ECN Wind Energy Industrial Support

Training Rotor Aerodynamics

EWIS

Being one of the leading institutes on wind energy research, ECN established the EWIS (ECN Wind Industrial Support) group in 2009 to better bring the R&D results to the market. During the last three decades, ECN has developed expertise on aerodynamics, structural analyses, turbine control, offshore operation and maintenance, and grid connection. With the growing wind industry, ECN received more requests for assistance and EWIS has become the vehicle to support the wind energy industry in their product developments.

EWIS's focus is on the high end of the market which means that we will make use of tools and knowledge that have been developed in-house and include the latest R&D results!

The EWIS team is a mixture of young professionals and experienced researchers which ensures a fast response and high quality.

More information

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Description of training

Purpose

The purpose of the training is to explain the main aerodynamic design principles of wind turbine (blades) including the underlying aerodynamic models and design rules.

Organisation and content

The training is generally held in two days. The first day deals with the so-called blade element momentum theory, i.e. the most important aerodynamic wind turbine model. It includes a discussion of the Betz optimum and various aerodynamic losses and culminates in an aerodynamic pre-design of a rotor blade.
The second day consists of two parts. The topic of the first part is airfoil aerodynamics, including selection criteria and ECN's experiences with popular wind turbine airfoils. Noise considerations are also included. The topic of the second part is vortex wake theory which forms an alternative to the blade element momentum theory and provides insight into various simplifications made in the derivation of the blade element momentum theory. Remedies to deal with these simplifications form the final part of the training.
The lecture material contains examples of various research projects in which ECN was involved (including validation of aerodynamic models with high quality measurements). The content of the lecture is regularly updated using the experiences from previous lectures and the most recent results from research projects.
Optionally a third day can be added in which the ATG and BOT tools are explained.

Content

Part 1 (Day 1):

Basic wind turbine aerodynamic models, pre-design of a wind turbine:

- Introduction
- Principles of energy extraction
- Fundamental Equations, momentum theory for an actuator disk
- Betz-Lanchester optimum
- Division of streamtube in independent annuli
- Wake rotation

CO-920 February 2011

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Target Group:	Wind turbine (blade) designers, research institutes, universities.
Required educational level of attendees:	Engineers or scientists. No aerodynamic expert knowledge is required but basic knowledge of mathematics and physics is expected.
Track record:	ECN has given this training for many years. A shortened version of this training is given on an annual basis at Dutch universities. The training is given by specialists with experience in wind turbine aerodynamics who do not only have decades of experience in wind turbine aerodynamics but who are experienced in educational activities as well.
Minimum/maximum number of participants:	The number of participants is not limited but if more than six persons are going to participate the training will become less efficient and special arrangements need to be made.

For more information about this training, please contact:

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Content

- Introduction to airfoil aerodynamics
- Blade Element Momentum (BEM) theory
- Losses (rotational losses, drag losses and tip losses)
- Design considerations, examples of blade optimisations, exercises

Part 2 (Day 2)

- Airfoil aerodynamics (extended):
- General discussion of airfoils and their behaviour
- Viscous effects (boundary layer)
- Origin of airfoil characteristics
- Choice of airfoils (criteria, roughness aspects, noise aspects, comments on popular airfoils, comments on wind tunnel measurements, suggestions for improvements)

Part 3 (Day 2)

- Vortex theory and additions to the BEM theory:
  - Vortex theory
  - Explanation of vortex wake theory
  - Simplified vortex wake theory. Comparison with results from momentum theory
- Additions to BEM theory, (e.g. tip losses, turbulent wake state, tower shadow, instationary airfoil aerodynamics, dynamic inflow, rotational effects, 3D geometrical effects, yaw)

Part 4 (Day 3 - Optional)

- The day starts with a short introduction on the ATG and BOT tools. In this introduction the theory behind the tools is explained based on the knowledge gained at the first two days. This is followed by an intensive hands-on training session, where an aerodynamic design is practised so that all aspects of these codes are covered.

The content of the lecture can be combined with an introduction on ECN's other design tools (Aeromodule and/or RFOIL). If desired a demonstration of these tools can also be added to the program.