Report 2022

Task 39

Photo: Eion King.

Quiet Wind Turbine Technology

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Wind turbine noise is recognised as a critical factor for social acceptance of wind energy.

The goal of IEA Wind TCP Task 39 is to accelerate the development and deployment of quiet wind turbine technology and consolidate the understanding of wind turbine sound emission, propagation, and ultimately, its perception by residents as well as their attitude toward noise. Technical experts have convened to investigate various aspects of wind turbine noise. The activities are distributed between four WPs, split between engineering aspects, including noise generation and noise propagation. Additionally, the socio-psychological aspects surrounding the assessment of noise effects on humans and perception of noise related to factors other than noise itself. Regarding the engineering aspects, a number of comparison benchmarks are recorded to identify the predictive

capabilities of modern simulation tools. In parallel, the effects of noise perception, annoyance and the impact on well-being and health continue further investigation. Furthermore, documents, including fact sheets on specific topics, are being drafted and should provide valuable and up-to-date technical information in an easily accessible format for larger audiences.

Introduction

Societal acceptance of new technologies is vital for their successful adoption. In some jurisdictions, there is concern about the potential impact of wind turbine noise. The goal of IEA Wind TCP Task 39 is to accelerate the development and deployment of quiet wind turbine technology and consolidate understanding of wind turbine sound emission, propagation, and ultimately its perception by residents in terms of noise impact and annoyance, in addition to psychological perception and acceptance. The Task will assemble an international expert panel to identify best practices in the prediction, measurement, and assessment of noise, as well as investigate regulatory aspects.

The first objective is to ensure that the latest available information on quiet noise technology is accessible to consultants, regulators, and developers. This ensures they are able to contribute to relevant international standards and government regulations. A second objective is to promote collaboration between researchers across different countries and disciplines on selected topics relevant to wind turbine noise-related technologies. The collaboration is carried out in a series of focused work packages (WPs). The first one is concerned with dissemination. Two WPs deal with engineering aspects, namely noise emission at the turbine level, and noise propagation from the turbine to the dwellings across the atmospheric medium. Two additional WPs are concerned with the human aspects related to wind turbine noise. One addresses the psycho-acoustical aspects and the physical perception of noise, as well as methods to quantify the objective annoyance and means to regulate noise emissions from wind farms, e.g. through penalty schemes. The last WP aims at characterising the external influences not related to noise on the noise perception that may yield additional annoyance and hinder social acceptance of wind energy.

There has been broad participation in Task meetings, involving experts from a diverse background of disciplines in industry, consultancy, and research. Web conferencing for meetings has allowed remote participation and presentation, which has extended participation to a wider group of experts. In addition, countries, either formally or informally, participating in Task activities have in-kind contributions. This has been seen in active participation in subtasks from the Task work programme. However, three countries have officially committed to participate in the Task with agreement from their relevant governmental organisations that grant participation to IEA Wind TCP activities (see Table 1).

Progress and Achievements

The first work package focuses on Interdisciplinary Education and Guidance. The corresponding activities have recently concentrated on writing two fact sheets and two technical documents. These documents are currently being drafted and reviewed by international experts in their

Table 1. Countries Participating in Task.

	COUNTRY	INSTITUTION(S)
1	**Denmark**	DTU, FORCE Technology, SGRE, Vestas
2	**Ireland**	NUIGalway, ULimerick, RPS Consulting
3	**Germany**	DLR, IAG & IFB Stuttgart, GE, Enercon, 3DS, MSH Hamburg, UHannover, IWES Franhaufer, TUMunchen, RWE
4	**The Netherlands**	TNO, TUDelft, UTwente, UHanze, Lagerwey
5	**Sweden**	KTH, Uppsala University

In addition to the above countries, a number of countries have expressed their interest in participating in Task 39 and/or have joined Task meetings, but are not fully committed yet. These countries and organisations are (non-exhaustively): Canada (HGC Engineering, Aeroacoustics), China (Goldwind, CGC), Finland (Poyry), Switzerland (Prona SA), UK (ION Acoustics, Hayes McKenzie, RWE, Hoare Lea), USA (NREL, CH2M UCDavis).

respective fields. A catalogue regarding the "International Wind Turbine Noise, International Wind Turbine Noise Limits and Regulations" will be published online so that they can be interactively updated by experts in the field.

The second and third WPs deal with physical and technical aspects of wind turbine noise emission and sound propagation. The following activities have been initiated and are ongoing: A wind turbine noise simulation code benchmark, conducted in collaboration with Task 29 and 47, the creation of a database of aerodynamic and noise measurements for the validation of a model for a serrated airfoil with measurement campaigns conducted in 5 acoustic wind tunnel facilities, the study of blade tip noise with wind tunnel noise measurements and model developments, noise propagation models of different fidelities are being compared for different configurations (e.g. offshore vs. onshore conditions).

The fourth and fifth work packages concern the psycho-acoustic aspects of wind turbine noise. Both groups are populated by experts from the fields of engineering and psychology. It was highlighted early that the group might need to develop an efficient knowledge exchange programme so experts from different backgrounds can communicate effectively. For example, annoyance is an important concept in both fields, but depending on one's background, the discussions on annoyance might deviate into one field. To address this issue, a seminar featuring presentations from experts in both engineering and psychology was held, followed by an open discussion forum. This seminar is available for all Task members to view. This knowledge exchange is coordinated through a shared working document (hosted on the Open Science Framework (https://osf.io) to enable effective collaboration and joint definitions of technical concepts. The aim is that this working document will form a state-of-the-art report on best practices in the area of wind farm annoyance.

Highlights

A first recent highlight is the initiation of a series of virtual meetings convening experts with various backgrounds ranging from engineering to psychology, including participants in Task 28 – Acceptance. The idea is to exchange technical knowledge between the attendees, providing a cross-disciplinary perspective on wind turbine noise and issues specific to each discipline. Ideally, these exchanges may lead to collaboration between researchers from these different disciplines and have resulted in some researchers receiving national funding including collaboration from Task 39 experts.

The longer-term effort, titled, Wind Turbine Noise Code Benchmark, which goals are to compare and verify simulations frameworks for the prediction of wind turbine noise as a source, has reached a milestone. A thorough analysis of the results produced by 7 participants (including academia and industry) has been concluded and will be presented at an international conference dedicated to the topic of wind turbine noise.

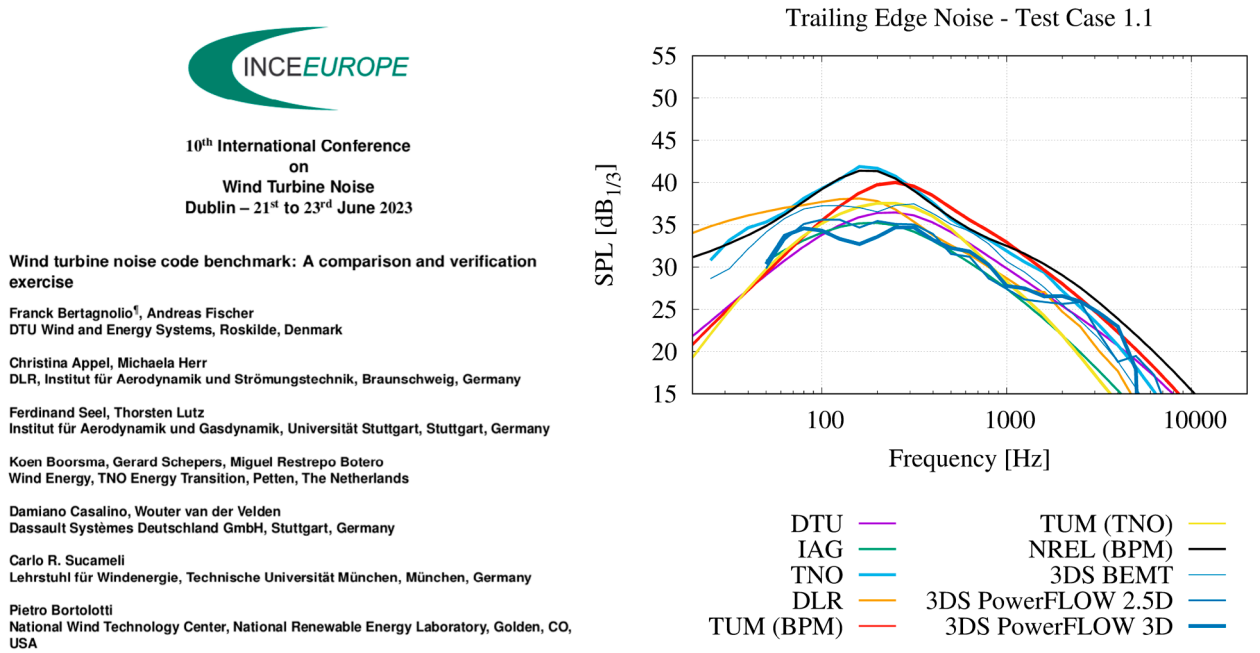

Figure 1: First publication of the results of Wind Turbine Noise Code benchmark at the Wind Turbine Noise 2023 international conference.

Outcomes and Significance

From a general point of view, developing noise mitigation technologies and recommending best practices for regulatory and siting processes is considered an essential step toward public acceptance. This should eventually facilitate the further deployment of wind energy. The new activities related to the psychology of noise will support the study of the acceptance of wind energy by the public. One key deliverable includes preparing a paper outlining the work of Task 39 related to the social-psychological effects of wind turbine noise, which identifies some key concerns that need further research.

On the engineering side, the benchmarking and comparisons of models between research institutes and industry contribute to improving the design tools for quiet wind turbine design and their siting. This should also help in developing best practices on how to use these tools.

Furthermore, the document reviewing existing noise regulations worldwide remains under development, but it is anticipated to provide a valuable overview for policymakers, especially in countries in the early stages of wind energy deployment.

Next Steps

Lessons learned from the code-2-code comparison benchmark will be considered to further investigate possible improvements in modelling. The second phase of the Task has started alongside new activities with a more significant focus on the psychology of noise, such as its perception and related social aspects.

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