

Scope

The wind energy industry has enjoyed a very successful decade across Europe, with improvements in the technology, reductions in costs and a large increase in the size of the industry. The next step is to take this technology offshore. Since 2000, the DUWIND Institute at Delft University of Technology has been providing a 2-day intensive course on the ‘Technology of Offshore Wind Energy’, aimed at professionals with an interest in this new industry.

The course covers wind turbine, electrical and offshore engineering aspects. The technology of offshore wind energy is treated on all levels, ranging from the fundamentals of hydrodynamic loading to integrated design methodology. The course doesn’t intend to upgrade expert knowledge but rather picks out issues of the underlying disciplines that are relevant to offshore wind energy. However, the lectures do not shun a profound treatment of these issues. In this way, the audience is encouraged to look beyond their own field of expertise, as well as being able to speed up the application of its own knowledge to the development of offshore wind farms. Technical executives will gain an understanding of the diverse range of disciplines involved.

The trajectory of offshore wind energy from conception to exploitation involves many technical and non-technical aspects. This course focuses on the technical aspects of design, implementation and operation. Non-technical issues, such as environmental impact assessment, regulations and financing are not part of the scope of this technology course.

Programme

8:45 - 9:00	<i>Welcome and coffee</i>	
9:00 - 10:00	Introduction to course and to current wind turbine design	<i>Gijs van Kuik</i>
10:00 - 11:00	Offshore wind climate and loading	<i>Wim Bierbooms</i>
11:00 - 11:20	<i>Coffee</i>	
11:20 - 12:20	Offshore wave and current climate & loading	<i>Jan van der Tempel</i>
12:30 - 13:30	<i>Lunch</i>	
13:30 - 14:10	Long-term loading situation	<i>Jan van der Tempel</i>
14:10 - 15:00	Offshore soil conditions and foundations	<i>Jan Meek</i>
15:00 - 15:20	<i>Coffee</i>	
15:20 - 16:00	Offshore support structure	<i>Jan van der Tempel</i>
16:00 - 16:30	Discussions	
	<i>Drinks</i>	
	<i>Diner</i>	

8:45 - 9:00	<i>Welcome and coffee</i>	
9:00 - 10:00	Dynamics of an offshore wind turbine	<i>Michiel Zaaijer</i>
10:00 - 11:00	Operation and maintenance	<i>Gerard van Bussel</i>
11:00 - 11:20	<i>Coffee</i>	
11:20 - 12:20	Electrical systems	<i>Sjoerd de Haan</i>
12:30 - 13:30	<i>Lunch</i>	
13:30 - 14:20	Electrical systems	<i>Sjoerd de Haan</i>
14:20 - 15:00	Integrated windfarm design	<i>Michiel Zaaijer</i>
15:00 - 15:20	<i>Coffee</i>	
15:20 - 16:20	Integrated windfarm design (cont.)	<i>Michiel Zaaijer</i>
16:20 - 17:00	Round-up of the course	<i>Gijs van Kuik</i>

(Optional)

9:00 - 12:30	Workshop - discussion - questions	
12:30 - 13:30	<i>Lunch</i>	

Contents

Introduction to course and to current wind turbine design

Gijs van Kuik

The first lecture presents a very brief summary of the principles of wind energy conversion and of some design recommendations. This lecture is particularly intended for those who enter the field of offshore wind energy with a different background than wind energy. The overview comprises basic aerodynamic theory, control strategies and systems, rotor dynamics and energy yield. As an introduction to the subject 'offshore wind energy' the terminology to be used is discussed.

Offshore wind climate and loading

Wim Bierbooms

No wind energy, without wind. But what are the properties of the wind at offshore locations and what is their effect on the wind turbine? After a general description of the origin and character of the wind the specific properties for the offshore environment are highlighted and illustrated with measurement data. The relation of the offshore wind with energy yield and important loading phenomena are explained.

Offshore wave and current climate & loading

Jan van der Tempel

No one can overlook the importance of wave and current climate for offshore wind energy. However, how to deal with this in the design process is not a straightforward issue. This lecture will examine the generation and development of waves and the nature and mathematical description of sea states. Different models for the water particle kinematics are presented and their suitability for different situations is discussed. Finally, the calculation of structural loading from the wave kinematics is treated.

Long-term loading situation

Jan van der Tempel

In the previous lectures wind, waves and current are treated as separate phenomenon. In the long-term these loading situations are correlated in magnitude and direction. This lecture describes how this correlation can be determined and how it can practically be presented. Several examples illustrate the long-term correlation between some environmental parameters. This lecture concludes with requirements for knowledge of long-term environmental conditions for load and performance analysis.

Offshore soil conditions and foundations

Jan Meek

Due to several reasons foundations for offshore wind turbines not only differ from their onshore counterparts, but also from other offshore structures. The lecture on offshore ground conditions and foundations deals with these differences and addresses several foundation types and construction methods. Special attention is given to the behaviour of pile foundations under axial and lateral loading.

Offshore support structure

Jan van der Tempel

Offshore support structures are very site specific, resulting in a large variety of structures for the oil and gas industry. The experience obtained with these structures are summarised and translated to lessons for offshore wind energy. Finally, this lecture describes the candidate concepts and a design approach for support structures for wind turbines.

Dynamics of an offshore wind turbine

Michiel Zaaijer

The structural dynamics of an offshore wind turbine are important, as well as complicated. To facilitate the understanding of the dynamics of the entire system an introduction of dynamics presents the relevant issue of mechanics. Following the analysis of the differences with other offshore structures and onshore wind turbines, the importance of structural dynamics of offshore wind turbines is explained. An overview is given of typical offshore aspects of the dynamic behaviour and of various analysis methods. Special attention is paid to the subject of fatigue loading, which is often a design driver for the support structure.

Operation and maintenance

Gerard van Bussel

Operation and maintenance is one of the less 'hard core technology' aspects of this course. This lecture provides a systematic approach toward analysis and planning of operation and maintenance activities. Relating issues that show up are system reliability, access methods, lifting equipment and maintenance strategies. The importance of these issues is illustrated with examples from existing offshore wind farms and a model of operation and maintenance.

Electrical systems

Sjoerd de Haan

This lecture consists of three parts namely the electrical system of the turbine, the electrical system of a wind farms and aspects of grid integration. The first part covers the conversion of mechanical power into electrical power. In this part the principles, characteristics and types of generators and power electronics are shown, in which emphasis is given to the role of the electrical components in a wind energy conversion system. In the second part the functionality of the electrical infrastructure and some of the constraints are reviewed such as transmission capacity of cables and transmission by AC and DC. Several configurations and types of clustering and provides examples of their costs and efficiency. The last part concerns the integration of wind power into the grid. The functions and operation of the power grid is reviewed. The effect of injection of wind power is considered with respect to voltage stability, faults, islanding and power quality is addressed shortly.

Integrated windfarm design

Michiel Zaaijer

This lecture gives a schematic representation of several design approaches. The abstract ideas are illustrated with examples from existing projects. The integrated design approach is identified as the most promising approach and discussed in more detail, emphasizing on the conceptual design phase. The lecture then focuses on key aspects of the integrated approach such as availability and levelised production costs. Some technical issues are singled out to demonstrate the importance of interactions between sub-systems.

Round-up of the course

Gijs van Kuik

The summary looks back at experience gained with design and implementation of current offshore wind farms and looks ahead at future perspectives. A context is given for the development of offshore wind farms in the medium and long-term future.

Workshop - discussion - questions

The technology of offshore wind energy raises many questions and points of discussion. During the course the participants can select on which of the topics they would like to elaborate with the lecturers and the other participants. During the workshop the lecturer will answer specific questions and chair a discussion. Two parallel sessions are organised, depending on the topics of interest of the participants.