Abstract No.

Engineering Cost Models for Onshore and Offshore Wind Farms: Towards the Integrated Design of Turbines and Farm Layout for Minimum LCoE

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The focus of wind energy system optimization is progressively moving from the single machine to the wind farm level. The most striking example of this fact is represented by the wind farm control. In fact, it was demonstrated that a turbine controller aimed at maximizing the production of a single machine does not necessarily imply to the maximum power of the entire farm [1]. Clearly, the very same argument can be applied also to different disciplines, such as turbine design, operations and maintenance (O&M), decommission and repowering.

In the wider context of a farm, each of the aforementioned factors has a mutual impact on the others and all contribute to the final Levelized Cost of Energy (LCoE) of the system. Consequently, the design of a farm and turbines associated to the minimum LCoE should consider all mutual interactions among all factors.

This fact becomes even more important for offshore, possibly floating, farms than for the onshore counterpart, where the layouts, as well as other design parameters, are constrained by the terrain orography. Indeed, floating offshore farms allow a higher number of degrees of freedom (e.g., maximum farm extension, spacing, typology of the floater, number of turbines, etc...) to be exploited in a suitable optimization procedure.

This discussion suggests that, on the top of any technological improvement, LCoE of offshore and onshore wind energy systems can be minimized through an integrated design of the farm which includes along with layout, also turbine types and controls, in a large optimization problem.

To persecute this goal, the fist step is to develop a wind farm cost model, to assist and drive the multidisciplinary design optimization of turbines and farms.

The present abstract deals with the on-going development of such a farm cost model. At the current status of the research, the tool is organized in four modules. In the first, the annual energy production (AEP) is computed given wind speed statistics through simulations of the farm flow with Floris [2]. In a second, the CAPEX is computed considering the balance of plant, the floater (or foundations) and the electrical connections. The third and fourth modules implement engineering models for O&M and decommission, respectively. This tool will be included in our Cp-Max design code [3].

For the sake of brevity, in this abstract, to demonstrate the potentiality of this tool, the sensitivity of LCoE with respect to the power density, defined as the ratio between the installed power and the total farm area, is considered. Different values of power density have been obtained changing the spacing among the turbines.

From Fig. 1, it appears that, as the density decreases, the AEP increases due to the lower wake loss (green curve). However, due to the increase in the electrical connection costs, there is an increase in LCoE at low densities, leading to a minimum LCoE at about 7 MW/km^2 in both on-shore and off-shore cases (yellow and red curves). That minimum is connected to the optimal turbine spacing for the selected scenario.

In the final presentation of this work, additional details about the farm cost model and a novel set of analysis will be presented.

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Keywords: ”Wind Farm Cost Model ” ”Design Tools ” ”Wind Farm Layout Optimization Tools ”

Images:
Link: https://s3-eu-west-1.amazonaws.com/static.vcongress.de/cms/forwind/paper/fd822e29-4693-4f67-b300-064e027d8534.png
Description: Figure 1: Effect of power density on AEP (green curve), LCoE for onshore (yellow curve) and LCoE for offshore (red curve).

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