Review of "Exploring future production scenarios for the Italian offshore wind power" by Medici, Tonna, and Segalini, submitted for publication to Wind Energy Science (WES)

It is hard to understand what the objective of this study is or who would benefit from it. After reading it, I conclude that the most valuable outcome of the study is the value 61%. This is the probability that a planned offshore wind farm will actually be built and produce power in Italy. This number comes from the ratio of 76 TWh of expected production based on the Montecarlo simulations over the 124 TWh possible if all the planned projects were actually built. This would be a valuable contribution indeed. However, there are so many major issues in the methods proposed to arrive at this value that unfortunately we cannot trust this value right now. I can only recommend publication if the major (and minor) issues below are properly addressed.

Major issues

1. The algorithm chosen to determine the optimal layout is ineffective because of two reasons: it ignores the wind rose (i.e., the joint frequency distribution of wind speed and wind direction) and it ignores common practices/requirements in the marine environment.
    a. Starting with the first issue (no wind rose): the proposed genetic algorithm maximizes the minimum inter-turbine spacing, thus it ignores which wind direction(s) is (are) prevailing or which wind speed occurs more often in which direction. By ignoring this information, the identified layout will not guarantee the highest Annual Energy Production (AEP), actually, it will not even guarantee a high AEP. Optimizing over the entire wind rose would be ideal, but possibly beyond the scope of the study. An alternative would be to maximize the spacing along the prevailing wind direction only. This would require the calculation of the prevailing wind direction at each of the 55 wind farms, thus not a terribly long task, and then the modification of the fitness function to maximize the average distance along that direction, rather than that along all the possible directions.
    b. The second issue is that the resulting optimal layout is very irregular, meaning that it will look like a Swiss cheese with apparently randomly-placed wind turbines in the project area (e.g., Figure 9b). While this is possibly OK over private onshore land with no vehicular traffic or no public access, in the marine environment offshore an irregular layout will likely encounter huge opposition from entities like the Guardia Costiera or the Marina Militare or even just fishing boats, because the ocean/sea is a public space. Navigating at night through such layouts will be a recipe for disaster and in fact in recent years the tendency for offshore layouts has been towards regular rows and columns that are aligned with the perpendicular and parallel directions with respect to the coastline, to facilitate fast deployment of emergency rescue boats and avoid collisions between boats and turbines even in bad weather and rough sea conditions. The genetic algorithm should be modified to accept only layouts with straight rows and columns.

2. The calculation of the actual AEP of each wind farm must take the wind rose into account. But the authors assumed, incorrectly, an even distribution of the wind directions, thus they

averaged the array efficiency over all wind directions. Instead, they should have calculated the actual production at each hour of the 31 years for whatever the wind direction and wind speed were at that hour (with the power curve, which is a function of wind speed at hub height, and then the Jensen model, which is a function of the wind direction at hub height), and then sum them all up for each year. Averaging over all directions, regardless of how often each wind direction may occur (from the wind rose), is unacceptable.

In fact, rather than identifying an optimal layout with the proposed genetic algorithm (which is not optimal at all) and then calculating the wake losses with Jensen (which is wrong if the wind rose is ultimately ignored), I recommend using a typical percent of wake losses (like 10%, although the average of the study is closer to 7.6% [(158-146)/158~ 7.6%], which seems too low to me) would be faster and possibly more accurate that going through all that work, plus it is already the approach chosen for transmission and generic other losses (15%).

3. The equation proposed to give a total score (Eq. 2), which is ultimately a probability of success used in the Montecarlo simulations later, is odd because it uses the squares of the individual scores. Since the individual scores, varying between 1 and 3, are higher for lower challenges (from Table 1), the equation effectively gives a lot more weight to lower challenges, which is counter-intuitive. In the proposed equation, a great challenge would receive a low weight (the square of 1 is 1), whereas a small challenge would receive a high weight (the square of 3 is 9), thus the approach implicitly favors wind farms with low challenges, which may be desirable, but it does not give enough weight to great challenges, which may actually be a game stopper. For example, wind farm A has 2 high challenges, 1 medium, and 1 low challenge, thus a score of 15; wind farm B has only medium challenges, thus a score of 12. The equation would favor A over B, which seems unrealistic. Either the equation should be changed to better reflect reality and give more weight to high challenges, or the use of squares should be justified.

4. I do not understand how the concept of L (Eq. 3) is used and why. It is not an optimal spacing because it assumes a uniform layout, which is not optimal in the real world (given the wind rose) and not even in the study ("[L] does not aim to be the optimal configuration"). At first I thought it was a purely theoretical value, one that may or may not even be feasible once the actual shape of the area is accounted for. But Figure 11b shows an actual efficiency for a layout made with L, thus I got confused. Why is L used and how do you obtain a layout with it, since "the irregular shape of the polygon makes the layout identification challenging"?

5. While the Montecarlo approach seems reasonable to me, there is no validation whatsoever of its results. How can we trust that the results obtained with it are close at all to the success/failure chance of an offshore farm in Italy? I realize that there is only one offshore wind farm in Italy today (if I am not mistaken), thus perhaps not enough data to validate the method, but there are many offshore wind farms in Norther Europe. I am not requesting a thorough validation here, but at a minimum a literature review on the topic and a

qualitative comparison are needed, otherwise this is all for nothing because it will be considered as a purely numerical exercise with no practical use.

Minor issues

6. L. 15: Also maintenance issue are important factors in offshore wind costs.
7. L. 24: I found a value of 4.6 GW, not 3.8 GW, on 4Coffshore.
8. L. 27: What exactly are these "ambitious targets"? Please specify how many GW for offshore wind.
9. L. 30 (related to #8): Of these 84 GW, how many are offshore wind?
10. L. 56: Assuming that "between" should be replaced with "among", how exactly were these 55 projects selected among all those submitted? How many were submitted (I think 64)?
11. L. 57: Why and how are these 35 clusters/geographical areas selected? I think that individual projects that have an overlapping area are grouped together in a cluster, but it is not clear. Maybe provide a list of the 35 and 55?
12. L. 59: Give the URL of the MASE website where the data were collected from.
13. L. 63 (related to #11): Define "proximity": how close do two wind farms have to be in order to be clustered together?
14. L. 64: How do you calculate the centroid? Show equation.
15. L. 83 and 87: Is it 31 or 37 years of data?
16. L. 82 (related to #11): Again, how are the 35 areas identified in the CERRA domain? Are they grid cells? The sentence does not make much sense, what does it mean "to obtain a comprehensive time history of the site representative of the cluster climate"? Which site? Which cluster? Rephrase.
17. L. 90: Here you state that you did not use ERA5, but then on L. 98 it looks like you did.
18. Fig. 2: This figure does not add much to the discussion because it has almost exactly the same pattern as Fig. 1, consider removing it or putting it in an Appendix.
19. L. 96: Spell out ECMWF the first time. Add details about the years and resolution etc. of the EMD WRF dataset.
20. L. 113: Almost a major issue: why use the power law, which is a rather poor approximation, when you have the model levels surrounding hub height and you could easily interpolate to hub height?
21. Fig. 3: Please use more resolution for the low bathymetry (0-500 m)! For example, 0-10, 10-30, 30-50, 50-100, 100-250, 250-500, 500-1000, >1000 m. At a minimum, add the intervals from Table 1. We do not need resolution for the high depths above 1000 m.
22. Fig. 4: Rephrase the caption as follows: "The cut-in and cut-out wind speeds are marked with red dashes."
23. Fig. 5: What power is this? The average? Median?
24. L. 145: Remove "Some", just say "Results of …"
25. L. 147: Are you sure it is an "optimal: time lag, perhaps you mean "worst"?
26. L. 143-156: Why talk about the time-lag analysis at all if you did not even use it ("30 years … a sufficiently representative climatology")? I do not understand what it means: is a positive value indicating that the first farm affects the second but not vice versa? What is the interpretation of the non-symmetric distribution? Consider removing this piece entirely.

27. Fig. 7: How did you use the Weibull distribution here exactly? What were the values of the shape and form coefficients?
28. Table 1: It seems to me that a large farm is more challenging and more complex to site, finance, build, and operate than a small wind farm. Why is the “Capacity” score opposite instead?
29. L. 234: In English “former” and “latter” are used when there are two terms to discuss. Here, there is only the fitness function, thus replace “the latter” with “the fitness function”
30. L. 238: What is “crossover”?
31. L. 240: What is “mutation”?
32. L. 241: What is “elitism”?
33. Fig. 10: This figure should have “all considered farms” from L. 252, thus 55 (or 35 clusters), but I count 49 dots.
34. L. 261: Why would a spacing of 8-10 diameters be indicative of a strongly unidirectional wind regime? Most offshore wind farms have a spacing of >8Dx8D.
35. L. 265: As mentioned in #2, it is not OK to average over all directions.
36. L. 266: What about Fig 11b? It is not discussed at all. There I count 40 dots, not 35, not 55 …
37. L. 287: Cannot use a capacity factor of 100%! Never ever!!!! You do not need to calculate the number of TWh if the CF was 100%, it would be misleading (plus the value would be 403 TWh, not 406). From the ratio of 158/403, the CF is about 39%, which is really good.
38. L. 292: This sentence is unclear. I think it means this: “the license to build should be granted to at least a third …”. Also at L. 330.