Mechanical Engineering Master's Defense

Numerical simulations of the impact of large wind farms on the local climate

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abstract

Due to decrease in fossil fuel levels, the world is shifting focus towards renewable sources of energy. With an annual average growth rate of 25%, wind is one of the foremost source of harnessing cleaner energy for production of electricity. Wind turbines have been developed to tap power from wind. As a single wind turbine is insufficient, multiple turbines are installed forming a wind farm. Generally, wind farms can have hundreds to thousands of turbines concentrated in a small region. There have been multiple studies centering the influence of weather on such wind farms, but no substantial research focused on how wind farms effect local climate. Technological advances have allowed development of commercial wind turbines with a power output greater than 7.58 MW. This has led to a reduction in required number of turbines and has optimized land usage. Hence, current research considers higher power density compared to previous works that relied on wind farm density of 2 to 4 W/m^2. Simulations were performed using Weather Research and Forecasting software provided by NCAR. The region of simulation is Southern Oregon, with domains including both onshore and offshore wind farms. Unlike most previous works, where wind farms were considered to be on a flat ground, effects of topography have also been considered here. Study of seasonal effects over wind farms has provided better insight into changes in local wind direction. Analysis of mean velocity difference across wind farms at a height of 10m and 150m gives an understanding of wind velocity profiles. Results presented in this research tends to contradict earlier belief that velocity reduces throughout the farm. Large scale simulations have shown that sometimes, more than 50% of the farm can have an increased wind velocity of up to 1m/s at an altitude of 10m.

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