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Editorial

Special Issue on Wind Turbine Aerodynamics II

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1. Introduction

To alleviate global warming and reduce air pollution, the world needs to rapidly shift towards renewable energy. As the pioneer of renewable energy, wind energy is developing very fast all over the world. In order to capture more energy from the wind and reduce the levelized cost of energy (LCOE), the size of a single wind turbine has recently increased to 16 Mega-Watt (MW) [1], and will be increased further in the near future. Big wind turbines and their associated wind farms have advantages, but also challenges in all wind energy sciences, including wind turbine aerodynamics. The typical effects are mainly related to the increases in Reynolds number, in blade flexibility, and possibly in wind turbine noise. This Special Issue collects a number of important works addressing these aerodynamic challenges. Aerodynamics of wind turbines is a classic concept, and is the key for wind energy development, as all other wind energy sciences rely on the accuracy of its aerodynamic models. There are also several Special Issues on wind turbine aerodynamics. This guest editor edited a Special Issue in Renewable Energy on aerodynamics of offshore wind energy systems and wakes in 2014 [2], which collected state-of-the-art research articles on the development of offshore wind energy, and a Special Issue in Applied Sciences on aerodynamics in 2019 [3], which collected various important aerodynamics problems.

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Citation: Shen, W.Z. Special Issue on Wind Turbine Aerodynamics II. *Appl. Sci.* **2021**, *11*, 8728. https://doi.org/10.3390/app11188728

Received: 15 September 2021
Accepted: 16 September 2021
Published: 18 September 2021

2. Current Status in Wind Turbine Aerodynamics

In the context introduced above, this Special Issue was to collect latest research articles on various topics related to wind turbine aerodynamics, which includes Wind turbine design concepts, Tip loss correction study, Wind turbine acoustics modelling, and Vertical axis wind turbine concept. A summary of the collected papers is given below in the order mentioned above.

There are also three papers dealing with Wind turbine design concepts. Sun et al. [4] presented a coned rotor concept with different conning configurations, including special cones with three segments. The authors made the analysis based on the DTU-10 MW reference rotor [5] and found that the different force distributions of upwind and downwind coned configurations agree well with the distributions of angle of attack, which are affected by the blade tip position and the cone angle, and the most upwind and downwind cones have a thrust difference up to 8% and a torque difference of up to 5%. The coned rotor concept has potential to be used for super-large wind turbines. The influence of tilt angle on aerodynamic performance of the virtual NREL 5 MW wind turbine [6] was studied by Wang et al. [7]. It was found that the change in tilt angle results in changing the angle of attack on wind turbine blade, which affects the thrust and power of the wind turbine, and the aerodynamic performance of the wind turbine is best when the tilt angle is about 4°. Subsequently, the effects of wind shear were also studied for the turbine with a tilt angle of 4°, and it was found that wind shear will cause the thrust and power of the wind turbine to decrease. Yang et al. [8] experimentally studied the effect of Gurney flaps on the performance of a wind turbine airfoil (DTU-LN221 airfoil [9]) under different turbulence levels (T.I. of 0.2%, 10.5%, and 19.0%) and various flap configurations. By further changing the height and the thickness of the Gurney flaps, it was found that the height of the Gurney flaps is a very important parameter, whereas the thickness parameter has little influence, and the maximum lift coefficient of the airfoil with flaps is increased by 8.47% to 13.50% under low turbulent inflow condition.

There is one paper dealing with tip loss correction study. Tip loss correction is important for predicting the aerodynamic performance of a wind turbine, and modelling the tip loss correction is essential in wind turbine aerodynamics. Zhong et al. [10] presented a tip loss correction study for actuator disc/Navier–Stokes simulations with the newly developed tip loss correction model in [11]. The study was conducted to simulate the flow past the experimental National Renewable Energy Laboratory (NREL) Phase VI wind turbine [12] and the virtual NREL 5 MW wind turbine [6]. Three different implementations of the widely used Prandtl tip loss function [13] are discussed and evaluated, together with the new tip loss correction in [10]. It was found that the performance of three different implementations [14–16] is roughly consistent with the standard Glauert correction employed in the blade element momentum theory, but they all tend to make the blade tip loads over-predicted, and the new tip loss correction shows superior performances in various flow conditions.

There is one paper dealing with the development of flow-structure-acoustics framework for predicting and controlling the noise emission from a wind turbine under wind shear and yaw [17]. A wind turbine operating under wind shear and in yaw produces periodic changes of blade loading, which intensifies the amplitude modulation (AM) of the generated noise, and thus can give more annoyance to the people living nearby. In this study, the noise emission from a wind turbine under wind shear and yaw is modelled with an advanced fluid-structure-acoustics framework, and then controlled with a pitch control strategy. The numerical tool used in this study is the coupled Navier–Stokes/Actuator Line model EllipSys3D/AL [18], structure model FLEX5 [19], and noise prediction model (Brooks, Pope, and Marcolini: BPM) [20] framework. Simulations and tests were made for the NM80 wind turbine [21] equipped with three blades made by LM Wind Power. The coupled code was first validated against field load measurements under wind shear and yaw, and a fairly good agreement was obtained. The coupled code was then used to study the noise source control of the turbine under wind shear and yaw.

There is one paper dealing with a study of orthopter-type vertical axis wind turbine (O-VAWT) concept [22]. The study by Wijayanto et al. [23] investigated the effects of horizontal shear flow on the power performance characteristics of an O-VAWT by performing wind tunnel experiments and computational fluid dynamics (CFD) simulations. A uniform flow and two types of shear flow (advancing side faster shear flow (ASF-SF) and retreating side faster shear flow (RSF-SF)) were employed as the approaching flow to the O-VAWT. The ASF-SF had a higher velocity on the advancing side of the rotor. The RSF-SF had a higher velocity on the retreating side of the rotor. It was found that the location where ASF-SFs with high shear strength dominantly occur is ideal for installing the O-VAWT.

3. Future Research Need

Although this Special Issue has been closed, more research in wind turbine aerodynamics is expected, as the goal of wind energy research is to help the technological development of new, environmentally friendly, and cost-effective large wind turbines and wind farms.

Funding: The special issue was funded by the key programs of the Ministry of Science and Technology, grant number 2019YFE0192600 (Research on Key Technologies of Low Noise Wind Turbine).

Acknowledgments: This Special Issue would not be possible without the contributions of various talented authors, professional reviewers, and the dedicated editorial team of Applied Sciences. Congratulations to all the authors. I would like to take this opportunity to record my sincere gratefulness to all the reviewers. Finally, I place my gratitude to the editorial team of Applied Sciences, and special thanks to Nicole Lian, Assistant Managing Editor from MDPI Branch Office, Beijing.

Conflicts of Interest: The author declares no conflict of interest.

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