EDITORIAL
published: 19 July 2022
doi: 10.3389/fenrg.2022.937914

Editorial: Aerodynamic Upgrades of Wind Turbines and Wind Farms

*Unai Fernandez-Gamiz[1], Alex Maurício Araújo[2] and Francesco Castellani[3]**

[1]Nuclear Engineering and Fluid Mechanics Department, University of the Basque Country, Bilbao, Spain, [2]Department of Mechanical Engineering, Center for Technology and Geosciences, Federal University of Pernambuco Recife, Recife, Brazil, [3]Department of Engineering, University of Perugia, Perugia, Italy

Keywords: wind turbine, flow control, passive devices, active devices, cost of energy

Editorial on the Research Topic

Aerodynamic Upgrades of Wind Turbines and Wind Farms

1 INTRODUCTION

At present, the reduction of fossil fuel reserves, environmental concerns, and energy security serve to focus our attention on developing ecologically compatible and renewable energy sources. Moreover, the power demand is also increasing in emerging economies such as China, Brazil, and India.

Currently, the optimization of renewable power systems is a key issue in competing in energy production and cost against other types of energy production. Wind energy has become a promising technology able to provide a large portion of the power requirements in many countries of the world. Wind turbines are a practical way to capture and convert the kinetic energy of the atmospheric air to either mechanical or, consequently, electrical energy.

According to the European Wind Energy Association (EWEA), wind power is the generating technology with the highest increase in new installations since 2014. However, even though the wind cost of energy has decreased in the last decade, a high initial investment is yet required. Consequently, it is essential to improve the lifetime and efficiency of wind turbines to keep this technology economically viable.

Therefore, wind energy, known for its cleanliness and cost-effectiveness, has developed rapidly in the past decades. Wind energy is a relatively new emerging research field characterized by a high degree of interdisciplinarity in the fields of mechanical and electrical engineering, physics, turbulence, energy technology, control, meteorology and long-term Wind forecasts, wind turbine technology, system integration, and energy economics. Studies and research for the development of wind energy can include multiple scales of atmospheric airflow phenomena, from the aerodynamics of the turbine blades and wakes generated to the climatic conditions of the micro-climate and the atmospheric boundary layer involved. Furthermore, different scales interact as atmospheric flows define wind conditions at the wind farm scale and further down the turbine scale.

These aspects demonstrate the importance and need for the development of knowledge on the subject of this Research Topic: Aerodynamic Upgrades of Wind Turbines (e.g., the aerodynamics of wind turbine blades and optimal design of blade geometry) and Wind Farms (e.g., wind turbine wakes with interactions with complex terrain). With this Research Topic, Frontiers in Energy Research is in the vanguard of Wind Energy.

Edited and reviewed by:
David Howe Wood,
University of Calgary, Canada

****Correspondence:***
Francesco Castellani
francesco.castellani@unipg.it

Specialty section:
This article was submitted to Wind Energy,
a section of the journal Frontiers in Energy Research

Received: *06 May 2022*
Accepted: *30 May 2022*
Published: *19 July 2022*

Citation:
Fernandez-Gamiz U, Maurício Araújo A and Castellani F (2022) Editorial: Aerodynamic Upgrades of Wind Turbines and Wind Farms.
Front. Energy Res. 10:937914.
doi: 10.3389/fenrg.2022.937914

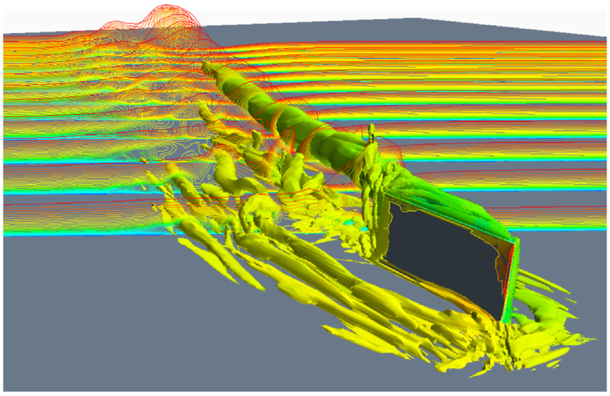

FIGURE 1 | Example of a numerical study of boundary layer control for aerodynamic performance optimization by a rectangular vortex generator.

Examples of the research fields to achieve these goals comprise the development of new materials, which allow a reduction in turbine weight or new blade designs to reduce the fatigue loads and increase the aerodynamic performance of the rotors. Nowadays, rotors of more than 180 m are a reality. They have blades made of soft, flexible materials that change shape in response to wind speed or aerodynamic loads, aerodynamically shaped rotating towers, flexible rotor systems with hinged blades, and other advanced control systems.

Figure 1 shows the stream-wise vortex generated by a rectangular vortex generator (VG) on a flat plate. VGs are widely used as flow control devices in the blades to improve wind turbine performance. These premises call for many interesting Research Topics, all sharing the final goal of boosting the efficiency of the wind energy conversion systems.

2 TACKLING THE BETZ–JOUKOWSKY LIMIT

The final efficiency of wind energy conversion is generally estimated using the power coefficient C_p, which is defined as the ratio between the final power output P and the available theoretical power on the intercepted swept area A given by $\frac{1}{2}\rho A v_\infty^3$, where ρ is the air density and v_∞ is the undisturbed speed of the wind.

It is well known by the one-dimensional Betz theory that the limit for $C_p = \frac{P}{\frac{1}{2}\rho A v_\infty^3}$ is finally $\frac{16}{27}$ and that this limit can be approached only by large Multi-MW horizontal axis machines.

This is also because much research focuses on upgrading and tackling the limits for the less efficient vertical axis configurations. When dealing with small applications for distributed production, the overall system effectiveness also needs to be studied on multiple time scales and generally under turbulent transient conditions. Optimization of the performance of wind turbines represents a fundamental requirement for the full exploitation of the valuable wind energy renewable source on multiple time and space scales. Qu et al. installed a wind concentrator with a complex shape in front of the impeller, which makes the airflow integrated and accelerated to improve the unit power of the wind-driven generator. The profile of the wind concentrator included two parts that are more than a simple right-angle flange or bell mouthparts: the contraction section and the expanding section. Therefore, this work has finally been devoted to studying how to improve the energy density and overall performance, especially for distributed applications. The other three studies focus on vertical axis technologies, which do not easily approach the theoretical Betz limit, so that their upgrade can represent an important milestone in the spreading of the application of such devices, which are much more indicated in urban areas. One of these studies (Li et al.) presents an important analysis of the possibility of improving the performance of a straight-bladed Darrieus-type vertical axis machine; the work is aimed at improving not only the operational performance but also the startup of the machine (of particular interest for the final dynamic efficiency).

The other two studies focus on enhancements (new design and blade shape optimization) for the Savonius drag-based machine (Mohamed et al.; Mohamed et al.).

The first article deals with the performance of a new wind turbine design consisting of three blades without a passage between them (closed center) derived from a conventional Savonius turbine investigated by numerical simulations with commercial software (ANSYS-Fluent 19). In the second article, the performance of a new wind turbine design derived from a conventional Savonius turbine is optimized by numerical simulation. The coupling between the CFD codes (ANSYS-Fluent) and the optimizer (OPAL) is used through an automatic procedure in the internal codes. An optimal solution was obtained in this optimization study. This kind of machine is characterized by relatively simple geometry and a soft operation, but it is affected by poor efficiency. Therefore, the results presented in the accepted manuscripts are valuable to making this configuration much more applicable.

3 CONCLUSION

The wind-energy sector is growing quickly, and evidence indicates that this tendency will continue in the following years. Active and passive flow control devices are designed as a solution to these problems. Improvements in the wind turbine performance of these types of devices can increase the life cycle of wind turbines and power generation and reduce the COE. This decrease in COE would allow increasing the competitiveness in price against other sources of energy production, including other renewable alternatives.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.