support structures, and drivetrain
- Data-driven inverse load identification of support structures, blades, and drivetrain
- Experimental modal analysis and health/condition monitoring of turbine components

Structural design, modelling and simulation of wind turbine rotor blades

Balzani C, Chen X, Czichon S

Rotor blades are key components of wind turbines as they transform the kinetic energy in the wind into rotation of the drive train. They become increasingly large and slender and are thus subjected to increasing extreme and fatigue loads. This makes structural designs more and more challenging. Hence, accurate and reliable simulation procedures, modeling approaches and material models are required in the structural design procedures for rotor blades.

This Mini Symposium aims to bring together scientists working in the challenging field of structural design, modeling and simulation of wind turbine rotor blades and to exchange their latest research. Contributions on design methods, simulation strategies, calculation procedures or experimental validation in this context are all invited. Topics of interest include - but are not limited to - high cycle fatigue and effects of defects, material modeling and qualification methods, numerical simulations and novel modeling approaches, and experimental characterization or validation techniques. Presentations with a strong focus on practical aspects of blade design and simulation are explicitly encouraged.

Structural integrity assessment and life cycle management of wind farms

De Waele W, Devriendt C, Morato P, Weijtjens W, Rigo P

Preserving wind farm structural assets in a good condition throughout their lifetime remains a challenge since they are continuously exposed to deterioration mechanisms and occasionally experience extreme or accidental events. To control the risk of structural failures while maximizing wind energy production, effective life cycle management strategies should be able to timely plan operational decisions, e.g., maintenance actions, lifetime extension. Efficient probabilistic methods and numerical tools are, therefore, needed for assessing the structural integrity based on collected operational data as well as for the identification of optimal life cycle policies.

In this context, this mini-symposium offers a forum for discussion and exchange of ideas, with emphasis on the development and investigation of deterioration models, damage detection techniques, and decision-making methods. We also welcome user stories related to life cycle management and invite contributions in, but not limited to, the following areas of interest:

- Life cycle infrastructure management
- Fatigue and corrosion deterioration
- Structural integrity and lifetime extension
- Value of information and structural health monitoring
- Risk and reliability assessment
- Decision-making under uncertainty
- Curtailment management strategies
- Uncertainty quantification
- Resilience under accidental/extreme events
- Machine learning and surrogate modeling
- Non-destructive and autonomous inspections

Theme 6: Reliability, monitoring and sensing, O&M

Digital twins for lifetime assessment of structures

Rolfes R, Branner K, Hübler C

Simulation models have been used for the design of wind turbines or their structural components decades. However, frequently, the structural behaviour predicted by the design model and the behaviour determined using measurements at the real structure during operation do not match. Reasons for these differences are, inter alia, model assumptions or unknown boundary conditions or loads, but also changes during the

lifetime of the wind turbine, e.g., scour. This is why the concept of digital twins is useful. Digital twins incorporate monitoring data – ideally in an automated manner – into the model so that individualised models are created that are continuously adapted to the current status of the real structure. This enables more accurate lifetime assessments as well as a better planning of O&M actions and increases the overall reliability of the wind turbine.
This mini-symposium welcomes submissions in the field of digital twins for wind turbines and/or their components which focus on the structural behaviour. Digital twins can be purely data-driven but also based on physics-based models (e.g., FE models), which are updated using monitoring data. Contributions focussing on "non-structural" digital twins, e.g., for the prediction of the energy production are out of the scope of this mini-symposium.

German research wind farm WiValdi – innovative instrumentation and advanced testing to enable a digital twin wind farm

Govers Y

The German Aerospace Center (DLR) is currently building the German research wind farm WiValdi together with partners from the Research Alliance Wind Energy in Lower Saxony, close to the North Sea in Krummendeich. The park will consist of two standard Enercon wind turbines E-115 EP3 E4, a wind measurement mast in front of the first wind turbine and a wind measurement array between the two turbines. Additionally, atmospheric monitoring is done by different lidar systems. The standard turbines are equipped with more than 2600 sensors from rotor and nacelle via tower to the foundation. Another smaller wind turbine with a 40m rotor is setup in a later stage to enable research with highly flexible blades.
This Mini Symposium gives insight in the research around the wind farm WiValdi dealing with the rotor blades as well as atmospheric and acoustic field measurements in Krummendeich before installation of the turbines. Details will be given about innovative sensor concepts, advanced rotor blade testing, atmospheric measurements in the field before installation of the turbines and simulations to generate data for digital twins.

Maintenance logistics organization for offshore wind energy

Jiang X

Offshore wind power capacity is increasing considerably in recent years. Operation & Maintenance (O&M) costs can account for more than 30% of the total costs of an offshore wind farm, and logistics makes up at least 34% of O&M costs.
Because of the remote location of offshore wind farms, there is a certain time interval called maintenance lead time between the determination of maintenance plans and the implementation of maintenance activities. Many logistic activities are planned and completed during the maintenance lead time and considerable maintenance support expenditures will be generated. To reduce such cost and optimize the organization of maintenance logistics, it is necessary to consider the following factors among others, weather window, spare parts inventory management, transportation mean, maintenance tool and maintenance technician, etc.
In order to reduce O&M costs and gain more profits, maintenance logistics should be taken into account as an important factor when planning the O&M activities for offshore wind farms. The studies on Maintenance logistics organization are capturing more attention from academia and industry now.

Monitoring the Performance of Operational Wind Turbines

Bradstock P

There has been an increasing focus on monitoring the performance of operational wind turbines in recent years as wind farm owners and operators try to detect and reduce causes of lost yield and thereby maximising revenues and profit margins. As turbines produce ever more data and are ever more connected, the application of live automated analytics to monitor turbine performance has become more common. However, due to the complexity of environmental conditions and inaccuracy of anemometry installed on most turbines, evaluating performance is not a trivial task. This has led to a wide variety of interesting algorithms and approaches to evaluate turbine performance and they continue to evolve rapidly.

These include, most notably (but not limited to), the detection and analysis of:

- Static yaw misalignment
- Long-term blade degradation
- Rotor mass or aerodynamic imbalance
- General power performance tracking (e.g. power curve analysis or neighbouring turbine power comparisons)
- Analysis of controller characteristics

Submissions to the this mini-symposium should focus on solutions to monitoring any aspects of performance from live or regular data streams, and may be machine learning models, but also statistical approaches or consisting of other deployable algorithms.

Prognostics and Health Management

Zappala' D, Castellani F, Watson S

This mini-symposium deals with wind turbine prognostics and health management (PHM). The full potential of high-frequency and low-frequency condition monitoring signals can be exploited for smart and autonomous detection of anomalies, diagnosis of faults and, more importantly, prediction of the remaining useful life of key wind turbine components, such as gearboxes, generators and blades. This is a crucial information as it can provide advanced warning of potential failures, and the opportunity to implement informed preventive measures to avoid catastrophic events, reduce unplanned downtime, optimise maintenance costs and maximise availability. This mini-symposium focuses on novel prognostics and health management approaches and their implementation on advanced monitoring and decision support systems. Abstracts dealing with the following subjects are especially welcomed:

- Physics-based, AI-based, stochastic-based, and hybrid prognostic techniques
- Explainable AI for PHM and predictive maintenance
- Deep learning models for health prognostics with uncertainty quantification
- Data-driven performance analysis, development, and validation
- Field case studies involving low and/or high-frequency monitoring data
- Data fusion approaches for diagnostics and prognostics
- Early fault analysis on key turbine components
- Implementation of prognostics in maintenance decision support systems
- Operational identification of blade performance drifts
- Interpretable Physics-Informed Machine Learning models

Recent progress on lifetime extension, decommissioning, Repowering and Repurposing of onshore and offshore wind turbines

Malekjafarian A, Desmond C, Kolios A

Wind turbines have life expectancy of about 20 to 25 years. Currently, about 28% of the European wind power are currently older than 15 years which means that they will soon reach the end of their designed service life. This clearly shows a significant increase in the capacity reaching its end of lifetime within next 15 years in onshore sector. Therefore, the wind industry needs to prepare for a significant upcoming challenge where an appropriate decision needs to be made about aging wind assets. When a turbine is approaching the end of its lifetime, there are three options available: (1) Lifetime extension, (2) Decommissioning and (3) Repowering. This mini symposia is aimed at bringing together experts from both academia and industry to present their latest developments in novel solutions for decision support tools for end-of-life wind turbines.

Topics of interest include, but are not limited to the following aspects:

- Novel structural health monitoring techniques improve the lifetime and reliability of wind turbines.
- Novel techniques to enhance the recyclability and sustainability wind turbines (including foundations and substructures).
- Emerging solutions for overall sustainability of wind energy systems.
- Innovative solutions for recycling and/or re-purposing of wind turbine components.

Structural Monitoring as a Tool for Managing Wind Farms Operation

Magalhães F, Chatzi E, Devriendt C

This mini-symposium deals with the monitoring of wind turbine structural components (foundation, tower and blades) with the goal of detecting structural faults/damage, identifying operating deficiencies with impact on the structural performance, and evaluating the effects of slow evolving deterioration processes (e.g. fatigue, erosion). These tools should undergo a Verification&Validation process on simulated and experimental data. They should be designed to provide the wind farm operator with information that supports the asset management, balancing energy production with turbine wear, forecasting the remaining useful life, and accordingly planning maintenance operations.

Structural monitoring applications that can be featured in this MS may include the measurement of environmental and operating conditions, structural load effects, structural response quantities in the form of strains, deformations, or general vibrational response indexes and dynamic properties, such as natural frequencies and damping. The exploitation of raw information and their fusion in a way that supports diagnostic and prognostic tasks and associated decisions is of particular importance. Applications of probabilistic machine learning and artificial intelligence algorithms, such as neural networks, Bayesian

networks and decision tree classifiers are encouraged, especially if applied at the wind farm level. Development of optimized sensing strategies to deal with wind turbine challenges are also welcomed.

Theme 7: Power conversion, drivetrain, grid connection and integration of wind based renewable plants

Drivetrain and electro-mechanical interactions

Nejad A, Eguinoa I

Design and operation of wind turbine and wind power plants are conditioned by the transformation and digitalization of the electric power systems and, progressively so, by the energy systems. Traditionally, the impacts were mostly seen at the electrical components and their related operational modes, in the form of grid code requirements. However, the transition of those power and energy systems towards decarbonisation is increasing their impacts, extending them further into the plant and turbine. The induced electromechanical interactions create stronger dependencies among the different subsystems within the wind power plant, which need to be addressed from a genuine multi-disciplinary approach, for both existing and new grid forming wind turbines. Modelling, simulation and model validation of drivetrain and electromechanical system, together with control strategies, play an important role in this context, both at turbine and farm level. This mini-symposium covers some of the latest progress in design and operation of electric power, drivetrain and electrotechnical system interactions.

Hybrid Renewable Plants

Das K, King J, Von Trezi D

This mini symposium will invite presentations for different aspects of design, control, operation, test and validation of renewable hybrid plants consisting of a mix of wind, solar, storage and power-to-X technologies. A renewable hybrid plants consists of multiple generation and or storage technologies co-operated as a singular plant for either electricity production (through a single grid connection) and/or production of other energy vectors (example - hydrogen). The mini symposium is hosted by IEA Wind Task 50 on Hybrid Power Plants and will also allow interaction of mini symposium attendees with the task.

Multidisciplinary optimization of wind power plants

Pérez-Rúa J, Cutululis N

Planning a wind power plant entails addressing a large variety of different optimization problems, which are in general of notorious technical difficulty. From the very early planning stages, including site selection and grid capacity adequacy, going through wind turbines layout optimization, up to infrastructures design, as electrical network (collection and transmission systems) or structural topology, several instrumental disciplines meet to come up with the overall best techno-economic solutions. Given the nature of a target problem, various types of physical phenomena and numeral algorithms are of interest, leveraging the features of the wind energy field together with computer science and applied mathematics theory. This mini-symposium intends to serve as an opportunity to present latest research results in the area of wind power plant optimization for individual and clusters of plants, covering both single problems and integrated

optimization frameworks in the context of multidisciplinary (co) design, applying state-of-the-art numerical algorithms to solve them.

Offshore Energy Hubs

Cutululis N

The session will address the challenges and opportunities arising from the development of large offshore infrastructure like the energy hubs/islands. The aim is to have presentations on the technical challenges in designing, developing and operating the offshore energy hubs

Pathways for Future Design, Connection and Testing of Wind Power Plants

Yang G

Wind power has emerged from a niche power source to one of the most promising generation technology. A rapid growth and large-scale adoption of wind power plants over the upcoming years is expected, in response to the climate goals set by the Paris Agreement. This foreseen growth is positive for the entire wind sector (e.g., manufacturers, developers, certification bodies). Furthermore, it enables the power system operators to intensify their efforts in developing new control, plant design, as well as grid connection assessment methods. By doing so, wind power connectivity tends to become safer, more economic, and more reliable. A session is proposed to collect the state-of-the-art research on the above mentioned topics. The main theme will focus on ongoing projects and initiatives taken within the wind industry to pave the way for the next level of grid integration of wind power.
Session setup:

- 7 presentations, 10 min each plus 5 min Q&A
- Final moderated discussions among the panels: 15 mins
- Presenters (Tentative):
- Gabriel Guerreiro
- Ramon Abritta Aguiar Santos
- Jose Angel Leiva Vilaplana
- Sujay Ghosh
- Sulav Ghimire
- Kaio Vinicius Vilera
- Callum Henderson

Reliability Services from Wind Power

Saborío-Romano O, Cutululis N

As the share of power production from conventional power plants decreases, wind power plants are increasingly expected to contribute to the secure operation of the electrical power systems connected to them by means of reliability services. Recent events, like the ones in the United Kingdom in August 2019 and in Tenerife, Spain in September 2019, indicate how important it is for wind power plants to provide such services. This mini-symposium addresses state-of-the-art research on the capabilities and limitations of wind (hybrid) power plants to provide such services. Suggested topics include:

- Disturbance ride-through, including both under and overvoltage events;

- Restoration (energisation, black start);
- Active power / frequency control, including very fast services and coordination between TSOs and DSOs for the provision of such services;
- Reactive power / alternating voltage control;
- Damping of electromagnetic oscillations (power oscillation damping); and
- Operation in weak grids / grid-forming control

Value-centred design of wind turbines and wind farms

Kühn M, Bottasso C

In addition to the Levelized Cost of Energy (LCoE), design drivers for wind turbines and wind farms are emerging that shift the focus to the broader concept of "value". For example, there is value in providing services and seamless integration in the overall energy system. Accommodating space limitations, environmental constraints, public acceptance or other societal concerns, both onshore and soon offshore can generate specific value. Considerations of the supply chain, employment, circularity, repowering, and lifetime extension are - among others - additional issues, leading to other flavours of the term "value". Within this background, governmental policies require the rapid upscaling of wind energy deployment in response to the societal, environmental and strategic need for accelerated decarbonisation.
In this mini-symposium, we will explore how the design of future wind turbines and plants will have to adjust to such complex, dynamically changing requirements. Example questions include:
- What are the relevant metrics, and what design perspective and benefits do they express compared to LCoE?
- How do such metrics impact design optimisation?
Typical applications of interest include the design for specific markets, higher revenues at lower wind speeds, optimal site exploitation, power-to-X, minimisation of impacts, and other concepts of "design beyond LCoE".

Wind Turbine Drive Train: Trends and Technologies

Ebrahimi A

Together with the rapid development of wind power, applications and growth in the installation capacity of wind turbines worldwide, research and development are being done to develop various turbine concepts to make wind energy conversion systems even more cost-effective. Therefore, this symposium will focus mainly on the new wind generator technologies, including design, simulation and tests and the generator-converter interactions.
Besides introducing the new generator concepts, the participants are also welcome to give a review of their current and future research topics.
The industrial applications including technical reviews of systems functionalities will also be included in this session. The researches and engineers from industry and academia are welcome to submit their abstracts to the Mini-Symposium on wind drive trains.
The topics of the Mini-Symposiums are (but not limited to):

- New generator technologies
- Super conducting generators

- Generator vibrations
- Generator design, calculation and simulation
- Bearing currents
- Generator-converter interactions
- Generator-converter topologies
- Generator-Gearbox interactions

WinGrid project - H2020-MSCA-ITN programme Wind farm grid interactions - exploration and development

Hansen A, Zhao X, Kheshti M

This mini symposium will contain presentations of the newest results achieved in the WinGrid project funded by the H2020-MSCA-ITN programme (grant agreement No 861398). The project aims to train 15 PhDs and launch the next generation of researchers on power system integration issues associated with the large-scale deployment of wind generation, focusing particularly on the modelling and control aspects of wind turbine and grid interface design, system stability and robust implementation. The consortium comprises a wide-ranging expert group of 10 academics from 8 beneficiary organisations including 7 leading universities and 8 internationally renowned industrial partners (ABB, Vestas, EirGrid, SGCC, FTI, Rotem, Dansk Energi, and ESC) ranging from wind turbine developers, transmission system operators, power system analysts and renewable energy consultants from 6 countries.

Theme 8: Floating Offshore Wind Turbines

COREWIND-Cost Efficient Floating Wind

Cheng P, Dominguez J

The COREWIND project aims at achieving significant cost reductions and enhancing performance of floating wind technology through the research and the optimisation of mooring and anchoring systems and dynamic cables.

These enhancements will be validated by means of simulations and experimental testing in both wave basin tanks and wind tunnel by taking as reference two concrete-based floater concepts (semi-submersible and spar) supporting large wind turbines (15 MW), installed at water depths greater than 40 m and 90 m, respectively. Special focus is given to development and validation of innovative solutions to improve installation techniques and operation and maintenance (O&M) activities. The project aims at proving the benefits of concrete structures to obtain an LCOE reduction of at least 15% compared to bottom-fixed offshore wind.

Experiments about floating wind turbines

Muggiasca S, Fontanella A

Preliminary analysis of precommercial plants show that floating wind technology has the potential to achieve a lower cost of energy than its fixed-bottom counterpart. This pushes designers of FOWTs to explore more advanced solutions for the floating foundation and mooring, for the control and operation of single turbines and at farm level. Experiments are key components of this innovation process, and can help develop new technologies as well as provide data for code validation. The goal of this mini-symposium is to favor discussion about the most recent experimental efforts about floating wind turbines, including conventional wave basin tests, hybrid hardware-in-the-loop experiments, utility-scale prototypes.

FLOATECH: The Future of Floating Wind Turbines

Saverin J

FLOATECH is a Horizon 2020 project funded focused on increasing the technical maturity and the cost competitiveness of floating offshore wind energy through two main research actions:
The first action is the development, implementation and validation of a user-friendly and efficient design engineering tool for performing simulations of floating offshore wind turbines with unseen aerodynamic and hydrodynamic fidelity.

The second action is the development of two innovative control techniques (i.e. Active Wave-based feed-forward Control and the Active Wake Mixing) for Floating Wind Turbines and floaters, combining wave prediction and anticipation of induced platform motions.

The anticipated influence of these two actions on market value and LCOE of floating offshore wind will furthermore be investigated to provide a pathway to exploitation.

This mini symposium provides an opportunity for the FLOATECH group to present development work, findings and future plans with with peers from the floating offshore wind energy community.

Floating Wind Farm Design and IEA Wind Task 49

Hall M, Desmond C, Shields M

This mini-symposium will feature research on the array-scale design and development of floating wind farms, including updates from IEA Wind Task 49: Integrated Design of Floating Wind Arrays.

Floating wind farms involve a set of interrelated design problems for the floating platforms, mooring systems, power cables, and array layout. The associated design choices affect many aspects of a wind farm including the feasible range of water depths, the wake losses, the capital and operating costs, the impact on the local environment and ocean users, and the reliability and failure risks. These topics and more will be discussed in the mini-symposium.

If your work relates to the challenges and opportunities presented by array-scale design and development of floating wind, we would be delighted to receive your abstract.

Floating wind: system design and lifecycle performance analysis

Taeseong K

The operating floating wind turbine systems such as Hywind Scotland have demonstrated their suitability to withstand storms in the Atlantic and in the North Sea. Others, such as Stiesdal, etc., are in progress. Despite its vast potential, floating wind needs further development, re-thinking and reviewing whether, what has been done so far, is enough to meet the ambitious expectations on floating technologies.
Innovation, not only in floating substructure design, but also on the rest of the value chain is a must. Importantly, to achieve the global scale impact resulting in increasing the commercial readiness level of floating offshore wind energy, the accompaniment from all the industry is needed. Innovation must be present not only on the entire chain design process, from the floater to the wind turbine, but also on the implementations gained in the wind power industry.
In this mini-symposia various innovative technological design and dynamic response analysis of floating wind turbine system will be presented and discussed. This session will be mainly supported by the research outcomes of two EU projects, Eurostar FOW-TLP-C2S and H2020 ITN STEP4WIND, which both focus on the innovative design, operational, and cost aspects of floating wind turbine systems and farms.

How does metocean adapt to floating offshore wind requirements?

Mawdsley R, Jeans G, Goward Brown A, Calverley M

Floating offshore wind is growing around the world and development work on commercial scale floating offshore wind farms is already well underway. As part of this work metocean is taking a prominent role as the industry aims to understand the response of a system made up of many different components.

Discussions within the metocean community have identified uncertainty in the best approaches for metocean data collection through the lifecycle of a floating offshore wind project. Metocean has well developed standards and experience in fixed bottom offshore wind and with floating structures in oil and

gas. However, floating offshore wind will present new challenges and the installation of 50+ moored floating structures and the interactions between the different components, mean that we need to consider what can stay the same and what needs to adapt to this new technology.

This mini-symposium aims to provide a better understanding of the pros and cons of different metocean data collection strategies. That could be in relation to the technology used or the parameters measured, the interaction between wind resource and metocean, the strategies for providing measurements during construction and maintenance activities, or even the timeline and scheduling of work.

Offshore Wind Modeling Tool Validation (OC6)

Robertson A

This session will focus on the verification and validation (V&V) of offshore wind (OW) modeling tools, performed through the International Energy Agency (IEA) Technology Collaboration Programme – Wind Task 30. Also known as the Offshore Code Comparison Collaborative projects (OC3-OC6), these projects bring together research laboratories, academia, and industry from across the globe to work collaboratively on ensuring the accuracy of engineering and high-fidelity tools used for designing OW systems. The V+V activities in the OC3-OC6 projects assess the accuracy of the modeling tools, provide a better understanding of their uncertainties, identify needed areas of improvement, and increase their acceptance within industry and wind research communities. The level of trust and acceptance of the tools directly translates to the perceived risk in wind project development, which impacts design methodology and bankability, both significant cost drivers. The presentations in this session will focus on the code development and V+V activities performed by those actively participating in the present OC6 project.

Wakes of floating wind turbines

Hölling M, Aubrun S

With the shift towards floating offshore wind farms, new problems arise when investigating the turbulent wakes of wind turbines. The additional motions due to the floating platforms affect the interaction of the turbine with the incoming wind field and thereby the generation of the wake. Different platform types show design-specific damping of their motion, which is induced by ambient ocean waves and the interaction of the turbine with the turbulent wind field. This could result, e.g. in motion patterns that could be printed on the dynamics of the wakes or even trigger a faster recovery of the wake velocity deficit. Specific floating-oriented wind turbine control strategies could even take benefit of this configuration to accelerate the recovery process and mitigate the wake interactions with downwind turbines. This mini-symposium aims at providing a forum place to researchers dealing with the topic of wakes of floating wind turbines, through analytical, numerical or experimental (full and lab scale) tools.

Theme 9: Economics, Health & Safety, and Environmental Impact

Exploring the socioeconomic and political challenges facing the development of the world's first energy islands

Hansen T

A massive and rapid scale-up of offshore wind energy depends on the success of several emergent technologies. One such technology is energy islands, i.e., offshore energy hubs that will collect and transmit offshore wind power to multiple countries. In June 2020, the Danish parliament was the first to authorize energy island projects—one on an existing island (Bornholm) in the Baltic Sea and another as an artificial island in the North Sea. Belgium, the Netherlands, and Germany have also initiated energy island projects.

These projects, being the first of their kind, face major challenges. Indeed, the Danish energy islands are often referred to as Denmark's "moon mission" or "mars mission." This mini-symposium will host researchers and practitioners exploring these challenges, through the lens of socioeconomics and politics. Tyler Hansen (mini-symposium organizer) will present ongoing research (co-authored by Lena Kitzing) on the challenges facing the Danish energy islands, through the lens of transformative innovation policy. Other presenters who will be invited include practitioners, e.g., from transmission system operators (TSOs) involved in the North Sea Wind Power Hub collaboration and the Danish Energy Agency, as well as researchers, e.g., Anupama Sen of Oxford University who is exploring energy island governance regimes.

Theme 10: Emerging Technologies and Special Sessions

Airborne Wind Energy

Schmehl R

This mini-symposium is a presentation and discussion platform for wind energy harvesting concepts using kites or tethered aircraft. Contributions should be about the current state of research and/or technology development. Possible topics include, a.o. resource potential and market, reference models, tools and metrics, safety and regulation, social acceptability and environmental footprint, and system architectures. The symposium invites contributions particularly also from members of the IEA Wind Task 48 "Airborne Wind Energy" (https://iea-wind.org/task48/).

Emerging floating technologies for offshore wind

Arredondo-Galeana A

The floating offshore wind industry is expanding rapidly, with major projects lined up over the next decade in Europe, Asia and America. Until now, the traditional approach for floating wind farms is to use an individual platform per wind turbine. Although this approach works, it is possibly not the most economical route towards deploying high power density wind farms. Therefore, there is an opportunity to develop innovative floating platforms, that help to reduce the levelised cost of energy of floating offshore wind, and possibly, increase the efficiency of wind farms. Hence, the scope of this mini symposium is to present and

discuss the latest research regarding novel floating technologies for offshore wind deployments. Different aspects that can be covered range from hydrodynamics, structural integrity, control engineering, material science, financial aspects, among others. It is envisioned that the mini symposium serves as a forum to exchange novel research ideas for floating technologies and to establish potential future collaborations among the attendees.

Machine learning and big data applications in wind energy

Landberg L, Göçmen T

Following previous WESCs' very successful mini-symposia this year's mini-symposium will again address all applications of machine learning (ML) in the wind energy space. Big data will be an important element too. The mini-symposium will emphasise the use of different machine learning and big data methods, and abstracts should address this.
The symposium will address the different ML techniques available, starting from simple perceptrons but the latest and most advanced models will also be described and discussed. A goal of this symposium is that the audience will get inspiration to not only how ML can be used in their own fields but also what the drawbacks are of the very wide range of methods available. Discussions about explainability are also envisaged, how can we prise valuable information out of these in principle black boxes? We will also discuss biases in training and testing data sets and how to avoid them, and finally reliability and applicability of the various methods will be discussed.

Multirotor wind turbine systems

Dalhoff P

This is to apply for a mini symposium on multirotor wind turbine systems.

University of applied Sciences Hamburg (HAW Hamburg) and University of Strathclyde (UoS) will hold an international multirotor seminar in February 2022.

It is very likely to have many follow-up topics from that seminar, which could be brought into a WESC mini symposium on multirotor wind turbine systems.

A growing industry interest from companies like windcatching, aerodyn, Mingyang and others, combined with research topics in the fields of concept design, loads, wind farm aerodynamics and O&M strategies for multirotor systems will create the basis of the mini symposium.

Ocean-REFuel: next generation Renewable Ocean Energy

Brennan F

Offshore Wind in Northern Europe has to date become a tremendous success surpassing most commercial and technical expectations. This success has buoyed investor confidence and led to ambitious targets, including a detailed Offshore Wind Sector Deal committed to 30GW of electric power with 60% local content by 2030 representing a major component of UK strategic electricity policy. Indeed, the UK government extended this ambition to 40GW by 2030 immediately following the December 2019 general

election. Such a large proportion of electricity from an intermittent renewable energy resource highlights the importance of energy storage, which the Ocean-REFuel project will directly address.

Local storage of energy can address the issue of electricity transportation by transferring the energy from the source of production to the consumer. Ocean-REFuel will address energy storage solutions, such as hydrogen and ammonia that can help manage the issue of intermittency, as the stored energy can be fed back into the grid when demand rises or used for other purposes. In addition, it can offer the potential to channel renewable energy to sectors which are difficult to decarbonise such as renewable heat, industrial and transport applications. Some limited technical and market potential studies have been explored by industry and academia at a conceptual level to consider the exploitation of the untapped wind energy potential far offshore. Concepts for multi-purpose platforms in deep waters have been investigated in the past by research projects such as the H2020 H2Ocean project considering a wind-wave power open-sea platform equipped for hydrogen generation yielding encouraging results. Technological, political and commercial developments have now contributed to the timeliness of this proposed initiative, which at the time of writing sees a heightened international escalation of the concern of climate change.

Running (inter)national wind energy training networks and how to learn from these for future upscaling

Mahieu M

We would like to explore the idea of how the current wind energy academic training for advanced skills can shift from individually based training (e.g. doctoral school sessions) to cohort training (e.g. ITNs, national or regional funding schemes) and how we can elevate this further to the level of entire ecosystems.

We often see the benefits and added value of ITN-related projects or networks and how this specific type of cohort training nurtures a clear collaborative mind-set and advanced networking qualities within participants. But, the whole concept remains only as good as the project or funding duration time, after which quite often the developed training programs remain further unused. Doctoral schools are mostly local or regionally funded and thus limited in duration or geographical coverage. ITNs, on the other hand, have a low approval rate which means only a limited number of researchers will reap the benefits. Both typically lack the opportunity to support « rolling » cohorts, whereby e.g. annual cohorts can be started under the same program.

Our mini-symposium wants to showcase best practices, explore how we can make these systems more sustainable, discuss the scope of these training networks and how we can upscale them.

Small wind turbines: the next ten years

Runacres M

Small wind turbines produce energy at higher and less predictable life-cycle cost than larger turbines but provide an attractive and cost competitive option to supply local energy needs, individually or combined with solar energy. Challenges to the greatly expanded use of small wind turbines are highlighted in a recent white paper (Bianchini et al, 2022, https://doi.org/10.5194/wes-7-2003-2022).

Small wind turbines also present a number of advantages and opportunities. Distributed wind energy has a huge potential to address near-term local clean energy needs that will have to be partly realised by smaller turbines (McCabe et al, 2002, https://www.nrel.gov/docs/fy22osti/82519.pdf). Recent advances in aero-elastic modelling allow for improved design and control of small wind turbines, putting lower costs and better performance prediction within grasp. The rising cost of electricity associated with the present energy crisis has made small wind turbine technology more economically viable than ever before.

The aim of the proposed mini symposium is therefore to bring together experts from research and industry to discuss how small wind turbines can best fulfil their potential to produce affordable, sustainable and reliable electricity. Ideally, the open discussion at the end of the mini symposium should set out a roadmap on how to achieve this goal.

Supporting and Encouraging Technology Transfer and Adoption in the Wind Energy Sector

Clifton A, Würth I

Addressing the challenges of a much larger wind energy industry that provides more energy will require many novel approaches to be used by the global wind energy industry.

Many of these approaches will be based on technological innovations created by research and development (R&D) organizations and will thus require a process of technology transfer (whereby innovations are spun out of the originating organization) and adoption by the end user (for example, as a new product or service).

To meet the needs of the global wind energy industry, technology transfer must happen as quickly and efficiently as possible.

This mini symposium will explore the needs, opportunities and initiatives in technology transfer and adoption across the wind energy sector. We welcome informative contributions about incubators, accelerators, and other supporting mechanisms and initiatives; success stories from academia, industry, technology transfer organsations, and startups; research into the effectiveness of different approaches; and any other relevant contributions. We anticipate a mixture of short, informative presentations as well as longer research contributions.

Towards an Ecosystem of FAIR Data and Open-Source Tools

Quick J, Barber S, Hammer F

As wind energy digitalization matures, increasingly large amounts of data are becoming available in all phases of the wind project life-cycle. The availability—and innovative usage— of this data allows for several opportunities for new processes and business models. The wind energy sector is increasingly adopting new protocols for data assimilation and analysis, although many challenges remain. The general consensus seems to be that data should become findable, accessible, interoperable and reusable (FAIR) for successful integration. This requires an ecosystem of machine-interpretable semantics. These semantics are being developed by the wind energy open-source software and data communities.

The aim of this mini-symposium is to present and discuss different approaches for FAIR data and open-source software within the wind energy sector, and to exchange knowledge of different perspectives encoded through different data semantics and schema. We welcome submissions from all researchers working with open-source software, data semantics, and FAIR data innovations.

Uncertainty in analysis, design and operations

Dimitrov N, Muskulus M, Nielsen J

Uncertainty plays an important part in the entire wind energy value chain, from design and manufacturing to operations and end-of-life considerations. Taking uncertainty into account and knowing what are the major factors causing this uncertainty could lead to design improvements, eliminating major risks, and more efficient operations. This mini-symposium welcomes papers focused on uncertainty quantification and uncertainty-capable model applications in the entire wind energy domain, including assessment of the impact of uncertainties. Such topics include, but are not limited to: uncertainty quantification and propagation studies and methodologies, design and optimization under uncertainty (including reliability-based design optimization, RBDO), stochastic simulation, risk assessment, decision making under uncertainty.

Vertical-axis wind turbines and wind farms, including multi-rotor systems

Simao Ferreira C

Despite its immense success, the Horizontal Axis Wind Turbine technology has three significant obstacles: scalability, low density wind farms, and dynamics in floating systems.
Recent research has demonstrated that the topologies of Vertical Axis Wind Turbines give a stronger justification for scaling up, allow for high energy density wind farms, and produce more effective solutions for floating wind. The feasibility of a multi-rotor system based on VAWT rotors can result in substantial cost reductions.
The symposium aims to discuss new developments in VAWT research, with an emphasis on high density wind farms, floating wind turbines, and multi-rotor systems.
In addition, the symposium will provide a venue for defining the next stages for development and knowledge transfer (e.g., a new IEA task) as well as the future demonstration of the technology at TRL 5-6.

Wind and Renewable Hydrogen

Starke G

As we strive for a decarbonized future, hydrogen is emerging as an alternative fuel source for multiple applications. Currently, fossil fuels are the main source for producing industrial hydrogen, but for a decarbonized future, large-scale production of hydrogen from renewable sources will be essential. As a major contributor in the renewable energy sector, wind energy would be an ideal candidate to produce hydrogen on an industrial scale. However, the combination of these two technologies includes multiple challenges, such as mitigating the effect of the variable nature of wind on the production of hydrogen for industrial applications. This mini-symposium will focus on the interactions between wind and renewable hydrogen produced through electrolysis and how these two technologies can be combined advantageously.

This session shall serve as a forum for focused discussions on this emerging research area and will also provide an overview of the current state and the future possibilities of using wind in other renewable applications.

XROTOR Offshore Wind Turbine Concept. EU H2020 XROTOR Project Update.

Leithead W

This Mini Symposium proposal is based around the XROTOR EU H2020 Project led by Professor Bill Leithead and Dr James Carroll: https://xrotor-project.eu/

The X-Rotor is a radical offshore wind turbine concept that has potential to reduce the LCoE from offshore wind through both CAPEX and OPEX savings.

Presentations will be from all project partners and work packages in the EU H2020 project. For example: Aerodynamic and Aeroelastic presentations from Professor Carlos Ferreira TUDelft and Dr Beatriz Lopez CENER, Control presentations from Prof Bill Leithead Strathclyde, Structural presentations from Professor Michael Muskulus NTNU, Electrical presentations from Professor Anya-Lara and Dr Campos Strathclyde, O&M presentations from Dr Carroll Strathclyde, Socio and environmental presentations from Dr Niall Dunphy UCC.

The EU project will be 2.5 years into a 3 year period during WESC, it is expected that early results can be presented in this session.