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WIND ENERGY SCIENCE DISCUSSIONS

Interactive comment on "Design and Analysis of a Wake Steering Controller with Wind Direction Variability" *by* Eric Simley et al.

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Dear Andreas,

Thank you for your comments and questions about our submitted manuscript and for your interest in this work. You have brought up some good points, and below you will find our response to your comments:

RC1 page 1 line 16f: In the abstract 128 %, energy gain is announced. When reading the manuscript it becomes clear that this is the relative recovery of losses due to wake effects. The wording can be somewhat misleading here.

Author response: Good point, and we have received this feedback from the other referee as well. In the revised manuscript we plan to re-word this to emphasize the ab-

solute change in the energy gain when comparing the "dynamic-optimal" and "static-optimal" yaw offsets (e.g., x% of wake losses recovered compared to y%), rather than a potentially-misleading percentage of a percentage change.

RC2 page 2 line 4f: The introduction begins with a description of wind farm control. Here one should be careful with this term. Wind farm control is usually something much more general, namely a power plant control, to comply with the grid codes. Yaw control usually belongs to the field of turbine control, and the advantages of coordinated yaw control on a wind farm level are only a "relatively" new subfield of wind farm control.

Author response: We will modify the phrase to emphasize that we are describing the subset of wind farm control for active wake control.

RC3 page 5 line 4f: Here it should be mentioned what kind of filter is used and, (if true) that it is also described in Bossanyi (2018).

Author response: We use a 1st order low pass filter with a time constant of 35 seconds. In Bossanyi (2018), a time constant of 30 seconds is used. We will include a description of the filter and a comparison with the Bossanyi filter in the revised manuscript.

RC4 page 5 line 5f: Why are you comparing the wind vane signal plus the nacelle position to the nacelle position and not just use the wind vane signal?

Author response: Although using the filtered wind vane signal would be fine for determining when the error threshold has been passed to initiate yawing, comparing the raw yaw position to the filtered sum of yaw position and wind vane helps in determining when to stop yawing. If only the filtered wind vane were used to determine when the yaw error reaches zero and the turbine should stop yawing, it would take too long to reach zero yaw error, due to the filter delay, and the controller would overshoot the desired yaw position. Comparing filtered absolute wind direction to the raw yaw position more accurately reflects when the yaw position becomes aligned with the low frequency wind direction.

RC5 page 7 line 25: The acronym SOWFA is quite well known in the community and should be mentioned here.

Author response: We'll change this to SOWFA (Simulator fOr Wind Farm Applications).

RC6 page 11 line 4f: To avoid confusion please mention, that \delta is the Kronecker-Delta.

Author response: Good point, the delta function should have been introduced here.

RC7 page12 line 1f: Which wind direction signal was used in the joint distribution in Fig. 7. The low-filtered wind direction or the "combined" wind direction?

Author response: Starting in Fig. 7, the wind direction being plotted is the low frequency wind direction, which we expect to be more relevant as an input to FLORIS. We will clarify that this is the low frequency wind direction in the revised manuscript.

RC8 page 13 Equation (9) For easier readability in the equations, I would advise to only italicize variables, as the ISO standard suggests. The l (in \hat\phi_l), FLORIS and the d of the integrator should be written in roman.

Author response: Thank you for the suggestion. We will incorporate this feedback.

RC9 page 13 Section 3.3: Here the parameters for the uncertainty in the wind direction (x-axis Fig.8) and the yaw (y-axis Fig. 8) are tuned using the simulation. But in the simulation, the yaw uncertainty should either not exist or be adjustable. Can you explain the result for the yaw uncertainty? Is it possible that the hysteresis of the Yaw controller and the Yaw process used in the simulation influences the parameterization?

Author response: It is true that there is no yaw uncertainty in the simulations, in the sense that we assume the yaw position reported by the controller is the true yaw orientation. Therefore, the yaw "uncertainty" we are modeling is due to the yaw controller possibly stopping at a different yaw position than was originally intended when the yaw maneuver begins. For example, as the yaw controller is in the process of yawing to

achieve a 20 degree offset determined by the lookup table, the wind direction could change enough so that the target offset switches to zero degrees. The controller could then stop part way toward the original 20 degree offset because it is now overshooting the new 0 degree offset target. While this doesn't mean there's any uncertainty in the yaw position measurement, it acts as uncertainty in the achieved yaw position as a function of wind direction compared to the intended static yaw position curve. Another example is if the yaw controller is still trying to track a target yaw offset of zero after the wind direction has shifted to the wake steering sector, because the wind direction filter in the wake steering controller hasn't yet reached the new wind direction as a result of filter delay. Some of this yaw "uncertainty" could be removed by using direct yaw control. However, we wanted to show the performance of a standard baseline yaw controller implementing wake steering. In the revised manuscript, we will plan to elaborate on the sources of yaw uncertainty.

RC10 page 16 Figure 10: The normalized power shown here is probably the sum of both turbines and not just the turbine downstream. This should be clearly stated.

Author comment: Yes, we will clarify that it is the sum of the upstream and downstream turbine powers.

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