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POWER ISSUES IN PAKISTAN AND POSSIBLE TRANSFORMATION TOWARDS RENEWABLE ENERGY

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Abstract

Pakistan electricity sector faces persistent reliability, affordability, operational-efficiency, and financial-management challenges, even as renewable-energy deployment accelerates. This study assessed the principal power-sector constraints and the managerial, investment, and policy conditions required for a sustainable energy transition. A descriptive secondary-data design combined documentary review with comparative analysis of published indicators from the Pakistan Economic Survey 2025–26 and the National Electric Power Regulatory Authority (NEPRA), supported by energy-policy and management literature. Reported installed electricity capacity increased from 45,782 MW in the July–March FY2025 comparison to 49,651 MW in July–March FY2026 (8.45%), while the officially defined non-hydropower renewable category rose to 10,101 MW, including 7,319 MW of registered net-metered solar. Although this category represented 20.3% of reported capacity, it accounted for 4.5% of centrally recorded generation during July–March FY2026; the different reporting coverage prevents interpreting these figures as comparable utilization rates. In FY2024–25, nine evaluated distribution companies recorded weighted-average transmission and distribution losses of 17.55% against an allowed 11.43%, with estimated excess-loss costs of PKR 265.01 billion. The findings indicate that renewable capacity growth alone cannot ensure low-cost, dependable electricity. A feasible transition requires simultaneous improvements in grid flexibility, utility accountability, revenue recovery, transparent investment appraisal, and stable rules for distributed energy. The study offers an integrated Business Administration interpretation of Pakistan energy-transition challenges while identifying priorities for further firm-level and causal research.

Keywords: Electricity-Sector Performance; Renewable Energy Transition; Energy Management; Distribution Losses; Pakistan.

1. Introduction

Reliable and affordable electricity is a foundational input to industrial production, agriculture, commercial services, communications, health systems, and household welfare. In Pakistan, power interruptions and financial stress in the electricity supply chain affect firms' operating costs, energy security, and investment decisions as well as broader economic development (Abdullah et al., 2020). Consequently, the national power problem cannot be understood solely as a question of the number of generating plants: it includes planning, contractual commitments, tariffs, governance, distribution performance, and consumers' ability to pay (Kessides, 2013; Shaikh et al., 2015; Mirjat et al., 2017; Ahmad & Jamil, 2024). The global transition toward solar photovoltaic (PV) power, wind generation, hydropower, energy storage, and efficiency technologies has created opportunities for electricity diversification. Nevertheless, falling technology costs do not by themselves guarantee affordable delivered power. Investments must be accompanied by grid connections, system balancing, credible procurement, financing mechanisms, coherent regulation, and

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commercially sustainable distribution companies (Geels, 2002; Solangi et al., 2019a; International Renewable Energy Agency [IRENA], 2026b). This article therefore examines the possible transformation of Pakistan electricity sector from a Business Administration perspective, integrating operational, organizational, financial, and policy evidence.

1.1 Pakistan electricity-sector challenges

The country has moved from periods of inadequate installed generation toward a more complicated configuration in which new capacity coexists with unaffordable electricity, contractual capacity obligations, and constrained delivery networks. The World Bank (2024) links the sectors financial vulnerability to weak coordination among generation investment, demand forecasts, transmission readiness, and commercial performance. Earlier research similarly documents policy discontinuities, institutional weaknesses, and problematic sector incentives (Kessides, 2013; Rafique & Rehman, 2017; Mirjat et al., 2017). These findings suggest that the economic value of new generation depends on whether electricity can be delivered and paid for efficiently. Power outages are especially relevant to business operations. Interruptions increase downtime, spoil inputs, require backup generation, and can reduce manufacturing productivity (Grainger & Zhang, 2019). Firms with stronger financing capacity can purchase generators, batteries, or rooftop solar systems, but smaller enterprises may face high up-front costs or restricted credit. Zhang (2019) identifies large economic costs associated with electricity-sector distortions across South Asia; Ahmad and Jamil (2024) further emphasize that outage mechanisms extend beyond generation scarcity. Thus, the distribution of reliability and electricity costs across firms should be considered part of the competitiveness question.

Circular debt reflects the accumulation of outstanding payments across generators, distributors, government entities, and other participants. Losses and weak collections, tariff and subsidy arrangements, and costly power-purchase obligations can produce persistent liquidity pressure (World Bank, 2024; International Monetary Fund [IMF], 2025, 2026). This can impede maintenance and transmission investment, increase financing costs, and weaken investor confidence. New renewable installations may lower the cost of some electricity supplies, but they do not automatically cancel existing capacity payments or resolve billing deficiencies. The sequencing of financial and technical reform is therefore central to transition planning.

1.2 Renewable resources, policy and business opportunities

Pakistan has substantial solar, wind, hydroelectric, and biomass resources. Country-focused assessments have documented renewable resource potential, opportunities for diversified power planning, and barriers to scaling technologies under local conditions (Asif, 2009; Farooq & Kumar, 2013; Ghafoor et al., 2016; Shakeel et al., 2016; Valasai et al., 2017). The availability of natural resources is only a starting point: site suitability, intermittent output, grid integration, land access, tariffs, and access to finance influence which technologies become commercially viable. Hydropower and solar should also not be treated as interchangeable because they present different seasonal and operational profiles (Ullah et al., 2019). The Alternative and Renewable Energy Policy 2019 established minimum targets of 20% of installed electricity-generation capacity from its specified alternative and renewable technologies by 2025 and 30% by 2030 (Ministry of Energy [Power Division], 2019). These are capacity targets, not measured shares of electricity actually produced, and they should not be confused with the separate hydropower category used in some national tables. Pakistan updated nationally determined contribution, and the broader Sustainable Development Goals provide a parallel environmental and development rationale for low-carbon energy investment (Government of Pakistan, 2021; United Nations, 2015; World Bank, 2022).

Recent studies show that financing and institutional design can facilitate or obstruct renewable energy adoption. Solangi et al. (2019a, 2019b, 2021) identify prioritization criteria and policy barriers for energy planning; Sher and Qiu (2022) examine the role of solar finance and subsidies; Aqeeq et al. (2023) assess utility-scale solar investment; and Saleh and Upham (2023) describe sociotechnical misalignments surrounding distributed PV in Pakistan. Public willingness to adopt or pay for renewable electricity may also respond to attitudes, perceived norms, and perceived behavioural control under the theory of planned behaviour (Ajzen, 1991; Ud Din et al., 2023, 2026), but consumer intentions cannot substitute for evidence about project finance, grid economics, and executed investments. Managerial opportunities extend beyond constructing power plants. Renewable investment may support domestic installation and maintenance

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businesses, energy auditing, performance contracting, equipment supply, financing products, and data-driven operations. Yet investment evaluation must consider risk-adjusted capital costs, equipment lifetime, load profiles, exchange-rate exposure, regulation, and how utilities recover network costs when customers self-generate (Tiep et al., 2021; Aqeeq et al., 2023; IRENA, 2026a, 2026b). Comprehensive appraisal is especially important in a system facing substantial inherited fixed costs.

1.3 Theoretical framework and research gap

Three complementary approaches frame the analysis. The resource-based view holds that firm performance may depend on valuable capabilities rather than technology ownership alone (Barney, 1991). The natural-resource-based view extends this logic to pollution prevention and environmental capabilities (Hart, 1995). For Pakistani enterprises, energy auditing expertise, access to finance, and effective maintenance may be as consequential as owning PV equipment. Porter and van der Linde (1995) additionally argue that carefully designed environmental strategies can, in some circumstances, support innovation and resource productivity; such benefits must be evaluated empirically rather than assumed. The multi-level perspective on sociotechnical transitions emphasizes interaction between emerging technologies, incumbent organizations and infrastructures, and wider economic pressures (Geels, 2002). It helps explain why rapidly growing distributed solar can coexist with slowly changing tariff structures, contractual obligations, and distribution networks. The institutional account is compatible with analyses of Pakistan's policy evolution and governance constraints (Saleh & Upham, 2023; Shahzad & Aruga, 2025).

Existing research addresses renewable resource potential, energy planning, outages, finance, and adoption, but these strands are frequently assessed with different metrics or at different organizational levels. This study contributes an integrated descriptive comparison of recent national capacity and generation statistics with distribution-company performance and investment-relevant policy evidence. It explicitly differentiates registered capacity from centrally recorded generation and separates regulator-assessed financial losses from broader circular debt. The resulting contribution is diagnostic and managerial rather than a causal estimate of the effects of a specific energy policy. Accordingly, the study addressed two research questions: (RQ1) what economic, financial, managerial, and infrastructure-related constraints most strongly characterize Pakistan electricity sector in the available secondary evidence? (RQ2) Under what complementary investment, regulatory, and operational conditions could renewable-energy expansion support a more reliable, affordable, and sustainable electricity system?

2. Materials and methods

I adopted a descriptive secondary-data design, combining quantitative comparisons of published electricity-sector indicators with thematic examination of policy documents, regulatory assessments, and peer-reviewed studies. Pakistan national electricity system was the primary unit of analysis, with the nine ex-WAPDA distribution companies evaluated by NEPRA used for an operational comparison. The main statistical sources were the Pakistan Economic Survey 2025–26 (Finance Division, 2026; especially Tables 14.1–14.3) and NEPRA Performance Evaluation Report of Distribution Companies for FY2024–25 (NEPRA, 2026a; especially Tables 1–3 and 15). Supporting materials included policy statements, NEPRA State of Industry Report (NEPRA, 2026b), and publications of the World Bank, IMF, and IRENA. No surveys, interviews, or experiments were conducted.

I extracted the following indicators: generating capacity (MW), electricity generation and sector consumption (GWh), technology shares (%), registered net-metered solar capacity (MW), utility transmission and distribution (T&D) losses, allowed loss benchmarks, regulatory estimates of excess-loss costs, and bill-collection recovery. I organized the indicators by unit, source, definition, and reporting interval. For two comparable observations, I calculated percentage change as 100 × (new value − previous value) / previous value; for proportions, percentage-point differences were used. Government series for July–March FY2025 and July–March FY2026 were compared with each other, while NEPRA FY2024–25 data were analyzed separately to avoid treating distinct reporting periods as one synchronized sample. Source-category totals and explanatory footnotes were checked for consistency before interpretation.

I compared published explanations of energy reliability, financial stress, renewable-energy investment, and institutional reform with the observed statistical patterns. Hydropower was retained as a

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separate technology category where the official tables presented it separately; net-metered solar was not double-counted in total renewable capacity. Generation shares were not interpreted as technology-specific capacity factors because behind-the-meter solar consumption is not fully covered by central generation reporting. I used publicly accessible aggregate data without identifying individuals. As a descriptive assessment, it cannot estimate causal effects, identify profitability for particular firms, or substitute for project-level engineering and financial studies.

3. Results

3.1 Growth and changing composition of installed capacity

The reported installed electricity capacity increased from 45,782 MW at the July–March FY2025 reporting point to 49,651 MW in the corresponding FY2026 period, an increase of 3,869 MW (8.45%). The increase was driven predominantly by the official non-hydropower renewable category, which rose by 4,421 MW (77.8%). Hydropower capacity increased by 980 MW (9.2%), thermal capacity declined by 1,532 MW (5.9%), and nuclear capacity remained at 3,530 MW. The renewable share reached 20.3% of reported capacity, compared with 12.4% at the earlier reporting point (Finance Division, 2026).

Table 1

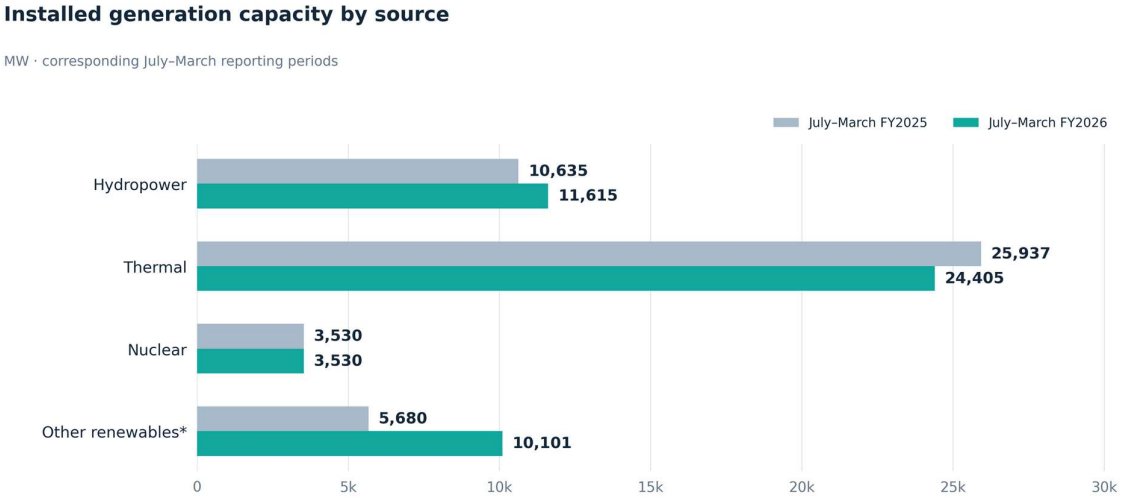
Installed electricity-generation capacity, matched July–March reporting periods

Source	FY2025 (MW)	FY2026 (MW)	Change (MW)	FY2026 share
Hydropower	10,635	11,615	+980	23.4%
Thermal	25,937	24,405	−1,532	49.2%
Nuclear	3,530	3,530	0	7.1%
Other renewables*	5,680	10,101	+4,421	20.3%
Total	**45,782**	**49,651**	**+3,869**	**100.0%**

Note. Source: Finance Division (2026), Table 14.1. FY2026 figures are provisional.

Figure 1

Installed electricity-generation capacity by technology, July–March FY2025 and FY2026.



3.2 Installed capacity and reported electricity generation

Recorded electricity generation increased from 89,809 GWh during July–March FY2025 to 92,835 GWh during July–March FY2026, a 3.37% rise. Thermal generation contributed 43,581 GWh (46.9%) in the latter period, followed by hydropower at 27,961 GWh (30.1%), nuclear at 17,133 GWh (18.5%), and other renewables at 4,160 GWh (4.5%). The 20.3% reported renewable capacity share therefore differs markedly from the 4.5% share of recorded generation. Because the capacity measure includes registered net-metered solar that may be consumed on site and the central generation series uses a different accounting boundary, these shares cannot be compared as if they constituted a measure of actual capacity utilization (Finance Division, 2026).

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Table 2

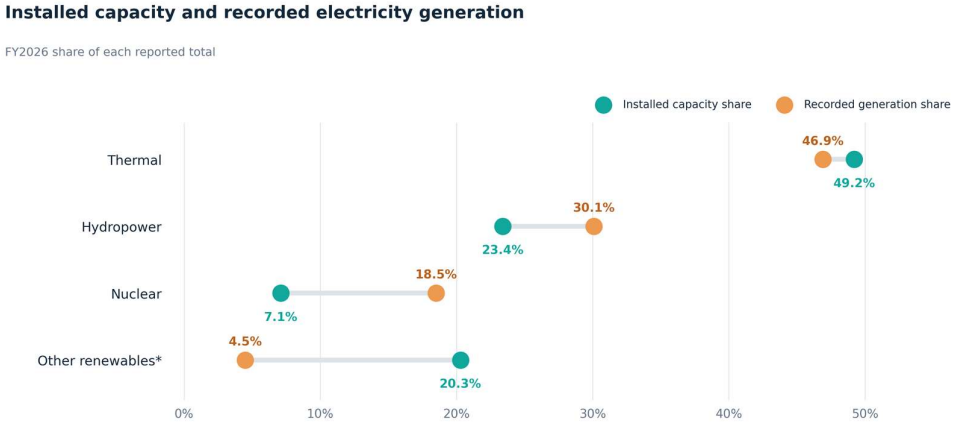
Recorded electricity generation and capacity composition, July–March FY2026

Source	Generation (GWh)	Generation share	Capacity share
Thermal	43,581	46.9%	49.2%
Hydropower	27,961	30.1%	23.4%
Nuclear	17,133	18.5%	7.1%
Other renewables*	4,160	4.5%	20.3%
Total	**92,835**	**100.0%**	**100.0%**

Note. Source: Finance Division (2026), Tables 14.1–14.2. Capacity and output shares refer to different measures; some behind-the-meter solar generation is not captured by the central generation table.

Figure 2

Reported installed-capacity shares and electricity-generation shares, FY2026.

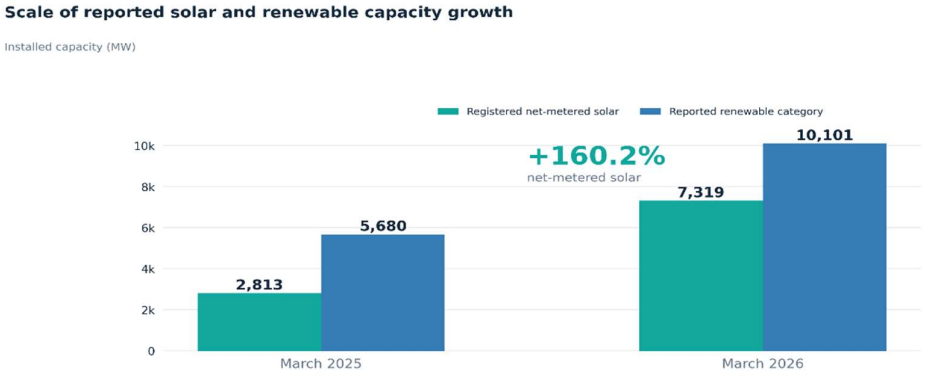


3.3 Expansion of registered distributed solar

Registered net-metered solar capacity increased from 2,813 MW in July–March FY2025 to 7,319 MW in July–March FY2026. The 4,506 MW increment corresponds to growth of 160.2%, making distributed solar a principal contributor to the increase in reported non-hydropower renewable capacity. By the second reporting point, net-metered solar accounted for approximately 72.5% of the 10,101 MW included in that category. This solar total is already included within national installed capacity and must not be added a second time (Finance Division, 2026).

Figure 3

Growth in registered net-metered solar and other renewable capacity.



3.4 Changes in electricity consumption by sector

Official Table 14.3 reports electricity consumption of 83,143 GWh during July–March FY2026 compared with 80,111 GWh in the corresponding prior-year table, an increase of approximately 3.8%.

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Industrial grid consumption rose from 21,083 GWh to 26,205 GWh (+24.3%), while commercial use increased by 2.2%. Household consumption declined by 0.6%, and agriculture declined by 42.3%. The FY2025 narrative in the source reports 80,811 GWh, whereas the table reports 80,111 GWh and the sector entries reconcile to the latter. The FY2026 sector entries also sum to 83,142 GWh, one GWh below the reported total of 83,143 GWh. This analysis follows the original tabulated total and flags the discrepancy (Finance Division, 2026).

Table 3

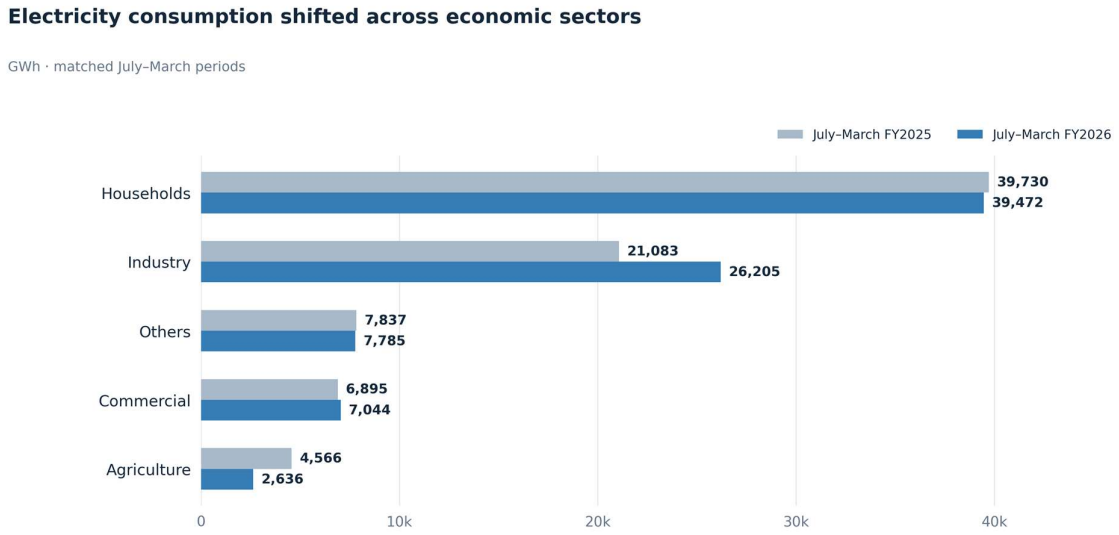
Electricity consumption by sector, matched July–March periods

Consumer sector	FY2025 (GWh)	FY2026 (GWh)	Change (%)
Households	39,730	39,472	−0.6
Industry	21,083	26,205	+24.3
Commercial	6,895	7,044	+2.2
Agriculture	4,566	2,636	−42.3
Others	7,837	7,785	−0.7
Total	**80,111**	**83,143**	**+3.8**

Note. Source: Finance Division (2026), Table 14.3. Percentage changes were calculated from tabulated values. The report prose prints a different FY2025 total; the table states 80,111 GWh. FY2026 sector entries sum to 83,142 GWh, one GWh below the reported total of 83,143 GWh; the published total is retained.

Figure 4

Electricity consumption by sector in comparable nine-month periods.



3.5 Distribution losses and cross-company differences

For FY2024–25, NEPRA reported weighted-average T&D losses of 17.55% across the nine evaluated ex-WAPDA distribution companies against a weighted tariff allowance of 11.43%, a gap of 6.12 percentage points. No evaluated company met its allowed loss benchmark. Losses ranged from 8.61% at IESCO to 39.18% at SEPCO. In percentage-point terms, QESCO exceeded its allowance by 24.57 points, SEPCO by 22.87 points, and PESCO by 17.89 points, while FESCO had an excess of 0.64 point (NEPRA, 2026a).

Table 4

Distribution-company T&D losses, allowance gaps and excess-loss costs, FY2024–25

Utility	Actual loss (%)	Allowed (%)	Excess (pp)	Loss cost (PKR bn)
PESCO	37.15	19.26	17.89	87.48
IESCO	8.61	7.31	1.30	4.78
GEPCO	10.60	8.90	1.70	5.50
FESCO	9.02	8.38	0.64	2.97

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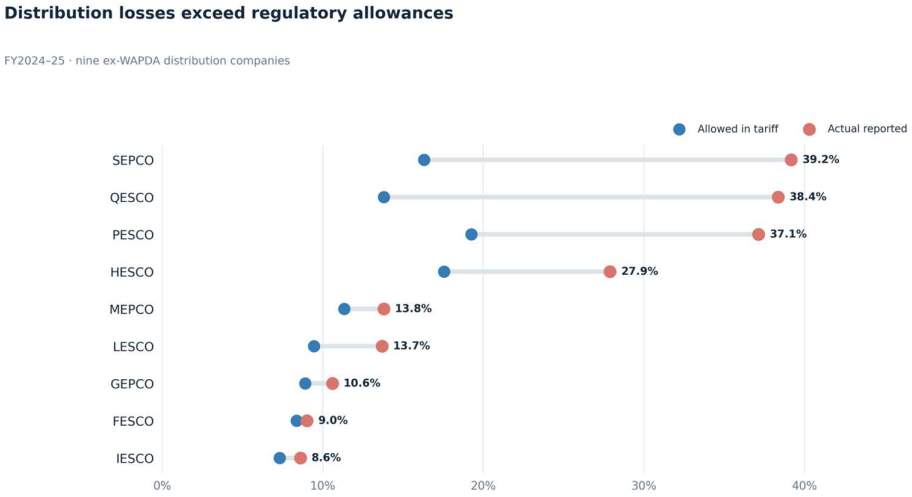
LESCO	13.70	9.46	4.24	35.17
MEPCO	13.81	11.34	2.47	14.01
QESCO	38.38	13.81	24.57	52.41
SEPCO	39.18	16.31	22.87	36.04
HESCO	27.89	17.55	10.34	27.14
Weighted / total	**17.55**	**11.43**	**6.12**	**265.01**

Note. Source: NEPRA (2026a), Tables 1–2. "pp" means percentage points; the weighted totals are as reported by NEPRA. K-Electric and TESCO are outside this nine-company comparison.

Figure 5

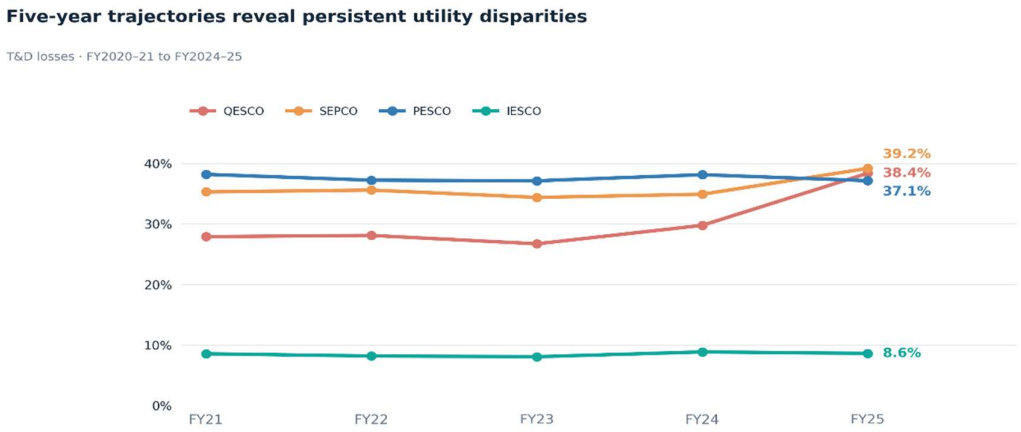
Actual versus allowed T&D Losses Across Nine Distribution Companies.



The five-year regulatory series showed that high losses persisted in several operating areas. PESCO's rate changed from 38.20% in FY2020–21 to 37.15% in FY2024–25; SEPCO's increased from 35.30% to 39.18%; QESCO's rose from 27.90% to 38.38%; and IESCO remained below 9% at both endpoints. These descriptive comparisons show variation in utility trajectories without identifying the causes of those differences (NEPRA, 2026a).

Figure 6

Selected Distribution-Company Loss Trajectories Across Five Fiscal Years.



3.6 Financial exposure and revenue collection

NEPRA attributed an estimated PKR 265.01 billion in financial burden to energy losses exceeding the tariff allowances of the evaluated companies in FY2024–25. The largest stated contributions were PESCO (PKR 87.48 billion), QESCO (PKR 52.41 billion), SEPCO (PKR 36.04 billion), and LESCO (PKR 35.17

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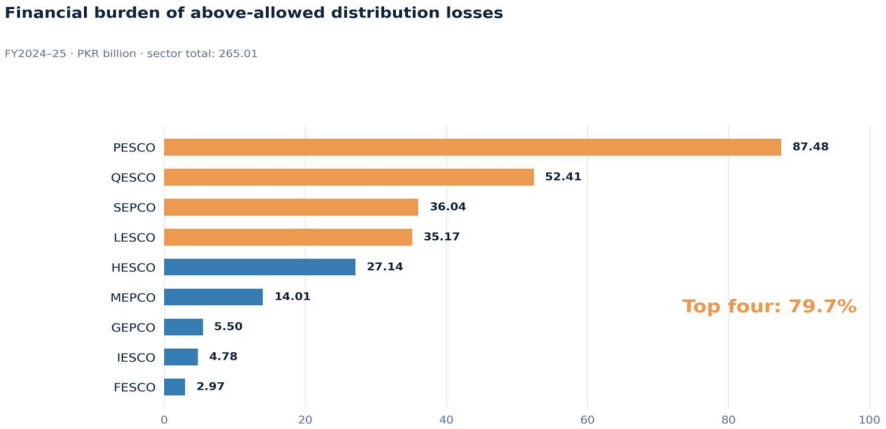
billion). These are regulatory estimates associated with above-allowed losses; they are not equivalent to the total stock of circular debt (NEPRA, 2026a).

Figure 7

Estimated utility financial burden associated with above-allowed electricity losses.



Reported weighted-average recovery of billed electricity charges was 96.6% in FY2024–25. Collection rates were above 100% at several utilities, which may reflect collection of earlier arrears. Recovery was 91.5% for PESCO, 74.8% for HESCO, 74.2% for SEPCO, and 38.7% for QESCO. NEPRA estimated an associated recovery shortfall exceeding PKR 132 billion across the evaluated ex-WAPDA companies. The loss-cost estimate and recovery shortfall refer to different accounting mechanisms and were therefore not added together as a measure of circular debt (NEPRA, 2026a).

Table 5

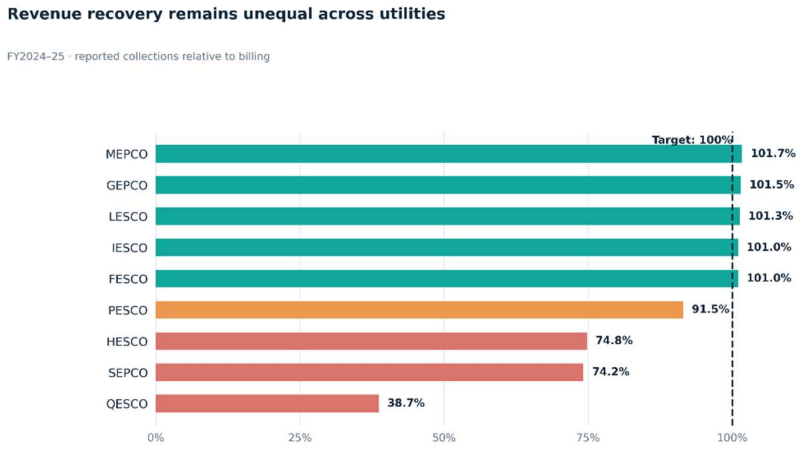
Reported electricity-bill collection recovery, FY2024–25

Utility	Collection recovery	Utility	Collection recovery
MEPCO	101.7%	PESCO	91.5%
GEPCO	101.5%	HESCO	74.8%
LESCO	101.3%	SEPCO	74.2%
IESCO	101.0%	QESCO	38.7%
FESCO	**101.0%**	**Weighted average**	**96.6%**

Note. Source: NEPRA (2026a), Table 3. Reported recovery above 100% may include collection of prior-period arrears.

Figure 8

Bill-Collection Recovery Across Nine Distribution Companies.



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4. Discussion

4.1 Why electricity problems persist despite higher installed capacity

The central finding is a persistent gap between expanding registered generation resources and the organizational conditions required to deliver reliable, financially sustainable electricity. Installed capacity rose by 8.45% and reported solar capacity grew rapidly, but the same reporting periods shows above-allowed distribution losses and substantial under-collection of billed revenue. These are not contradictory outcomes: new generation can expand the nominal resource base without removing transmission bottlenecks, poor metering, technical losses, theft, capacity-payment obligations, or inadequate revenue recovery. The evidence supports the institutional diagnosis developed by Kessides (2013), Mirjat et al. (2017), and the World Bank (2024), now viewed through more recent reported performance indicators. The distinction between installed capacity and recorded generation has additional implications for policy evaluation. The FY2026 renewable-capacity category included substantial distributed solar, whereas the centrally recorded generation account does not consistently include behind-the-meter electricity consumed by users. The observed gap between 20.3% capacity and 4.5% recorded output must therefore not be interpreted as proof of idle renewable infrastructure. Policymakers and investors need comparable measures of grid injections, self-consumption, system peak contribution, generation availability, and financial impacts. Without these, renewable growth can be simultaneously overstated and understated, depending on the selected denominator (Finance Division, 2026; IRENA, 2026a).

4.2 Operational efficiency, business costs and utility management

The utility comparison identifies a particularly important management issue: sector-wide averages conceal very large differences in operating outcomes. FESCO operated only 0.64 percentage point above its allowed losses, whereas QESCO and SEPCO exceeded their allowances by more than 22 points. Such variation suggests value in utility-specific diagnostics, including feeder-level metering, transformer maintenance, billing controls, collection strategy, and incentive-compatible performance management. The available aggregate figures do not identify how much of any loss is technically unavoidable or related to theft and commercial processes; detailed local investigation is needed before specifying a remedy (NEPRA, 2026a; Tiep et al., 2021). These weaknesses have business implications. Revenue loss raises financing pressure on electricity suppliers and can increase the cost of maintaining infrastructure. For firms, unreliable service can create expenses for backup generation, idle capital, and production delays, while high tariffs affect competitiveness (Grainger & Zhang, 2019; Zhang, 2019). The increase in recorded industrial electricity use in the comparison period is consistent with greater grid consumption but cannot be interpreted as causal evidence that industrial output improved. A firm-level analysis linking electricity quality, investment in self-generation, production, and profitability remains necessary.

4.3 Renewable-energy transformation as an investment and governance challenge

The 160.2% increase in registered net-metered solar points to an expanding decentralized energy market. For businesses, rooftop solar may be financially attractive when electricity demand aligns with daylight generation, equipment and maintenance quality are adequate, financing is affordable, and tariff rules remain predictable. For utilities, rapid customer self-generation complicates demand forecasting and recovery of fixed network costs. The balance between private adoption incentives and system-wide revenue sustainability must therefore be designed explicitly, rather than assumed to emerge from market growth alone (Sher & Qiu, 2022; Saleh & Upham, 2023; Aqeeq et al., 2023). A practical transition also requires investment in network flexibility, digital management, storage where economically justified, competitive procurement, and transparent treatment of legacy contractual costs. Country-specific planning studies caution that renewable technologies differ substantially in dispatchability, seasonal output, financing needs, and land or transmission requirements (Farooq & Kumar, 2013; Shakeel et al., 2016; Solangi et al., 2019b; Ullah et al., 2019). Renewable expansion can contribute to energy security and diversification, but affordability cannot be established simply by citing global average renewable-generation costs without accounting for Pakistani financing, storage, integration, and network costs (IRENA, 2026b).

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4.4 Priorities for managers, investors and policymakers

The findings support an integrated reform package. Distribution companies should prioritize measured loss reduction, strengthened collections, and service-quality reporting; investors should evaluate lifecycle costs and regulatory exposure; and public authorities should link renewable procurement to network capacity and commercial viability. Table 6 converts the observed results into practical areas for decision-making while distinguishing management implications from effects that still need empirical testing.

Table 6

Evidence-Based Priorities for a Financially Sustainable Energy Transition

Observed result	Managerial or policy implication	What still requires testing
Renewable capacity +77.8%	Plan connections and grid flexibility together	Local hosting capacity and storage costs
Net-metered solar +160.2%	Develop stable solar investment and billing rules	Firm payback and distributional impact
T&D loss excess: 6.12 pp	Prioritize utility loss reduction and network audits	Feeder-specific technical and commercial losses
Excess-loss cost: PKR 265 bn	Target the highest-cost utility interventions first	Project-level savings and implementation cost
Recovery: 96.6% overall	Improve collections and receivables management	Customer-level default mechanisms
Industry use: +24.3%	**Assess reliability as a productivity-related input**	**Causal link to industrial output**

Note. Drawn from the descriptive evidence in Finance Division (2026) and NEPRA (2026a). Recommended actions are interpretations, not experimentally estimated benefits.

From the resource-based and natural-resource-based perspectives, the commercial value of energy-efficiency and renewable-electricity strategies depends on the organizational capabilities needed to execute them: finance, technical staff, reliable maintenance, and data-driven management (Barney, 1991; Hart, 1995). The multi-level transition framework further explains why technologies may change more quickly than infrastructure and institutions (Geels, 2002). This study does not statistically test these theories; rather, they organize the managerial meaning of the official data. The environmental competitiveness proposition of Porter and van der Linde (1995) remains plausible for some investments but must be evaluated against real implementation costs and measured business outcomes.

4.5 Strengths, limitations and measurement considerations

A strength of the study is its reliance on published primary regulatory and government statistics and its explicit treatment of measurement boundaries. The capacity and consumption figures use matched July–March reporting windows, while the distribution-company indicators are from FY2024–25. Hydropower is retained in the government separate category, registered net-metered solar is not counted twice, and the difference between installed capacity and centrally measured output is not treated as a utilization estimate. The FY2025 consumption total stated in the source narrative conflicts with its table, and FY2026 sector entries show a one-GWh difference from the published total; I retained the published tabulated totals and disclosed both inconsistencies. The analysis nevertheless has important limitations. NEPRA's nine-company comparison is not a complete measure of every electricity distribution arrangement in Pakistan; K-Electric and TESCO are not included on the same basis. The available sources provide national or utility-level aggregates rather than plant-, feeder-, household-, or firm-level observations. As a result, the study does not estimate causal effects of renewable adoption on outages, quantify actual corporate returns, evaluate distributional effects, or isolate the separate impacts of theft, technical losses, tariffs, and governance. Reported figures are also vulnerable to later revisions and changing accounting rules. The conclusions should therefore be interpreted as an evidence-based diagnosis and agenda for more targeted research, not as a forecast of guaranteed renewable-energy outcomes.

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5. Recommendations for future research

1. Future studies should examine business adoption of solar PV, storage, and energy-efficiency investments at the firm level. A stratified survey and matched financial records from small, medium, and large enterprises could measure system costs, financing terms, payback periods, production interruptions, and changes in electricity expenditure. Where feasible, panel data and credible comparison groups would help distinguish the effects of self-generation from pre-existing differences in firm size, profitability, and management capacity. Such work could test the resource-based mechanisms discussed in this paper rather than assuming that technology ownership alone produces competitive advantage.
2. Researchers should construct more complete renewable-energy accounting datasets. Hourly information on utility-scale generation, net-metered exports, self-consumed rooftop solar, feeder demand, weather patterns, and curtailment would permit defensible estimates of renewable contribution during peak hours and of potential storage requirements. A consistent measurement framework would also help interpret changes in reported capacity and generation after revisions to net-metering or prosumer rules. This would correct a principal limitation of relying on capacity shares and conventional grid generation figures.
3. Rigorous evaluation of distribution-company reforms is needed. Feeder-level studies could compare advanced metering, anti-theft interventions, preventive maintenance, collection changes, and performance-based management across matched service areas. Interrupted time-series or difference-in-differences designs, applied only where their assumptions are defensible, could estimate impacts on technical losses, collections, outage duration, customer satisfaction, and operating cost. Cost-effectiveness analysis should accompany such evaluations because improvements that are technically successful may not be financially scalable.
4. Techno-economic and financial modelling should test renewable investment under Pakistan-specific conditions, including the cost of capital, currency movements, capacity-payment obligations, evolving tariffs, battery degradation, system integration, and transmission constraints. Scenario analysis could compare centralized solar and wind generation with behind-the-meter PV, energy storage, and demand-side management. Findings should report uncertainty ranges and effects on utility revenue as well as private investor returns, avoiding a single “best” technology recommendation that ignores differences among locations and users.
5. Subsequent research should investigate equity and political economy. Rural households, low-income consumers, agricultural users, and small firms may face different barriers to adopting renewable technologies. Mixed-methods work should evaluate who can access affordable finance, who benefits from subsidy and tariff structures, and who bears residual grid costs as self-generation expands. Combining these perspectives with environmental indicators, employment outcomes, and regional comparisons would provide a fuller assessment of a socially inclusive renewable-energy transition.

6. Conclusion

This study examined Pakistan electricity-sector constraints and the potential for renewable-energy transformation using official secondary data and an integrated management-oriented literature review. The results show that reported installed capacity expanded to 49,651 MW in March 2026, with non-hydropower renewable capacity reaching 10,101 MW, including 7,319 MW of registered net-metered solar. Yet rapid capacity growth was accompanied by persistent operational and financial challenges. In FY2024–25, the nine evaluated distribution companies recorded weighted-average T&D losses of 17.55% against an allowed 11.43%, generating a reported excess-loss burden of PKR 265.01 billion. Revenue recovery was uneven, indicating that capacity expansion and commercial sustainability are distinct objectives (Finance Division, 2026; NEPRA, 2026a). The first research question was answered by identifying an interdependent set of constraints—network inefficiencies, revenue shortfalls, tariff and contractual pressures, uneven management performance, and limited comparability of some energy statistics. The second was answered conditionally: renewable energy could strengthen diversification and offer valuable business opportunities, but its contribution to reliable and affordable supply depends on grid readiness, investment appraisal, stable and

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equitable market rules, and performance-oriented utility reform. Neither the recorded capacity expansion nor global estimates of renewable costs alone establish an immediate reduction in electricity bills in Pakistan or outages. The principal implication for Business Administration is that energy transition must be managed as an organizational and financial transformation alongside technological change. Decisionmakers should prioritize loss reduction and collections, evaluate energy investments using local lifecycle costs and operational needs, and coordinate renewable procurement with infrastructure and regulatory capacity. Future firm-level, feeder-level, and causal research can establish which reforms yield the greatest measurable benefits. On the evidence currently available, Pakistan's pathway toward sustainable electricity depends on aligning renewable growth with governance, operational performance, investment discipline, and social inclusion.

Declarations

Author contributions

Adeel Shahzad: Conceptualization; methodology; investigation; secondary-data collection and curation; formal analysis; interpretation; visualization; writing-original draft; writing-review and editing. The author takes responsibility for the manuscript and approves the submitted version.

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Ethics approval and consent to participate

Not applicable. This study analysed publicly available, aggregated secondary data and published documents; no human participants, identifiable personal data, or animal subjects were involved.

Consent for publication

Not applicable. No identifiable individual-level information is presented.

Conflict of interest

The author declares no known financial or non-financial competing interests relevant to this work.

Data availability

All numerical indicators analysed in this article were obtained from publicly available Pakistan Economic Survey and NEPRA publications cited in the reference list. The study did not collect new participant-level data.

Declaration of AI-assisted preparation

AI-assisted tools were used during manuscript drafting, language editing, and preparation of data visualizations. The author remains responsible for verifying the source data, calculations, citations, interpretations, and final manuscript content.

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