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Mapping the Energy Transformation: Structural Signatures in Scenario–Model Dynamics

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Extended Abstract

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Abstract Summary

Overview

Long-term energy scenarios play a central role in guiding Europe's transition toward climate neutrality, yet their interpretation remains challenging due to substantial divergence across modelling frameworks. Even under similar temperature targets, integrated assessment models (IAMs) generate markedly different technology deployment pathways, reflecting differences in structural assumptions, technology representations, and policy responses (Bloomfield et al. 2021). Recent cost reductions in renewable energy technologies, in particularly solar photovoltaics, wind power, and storage, have further reshaped expectations about feasible decarbonization pathways (Breyer et al. 2022; Luderer et al. 2021). Emerging literature highlights that these differences are not random but reflect persistent structural characteristics of models, often described as "model fingerprints," which systematically shape mitigation pathways (Dekker et al. 2023). However, the extent to which such structural features drive variation in European energy transition scenarios remains insufficiently understood. This study develops a diagnostic framework to identify structural signatures in scenario–model dynamics and to attribute observed differences in electricity transition pathways to underlying modelling assumptions. By combining statistical classification with variance decomposition, the analysis links observable scenario trajectories to their structural drivers, thereby improving the interpretability of large scenario ensembles.