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Electricity as an Enabler of Ease of Doing Business in India: Power-Sector Reforms and Evidence from Industrial Activity

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Abstract

India's power-sector reforms have built a business-enabling platform that now extends well beyond universal access. UDAY, Saubhagya, consumer-rights rules, RDSS, smart metering, payment discipline, and green open access strengthen the reliability, efficiency, transparency, and procurement conditions required for pro-ductive electricity use. This paper develops a 'Using Electricity for Business' framework and presents a state-panel case study of supply adequacy and network-loss reduction. A near-balanced panel of 27 states for FY2015–16 to FY2023–24 combines CEA, NSO/ASI, and RBI data. State and year fixed-effects models re-late energy deficits and reported T&D losses to manufacturing value added, factories, employment, and fixed investment. Electricity performance improved substantially alongside broad industrial expansion. In the base-line model, a one-percentage-point reduction in reported T&D losses is associated with 2.71% higher nominal GFCF among positive-investment observations (wild-bootstrap p = 0.0307). The estimate remains directional-ly stable across several checks, although precision varies in stricter specifications. The findings are consistent with improved electricity efficiency strengthening the investment environment alongside wider infrastructure, credit, and industrial-policy reforms. AI-enabled distribution and consumer services can extend this advantage.

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1. INTRODUCTION

Electricity is a general-purpose intermediate input linking machinery, labour, communications, cooling, data systems, and logistics. For a firm, access creates value only when supply is dependable, power quality is adequate, costs are predictable, utility services are responsive, and procurement options match operating and decarbonisation needs. These conditions affect project commissioning, capacity utilisation, downtime, working capital, technology choice, and location. Electricity policy therefore influences business performance through the quality of continuous service, not only through the initial connection.

The World Bank's discontinued Doing Business programme brought electricity into the measurement of business regulation. Its Getting Electricity topic was designed primarily around a standardised new connection—procedures, time, and cost—while later editions added supply reliability and tariff transparency[1]. Even the expanded methodology could not fully represent the continuing service conditions faced by operating firms. Doing Business was discontinued in September 2021[2]. Its successor, Business Ready (B-READY), assesses regulatory frameworks, public services, and operational efficiency under the broader Utility Services topic[3]. The two systems are not a continuous score series, but their evolution supports a more complete policy question: how easily can a connected firm use electricity to produce, invest, and expand.

India has answered this question through a broad and sequential reform programme. UDAY strengthened attention to distribution finances and operational discipline[4]; Saubhagya completed the access foundation[5]; the Electricity (Rights of Consumers) Rules established service standards for connections, supply, metering, billing, and grievance redressal[6-7]; RDSS links distribution investment with results, loss reduction, and smart metering[8]; the Green Energy Open Access Rules widen procurement choice[9]; and the Late Payment Surcharge Rules improve financial discipline across the value chain[10]. By 2025, the Ministry reported average electricity availability of 22.6 hours in rural areas and 23.4 hours in urban areas, while the national energy shortage had declined to 0.03% in FY2025–26 [11]. These outcomes show that the policy frontier has moved decisively from physical access towards dependable and manageable service.

The central research question is how India's electricity reforms and measurable improvements in sector performance have enabled industrial and business activity. The paper makes three contributions. First, it maps the Ministry of Power's major reforms to the business frictions they address. Second, it develops an Electricity Business Enablement Framework that distinguishes policy reform, service performance, firm response, and economic outcome. Third, it presents a focused state-panel case study testing whether improved adequacy and lower reported T&D losses are associated with manufacturing activity. The case study supplies one measurable outcome channel within the wider reform architecture.

2. LITERATURE REVIEW AND RESEARCH GAP

2.1 From Connection Efficiency to Productive Use

Getting Electricity translated a common entry constraint into observable procedures, elapsed time, connection cost, reliability, and tariff transparency. B-READY retains regulatory and public-service assessment while giving greater attention to operational efficiency. India's reform sequence is especially relevant because ease of using electricity is delivered in linked stages. National rules define consumer rights and service standards; utility reform and distribution investment build the capability to meet them; and digital systems translate these standards into faster and more transparent service at the premises. Evaluating only the connection stage misses these continuing conditions.

The empirical literature explains why service quality matters after connection. Allcott, Collard-Wexler, and O'Connell find that electricity shortages reduce Indian manufacturers' revenue and producer surplus, although

firms partly adapt through backup generation and input adjustment[12]. Cross-country Enterprise Survey evidence links power constraints with lower firm productivity[13]. Recent Indian evidence values reliability over a longer horizon[14], while Abeberese shows that electricity cost can alter firms' product choices and productivity growth[15]. The resulting burden is not confined to the tariff: interruptions, captive generation, uncertainty, and delayed commissioning raise the effective cost of usable electricity.

2.2 Reform Mechanisms and the Research Gap

The Ministry of Power's initiatives form a coherent business-enablement architecture rather than a collection of isolated schemes. UDAY addresses utility finances and operational discipline; Saubhagya provides the access base; consumer-rights rules reduce service uncertainty; RDSS strengthens networks and digital visibility; the Late Payment Surcharge Rules support payment security; and green open access gives eligible consumers greater procurement flexibility[4-10]. Each intervention tackles a distinct constraint, while their combined effect is expressed through greater availability, improved network efficiency, clearer service obligations, stronger sectoral finances, and wider access to clean power. For enterprises, these changes reduce downtime and backup costs, accelerate energisation, improve cost planning, and widen the options available for expansion and decarbonisation.

The remaining research question is no longer whether outages can harm firms; that relationship is well established. The challenge is to connect India's multi-layer reform programme with observable business outcomes while recognising that industrial growth can itself induce electricity investment. Geographic instruments for Brazilian electrification show why simple correlations are insufficient[16]. In India, changes in industrial load may also influence the measured loss ratio. This paper therefore uses a state-panel case study to test one measurable channel—adequacy and loss reduction—while the reform framework captures the broader routes through which policy shapes the business environment.

3. POWER-SECTOR REFORM AND BUSINESS ENABLEMENT

Table 1 sets out the Ministry's reform architecture. The sequence is cumulative: access reform expands the potential market; financial and operational reform strengthens distribution utilities; consumer rights and digital systems reduce transaction costs; and procurement reform helps firms manage energy cost and carbon requirements. Figure 1 translates this architecture into a theory of change from policy reform to electricity performance, firm response, and economic activity. The framework evaluates reform through the service experienced and the business decision enabled.

The empirical case study tests the following hypothesis. **H1:** *Improved electricity performance is positively associated with industrial activity.* The state-panel case study examines whether states with larger improvements in energy adequacy and reported T&D losses also record stronger changes in manufacturing value added, factory presence, fixed investment, and employment. H1 captures the adequacy-and-efficiency channel in Table 1. Connection service, power quality, digital convenience, tariff predictability, and renewable procurement remain part of the policy framework and future measurement agenda, but are not presented as separately tested hypotheses.

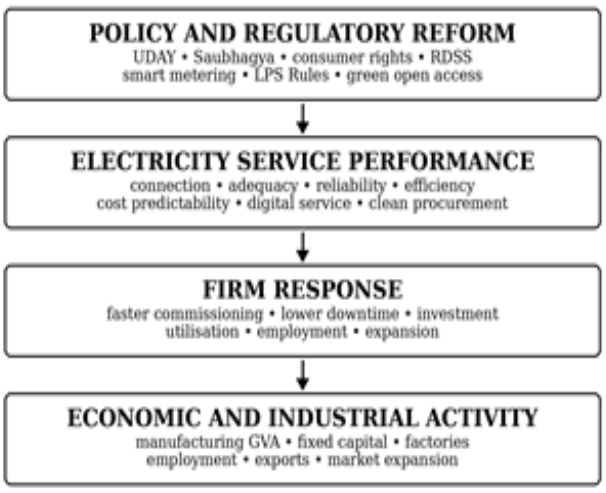


Figure 1. Electricity business enablement framework.

Table 1. Selected ministry of power reforms and business-enablement channels

Reform	Electricity-sector Mechanism	Business Friction Addressed	Business-enablement Contribution
UDAY (2015)	Debt restructuring and operational targets for DISCOM losses and revenue gaps.	Weak utility finances and limited capacity to maintain and expand networks.	Strengthens the basis for network investment, service reliability, and greater cost predictability.
Saubhagya (2017)	Last-mile connectivity and universal household electrification.	Uneven access constrained local markets, home enterprises, skills, and digital participation.	Expands the economic base on which enterprise formation and service-quality reforms can operate.
Consumer Rights Rules (2020–24)	Time-bound connections—3/7/15 days in metropolitan/municipal/ rural areas—and standards for supply, metering, billing, and redressal.	Commissioning delays, repeated utility interfaces, billing disputes, and uncertain redress.	Supports faster energisation and more transparent, accountable, and convenient electricity service.
RDSS (2021)	Results-linked network strengthening, loss reduction, and feeder, DT, and consumer smart metering.	Outages, weak network visibility, inaccurate billing, and high distribution losses.	Reduces operating risk through better reliability, fault response, billing accuracy, and energy management.
Green Energy Open Access Rules (2022)	Lower 100-kW eligibility threshold and a single-window framework for eligible green procurement.	Limited procurement choice and difficulty accessing competitive and verifiable clean electricity.	Supports cost management, decarbonisation, export compliance, and ESG-sensitive investment.
Late Payment Surcharge Rules (2022)	Structured legacy-dues resolution and stronger payment discipline across the power value chain.	Generator and transmission cash-flow stress, counterparty risk, and constrained investment.	Supports capacity availability, supply continuity, and confidence in sector investment.

Note: The case study tests H1 through energy deficit and reported T&D loss; the remaining rows identify Ministry-documented reform mechanisms and enterprise channels. Sources:[4–10].

In the case study, market expansion is observed through four separate outcomes rather than an arbitrary composite index. Factory stock captures establishment presence; GFCF records additions to productive capacity; manufacturing value added measures production; and persons engaged capture employment in ASI-covered factories. Together they represent enterprise presence, investment, production, and employment while preserving the economic meaning and unit of each series.

4 EMPIRICAL CASE STUDY AND METHODOLOGY

4.1 Case-study Data and Measurement

The state-year skeleton contains 27 states and nine financial years from FY2015–16 through FY2023–24 (243 cells). The latest common vintage combines CEA electricity statistics, NSO/ASI industrial data, and RBI state statistics[17-19]. CEA's General Review 2025 supplies state T&D losses for FY2023–24, extending the RBI

loss series by one year. Union territories, boundary-changing Jammu and Kashmir, and Mizoram, for which early ASI outcomes are absent, are excluded. Gujarat's FY2023–24 manufacturing-GVA observation is unavailable in the official series, so that model uses 242 observations; it is not imputed.

Energy deficit is 100 times requirement minus availability, divided by requirement. Since published availability may be capped at requirement, a zero annual deficit does not by itself measure every interruption. CEA's reported T&D-loss measure includes energy lost in transformation, transmission, and distribution and energy unaccounted for. It is distinct from AT&C loss and from direct measures of outage duration, frequency, or voltage quality. These indicators were selected because they offer comparable state-year coverage and correspond directly to the adequacy-and-efficiency channel tested in H1.

Outcomes are real manufacturing GVA at constant 2011–12 prices, the ASI factory count, ASI persons engaged, and ASI GFCF at current prices. Three non-positive net GFCF flows are excluded only from the logarithmic investment model, leaving 240 observations, and are retained in a signed asinh robustness specification. Year effects absorb common price movements, so the GFCF coefficient remains a nominal association rather than a real investment-volume estimate. No observation is interpolated or winsorised. FY2024–25 and FY2025–26 sector statistics are used to describe the current policy context, but not in the regressions because a consistent common state panel is not yet available beyond FY2023–24.

4.2 Fixed-effects Design and Inference

For each outcome, the baseline model is

$$ln\ Y_{st} = \alpha + \beta_1 D_{st} + \beta_2 L_{st} + \gamma\ ln\ C_{s,t-1} + \mu_s + \lambda_t + \varepsilon_{st} \quad (1)$$

where Y is an industrial outcome, D is energy deficit, L is reported T&D loss, and C is scheduled commercial bank credit outstanding in the March preceding the financial year. Credit is a parsimonious financial-condition control. State fixed effects absorb persistent state differences, and year fixed effects absorb national shocks and reforms implemented broadly across states. The model therefore asks whether a state that improves electricity performance relative to its own history also records stronger industrial outcomes. It is a demanding relative-performance test: nationwide benefits that move all states together are absorbed by the year effects rather than estimated as a separate Ministry-level coefficient.

Reverse causality remains relevant because industrial expansion can induce electricity investment, while a larger high-voltage industrial load may also affect the reported loss ratio. One-year lags, state-specific trends, alternative adequacy measures, road-infrastructure controls, pandemic-year exclusions, and leave-one-state-out estimates test sensitivity. A difference-in-differences design is not imposed because comparable state treatment dates and defensible pre-trends are unavailable for this national reform sequence.

Cluster-robust (CR1) standard errors allow observations within each state to be correlated over time. With 27 state clusters, two-sided restricted wild-cluster bootstrap-t p-values use 9,999 Rademacher draws[20]. Holm adjustment covers the prespecified family of eight electricity coefficients[21]. Within-state variance-inflation factors are low (1.03–1.09 in the investment model), and leave-one-state-out estimates assess influential states. Statistical precision and economic magnitude are reported separately.

5 CASE-STUDY RESULTS AND BUSINESS INTERPRETATION

5.1 Power-sector Progress and the H1 Test

The official panel records substantial electricity-sector progress alongside industrial expansion. From FY2015–16 to FY2023–24, the unweighted mean energy deficit across the 27 states fell from 2.09% to 0.67%, while mean reported T&D loss declined from 25.59% to 18.85%. Across the 26 states with comparable GVA at both endpoints, real manufacturing GVA rose from ₹15.54 trillion to ₹23.26 trillion at 2011–12 prices. Factory stock increased from 224,208 to 252,384, persons engaged from 13.84 million to 19.09

Table 2. State and year fixed-effects estimates, FY2015–16 to FY2023–24

	Dependent variable: natural logarithm			
	Real GVA	**Factories**	**Employment**	**GFCF[a]**
Energy deficit	0.0163	−0.0039	0.0082	0.0218
Clustered SE	(0.0101)	(0.0030)	(0.0080)	(0.0177)
WCB p	0.0792	0.1525	0.3142	0.1994
Holm WCB p	0.5544	0.9150	0.9970	0.9970
Reported T&D loss	0.0031	−0.0026	0.0024	−0.0267
Clustered SE	(0.0040)	(0.0023)	(0.0036)	(0.0107)
WCB p	0.4540	0.2389	0.5565	0.0307
Holm WCB p	0.9970	0.9970	0.9970	0.2456
Lagged credit	Yes	Yes	Yes	Yes
State/year FE	Yes / Yes	Yes / Yes	Yes / Yes	Yes / Yes
Obs.	242	243	243	240
Within-R^2	0.074	0.123	0.048	0.037

Notes: Indicators enter jointly in percentage points. CR1 standard errors cluster by state (27 clusters). WCB: restricted wild-cluster bootstrap-t, 9,999 Rademacher draws. Holm adjustment covers eight WCB p-values. All outcomes are in logs. [a]Current-price GFCF; three non-positive observations are excluded from the log model. State and year fixed effects and lagged bank credit are included throughout. Source: author's calculations from[17–19].

million, and nominal GFCF from ₹3.73 trillion to ₹6.79 trillion. These parallel movements establish the scale and direction of change and motivate the within-state test of H1.

Table 2 reports the joint fixed-effects estimates. The clearest positive signal appears in the investment channel: lower reported T&D losses are associated with higher fixed investment in the baseline model. The coefficients for manufacturing GVA, factory stock, and employment are not estimated precisely over the short panel. A plausible economic interpretation is that network efficiency first affects the forward-looking decision to commit capital, while output, establishment, and employment responses emerge with longer and less uniform lags. The data do not establish that timing, but the investment result aligns with the mechanism set out in H1.

For positive GFCF observations, the reported T&D-loss coefficient is −0.02675 (clustered SE 0.01074; wild-bootstrap p = 0.0307). A one-percentage-point reduction in loss is therefore associated with 100[exp(0.026749)−1] = 2.71% higher nominal fixed investment in the baseline model; the CR1 95% interval is approximately 0.47% to 5.00%. The magnitude is economically meaningful and supports H1 at the investment margin. Fixed capital formation records a decision to expand productive capacity, so its positive relationship with lower losses is a revealed-behaviour indicator of a more enabling business environment. The Holm-adjusted p-value of 0.2456 shows that the precise magnitude cannot be assigned to electricity performance alone. Rather, the estimate captures electricity efficiency operating as a complementary backbone alongside credit, logistics, industrial policy, and demand.

5.2 Robustness and Reform Mechanisms

The investment relationship retains the expected direction when peak deficit replaces energy deficit (−0.02769; CR1 p = 0.016), when pandemic years are excluded (−0.03425; p = 0.001), and in every leave-one-state-out estimate (−0.03270 to −0.02095). This sign stability strengthens the interpretation that improved network efficiency accompanies a more favourable investment environment. Precision is lower with a one-year lag (−0.01718; p = 0.265), state-specific trends (−0.01453; p = 0.163), a road control on the available subset (−0.02249; p = 0.083), and a signed asinh specification retaining all GFCF values (p = 0.093). The evidence therefore supports a positive enabling role while recognising that the strength and timing of the investment response vary across specifications.

The aggregate design also captures only a narrow part of the reform benefit. Annual energy deficits are already low and contain limited within-state variation; reported T&D loss is not a direct measure of interruption duration or power quality; and investment responses may exceed the nine-year window. Most importantly, year fixed effects absorb nationwide improvements. The case study should therefore be read as evidence on relative state performance, while the common national gains from UDAY, RDSS, consumer rights, smart metering, payment discipline, and green open access remain part of the broader policy record.

The economic mechanisms are direct. Stronger networks and reliable supply reduce interruption and backup-generation costs; faster connections shorten project gestation; digital services reduce transaction and compliance effort; predictable charges improve planning; and green open access supports procurement choice and export decarbonisation. These gains are particularly valuable for MSMEs with limited backup capacity, electricity-intensive manufacturing, high-technology plants, data centres, and export-oriented firms.

6. POLICY IMPLICATIONS

India now has the core policy architecture required to move from Getting Electricity to Using Electricity for Business. UDAY created a framework for distribution discipline; Saubhagya broadened the access base; consumer-rights rules made service expectations explicit; RDSS integrates results-linked finance with network and metering modernisation; the Late Payment Surcharge Rules strengthen payment security; and green open access expands procurement choice. Firms experience these reforms together through better availability, reliability, efficiency, convenience, and flexibility. This cumulative architecture is the Ministry of Power's central contribution to electricity-related ease of doing business.

Implementation has continued beyond the regression period. The Ministry's 2025 review reported ₹38,187 crore released under RDSS by 31 December 2025. It also reported that provisional national AT&C losses and the ACS–ARR gap had declined from 21.91% and ₹0.69/kWh in FY2020–21 to 16.16% and ₹0.11/kWh in FY2024–25, respectively[11]. Alongside an energy shortage of 0.03% in FY2025–26 and average availability of 22.6 rural and 23.4 urban hours, these figures demonstrate the scale of operational and financial improvement delivered by the reform programme. They are current policy context and are not inputs to the FY2015–16–FY2023–24 regression.

The next step is an enterprise-centred electricity dashboard. It should combine actual connection time, cost, and procedures with SAIDI and SAIFI by consumer class, voltage quality, effective industrial electricity cost, tariff predictability, end-to-end digital completion, grievance resolution, and renewable-procurement access. Statutory timelines should be paired with realised delivery, and RDSS investments should be evaluated through reliability and business outcomes in addition to physical and financial milestones. Securely linking dated utility implementation, feeder performance, and anonymised enterprise records would allow the Ministry to quantify effects on commissioning, investment, production, employment, and exports.

The digital infrastructure created under RDSS also prepares the sector for AI-enabled operations. Smart-meter, feeder, and distribution-transformer data can

support load forecasting, predictive maintenance, fault localisation, loss analytics, automated service requests, and earlier detection of power-quality problems. With appropriate cybersecurity, interoperability, and human oversight, these applications can shorten restoration time and make energy costs more predictable. This capability can strengthen India's investment proposition for advanced manufacturing, data centres, and export-oriented firms that require dependable and verifiably clean electricity.

7. CONCLUSION

India's electricity-related ease-of-doing-business agenda has moved decisively from access towards dependable, efficient, affordable, and manageable service. Universal electrification expanded the market; generation and transmission additions reduced shortage; UDAY and RDSS strengthened distribution; consumer-rights rules made service accountable; payment reform improved sectoral discipline; smart metering created digital visibility; and green open access widened consumer choice. Together, these measures provide a credible policy and infrastructure platform for firms to connect, operate, invest, expand, and decarbonise.

The state-panel case study adds quantitative evidence to that policy record. From FY2015–16 to FY2023–24, adequacy and reported T&D losses improved alongside substantial growth in manufacturing production, factories, fixed investment, and employment. The baseline estimate associates a one-percentage-point reduction in reported T&D loss with 2.71% higher nominal GFCF among positive-investment observations. The result supports H1 at the investment margin and indicates that network efficiency can shape firms' willingness to commit capital. Electricity does not act in isolation; it enables the returns to credit, logistics, GST, industrial policy, FDI, and digitalization.

The evidence therefore supports a clear policy conclusion: the Ministry of Power's reforms have materially strengthened electricity as the backbone of ease of doing business in India. The next phase should convert system-level gains into verified consumer-class reliability, power-quality, cost, and digital-service outcomes, while using AI-enabled systems to anticipate faults and serve enterprises proactively. The next generation of electricity reform should be judged by the extent to which it enables firms to invest, produce, employ, compete, expand, and decarbonize. The author acknowledges the management of CPRI for its continuous support and encouragement.

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