Comparison of Levelized Cost of Energy of a 10 MW superconducting and magnetic pseudo direct drive generator targeted for the INNWIND.EU reference turbine

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BOOK OF ABSTRACTS

WESC2017 – Wind Energy Science Conference
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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: Superconducting direct drive, Magnetic Pseudo direct drive, Levelized Cost of Energy (LCoE) comparison

Comparison of Levelized Cost of Energy of a 10 MW superconducting and magnetic pseudo direct drive generator targeted for the INNWIND.EU reference turbine

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Innovative drive trains targeted at 10-20 MW offshore turbines are investigated in the INNWIND.EU project in order to determine the impact on the Levelized Cost of Energy (LCoE) resulting when installed in the North sea at 50 m of water [1]. The two main technologies studied are superconducting direct drive (SCDD)[2] and the magnetic pseudo direct drive (PDD) [3] generators, which are both capable to providing compact drive trains with low weight and a small number of moving parts compared to a gearbox based drive train (see figure 1a). Superconducting field coils are used to provide the torque in the direct drive generators, where the armature windings are based on conventional copper wire and magnetic steel laminates operated at ambient temperature. Magnetic pseudo direct drive generators consist of a magnetic gearbox made of an inner free rotor (rotating at a geared up speed to the blade input) and an intermediate drive rotor inserted into an outer static armature winding, where the electricity is harvested.

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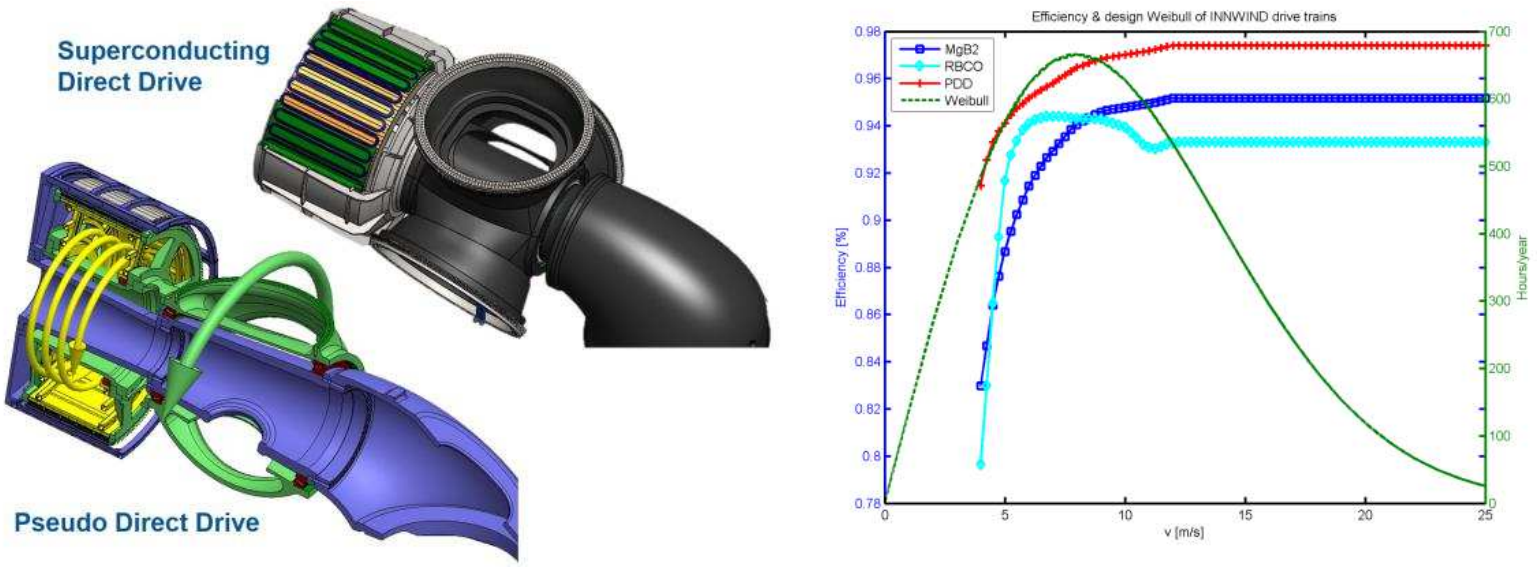

Figure 1: (a) Superconducting direct drive (top) and Pseudo Direct drive (bottom) (b) Partial load efficiencies of 10 MW superconducting direct drive generator based on (MgB_2) and the high temperature superconductor (RBCO) as well as pseudo direct drive (PDD). The Weibull distribution of the target position in the North Sea is also shown for evaluation of the Annual Energy Production (AEP).

The Levelized Cost of Energy is here defined as the sum of the CAPital EXpenditure (CAPEX) and the OPerational Expenditure (OPEX) divided by the Annual Energy Production (AEP) and discounted by the interest rate w of the similar investment over the Life Time (LT) of the equipment. The paper will discuss how the relative difference in LCoE of a superconducting direct drive can be compared to a pseudo direct drive by taking into account the partial load efficiencies of the two drive trains including the power electronics as shown in figure 1b. The Annual Energy Production is obtained by specifying the Weibull wind distribution of the North Sea and integrating the power curve of the 10 MW INNWIND.EU reference turbine multiplied by the partial load efficiency. From figure 1b it is seen that the efficiency of the PDD drive train is substantially higher than that obtained for the superconducting direct drive generators, because of the combined magnetic gearbox and generator. The consequence is that the PDD has a 4 % lower LCoE than the RCBO superconducting generator. Similarly, the LCoE of the MgB_2 superconducting generator is about 1% lower than for the RBCO generator. In the paper it will be discussed that cost differences between the drive trains has quite little impact in the LCoE, since the CAPEX also contains the large contribution from the rest of the turbine and the offshore foundation.

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