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Revenue loss due to wake effects between offshore wind farms in the North Sea

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Extended Abstract

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Abstract Summary

As offshore wind capacity in the North Sea expands, inter-farm wake effects are becoming increasingly important. While the energy losses caused by these wakes have been widely studied, their economic implications remain underexplored. This study quantitatively assesses the revenue losses associated with inter-farm wake effects by explicitly accounting for hourly electricity price variations.

Focusing on the Belgian offshore wind region, our analysis examines the impact of a planned 3.5 GW wind farm zone, the Princess Elisabeth Zone (PEZ), located 10 km from the existing Belgian offshore wind cluster. Hourly power losses for the existing zone due to wakes of the PEZ are derived from mesoscale atmospheric model simulations and combined with historical Belgian day-ahead electricity prices for the period 2016–2024. This enables a direct comparison between energy losses and corresponding revenue losses.

The revenue loss depends on three coupled factors: the magnitude of power losses, the frequency of wind conditions that induce wakes, and the electricity price at the time of occurrence. The average price for wake losses was found to be similar to that of the cluster's electricity generation, causing revenue losses (9.0%) that closely mirror energy losses (8.8%). Alternative PEZ locations reduce total wake losses but can shift them to higher-priced hours, leading to revenue losses that exceed energy losses by up to 13.8%.

The study further demonstrates that increasing wind energy penetration alters price dynamics, amplifying the relative revenue impact of wake losses even when energy losses remain unchanged. Overall, the findings highlight that inter-farm wake effects can lead to economic losses that scale proportionally, or even more than proportionally, with energy deficits.

The authors conclude that incorporating price dynamics into wake loss assessments is essential for fair spatial planning and effective policy design, aligning the interests of wind farm developers with those of society.

Presenting Author Biography

Ward Winters obtained his Master of Engineering with a special focus on energy from KU Leuven (Belgium) in 2024. Since 2025, he has been pursuing an interdisciplinary PhD in mechanical engineering and geography, researching the economic consequences of inter-farm wake effects between offshore wind farms. To this end, he combines climate modelling with energy system modelling.