Numerical investigations into the idealized diurnal cycle of atmospheric boundary layer and its impact on wind turbine's power performance - DTU Orbit (14/08/2019)

The power generated by a wind turbine largely depends on the properties of wind resource. In this work, wind characteristics in different regimes occurring throughout the idealized diurnal cycle and its impact on wind turbine's power performance are investigated systematically by means of large-eddy simulation (LES), and blade element momentum method (BEM), respectively. Through a precursor simulation of the atmospheric boundary layer (ABL) over a homogenous surface throughout a day, it is found that the resulting shapes of wind profiles (including wind speed, wind direction and turbulence level) vary significantly at different time periods, induced by distinct stabilities of the atmosphere. The simulated wind field data are then applied to a NREL 5 MW wind turbine for its power evaluation. Due to variabilities in wind shear and turbulence, the equivalent (disk-averaged) wind speed is introduced for power prediction. It is found that the magnitude and fluctuation of turbine's diurnal power are closely related to the atmospheric stability. In general, the average power production is higher under convective conditions during the day than under stable conditions at night, with a difference approaching 24.4%. This indicates that wind energy resource assessment will close to reality and benefit from increased accuracy if atmospheric stability impacts are considered for turbine's power predictions.

General information
Publication status: Published
Organisations: Fluid Mechanics, Department of Wind Energy, Nanjing University of Aeronautics and Astronautics
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Number of pages: 9
Pages: 419-427
Publication date: 2020
Peer-reviewed: Yes

Publication information
Journal: Renewable Energy
Volume: 145
ISSN (Print): 0960-1481
Original language: English
Keywords: Atmospheric boundary layer (ABL), Atmospheric stability, Diurnal wind characteristics, Large-eddy simulation, Wind power output, Wind turbine
DOIs: 10.1016/j.renene.2019.05.038
Source: FindIt
Source-ID: 2450257821
Research output: Contribution to journal › Journal article – Annual report year: 2020 › Research › peer-review