ESTABLISHING A COMMON DATABASE

FOR TURBINE FAILURES

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Fraunhofer Institute for Wind Energy and Energy System Technology (IWES)
The Fraunhofer Society in Germany

60 Institutes at 40 locations

2010
Staff 18 000
R&D-budget 1 650 Million €
Fraunhofer Institute for Wind Energy and Energy System Technology (IWES)

Bremerhaven and Kassel

Advancing Wind Energy and Energy System Technology

Research spectrum:
- Wind energy from material development to grid optimization
- Energy system technology for all renewables

Foundation: 2009  Annual budget: approx. 22 million euros
Personal: approx. 230 (full-time: 160)
Directors: Prof. Dr. Andreas Reuter, Prof. Dr. Jürgen Schmid

Formerly:
- Fraunhofer Center for Wind Energy and Maritime Engineering CWMT in Bremerhaven
- Institute for Solar Energy Technology ISET in Kassel
ESTABLISHING A COMMON DATABASE

■ Introduction
  ■ Motivation
  ■ Maintenance strategies / organization
  ■ Value of experience

■ Failure Databases
  ■ Past
  ■ Present
  ■ Future

■ Conclusions & Outlook
Introduction

Motivation

Starting Point: Modern wind turbines achieve high availability

Number of faults cause unplanned downtimes \(\Rightarrow\) high maintenance efforts and costs

Offshore: drop of availability expected
Introduction

Maintenance strategies

It can be distinguished between reactive and preventive maintenance strategies.

Within the **break down** maintenance strategy the system will be operated until a major failure of a component will result in a shut down.
Introduction

Maintenance strategies

Preventive maintenance strategies try to react before a failure occurs.

With the cyclic maintenance strategy components of the wind turbine will be inspected and maintained cyclically, e.g. on semi annual intervals.
Introduction
Maintenance strategies

The **condition based** maintenance strategy tries to find the optimum point in time for carrying out the required maintenance actions by monitoring the current state of a specific component.
Introduction

Maintenance strategies

The reliability based maintenance tries to find the right time for maintenance measures through analysing a broad database filled with experiences from the past.
Introduction

Maintenance organisation

- Lacking of a closed maintenance loop

Strategy
- reactive
- time based
- condition based
- reliability based

Event
- failure
- fault
- inspection
- repair

Analysis
- MTBF, MTTR
- weak points
- expenses
- life cycle cost

Planning
- improvement
- consolidation
- interval opt.
- responsibility

Documentation
- subassembly
- cause
- time steps
- cost

Archiving
- core data (RDS-PP)
- in-service data
- event data (EMS)

Design
- verification
- modification

Use of operating experiences

Accurate, detailed documentation
Consistent naming of components
Unified description of irregularities and activities
Introduction
Value of Experience

mean annual failure frequency

year of operation

year of production

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Failure Database – WMEP

Past


- 193,000 monthly operation reports
- and 64,000 Incident reports
- from 1,500 wind turbines

Technology development
Learning curves
Reliability
Failure Database: WMEP

75% of all failures with downtimes ≤1 day responsible for 5% of annual downtime
Failure Database – WMEP

Past
## Failure Database – Other sources

### Past

<table>
<thead>
<tr>
<th></th>
<th>WMEP</th>
<th>LWK</th>
<th>WIND-STATS</th>
<th>WIND-STATS</th>
<th>VTT</th>
<th>ELFORSK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country</strong></td>
<td>Ger</td>
<td>Ger</td>
<td>Ger</td>
<td>Dk</td>
<td>Fin</td>
<td>Swe</td>
</tr>
<tr>
<td><strong>Number of turbines</strong></td>
<td>1468</td>
<td>241</td>
<td>4285</td>
<td>904</td>
<td>92</td>
<td>723</td>
</tr>
<tr>
<td><strong>Years of experience</strong></td>
<td>~15.000</td>
<td>5.719</td>
<td>27.700</td>
<td>18.700</td>
<td>356</td>
<td>4.378</td>
</tr>
<tr>
<td><strong>Average failure rate</strong></td>
<td>2.4</td>
<td>1.9</td>
<td>1.8</td>
<td>0.7</td>
<td>1.5</td>
<td>0.9</td>
</tr>
<tr>
<td>[failures/turbine/year]</td>
<td>over whole survey period</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Annual downtime</strong></td>
<td>156</td>
<td>27</td>
<td>93</td>
<td>-</td>
<td>237</td>
<td>58</td>
</tr>
<tr>
<td>[hours/turbine/year]</td>
<td>over whole survey period</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Highest failure rate

- Electric Control
- Electric Blades
- Electric Sensors
- Control Blades
- Yaw-Syst.
- Hydraulic Blades
- Gearbox
- Electric Sensors

### Longest downtime per failure

- Gearbox
- Drive train
- Blades
- Electric
- Gearbox
- Blades
- Drive Train
- Gearbox
- Blades
- Structure
- Gearbox
- Drive train
- Yaw-Syst.
- Gearbox
Failure Database – Appropriate failure statistics

Past

For differential analysis distinctions regarding size, technical concepts, site conditions, etc. must be made.
Interim Conclusions

- Potential for reliability improvement and for reducing maintenance effort exists
- Data collections from the past show similar results but are not able to consolidate
- Common database needed due to parameter diversity
- Different concepts are necessary
  - Overall data structure
  - Standards and definitions
  - Accessibility of information
Failure Database – EVW (Increasing availability of WTs)

Present

- Funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

- Task: Knowledge management and maintenance optimization as methodical base for increasing the availability of wind power plants
Failure Database – EVW (Increasing availability of WTs)

Present

- Developing a test and demonstration system
- Preparing recommended practices for reliability based maintenance
- Technical guidelines / standards (Federation of German Windpower)
The project is a follow-up project to the onshore wind energy monitoring program ‘Scientific Measurement and Evaluation Program’ (WMEP) and accompanies the offshore wind energy deployment in Germany.

Funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.
Failure Database – Offshore~WMEP
Future – General monitoring

- Core issues
  - Site-specific offshore conditions
  - Installation
  - Energy output
  - Reliability
  - Availability
  - Facility concepts
  - Operation and maintenance concepts
  - Investment and operating costs
Optimization of intervals

Constitute priorities

Optimization of strategies

LCC prediction

Source: IZP Dresden
Failure Database Present

NERC = North American Electric Reliability Corporation
GADS = Generating Availability Data System
CREW = Continuous Reliability Enhancement for Wind

NERC – GADS
Wind Turbine Generation

CREW Database (Sandia)

Gearbox Reliability Database (NERL)
Blade Reliability Database (SNL)

Portion of National Fleet

Increasing Detail

Increasing Breadth

Sandia National Laboratories

CREW Database Program:
Partner Maturity

Conversations with operations
Early Partners
ORAP Pilot Partners
ORAP Users & CREW Partners

2007 2008 2009 2010 2011 2012*

Maintenance Data:
Scheduled & Unplanned

- No documentation (tribal knowledge)
- "If you got my work orders up here, I'll tile head" -
- Paper work orders
- Scanning or typing paper forms
- CMMS with true electronic work orders

Failure Data

- Not captured from SCADA
- Data captured; large amounts of time unaccounted (10-15%)
- SCADA data reviewed, and errors addressed

Data Infrastructure

- Flat text files
- FTP sites
- Data transfer processes
- SCADA & Work Orders disconnected
- SCADA, CMMS, data historian linked
- SCADA "events" drive work orders

Manual collection
Hard copy
Data historian
Automated

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Final Conclusions

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Final Conclusions

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- Different concepts are necessary
  - Overall data structure
  - Standards and definitions
  - Accessibility of information
- Several groups and projects dealing with the topic of establishing failure database to improve reliability of wind turbines
- Harmonization is needed → focus on structuring the format for data collection, setting up procedures for analyses and reporting, and developing a central database that can be accessed by industrial and scientific parties, keeping in mind the confidentiality aspects.
Conclusion/Outlook

- Fraunhofer IWES has great experience with reliability databases due to the WMEP and builds up a more sophisticated database within the project EVW
- The Offshore-WMEP establishes a common database to monitor the offshore deployment and support offshore operators
- TASK 11 IEA Wind:

BASE TECHNOLOGY INFORMATION EXCHANGE
Topical Expert Meeting #65 (March 30-31, 2011) on

“INTERNATIONAL STATISTICAL ANALYSIS ON WIND TURBINE FAILURES”

Result:

Discussion paper for launching an IEA-Task “Wind Turbine Failure Statistics”
Thank you for your attention

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Reliability & Maintenance strategies
R&D Division Energy Economy and Grid Operation

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