Cost modelling for offshore wind farms using dynamic cost functions and engineering wake models

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As offshore wind farms increase in scale to support the transition to a low carbon power system, accurate assessment of project costs and energy generation is essential to deliver accurate levelized cost of energy (LCoE) values. In addition to increasing turbine size, designers will face more challenges as farms are deployed in areas where only floating wind turbines are viable. Instead of minimizing the cost of a single unit, the design should follow a holistic systems engineering approach at farm level. To drive this design, detailed cost models coupled with wake analysis are necessary. This work presents such a wind farm cost model, which is capable of modelling both onshore and offshore farms and includes dynamic cost functions to accurately evaluate a project's financials at any time, instead of static costs that are fixed. A validation study has been performed on two projects in operation, one fixed-bottom and one with floating substructures.

The recently published cost model used in this study, i.e., CosMo-WF (Cost Model for Wind Farms), is implemented in MATLAB and further developed with new functionalities. To calculate wind farm LCoE, it requires a set of information with regards to turbine and substructure design, farm layout, site characteristics, resource assessment, electrical infrastructure, installation and financial parameters. Total annual energy production (AEP) is calculated using the steady state engineering wake models in FLORIS, considering site-specific wind speed and direction probability distributions. Based on look-up tables of power and thrust coefficients, FLORIS models the flow within the wind farm and calculates the power output accordingly. The cost functions of different components and sub-systems are derived from raw data, reports, research and market studies available in the literature.

In order to validate the presented model, two well-known wind farms, Alpha Ventus and Hywind Scotland, are modelled with public data. A parameter study for the case of Alpha Ventus is performed by fixing the wind farm area and changing the number of turbines while respecting the physical rectangular layout. The results show that the minimum LCoE is found with 12 turbines (4 rows x 3 columns), which corresponds to the actual layout. For the second case, a direct approach is followed, where the LCoE of Hywind Scotland is calculated by the cost model as 221.3 €/MWh, which agrees well with the reference value 220 €/MWh found in reports.

A methodology to perform validation of wind farm cost models is presented in this work. Initial testing shows accuracy for both fixed-bottom and floating cases. Future studies will apply commodity and energy adjustment factors to obtain realistic component prices at the time of acquisition. Final work for the conference will include details on cost models and additional analyses regarding wind farm micro-siting. Case studies will be presented, where optimization on site selection and farm layout is performed using wind resource and geographical data from public databases.

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