Improved yaw control using wind farm information (extended abstract)

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1 Background

Yaw control in wind turbines is an area which is often overlooked; however, studies have shown that a large number of wind turbines are operating with large yaw errors which can lead to significant reductions in power "1" and large increases in turbine loading "2". Typically a wind turbine will yaw based on the measurements of wind direction from its own wind vane, placed on the back of the nacelle. These wind vanes could become misaligned, see a highly disturbed flow from the turbines and see a highly variable wind field, all of which could lead to errors between the turbine and wind direction. There have been several studies which suggest that a more reliable method of controlling turbine yaw is to use wind direction measurements from an array of turbines rather than each single turbine "3,4". These studies conclude that by using wind farm directional measurements to control yaw, there can be increased power production when individual turbines are suffering from wind vane errors, and that there can be significant reductions in yaw system activity due to the reduced variability of the wind farm directional measurements compared to single turbine measurements.

2 Aim

The aim of this short, 8-week project was to test this theory by creating a simple model of a wind turbine wind vane using measured wind data, then expand this model over an array of turbines to produce wind direction data at a wind farm level. This could then be used to design and test a simple yaw controller for a single turbine, design a yaw controller which can use wind direction data from an array of turbines, and then compare the performance between the individual and collective control strategies.

3 Method

A simple yaw controller for a single wind turbine was set up in Simulink, based on yaw controller logic given in literature "2". Firstly the turbine wind vane direction is averaged over a 60 second and 10 second period and is compared to the current turbine position to determine the yaw error. These values are then compared to a set maximum yaw error value and if this error is exceeded the turbine will then yaw to a new position based on the value of the mean yaw error. Once the new set value has been reached the turbine stops yawing and remains in position until the maximum yaw error value is next reached. To model the turbine yaw control based on wind farm direction values, the same controller was used as for the individual turbines. However, the wind direction used was the mean of the wind direction values from an array of four turbines. The other controller parameters were unchanged.

Four scenarios were then run using these wind direction values and the yaw controller. Scenario 1 was all turbines being controlled using their own wind vane data, this wind vane data was then averaged over the four turbines and these values used to control the position of all turbines - this was scenario 2. For scenarios 3 and 4 an error was introduced into the wind vane of turbine 1. During the simulation the wind direction measured by the wind vane was held at a constant position of 180 degrees. Scenario 3 was done in the same manner as scenario 2, where an average direction, including the broken wind vane value, is used to control all turbines. Scenario 4 was then each of the turbines controlling their position based on their own wind vane values, where the wind vane on turbine 1 is broken.

4 Results

In this simulation, when all wind vanes are operating well, the lowest mean yaw error is seen when the turbines are controlled using their own wind vane values. However, when an issue with one of the wind vanes is introduced (scenarios 3 and 4) the average turbine yaw error is reduced when the collective control is used. The total distance yawed by the turbines for scenarios 1 and 2 were also taken from the simulation. This shows that the distance yawed by the turbines during collective control was only 16 percent of that during the simulation with individual control. These values are highly dependent on controller settings but show a significant reduction with collective control over individual control. A similar trend was found with the energy production as was seen with yaw error and again shows that, when all wind vanes are operating well, individual control produced the most power, however when a wind vane error is introduced into one of the turbines, greater overall power capture is seen with the collective control approach.

5 Conclusions

This simple simulation has shown that there could be potential benefits in using collective wind turbine control when wind vanes within the array are subject to large error. But also shows a reduction in energy capture across the array when all wind vanes are operating well. However, there is still a large scope for optimisation of the collective wind turbine controller to bring performance closer to the individual turbine control in all scenarios. This includes optimising the controller settings and how the wind vane data is used from each turbine by the controller. In this simulation there is also the benefit of significantly reduced activity in the yaw system when using collective turbine control. This would have benefits in terms of reduced power consumption by the yaw system and longer component lifetime.

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