

Electricity Consumption, Energy Structure, and Carbon Emissions in Central Asia: Evidence from ARDL, VAR, and Granger Causality Analysis

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[https://doi.org/10.35609/gcbssproceeding.2026.1\(56\)](https://doi.org/10.35609/gcbssproceeding.2026.1(56))

ABSTRACT

Central Asian economies—Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan—have experienced increasing electricity demand alongside economic growth and structural transformation. This rise in energy consumption has raised environmental concerns, particularly regarding carbon dioxide (CO₂) emissions. The region has a mixed energy structure: some countries rely heavily on hydroelectric power, while others depend on fossil fuel-based electricity generation. This creates an important context for analyzing how electricity consumption and the composition of energy sources affect environmental outcomes. While higher electricity use typically contributes to increased emissions, cleaner energy sources such as hydropower and renewables may mitigate this effect. In addition, factors such as GDP per capita, globalization, and financial development can influence the electricity–emissions relationship through changes in production patterns, technology adoption, and investment in energy infrastructure. Therefore, the main research problem of this study is to examine whether electricity consumption necessarily leads to higher CO₂ emissions in Central Asia, or whether energy structure and economic factors can reduce this impact. The study also seeks to identify both long-run relationships and causal links among the key variables.

JEL Codes:

Keywords: Electricity Consumption, Carbon Dioxide Emissions, Central Asia