360 CFD simulation for small wind turbines to increase annual energy production and reduce maintenance cost

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Abstract

What is the problem? Which group of persons need to be informed?
Small wind turbines (SWT) which are available on the market refer to a predicted AEP (Annual Energy Production) by the manufacturer. A lot of Small Wind Turbines (SWTs) produce less annual energy than the manufacturer guarantee. Many reports of effect are published by private owners or companies of small wind turbines, see BWE report for Small Wind Turbines (BWE – Marktübersicht spezial Kleinwindanlagen). In general, a measured wind speed of a specific height is used to estimate the wind speed for the hub height for small wind turbines with the help of roughness classes for the specific terrain. The other problem is that the turbulence intensity changes with its height and causes serious errors in yaw angle to the actual wind direction and damaged to the small wind turbine.

What is the aim of the work?

The aim of this work by the author is to investigate a specific terrain or area for the installation of a Small Wind Turbine. Due to the usage of OpenFoam, an open source software for computational fluid dynamics (CFD), will be used for the investigation. During the lifetime of 20 to 30 years of a small wind turbine the annual energy production can be increased, and the maintenance cost can be reduced which refers to the turbulence intensity in its investigated area.

Wind park planning software considers only the roughness of terrain and is configured for higher hub heights. Those software does not suit small wind turbines and its installation at a specific location. Either CFD simulations are made by companies for wind park sites, but it is not available for small wind turbines for now.

Which method will be used?

The described issues can be sorted out by a 360-degree CFD simulation. Available wind data on a specific altitude above the terrain will be used for investigation. Followed by using drone images of the terrain and using a photogrammetry software for the generation of a detailed terrain surface file, a Stereo Lithography - file (STL). This STL-file must be modified. During the lifetime of a small wind turbine surroundings change in growth, buildings might be added to the terrain and deciduous trees have an effect in summer and wintertime within the CFD simulation. Modifications will take place through a mathematical function

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to imitate the growth of flora, new buildings can be added through geometry and deciduous trees can be set up with the help of a permeability. At the end of the CFD simulation, the mean wind speed on hub height of the small wind turbine and the turbulence intensity on the entire terrain will be determined by all wind directions.

What is the most important result?
These new insights show the most suitable position at the investigated terrain during the life time of the small wind turbine through less turbulences which will be detected through the 360-degree CFD simulation. Annual Energy Production can be increased, in fact of turbulences cause high misalignments in yaw angle of the wind turbine to its actual wind direction and reduces maintenance cost.

Keywords: Small Wind Turbine, Computational Fluid Dynamic, site specific investigation, Turbulence, photogrammetry, STereoLithographie (STL)