Fraunhofer IWES

Data and facts

Understanding and improving O&M activities – a service provided by Fraunhofer IWES

Why Fraunhofer IWES? – Specific O&M experience

Fraunhofer IWES has a long track record of publicly funded projects related to power converter reliability, root cause analysis, condition monitoring, and the digitalization of O&M data. Through several years of research, Fraunhofer IWES has amassed extensive expertise in the field of exploring the failure causes of wind turbine components. We have conducted a variety of projects and are continuously expanding our expertise in ongoing projects in close collaboration with stakeholders from all parts of the value chain, with the overall objective of improving reliability and reducing both costs and associated risks. In addition to these public case studies, Fraunhofer IWES has worked on confidential projects funded directly by industry on reliability issues of wind turbine components, root cause analysis, and condition monitoring. Additionally, Fraunhofer IWES has experience in O&M modeling, cost-benefit analysis, and the optimization of O&M strategies on the basis of field data.

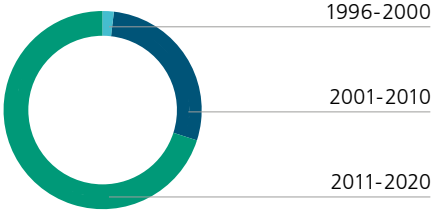
Our competences at a glance

- Analysis of field data from more than 10,000 wind turbines to compare and evaluate experiences in the operation of wind farms
- Exploration of failure causes of wind turbine components
- O&M modeling, cost-benefit analysis, and optimization of O&M strategies based on field data
- Experience in standards and guidelines for digitalizing O&M data
- Independent and trustworthy data analyst and adviser

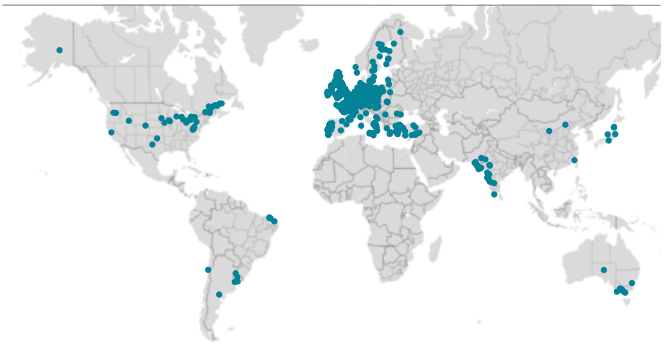
The above-mentioned projects have produced an extensive field data collection, which is continuously growing. This data set is unique due to its size, diversity, and recentness, plus it covers a variety of turbine ages, manufacturers, and sites.

Current status and key characteristics of the Fraunhofer IWES field data set

Failure data available	>10,000 WTs
Total number of evaluated WT operating years	> 20,000 years
Failure data from years	2003-2023
SCADA operating data available	>1700 WTs



Compilation of wind turbine commissioning years



Operating sites

What services do we provide?

Use case 1: Reliability data for OPEX modeling in the bid stage
Reliability KPIs such as failure rates for major and minor components can be extracted on the basis of the available field data. Differentiations can be made between onshore and offshore wind turbines, turbine sizes, and topologies. A reliability comparison among data subsets reveals how failure rates differ. A Weibull analysis makes it possible to understand how failure rates develop over component age. These insights can also be used for improved spare parts management.

Use case 2: How can O&M data be utilized for early fault detection?
Early fault detection aims to detect and localize the development of damage in components in order to initiate preventative measures and avoid unexpected failures and consequential damages as effectively as possible. Until now, this has been done using dedicated condition monitoring systems, which are associated with additional costs. In contrast, early fault detection based on operating data recorded by the SCADA system is widely considered to be a cost-effective and very promising approach.

IWES is dedicated to developing early fault detection and diagnosis methods based on high resolution (1 Hz) operating data recorded by standard instrumentation to provide cost-effective condition monitoring and data-based decision support in maintenance. Physical models and data-driven methods including machine learning are utilized for monitoring KPIs and setting alarms.

Use case 3: Root cause analysis
Exploratory data analysis has the potential to reveal factors and conditions leading to frequent failures. Results can be utilized to learn from the past so as to avoid similar failures and develop countermeasures such as improving the design or procedures. The field experience based root cause analysis approach followed at IWES is typically based on three pillars:

- Systematic **analysis of field failure**, operating data, and environmental data from the turbine models and sites of interest
- **Post-mortem lab analysis** of damaged components from these sites
- **Field measurements** for assessing the conditions in the failure-prone turbines

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Use case 4: How should O&M data be handled?
Standardized data is crucial to facilitate the development of data-driven models and KPI-driven maintenance optimization. Using standards and predefined workflows enables the interoperability of various data sets from different enterprises and stakeholders. Fraunhofer IWES helps to implement such procedures and render experiences in the operation of wind farms comparable. Non-digitalized maintenance reports from the past can be made available via a developed digitalization workflow. In combination with AI-based classifier methods, this massively reduces the workload for preprocessing and labeling service reports, which had to be done manually in the past.

Use case 5: Cost-benefit analysis
In order to take informed decisions, new technologies and concepts need to be evaluated quantifying the impact not only on CAPEX but also on OPEX. A cost-benefit analysis compares overall costs with overall revenue to examine if economic feasibility is given. Possible applications comprise evaluating:

- New technologies, component designs, and features
- Change of O&M strategy
- Lifetime extension

Further information

Fraunhofer IWES secures investments in technological developments through validation, shortens innovation cycles, accelerates certification procedures, and increases planning accuracy by means of innovative measurement methods in the wind energy and hydrogen technology sectors. At present, there are more than 300 scientists and employees as well as more than 100 students employed at the nine sites: Bochum, Bremen, Bremerhaven, Leer, Görlitz, Hamburg, Hannover, Leuna, and Oldenburg.

Contact

Julia Walgern
Group Manager
Technical Reliability
Phone: +49 471 14290-549
julia.walgern@
iwes.fraunhofer.de

Dr.-Ing. Katharina Fischer
Senior Scientist
Phone: +49 471 14290-542
katharina.fischer@
iwes.fraunhofer.de

Fraunhofer Institute for Wind Energy Systems IWES
Postkamp 12, 30159 Hannover, Germany
www.iwes.fraunhofer.de