INTRODUCTORY NOTE

IEA WIND TASK 11 TOPICAL EXPERT MEETING #112

ON

IMPACT OF EXTREME WEATHER CONDITIONS ON WIND ENERGY SYSTEMS

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A. VALUE FOR IEA WIND TCP

BACKGROUND

This Topical Experts Meeting (TEM) targets potential gaps in the wind turbine design processes that may exist due to the wind industry's incomplete understanding of certain extreme external conditions. There are many examples of extreme conditions including tropical cyclones, extratropical winter storms, extreme precipitation (e.g., monsoons), extreme terrestrial turbulence, freshwater ice floes and ice ridges, breaking waves, lightning, hail, tornados, earthquakes, and extreme temperatures etc. This TEM will focus on to tropical cyclones and extratropical extreme conditions.

The governing international design standards for wind turbines, IEC 61400-1, Edition 4, Wind turbines – Part 1: Design requirements (IEC 2019a), IEC 61400-3-1 Edition 2 (IEC 2019b) for fixed bottom offshore wind turbines, and IEC 61400-3-2 for Floating Wind Turbines may not provide accurate representations of some extremes and industry best practices may differ. Wind turbines are now being installed in windy regions where extreme conditions driven by tropical and extratropical cyclones may exceed the conditions prescribed under the accepted standards and engineering practices. In some cases, the IEC-prescribed design load cases (DLC) may under-represent or oversimplify the extreme physical phenomena. These potential deficiencies may be due to poor understanding of the complex physics of these extreme events, inadequate modeling tools, lack of physical data to characterize the specific phenomenon, low prioritization of research in regions with little or no wind energy market, new uncertainties introduced by climate change, or lack of operating experience in a particular environment.

As the wind energy industry matures and begins deployment to the far reaches of our windy planet, the need to address design deficiencies for tropical cyclones and extreme extratropical conditions is increasing. Simultaneously, the engineering tools, available weather data, and operational information have advanced considerably to allow more rigorous methods to account for such extreme events.

This concern is relevant in many offshore wind regions such as southeast Asia, the U.S. Southern Atlantic, Gulf of Mexico, Caribbean Sea, and Hawaiian Islands. Significant new evidence is emerging that the prescribed load cases and wind shear coefficients may not fully represent the response of idling rotors during IEC Class 1 and T-Class limit states during tropical cyclones. Further, the IEC T-Class design parameters may be insufficient for many regions, while climate change will likely increase the frequency and severity of these storms.

If approved by the IEA Wind Executive Committee, The National Renewable Energy Laboratory in the United States is proposing to hold this TEM at a venue (TBD) near Rutgers University in New Jersey, USA on October 28-29 as a day and a half event beginning at 1pm on Oct 28.

MOTIVATION

To remain on track and meet the 1.5°C target of the Paris Agreement, the IEA Roadmap for Net Zero by 2050 estimates that annual additions of 360 GW of new wind energy installations will be needed globally. To achieve these ambitious goals, wind energy system design practices will need to accommodate conditions present in all global regions where wind energy might be feasible which may include technology modifications and upgrades that account for exposure to tropical cyclones and extratropical extreme conditions differ from common industry experience. To meet their net zero carbon targets, each country may have to adapt uniquely for optimum performance and reliability.

ADDED VALUE OF COLLABORATION

The proposed collaboration will bring researchers from member countries together to share data and experiences that highlight possible needs for design improvements and to raise collective awareness about possible impacts to structural reliability and long-term survivability. The anticipated exchange from this TEM will draw attention to any potential gaps in the international standards and industry design codes, which may identify further research needs and a possible new IEA Task of weather extremes.

ALIGNMENT WITH IEA WIND STRATEGY

The survival of wind turbines during tropical cyclones and extratropical extreme conditions has not been explored in sufficient detail. Extreme conditions in the current IEC standards may under-state or oversimplify extreme DLCs and were developed without the benefit of today's advanced high performance weather models. This TEM effort is focused on the understanding and characterization of extreme external conditions to illuminate critical areas where improvement to the design tools and design basis area needed. This is especially needed for the industry to design reliable systems in multiple new regions. In turn this will enable the expansion of wind energy globally while decreasing costs and reducing project development timelines in areas where higher development risks are perceived. Increasing site suitability, and lowering cost and development timelines are key objectives of IEA-Wind TCP. The proposed TEM is also aligned with the grand science challenges, as a key benefit will be to accelerate the expansion of the knowledge base through our collective industry expertise, researching the complex interactions between the atmosphere and the next generation of wind turbines.

B. MEETING FORMAT AND GOALS

OBJECTIVES

The objectives of this TEM are to hold a 1.5 day in-person meeting to:

1. Solicit state-of-the-art research from member countries on tropical cyclones and extratropical extreme conditions that may impact wind turbine reliability and life expectancy globally.
2. Determine if there are gaps in the current design processes that may warrant the formation of a new IEA TCP Task focusing on the most urgent and widely recognized subset of extreme conditions.
3. Document the TEM findings in a published summary report, peer reviewed by the TEM participants.

Should a follow-on Task be justified, collaboration with other TCPs is anticipated but it may be too soon to assess all the synergies among the existing IEA Tasks. However, follow-on efforts to this TEM would investigate possible collaborations with: Tasks 49, on floating wind arrays; Task 51, on forecasting weather-driven energy systems; Task 46, on the erosion of wind turbine blades; Task 47, TURBINIA, on the measurement of complex turbulence - extended to the idling rotor cases; Task 55, defining reference turbines that possibly incorporate higher resolution extremes; and Task 53, to define the cost variability associated with siting diversity.

Some of the key research questions are:

- What extreme conditions do wind turbines (land-based, offshore fixed, offshore floating) experience in non-hurricane regions where projects have already been deployed that may not have adequate design guidance from the standards?

- What are the state-of-the-art design practices in deploying wind turbines in areas prone to major tropical cyclones?

- What are the possible solutions leading to more accurate design practices for offshore wind turbines exposed to major hurricanes?

- How can wind turbines deployed in low wind speed regions and exposed to tropical cyclones be optimized to survive extreme wind and wave conditions while simultaneously maximizing energy production?

SPECIFIC OUTCOMES

The expected outcome of this TEM will be to expand the common knowledge base of the global wind industry that identifies the most important design challenges for wind turbine systems to optimally survive extreme external conditions. This new understanding will

enable us to determine a course of action to incorporate the findings into a new consensus-based framework to update current design practices or standards.

The TEM organizers at NREL are committed to documenting the content of the experts' meeting in a published written report peer reviewed by all attendees. In addition, based on participation, we will follow-up with key participants and interested countries to create a plan to narrow the focus to address the most critical topics under a more comprehensive IEA Task on extreme external conditions.

INTENDED PARTICIPATION

The intended participants will be all member countries of the IEA Wind TCP, but in particular, countries with resource areas prone to hurricanes, and other extratropical weather extremes. These countries might include most Asian countries, the United States, northern European countries, and Canada. Research organizations might include:

USA - NREL

Denmark- DTU

Norway –

Finland-

Japan - Waseda University, Kyoto University,

Korea

Canada –

Spain -

TENTATIVE PROGRAM

The proposed meeting will take place October 28-29, 2024, on the campus of Rutgers University in New Jersey, USA. Researchers from member countries will be invited to make presentations of their research to the experts and NREL organizers will collect and compile the results to provide a summary document.