An Understanding of Turbulence in the Atmospheric Boundary Layer

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ABSTRACT

A turbulent wind is characterized by low energy content and large fluctuations. Turbulence in the atmospheric boundary layer causes fluctuations in both wind speed and direction, which are key factors in wind turbine siting and blade design for efficient power production. The paper seeks to explain the main mathematical models widely used to approximate the wind velocity and turbulence intensity profiles in the atmospheric boundary layer. The wind velocity and turbulence intensity profiles will be empirically obtained by putting up masts with anemometers at the wind tunnel test section and the wind speed measured over time in the absence of a turbine. A pitot-static pressure probe will be placed in an empty tunnel test section, 0.8 m high, which will be the position of the center of the VAWT rotor to find the real reference wind speed. Eight measuring positions at interval of 0.2 m will be taken with three positions below and five positions above the reference level. Finally, the mathematical models will be employed to estimate vertical wind shear for a small-scale wind turbine for an urban target site. The wind velocity and turbulence intensity profiles data from wind tunnel test will be compared to that from theoretical power law. Hopefully, the results will provide an understanding of free-stream turbulence in the atmospheric boundary layer. In addition, the present study approach to analyze turbulence in the atmospheric boundary layer and capture associated energy on a H-Darrieus wind rotor in a fluctuating free-stream can be extrapolated to other slightly complex VAWT configurations.

Keywords: Turbulence, ABL, Wind velocity, Mathematical models, Power law, Wind shear