Modeling the wind speed perceived by a wind turbine placed downwards of a hill obstacle

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ABSTRACT

The performance of a wind turbine depends hugely on the actual characteristics of the air flow as well as the real conditions of atmospheric boundary layer. Wind flow is dramatically affected by the presence of an obstacle, the mean curvature radius of this obstacle, the ground roughness and temperature gradient. To evaluate the amount of wind energy that is liable to be extracted by a wind turbine, it is required to have the accurate height distribution of wind speed for the implementation site of that wind turbine. There are actually many procedures that can be used to study the boundary layer characteristics in terms of skin-friction, dissipation, turbulence and loads that can be generated [1].

In this study, circular motion of the atmosphere that is induced by the existence of a hill obstacle is investigated by using a 2D approximation of the problem. The hill profile was approximated by a half-ellipse curve. Computational fluid dynamics (CFD) [2] was performed for the turbulent air flow as modeled by the Navier-Stokes equations coupled with various turbulence models [3]. Appropriate boundary layer conditions were applied. We examined the convergence of the model as function of the mesh size and the location of the border of the field of calculation. The boundary condition at the ground surface was fixed by a wall law. To solve the equations, COMSOL software [4] that is based on the finite element method (FEM) was used.

This modeling has enabled catching the spatial heterogeneities of the air flow and to re-estimate the profiles of wind speed as affected by flow turbulence according to the turbulence model used. In comparison with a flat ground, a noticeable modification of the available wind energy resulted for a wind turbine which is placed downwards the hill obstacle.

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