Renewable Expansion without Structural Decarbonization:Evidence from India's Electricity Sector (2015–2024)

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ABSTRACT

This paper examines whether the expansion of renewable energy in India has resulted in structural decarbonization of the electricity sector or has instead produced diversification within a system that remains dependent on fossil fuels. Drawing on a quantitative longitudinal analysis (2015–2024), the study evaluates structural change through multiple indicators including generation share, emissions, and coal utilization. The findings indicate that renewable expansion has largely accommodated rising demand rather than displacing coal, suggesting diversification rather than structural decarbonization.

Keywords: Energy transition; structural decarbonization; renewable energy; coal dependence; electricity sector; India

Introduction

The expansion of renewable energy has become a central indicator of progress in global climate governance. In India, this expansion has been particularly rapid over the past decade, driven by declining technology costs, competitive procurement mechanisms, and increasingly ambitious policy targets. However, interpreting renewable expansion as evidence of systemic decarbonization requires careful analytical scrutiny. A dominant assumption is that increases in renewable capacity lead to reductions in fossil fuel dependence, which is not always the case in rapidly growing economies. In such contexts, renewable energy may be absorbed by rising demand rather than replacing existing fossil-based generation. This study examines this distinction by analyzing structural indicators of India's electricity sector between 2015 and 2024.

Methodology

This study adopts a quantitative longitudinal approach to analyze changes in India's electricity sector between 2015 and 2024. Data are sourced from official institutions including the Central Electricity Authority, Ministry of Power, and international datasets. Structural decarbonization is evaluated using five indicators: fossil fuel share in generation, absolute fossil generation, total emissions, coal plant load factors, and renewable growth relative to electricity demand. Trend analysis is used to assess whether structural transformation has occurred.

Results

The expansion of renewable energy capacity in India between 2015 and 2024 has been substantial, particularly in solar power. However, this expansion has occurred alongside the continued dominance of coal within the electricity system. Electricity generation data indicate that while renewable output has increased significantly, coal-based generation has not undergone a sustained decline. Following a temporary contraction around 2019–2020, coal generation rebounded and continued to account for the majority share of electricity production. Over the same period, total electricity demand increased sharply. Renewable expansion has therefore largely absorbed incremental demand rather than displacing fossil fuel generation. Coal plant load factors declined initially but later recovered, indicating continued reliance on thermal generation. Carbon intensity declined, but total emissions increased, indicating the absence of structural decarbonization.

Discussion

The findings challenge dominant interpretations of energy transition that equate renewable expansion with systemic decarbonization. In India, the transition is better understood as a process of parallel expansion, where renewable and fossil energy systems grow simultaneously. Demand growth acts as a structural constraint, absorbing renewable capacity before it can displace fossil fuel generation. At the same time, institutional and infrastructural factors reinforce fossil fuel persistence, consistent with carbon lock-in theory. The distinction between diversification and substitution is therefore critical, as structural decarbonization requires sustained reductions in fossil fuel generation and emissions.

Conclusion

This study demonstrates that India's electricity transition has not yet achieved structural decarbonization. While renewable expansion has improved carbon intensity, fossil fuel dependence remains significant. Renewable growth has primarily accommodated rising demand rather than replacing coal-based generation. Achieving structural decarbonization will require policy measures beyond capacity expansion, including fossil fuel phase-down strategies and institutional reform.

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