Policy Pathways for a Green Transition: Assessing the Interplay of Energy Diversification and Economic Complexity on the OECD's Load Capacity Curve

Energies • Article • *Open Access* • 2026 • DOI: 10.3390/en19040923

Afroz, Rafia [a] ; Sarabdeen, Masahina [b]

[a] Department of Economics, Kulliyyah of Economics and Management Science, International Islamic University Malaysia, Kuala Lumpur, 53100, Malaysia

Abstract

This study investigates policy-relevant pathways for achieving a green transition by examining the impact of energy diversification (ED) and economic complexity (EC) on load capacity factors (LCFs) across the Organization for Economic Co-operation and Development (OECD) countries from 1999 to 2021. To capture structural heterogeneity in environmental performance, this study develops a novel Energy Mix Concentration Index (EMCI), based on the Herfindahl–Hirschman Index, and employs Method of Moments Quantile Regression (MMQR), allowing for distribution-specific analysis beyond conventional mean-based estimators. The empirical framework integrates three distinct dimensions of ECI trade-based (ECI-Trade), technology-based (ECI-Technology), and research-based (ECI-Research) alongside GDP per capita and its squared term to test the validity of the load capacity

curve (LCC) hypothesis. The findings of MMQR confirm the validity of the LCC hypothesis in OECD countries. ED is found to exert a statistically significant downward pressure on LCFs across all quantiles, with particularly strong adverse effects in environmentally constrained economies, highlighting the relevance of Jevons' paradox when diversification is not explicitly oriented toward low-carbon energy sources. Regarding EC, research-driven complexity positively affects LCFs, especially in lower LCF quantiles, by facilitating structural shifts toward cleaner, knowledge-intensive activities. In contrast, trade- and technology-based ECI reduce LCFs due to scale effects, supply-chain emissions, and rising energy demand, except in high-performing economies where strong institutions, stringent environmental regulations, and advanced renewable systems enable complexity-induced eco-innovation. These results underscore that innovation and diversification are not environmentally neutral and must be strategically directed. Overall, this study demonstrates that a successful green transition requires more than ED and economic upgrading alone. Effective policy pathways must combine targeted low-carbon energy strategies, mission-oriented research and development, and demand-side regulatory frameworks to ensure that EC reinforces, rather than undermines, environmental sustainability. The findings offer nuanced guidance for OECD policymakers seeking to align post-pandemic recovery strategies with long-term ecological resilience.

Author keywords

economic complexity; energy diversification; green transition; load capacity curve

Indexed keywords

Engineering controlled terms

Carbon; Economic analysis; Economic and social effects; Energy economics; Energy policy; Environmental management; Environmental regulations; Environmental technology; Green development; International trade; Pollution control; Supply chains; Sustainable development

Engineering uncontrolled terms

Capacity curves; Capacity factors; Development countries; Economic complexity; Energy diversification; Energy economics; Green transitions; Load capacity; Load capacity curve; Organization for economic co-operation and development

Engineering main heading

Method of moments

Funding details

Details about financial support for research, including funding sources and grant numbers as provided in academic publications.