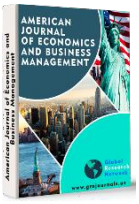

American Journal of Economics and Business Management

Vol. 8 Issue 5 | **pp**. 2181-2189 | **ISSN:** 2576-5973
Available online @ https://www.globalresearchnetwork.us/index.php/ajebm

Balancing Energy Security and Sustainability: The Rationale Behind India's Continued Dependence on Coal

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Abstract:
India's reliance on coal for energy security presents a complex challenge to balancing economic growth, energy access, and environmental sustainability. This study examines India's coal dependence, the socioeconomic implications of a rapid coal phase-out, and potential strategies for a sustainable energy transition. Employing a mixed-methods approach, this study analysed coal production and employment trends using data from Coal India Limited (CIL) and evaluated international coal phase-out experiences. The findings reveal that despite the growth of renewables, India's coal production reached a record high of 997.8 million tonnes in 2023-24, driven by rising energy demand and import substitution policies. However, CIL's workforce composition has shifted, with a decline in permanent employees and an increase in contractual workers, raising concerns about job security and labor rights. A comparative analysis of coal phase-out strategies in Germany, the United Kingdom, Indonesia, the United States, and China highlighted the significance of institutional capacity, policy coherence, and context-specific transition mechanisms. The study concludes that India's energy transition requires a balanced and gradual approach that prioritizes energy access, economic stability, and social equity. Policy recommendations include strengthening the renewable energy infrastructure, developing regional transition plans, and ensuring social protection for coal-dependent communities. Future research should explore the feasibility of clean coal technologies and the role of international climate finance in supporting India's transition to sustainable energy.

Keywords: Energy Security, Sustainable Energy Transition, Coal Production Trends, Employment Shifts, Institutional Capacity, Policy Coherence, Clean Coal Technologies

Citation: Kurmi, D., & Sharma, K. K. (2025). Balancing Energy Security and Sustainability: The Rationale Behind India's Continued Dependence on Coal. American Journal of Economics and Business Management, 8(5), 2194–2202. Retrieved from https://globalresearchnetwork.us/index.php/ajebm/article/view/3576

Received: 12 Mar 2025
Revised: 28 Mar 2025
Accepted: 15 Apr 2025
Published: 17 May 2025

I. Introduction

"*Phasing out coal in developing economies is not as simple as flipping a switch. It must be a gradual process, one that prioritizes people and economic growth*." India, a rapidly developing nation with a growing population, is facing a critical challenge in balancing its energy security needs with its commitment to environmental sustainability. Coal plays a crucial role in meeting the increasing energy needs of India, which is the world's third largest energy consumer. Electricity generation in India relies heavily on coal, which contributes approximately 72% of the country's power production. This substantial dependence on coal underscores its crucial role in sustaining energy supplies in India's industrial, commercial, and household sectors. Rapid economic expansion, urbanization, and industrialization over the past two decades have significantly increased India's energy consumption. As of 2023-24, India's domestic coal consumption reached 964.02 million

tonnes **(ICE-Data Insights, 2024)**. Although there are worldwide efforts to shift towards cleaner energy alternatives, coal remains vital to ensuring India's energy security because of its affordability, domestic availability, and role in ensuring a stable electricity supply for industries and households. However, this reliance presents a significant challenge in the context of global efforts to mitigate climate change and promote sustainable development. Although India has made significant strides in expanding its renewable energy capacity **(Mahida, 2024; Srivastava, 2023)**, the immediate abandonment of coal is not a feasible or rational option because of several interconnected factors. Despite the global pressure to transition to cleaner energy sources, the country faces significant challenges in phasing out coal owing to economic and infrastructural constraints. Despite global commitments to reduce carbon emissions, an abrupt phase-out of coal in India is impractical because of its socioeconomic consequences. Coal-dependent regions, industries, and employment sectors would face severe disruptions that lead to economic instability. Furthermore, India's renewable energy infrastructure is not yet equipped to fully replace the role of coal in ensuring a consistent power supply. Therefore, a well-planned gradual transition is essential.

This seemingly contradictory approach necessitates a deeper examination of the complex interplay between economic, political, and social factors driving India's energy choices. This study aims to examine India's complex relationship with coal-based energy and the challenges it faces in transitioning to cleaner alternatives. By analysing the economic, social, and environmental factors influencing India's energy policies, this study provides insights into the country's potential pathways for balancing energy security, economic growth, and environmental sustainability.

II. Research Objectives

This study attempts to fulfil the following research objectives:

1. To assess India's current dependence on coal for energy security.

2. To address livelihood concerns associated with abrupt coal phase-outs in India.

3. To explore sustainable energy transition strategies that balance economic growth and environmental responsibility.

By integrating insights from coal production, employment, and global energy transition experiences, this study provides evidence-based recommendations for India's future energy strategies.

III. Literature Review

This study draws an extensive review of the existing literature on India's energy sector to provide a comprehensive and nuanced understanding of this critical issue. The ultimate goal is to contribute to a more informed discussion of India's energy future and the pathways towards a sustainable and secure energy system.

India's dependence on coal is deeply intertwined with its political and economic aspirations. Historically, coal mining has played a pivotal role in shaping India's industrial trajectory and continues to be a symbol of national development **(Lahiri-Dutt 2014)**. Although India has made significant progress in adopting renewable energy, coal remains the primary source of power in the country's energy sector. Studies have examined this contradiction, emphasizing the importance of developing a comprehensive energy strategy that incorporates both coal and renewable sources **(Roy & Schaffartzik)**. The widespread dependence on coal is viewed as an obstacle to the transition towards cleaner energy sources. Consequently, it is essential to address the socio-political factors that sustain this dependency on coal. **(Janardhanan & Tamura)**. To mitigate the negative impacts of coal, India is exploring technological solutions such as Carbon Capture and Storage (CCS) to reduce emissions from coal-fired power plants **(Garg & Shukla)**.

However, the viability of coal as an energy source faces significant environmental and societal obstacles. Bhattacharyya highlights the environmental degradation associated with coal mining and consumption and advocates for improved regulatory measures and controls (**Bhattacharyya)**. Furthermore, the socioeconomic implications of coal dependency, particularly in coal mining regions, necessitate a focus on transitions to foster sustainable development **(Bhushan et al.)**.

India's shift towards sustainable energy relies heavily on advancements in technology and policy changes. Implementing carbon pricing mechanisms and improving renewable energy technologies are key strategies that could help reduce a country's dependence on coal **(Pradhan & Ghosh)**. However, the policy framework needs to be robust enough to manage the socio-economic impact of transitioning away from coal (**Tongia and Gross)**.

The sociopolitical dynamics of India's coal dependency are complex. On the one hand, coal is a significant economic driver that provides employment and energy security. However, the transition to renewable energy requires careful management of workforce displacement and regional economic impacts **(Lal et al.)**. Understanding these dynamics is crucial for the development of policies that support a sustainable energy future.

IV. Research Gap

While the existing literature highlights the environmental benefits of phasing out coal, there is limited research on the socio-economic consequences of a sudden transition in India. This includes the impact on employment in coal-dependent regions, industrial competitiveness, and energy affordability for the vulnerable populations. Many studies have predominantly focused on the environmental implications of coal usage. However, a multidimensional analysis that includes energy security, economic growth, and social equity perspectives is lacking. These gaps highlight the need for a holistic, India-specific study that not only assesses the current dependence on coal, but also formulates actionable, context-sensitive strategies for a sustainable transition.

V. Research Methodology

1. Research Design

This study employs a mixed-methods approach that integrates a quantitative trend analysis with a qualitative policy evaluation.

2. Data Collection

Secondary Data Sources:

- Coal production and employment data from the Annual Reports, Ministry of Coal.
- Energy transition strategies and data from government documents, energy agency reports, and climate-policy databases.

These sources were selected based on their reliability, comprehensiveness, and relevance to research objectives.

3. Data Analysis Techniques

This study incorporated trend analysis to examine coal production and workers' job trends (2019-2024) and a comparative case study approach to international energy transition experiences.

VI. Data Analysis and Findings

Coal India Limited (CIL) is the world's largest coal-producing company and a Maharatna public-sector enterprise under the Ministry of Coal, Government of India. It contributes significantly to India's energy sector by supplying coal to power plants, the steel industry, and other sectors**.** Despite global climate commitments and a domestic push for renewable

energy, India's growing dependence on coal presents a complex policy dilemma. Coal remains India's most abundant and accessible fossil fuel, accounting for over 70% of electricity generation in 2023 **(Ministry of Power, 2023)**. While renewable energy capacity has expanded, the absolute demand for coal has also increased owing to the country's rapid industrialization and rising energy needs. Studies have observed a paradoxical trend, in which the growth of renewables coexists with increasing coal usage. According to the International Energy Agency (IEA, 2023), India saw a surge in coal demand post-pandemic, driven by rising electricity consumption and inadequate grid-scale storage of renewables. The report also highlights that new coal-based power plants are under construction or are planned, indicating institutional support for continued coal use. Analysts argue that India's developmental objectives are closely related to coal. Coal is perceived as a dependable, low-cost energy source essential for energy access and economic growth, particularly in states with poor infrastructure **(Bhushan & Kumar, 2022)**.

Fig. 1 shows the coal production by the CIL over the last five years. Despite efforts to encourage the use of renewable energy, reliance on coal has increased. India's coal production has been on an upward trajectory, with significant increases in recent years. In fiscal year 2023-24, the country achieved its highest-ever coal production, reaching approximately 997.8 million tonnes (MT), marking an 11.71% growth compared to the previous year's 893.2 MT.

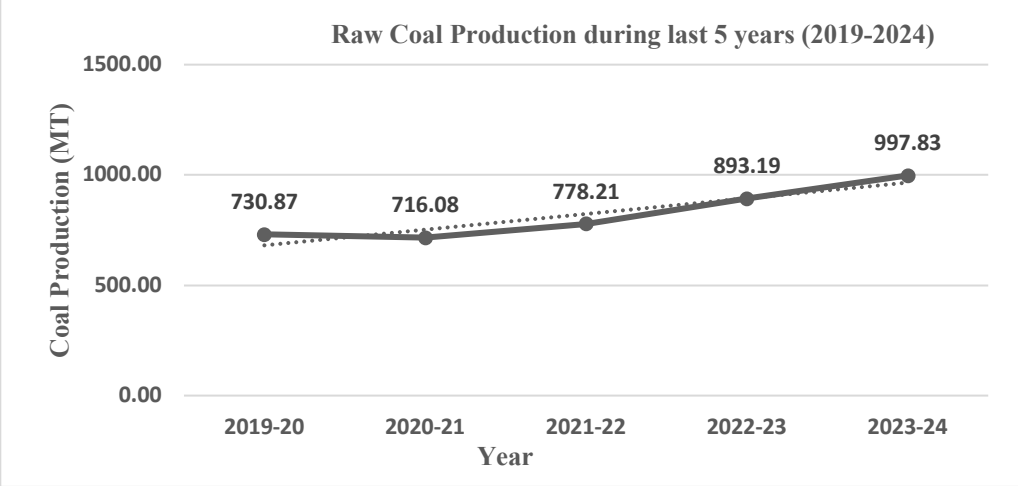

Fig. 1 Coal Production by CIL as mentioned in its annual reports *from 2019-20 to 2023-24, available on https://coal.gov.in/en/public-information/reports/annual-reports*

This surge in coal output is not an isolated event, but part of a broader strategy by the Government of India to bolster domestic coal availability in response to rising industrial and power sector demands. Additionally, the high global prices of imported coal in recent years have motivated domestic production expansion to enhance energy security and reduce import bills. The sharp rise in production indicates the government's recognition of coal as a "transition fuel" -one that will remain vital until renewable sources and storage technologies become reliable and scalable enough to handle base-load energy demands.

However, this growing dependence on coal raises environmental and sustainability concerns. Higher coal extraction leads to increased emissions, land degradation, and displacement in mining regions. As such, while coal production is likely to surpass 1 billion tonnes in the near future, balancing economic growth with ecological responsibility will be a critical policy challenge for India moving forward.

Fig. 2 clearly indicates that in recent years, Coal India Limited (CIL), the world's largest coal-producing company, has undergone a notable shift in workforce structure. Between 2019-20 and 2023-24, there has been a consistent decline in the number of permanent employees,

dropping to approximately 229,000 by 2023-24, the lowest in several decades. In contrast, the number of contractual workers engaged through registered contractors has seen a steady rise, increasing from approximately 63,000 in 2019-20 to over 110,000 by 2023-24. This trend is largely driven by cost-cutting strategies, the need for operational flexibility, and outsourcing of labor-intensive functions.

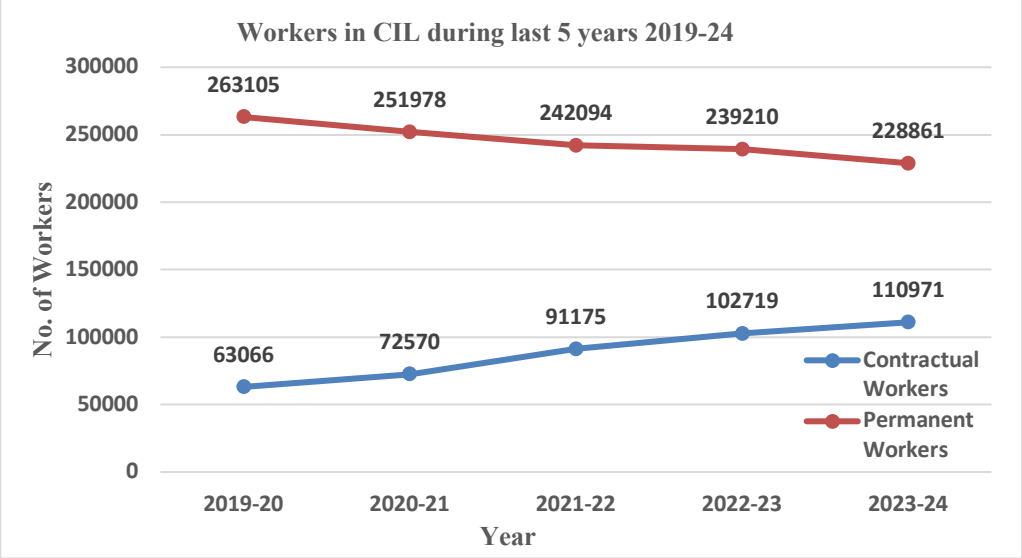

Fig. 2 Workers in CIL as mentioned in its annual reports *from 2019-20 to 2023-24, available on https://coal.gov.in/en/public-information/reports/annual-reports*

This shift indicates a strategic reliance on informal and flexible labor to meet the dynamic demands of coal production, especially in open-cast mining, where short-term deployment is easier. By outsourcing labor-intensive tasks, such as overburden removal, loading, and transport, CIL aims to reduce costs, increase operational efficiency, and maintain productivity in a competitive energy market.

However, this trend raises critical concerns from a socioeconomic and labor rights perspective. Contractual workers often lack job security, wage stability, social security benefits, and safety protections guaranteed to permanent employees under Indian labor laws. Studies have pointed out that contract workers in the coal sector face higher occupational hazards and have limited access to healthcare, compensation, or representation in decision-making processes. Moreover, the growing informalization of the workforce can undermine long-term institutional capacity, demotivate the core workforce, and pose challenges for labor unions. It also reflects a broader shift in India's public sector employment paradigm, where even large PSUs, such as CIL, are increasingly mirroring private sector practices.

From a policy standpoint, although this approach may align with short-term fiscal goals and rising energy demands, it calls for a balanced strategy that ensures decent working conditions, social protection, and skill development for all categories of workers.

VII. Discussion

The global transition from coal as a primary energy source has taken diverse trajectories shaped by national contexts, political economies, institutional capacities, and socio-environmental imperatives. A comparative analysis of coal phase-out strategies across five countries—Germany, the United Kingdom (UK), Indonesia, the United States (US), and China—reveals both convergences and divergences in their approaches to managing energy transition.

Germany and the UK were among the early movers in coal phase-out strategies among

industrialized nations. Germany's approach has been grounded in the principles of a Just Transition, with a legislated coal exit target of 2038, potentially accelerating to 2030 **(Agora Energiewende, 2023)**. A key element of its strategy is the €40 billion support package allocated to coal-dependent regions, reflecting a strong institutional commitment to mitigate socio-economic disruptions. Germany's rapid renewable energy expansion, especially in solar and wind energy, has further supported its decarbonization efforts. However, energy security concerns, particularly following the Russian invasion of Ukraine, have prompted the temporary reserve status of some coal-fired plants **(IEA, 2023a)**.

In contrast, the UK has executed one of the fastest coal phase-outs among the G7 countries, with coal accounting for less than 1% of its electricity generation by 2023 **(UK Government, 2023)**. Its success has been driven largely by market-based mechanisms, including a carbon price floor and capacity market, both of which make coal economically unviable and incentivize a shift towards natural gas and renewables **(Carbon Brief, 2022)**. The UK's clear regulatory framework, early investment in offshore wind power, and strong public support have been instrumental in ensuring grid stability and advancing energy diversification.

Emerging economies, such as Indonesia, present a more complex case. Indonesia's coal phase-out strategy is part of a long-term vision extending to 2056, shaped by its heavy economic reliance on coal for both domestic power (approximately 60% of electricity) and export revenues **(IEA, 2022)**. Under the Just Energy Transition Partnership (JETP), Indonesia secured a $20 billion climate finance package aimed at accelerating coal retirement and scaling up renewables **(JETP Secretariat Indonesia, 2023)**. Despite this progress, implementation challenges remain due to regulatory fragmentation, vested interests in the coal economy, and the need for capacity building and local ownership of the transition process.

The United States illustrates a case in which the absence of a formal national coal phase-out mandate has not hindered the rapid decline in coal usage. Market dynamics—particularly the rise of low-cost natural gas and renewables—have been central to this transition, reducing coal's share in electricity generation from around 50% in 2005 to 17% in 2023 **(U.S. Energy Information Administration [EIA], 2024)**. The Inflation Reduction Act (IRA) of 2022 further bolstered clean energy investment and emission reductions. However, resistance in coal-producing states and the federal structure of energy governance pose significant barriers to a unified coal phase-out strategy **(NRDC, 2023)**.

Finally, China, the world's largest coal consumer and producer, has pursued a dual-path strategy. While committing to carbon neutrality by 2060, China will continue to expand its coal capacity in the short term to meet industrial and energy security needs **(IEA, 2023b)**. Simultaneously, it is also the global leader in renewable energy investment, having installed record capacities for solar and wind energy in recent years. This strategy reflects China's pragmatic balancing of development objectives with its climate commitments, emphasizing the role of coal in maintaining base-load stability while renewables and storage technologies scale up **(Ember, 2023)**.

Table 1: *Coal Phase-Out Strategies: Comparative Overview*

Country	Phase-Out Target	Key Strategy	Coal in Power Mix (2023)	Main Challenge
Germany	2030 (ideal), 2038	Just Transition + Renewables	~25%	Energy security
UK	2024	Carbon pricing + Renewables	<1%	Grid reliability
Indonesia	2056	Just Energy Transition Partnership (JETP) + Conditional Finance	~60%	Economic reliance on coal
USA	No national target	Market forces + Inflation Reduction Act (IRA)	~17%	Political resistance

China	None (Net-zero 2060)	Dual path: Coal + Renewables	~55%	Balancing growth and emissions

Source: Compiled by the author based on data from the IEA (2023), UK Government (2023), JETP Secretariat Indonesia (2023), EIA (2024), and other national energy documents.

Several themes emerged when these cases were compared. First, institutional capacity and policy coherence are central to successful coal transition. Countries with robust regulatory frameworks (e.g., the UK and Germany) have managed the shift more effectively. Second, economic dependency on coal, whether as a domestic energy source (Indonesia, China) or as a regional employment anchor (parts of the US), remains a significant determinant of the transition's pace. Third, while the rhetoric of a Just Transition is common across all cases, its practical implementation varies considerably. For example, Germany and Indonesia have developed structured financial and social support systems, while others have adopted a more market-driven or decentralized approach.

Ultimately, while the global coal phase-out narrative converges in intent, it remains highly differentiated in execution and shaped by domestic political economies, international climate finance mechanisms, and evolving geopolitical landscapes. This underscores the need for context-specific adaptive policy instruments that align national development trajectories with global climate goals.

VII. Conclusion

"You cannot switch off coal overnight when millions still wait to switch on a light." This study critically examines India's enduring dependence on coal as a cornerstone of its energy security strategy, and the complex challenges it faces in transitioning to cleaner energy alternatives. While renewable energy sources have seen substantial growth in recent years, India's coal production has surged to a record high of 997.8 million tonnes in 2023–24. This increase has been largely driven by rising domestic energy demands, rapid industrialization, and policy efforts aimed at reducing dependence on coal imports through increased indigenous production. However, alongside these production trends, the structure of employment in the coal sector, particularly in Coal India Limited (CIL), the largest state-owned coal producer, has undergone significant transformation. The number of permanent employees has steadily declined, replaced by a growing share of contractual workers, a shift that raises serious concerns about job security, workers' rights, and long-term social protection for labor in this sector. These developments underscore the importance of addressing the social dimensions of energy transitions, particularly the need for a just and inclusive approach. To place India's challenges from a broader perspective, this study conducted a comparative analysis of coal phase-out strategies in countries such as Germany, the United Kingdom, Indonesia, the United States, and China. The comparison reveals that institutional capacity, policy coherence, long-term planning, and region-specific adaptation mechanisms are critical factors in enabling a smooth and equitable transition away from coal.

The study concludes that India's path forward must be guided by a balanced and context-sensitive energy transition strategy—one that simultaneously upholds energy access for all, economic resilience, and social equity. This will require not only technological and financial investments but also institutional reforms and robust labor policies that safeguard the interests of coal-dependent communities during the ongoing energy shift.

VIII. Policy Recommendations and Future Research Directions

Several strategic policy measures are necessary to ensure a balanced and inclusive energy transition. First, India must develop a comprehensive transition roadmap that aligns its national energy goals with regional developmental needs. This plan should be phased, flexible, and rooted in India's resource realities, ensuring that coal continues to play a stabilizing role while gradually expanding its share of renewables. Second, policymakers

should implement region-specific transition strategies, particularly in coal-dependent states, such as Jharkhand, Chhattisgarh, and Odisha. These strategies must address local economic vulnerabilities, promote regional industrial diversification, and facilitate skill development to enable smooth transition for affected communities. Third, there is a critical need to strengthen worker protection and social safety nets for workers employed in the coal sector. This includes retraining programs, alternative employment schemes, pension support, and investment in job-creating infrastructure projects in the coal regions. A transition must prioritize livelihoods along with sustainability. Fourth, India should invest in clean coal technologies, such as supercritical and ultra-supercritical combustion systems, carbon capture and storage (CCS), and coal gasification. These technologies can significantly reduce emissions from coal plants, allowing for cleaner use of the existing infrastructure during the transition phase. Finally, the country must leverage international climate finance mechanisms, such as Green Climate Fund, to support decarbonization efforts without undermining domestic development priorities. Accessing global financial and technological support is key to managing the high costs of transition and modernizing India's energy systems.

Future research should focus on evaluating the effectiveness and scalability of clean coal technologies in India, especially in terms of cost efficiency and environmental impact. Additionally, there is a need for in-depth studies on climate finance accessibility and governance to explore how India can better integrate global climate funds into national energy planning. Finally, researchers should examine the socioeconomic implications of workforce shifts within the coal sector, particularly the impact on employment, regional inequality, and migration patterns, to inform policies aimed at ensuring a just and equitable transition.

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