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The Potential Future Role of Floating Wind Turbines and Airborne Wind Energy Systems in the North Sea Region

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In light of the energy transition to a fossil-free energy system, Europe is experiencing a substantial shift toward renewable energy generation. To facilitate this shift, new conversion technologies and energy resources are being investigated. Novel airborne wind energy (AWE) and floating wind turbines have the potential to unlock untapped wind resources and contribute to the balancing of the energy system in unique ways. So far, the techno-economic potential of both technologies has only been investigated at a small scale, while the most significant benefits will likely play out on a system scale. Demonstrating the economic viability and additional benefits of emerging technologies in an energy system context is vital to accelerate political support and funding.

This research aimed to find the main system-level trade-offs in integrating AWE systems and floating wind turbines into a highly renewable future energy system [1]. We developed a modeling workflow consisting of future costs and performance estimations and wind resource assessment integrated into a high-resolution large-scale energy system cost-optimization model based on the Calliope modeling framework [2]. The investigated region contains 10 countries in the North Sea region. The wind resource and system balancing are hourly-resolved.

The results show that onshore AWE can achieve higher capacity factors than conventional onshore wind turbines due to higher wind resource availability and hourly generation profiles that are different and sometimes complementary. The main limiting factor in large-scale onshore AWE deployment is the achievable power density per ground surface area. Offshore AWE shows highly identical performance compared to offshore wind alternatives. Therefore, its deployment is driven by whether it can compete on costs. Floating wind turbine technology demonstrates great potential because of the high capacity factors that can be achieved in high wind resource areas where conventional offshore wind technology is not technically feasible.

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