2. Renewable Energy to Dominate India's Grid By 2070 – S & T

India's Energy System in Transition

India is undergoing a long-term structural transformation of its power sector from a coal-dominated system to a diversified low-carbon energy architecture. However, the transition is expected to be gradual rather than abrupt due to developmental, economic, and grid-stability compulsions.

Major Highlights of the Study – Expanded Analysis

Coal as the Backbone of Electricity- Coal currently accounts for nearly 74% of total electricity generation, making it the primary source of dependable base-load power.

Coal plants provide

1. Round-the-clock supply
2. Grid frequency stability
3. Peak demand support
4. Low-cost electricity compared to storage-backed renewables

India possesses substantial domestic coal reserves, reducing energy import vulnerability relative to oil and gas.

Implication- Coal remains indispensable in the medium term despite climate commitments.

Renewable Energy Growth Under Current Policy Scenario (CPS)

Under CPS, renewable energy (RE) share in electricity generation is projected to-

1. Increase from ~20% (2024–25)
2. To more than 80% by 2070.

This implies

1. Massive solar and wind deployment
2. Strong grid expansion
3. Large-scale storage integration
4. Electrification of end-use sectors (transport, industry)

Interpretation- India is pursuing a gradual decarbonisation pathway aligned with net-zero 2070 goals.

Decline in Coal's Share

Coal's share could decline to 6–10% by 2070.

However, this does not necessarily imply immediate reduction in installed capacity.

Coal may-

1. Operate as reserve capacity
2. Function at low Plant Load Factor (PLF)
3. Provide backup during RE intermittency

Key Insight- Coal shifts from "primary generator" to "system stabiliser."

Expansion of Nuclear Power

Nuclear share expected to increase from ~3% currently to 5–8% by 2070. Capacity projected to rise from 8.18 GW (2025) to 90–135 GW by 2070.

Nuclear offers-

1. Firm, low-carbon base-load power
2. High capacity factor (~85–90%)
3. Strategic energy security
4. Support for green hydrogen production

Strategic Role- Nuclear becomes a reliability anchor in a high-RE grid.

India's Energy Share – Current Status (2025)

Installed Capacity Overview

1. Total Installed Capacity- 500.89 GW
2. Non-Fossil Fuel Sources- 256.09 GW (over 51%)
3. Includes Solar, Wind, Hydro, Nuclear
4. Fossil Fuel-Based Sources- 244.80 GW (~49%)

Important Distinction- Installed capacity ≠ actual generation share. Coal contributes ~74% of generation despite only ~49% capacity share due to higher utilisation.

Renewable Energy Breakdown

1. Solar Power- 127.33 GW
2. Wind Power- 53.12 GW
3. Other sources- Hydro, biomass, small hydro

Capacity Addition Trends (FY 2025–26)

1. 28 GW added in non-fossil capacity
2. 5.1 GW added in fossil capacity

Trend Analysis- Renewable expansion significantly outpaces fossil addition. Policy clearly tilted toward clean energy growth.

Structural Challenges in Energy Transition

Limited Share in Actual Generation

RE generation increased only from

1. 19.6% (2013–14)
2. To 22% (2024–25)

Reasons

1. Lower PLF of solar and wind
2. Curtailment issues
3. Transmission bottlenecks

Structural Bottleneck- Capacity growth is faster than effective integration.

Intermittency Challenge

Solar

1. Daytime-only generation
2. Seasonal variation

Wind

Seasonal and unpredictable

Coal remains essential for

1. Frequency regulation
2. Evening peak demand
3. Emergency load balancing

Limited Energy Storage- Grid-scale battery systems remain underdeveloped. Pumped hydro storage insufficient. Storage economics still evolving. Without storage, 80% RE generation is technically infeasible**.**

Import Dependence on Critical Minerals

India depends heavily on imports for

1. Lithiu
2. Cobalt
3. Nickel
4. Rare earth elements

Risks

1. Supply chain disruption
2. Geopolitical tensions
3. Price volatility
4. China-dominated mineral processing

Financial & Policy Hurdles

1. High upfront capital cost for RE and storage.
2. DISCOM financial stress affecting payment security.
3. Regulatory delays.
4. Slow transmission infrastructure approvals.

Land & Social Constraints

1. Large solar parks require extensive land.

2. Conflicts with agriculture and biodiversity.
3. Wind projects face local resistance.

Technological & Skill Gaps

Need for

1. Smart grids
2. AI-based demand forecasting
3. Hybrid RE systems
4. Storage optimisation

Shortage of skilled manpower for installation and maintenance.

Government Initiatives – Expanded Policy Framework

National Solar Mission (2010)

1. Part of National Action Plan on Climate Change.
2. Boosted utility-scale and rooftop solar.
3. Catalysed India's rise as a global solar leader.

National Clean Energy Fund (NCEF)

1. Finances research and innovation.
2. Supports emission-reduction technologies.

National Wind Energy Mission

1. Target- 140 GW wind capacity by 2030.
2. Promotes onshore and offshore wind development.

Financial Instruments

1. Viability Gap Funding (VGF) for hybrid and storage projects.
2. Production Linked Incentive (PLI) for domestic solar manufacturing.
3. Rooftop solar subsidies.
4. Renewable Energy Certificates (RECs) for market-based trading.

Infrastructure Development

1. Green Energy Corridor for RE transmission.
2. PM-KUSUM for solar pumps.
3. Revamped Distribution Sector Scheme (RDSS) for DISCOM reform.

Emerging Technologies

1. Battery Energy Storage Systems (BESS).
2. Hybrid solar-wind-storage projects.
3. Offshore wind and floating solar.
4. National Green Hydrogen Mission.

International Partnerships

1. International Solar Alliance (ISA) leadership.
2. Climate finance mobilization.
3. Technology partnerships with advanced economies.

Way Ahead – Strategic Energy Architecture

Nuclear as Strategic Pillar

1. Provides stable low-carbon base-load.
2. Supports hydrogen economy.
3. Reduces over-reliance on coal backup.

However

1. Requires faster regulatory clearances.
2. High capital costs.
3. Long gestation periods.

Coal's Continued Role

1. May peak at 450–470 GW by 2050.
2. Operates at lower PLF.

3. Acts as strategic reserve capacity.

Energy security and grid stability remain priorities.

Core Transition Constraints

India's transition hinges on

1. Cost reduction in storage technologies.
2. Faster land acquisition processes.
3. Transmission expansion.
4. Mineral supply security.
5. Nuclear deployment acceleration.
6. DISCOM financial reform.

Conclusion- India's Energy Transition Model

India is not pursuing a "coal exit" model like Europe.

Instead, it is pursuing

1. Gradual decarbonisation
2. Parallel expansion of renewables
3. Strategic use of nuclear
4. Managed decline of coal
5. Strong emphasis on energy security

The transition is developmental, not purely environmental — balancing

1. Economic growth
2. Energy access
3. Industrial expansion
4. Climate commitments
5. Geopolitical security

Conclusion- India stands at a critical juncture where governance is increasingly shaped by complex scientific and technological challenges. The current administrative framework, designed primarily for generalist bureaucrats, is not fully aligned with the methodological and institutional needs of modern scientific policymaking.

Source- https-//indianexpress.com/article/explained/explained-economics/renewables-to-dominate-indias-grid-by-2070-but-structural-challenges-are-slowing-the-pace-10527462/