Review of the manuscript wes-2024-176 entitled “Exploring future production scenarios for the Italian offshore wind power” by D. Medici, A. Tonna and A. Segalini

Overview

This study addresses challenges and opportunities associated with the development of offshore wind energy along the coasts of Italy. Based on 55 already existing project areas and historical data for over 30 years, the authors estimate the wind energy that would have been produced by installing IEA 15 MW turbines within the selected regions. Each wake loss is modeled by the Jensen model, the wind farm layout is optimized via genetic algorithm, and the randomness associated with the construction risks, wind pattern and array efficiency are modeled via Monte Carlo approach. The results show that offshore wind energy is a profitable market for Italy upon careful selection of the wind farm areas and layouts.

The problem is well stated and addressed, the approach is original and delivers results with acceptable uncertainty levels. Thus, I recommend its publication after few major reviews I detailed in the remainder of this review.

General comments

- Line 13: I would replace “power” with “energy” as it sounds more appropriate.
- Line 31: Please replace “address” with “addressing”.
- Line 64: Which percentage of the total lease areas is shared between multiple projects?
- Line 78: I feel that Fig. 1 and 2 deliver essentially the same message. Therefore, I recommend keeping only one of these two figures or, alternatively, organizing them as panels (a) and (b) of just one figure.
- Lines 104-105: What about the remaining 57% of the planned farms?
- Line 106: Is there any available turbine model featuring 100m hub height instead of 150m? I am a bit concerned about the uncertainty introduced by the shear exponent as it is strongly dependent on stability and, in some cases, wind direction. Alternatively, please report some literature references motivating your choice of shear exponent.
- Line 115: From Fig. 4, the transition between region II and region III is around 11 m/s, which is lower than the average wind speed at 100m shown in Fig. 1 for the selected areas. This means that, for a significant portion of the time, the chosen wind turbine will be in region III. Please address this aspect.
- Line 149-150: I believe it is useful to state which wind direction and speed you considered to quantify these correlation functions.
- Line 212: When I read Sect. 5 for the first time, it was unclear to me why you ignored wake losses so far and then you decided to introduce them. Only at the end it was clear that this

result is preliminary towards the Monte Carlo simulation. I would explicitly mention at the beginning of Sect. 5 that, just like the previously introduced score range, wake loss modeling (and layout optimization) are instrumental to the Monte Carlo simulation.

- Line 215: Is the number of turbines decided a priori? If so, which source did you use to obtain this value?
- Line 234-236: I am not sure that the current choice of fitness function is better than the AEP. It is true, as the authors state, that larger spacing between neighboring turbines is beneficial to the overall power production. However, the intra-wake region of a large operating wind farm is a place of complex flow interactions involving, for instance, speed-ups among turbines which are compelling features to enhance power production. Thus, I recommend showing at least one wind farm case where the optimization of the AEP leads to a similar layout as the optimization of the turbine spacing.
- Line 254: I would not label the cases where $L_{\mathrm{opt}} > L$ as "outperforming". The optimization algorithm always (hopefully) outperforms the uniform spacing solution in terms of finding the best layout, otherwise it would be detrimental. I suggest to rephrase this sentence saying, for example: "where the optimization algorithms converge towards a spacing larger than the uniform solution".

  Also, if you believe there is a correlation between $L_{\mathrm{opt}} > L$ and the number of turbines, it would be interesting to plot Fig. 10 as a scatter plot where each point is colored according to the number of turbines present on each wind farm.
- Line 268: Please make an explicit mention to Fig. 11b.
- Line 294: Since the unit on the *y*-axis in Fig. 13 is TWh/yr, I would replace "power production" with "energy production".
- Line 295-296: How do you explain this trend? Could it be due to the seasonal variability of the available wind resources? This point deserves further explanation.