

AWAKEN BENCHMARK

(KING PLAINS WIND FARM, OKLAHOMA, USA)

ONSHORE TEST CASE

THE TEST CASE

- **Main goal:** Installation of a new turbine at the King Plains wind farm (Oklahoma, USA), assessment of energy production, and verification that the loads did not exceed design limits.
- **Location context:** The selected site was highly instrumented as part of the American wake experiment ([AWAKEN](#)). This made available a large amount of atmospheric and turbine data over 4-years of operation, valuable for verifying predictions.
- **Partners:** Technical University of Denmark, TU Delft, Technical University of München, Whiffle with advisory from [NLR](#) (formerly NREL) and General Electrics.

TECHNOLOGY OVERVIEW

- **Key features:** Onshore wind farms are unique in that:
 - 1 The turbines are typically densely spaced to minimise land use;
 - 2 The turbine size is notably smaller than offshore counterparts;
 - 3 The terrain around the farm can be complex;
 - 4 The atmospheric conditions vary notably.
- **Model:** Unique to this test case site selected is the availability of a **digital twin of the GE 2.8-MW turbine** that populates the site. Though the original turbine is proprietary, the twin enables more accurate verification of models applied to the test case.

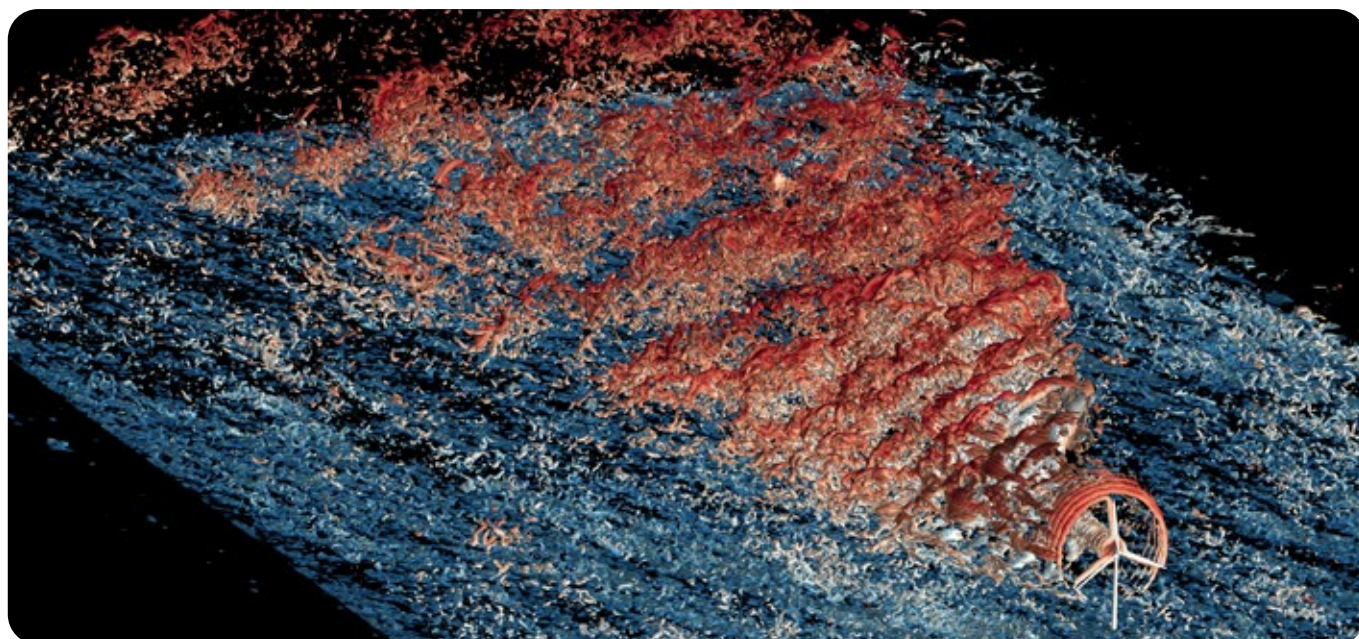
DEMONSTRATOR ACTIVITIES

→ Validation studies

As part of the IEA Wind TCP Task 57 Joint Assessment of Models, many partners participated in the AWAKEN Benchmark campaign. Here, data from one day of operation was made publicly available to all interested partners. The goal was to **use the data to improve simulation of the King Plains wind farm** at a variety of numerical fidelity levels: from engineering models to meso-scale weather models.

→ Environmental conditions of interest for the study

With mildly complex terrain, there is an interest in determining the impact of this terrain on the farm performance. As an onshore site, the **atmospheric conditions vary notably from day to night**, which is known to impact loads and power production. Additionally, there is a **neighbouring wind farm** that, at certain wind directions, can impact the performance of the King Plains wind farm. All of these features make this site complex and interesting to study.



DOE AWAKEN Project. Illustration by Matt Churchfield, NREL

CHALLENGES

Specific information about the wind farm and how it is operated is proprietary, such as the turbine model. Availability of operational power production data is typically also limited, and operational turbine load data is even harder to access. While a wealth of data was made available for this site through the AWAKEN campaign, data-sharing restrictions also typically make the verification of our predictions difficult – most typically for turbine fatigue and extreme loads.

KEY FINDINGS

This case study shows the clear influence of complex environmental factors (terrain, atmospheric conditions, neighbouring farms) on accurately predicting the energy yield and load of a farm, but **more data is needed to help researchers fully understand these complexities**. More **collaboration between the industry and academic partners** is necessary, including detailed measurement campaigns at wind farms.

Accuracy of power and load prediction at a specific operational site depends on having accurate **weather and atmospheric information**. By having measurement data available to academic partners, such as lidar and SCADA data, **improvements in in-flow modelling** at all fidelity levels was enabled.

SUSTAINABILITY AND REPEATABILITY

These site-specific simulation improvements help researchers better predict power and loads over the operational history of a wind farm. This has two benefits:

- 1** It enables researchers and wind farm managers to accurately predict the operational lifetime of a turbine at a given site and to determine how to extend the operational life, leading to more energy yield;
- 2** The wealth of historical operational data and verified simulations can help improve performance predictions of repowered sites for improved energy yield.

DATA SHARING

The King Plains digital twin turbine model is open-source, and the AWAKEN benchmark data is available to participating nations in the IEA Wind TCP Task 57. Any relevant simulation data sets can be included in the WindLab data hub for anyone to access and repeat the studies.

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