Energy Interaction of Vertical Axis Wind Turbines Working In Pairs:
A Case Study And An Application of IEC61400-12-1:2017

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Abstract
The increasing demand for energy yields to a continuous development in horizontal axis wind turbine (HAWT) technology, mostly by means of increasing rotor diameter and hub heights. Each individual HAWT in a wind power plant (WPP) requires more land space to avoid deteriorating effects of wakes from upstream turbines. The corresponding footprint-power-density ends up with 3 - 5 W power output per each meter square of the WPP site. It is known from recent studies that footprint-power-density can be increased dramatically by using vertical axis wind turbines (VAWTs) working in closely spaced groups and counter-rotating pairs instead of the classical HAWTs [3]. Towards exploring the true potential of this concept, we present an investigation of energy interactions of VAWTs working in pairs as a case study in a test site located in İzmir City of Turkey based on the new IEC 61400-12-1:2017 standard.

Objectives
VAWTs are one of the most promising topics for the wind industry in the past decade due to the importance of small-scale wind turbines and the necessity of effectively used land spaces for large-scale WPPs. This study features valuable on-site experimental results of the power performance measurement of a stand-alone and a counter-rotating pair of H-Darrieus type VAWTs and contributes industrial knowledge.

Methods
A near-shore site located in Çaltılıdere region of İzmir is selected for the field study. Site characteristics are defined by a year-long wind measurement at 60m altitude. Two identical H-Darrieus type VAWTs are produced for the field study. A measurement system is also located on the site for hub height wind data and performance measurements. The field study of a stand-alone H-Darrieus type VAWT and two VAWTs working in pairs will be investigated afterward. For the first time in the literature, the effects of the distance between the turbines on power performance of VAWTs will be performed meeting the suggestion of Annex H of IEC61400-12-1:2017 Standard.

Results
Near-shore experiment site promises a wide range of wind speeds and turbulence intensities during the experiments. The first phase of the study includes power performance measurement of a stand-alone H-Darrieus type VAWT called reference VAWT.

The next planned step is the field measurements of paired VAWTs and obtain insight about energy interactions and corresponding enhancement of power output of reference turbine under different operating conditions.

Conclusions
One of the most important concern for the large-scale HAWT WPPs is land acquisition. It may become a serious problem to find sufficiently large land for large-scale WPPs with unfavorable energy interactions to minimize wake losses. Using small-scale, closely located, counter rotating pairs of VAWTs inside of the existing HAWT WPPs, called “bush and tree” concept, is an interesting concept for increasing footprint power density [4]. In conclusion, VAWTs, specially Darrieus-type, working in pairs, offers a bright future for the wind industry. However more studies are needed to realize this into real life applications.

References

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