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Interactive comment on "Coupled Wind Turbine Design and Layout Optimization with Non-Homogeneous Wind Turbines" *by* Andrew P. J. Stanley and Andrew Ning

Anonymous Referee #1

Received and published: 6 September 2018

The paper presents an interesting analysis on the optimization of wind farm layout. The authors find that an integral optimization approach of the wind farm layout and turbine design together gives improved results when compared to more traditional approaches in which first the turbine design is optimized before considering the optimization of the wind farm layout. The results are interesting to the community and for publications on the Wind Energy Science journal. I believe that several aspects need some clarification as indicated in the list below.

**** General comments

– In the abstract the authors should mention under which conditions the 2 to 5% reduc-

tion was obtained (which spacing, wind shear, etc) and mention the benefit is larger when the inter turbine spacing is smaller.

– Mention in the abstract that only two turbine designs are allowed in the optimization procedure in a fixed one to one ratio. Now the abstract gives the impression the turbine design is changed for each turbine.

– In several places the authors mention that certain modeling choices were given by the need to restrict the computational time used by the optimization procedure.

– Page 3: What is the wake profile in the FLORIS model? The authors define the wake interaction model in detail, but do not provide any details on the actual wake model. Please also use L only for one thing.

– Page 7 cost model: The authors refer to a reference that is not yet available to the referee. Without access to this paper it is impossible to see what the authors exactly did. If the paper will appear soon there is no need to repeat things here if all is identical, but for the moment this cannot be checked.

– Page 7 section 2.6: The authors say it does not matter too much how many different groups are used, but no actual numbers are mentioned. Please provide these numbers to back up this statement.

– page 9 last section (also page 11 top): I found the description of the "spacing multiplier" very confusing. Figure 8 helps a lot, but the text in the mentioned paragraph should be clarified.

– page 14 first section: Did the authors try to see what happens when they use the turbine designs obtained a a training wind farm as input for the actual optimization algorithm. How close would the result be to the coupled optimization approach? Obviously the coupled optimization approach always gives a better results (assuming obviously that the model would be perfect), but how much is the difference? In the results we namely also see that for very small spacings the "sequential turbine design then lay-

out" is worse than just using the "layout" optimization. Is this because the reference turbines are already somewhat optimized to be located in a wind farm? And would a better design of more appropriate reference turbines reduce the benefit of the coupled optimization approach?

– How exactly does this work compare to earlier work by the same authors, i.e.

Stanley, A. P. J., Thomas, J., Ning, A., Annoni, J., Dykes, K., and Fleming, P., "Gradient-Based Optimization of Wind Farms with Different Turbine Heights," Wind Energy Symposium, Grapevine, TX, AIAA, Jan. 2017. doi:10.2514/6.2017-1619

Stanley, A. P. J., Ning, A., and Dykes, K., "Benefits of Two Turbine Rotor Diameters and Hub Heights in the Same Wind Farm," Wind Energy Symposium, Kissimmee, FL, Jan. 2018. doi:10.2514/6.2018-2016

These papers are not referenced at the moment, but seem to follow for a big part the optimization philosophy outlined here, with the present work focusing on the coupled layout wind turbine design approach. It may be possible to compare the results obtained here with the previous results.

– Can the authors compare their optimization results with methods already presented in the literature?

– The authors only show results of the turbine designs obtained using the optimization. I would also be interested in seeing the corresponding wind farm layouts of the most optimal configuration that was found.

**** Specific comments

– Page 1: References on the mentioned gradient-free and gradient-based optimization methods are missing.

– Page 2: in this study for additional improvements. -> It should read "in the presented approach" as the authors do not actually consider yaw optimization in this study.

– Page 2-3: Please clarify the numbers presented here, i.e. the increases in production / reduction in the cost of energy are determined with respect to some reference case, but not for all cases the respective reference cases are clearly defined.

– Page 4: Rotation of each wind turbine -> rotation of the blades

– Page 4: Please define x in equation 5.

– Page 4: The direction data we had -> Please provide the appropriate references / explain. I assume most of the data in figure 5/6 is actually obtained from some literature reference.

– Page 5 line 20: Maybe I missed it, but please give the airfoil used in this work.

– Page 5 figure 1: Please provide units of Frequency shown here.

– Page 6 line 1: What 10 groups are used?

– Page 6 figure 2: Please give the appropriate units in the figure.

– Page 8 equation 6: What is D_rotor? In the optimization both D1 and D2 are used. Which one is used for D_rotor?

– Page 8 equation 6: Please write D(1,j),D(2,j), etc

– Page 8 equation 6: Shell buckling does not seem to be defined in the paper. Why are these values used? What are the units?

– Page 9 line 2: that -> than

– page 9 last section: the "shear exponent" does not seem to be properly defined yet.

– page 11 line 13: "random amount" -> How much approximately.

– page 12 figure 8: Please mention that D=80 meters (and fixed) for the purposes of this plot. This only became clear much later.

– page 20 table 1: For clarity mention in the caption what the reference case is.

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