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DOES ENERGY SECURITY IMPOVES UNDER ENERGY TRANSITION: A STUDY OF CLEAN ENERGY MATERIALS

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Extended Abstract

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Abstract Summary

The global energy transition introduces new supply chain vulnerabilities that may reshape energy security paradigms. Our study develops a framework to analyze how shifting from fossil-fuel-based electricity generation to renewable energy technologies transforms import dependencies on critical materials and their supply chains. We employ a three-stage methodology. First, we utilize the DSCALE algorithm to disaggregate regional energy transition scenarios into country-level projections of solar and wind capacity installations for 157 countries, differentiating between generation technology types. Second, we construct a multi-layer network mapping material flows from extraction through processing to manufacturing, weighted by physical trade volumes. Third, we apply a Leontief production structure combined with disruption simulations to identify binding constraints. Finally, we test the resulting network resilience properties. Our results demonstrate that supply concentration is higher at processing stages than at primary extraction. Herfindahl-Hirschman Index calculations reveal acute concentration in graphite refining (0.92), rare earth refining (0.84), and lithium refining (0.54), exceeding their respective mining levels. We conclude that the energy transition transforms rather than eliminates import dependency. Conventional resource diplomacy targeting mining rights proves insufficient; diversification strategies must prioritize refining capacity development. Critically, mineral supply disruptions constrain capacity expansion rates rather than existing operations, offering longer adjustment windows than fossil fuel shocks but demanding anticipatory investment. Maintaining technology portfolios with cross-technology substitutability provides additional resilience against material-specific disruptions.

Presenting Author Biography

Sofia A. Berdysheva is a postdoctoral researcher at the EPFL College of Management of Technology. She holds a PhD from the Technical University of Munich (TUM) and completed a two-year postdoctoral fellowship at the University of Texas at Austin. Her research

focuses on energy economics, with particular emphasis on energy security and supply chain network analysis. Her current work examines how the transition from fossil fuels to renewable energy technologies reshapes global dependencies, using network-based approaches to identify vulnerabilities in critical mineral supply chains and evaluate diversification strategies.