



Report 2023

Task 44

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Wind Farm Flow Control

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Task 44 is advancing wind farm control (WFC) by bringing together international experts to collaborate on cutting-edge research and best practices.

Its main goals are to gather, organise, and share the latest knowledge, set up groundwork for field validation and uncertainty quantification, identify essential control algorithms, and work closely with other IEA Wind Tasks and research projects. By doing this, Task 44 hopes to boost the performance, reliability, and sustainability of wind farm operations.

In 2023, Task 44 progressed with its four Work Packages (WP). WP1 and WP3 launched a project Wiki, which provides a database for research results. WP2 prioritised key publications on forward and inverse uncertainty quantification and field validation. WP4 published a project catalogue on the Task 44 wiki and organised collaborative workshops. These efforts have built a strong

foundation for future progress in wind farm control, fostering international cooperation and knowledge sharing.

Task 44 has seen active participation from industry leaders, academic institutions, and research organisations worldwide, including major contributors such as, Engie, Siemens Gamesa Renewable Energy, Vestas, and DNV. Additionally, the Task has engaged with various EU-funded projects and national initiatives, ensuring a broad and meaningful impact. Regular workshops and meetings have provided opportunities for valuable input from diverse stakeholders, enhancing the relevance and practical application of Task 44's work.

Introduction

Task 44 is pushing the boundaries of wind farm control (WFC) through a collaborative effort across multiple Work Packages (WPs). These WPs focus on different areas of wind farm flow control, such as gathering

cutting-edge research, setting best practices for validation and managing uncertainty, defining key control algorithms, and promoting international cooperation. By tapping into the expertise of academia, industry, and research institutions, Task 44 aims to share best practices, highlight areas that need more research, and drive the development of WFC technology forward.

WP1, led by Paul Fleming of NREL, works towards the collection of current research results, the establishment of WFC terminology, and the initiation of expert elicitation processes to gather consensus on best practices.

The goal of WP2, led by Eric Simley of NREL, is to provide a foundation and best practices for both field validation and realistic model-based evaluation of WFC, in addition to an uncertainty set to be used when developing and benchmarking WFC algorithms. The WP is organised into three categories of uncertainty quantification (UQ) applications: 1) forward UQ, 2) inverse UQ, and 3)

field validation.

WP3, led by Marcus Becker of TU Delft, aims to provide an overview of the software and algorithms essential for wind farm flow control. The work involved characterising different algorithmic building blocks, assessing their specifications and readiness levels, and identifying barriers and opportunities within the solution space. WP3 developed the Task's Wiki.

WP4, led by Tuhfe Göçmen of DTU, focuses on collaboration and coordination with other IEA Wind Tasks and related R&D activities.

Progress and Achievements

WP1 and 3 have successfully launched a [project wiki](#) to consolidate and share state-of-the-art wind farm control research.

WP2 developed outlines for two review and best practices journal articles on 1) forward uncertainty quantification for wind farm flow

Table 1. Countries Participating in Task 44.

| COUNTRY/SPONSOR | INSTITUTION(S) |
|-----------------|---|
| United States | NREL; Sandia; GE; MIT; Northeastern Univ. |
| United Kingdom | Strathclyde; DNV; ORE Catapult; Durham University |
| Spain | CENER; Naturgy |
| Finland | VTT |
| Ireland | Technical University Dublin; Trinity College |
| Denmark | DTU; Aarhus University; Aalborg University; DNV; Vestas; SGRE; Ørsted; Vattenfall |
| Germany | TU Munich; Forwind; University of Oldenburg; Innogy; RWE; Stuttgart University; Flesburg University; Fraunhofer |
| Norway | SINTEF, Equinor, NTNU |
| Japan | Kyushu Univ. |
| Netherlands | RVO |

Countries observing are China, Belgium, and France; they plan to join Task 44 in 2024.



Figure 1. Task 44 May 2023 General Meeting participants.



Figure 2. Task 44 Logo.

control, and 2) field assessment of wind farm flow control. Because the author lists overlap considerably, the WP decided to focus on the field assessment paper in 2023 and develop the forward UQ paper in later years. Currently, a draft of the “Review” section of the wind farm flow control field assessment paper is complete, which summarises methods for assessing the change in energy production and/or structural loads from wind farm flow control described in over 20 publications. The “Review” section contains subsections dedicated to assessment strategies, performance metrics, instrumentation, data processing, and uncertainty quantification. The WP is currently revising this section and writing

the “Recommendations” section, in which the authors are providing recommendations for assessing wind farm flow control, addressing the abovementioned categories, based on lessons from the existing literature and the authors’ own expertise.

Another highlight from WP2 were the four presentation meetings:

- January 2023: Nassir Cassamo, TNO, “Active Wake Control Validation Methodology”
- April 2023: Kerry Klemmer and Michael Howland, MIT, “Forward and Inverse Uncertainty Quantification for Robust Wind Farm Design and Control”
- June 2023: Jaime Liew, MIT, “Loads Uncertainty in an Aeroelastic Simulation Environment”
- November 2023: Søren Anderson, DTU Wind and Energy Systems, “Uncertainty of toggling in wake steering experiments under different atmospheric conditions: An LES study”

A comprehensive project catalogue has been published on the [Task 44 wiki](#), detailing ongoing and newly started activities in both academia and industry. This resource serves as a growing database categorised by relevance to IEA Wind tasks, EU-funded projects, national and international activities, and commercial

endeavours.

Task 44 WP4 has facilitated important workshops, such as the “New European Projects on Integrated Wind Farm Control,” which featured projects like WILLOW, SUDOKO, ICONIC, and TWAIN.

Monthly meetings among WP leads and regular workshops have ensured continuous progress and engagement.

Highlight(s)

- **Project Wiki Launch:** A platform for disseminating research, results, and expert consensus on wind farm control.
- **Literature Review Databases:** Comprehensive resources for best practices in field validation and uncertainty quantification.
- **Key Publications:** Drafts on forward and inverse uncertainty quantification and field validation, providing a foundation for future research.
- **Collaborative Workshops:** Engagement with international projects and stakeholders promoting knowledge exchange and identifying new research opportunities.
- **Database Contributions:** Key additions to the project catalogue, to enhance accessibility to current WFC activities and developments.

Outcomes and Significance

Task 44 has made great progress in consolidating and advancing WFC knowledge. By establishing a comprehensive wiki, creating thorough literature review databases, and publishing foundational papers, the project has set a high standard for best practices in the field. These efforts are vital to improve the reliability and efficiency of wind farm operations.

With input from stakeholders across different countries and sectors, the project’s collaborative approach ensures that the findings and recommendations are both globally relevant and practically applicable. The outcomes of the Task not only contribute to academic research but also have real-world impacts on industry practices. Ultimately, this will boost the performance and sustainability of wind energy systems.

Next Steps

Moving forward, Task 44 will focus on completing its key deliverables, including the overview paper on uncertainty assessment, planning a series of collaborative workshops, and producing a final comprehensive report. An overview of WFC activities and the development of a research roadmap will be continuously updated to guide future projects in WFC and drive progress and innovation in the field.

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