

Bridging Markets at Sea: Welfare Effects and Security of Supply under Alternative Offshore Wind Hub Designs in European Electricity Markets

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Extended Abstract

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Abstract Summary

The expansion of offshore wind energy in Europe, particularly in the North Sea, is a key element in achieving climate neutrality. However, integrating large-scale offshore generation into electricity systems poses significant technical and economic challenges. Traditional radial grid connections, which connect each wind farm directly to a single country, risk locking in inefficient infrastructure, underutilized transmission capacity, and fragmented cross-border markets.

Offshore energy hubs have emerged as a promising alternative to improve offshore grid efficiency, offering financial, technical, and ecological advantages. These hubs act as centralized platforms, connecting offshore wind farms to several market zones simultaneously. Offshore hubs thus serve a dual function as connection infrastructure for offshore wind farms and as interconnectors between market zones, enabling more efficient transmission, enhanced market integration, and improved system reliability. Despite growing policy interest, uncertainty remains regarding the optimal design and spatial configuration of such hubs and their implications for connected market zones.

This paper assesses the economic effects and security of supply implications of alternative offshore hub designs in the European North Sea for the 2030-2040 horizon. The analysis is based on a coupled European electricity system modeling framework using ELTRAMOD and ELMOD. The study compares radial and hub-based grid designs, as well as different operating modes, evaluating their economic impacts and effects on security of supply using techno-economic and system adequacy indicators.

Preliminary results indicate that offshore hubs can enhance system welfare compared to radial connection designs, primarily by reducing congestion and enabling more efficient grid utilization and cross-border electricity exchange. At the same time, system performance depends strongly on hub design and operating mode. The paper contributes by providing a systematic evaluation framework and informing the development of efficient

offshore market design in Europe, supporting the energy trilemma with a focus on energy security and affordability.