Investigation and Assessment of the Benefits For Power Systems From Wind Farm Control

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Introduction

As wind power increases its share of grid penetration, especially through large offshore arrays with capacities into hundreds of megawatts, there are increased requirements on wind farms to provide ancillary services, such as frequency support. The aim of my PhD is to research the benefits for power systems from wind farm control by designing discretised models with short time steps in order to model abnormal operating conditions using Strathfarm.

Strathfarm

Strathfarm is a program which has been developed by Lindsey Amos to model the behaviour of wind farms in a computationally straightforward manner with the goal of being able to use it on a standard desktop PC.

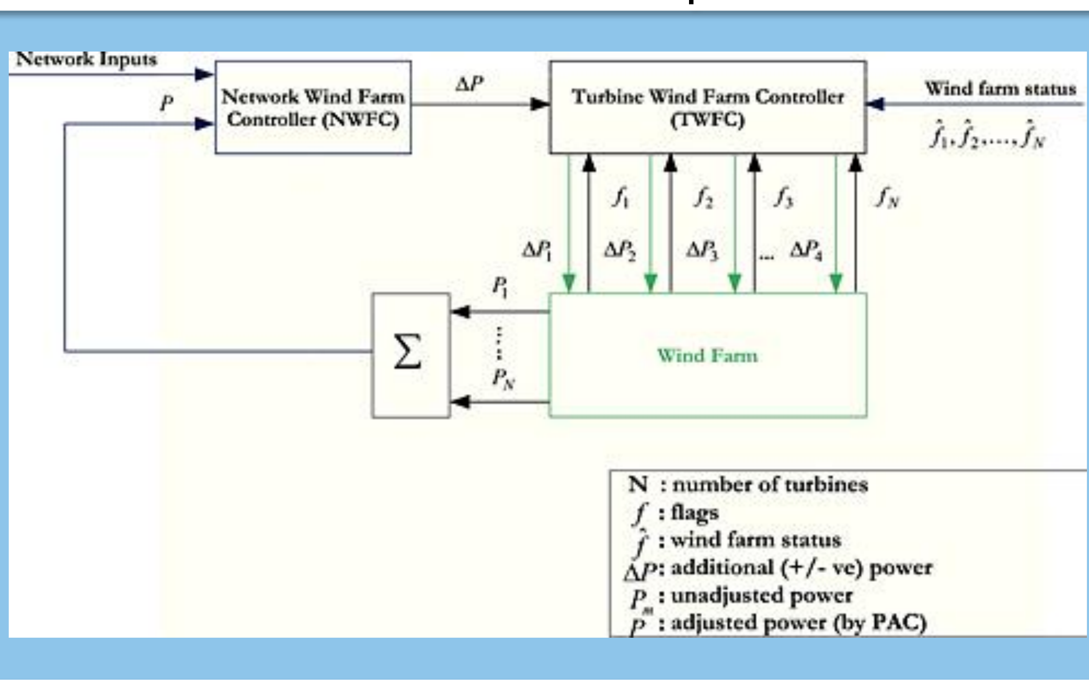

Figure 1. The control structure used in Strathfarm. Edited from (Hur & Leithead 2015).

Wind Farm Controller

The power output of the wind farm is regulated to a set-point by a PI controller. The total required level of power reduction is allocated across the wind turbines by how far each turbine is from its uncurtailed operating strategy. However, as the wind turbines operate along their power curve there is variation in the bending moment of the turbine towers, leading to an increased structural fatigue.

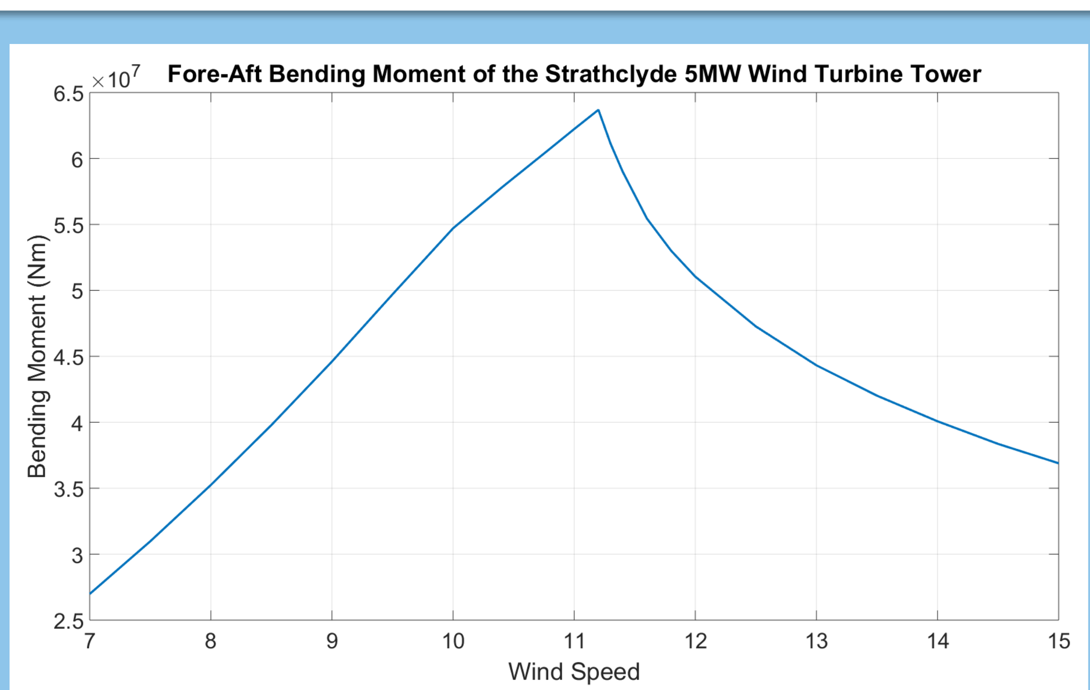

Figure 2. The fore-aft bending moment of the tower of the Strathclyde 5MW wind turbine over a range of wind speeds.

Allocation of curtailment to avoid high loads

- By changing the power curve of the wind turbines in Strathfarm so that the bending moment of the tower is kept constant as the wind speed changes the variation in the bending moment of the tower can be reduced leading to a reduction in fatigue.
- Using the flexibility of the PAC, turbines which are experiencing high wind speeds can be overrated, allowing the turbine to maintain a constant load but also to provide more curtailment to turbines near the rated wind speed so that they avoid high tower bending moments.
- The curtailment is distributed across the wind turbines, using the wind speed estimate from the PACs, so that all of the wind turbines operate on the same contour of constant tower load to reduced changes in the bending moment as the wind speed changes.

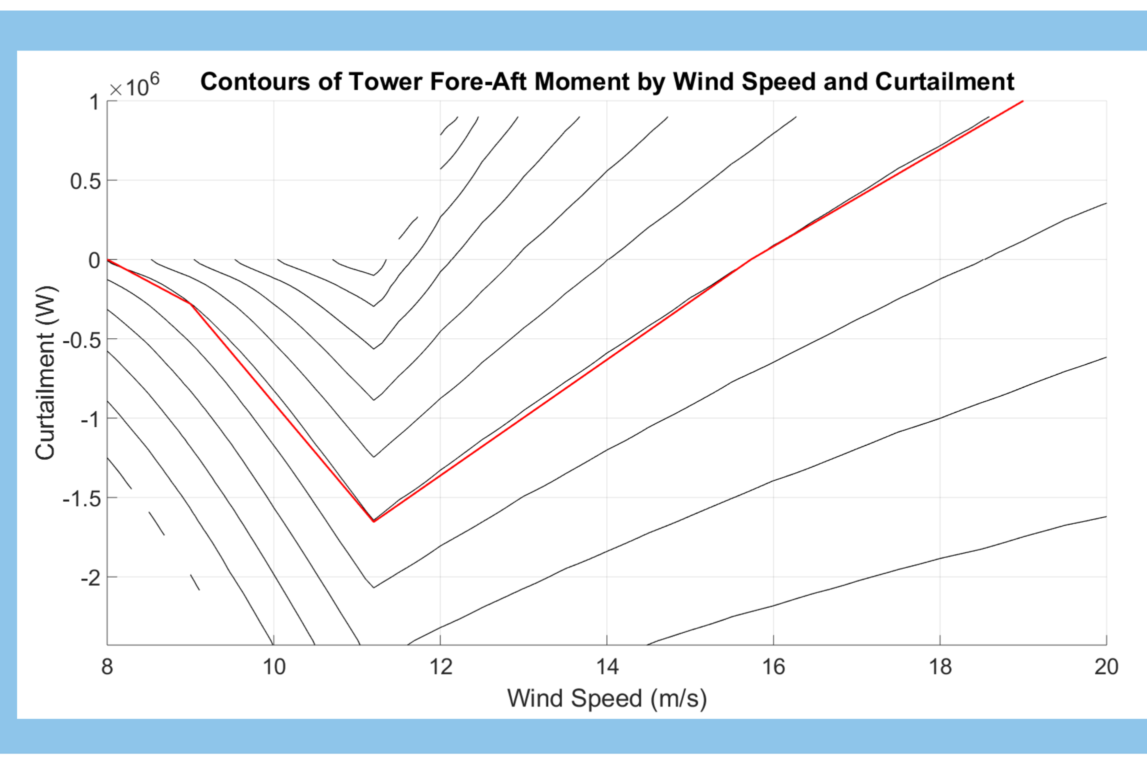

Figure 3. Contours of Constant tower load by wind speed and level of curtailment. and with new baseline power curve in red.

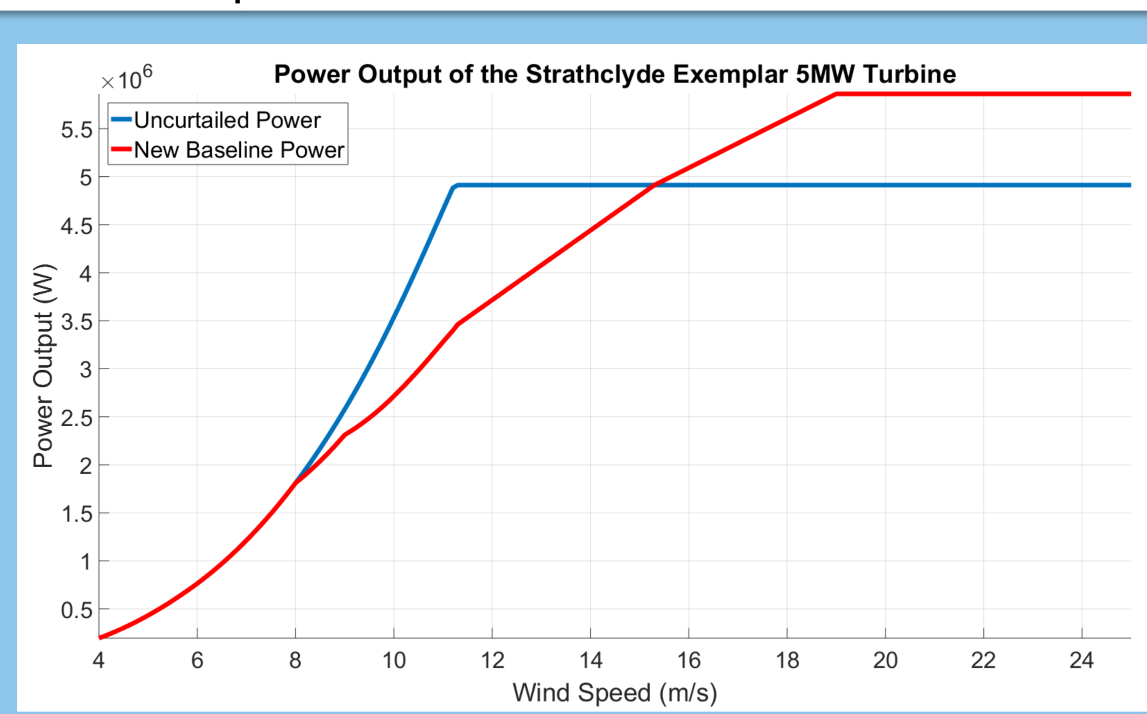

Figure 4. The uncurtailed power curve compared with the new baseline power curve.

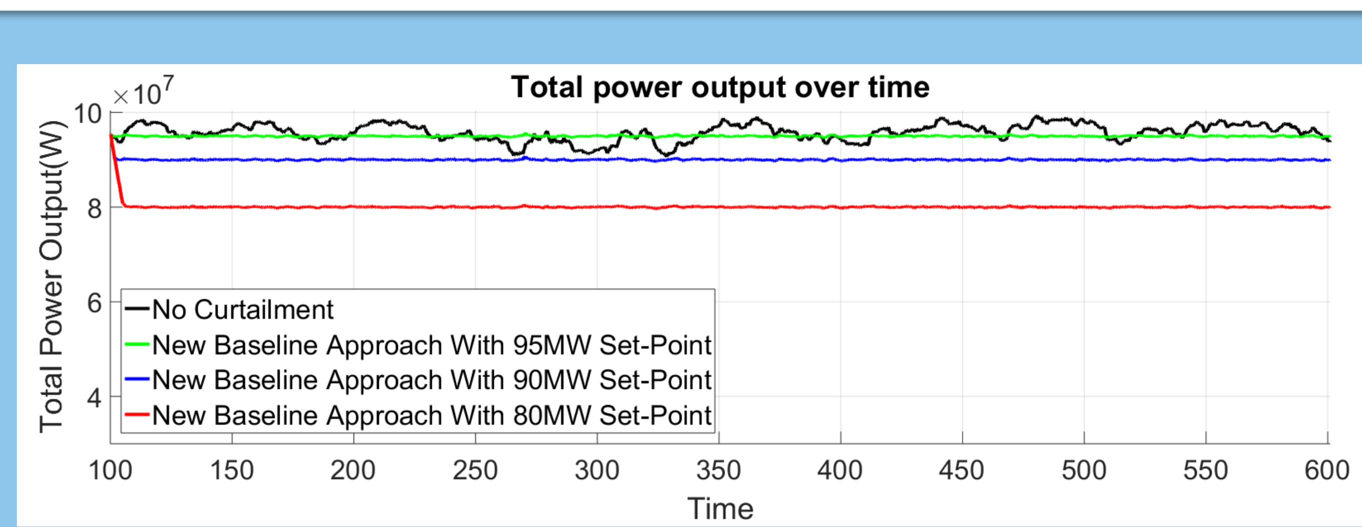

Figure 5. The power output of a wind farm of 20 turbines in a 12m/s wind field with a turbulence intensity of 0.1 at different power set-points.

Power Set-Point	Mean Reduction In Tower DELs	Mean Reduction In Blade DELs
95MW	25.5851%	21.3699%
90MW	30.8308%	24.2163%
80MW	37.0105%	28.2637%

Figure 6. The reduction in damage equivalent loads across a wind farm of 20 turbines in a 12m/s wind field with a turbulence intensity of 0.1.

Future Work

- Designing a power system model for implementation within Strathfarm for investigating the provision of ancillary services.
- Investigate the impact of ancillary service provision on structural loads and how different control strategies can be used to mitigate them.

References

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