Project title	Wind power in forest – the effects of clearings
Project number	TG2-22
Organisation	Chalmers University of Technology, Fluid Dynamics
Project leader	Lars Davidson
Other participants	Johanna Matsfelt (PhD student)
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Participating companies	Meventus, Stena Renewables

Project description

The wind flow over forested terrain is characterized by a slow down in wind speeds, higher wind shear and increased turbulence. These are factors that increase fatigue loads on turbines, and most wind turbines today are not designed for these loads. This leads to higher maintenance costs and a decrease in overall life time. In this project we will investigate how forest clearings impact the wind conditions in a wind farm. The aim is to learn more about the effects of clearing forest around a wind turbine to increase production and minimize loads. The study will cover the effect of larger clearings. In the project LIDAR scanning and advanced CFD modelling will be used to provide recommendations on how and when to clear forest around wind farms and wind turbines. The CFD tool SOWFA (Simulation fOr Wind Farm Application) developed by NREL will be further developed. SOWFA is OpenFOAM coupled to the aeroelastic solver FAST developed by NREL this is done using ALM (Actuator Line Model). The ABL (Atmospheric Boundary Layer) is here simulated using LES (Large Eddy Simulation).

Results

SOWFA was further developed by implementing a drag and heat source term to represent the forest. The Ryningsnäs setup is simulated with homogenous forest, with the current clearing and with an extend clearing. The flow field is investigated, and the results obtained from FAST is evaluated. To obtain the fatigue loads the Rainflow counting algorithm has been applied to the load history of the data obtained from FAST.

It was found that the shortest recommended length for a precursor in SOWFA was too short because streaks occurred. The length needed to have a streak free precursor was found to be more than 3 times the length of the recommended. This streak free precursor was then be used as inlet for the simulations.

Atmospheric boundary layer simulations showed that the current clearing could be used to turn the flow field. One dimensional momentum theory used on the atmospheric boundary layer simulations showed the same trends but different magnitudes except for the second wind turbine in the extended clearing. For this wind turbine the one dimensional momentum theory showed that the electrical generator power is higher than in the homogeneous forest but FAST show a decrease. This show the complexity of the problem and the importance of using FAST. The extend clearing showed the lowest average and fatigue loads of the bending moment around the y-axis. More research is needed to find the optimal clearing and location of the wind turbines in relation to it to both increase the electrical generator power and decrease the loads.

Fulfilment of SWPTC's goals

The project will lead to increased knowledge of wind power in forest regions, and how clearings effect the fatigue loads and maintenance costs of wind turbines. The project will contribute to the following goals:

- Lead to an increased life time of wind turbines (optimized wind power in forest regions)
- Better prediction of fatigue loads in forest regions. The project will lead to a total weight loss (because of more accurate load predictions, the safety margin can be reduced)
- Better understanding of how different forest clearings impact wind turbine fatigue loads

Deviations from project plan

As validation study and first setup Ryningsnäs was used. Here the flow field is investigated both with and without turbines. To avoid the second wind turbine behind the clearing being affected by the wake of the first wind turbine on the side of the clearing, simulations with only wind turbine two is ran. Simulations with homogenous forest, the current clearing and an extended clearing is evaluated to be able to isolate changes. The wind turbines are also investigate using the results from FAST.

Publications

External activities

- Attendance, The Science of Making Torque from Wind (TORQUE 2016), 5-7 October 2016, Munich, Germany.
- Presentation, “Wind power in forest – The effects of clearings”, Vindkraftforskning i fokus 2017, 3-4 April 2017, Gothenburg, Sweden.
- Presentation, “Influence of generated wind field on Wind-turbine power production in forest Region”, Wind Energy Science Conference 2017, 26-29 June 2017, Copenhagen, Denmark.
- Presentation, “Inverkan av gläntor i skog”, Energimyndigheten Energivärlden tema vind, 29-30 May 2018, Stockholm, Sweden.
- Presentation, “Large-eddy simulation study of effects of clearing in forest on wind turbines”, OpenFOAM Wind power, 13-15 June 2018, Visby, Sweden.