

Energy Futures and Markets under Geopolitical Uncertainty: Five Scenario Pathways for Europe's Energy Transition 2050

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Extended Abstract

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Abstract Summary

Recent crises and market disruptions highlight how geopolitical developments increasingly shape energy markets, investment decisions, and energy security in Europe. However, many energy system model focus primarily on techno-economic modelling and insufficiently account for geopolitical and societal dynamics. This paper addresses this gap by developing and quantifying alternative energy futures that explicitly integrate the geopolitics–energy–society nexus. As a method, the study combines qualitative scenario development with quantitative energy system modelling. For scenario development a Cross-Impact Balance approach combined with PESTEL-based factor identification, system-relevance, and actor analysis. To translate the qualitative narratives into quantitative pathways, the paper proposes a five-step approach: (1) selecting an appropriate modelling framework, (2) translating scenario narratives into structured scenario dimensions, (3) deriving modelling-relevant assumptions, (4) parameterising key model inputs, and (5) implementing and validating the scenario assumptions within the quantitative model. The resulting scenarios are modeled using the energy system model GENeSYS-MOD. Our results reveal five plausible and consistent futures: (1) *Fossil Revival and Instability* (2) *Unified EU for Sustainability*, (3) *Security First, Sustainability Second*, (4) *Shifting Powers, Shared Goals*, and (5) *Divided EU Slows Transformation*. Our quantification results can be divided into three areas. For each scenario, numerical pathways are derived for (1) electricity generation (energy mix) and electricity consumption, (2) sectoral emissions, and (3) electrification rates, all across the sectors industry, transport, and buildings. We discuss implications for energy policy design and limitations of our study. In conclusion, the study demonstrates how geopolitical developments, policy coordination, and societal acceptance strongly influence the speed of the energy transition, technology deployment, and emissions trajectories in Europe. The findings highlight how geopolitical fragmentation increases system costs and investment risks while slowing decarbonization, thereby intensifying

trade-offs between energy security, sustainability, and affordability. It underlines the importance of integrating such factors into energy scenarios and energy policy research.

Presenting Author Biography

Dr. Franziska Hoffart is a guest professor for “Sustainability Economics and Transformation” at the Kassel Institute for Sustainability at the University of Kassel, a senior researcher at SOFI Göttingen, and a research associate at DIW Berlin. In her research, she focuses on the economics of the socio-ecological transition and the just energy transition.