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Topography Effects on Wind Turbines Wake Flow

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Abstract : A numerical study was conducted to optimize the positioning of wind turbines over complex terrains. Thus, a two-dimensional disk model was used to calculate the flow velocity deficit in wind farms for both flat and complex configurations. The wind turbine wake was assessed using the hybrid methods that combine CFD (Computational Fluid Dynamics) with the actuator disc model. The wind turbine rotor has been defined with a thrust force, coupled with the Navier-Stokes equations that were resolved by an open source computational code (Code_Saturne V3.0 developed by EDF) The simulations were conducted in atmospheric boundary layer condition considering a two-dimensional region located at the north of Algeria at 36.74°N longitude, 02.97°E latitude. The topography elevation values were collected according to a longitudinal direction of 1km downwind. The wind turbine sited over topography was simulated for different elevation variations. The main of this study is to determine the topography effect on the behavior of wind farm wake flow. For this, the wake model applied in complex terrain needs to selects the singularity effects of topography on the vertical wind flow without rotor disc first. This step allows to determine the existence of mixing scales and friction forces zone near the ground. So, according to the ground relief the wind flow waS disturbed by turbulence and a significant speed variation. Thus, the singularities of the velocity field were thoroughly collected and thrust coefficient Ct was calculated using the specific speed. In addition, to evaluate the land effect on the wake shape, the flow field was also simulated considering different rotor hub heights. Indeed, the distance between the ground and the hub height of turbine (Hhub) was tested in a flat terrain for different locations as Hhub=1.125D, Hhub = 1.5D and Hhub=2D (D is rotor diameter) considering a roughness value of z0=0.01m. This study has demonstrated that topographical farm induce a significant effect on wind turbines wakes, compared to that on flat terrain.

Keywords : CFD, wind turbine wake, k-epsilon model, turbulence, complex topography
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