

Combining economic and fluid dynamic models to determine the optimal spacing in very large wind farms

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Abstract-

Wind turbine spacing is an important design parameter for wind farms. Placing turbines too close together reduces their power extraction because of wake effects and increases maintenance costs because of unsteady loading. Conversely, placing them further apart increases land and cabling costs, as well as electrical resistance losses. The asymptotic limit of very large wind farms in which the flow conditions can be considered ‘fully developed’ provides a useful framework for studying general trends in optimal layouts as a function of dimensionless cost parameters. Earlier analytical work by Meyers and Meneveau (Wind Energy 15, 305–317 (2012)) revealed that in the limit of very large wind farms, the optimal turbine spacing accounting for the turbine and land costs is significantly larger than the value found in typical existing wind farms. Here, we generalize the analysis to include effects of cable and maintenance costs upon optimal wind turbine spacing in very large wind farms under various economic criteria. For marginally profitable wind farms, minimum cost and maximum profit turbine spacings coincide. Assuming linear-based and area-based costs that are representative of either offshore or onshore sites we obtain for very large wind farms spacings that tend to be appreciably greater than occurring in actual farms confirming earlier results but now including cabling costs. However, we show later that if wind farms are highly profitable then optimization of the profit per unit area leads to tighter optimal spacings than would be implied by cost minimization. In addition, we investigate the influence of the type of wind farm layout.

Index Terms- wind farm; engineering economics; fluid dynamic models; coupled wake boundary layer model; optimal turbine spacing; wind farm design; turbine wakes; renewable energy

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