Impacts of Climate Change on Wind Farms in Europe

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Positioning of the Thesis

Wind energy is one of the major sources of renewable energy for the global energy transition towards net-zero emission to mitigate climate change. However, climate change also causes some impacts on wind turbines and thus on wind farms, which are mainly the variations in the patterns of air turbulence, in wind speeds and wind directions, in wake losses, and extreme weather events resulting from the rising atmospheric temperature. Therefore, it is essential to investigate how the performance of wind farms would vary under the effects of climate change, in order to predict and plan the future development of wind energy more effectively and accurately. Also, Europe is a region that leads the development of wind power globally, with many existing and future wind farms and the trend of upscaling wind turbines. Hence, this thesis researches the impacts of climate change on wind farms in Europe, with a focus on offshore wind farms.

Objectives

This thesis aims at obtaining the characteristics of the fluctuations in the Annual Energy Production (AEP) of wind farms as the primary goal, as well as the changes in the load on wind blades and thus their operational lifetime as the secondary goal, both with a main focus on offshore wind farms. For the primary goal, the long-term wind characteristics will be predicted by the Measure-Correlate-Predict (MCP) method based on short-term measurement data using Python, such as wind speeds and their vertical profiles with respect to height, and the intensities and the frequencies of occurrence of air turbulence are estimated.

For the secondary goal, this research will be limited to the aerodynamic loads on wind blades, with the loads and their variations being calculated and simulated by using Finite Element Analysis (FEA) or Computational Fluid Dynamics (CFD). From the results, the operational lifetime of blades can be determined, as well as whether the loads stay within the structural safety limits of one or more types of blades.