Syllabus: Reliability, Availability, Maintenance Strategies

Online M.Sc. Wind Energy Systems // Summer Semester 2017

Instructors

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Course goals

Students know different approaches regarding collection and analysis of reliability data in order to use the information for maintenance optimization. They know regulatory requirements, industry standards and optimization strategies. They are able to apply these strategies to the operation and maintenance of wind farms and to make use of experience gained during wind turbine operation as well as additional information coming from different monitoring systems.

Pre-requisites

There are no pre-requisites for this course. However, basic knowledge in mathematics and wind turbine technology is helpful.

Seminar structure, seminar location and times

This module is divided into thirteen units. In addition a separate unit for the introduction part and the final exam round off the module.

Participation requirements

Each unit lasts one week and consists of the following parts:

1. Lecture: The lecture is made available via Moodle in form of a video. The slides the lecturer uses in these videos will be made available, too.

2. Online live tutorial: These live online sessions are held biweekly via Adobe Connect in eCampus. The homework assignments will be discussed here. The students are able to actively participate in solving the problems and ask questions. The tutorial will be held Friday in the afternoon. The specific dates and times of the online tutorial sessions will be announced in Moodle. After each session, the video will be made available, so the students that could not participate can view it later.

3. Homework assignment: The assignments are provided and submitted via Moodle.
All questions on understanding the material should be directed to your fellow students in the online forums first. Any questions which could not be answered already by your classmates will be answered by the lecturer in the online forums, via email or in the online tutorial sessions.

**Texts, reading and other materials**

All the available materials will be posted on Moodle. All seminars will be recorded and made available.

**Hardware and software requirements**

All students will need a computer for this course; only the usual Microsoft office programs will be used.

**Examination**

The overall module grade is made up entirely of a final exam at the end of the module. This final exam will be an oral exam and appointments will be fixed individually with each student.

**Grading policy**

The grading scale used in this course is the same as for all WES courses. For all single assignments, the following scale is used:

<table>
<thead>
<tr>
<th>Category</th>
<th>Grade range</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good</td>
<td>1,0 1,3</td>
<td>Excellent performance</td>
</tr>
<tr>
<td>Good</td>
<td>1,7 2,0 2,3</td>
<td>Performance significantly above average</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>2,7 3,0 3,3</td>
<td>Average performance</td>
</tr>
<tr>
<td>Sufficient</td>
<td>3,7 4,0</td>
<td>Performance which, despite some shortcomings, meets the minimum standards of the course</td>
</tr>
<tr>
<td>Fail</td>
<td>5,0</td>
<td>Does not meet minimum course requirements</td>
</tr>
</tbody>
</table>
Unit 0  
KW 17

**Introduction**

Content

In this preceding unit we provide a general introduction of the module structure. Topics included:

- Overview about the whole course
- Introduction of lecturers
- Overall target
- Prerequisites

Unit 1  
KW 17

**O&M of decentralized plants for renewable energy sources**

Content

In this first unit we are setting the scene and provide some basic information about maintenance in general and the specialties of decentralized renewable power plants. Topics included:

- Motivation
- Basics of maintenance tasks
- Specialties of decentral units, renewables, wind turbines
- Definitions
- Industry standards

Homework: Checking all answers provided in this session or answering open questions.

Unit 2  
KW 18

**Processes and actors**

Content

Today, the wind energy industry lacks cooperation among parties: operators, manufacturers, component suppliers, designers, service providers, and researchers. In this unit the most relevant stakeholders or roles in the wind industry and their objectives for dealing with reliability and maintenance data will be introduced. Topics included:

- Roles and objectives
- Real processes and implementations
- Demand for information and decisions
- Prioritizing

Homework: Checking all answers provided in this session or answering open questions.
### Unit 3
**KW 19**

#### Inspections & reports

**Content**

Although wind energy use has been established well during the recent years, still common standards for the documentation of O&M measures as well as for a uniform structure of data bases are missing. In this unit we introduce regulatory requirements in the maintenance process and the current approaches for documenting maintenance information.

Topics included:
- Documentation of turbine, permission, requirements
- Documentation of maintenance measures and results
- Obligatory inspections and certificates
- Faults and failures
- Example for root cause analysis

**Homework**

Checking all answers provided in this session or answering open questions.

### Unit 4
**KW 20**

#### Reliability & Availability

**Content**

Extensive national research projects dedicated to reliability analyses on wind turbine failures have been performed during the last years. So, several different failure statistics exist and on a certain degree there is agreement in components affected. In this unit we introduce the most important failure statistics and their results.

Topics included:
- Introduction to wind turbine failure statistics
- Existing initiatives (WMEP, CREW, …)
- Analyses results from real wind turbines

**Homework:**

Checking all answers provided in this session or answering open questions.
## Unit 5  
**KW 21**  
**Data management**  

**Content**  
The first step towards improved products, projects or maintenance is the acquisition of detailed and standardized O&M data. In this unit we introduce a comprehensive concept for O&M data based on industry standards such as RDS-PP and ZEUS.  
Topics included:  
- Roles, ambitions, objectives  
- Data groups and sub groups  
- Data entries and taxonomies  
- Standards and guidelines  
- Data acquisition, data sources  

**Homework**  
Checking all answers provided in this session or answering open questions.

## Unit 6  
**KW 22**  
**Qualitative failure mode analyses**  

**Content**  
The evaluation of operation and logistic information by RAMS-LCC techniques (Reliability, Availability, Maintainability and Safety Life Cycle Cost) provides an assembly of specific reliability values. In this unit we introduce methodologies like the failure mode and effect analysis, fault-trees and reliability block diagrams.  
Topics included:  
- FMEA  
- FTA  
- RBD  

**Homework**  
Checking all answers provided in this session or answering open questions.
## Unit 7
### KW 23
#### Statistical reliability analyses

**Content**
Well-structured and comprehensive O&M data is the basis for statistical analyses which are essential to determine reliability characteristics, weak points and cost-drivers. In this unit we introduce the approach of extracting knowledge out of O&M data.
Topics included:
- Definitions of MTBF, MTTF, MTTR, Waiting time, availability, reliability
- Representative samples
- Censored samples
- Statistical methods

**Homework**
Checking all answers provided in this session or answering open questions.

## Unit 8
### KW 24
#### Data driven reliability models

**Content**
Big Data management is a possibility to improve Wind Power farms reliability, sustainability and overall performance. In this unit we introduce advanced technological aspects and tools and techniques for the Big Data Value extraction and Big Data analysis outputs.
Topics included:
- Introduction to Big data
- Data mining
- Neural networks

**Homework**
Checking all answers provided in this session or answering open questions.
### Unit 9  
**Unit 9 KW 25**  
**Condition monitoring / structural health monitoring**

#### Content  
With the increasing size and developing technology of the next wind turbine generation, new approaches for measurement equipment as well as for signal acquisition and evaluation will be required to perform condition monitoring and fault prediction tasks.  
Topics included:  
- Basic possibilities of condition based maintenance  
- Examples for condition monitoring systems  
- Examples for structural health monitoring

#### Homework  
Checking all answers provided in this session or answering open questions.

### Unit 10  
**Unit 10 KW 26**  
**Maintenance optimization**

#### Content  
The mathematical description of the reliability behavior enables using operational experience for optimizing maintenance procedures. Especially the right choice of a maintenance strategy is getting more and more important for the wind energy use.  
Topics included:  
- Renewal function  
- Prioritizing & grouping of measures  
- logistics (e.g. spare part and stock keeping)

#### Homework  
Checking all answers provided in this session or answering open questions.
## Unit 11
**Decision support tools**

### Content
Plans to build a large number of offshore wind farms have created a need for decision support in the planning process to choose the most cost-efficient alternatives. This unit gives an overview of existing commercial as well as non-commercial decision support models along with their main characteristics. Topics included:
- Simulation of maintenance processes
- Modelling failure behaviour
- Capabilities of existing tools (e.g. Offshore times, MAS)

### Homework
Checking all answers provided in this session or answering open questions.

## Unit 12
**Research & development**

### Content
Reliability is a critical issue for the growing wind energy industry. Safety, availability, maintenance, logistics and costs are all impacted by reliability. Furthermore, reliability is dealt with during all phases of lifetime, from design, testing, construction and operation to decommissioning. In this unit the needs and current activities regarding future research are presented. Topics included:
- Research needs (e.g. strategic research agenda (ETIP))
- Introduction of current research activities (e.g. IEA Wind task 33, WInD-Pool, SPARTA, ModernWindABS)

## Unit 13
**Economic efficiency**

### Content
As the global operational wind turbine fleet ages, pressure to reduce both the subsidies associated with wind energy and the Levelized Cost of Energy (LCoE) of wind energy continues. This confluence of events drives the need to improve the reliability of wind assets if profit margins are to be maintained while reducing costs. In this unit the approaches described in the module are examined regarding their economic efficiency and some business cases will be presented. Topics included:
- Business case regarding condition based maintenance
- Business case regarding improved data management

### Homework
Checking all answers provided in this session or answering open questions.
**Final Exam**
**KW 31-35**

**Oral exams will be held in August.**
Specific appointments will be fixed individually with each student.