DIPARTIMENTO DI INGEGNERIA
CORSO DI DOTTORATO IN INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE -
PHD COURSE IN INDUSTRIAL AND INFORMATION ENGINEERING - 35TH CYCLE

Title of the research activity:	Innovative approaches for Wind farms analysis in complex terrain
State of the Art:	Large onshore wind turbines represent an authoritative candidate for being the most efficient renewable energy technology of the next decades and for this reason this topic has been attracting a growing amount of scientific literature [1, 2]. There are several critical points as regards the comprehension of the performance and of the mechanical behaviour of large wind turbines sited onshore. While for offshore wind farms the most relevant phenomenon affecting performance and residual useful lifetime (RUL) is wake interactions between nearby wind turbines [3], for onshore wind farms the focus is shifted to the interactions between the wind flow, the terrain and the wind turbines. There are growing evidences [4, 5] of the fact that wakes could recover faster in complex terrain than in flat terrain because of the wake-terrain interaction turbulence. This matter of fact on one side indicates that power losses caused by wakes have a lower importance for onshore wind farms with respect to offshore ones. On the other side, in complex terrain the wind turbines might be affected by more severe mechanical loads and their residual lifetime might be consequently affected. On these grounds, there are several open questions about onshore wind farm operation. The most important can be enumerated as follows: 1. Numerical modelling of the wind flow in complex terrain [6]; 2. Numerical modelling of wakes in complex terrain and performance interpretation through operation data analysis [7, 8]; 3. Characterization of the mechanical behaviour of wind turbines in complex terrain [9].

Short description and objectives of the research activity:	The Department of Engineering has established consolidated cooperation with companies owning and managing onshore wind farms and this has guaranteed disposal of operation data for research purposes. Furthermore, a long-standing collaboration has been established with one of the leading software companies of Computational Fluid Dynamics simulation for wind energy purposes. On these grounds, the research group is a fertile environment for studies about onshore wind farms and has been recognized among the leading experts about the use of operational data and numerical simulations performance analysis and interpretation. The research project therefore deals in general with this topic, with particular attention to the interaction between the fluid and the machine. Under this framework, several possible objectives can be accomplished: • Modelling and analysis of wind turbine wakes in complex terrain. Particular attention can be devoted to the Actuator Disk formulation [10]. • Characterization of the mechanical loads and fatigue life estimation for wind turbines in complex terrain. • Wind power forecast in complex terrain: hybrid approaches for the Numerical Weather Prediction (NWP) model data can be explored. They can be based on artificial intelligence and-or CFD simulations [11].
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