Wind Farm Cable Routing Optimization for Floating Offshore Wind

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Most existing offshore wind turbines are built with bottom-fixed foundations in water depths under 50 meters. However, countries like Japan, the United States, and those in Western Europa often have limited coastal areas with such shallow waters. As a result, over the past decade, there has been a significant interest in floating offshore wind turbines [1]. Deep offshore regions, in contrast to nearshore areas, provide more stable wind speeds and abundant wind energy resources. It is estimated that about 80% of Europe's offshore wind potential is located in waters deeper than 60 meter, making floating turbines increasingly relevant [2]. Furthermore, these deep water locations are typically remote from human habitats, which reduces the impact on human activities and lessens potential conflicts related to nearshore development [2], [3].

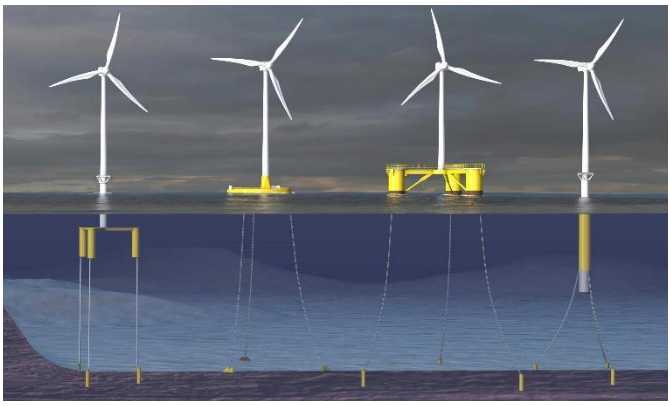

Figure 1: Different foundation options for offshore floating wind turbines. Modified from [4].

Although the first floating wind farms have been commissioned, the primary challenge in achieving commercial viability for floating wind power is the substantial initial capital investment required, which significantly exceeds that of bottom-fixed turbines. A study by Maienza et al. [5] concluded that the capital expenditures (CAPEX) of floating offshore wind turbines is twice as high as that of bottom-fixed wind turbines. This increased initial cost of floating offshore wind farms stems primarily from three factors intrinsic to their floating nature. Firstly, floating turbines require longer export cables, due to the turbines being located in deeper waters further from shore. Secondly, floating offshore wind turbines necessitate the use of dynamic inter-array cables that can adjust to the movements of the floating platform, resulting in higher costs compared to static cables [6]. Thirdly, the inter-array cables face obstacles created by the uncrossable mooring lines of the anchors, resulting in an additionally lengthy cable routing and thus additional costs. These three factors that increase the costs associated with inter-array cables highlight the importance of optimizing the wind turbine layout to minimize the cable length. However, there is an inherent trade-off between wind turbine placement and the cable routing, as they usually compete with each other. Spreading turbines apart can reduce wake losses, thus enhancing the annual energy production (AEP), but it also leads to longer inter-array cables, increasing the costs in the collection system [7].

However, although there is a large body of knowledge concerning the layout optimization of bottom-fixed offshore wind farms, similar studies on floating offshore wind farms are less abundant. This identifies a significant gap in the current state-of-the-art knowledge. Consequently, the primary objective of this research is to create a tool designed to optimize cable routing and mooring layouts for floating offshore wind farms, potentially expanded to also include wake loss reduction and facilitate anchor sharing.

References

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