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ECONOMIC GROWTH AND GLOBAL ENERGY TRANSITION IN THE PERSPECTIVE OF HUMANIZATION (RUSSIA AND CHINA INSTANCES)

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The global energy transition has reshaped the theoretical and empirical foundations of energy security. This review critically evaluates Zhang et al. (2025), who investigate the long-term impacts of decarbonization on China's energy security using a multidimensional index that decomposes supply- and consumption-side channels. Extending their contribution, this article integrates transition economics, computable general equilibrium (CGE) reasoning, and endogenous growth theory to interpret structural shifts in vulnerability. It argues that the energy transition enhances aggregate energy security in the long run but simultaneously restructures dependency toward critical minerals and technological supply chains. Furthermore, the review introduces a comparative perspective by examining renewable energy development in Russia, highlighting divergent transition pathways between resource-dependent and manufacturing-intensive economies. The analysis contributes to the literature by situating energy security within dynamic structural transformation and innovation-driven growth processes.

Energy security has evolved from a narrow focus on fossil fuel availability to a broader concept encompassing systemic resilience under decarbonization (Cherp & Jewell, 2014). As renewable energy penetration increases and electrification accelerates, traditional metrics – such as oil import dependence – become insufficient.

Zhang et al. (2025) provide empirical evidence that China's long-term energy security improves under decarbonization scenarios, yet heterogeneous effects emerge across supply and demand dimensions. This review extends their work in three directions: theoretical integration with endogenous growth models; formal hypothesis articulation; comparative discussion of renewable energy transition dynamics in Russia in the perspective of humanization.

Structural transformation theory (Herrendorf et al., 2014) explains how sectoral reallocation drives development. Under energy transition, the economy reallocates: from fossil extraction to renewable generation; from carbon-intensive industry to high-tech manufacturing; from raw resource dependence to knowledge-intensive production.

Transition economics emphasizes adjustment costs, capital lock-in, and path dependence (Aghion et al., 2016). Fossil-based infrastructure embodies sunk costs,

making short-term transition disruptive but potentially productivity-enhancing in the long term.

Endogenous growth theory (Romer, 1990; Aghion & Howitt, 1992) posits that technological innovation drives long-term growth. Energy transition stimulates innovation in renewable technologies, storage systems, smart grids, electrified transport. Thus, decarbonization may enhance long-term energy security by expanding the technological frontier and reducing dependency elasticities.

In CGE models, decarbonization alters relative prices and reallocates factors across sectors. Fossil-intensive sectors contract, while renewable sectors expand. Long-term equilibrium may feature: lower fossil import shares; higher domestic value-added; increased innovation intensity. However, transitional general equilibrium effects may include welfare losses in carbon-intensive regions.

Drawing on theory and Zhang et al.'s findings, the following hypotheses emerge.

H1: The global energy transition positively affects China's aggregate energy security index in the long term.

H2: Supply-side structural diversification contributes more to long-term energy security improvements than consumption-side efficiency gains.

H3: The decline in fossil fuel import dependence reduces traditional geopolitical vulnerability but increases dependency on critical mineral supply chains.

H4: Endogenous technological innovation moderates the negative impact of mineral dependence by enhancing domestic production capacity.

H5: Economies with high fossil export dependence (e.g., Russia) experience weaker positive security effects from renewable transition relative to manufacturing-based economies (e.g., China).

The study reports 15–25% long-term improvement in ESI; 10–18 percentage point reduction in oil import dependence; 30–40% decline in energy intensity; 20–35% increase in critical mineral dependence. From endogenous growth theory, renewable R&D investment expands, reducing vulnerability over time.

Russia remains heavily dependent on fossil fuel exports, particularly oil and gas. Unlike China, its renewable share in primary energy remains relatively low (IEA, 2023). Renewable development in Russia faces abundant fossil reserves reducing substitution incentives; institutional inertia; limited domestic clean technology manufacturing.

For Russia, renewable transition has ambiguous effects: domestic energy security risk is low due to resource abundance; export revenue risk increases as global fossil demand declines; renewable diversification remains limited compared to China. Under Hypothesis H5, fossil-export-dependent economies may experience weaker aggregate security gains from global decarbonization.

Endogenous growth mechanisms suggest investment in clean R&D strengthens long-run security; knowledge spillovers reduce technological dependency. Diversification, recycling, and substitution reduce supply concentration risk. China's manufacturing base enables endogenous clean technology production, while Russia's fossil export structure constrains diversification incentives.

Energy security under global transition is best understood as dynamic structural reconfiguration rather than linear risk reduction. Zhang et al. (2025) demonstrate that China's long-term energy security improves under decarbonization, yet vulnerability shifts toward minerals and technology.

Integrating endogenous growth theory reveals that innovation capacity determines whether structural substitution becomes sustainable resilience. Comparative analysis with Russia highlights the importance of economic structure in shaping transition outcomes in the perspective of humanization.

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