On the kidney shape of the wake of a HAWT in yaw

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BOOK OF ABSTRACTS

WESC2017 – Wind Energy Science Conference
Technical University of Denmark, Lyngby
June 26th – 29th, 2017

Preface

Wind Energy Science Conference 2017 (WESC-2017) is held at the Technical University of Denmark in Lyngby during June 26-29, 2017. This conference is the first of a series of bi-annual conferences launched by the European Academy of Wind Energy (EAWE). The purpose of the conference is to gather leading scientists and researchers in the field of wind energy to present their latest findings. The conference aims at covering all scientific topics in wind energy, comprising from most fundamental aspects to recent applications. It provides a world-wide forum for scientists to meet each other and exchange information of all aspects of wind energy, including aerodynamics, turbulence, wind resource assessment, wind farms and wakes, aero-serve-elasticity, loads, structural mechanics, control, operation and maintenance, generator technology, grid integration, structural design and materials, new concepts, as well as community acceptance, environmental aspects, and economics.

This volume of abstracts comprises all presentations of the conference, including two plenary lectures, and nearly 370 contributed papers, presented in either oral sessions or during 13 mini symposia. The abstracts are sorted chronologically after the day of presentation, corresponding to the way they appear in the conference programme. At the end of the book you will find a list of presenting authors, listed alphabetically, and the page number where their abstract appear.

I like to thank the scientific committee and the local organizing committee for their work with the evaluation and selection process. In particular, I thank Marianne Hjorthede Arbirk for her invaluable help in preparing the conference and this book of abstracts.

Jens N. Sørensen, chairman WESC-2017
Lyngby, June 2017

Keywords or mini-symposium identification: wake in yaw, vortex method

On the kidney shape of the wake of a HAWT in yaw

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A PhD project is being carried out on the topic of far-wake aerodynamics of Horizontal Axis Wind Turbines (HAWTs) in yawed conditions, which has a large relevance for wind farm design and optimization. Characteristic for a turbine in yaw are the inherent unsteady and non-uniform rotor loading, and the typical wake deflection and strong three-dimensional deformation effects under influence of self-induction (see figure 1). Investigation of HAWTs in yaw is important, as the larce-scale eddies of the turbulent atmosphere dictate that a wind turbine is in practise always operating in unsteady yaw, while the resulting wake effects are already significant for small yaw angles. Despite this relevance, research into the far-wake of yawed wind turbines has been very limited and the symmetry assumptions on which common wake engineering models are based conflict with the physics of the skewed wake of a yawed turbine. Nevertheless, there is an increasing interest into this topic, as it is recognized that the effect of wake deflection can be exploited as a way to optimize the overall wind farm power production through active yaw control. For this purpose, simple two-dimensional models are applied for approximating the wake deflection, but which are unable to capture the typical three-dimensional deformation effects. In summary, there is a large gap of fundamental knowledge on wake physics in yawed conditions, and what the relevance of these phenomena is on the development and issues like the re-energization process of the far-wake.

To bridge this gap, the PhD project aims at improving our understanding of the wake physics of HAWTs in yaw and to draft guidelines for reduced-order models that can be applied for wind farm design and optimization. In support of this aim, the objective is to analyze the different physical “modes” that play a role in the yawed wake, through a numerial and experimental investigation of the skewed wakes aft of HAWTs and actuator discs. The results from these investigations are collected (along with results from third parties) into a high-fidelity benchmark database for model validation purposes and to be able to derive the reduced-order models.

For the current conference, results will be presented of both two- and three-dimensional free-wake vortex simulations of an actuator disc in yaw. The focus is put on the crescent or kidney shaped convective wake deformation (figure 1), which is naturally not present in a two-dimensional simulation. The magnitude of this phenomenon is investigated as function of the yaw angle and thrust coefficient, and the effect on global wake parameters is assessed such as the wake deflection and velocity profile. The outcomes of this investigation are relevant for assessing the validity of two-dimensional assumptions made in current yaw models regarding the wake deflection, definition of the wake center and width, and the wake profile.

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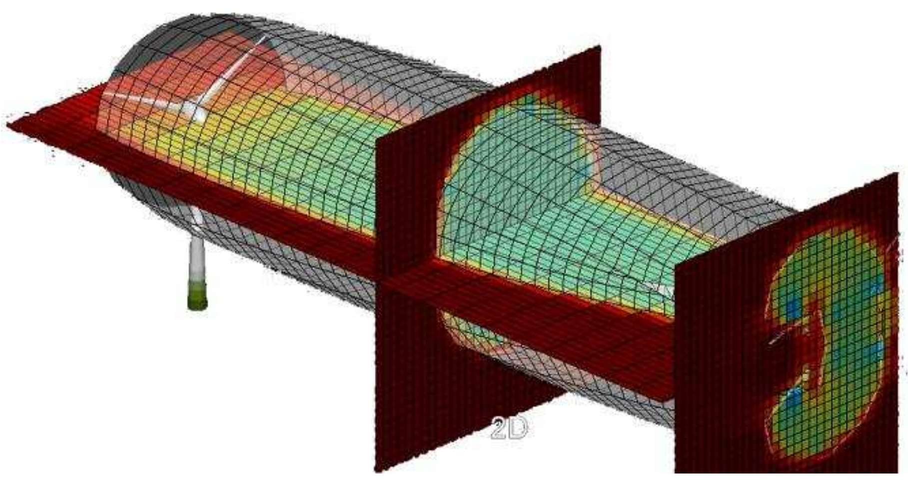

Figure 1: Wake deflection and deformation aft of a turbine in 20 degrees yaw, via a free-wake vortex ring simulation.