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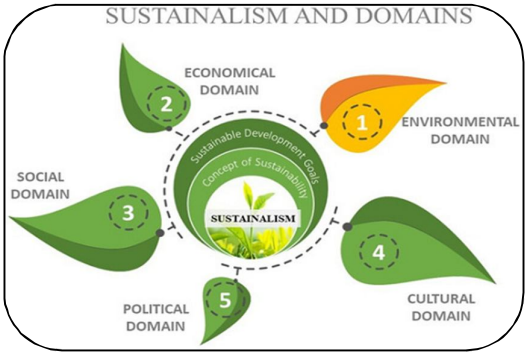
"INDIA'S ENVIRONMENT–ENERGY ECONOMICS LANDSCAPE: POLICY, MARKETS & REGULATION"

Kanhopatra Kerappa Teli
MA in Economics,
At-Post - Vadgaon Shiddheshwar, TQ – Dharashiv, District - Dharashiv, Maharashtra (India).

ABSTRACT



India's environment–energy nexus is being reshaped by rapid growth in electricity demand, expanding renewable energy (RE) capacity, and tightening (and sometimes recalibrated) environmental regulation. Using secondary data from Indian government sources (e.g., Ministry of Power, Ministry of New and Renewable Energy, Press Information Bureau), sector regulators (e.g., Central Electricity Regulatory Commission), and international analysis (International Energy Agency), this article maps India's evolving environment–energy economics landscape across three interlinked domains: (a) policy and institutions governing electricity and environmental compliance; (b) market design and price discovery in short-term power markets and green procurement; and (c) regulatory approaches to managing local air pollutants and greenhouse gas (GHG) emissions, including emerging carbon market architecture. Evidence indicates that India's generation mix is in transition: as of 31 December 2024, total installed capacity was 462,002 MW with non-fossil at 47.1% and coal still the single largest source (46.0%). Short-term electricity transactions have deepened, with power exchanges accounting for 55.7% of total short-term and deviation settlement mechanism (DSM) volume in FY 2023–24. On air quality, government reporting notes measurable progress in PM_{10} outcomes for many cities, while structural challenges persist. The paper concludes with policy recommendations focused on investment de-risking, distribution utility reforms, credible enforcement, and aligning market incentives with air quality and decarbonization goals.

KEYWORDS: *India, energy economics, environment policy, electricity markets, regulation, air pollution, carbon markets, renewable energy.*

INTRODUCTION

India's development trajectory depends on affordable, reliable energy yet the same energy system is a major driver of local air pollution and a growing contributor to global emissions. The economic question is not merely "how to add capacity," but how to do so while internalizing environmental externalities, managing distributional impacts, and maintaining system reliability. This is a classic environment–energy economics problem: energy prices, market rules, and environmental standards jointly shape investment, dispatch, and technology choice.

India's electricity system is governed by a layered institutional structure. The Electricity Act, 2003 created a competitive framework (e.g., licensing reforms, open access, trading) and strengthened independent regulation. Parallelly, environmental governance through statutes, standards, and enforcement institutions sets ambient targets and source-level limits, mediated by central and state pollution control boards.

This article reviews India's environment–energy economics landscape through secondary data, with emphasis on three anchor institutions that practitioners often cite for "official" grounding: the Central Electricity Authority (CEA) (via Ministry of Power reporting), the International Energy Agency (IEA), and the Central Pollution Control Board (CPCB). It integrates these with market monitoring by the Central Electricity Regulatory Commission (CERC) and policy announcements through the Press Information Bureau (PIB).

METHODOLOGY AND DATA

This is a secondary-data-based research article. Data and claims are drawn from:

1. Power sector snapshots and capacity/generation statistics published by the Ministry of Power (sourced from CEA).
2. Renewable capacity progress from MNRE's physical achievements dashboard.
3. Short-term market structure, volumes, and segment shares from CERC's annual market monitoring report for FY 2023–24.
4. Air quality policy targets and reported progress from PIB releases under MoEFCC.
5. Investment context from IEA's World Energy Investment analysis for India.
6. Standards and regulatory reference points including CPCB's National Ambient Air Quality Standards (NAAQS) notification.
7. Carbon-market and energy-efficiency instruments from the Energy Conservation (Amendment) Act, BEE documentation on PAT, and BEE's carbon market framework pages.

Interpretation is analytical and economic: the focus is on incentives, compliance costs, price signals, institutional capacity, and market design.

POLICY AND INSTITUTIONAL ARCHITECTURE

Electricity governance: from planning to markets

India's electricity governance sits at the intersection of planning (CEA and resource adequacy), regulation (CERC/SERCs), and commercial operations (generators, DISCOMs, open access consumers, traders, and exchanges). Ministry of Power reporting reiterates that the Electricity Act, 2003 aimed to introduce competition, protect consumers, and enable open access and trading. A key economic implication of this architecture is that prices are fragmented: long-term PPAs lock in capacity and energy charges; regulated retail tariffs often embed cross-subsidies; and short-term markets clear marginal energy needs. Thus, environmental policy that relies on market price signals must contend with a hybrid structure.

Environmental governance: ambient standards, sectoral limits, and enforcement

On the environment side, the CPCB plays a central role in standard-setting and coordination. The NAAQS notification (2009) formalizes nationwide ambient concentration standards across multiple pollutants and averaging periods, serving as the benchmark for "attainment" and "non-attainment" classification in city-level programs. A practical enforcement pathway increasingly emphasized in official responses is continuous monitoring for high-polluting sectors. For example, MoEFCC reporting notes CPCB directions for highly polluting industries to install online continuous emission monitoring systems (OCEMS) to strengthen compliance.

ENERGY SUPPLY, DEMAND, AND THE ECONOMICS OF TRANSITION

Capacity mix: non-fossil growth alongside coal dominance

As of 31 December 2024, India's total installed capacity was 462,002 MW. Coal remained the largest category at 212,350 MW (46.0%), while total non-fossil was 217,625 MW (47.1%); renewables (including hydro) were reported at 209,445 MW (45.3%), and nuclear at 8,180 MW (1.8%). This composition captures India's central trade-off: deepening decarbonization without sacrificing affordability and reliability, even as coal continues to provide dispatchable baseload and balancing services in many regions.

Generation growth: rising electricity needs as a structural driver

Ministry of Power reporting places total electricity generation (including renewables) in FY 2023–24 at roughly 1,739 BU, with year-on-year growth around 7%; it sets a higher target for FY 2024–25. From an energy-economics perspective, demand growth raises the shadow price of reliability. This tends to (a) increase the value of firm capacity, (b) intensify peak pricing concerns, and (c) make environmental retrofits and compliance timelines politically and commercially sensitive.

Investment trends: clean investment rising, cost of capital remains pivotal

IEA analysis highlights a sharp rise in clean energy investment in India: USD 68 billion in 2023, up nearly 40% from the 2016–2020 average, while fossil fuel investment reached USD 33 billion in 2023. The IEA explicitly flags the cost of capital as critical to meeting energy and climate goals. In India, this interacts with DISCOM credit risk, curtailment risk, payment delays, and regulatory uncertainty, factors that shape the weighted average cost of capital (WACC) and, therefore, the levelized cost outcomes.

POWER MARKETS: PRICE DISCOVERY, LIQUIDITY, AND GREEN PROCUREMENT

Short-term markets are now systemically important

CERC's market monitoring shows that total short-term transactions (including DSM volume) reached an "all-time high" of 218.22 BU in FY 2023–24, about 12.5% of total electricity generation. Within this, power exchanges are central: 55.7% of total short-term transactions and DSM volume in FY 2023–24 occurred through exchanges, compared with 18.8% via traders, 13.3% via direct bilateral transactions, and 12.3% via DSM volume. Economic significance: this implies that marginal price signals especially in day-ahead and real-time segments meaningfully influence dispatch and balancing decisions, and can be leveraged for integrating variable renewables, if market products and grid constraints are well managed.

Market coupling: toward a single reference price

Recent regulatory developments point toward deeper market integration. Reuters reported that CERC would implement market coupling for power exchanges in a phased manner, initially integrating the day-ahead market to establish a uniform price across exchanges. From a market design standpoint, coupling can reduce fragmentation and improve efficiency of price discovery, but it also changes competitive dynamics among exchanges and may alter hedging/liquidity strategies.

Green Open Access: expanding RE procurement options

Government reporting on Green Energy Open Access rules emphasises reduced thresholds for open access to green energy, down from 1 MW to 100 kW, and an obligation for DISCOMs to supply green power on demand (subject to eligibility). Economically, this widens the addressable market for corporate and institutional buyers seeking RE, potentially increasing willingness-to-pay for firmed green products and creating pressure for better banking, wheeling, and surcharge design.

Payment discipline and utilization incentives

On the distribution side, the Late Payment Surcharge (LPS) framework reflects persistent payment-risk concerns. A 2024 PIB release described amendments intended to ensure better utilization of available generating capacity by requiring that surplus (unrequisitioned) power be offered in exchanges for certain fixed-charge eligibility contexts. This is a policy attempt to improve allocative efficiency: if DISCOMs do not schedule power, capacity should be made available to the market rather than remaining idle while consumers face scarcity pricing or load-shedding risk.

ENVIRONMENTAL REGULATION AND LOCAL AIR POLLUTION ECONOMICS

NCAP: targets, funding, and reported outcomes

MoEFCC's NCAP sets national goals for particulate matter reduction, with a revised target of achieving up to 40% reduction in PM or meeting NAAQS by 2025–26. Official reporting states that 95 of 131 NCAP cities improved annual PM_{10} levels in FY 2023–24 compared to the FY 2017–18 baseline, and 18 cities met the PM_{10} NAAQS (60 μg/m^3) in FY 2023–24.

From an economics angle, NCAP is a multi-level governance model relying on: (a) city action plans, (b) earmarked fiscal transfers, and (c) monitoring/reporting. The incentive challenge is classic: cities bear implementation costs while benefits are dispersed across populations and time. Credible metrics and conditional grants can improve performance alignment, but only if monitoring is robust and enforcement is meaningful.

Emission standards for coal plants: tightening vs. recalibration

Coal plant emissions standards have been central to India's air-quality policy debates. A 2015 PIB release described stricter standards aimed at reducing particulate matter, SO_2, and NO emissions from coal-based thermal power plants. Policy has also evolved. Reuters reported that in July 2025 India eased sulphur-emission rules by exempting a large share of plants located farther from densely populated/polluted areas from mandatory flue-gas desulphurisation (FGD) installation, with tighter requirements retained for plants closest to major cities and case-by-case determinations for others.

This shift is economically interpretable as a move toward spatially differentiated regulation (an airshed-risk approach) rather than uniform technology mandates. The welfare outcome depends on whether (a) dispersion and exposure modeling is credible, (b) enforcement is reliable, and (c) remaining sources are sufficient to achieve ambient targets. There is also a sunk-cost and regulatory-risk issue, as investments already initiated under previous mandates face altered cost-recovery expectations.

ECONOMIC INSTRUMENTS: EFFICIENCY TRADING AND EMERGING CARBON MARKETS

PAT (Perform, Achieve and Trade): efficiency as a compliance market

India's energy-efficiency governance includes market-based compliance. BEE notes that implementation of PAT Cycle I delivered 8.67 MTOE of energy savings and avoided about 31 million tonnes of CO_2. In environmental economics terms, PAT is an intensity-based mechanism with tradable certificates (ESCerts), designed to equalize marginal abatement costs across designated consumers. Its effectiveness depends on target stringency, monitoring/verification credibility, and certificate liquidity.

Carbon Credit Trading Scheme (CCTS): institutional framework for an Indian carbon market

The Energy Conservation (Amendment) Act, 2022 explicitly empowers the central government to "specify the carbon credit trading scheme." BEE's carbon market framework page states that the Carbon Credit Trading Scheme has been notified for a compliance market and outlines an institutional framework. As a baseline-and-credit (rate-based) approach (as discussed in official and policy commentary), the key economic design issues include: baseline setting, additionality, measurement and verification, banking/borrowing rules, market power, and linkage with existing instruments (PAT, RECs, green obligations). The success condition is credibility: if certificates are perceived as low-integrity, prices collapse and the scheme becomes a box-ticking mechanism rather than a driver of real abatement.

DISCUSSION: WHAT THE EVIDENCE SUGGESTS

1. **India is already in a dual transition**: rapid RE scale-up plus continued coal reliance for reliability. The 31 Dec 2024 capacity mix shows near parity between fossil and non-fossil sources, with coal remaining the single largest source.
2. **Short-term markets are no longer marginal**. With exchanges accounting for 55.7% of total short-term and DSM volumes, market design has system-level consequences for dispatch, renewable integration, and scarcity pricing.

3. **Air quality policy is producing measurable improvements in many cities**, but outcomes remain uneven and structurally difficult. The reported PM_{10} improvements across 95 cities indicate progress, yet only 18 meeting the standard signals that compliance is still a high bar.
4. **Regulatory uncertainty is an economic variable.** Shifts such as revised compliance obligations for coal plant pollution control change expected returns and can raise risk premiums for all infrastructure, fossil, and clean unless transition pathways and cost recovery rules are transparent.
5. **Carbon markets will complement, not replace, sector regulation**. In an economy with varied institutional capacity and high development needs, hybrid policy packages standards, markets and targeted finance are likely to dominate. The CCTS architecture is a step forward, but its impact will depend on the details of the rules and enforcement capacity.

CONCLUSION AND POLICY RECOMMENDATIONS

India's environment–energy economics landscape is defined by a pragmatic balancing act: ensure reliability and affordability while improving air quality and bending the emissions trajectory. The evidence base from official statistics and regulator reports suggests that: (a) RE expansion is substantial and accelerating; (b) market mechanisms, especially exchanges, are becoming central to dispatch and balancing; and (c) environmental regulation is active but evolving toward more differentiated approaches.

Policy recommendations:

1. **De-risk clean investment at scale** by improving payment security and contract certainty, lowering WACC consistent with IEA's emphasis on cost of capital.
2. **Strengthen market design for flexibility** (granular ancillary services, better congestion management, and effective coupling governance) to integrate higher RE shares without relying on out-of-market interventions.
3. **Align air-quality regulation with exposure risk** using transparent airshed evidence and predictable cost recovery for mandated investments (to avoid destabilizing investment expectations).
4. **Build credible MRV and enforcement capacity** (OCEMS/CEMS integrity, audits, penalties) as the foundation for both command-and-control standards and market instruments like PAT and CCTS.
5. **Design carbon markets for integrity first**: conservative baselines, clear sectoral scope, and anti-gaming mechanisms so carbon prices reflect scarcity and drive real abatement rather than symbolic compliance.

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