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Assessing Power Sector Reforms in India: Regulatory Performance, Distribution Stress and Reform Pathways

[1]Lukesh Dhangaonkar, [2]Mahadeo Narlawar

[1]Independent Researcher, Pune, India
[2]Department of Electrical Engineering, VESP, Mumbai, India
Correspondence: lukesh.dhangaonkar88@gmail.com

Abstract

India's power sector has evolved through successive phases of state-led development, market-oriented reforms, and regulatory restructuring, culminating in the Electricity Act, 2003. While regulatory reforms have enabled significant progress in generation capacity expansion, grid integration, renewable energy deployment, and electricity access, persistent challenges remain in distribution sector performance, tariff rationalization, subsidy dependence, and regulatory effectiveness. This paper critically examines the evolution and outcomes of power sector reforms under regulatory control in India, with a focused assessment of distribution sector stress, contemporary operational challenges, and emerging structural shifts driven by decentralization, digitalization, and changing consumer roles. Drawing on policy analysis and sectoral experience, the study identifies gaps between reform intent and outcomes and proposes a concise, integrated reform framework centered on financial sustainability, regulatory governance, pricing correction, and adaptive implementation. The paper contributes policy-relevant insights for strengthening the power sector's role in supporting India's long-term economic growth and energy transition.

Keywords: Power sector reforms; Electricity regulation; Distribution utilities; Tariff policy; Energy transition; Indian Energy Sector;

1. Introduction

Electricity remains a foundational input for economic growth, industrial competitiveness, and social development. In India, sustained economic expansion, urbanization, and increasing electrification of economic activity have intensified the demand for reliable, affordable, and sustainable power. Recognizing the limitations of the pre-reform model, India initiated structural and regulatory reforms in the power sector, most notably through the Electricity Act, 2003, which sought to introduce independent regulation, commercial discipline, and competitive market mechanisms.

Over the past two decades, these reforms have delivered important gains, including substantial capacity addition, near-universal electrification, improved grid connectivity, and rapid growth of renewable energy. However, persistent financial stress in distribution utilities, continued reliance on cross-subsidies and subsidies, and uneven regulatory outcomes highlight structural weaknesses that constrain sectoral sustainability. At the same time, the sector is undergoing transformation driven by renewable energy integration, digitalization, decentralization, and evolving consumer behavior.

Against this backdrop, this paper examines power sector reforms under regulatory control in contemporary India. Rather than reiterating historical narratives, it focuses on assessing reform performance, identifying current challenges and structural shifts, and analyzing the need for regulatory and pricing course correction. Building on this assessment, the paper proposes a practical reform framework aimed at restoring distribution sector viability, strengthening regulatory credibility, and enabling the power sector to effectively support

India's economic growth and energy transition objectives.

2. Power Sector Evolution in India

The evolution of India's power sector mirrors the broader trajectory of the country's economic development, policy priorities, and institutional reforms. Electricity has long been recognized as a critical input for industrialization, social development, and improvement in living standards. Since Independence, the power sector has undergone multiple phases of transformation, influenced by state-led planning, market-oriented reforms, and, more recently, sustainability and energy transition imperatives [1], [2].

2.1. State Monopoly and Planned Development (1947–1990)

In the post-independence period, India adopted a centrally planned development model, under which electricity generation, transmission, and distribution were primarily state-controlled. The Electricity (Supply) Act, 1948 enabled the establishment of State Electricity Boards (SEBs), which were responsible for planning, development, and operation of power systems within states [3]. The central objective during this phase was to support industrial growth, irrigation expansion, and rural electrification through public investment.

Significant capacity addition occurred through large hydroelectric projects and coal-based thermal power plants. Electricity tariffs were kept low, particularly for agriculture and households, as part of social welfare and developmental priorities. Cross-subsidization emerged as a key pricing mechanism, wherein industrial and commercial consumers subsidized agricultural and domestic consumption [4]. While this approach facilitated access expansion, it gradually eroded the financial health of SEBs.

By the late 1980s, structural inefficiencies became pronounced. High technical and commercial losses, inadequate billing and collection systems, political interference in tariff determination, and insufficient investment in maintenance and network upgradation resulted in mounting financial losses [5]. The power sector increasingly became a fiscal burden on state governments, limiting its ability to respond to rising demand.

2.2. Liberalization and Early Reform Attempts (1991–2002)

The economic liberalization initiated in 1991 marked the beginning of reform efforts in India's infrastructure sectors, including power. Recognizing the limitations of public financing, the government sought to attract private investment, particularly in electricity generation. Independent Power Producers (IPPs) were encouraged through policy initiatives aimed at augmenting capacity and improving efficiency [6].

However, early reform attempts yielded mixed results. The absence of an independent regulatory framework, lack of transparent tariff-setting mechanisms, and weak contractual enforcement undermined investor confidence. Financially distressed SEBs posed significant counterparty risks, leading to stalled projects and renegotiations [7]. These challenges highlighted that isolated private participation without institutional and regulatory reforms was insufficient for sustainable sectoral transformation.

2.3. Electricity Act, 2003: Structural and Regulatory Reform

A comprehensive reform framework emerged with the enactment of the Electricity Act, 2003, which consolidated existing laws and established a unified legal structure for the sector [8]. The Act aimed to promote competition, ensure transparency, protect consumer interests, and enhance efficiency across generation, transmission, and distribution.

Key provisions of the Electricity Act, 2003 included unbundling of vertically integrated SEBs, establishment of independent regulatory commissions at the central and state levels, introduction of open access, promotion of electricity trading, and gradual reduction of

cross-subsidies through cost-reflective tariffs [9]. Regulatory institutions were expected to depoliticize tariff determination and enforce commercial discipline. Following the Act, most states undertook unbundling reforms. In Maharashtra, the erstwhile SEB was reorganized into separate generation, transmission, and distribution entities, laying the foundation for improved governance and accountability [10].

2.4. Post-2003 Expansion and Market Development

The post-2003 period witnessed substantial growth in installed generation capacity, leading to improved supply adequacy at the national level. Expansion of transmission infrastructure enabled the development of a national grid, facilitating inter-regional power transfers and enhancing system reliability [11]. Short-term electricity markets and power exchanges emerged, improving price discovery and operational flexibility [12].

Rural electrification initiatives accelerated access, contributing to near-universal village electrification. However, distribution utilities continued to face financial stress due to high aggregate technical and commercial losses, delayed subsidy payments, and persistent political influence over tariffs [13]. As a result, the benefits of market reforms remained uneven, particularly at the retail consumer level.

2.5. Energy Transition and Digital Transformation

In recent years, the evolution of India's power sector has been shaped by the global energy transition and domestic climate commitments. Rapid expansion of renewable energy capacity, particularly solar and wind, has altered the generation mix and introduced new operational challenges related to grid stability and variability management [14]. Integration of renewable energy has increased the need for grid flexibility, forecasting accuracy, and storage solutions.

Simultaneously, digitalization and smart grid initiatives have gained prominence. Advanced metering infrastructure, smart meters, and data-driven network management systems are being promoted to improve billing efficiency, reduce losses, and enhance consumer engagement [15]. Policy discussions have also emphasized consumer-centric reforms, separation of carriage and content, and the development of competitive retail electricity markets.

2.6. Evolutionary Trajectory and Implications

Overall, India's power sector has transitioned from a state-dominated monopoly to a regulated, multi-actor system characterized by market mechanisms and independent regulation. The sector has moved from chronic supply shortages to relative adequacy, and from administrative control to regulatory governance [16].

Despite these advances, the evolution remains incomplete. Structural weaknesses in distribution, implementation gaps in regulatory reforms, and financial fragility of utilities continue to constrain performance. A clear understanding of this historical evolution is essential for designing future reforms that address underlying institutional and economic challenges rather than relying on incremental or short-term measures.

3. Regulatory Framework and Reform Experience under the Electricity Act, 2003

The Electricity Act, 2003 marked a decisive shift in India's power sector from administrative control to independent regulatory governance. The reform sought to introduce transparency, commercial discipline, and consumer protection through rule-based tariff determination and oversight by Central and State Electricity Regulatory Commissions [8]. More than two decades later, the regulatory experience reveals both structural progress and persistent limitations.

3.1. Objectives of Regulatory Reform

Regulatory reform was intended to insulate tariff-setting from political intervention, ensure cost recovery, promote efficiency, and create

investor confidence [17]. Independent regulators were empowered to balance utility viability with consumer interests while facilitating competition and long-term sustainability. From an operational perspective, this shift was essential to address chronic under-recovery of costs and declining financial health of utilities [16].

3.2. Tariff Regulation and Cross-Subsidy Constraints

Despite statutory provisions mandating cost-reflective tariffs and gradual reduction of cross-subsidies under Section 61 of the Act, tariff rationalization has remained limited in practice [18]. Political sensitivities around electricity pricing have constrained timely tariff revisions, resulting in persistent revenue gaps. Regulators have frequently relied on regulatory assets to defer recovery, weakening financial discipline and creating intertemporal inequities [19].

3.3. Subsidy Dependence and Utility Finances

Contrary to reform expectations, subsidy dependence has increased in several states, with delays in reimbursement exacerbating cash flow stress for distribution utilities [13]. Although regulatory frameworks require advance subsidy commitments, enforcement has been inconsistent [20]. Operationally, delayed subsidies affect power procurement, maintenance, and capital investment, undermining service quality and financial stability.

3.4. Assessment of Reform Outcomes

Regulatory control has improved transparency and performance monitoring, yet financial sustainability of distribution utilities remains elusive. AT&C losses persist in many jurisdictions, reflecting governance and implementation gaps [21]. The experience suggests that regulation alone cannot overcome structural inefficiencies without parallel reforms in subsidy delivery, utility management, and political commitment to cost recovery [22].

3.5. Implications for Future Reforms

The partial fulfilment of reform objectives highlights the limits of regulation in isolation. Strengthening regulatory autonomy, enforcing timely tariff adjustments, and aligning state-level fiscal policies with regulatory decisions are critical for restoring sector credibility [23]. As the sector confronts renewable integration, digitalization, and evolving consumer roles, regulators must transition from tariff arbiters to system-level stewards [24], [15].

4. Performance Assessment of Power Sector Reforms and Distribution Sector Stress

While regulatory reforms have improved transparency, reporting standards, and capacity addition, their impact on operational and financial performance has been uneven across the power value chain. A sector-wide assessment indicates that generation and transmission segments have benefited more from reform momentum, whereas distribution continues to remain structurally stressed.

4.1. Supply Adequacy versus Distribution Performance

At the national level, installed generation capacity has expanded significantly, reducing chronic energy and peak shortages. The development of the national grid and improved inter-regional transfers have enhanced system reliability. However, these supply-side gains have not translated proportionately into improved distribution performance, particularly in terms of financial sustainability and service quality [25].

From an operational standpoint, the persistence of distribution inefficiencies has diluted the benefits of upstream investments. Power availability does not automatically ensure power delivery unless distribution networks are financially viable and operationally efficient.

4.2. Aggregate Technical and Commercial Losses

Aggregate Technical and Commercial (AT&C) losses remain a critical indicator of reform outcomes. Despite targeted programs and regulatory monitoring, losses continue to be high in several states, reflecting a combination of technical weaknesses, inadequate metering, billing inefficiencies, and governance

challenges [26]. Loss reduction has been incremental rather than transformative, indicating limitations of compliance-driven approaches.

4.3. Financial Stress of Distribution Utilities

The financial performance of distribution utilities remains the most significant reform gap. Persistent tariff gaps, delayed subsidy reimbursements, and high-power purchase costs have resulted in recurring losses and rising debt levels [27]. Although regulatory scrutiny has improved cost transparency, structural issues—rather than accounting practices—continue to drive financial stress.

Operational experience suggests that financial distress constrains routine maintenance, network modernization, and consumer service improvements, creating a self-reinforcing cycle of inefficiency.

4.4. Reform Outcomes: A Synthesis

The performance assessment highlights a clear asymmetry in reform outcomes. Regulatory and market reforms have been more effective where commercial incentives are strong and political intervention is limited. In contrast, distribution remains constrained by tariff sensitivity, subsidy dependence, and weak enforcement [28]. This divergence underscores that regulatory reform, while necessary, is insufficient without complementary governance, fiscal, and institutional reforms at the state and utility levels.

5. Contemporary Challenges in India's Power Sector

As India's power sector enters a phase of relative supply adequacy, the nature of challenges has shifted from capacity creation to system management, financial resilience, and transition readiness. These challenges are qualitatively different from those addressed in earlier reform phases and require regulatory and institutional responses that go beyond conventional tariff and compliance frameworks.

5.1. Renewable Energy Integration and System Flexibility

Rapid expansion of renewable energy, particularly solar and wind, has introduced variability and uncertainty into grid operations. While capacity addition targets have largely been met, the supporting ecosystem—flexible generation, storage, forecasting accuracy, and ancillary services—has not expanded at the same pace [29]. This mismatch places increasing operational stress on distribution utilities and system operators, especially during peak and ramping periods.

5.2. Financial Stress under a Changing Cost Structure

The evolving generation mix has altered the cost structure of electricity supply. Long-term thermal power purchase agreements, combined with variable renewable generation and must-run obligations, have reduced operational flexibility for distribution utilities [30]. As a result, DISCOMs face rising fixed cost burdens even when demand growth is uneven, reinforcing existing financial stress rather than alleviating it.

5.3. Fuel Supply and External Dependencies

Fuel availability, particularly domestic coal supply and gas pricing, continues to influence generation economics and system reliability. Periodic supply constraints and price volatility introduce risks that are largely outside the control of electricity regulators but directly affect sector performance [31]. Weak coordination between fuel policy and power sector planning remains a structural vulnerability.

5.4. Changing Consumer Behavior and Market Signals

Large consumers are increasingly adopting captive generation, open access procurement, and rooftop solar solutions. While this reflects rational economic behaviour, it also erodes the high-paying consumer base of distribution utilities, intensifying cross-subsidy pressures [32]. Regulators now face the challenge of balancing consumer choice with the financial viability of the grid.

5.5. Implications for Regulation

These contemporary challenges highlight the limits of static regulatory instruments in a dynamically evolving sector. Regulation must increasingly focus on system-level coordination, risk allocation, and long-term

adaptability rather than retrospective cost approval alone [33].

6. Emerging Trends and Structural Shifts

Beyond immediate operational challenges, India's power sector is undergoing deeper structural shifts that are reshaping institutional roles, market design, and regulatory priorities. These trends do not represent incremental extensions of earlier reforms but signal a redefinition of how electricity systems are organized and governed.

6.1. From Centralized Supply to Decentralized Systems

The traditional model of centralized generation feeding passive consumers is gradually giving way to a more decentralized architecture. Rooftop solar, storage systems, and microgrids are enabling consumers to participate actively in electricity generation and management. This structural shift challenges legacy regulatory assumptions regarding cost recovery, grid usage, and revenue allocation, particularly for distribution utilities [34].

6.2. Digitalization and Data-Driven Operations

Digital technologies are emerging as structural enablers rather than operational add-ons. Smart meters, real-time monitoring, and data analytics are altering the basis of network planning, loss management, and consumer engagement. Importantly, digitalization creates the possibility of moving from average-cost regulation to more granular, usage-based pricing and performance incentives, provided regulatory frameworks adapt accordingly [35].

6.3. Separation of Network and Supply Functions

Policy discourse increasingly emphasizes functional separation between the wire business and electricity supply. Such separation aims to reduce conflicts of interest, enable competition in retail supply, and improve transparency in network cost recovery. While still at an exploratory stage, this structural shift has significant implications for regulatory capacity, risk allocation, and institutional design [36].

6.4. Evolution of Consumer Roles

Consumers are no longer passive recipients of regulated supply. Large users are exercising choice through open access and captive generation, while smaller consumers are beginning to respond to pricing signals and service quality. This evolution necessitates a regulatory transition from consumer protection through price suppression to consumer empowerment through information, choice, and service standards [37].

6.5. Structural Implications for Regulation

These emerging trends collectively suggest that future reforms must focus less on static compliance and more on adaptive governance. Regulators will need to balance flexibility with financial stability, facilitate innovation without undermining grid integrity, and manage the transition toward competitive and decentralized systems [38].

7. Regulatory and Pricing Reforms : The Need for Course Correction

The cumulative reform experience indicates that India's power sector challenges are no longer rooted in policy absence but in misaligned regulatory incentives and pricing distortions. As the sector transitions toward decentralization, renewable integration, and greater consumer choice, regulatory and pricing frameworks require a deliberate course correction to ensure financial viability and systemic stability.

7.1. From Cost Recovery to Cost Alignment

While regulatory mechanisms formally recognize cost-reflective tariffs, implementation has often lagged changing cost structures. Pricing frameworks must move beyond retrospective cost approval toward forward-looking cost alignment that reflects evolving generation mixes, flexibility requirements, and network usage. Without such alignment, utilities remain exposed to structural deficits despite regulatory compliance [39].

7.2. Rationalizing Cross-Subsidies and Subsidy Delivery

Cross-subsidies, originally designed as transitional instruments, have become

entrenched and increasingly distortionary. As high-value consumers migrate toward alternative supply arrangements, the existing subsidy architecture amplifies financial stress on distribution utilities. A gradual transition toward targeted subsidies—preferably through direct benefit mechanisms—can preserve social objectives while restoring tariff integrity [40].

7.3. Pricing Signals and Consumer Behaviour

Static tariff structures fail to reflect temporal and locational variations in system costs. Introducing time-sensitive and service-linked pricing can improve demand responsiveness, reduce peak stress, and enhance system efficiency. Such reforms also align consumer incentives with system realities, shifting regulatory focus from price suppression to efficient consumption [41].

7.4. Strengthening Regulatory Credibility

Regulatory effectiveness ultimately depends on predictability and enforcement. Timely tariff orders, consistent application of regulatory principles, and credible enforcement of cost recovery are essential for restoring confidence among utilities, investors, and consumers alike. Regulatory discretion must be exercised within clearly articulated long-term objectives rather than short-term fiscal or political considerations [42].

7.5. Implications of Pricing Reform

A calibrated correction in regulatory and pricing frameworks can stabilize utility finances, support energy transition goals, and enable innovation without compromising equity. Pricing reform, when combined with transparent subsidy mechanisms and strengthened regulatory autonomy, emerges as a central lever for sustainable power sector transformation [43].

8. Proposed Reform Framework for Sustainable Power Sector Growth

Building on the assessment of regulatory performance, contemporary challenges, and emerging structural shifts, this section proposes an integrated reform framework aimed at restoring financial sustainability, enabling the energy transition, and strengthening regulatory governance. The framework is designed to be practical, implementation-oriented, and consistent with India's institutional realities.

8.1. Financial Sustainability as the Core Anchor

Sustainable reform must begin with restoring the financial viability of distribution utilities. This requires a shift from episodic financial restructuring to continuous financial discipline through timely tariff adjustments, transparent subsidy provisioning, and enforceable performance benchmarks. Direct Benefit Transfer–based subsidy delivery can decouple social objectives from tariff design, enabling cost-reflective pricing without compromising equity [44].

8.2. Regulatory Governance and Accountability

Regulatory institutions must evolve from compliance-focused adjudicators to system-level stewards. This entails strengthening functional autonomy, enhancing analytical capacity, and embedding long-term sector objectives into tariff and market decisions. Clear accountability mechanisms—covering timelines, enforcement, and outcome monitoring—are essential for restoring regulatory credibility [45].

8.3. Market and Network Coordination

As the sector becomes more decentralized and renewable-heavy, coordination between markets and networks becomes critical. The proposed framework emphasizes integrated planning across generation, transmission, and distribution, supported by market-based mechanisms for flexibility, ancillary services, and congestion management. Such coordination reduces system costs while improving reliability [46].

8.4. Technology-Enabled Efficiency and Consumer Engagement

Digitalization should be leveraged as a reform enabler rather than a standalone intervention. Universal smart metering, data-driven loss management, and demand-side response mechanisms can improve operational efficiency and empower consumers. Regulatory support for dynamic pricing and service differentiation is central to aligning consumer behavior with system needs [47].

8.5. Sequenced and Adaptive Implementation

Recognizing institutional diversity across states, reforms should follow a sequenced and adaptive approach rather than uniform mandates. Pilot-based implementation, learning loops, and mid-course corrections can reduce transition risks while preserving reform momentum. Regulatory frameworks must explicitly accommodate learning and adjustment as system conditions evolve [48].

9. Policy Implications and Way Forward

The analysis underscores that sustainable power sector reform in India requires a shift from episodic interventions to coherent, long-term policy alignment. Regulatory strengthening, financial discipline, and technological adaptation must advance simultaneously rather than sequentially. Fragmented reforms risk undermining systemic stability, particularly in the distribution segment.

Policy focus should prioritize predictable tariff pathways, transparent subsidy delivery, and enforceable regulatory timelines to restore institutional credibility. Strengthening coordination between electricity regulation, fuel policy, and fiscal frameworks is essential to reduce structural risk and improve investment signals.

Going forward, reform implementation must be adaptive and state-sensitive, allowing for contextual flexibility while adhering to national sustainability and efficiency objectives. A governance framework that integrates market signals, digital tools, and consumer participation can enable the power sector to support economic growth while navigating the energy transition.

10. Conclusion

India's power sector reforms under regulatory control have delivered measurable progress in capacity expansion, access, and transparency, yet persistent structural and financial challenges continue to constrain long-term sustainability. The reform experience demonstrates that regulation, while necessary, cannot succeed in isolation without aligned pricing signals, disciplined subsidy mechanisms, and credible enforcement.

As the sector confronts the dual pressures of energy transition and evolving consumer behaviour, future reforms must move beyond incremental adjustments toward integrated, adaptive governance. Strengthening regulatory autonomy, restoring distribution utility viability, and leveraging digital and market-based tools are central to this transition.

A balanced reform approach grounded in financial realism, regulatory credibility, and technological enablement can position the power sector as a stable foundation for India's economic growth and sustainable development in the coming decades.

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