

Economic potential of the energy transition: A regionalized input-output analysis of wind power in Lower Saxony, Germany

Topic: Input-Output Analysis: Regional policies (3)

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Wind power plays a central role in global decarbonization efforts and has diverse economic implications. While national studies dominate, regional analyses gain relevance due to different regional conditions. Northern German federal states like Lower Saxony are particularly well-suited for wind energy production due to high full load hours and the coastal access, enabling offshore wind parks. However, the regional economic and environmental impacts of the wind energy sector remain underexplored, mainly due to the limited sub-national data. In order to address these gaps, the study aims to answer the following research questions: (1) To what extent is the economic footprint of wind power influenced by the underlying data sources? (2) How do economic multipliers of wind power differ by technology, lifetime phase, and effect type? (3) What are the economic and environmental impacts of regional wind power expansion?

Therefore, we construct a regional input-output table (rIOT) with 72 sectors for Lower Saxony based on raw data from the Statistical Office of Lower Saxony and the Federal Statistical Office (Destatis). We employ various methods, including least square optimization and the cross-hauling adjusted regionalization method, and incorporate national-level data to construct a comprehensive and consistent rIOT for the year 2019. Thereafter, wind energy is integrated as two novel sectors, distinguishing between onshore and offshore wind. The integration is based on a detailed supply chain analysis and spans the entire lifecycle - from the manufacturing of key components through installation to the operational phase. The study uses the synthetic industry and a full inclusion approach. A subsequent multiplier and linkage analysis highlights the economic structure of wind energy in Lower Saxony.

Results for the first research question show that Lower Saxony's wind power input sectors have lower backward linkages than at the national level. This doesn't imply weaker benefits but highlights the need for detailed regional data. Including industry data, wind power is found to account for 1.3% of regional economic output. In terms of production multipliers, onshore key component manufacturing (17th) and offshore operation (24th) rank relatively high among 78 sectors and underline wind power's economic importance for Lower Saxony. Findings for the second research question reveal strong variation in multipliers by phase, technology, and effect type. Onshore wind shows higher GVA and employment multipliers, particularly in key component manufacturing. While direct effects dominate, indirect and induced effects contribute up to 52% and 42%, respectively. This confirms the importance of differentiating by activity and effects type. The per-GWh analysis shows stronger effects from offshore wind due to capital intensity and labor demand during installation and operation. The third research question addresses future scenarios. Gross effects show substantial potential, especially from offshore wind. Scenario outcomes vary by a factor of 2.2, depending on regional value chain integration. Net impact results show positive GVA effects from a wind-based electricity mix replacing conventional power sources. However, net employment effects are negative. Regarding environmental impacts, all scenarios show large benefits through significant reductions in CO₂ emissions and water use.

The study's contributions are fourfold: (1) We provide a novel and comprehensive (rIOT) for Lower Saxony, enabling diverse economic analyses. (2) We show the importance of underlying data sources when conducting regional analyses on wind power. (3) We provide a detailed and differentiated analysis of wind power multipliers. (4) We offer insights into wind power's economic and environmental contribution at regional level, highlighting the role of local supply chains, import dependencies and upstream linkages. These findings are relevant for policymakers aiming to align environmental goals with regional economic development. Future research should focus on comparative analyses across federal states and extend the analysis on further sustainable

energy sources, such as green hydrogen.