Review of "Turbine- and farm-scale power losses in wind farms: an alternative to wake and farm blockage losses" by A. Kirby, T. Nishino, L. Lanzilao, T. Dunstan, J. Meyers

This paper analyses large-eddy simulation (LES) results of finite-sized large wind farms subjected to a conventionally neutral boundary layer flow with varying capping inversion heights, strengths and lapse rates. Perfectly staggered and aligned configurations are studied, along with half-length and twice-spaced configurations. The LES results are analysed in the context of the two-scale momentum theory developed previously by the authors. Conventional definitions of farm efficiency, wake efficiency and non-local efficiency are all found to be a function of the atmosphere-farm scale interactions as well as of turbine wake-farm interactions. Alternate metrics of farm efficiency are proposed, namely farm-scale efficiency and turbine-scale efficiency. These two metrics are found to be sensitive to either the atmosphere-farm scale interactions alone or to the turbine wake-farm scale interactions alone, but not to both. The product of these two metrics gives the combined effect of atmosphere-farm and farm-turbine wake scale interactions. The LES results show that the power degradation in most of the wind farms studied is primarily because of atmosphere-farm scale interactions and are characterized by small values of the farm-scale efficiency. An empirical model for the farm-scale efficiency is shown to agree with the LES results with reasonable accuracy.

Overall, this is a well-written paper with several novel contributions. The first is the verification that the internal thrust coefficient is a function of turbine array properties alone while the farm availability factor is a function of the atmospheric conditions alone. Second is the novel metrics that clearly respond only to the farm-scale properties or to the atmospheric conditions alone. The last is the analytical model for farm-scale efficiency.

The paper can be improved by providing some more clarity on the LES setup, the algorithm for calculating the turbine-scale and farm-scale efficiencies, and a few intermediate quantities (i.e. quantities that are not directly compared between model and LES, but are needed as a step towards calculating quantities that are compared, e.g. the efficiencies). Please see detailed comments below.

Major Points:

1. Section 3 describes the LES setup very briefly and refers to Lanzilao & Meyers [JFM, v. 979, 2024] for more details. However, there are a few additional details that should be part of this paper itself to make it self-contained. For example, please mention the surface roughness, Coriolis frequency, the driving force (presumably it is a geostrophic wind) and the upstream fetch. Also mention what are the additional 5 simulations performed here.

2. Lines 170 – 180: Fig. 5 plots the wake efficiency against the farm-averaged yaw angle and shows that there is a weak correlation between them. I think it is inappropriate to take an average of the yaw angles across all turbines in a wind farm. This is because all turbines do not yaw in the same direction, i.e. some yaw clockwise and others yaw anticlockwise, as seen in Fig. 7 of Lanzilao & Meyers [JFM, v. 979, 2024]. Thus, farm-averaged power and farm-averaged turbine yaw angles are likely never going to be correlated. Perhaps it would be better to check some measure of power of each turbine against the individual yaw angles across all the LES cases (no. of data points would be 38 cases times the number of turbines in each case) to arrive at a conclusion regarding whether effective turbine layout is correlated with the wind farm performance.

3. Lines 195 – 200: Figs. 8 and 9(b) show that a lower wake efficiency is obtained for higher k* values. Is the initial wake width (ε) almost the same across the turbines? It is possible that between two wind farms, the wake growth rate (k*) is larger but the total wake width ($k^*x + \varepsilon$) is actually smaller, and hence the wake efficiency is smaller. Do the authors ensure that this does not happen in their LES results?

4. In the algorithm shown in Fig. 13, β can be calculated directly from the LES (from velocities U_F and U_{F0}). This is used to calculate M_{LES} and then ζ_{LES}. Then another β is calculated in Step 3. The existence of two values of β is confusing. Is an iterative procedure used, i.e. Steps 1, 2, 3 are repeated until convergence? If not, how different are the values of β and β_{LES}? What is the meaning of two different β values? Why not use β_{LES} directly in Step 4?

5. Lines 280 – 285: C_T* values shown in Fig. 11 are not 0.974. What is the justification for using this value for C_T* in Section 4.3? It does not appear to be adjusted upwards when compared to Fig. 11.

6. Lines 275 – 285: The multiplication by the correction factor N or its powers following Shapiro et al. (2019) seems to be an ad-hoc fix. Are the results of the analytical model sensitive to this ad-hoc fix? I wonder if it is possible to conduct one simulation where these corrections are incorporated and check whether an ad-hoc fix is no longer needed?

Minor Points:

1. Section 2: It would help to know under what conditions (if any), $C_{P,\ Nishino}$ reduces to C_P, i.e. Eq. (6) reduces to eq. (7).

2. Lines 215 – 225: The last paragraph on pg. 12 and first paragraph on pg. 13 refer to Eqs. (11), and (12a), (12b), (12c). However, these equations are written after the text, which is usually not done. Please reorder the text and the equations and reword appropriately.

3. Are the intermediate quantities, such as T_i, U_F, U_{F0}, $C^*_{T, LES}$, needed to compute M_{LES} and β_{LES}, provided in the dataset? It would be very helpful for other researchers to have access to these quantities for all the LES cases.
4. In Eq. (20), is τ_{t0}/τ_{w0} obtained from the precursor LES? That seems to be the only parameter that responds to the atmospheric conditions and is the key that leads to different wake efficiencies. It would be instructive to show this value for the three cases in Fig. 20.