

Strategic Framework

Enhancing Electricity Demand & Reducing Costs

November 2026

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The Pakistan Business Council

FOSTERING ECONOMIC GROWTH

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List of Acronyms

AC	Alternating Current
AD	Aggregate Demand
AI	Artificial Intelligence
APC	Average Power Cost
BESS	Battery Energy Storage System
BoP	Balance of Payments
CAD	Current Account Deficit
CAPEX	Capital Expenditure
CD	Circular Debt
CO_2	Carbon Dioxide
CPP	Capacity Payments
CPEC	China–Pakistan Economic Corridor
DC	Direct Current
DISCO	Distribution Company
DSM	Demand Side Management
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
ECNEC	Executive Committee of the National Economic Council
ER	Exchange Rate
EV	Electric Vehicle
FDI	Foreign Direct Investment
FO	Furnace Oil
FY	Fiscal Year
GDP	Gross Domestic Product
GENCO	Generation Company
GHG	Greenhouse Gas
GWh	Gigawatt-hour
HV	High Voltage
IMF	International Monetary Fund
IPP	Independent Power Producer
IRR	Internal Rate of Return
IT	Information Technology
KE	Karachi Electric
kV	Kilovolt
kWh	Kilowatt-hour
LCOE	Levelized Cost of Electricity
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LT	Low Tension
MoE	Ministry of Energy
MoF	Ministry of Finance
MW	Megawatt
MWh	Megawatt-hour
NEPRA	National Electric Power Regulatory Authority
NTDC	National Transmission and Dispatch Company
O&M	Operations and Maintenance
OGRA	Oil and Gas Regulatory Authority
PKR	Pakistani Rupee
PLF	Plant Load Factor
PPA	Power Purchase Agreement
PPP	Public–Private Partnership
RE	Renewable Energy
RLNG	Regasified Liquefied Natural Gas
SBP	State Bank of Pakistan
SCADA	Supervisory Control and Data Acquisition
SEZ	Special Economic Zone
SOE	State-Owned Enterprise
T&D	Transmission and Distribution
TCO	Total Cost of Ownership
TOU	Time-of-Use
USD	United States Dollar
VC	Variable Cost
VRE	Variable Renewable Energy
WACC	Weighted Average Cost of Capital
WB	World Bank

Executive Summary



Executive Summary

Pakistan's electricity sector has evolved into a structural constraint on growth, fiscal stability, and external balance. The system operates approximately 49,651 MW of installed capacity against annual consumption of only ≈120–130 TWh, resulting in chronic underutilization. Fixed capacity payment obligations exceed PKR 1.8 trillion a year and must be recovered regardless of how much electricity is actually consumed. This has pushed the average Power Purchase Price to ≈PKR 23.37/kWh derived from an Energy Purchase Price of PKR 1,149 billion and a Capacity Purchase Price of PKR 1,807 billion for roughly 126.5 TWh procured with end-consumer tariffs (basket price ≈PKR 34.01/kWh) running considerably higher once distribution margins, transmission charges, taxes, and surcharges are added. The result is a power sector that burdens the economy rather than enabling it.

The sector is caught in a utility death spiral that simultaneously erodes demand and inflates cost. High tariffs are driving industrial and commercial consumers off the grid toward captive generation, solarization, and diesel alternatives. Every consumer who exits reduces the volume over which fixed capacity costs are spread, pushing per-unit tariffs higher still and accelerating further defection a self-reinforcing cycle now deeply embedded in the system.

The core constraint is insufficient productive demand, not insufficient supply. Because the system carries surplus capacity, its economics are governed by a denominator effect: growing electricity demand, particularly from productive sectors, spreads fixed capacity payments over a larger base and lowers the average cost per unit. This reframes the policy priority from adding supply to expanding demand as the primary lever for restoring affordability.

Electrification as the Primary Growth Lever

The report identifies electrification across five domains transport, industry and commerce, households, agriculture and cold chain, and digital infrastructure as the most immediate, structurally sound pathway to expand grid demand while displacing imported fuels. Aggregated across sectors, the additive technical potential exceeds **140 TWh of new demand**, more than doubling current consumption. Under a full-realization case, average system cost falls to approximately **PKR 14–16/kWh**, a reduction of over 30 percent driven by improved utilization of existing capacity.

Summary of Proposed Interventions

The report sets out a coordinated, three-phase intervention programme, sequenced so that low-cost regulatory measures create the institutional conditions for larger capital-intensive electrification, which in turn is reinforced by structural and financial reform of the cost base itself.

Phase 1 — No-Cost and Low-Cost Interventions (Immediate)

Eight regulatory and governance measures requiring no new generation or transmission investment can be initiated immediately through notifications and directives:

- DISCO connection process reform and transformer-upgrade streamlining to clear the 1,021 MW+ connection backlog
- EV and charging-infrastructure policy facilitation
- Net metering optimization to better align solar-plus-electric load
- DISCO governance and AT&C loss-reduction enforcement
- Appliance MEPS standards and consumer awareness campaigns
- Time-of-use pricing to unlock off-peak and shoulder demand
- Structured grid integration of industrial captive BESS and solar
- Public infrastructure and street-lighting electrification

Combined, conservative implementation of these eight measures is projected to add approximately **8,500–9,300 GWh** of annual demand (≈7.4% of FY25 grid purchase volume), cutting the average bulk purchase cost from PKR 23.37 to approximately **PKR 22.4–22.5/kWh** and delivering **PKR 99–108 billion** in annual consumer savings without public capital investment.

Phase 2 — Sectoral Electrification (Medium Term)

Capital-intensive electrification across five demand-side sectors is enabled once Phase 1 institutional barriers are removed:

- **Transport** — 5,000 electric buses in Punjab, EV adoption under the NEV Policy, and Pakistan Railways ML-1 electrification
- **Industry & commerce** — gas-to-grid conversion of thermal loads, the largest single structural demand opportunity
- **Households** — substitution of gas and LPG appliances with electric equivalents
- **Agriculture & cold chain** — solarization of diesel tubewells and cold-storage expansion
- **Digital infrastructure** — data-center development and telecom tower de-dieselization

Aggregated additively, technical potential across these sectors exceeds **140 TWh**, but accounting for phased adoption, overlapping demand, and infrastructure constraints, the **realistic medium-term expansion is 50–70 TWh** (≈40–50% of technical potential), sufficient to cut industrial tariffs by **15–27 percent**.

Phase 3 — Financial and Structural Reform (Enabling)

Reducing the fixed cost base itself, in parallel with demand growth:

- **Capacity payment restructuring** — reclassifying CPEC coal payments as sovereign debt and shifting low-utilization plants to performance-based payments; estimated **PKR 3–5/kWh** reduction
- **Subsidy redirection** — reallocating up to **PKR 600 billion** toward capacity payment relief
- **Cross-subsidy elimination and tariff rationalization** — estimated **PKR 96–181 billion** annual savings for industry and commerce
- **NEPRA regulatory reform** toward output-based regulation and faster tariff adjustments
- **DISCO privatization and franchising** of high-loss zones, with microgrid substitution to eliminate energy theft
- **Circular debt governance** through ring-fenced DISCO revenues, automated settlement, and multi-year tariff frameworks
- **Concessional and climate finance** (Green Climate Fund, ADB concessional financing, IFC guarantees) to lower the capital cost of grid modernization, BESS, and microgrids

Key Results

The integrated scenario model translates these interventions into four system-level outcomes, benchmarked against the FY25 baseline of 126 TWh demand and PKR 23.37/kWh average cost (Table 1):

Table 1: Key Results Across Scenarios

Scenario	Demand (TWh)	Avg Cost (PKR/kWh)	Export Impact	GDP Growth	Circular Debt
Status Quo	122	25.40	–$1 bn	–0.3 to –0.5 pp	Deteriorates
Partial Recovery	142	21.30	+$1–2 bn	+0.5 pp	Stabilizes
Integrated	162	18.30	+$3–5 bn	+1.0–1.4 pp	Improves
Transformation	187	15.70	+$6–7 bn	+2.0 pp	Reduces materially

The **Integrated** scenario the report's central, policy-relevant case, corresponding to the 50–70 TWh realistic demand expansion raises electricity demand to **162 TWh** and cuts average cost to **PKR 18.3/kWh**, a reduction of roughly 22 percent from baseline, while improving exports by **$3–5 billion** and GDP growth by **1.0–1.4 percentage points**. The **Transformation** scenario represents the technical upper bound of full sectoral realization:

Full-Realization (Transformation) Outcomes

- Industrial tariff reduction of **19–26 percent**
- Export gains of **$7–9 billion**
- Net foreign exchange improvement of **$10–14 billion**
- GDP growth uplift of **2.0–2.5 percentage points**
- Inflation reduction of **1.8–2.8 percentage points**
- Circular debt improvement of **PKR 0.9–1.3 trillion**
- Displacement of **2.5–4.5 billion litres** of petrol/diesel and **3.21 billion litres** of diesel via tubewell solarization, plus reduced reliance on 1,351 MMCFD of gas and 2.8 million tonnes of LPG
- Annual carbon emissions reduction of **8–12 million tonnes CO_2e**

A Self-Reinforcing Cycle

Together, these measures create a virtuous cycle: as demand rises, average costs fall; as costs fall, tariffs decline; as tariffs decline, more consumers reconnect to the grid, further raising demand. This reverses the present dynamic of shrinking demand and rising cost, replacing the **downward spiral** with an **upward cycle** of expanding consumption and improving affordability provided reforms are implemented with coherence and commitment.

Conclusion

Pakistan's power sector can be transformed from a fiscal liability into a strategic asset for economic growth. Its existing surplus capacity, currently underutilized and financially burdensome, represents an opportunity to support industrialization, expand exports, and attract investment. The policy imperative is to align electrification, cost reform, and institutional restructuring within a single coherent strategy: fragmented or partial reforms will not break the current equilibrium. Pakistan stands at a critical inflection point continued inaction deepens the cycle of high cost and declining demand, while a decisive, integrated electrification strategy offers a credible path to lower tariffs, stronger external balances, improved fiscal outcomes, and sustained economic growth.

Units, Benchmarks, and Definitions

A persistent source of confusion in Pakistan's energy policy discourse is the conflation of capacity and energy units. Clear definitional boundaries are essential for credible planning and public communication. Table 2 below defines the key technical measures.

Table 2: Key Units, Benchmarks, and Definitions

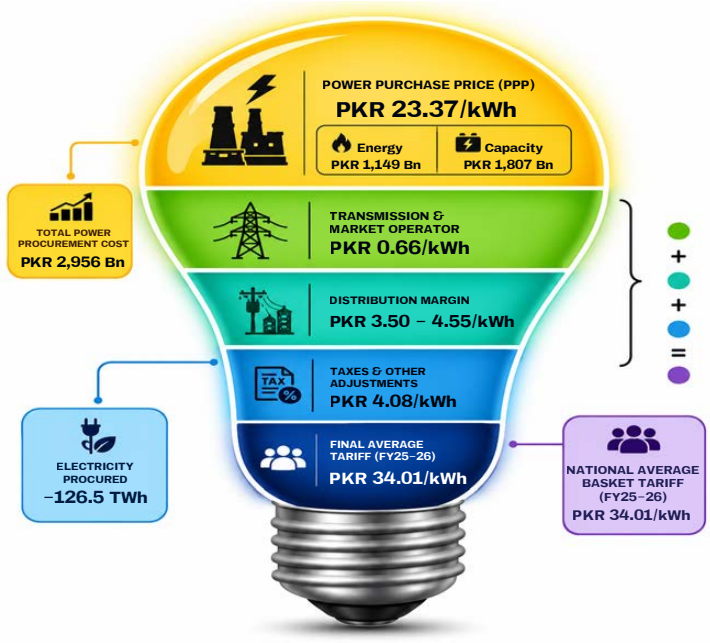
Unit	Full Form	What It Measures	Typical Use Context
kWh (Kilowatt-hour)	Kilowatt-hour	Energy used by a 1 kW device in one hour	Household electricity billing, small appliances, EV charging
MW (Megawatt)	Megawatt	Instantaneous power / generation capacity	Installed capacity, plant size, grid demand at a point in time
MWh (Megawatt-hour)	Megawatt-hour	Energy delivered or consumed over time	Billing, energy payments, storage capacity (e.g., BESS)
MWp (Megawatt-peak)	Megawatt-peak	Rated output of solar PV under standard test conditions	Solar PV project sizing and procurement
GWh	Gigawatt-hour	1,000 MWh; bulk energy statistics	Annual generation, large storage systems, national energy accounts
TWh	Terawatt-hour	1,000 GWh; macro-level consumption	Annual national electricity consumption (Pakistan ≈ 130–140 TWh/year)

Introduction and Background

Pakistan's electricity sector is characterized by structurally high-end-user tariffs, declining grid utilization, and weak industrial competitiveness. While successive power sector reforms have attempted to stabilize generation supply, the country now faces an inverse problem: significant unused generation capacity coexists with depressed economic activity and stagnant industrial electricity consumption. This divergence has constrained business growth, escalated fiscal liabilities through rising capacity payments, and limited the sector's ability to finance new investment. In this context, the restoration and expansion of electricity demand, particularly among productive industrial and commercial loads, has emerged as a critical lever for reducing the effective price of power and improving national competitiveness.

It is important to distinguish clearly between the Power Purchase Price and the final consumer-end tariff. According to NEPRA determinations, the national average basket price (revenue requirement) for FY25–26 is approximately PKR 34.01 per kWh. This comprises the National Average Power Purchase Price (NAPP) of around PKR 25.98 per kWh (including Capacity Charges of approximately PKR 17.05 per kWh and Energy Charges of PKR 10.87 per kWh), along with Distribution Margin (including DISCO losses) of roughly PKR 3.50 to 4.55 per kWh, and Transmission Margin, Use of System Charges, and Market Operator Fees of approximately PKR 0.66 per kWh. These baseline numbers do not factor in additional government taxes, surcharges, and monthly fuel cost adjustments (FCA) that are added to end-consumer bills (see Figure 1).

Figure 1: Build-up from the FY25 Power Purchase Price to the National Average Tariff (FY2025–26)



(Source: Authors' illustration based on NEPRA data)

The analysis in this report deliberately concentrates only on the Power Purchase Price component (PKR 23.37 per kWh). While reforms in distribution margins, transmission charges, taxes, and surcharges are essential for comprehensive consumer tariff relief, they fall outside the scope of this study. The primary objective is to demonstrate how increasing productive grid demand can dilute the fixed capacity payment burden at the procurement level.

For context on energy flow in FY25, NEPRA data indicates that Pakistan generated approximately 127,159 GWh of electricity. After transmission losses, around 124,000 GWh were injected into the national grid, while net distributed sales to paying consumers stood at approximately 103,600 GWh. The difference reflects system losses and theft averaging around 17.55% (AT&C losses), resulting in roughly 22,300 GWh of unbilled energy.

All per-unit price impact calculations in this report are therefore based solely on changes in the Power Purchase Price (capacity and energy payments). This focused scope enables a clear assessment of the core mechanism: spreading fixed capacity payments over a larger volume of metered electricity sales.

From Shortage to Surplus: How the Sector Reached the Present Imbalance

Pakistan's power sector reflects policy choices aimed at expanding access, addressing shortages and attracting private investment. Each phase answered an immediate national need, but the absence of long-term integrated planning has produced a paradox of surplus capacity alongside high electricity costs, weak demand growth and mounting financial liabilities. In the 1980s the priority was universal electrification, notably through the national Rural Electrification Program approved in December 1985, which aimed to electrify 24,085 villages through WAPDA; access expanded without matching cost-recovery mechanisms, leaving a legacy of low bill recovery, high system losses and dependence on cross-subsidies. The 1994 Power Policy then opened generation to Independent Power Producers (IPPs) to end shortages that had reached an estimated peak-load shortfall of about 2,000 MW, but the financial risk stayed with the public sector: capacity payments were due monthly whether or not a plant generated and were backstopped by government Implementation Agreements, and unpaid dues accumulated as circular debt (in 2013 the federal government had to clear about PKR 480 billion). The 2002 and 2015 policies added further capacity, largely through IPPs, after acute load shedding in the late 2000s and early 2010s, but without coordination with realistic demand projections, fuel diversification or transmission constraints.

Pakistan has therefore moved from chronic undersupply to oversupply. Installed capacity is about 49,651 MW, against average generation of about 15,400 MW in FY25 and recorded maximum demand of 23,848 MW on the NTDC system and 3,707 MW on the K-Electric system: more than three times average load, and about 22,000 MW above combined peak demand (about 14,800 MW if the 7,319 MW of behind-the-meter net-metered solar is excluded). In FY25 CPPA-G, acting as the single buyer on behalf of the distribution companies, purchased approximately 126.5 TWh from IPPs, public-sector generation companies, WAPDA's hydropower stations and nuclear plants, while end-user sales were lower because of transmission and distribution losses, theft and other inefficiencies.

The cost of this mismatch is the most visible symptom. Between FY2020 and FY2025 total power purchase costs more than doubled, from PKR 1,411 billion to PKR 2,956 billion, as capacity payments nearly tripled from PKR 612 billion to PKR 1,807 billion and the average power purchase price rose from PKR 12.18 to PKR 23.37 per kWh (see Table 4 in Chapter 1). Capacity payments are fixed charges, covering debt servicing, return on equity and fixed operating costs, that are payable irrespective of dispatch and backed by government guarantees; in FY2024–25 they were about 61% of the power purchase bill (roughly PKR 14.3 per kWh) while thermal plants operated at only 42.5% utilization. Whatever tariffs do not recover accumulates as circular debt or is financed from the federal budget, so idle capacity is a direct fiscal loss. Once losses, cross-subsidies, taxes and surcharges are added, NEPRA's national average basket price for FY2025–26 is about PKR 34.01 per kWh before taxes (roughly 1.5 times the base cost) and many households pay more than PKR 50 per unit, which makes electricity increasingly unaffordable, particularly for industrial and commercial consumers.

The Utility Death Spiral: Grid Defection and Net Metering

High tariffs discourage consumption, especially in industry and transport; lower consumption spreads the fixed capacity payments over fewer units, raising the per-unit cost and tariffs again. This self-reinforcing cycle of high tariffs, declining grid demand and rising per-unit costs is visible in recent sales data (Table 3 below): consumers above 200 units, mainly middle and upper-middle class households and small commercial users, are leaving the grid through rooftop solar, and many now fall back into the lower slabs, shrinking the paying base and raising the burden on those who remain.

Table 3 clearly illustrates the core challenge: only protected (low-consumption) consumers are increasing their grid usage, while higher-consuming categories are migrating to solar. The result is a shrinking and increasingly regressive consumer base that is unable to support the fixed cost structure of the power sector.

Table 3: Estimated Sales to Residential Consumers (GWh)

	FY23	FY26	percent Change	FY26 Tariff, Rs/kWh
For peak load requirement less than 5kW				
0-50 Lifeline	634	361	-43.06 percent	3.95
50-100 Life-line	253	398	57.31 percent	7.74
0-100 Protected	**8918**	**12794**	**43.46 percent**	10.54
100-200 Protected	**2266**	**3068**	**35.39 percent**	13.01
0-100	3440	3211	-6.66 percent	22.44
100-200	7047	6488	-7.93 percent	28.91
201-300	12587	10398	-17.39 percent	33.1
301-400	7158	4912	-31.38 percent	37.99
401-500	3953	2509	-36.53 percent	40.2
501-600	2289	1419	-38.01 percent	41.62
601-700	1482	860	-41.97 percent	42.76
Above 700	3700	2036	-44.97 percent	47.69
For peak load requirement over 5kW				
ToU – Peak	**519**	**582**	**12.14 percent**	46.55
ToU - Off-Peak	**2156**	**2441**	**13.22 percent**	40.53
Temporary Supply	7	7	0.00 percent	57.94

Source: NEPRA Consumer Tariff Determinations

Industrial and commercial consumers are solarizing for partly different reasons: alongside reducing energy costs and securing supply, export-oriented manufacturers, particularly in textiles, are adopting solar to lower their carbon footprint and meet the sustainability requirements of international buyers. Industrial grid consumption has nevertheless started to recover, to 26,205 GWh in July–March FY2026 from 21,083 GWh a year earlier, following the 2025 tariff reductions and the levy on captive gas-fired generation.

Net metering has been both a success and a source of strain. It enabled one of the world's fastest rooftop-solar expansions (about 17 GW of panels imported in 2024 and 4,124 MW of net-metered capacity across some 283,000 consumers by December 2024), giving households and businesses cheaper daytime electricity and greater supply security. However, because net-metered consumers continue to rely on the grid while contributing less to its fixed

costs, the government estimated that they had shifted about PKR 159 billion onto other consumers by December 2024. The buyback rate for new contracts was cut from PKR 27 to PKR 10 per unit in March 2025, and NEPRA's Prosumer Regulations, 2026 moved new prosumers to net billing (see Chapter 2).

The Way Forward: Demand Expansion, Tariff Rationalization and Integrated Planning

The key goal of this study is to rationalize the uniform tariff to PKR 16 per kWh or below for all consumers. Residential solar paired with a medium-sized battery, needed to supply electricity beyond daylight hours, currently delivers electricity at around PKR 20 per kWh, so a grid tariff of PKR 16 per kWh or below would undercut round-the-clock self-supply and encourage solar and diesel-based captive users to return to the grid, although daytime-only solar self-consumption may remain competitive. Higher consumption is part of the solution because capacity payments are largely fixed: holding them at PKR 1,807 billion, the capacity component (about PKR 14.3 per kWh) would fall to about PKR 11.9 if grid purchases rose by 20% to about 152 TWh and to about PKR 9.5 if they rose by 50% to about 190 TWh, reducing the average power purchase price from PKR 23.37 to about PKR 21.0 and PKR 18.6 per kWh respectively (energy cost held at PKR 9.08 per kWh). This is illustrated for each electrification pathway in Figure 27 and quantified across scenarios in Chapter 1.

Demand can be expanded through several pathways. Transport electrification is largely a medium- to long-term opportunity given the infrastructure gap: only a little over 70 charging-station licenses had been issued by mid-2026 against a target of 3,000 stations by 2030, and the only electrified railway section, the 286 km Lahore–Khanewal line, had largely ceased electric operations by 2010. Nearer-term gains are more likely from industrial process heat, heating and agriculture: Agora Energiewende and PRIED find that low- and medium-temperature process heat in food processing, textiles, paper and fertilizers should be prioritized, with energy savings of around 36%. Reducing capacity payments through contract renegotiation, retirement of inefficient plants and better dispatch, and cutting transmission and distribution losses, remain critical but are insufficient without demand growth. The sector-level assessments are set out in Chapter 1.

A further critical gap is the lack of integrated, system-wide planning, that is, planning generation, transmission, distribution and demand (including electrification-driven growth) together within a single least-cost framework. NEPRA found "serious inconsistencies" between the demand estimates in the system operator's Integrated System Plan and those of the distribution companies and CPPA-G, and in 2026 it penalized the National Grid Company and CPPA-G after the 4,000 MW Matiari–Lahore HVDC line was operated at only about 2,800 MW while consumers were billed for its full capacity and around 852 GWh was generated from costly furnace-oil and diesel plants outside the merit order. Responsibilities need to be clearly assigned: the Power Division should lead integrated planning; ISMO (which prepares the IGCEP) and the National Grid Company should align generation and transmission with realistic demand projections that incorporate electrification; NEPRA should approve plans only when they are mutually consistent and enforce economic dispatch; and CPPA-G and the distribution companies should reflect new demand in procurement and network plans. Targeted recommendations for these institutions are set out in Chapter 3.

Surplus capacity can also be turned from a liability into a competitive advantage that supports industrialization and new sectors such as data centers (provided they adopt water-efficient cooling, given that Pakistan's per capita water availability has fallen below 1,000 cubic metres a year), green hydrogen and advanced manufacturing, but this requires a deliberate shift toward demand creation and tariff rationalization.

Guaranteed Power Reliability: The Most Important Requirement for Industrial Electrification

Pakistan faces a power paradox: despite its surplus capacity, supply is unreliable. In April 2026 a shortfall of 6,500 MW, with only about 15,400 MW available against roughly 22,000 MW of demand, left urban areas such as Lahore and Karachi with 3 to 6 hours of unscheduled outages a day and rural areas and slum settlements (both regularized and unregularized) served by high-loss feeders with 10 to 16 hours. In Balochistan, 604 of QESCO's 814 feeders faced more than 10 hours of daily load-shedding in early 2026, with outages of up to 16 hours a day in interior areas during the April 2026 shortfall, and industrial clusters in Faisalabad, Gujranwala, Sargodha and Sheikhupura were severely affected. In January 2025, 187 of 568 textile mills were reported to have stopped operating, and although the federal cabinet decided in 2022 that industries on dedicated feeders should be supplied without load-shedding, industries on mixed feeders and in smaller clusters remain exposed. The cause is poor management of the system rather than a lack of plants: fleet utilization is only about 34%, capacity charges of PKR 1,806 billion are paid even when plants produce little, about 17.6% of electricity is lost in transmission and distribution, and circular debt stood at Rs 2.396 trillion in March 2025. The national average tariff determined by NEPRA was Rs 35.50 per unit in FY2024–25 and about Rs 34 in FY2025–26, and tariffs for a typical household rose by about 290% between 2014 and 2023.

This affects every electrification plan in this report: railways, electric buses and vehicles, data centers, cold chains, tubewells and large industry all need continuous supply, and without it they will keep relying on diesel generators. Process industries are the most exposed. Copper and mineral furnaces must run without interruption, which is why Reko Diq has built its own 204 MW plant; the mineral sector contributes only about 3.2% of GDP but is strategically important for exports (copper exports to China were worth about US$482 million in the first half of 2025). Pharmaceutical and textile manufacturers run automated, batch-based processes in which an interruption can spoil an entire batch, so many maintain captive generation, and data centers need almost perfect reliability. Across firms, 50.7% experienced outages in 2022, averaging 22 a month. If the grid is not reliable, industry keeps its own diesel generators, which worsens idle capacity and capacity charges for everyone.

To solve this, the government should create dedicated industrial feeders for large consumers (above 5 MW) that are protected from load shedding, backed by guarantees on voltage and frequency with compensation when standards are missed, and allow hybrid arrangements that keep some captive generation as backup while load shifts gradually to the grid. This has limitations: backup duplicates fixed capital and maintenance costs, diesel back-up is expensive (around PKR 120 per kWh, roughly six times the cost of solar electricity), and gas-fired captive generation is becoming costlier under the Off-Grid (Captive Power Plants) Levy Act, 2025, so hybrid arrangements need clear rules on synchronization, protection and standby charges. The feeders would need express 11 kV or 132 kV lines with dedicated bays and transformers, N-1 redundant supply, upgraded protection and SCADA, and advanced metering of voltage, frequency and interruptions; the cost could be recovered through connection charges and the additional sales they enable. Steady, high-load-factor industrial demand would help reverse the decline in system load factor from a historical 70–73% to around 58–60%, spread fixed capacity costs over more units, reduce reliance on diesel, lower fuel imports and strengthen export competitiveness. Reliable supply should also be a firm condition for major investments under the Special Investment Facilitation Council (SIFC), which lists energy among its five priority sectors.

Based on the articulated information, it is recommended to develop Power Reliability Agreements (PRAs) for large consumers. Under these agreements the government guarantees uninterrupted supply at an agreed price and, in return, the industry commits to buy a minimum amount of electricity every year, giving the power system steady revenue and reducing per-unit costs for all consumers. Reko Diq's private power plant should be planned to connect to the national grid once transmission improves, turning its 204 MW (and future additional demand) into useful capacity for the whole country. Since projects of Reko Diq's scale are rare, PRAs should also target recurring,

continuous-process mineral-based industries, for example soda ash manufacturing based on locally mined rock salt and limestone, where the Khewra plant is being expanded from 560,000 to 760,000 tonnes a year. Pakistan already has a large generation base; what is missing is the ability to deliver reliable electricity. Dedicated feeders, strong contracts and proper planning would make the electrification strategies in this report succeed, lowering per-unit costs, bringing more demand to the grid, reducing fuel imports and supporting stronger economic growth.

Objective

The objective of this study is to examine how electricity demand on Pakistan's grid can be increased in a cost-efficient, market-aligned, and policy-consistent manner, using a combination of technical, financial, tariff, and regulatory interventions. The study reframes the electricity price challenge from a static analysis of tariff formation to a dynamic resource utilization problem in which higher consumption of existing capacity lowers unit costs, reduces circular debt formation, improves sector liquidity, and enhances export competitiveness. This framing aligns with contemporary international approaches where demand expansion, rather than tariff suppression alone, is treated as a viable pathway for economic competitiveness, as evidenced by recent developments in India and Australia. Regional peers whose socio-economic conditions are closer to Pakistan's offer more directly relevant lessons. Bangladesh faces a comparable overcapacity problem, with about 27.7 GW of installed capacity (October 2024) against a peak demand of about 17.2 GW (April 2024) and capacity charges paid to idle plants, and has been advised to shift captive industrial load to the national grid and to electrify gas-fired boilers in order to raise grid demand. In Indonesia, the state utility PLN, facing an electricity oversupply of around 6.7 GW, proposed in 2022 to convert 15 million households from LPG to induction cooking to absorb surplus power, but cancelled the programme citing the socio-economic conditions of households during the post-pandemic recovery. These experiences underline that demand-expansion strategies must be tailored to local context, affordability, and socio-economic conditions.

The report is organized in three distinct chapters, which follow this Introduction and Background:

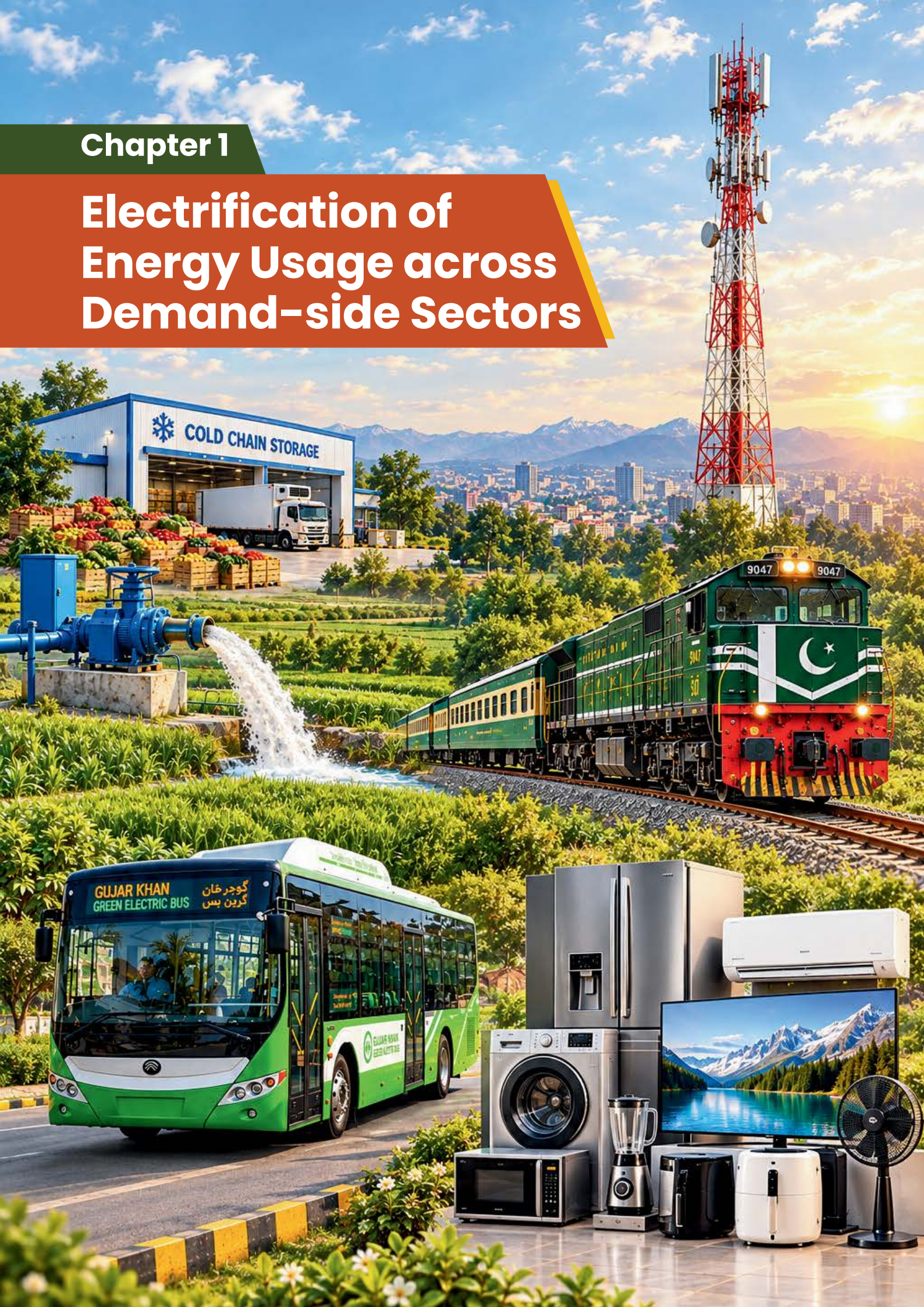
- **Chapter 1:** Electrification of Energy Usage across Demand-side Sectors: This chapter examines additive and integrated domains for utilizing excess power and their resulting impacts.
- **Chapter 2:** No-Cost and Low-Cost Interventions to Rapidly Boost Electricity Demand: This chapter examines practical no-cost and low-cost interventions designed to accelerate electricity demand growth.
- **Chapter 3:** Financial, Structural, and Policy Pathways to Competitive Electricity Pricing: This chapter pairs each financial and structural pathway for reducing the fixed cost base with the policy reform that delivers it, and consolidates them in one indicator table.

Statement of Limitations

This report focuses specifically on the Power Purchase Price (PPP) paid by the Central Power Purchasing Agency (CPPA-G) to power producers, which forms the largest and most critical component of electricity costs. All calculations and projected tariff impacts presented in this study are based on the FY25 baseline Power Purchase Price of PKR 23.37 per kWh. This value is derived from official data showing Energy Purchase Price of PKR 1,149 billion and Capacity Purchase Price of PKR 1,807 billion, resulting in a total of PKR 2,956 billion for approximately 126.5 TWh of electricity procured.

Chapter 1

Electrification of Energy Usage across Demand-side Sectors



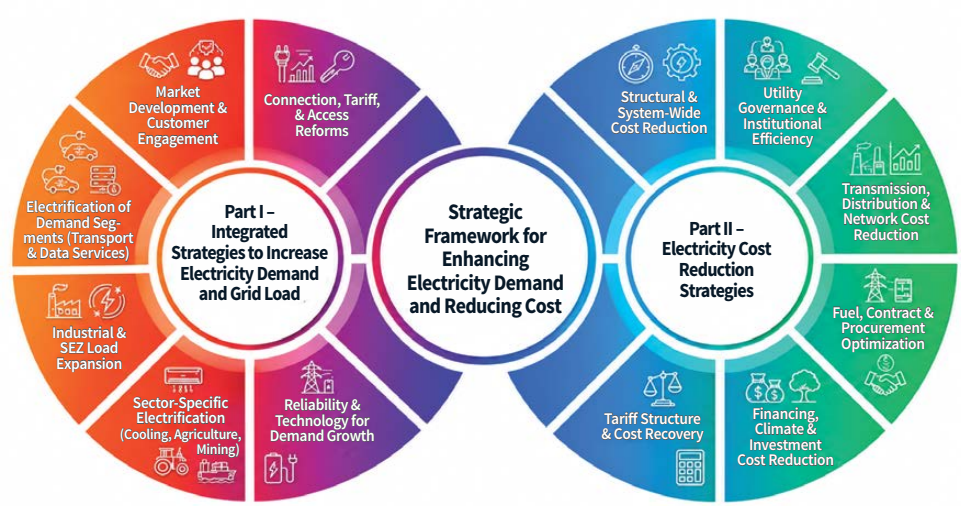
Chapter 1

Electrification of Energy Usage across Demand-side Sectors

As discussed in the Introduction and Background, Pakistan's power sector is afflicted by a structurally perverse equilibrium: the country has installed 49,651 MW of generation capacity yet purchases only approximately 126.5 TWh of electricity annually through the national grid system, while end-user electricity sales remain substantially lower due to system losses and inefficiencies. As a result, a large share of dispatchable capacity remains underutilized for significant portions of the year. The financial consequences of this underutilization are severe. Capacity Purchase Price (CPP) obligations fixed payments owed to power producers regardless of whether electricity is generated must be recovered across a limited base of electricity consumption, pushing per-unit tariffs to internationally uncompetitive levels. These high tariffs, in turn, accelerate consumer migration to off-grid solar solutions, further compressing grid demand. This self-reinforcing spiral constitutes one of the central structural challenges facing Pakistan's power sector.

Electrification of demand the deliberate policy of converting existing fossil-fuel-based energy consumption in transport, industry, services, and households into grid electricity consumption is the most structurally sound response to this crisis (Figure 2). Unlike supply-side solutions that add further capacity, electrification adds demand against a fixed CPP base, thereby spreading fixed costs over more units and reducing the per-unit tariff burden for all consumers. This chapter presents a rigorous analytical assessment of electrification across five key domains: (i) electrification of railways; (ii) electrification of public and private transport; (iii) electrification of the agriculture and fisheries sectors; (iv) electrification of data centers and digital infrastructure; and (v) broad-based electrification across residential, industrial, and commercial sectors. This approach is consistent with globally recognized frameworks. The International Energy Agency identifies the electrification of transport, buildings, and industry as a central pillar of secure and affordable energy transitions: electricity currently meets around 23% of global final energy consumption, electric vehicles are two to four times more efficient than internal-combustion vehicles, and heat pumps deliver three to five units of heat per unit of electricity. IRENA similarly projects electricity's share of final energy rising to 35% by 2035 and above 50% by 2050, describing electrification as a "no-regret" pathway that reduces emissions, strengthens energy security, improves affordability, and supports green industrialization. For Pakistan, the principal benefits of electrifying the five domains are lower per-unit electricity costs through better use of existing capacity, reduced fossil-fuel imports and foreign-exchange outflows, improved air quality and public health, and lower greenhouse-gas emissions. These domains also align with Pakistan's national climate commitments: the third Nationally Determined Contribution (NDC 3.0), submitted in September 2025, targets electric vehicles accounting for 30% of new vehicle sales and 3,000 charging stations by 2030, the expansion of e-buses and mass transit, and the electrification of key railway routes, alongside 60% renewable energy in the national mix by 2030.

Figure 2: Strategic framework for enhancing electricity demand and reducing cost



Baseline: Pakistan's Power Purchase Cost Structure (FY2020–FY2025)

Table 4 reproduces the power purchase cost data from NEPRA's annual performance reports, extended with derived units-sold and CPP-share metrics. These form the baseline against which post-electrification projections are calculated. A five-year baseline (FY2020–FY2025) is used because this period captures the major changes in the cost structure: capacity payments nearly tripled as new plants came online and as rupee depreciation and higher interest rates raised dollar- and interest-indexed payments, with the State Bank of Pakistan's policy rate peaking at a record 22% in June 2023; the Power Division estimates that exchange-rate losses alone raised the effective base tariff by 44% between FY2023 and FY2025 even though it was largely unchanged in dollar terms; and from October 2024 the government terminated or renegotiated contracts with several IPPs, contributing to the modest easing of capacity payments in FY2025.

Table 4: Power Purchase Cost Structure, FY2020–FY2025

Fiscal Year	EPP (Bil. PKR)	CPP (Bil. PKR)	Total (Bil. PKR)	Per Unit (PKR/kWh)	Units Sold (BU)	CPP as % of Total
FY20	799	612	1,411	12.18	115.8	43.4%
FY21	819	614	1,433	11.59	123.6	42.8%
FY22	1,495	776	2,271	16.64	136.5	34.2%
FY23	1,273	1,307	2,580	21.30	121.1	50.7%
FY24	1,189	1,902	3,091	25.81	119.8	61.5%
FY25	1,149	1,807	2,956	23.37	126.5	61.1%

Note: These are bulk power purchase costs incurred by CPPA-G on behalf of the distribution companies. Under NEPRA's uniform tariff they are passed through to all consumer categories (residential, commercial, industrial, and agricultural); differences between categories arise from distribution margins, cross-subsidies, and taxes.

The data reveal a critical structural deterioration: CPP as a share of total power purchase cost rose from 43.4% in FY2020 to 61.5% in FY2024, before easing marginally to 61.1% in FY2025 as some IPP capacity payments were renegotiated. The per-unit tariff rose from Rs 12.18/kWh in FY2020 to a peak of Rs 25.81/kWh in FY2024 a 112% increase over four years. Meanwhile, units sold declined from a high of 136.5 BU in FY2022 to 119.8 BU in FY2024, with a partial recovery to 126.5 BU in FY2025. This volume contraction caused by tariff-induced demand destruction and off-grid solar migration is the proximate cause of the tariff spiral. In other words, because capacity payments are largely fixed, every fall in units sold raises the capacity cost that must be recovered from each remaining unit: had FY2024 sales remained at the FY2022 level of 136.5 BU, the capacity component would have been about PKR 13.9/kWh instead of PKR 15.9/kWh. The resulting higher tariffs push still more consumers towards off-grid solar, reducing sales further, which is what turns rising costs into a self-reinforcing spiral.

Electrification of Punjab's Public Transport: Impact of 5000 Electric Buses

Shifting 5,000 buses to electric buses (e-buses) in Punjab would add a modest incremental load to the national electricity system while replacing a substantial volume of diesel consumption in public transport. Punjab's e-bus initiative is expanding rapidly, with planned deployment exceeding 1,000–1,500 buses across multiple phases (including targets of 1,115 buses by late 2025 and an additional 1,000 buses approved in early 2026). Scaling to 5,000 buses represents an ambitious but plausible long-term expansion across major cities and intercity routes in the province. The estimates in this section are based on publicly available programme information and on technical assumptions that are widely used internationally, as set out in the Methodology note below.

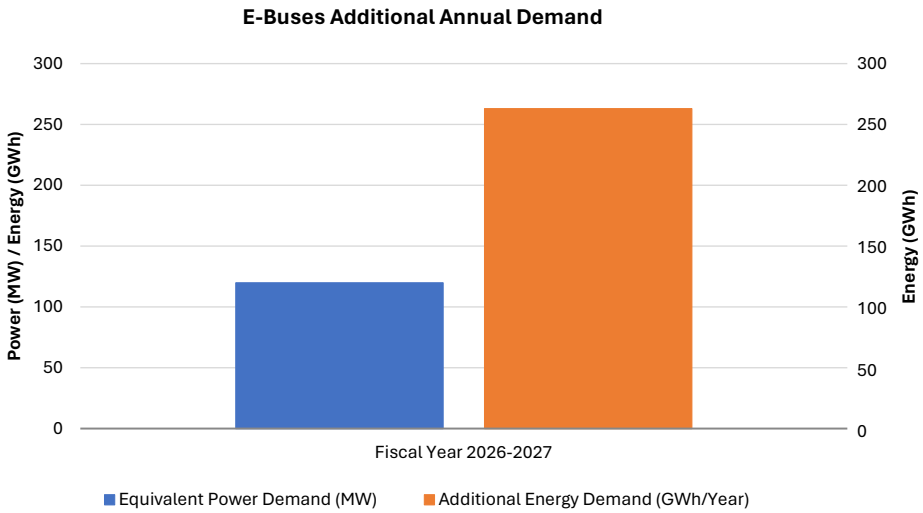
Using the FY25 national electricity baseline (total electricity purchased ≈126,487 GWh; variable payment ≈1,149 billion PKR or 9.08 PKR/kWh; capacity payment ≈1,807 billion PKR; average tariff ≈23.37 PKR/kWh), the diesel baseline for replacement is derived from typical Punjab/Lahore bus operations. Diesel buses operate at approximately 2 km per liter (as reported for Lahore's conventional bus fleet), and calculations based on typical urban bus operation indicate 40–50 tons of CO_2 reduction per bus annually (see the Methodology note below). Using an average of 45 tons CO_2 and a diesel emission factor of 2.68 kg CO_2 per liter, each bus saves approximately 16,791 liters of diesel annually, corresponding to about 33,582 km of yearly operation. For a 5,000-bus fleet, total diesel savings amount to approximately 83.96 million liters per year.

Electricity demand for the electrified fleet remains relatively small at the system level. Under Pakistan-specific operating conditions (traffic congestion, high temperatures, and air-conditioning loads), e-buses consume approximately 1.56 kWh per km. This results in annual electricity consumption of about 52,387 kWh per bus. For 5,000 buses, total electricity demand increases by approximately 261.94 GWh per year (shown in Figure 3), representing only about 0.21% of national FY25 electricity consumption. This additional load is modest and can be accommodated within existing surplus generation capacity without requiring new capacity investments.

Methodology. The fleet-level estimates follow a simple bottom-up calculation using assumptions that are widely applied internationally. The CO_2 abatement range of 40–50 t per bus per year is calculated for typical urban operation of about 30,000–37,000 km a year (roughly 80–100 km a day): at a diesel fuel economy of 2 km per litre, this corresponds to about 14,900–18,700 litres of diesel a year, and at the standard diesel emission factor of 2.68 kg CO_2 per litre, to 40–50 t of CO_2. Taking the midpoint of 45 t, annual diesel displaced per bus is 45 t ÷ 2.68 kg CO_2 per litre = 16,791 litres; multiplying by 2 km per litre gives an annual operating distance of 33,582 km; and multiplying this distance by the assumed e-bus consumption (1.56 kWh per km) gives 52,387 kWh per bus, or 261.94 GWh for 5,000 buses. The tariff effect is then estimated by adding this demand to the FY25 baseline at the variable energy cost of PKR 9.08 per kWh while holding capacity payments constant. The consumption assumption of 1.56 kWh per km is deliberately conservative: measured consumption for 9–12 m e-buses in Indian cities ranged from about 0.8 to 1.2 kWh per km, while 18 m articulated e-buses typically consume around 1.6–1.8 kWh per km,

so the assumed value lies towards the upper end of the range and implicitly allows for congestion, high ambient temperatures, and air-conditioning loads.

Figure 3: E-Bus Fleet Electrification (Punjab) — 5,000 electric buses (Energy Vs Power (25% Assumed Capacity))



The impact on the national average electricity tariff is marginal but directionally beneficial. With the additional demand, total electricity consumption rises to approximately 126,749 GWh (Figure 4), while variable payments increase to around 1,151.38 billion PKR. Capacity payments remain unchanged at 1,807 billion PKR, implying further dilution of fixed costs. As a result, total system payments increase to about 2,958.38 billion PKR, and the average per-unit electricity price declines slightly from 23.37 PKR/kWh to 23.34 PKR/kWh (a reduction of 0.03 PKR/kWh, or approximately 0.13%) (Figure 5).

In addition to electricity system effects, the transition yields substantial fuel savings. The elimination of approximately 83.96 million liters of high-speed diesel annually translates into significant reductions in Pakistan's fuel import bill and contributes to improved urban air quality across Punjab's major cities (Table 5).

Figure 4: Grid Sales After electrification of E-Buses Punjab (Source: REN21 GSR 2025 Snapshot: Pakistan; NEPRA State of Industry Report 2025; authors' calculations)

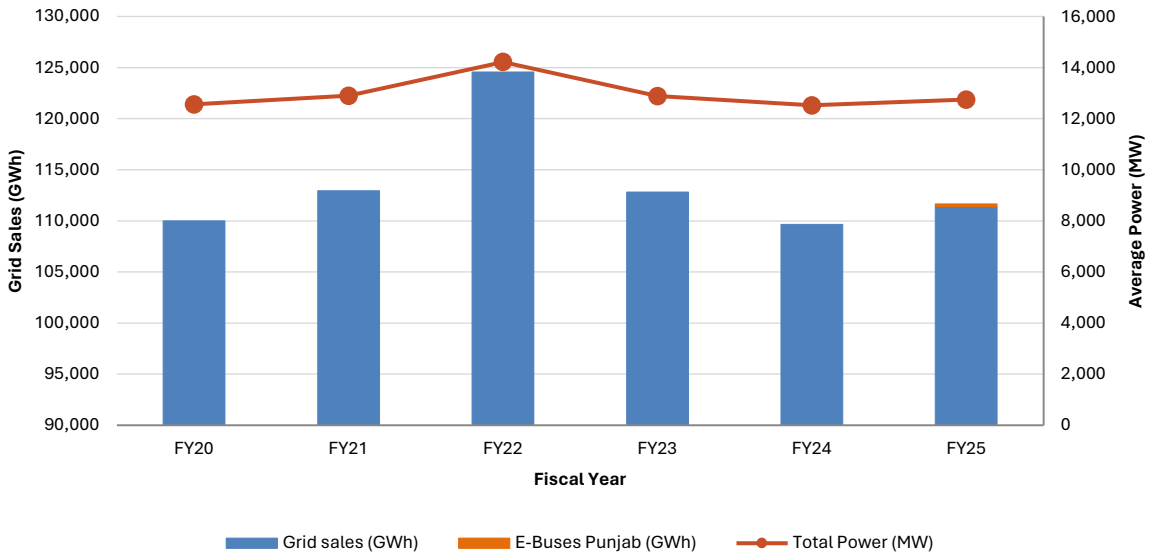
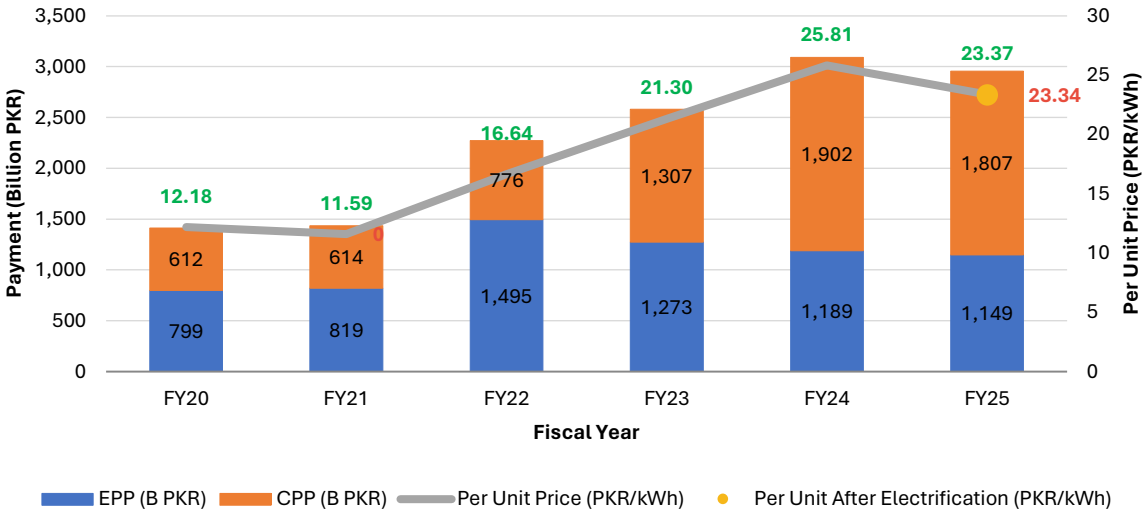


Table 5: Summary: Before vs. After 5000 E-Buses (Punjab)

Parameter	Before (FY25)	After (5,000 e-buses)	Change / Impact
Total electricity demand (GWh)	126,487	126,749	+261.94 GWh (+0.21%)
Energy (variable) purchase (Bil. PKR)	1,149	1,151.38	+2.38 B
Capacity (fixed) purchase (Bil. PKR)	1,807	1,807	No change (diluted)
Total purchase payment (Bil. PKR)	2,956	2,958.38	+2.38 B net
Per-unit price (PKR/kWh)	23.37	23.34	↓0.03 (–0.13%)
Diesel consumption (million litres/year)	83.96	0 (fully replaced)	Saved: 83.96M litres/year

Figure 5: Per Unit Price After Public Transport Electrification



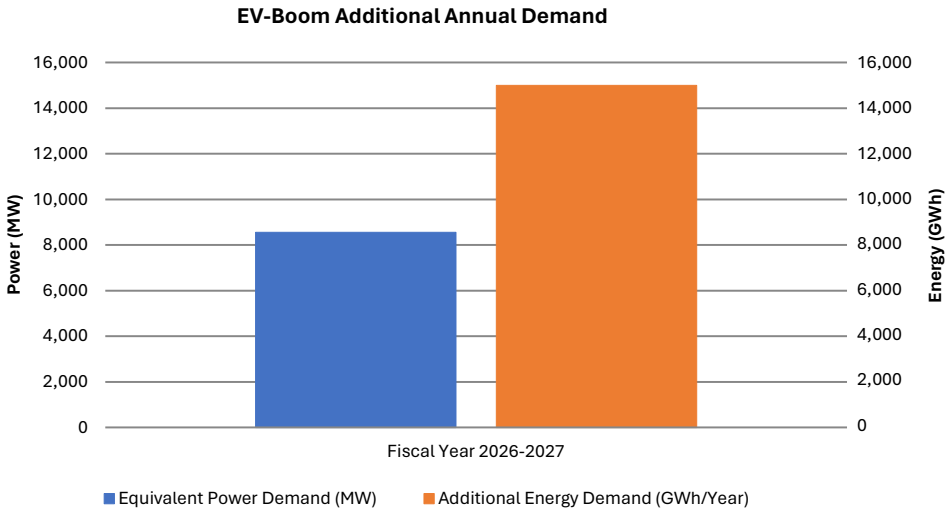
Overall, the electrification of 5,000 buses in Punjab demonstrates that even large-scale adoption of electric public transport imposes only a limited increase in electricity demand while delivering substantial economic and environmental benefits. The intervention reduces diesel consumption at scale, lowers pressure on foreign exchange reserves, and improves air quality and public health outcomes. Similar to railway electrification, this transition enhances grid utilization by spreading fixed capacity costs over higher electricity sales, thereby exerting a small downward effect on tariffs. When combined with other demand-side electrification measures, the cumulative impact could become significantly more pronounced, reinforcing the case for large-scale transport electrification in Pakistan.

Public receptiveness will, however, be decisive for realising these benefits at scale. Early signs are encouraging: when Punjab offered free travel across its mass-transit network in April 2026, daily ridership reached a record of more than 1.14 million passengers. Systematic evidence on commuters' perceptions of e-bus services (fares, frequency, comfort, safety, and reliability) nevertheless remains limited. A structured consultation with the Transport and Mass Transit Department, the Punjab Masstransit Authority, bus operators, and other identified stakeholders, including commuter groups, is therefore recommended to gauge acceptance and inform route and service design before scaling up to 5,000 buses.

Electrification via the EV Boom: System-Wide Impacts under NEV Policy Targets

Electrification through a large-scale electric vehicle (EV) transition rising from the current ~2% share in new vehicle sales to the National Electric Vehicle (NEV) Policy 2025–2030 target of 30% by 2030 would introduce a substantial new electricity load while displacing a significant share of imported petrol and diesel in Pakistan's transport sector. The national vehicle fleet has reached approximately 39.09 million registered units nationwide (cumulative registrations, which likely overstate the number of vehicles in active use), dominated by 30.52 million motorcycles (around 78% of the fleet), which alone consume about 1.92 million metric tonnes of petrol annually nearly a quarter of total fossil fuel use. The fleet is also ageing, with an average motorcycle age of 8 years and approximately 9.4 million units over 10 years old, resulting in 20–40% higher fuel consumption. Recent fuel price shocks (including increases exceeding PKR 100 per liter in certain periods) have further intensified the economic burden, with petroleum imports reaching approximately US$14.2 billion annually (about 67% of the trade deficit). Using the FY25 national electricity baseline (total electricity purchased ≈126,487 GWh; variable payment ≈1,149 billion PKR or 9.08 PKR/kWh; capacity payment ≈1,807 billion PKR; average tariff ≈23.37 PKR/kWh), the current EV penetration (~2% of new sales, largely two- and three-wheelers) contributes negligibly to national electricity demand (well below 1 TWh annually). Therefore, the FY25 baseline effectively represents the "before" scenario, although rising fuel prices are already accelerating consumer interest in electric mobility, particularly in the two-wheeler segment.

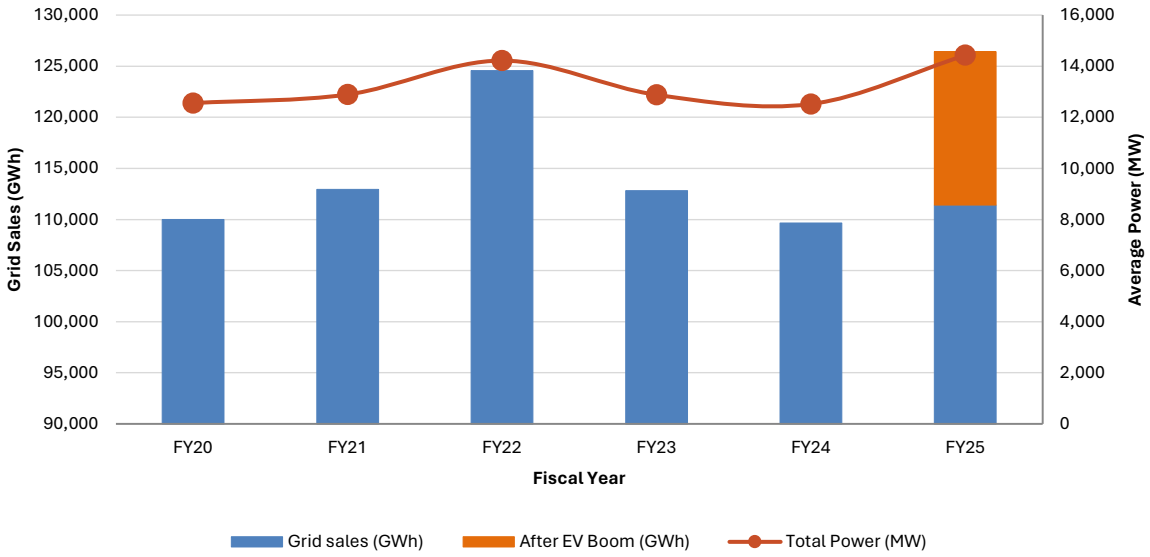
Figure 6: Electrification — EV-Boom (Energy Vs Power (20% Assumed Capacity))



Under the NEV Policy trajectory and broader transport electrification strategy, EV adoption is expected to scale rapidly. The policy targets 30% of all new vehicle sales to be electric by 2030, including motorcycles, cars, and rickshaws. Complementary projections indicate expansion to approximately 1.5 million new electric motorcycles annually by 2031 (cumulative ~4.5 million units), around 290,000 electric and hybrid cars, and approximately 8,000 electric buses. Based on these projections, direct grid electricity demand from the core NEV target is estimated at approximately 5,400 GWh (5.4 TWh) annually, replacing approximately 2.07 billion liters of petrol and diesel each year. Under a broader transport electrification pathway including accelerated EV adoption, higher commercial vehicle penetration, and expanded charging infrastructure total electricity demand could increase by approximately 15,000 GWh (15 TWh) per year by 2030–2031 (Figures 6 and 7). Additional demand may be partially offset by off-grid solar charging and distributed renewable systems (e.g., agricultural tubewells and telecom towers). Broader electrification strategies could also displace up to 2.6 million metric tons of petroleum products annually (around 15% of current consumption), generating cumulative foreign exchange savings of up to US$5.8 billion over five

years. The impact on the national electricity tariff is significant and structurally favorable. With an additional 15,000 GWh of electricity demand, total consumption increases to approximately 141,487 GWh. Variable payments rise proportionally to approximately 1,285.2 billion PKR, while capacity payments remain fixed at 1,807 billion PKR. This results in total system payments of approximately 3,092.2 billion PKR. Due to the spreading of fixed capacity costs over a larger electricity base, the average per-unit electricity price declines from 23.37 PKR/kWh to approximately 21.85 PKR/kWh, representing a reduction of 1.52 PKR/kWh (about 6.5%) (Figure 8). With more aggressive EV adoption (e.g., exceeding 15 TWh annual addition), the tariff reduction could become even more pronounced.

Figure 7: After EVs Boom Grid Sales

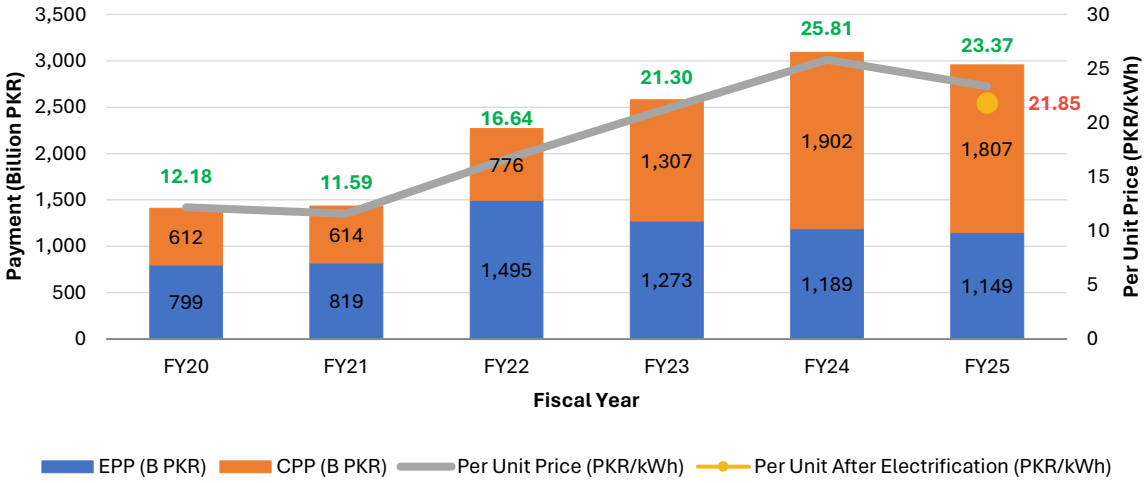


Beyond electricity system impacts, the EV transition delivers large-scale fuel savings and macroeconomic benefits. Total displacement is estimated at approximately 2.07–4+ billion liters of petrol and diesel annually, driven primarily by the motorcycle segment. This translates into annual foreign exchange savings in the range of US$1–2.8 billion, while also reducing vulnerability to global oil price volatility. At the household level, electric motorcycles can reduce annual fuel expenditures by approximately PKR 25,000–40,000 per user compared to conventional petrol bikes. Environmental benefits are also substantial, with potential emissions reductions exceeding 4.5 million tons of CO_2 annually, alongside significant improvements in urban air quality and public health outcomes (Table 6).

Table 6: Summary: Before vs. After EV Boom (NEV Policy 2025–2030 Target)

Parameter	Before (FY25, ~2% EV share)	After (NEV 30% target + broader electrification)	Change / Impact
Total grid electricity demand (GWh)	126,487	141,487	+15,000 GWh (+11.9%)
Energy (variable) purchase (Bil. PKR)	1,149	1,285.2	+136.2 B
Capacity (fixed) purchase (Bil. PKR)	1,807	1,807	No change (heavily diluted)
Total purchase payment (Bil. PKR)	2,956	3,092.2	+136.2 B net
Road transport fuel replaced	Negligible	2.07–4+ billion liters/year	Saved: US$1–2.8B+ annually
Per-unit price (PKR/kWh)	23.37	21.85	↓1.52 (–6.5%)

Figure 8: Per Unit Price After Private Transportation Electrification as per NEVP 2030 and Dawn, EOS, April 12th, 2026



Overall, large-scale electrification driven by the EV boom represents a transformative structural shift for Pakistan's energy and transport systems. While it significantly increases electricity demand, this demand is efficiently absorbed by existing surplus generation capacity, improving system utilization and reducing per-unit electricity costs. At the same time, it delivers substantial reductions in petroleum imports, enhances energy security, and mitigates exposure to global oil price shocks. Similar to railway and public transport electrification, this transition aligns economic efficiency with environmental sustainability, positioning EV adoption as a high-impact, low-regret strategy for Pakistan's long-term energy transition.

Electrification of Households, Industry, and Commercial Sectors

Electrification of gas-based energy consumption across households, commercial establishments, and selected industrial thermal processes including cooking, water heating, and low- to medium-temperature industrial boilers represents one of Pakistan's most significant long-term opportunities for productive electricity demand growth. This opportunity is becoming increasingly relevant as domestic natural gas reserves continue to decline, imported LNG dependence rises, winter gas shortages persist, and consumers increasingly adopt electric and hybrid alternatives in response to fuel supply constraints.

According to the Pakistan Economic Survey FY25 and OGRA consumption statistics, combined natural gas consumption across domestic, commercial, and general industrial users currently stands at approximately 1,351 MMCFD (Domestic: 777 MMCFD, Commercial: 38 MMCFD, General Industry: 536 MMCFD). On an annualized basis,

this corresponds to approximately 493 billion cubic feet. In parallel, Pakistan's annual LPG consumption is estimated at approximately 2.8 million tonnes.

The technical attractiveness of electrification arises from superior end-use efficiency. Conventional gas-based cooking systems typically operate at thermal efficiencies of approximately 40–60 percent, whereas modern induction cooking technologies generally achieve 85–95 percent efficiency.

Similarly, electric water-heating systems and electric boilers deliver significantly higher useful-energy conversion efficiencies compared to direct gas combustion.

Despite this efficiency advantage, immediate large-scale conversion is neither technically feasible nor operationally prudent under present network conditions. Pakistan's transmission and distribution system continues to face transformer constraints, feeder congestion, voltage instability, and reliability challenges across multiple DISCO territories. Accordingly, gas-to-grid electrification must proceed through a carefully phased implementation strategy aligned with practical network expansion and system readiness.

Phased Implementation Strategy:

- Phase 1 (5–7 years): Prioritize urban households, commercial clusters, and small & medium industries where distribution infrastructure is relatively stronger. This phase could realistically generate 10–20 TWh of additional productive electricity demand through widespread adoption of induction stoves, electric geysers, and efficient electric thermal appliances.
- Phase 2 (8–12 years): Supported by targeted feeder reinforcement, transformer augmentation, and reliability improvements, cumulative additional demand could expand to 25–40 TWh.
- Long-term Phase (13–18+ years): With deeper network modernization, cumulative additional productive demand could reach 40–60 TWh, representing a substantial but manageable structural increase in electricity utilization.

Using Pakistan's FY25 electricity system baseline of approximately 126.5 TWh purchased at an average system cost of PKR 23.37 per kWh, incremental productive demand growth of 10–20 TWh in the first 5–7 years could reduce average bulk power purchase costs by approximately PKR 1.0–2.0 per kWh through improved dilution of fixed capacity payments (holding capacity payments at PKR 1,807 billion and pricing the additional units at the FY25 variable cost of PKR 9.08 per kWh). A reduction of about PKR 3.5 per kWh, to approximately PKR 19.87 per kWh as shown in Figure 9, would require roughly 40 TWh of additional demand, which corresponds to the later phases outlined above.

The broader strategic benefits of this transition are substantial. Reduced dependence on imported LNG and LPG would strengthen Pakistan's external sector resilience and reduce exposure to international fuel price volatility. Lower utilization of aging gas distribution infrastructure would help reduce methane leakage losses. The transition would also stimulate domestic manufacturing of induction systems, electric geysers, electric boilers, and associated appliances. Gas displaced from low-efficiency end-uses could be redirected toward higher-value applications such as fertilizer production, thereby improving national resource allocation.

Successful implementation will require active facilitation by distribution companies, including timely new connection approvals, transformer upgrades, feeder-level reinforcement, and targeted reliability improvements. Complementary policy incentives for efficient electric appliances and structured consumer conversion support will also be essential.

Gas-to-grid electrification should therefore be treated as one of Pakistan's most important phased structural demand interventions. Its principal value lies not only in tariff reduction but in strengthening long-term energy security, improving utilization of fixed power sector assets, reducing imported fuel dependence, and enabling a more efficient and resilient national energy system.

Investment Case: CAPEX, OPEX, and Return on Investment

A detailed techno-economic assessment across all three sectors reveals a compelling but differentiated investment case. The table below summarizes end-use efficiency improvements the primary driver of operating cost savings across the principal electrification applications:

End Use	Gas Efficiency	Electric Efficiency	Key Technology
Cooking	40–50%	90–95%	Induction stove
Water Heating	50–60%	80–95%	Electric geyser
Space Heating	60–90%	COP 3–4 (300–400%)	Inverter AC / ASHP

At the household level, electric cooking appliances carry the highest upfront premium, costing 3–6 times more than equivalent gas stoves. Electric geysers, by contrast, carry comparable upfront costs to gas geysers, making water heating the lowest CAPEX-barrier entry point for residential electrification. Space heating via inverter AC units offers a near-zero additional CAPEX pathway for households already owning inverter systems, while Air Source Heat Pumps represent the largest affordability challenge. Across all appliances, full household electrification requires an estimated additional capital outlay of PKR 150,000–300,000 above equivalent gas appliance costs. Annual operating cost savings, driven by efficiency gains, are estimated at 50–70 percent of current household gas expenditure equivalent to PKR 30,000–84,000 per year assuming typical household gas spending of PKR 60,000–120,000 annually.

In the commercial segment, induction cooking systems require PKR 0.5–1.5 million per unit, electric water heating systems PKR 0.3–1.0 million, and ASHP space conditioning installations PKR 1.5–4.0 million. Operating cost reductions are estimated at 35–65 percent. The commercial sector's 38 MMCFD gas demand, if electrified, could generate an additional 2–3.5 TWh of annual productive electricity load (38 MMCFD is equivalent to about 13.9 billion cubic feet, or roughly 4 TWh of thermal energy, a year; at electric end-use efficiencies of 95–99 percent against 50–85 percent for gas appliances, this corresponds to about 2–3.5 TWh of electricity) a useful contribution to capacity utilization and fixed cost dilution. For the industrial segment, electric boilers for low-temperature process heat require PKR 5–20 million per unit, industrial induction heating systems PKR 10–50 million, and SME thermal process upgrades PKR 2–8 million. Electric technologies achieve thermal efficiencies of 95–99 percent versus 65–85 percent for gas-fired equivalents, and at prevailing LNG-linked industrial gas prices which have risen above PKR 2,500–3,000 per MMBtu, the operating savings case has materially strengthened over recent years.

Lifetime Cost and Simple Payback Analysis

The 10-year lifetime cost comparison is the most instructive measure of the electrification investment case at the household level:

Scenario	10-Year Cost (PKR M)	vs Gas Baseline
Gas System (Baseline)	0.89–0.95	—
Grid-only Electrification	1.39–1.82	+56–91% higher
Solar-assisted Electrification	0.20–0.53	78% lower ✓

Grid-only electrification without on-site solar generation results in a lifetime cost premium of 56–91 percent over a conventional gas household under current tariff structures, reflecting the adverse interaction between Pakistan's elevated electricity tariffs and the higher energy consumption of grid-supplied electric appliances relative to gas. Solar-assisted electrification fundamentally reverses this outcome: combining electric appliances with rooftop photovoltaic systems reduces the 10-year household energy cost to PKR 0.20–0.53 million, a saving of approximately 78 percent relative to the gas baseline of PKR 0.89–0.95 million. This establishes solar-assisted electrification as the financially dominant pathway. Simple payback and ROI across the residential scenarios are summarized below:

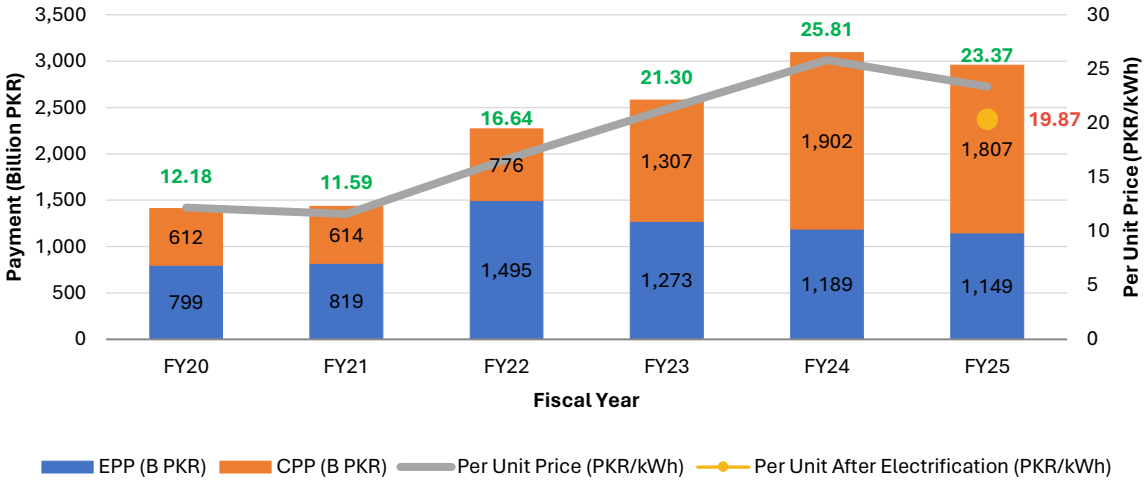
Case	Add. CAPEX (PKR)	Annual Saving (PKR)	Payback	ROI
Conservative	300,000	30,000	10 yrs	10%
Moderate	200,000	60,000	3–4 yrs	20–30%
Optimistic	150,000	84,000	1.8 yrs	40–55%

The wide range of returns reflects household energy expenditure levels and appliance mix. Water heating electrification consistently delivers the strongest standalone ROI given near-equivalent CAPEX and a 3–5 times improvement in energy efficiency. Leveraging existing inverter ACs for winter heating offers exceptional value given near-zero incremental CAPEX. Industrial and commercial investments follow a broadly similar logic at larger scale, with electric boiler and ASHP payback periods of 3–8 years and ROI of 15–40 percent under prevailing energy price conditions returns further strengthened by the ongoing rise in imported LNG costs.

Broader Strategic Value

Beyond direct financial returns, the electrification of households, commercial establishments, and industrial thermal processes delivers a set of compounding structural benefits that justify treating this as a priority national energy policy initiative. Partial electrification of the industrial sector's 536 MMCFD gas demand even at 20–30 percent conversion over a decade could generate 8–15 TWh of additional annual productive electricity demand, materially improving system load factors and reducing per-unit capacity costs. Gas volumes displaced from low-efficiency thermal applications can be redirected toward fertilizer production, where each MMCFD of conserved gas yields substantially higher national economic value. Reduced LNG and LPG import dependence would improve Pakistan's current account position and insulate the energy system from international fuel price volatility. Successful delivery requires DISCOs to provide timely connection approvals, feeder reinforcement, and transformer upgrades, supported by policy frameworks that offer transparent long-term electricity price signals and structured consumer financing for appliance transition.

Figure 9: Per Unit Price After Residential, Commercial and Industrial sector Electrification



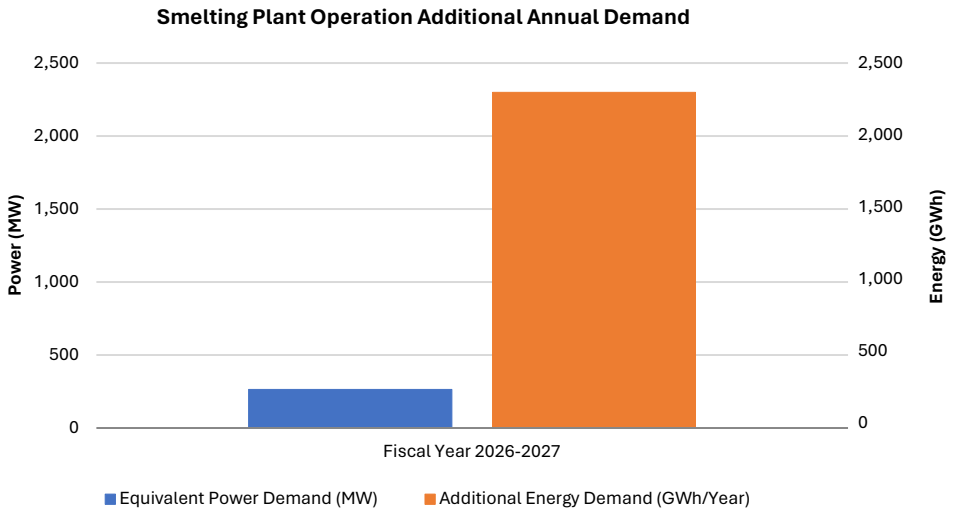
Industrial Base-Load Creation Through Reko Diq Mining, Copper Smelting, and Downstream Mineral Processing

Pakistan's mineral sector presents one of the largest untapped opportunities for creating productive industrial electricity demand. Historically, the country has exported mineral concentrates and low-value processed materials while capturing only a limited share of downstream value addition. The absence of large-scale domestic smelting and refining facilities means that substantial industrial activity, employment generation, export earnings, and electricity consumption occur outside Pakistan. Establishing domestic copper smelting, refining, and associated mineral-processing industries linked to the Reko Diq project would therefore create a significant new source of continuous industrial electricity demand while simultaneously increasing the value retained within the national economy.

The Reko Diq copper-gold project is among the largest undeveloped copper deposits in the world. According to the updated feasibility study completed in 2025, Phase 1 is expected to process approximately 45 million tonnes of ore annually beginning in 2028, while Phase 2 is expected to increase throughput to approximately 90 million tonnes annually by 2034. Over its operating life, the project is projected to produce approximately 13.1 million tonnes of copper and 17.9 million ounces of gold, positioning Pakistan among the world's significant copper-producing nations.

Large-scale copper mines derive most of their electricity demand from crushing, grinding, flotation, pumping, dewatering, and material-handling systems. International mining benchmarks indicate electricity consumption of approximately 15–25 kWh per tonne of ore processed for large porphyry copper operations. Applying a midpoint assumption of 20 kWh per tonne to the planned Phase 2 throughput of 90 million tonnes annually yields an estimated electricity requirement of approximately 1.8 TWh per year, equivalent to an average continuous electrical load of approximately 205 MW. Such demand alone would rank among the largest industrial electricity loads in Pakistan (Figure 10).

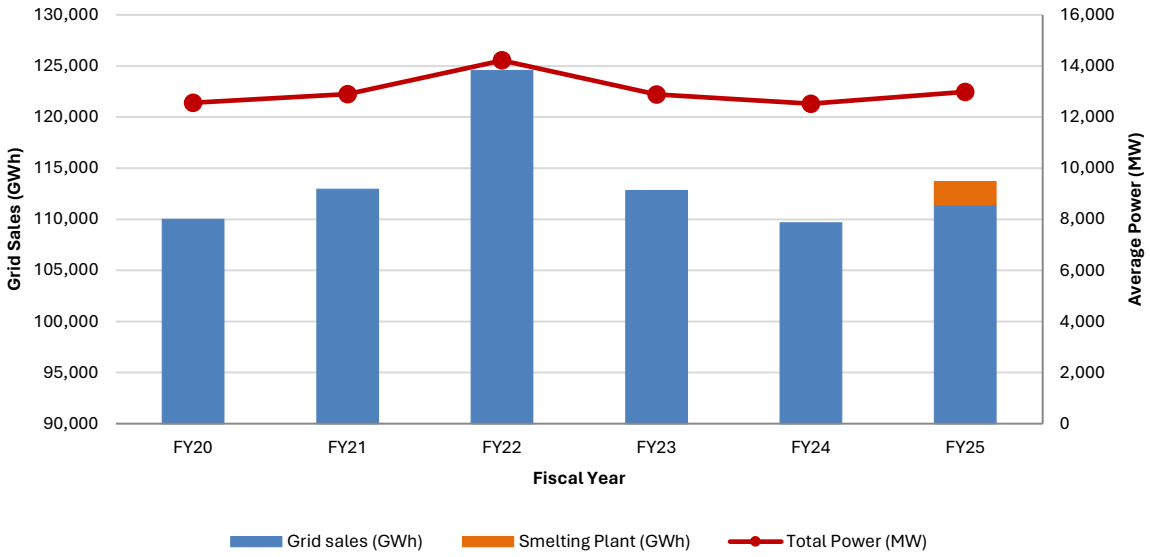
Figure 10: Smelting Plant Electrification – Operation (Energy Vs Power (99% Assumed Capacity))



The strategic opportunity extends beyond mining and concentration activities. Although current development plans focus primarily on concentrate production, Pakistan could substantially increase economic value addition and industrial electricity demand through domestic copper smelting and refining. At present, copper concentrates are typically exported for processing abroad, allowing foreign jurisdictions to capture the downstream industrial activity and associated economic benefits. A future world-scale copper smelter and refinery capable of processing approximately 400,000 tonnes of refined copper annually would require significant electricity consumption while enabling Pakistan to retain a larger share of the mineral value chain.

Using a conservative integrated electricity intensity of approximately 1,250 kWh per tonne of refined copper, such a facility would require roughly 500 GWh of electricity annually, corresponding to an average continuous load of approximately 57 MW. When combined with mining and concentration activities, the broader Reko Diq value chain including mineral processing, smelting, refining, sulfuric-acid production, oxygen-generation systems, and supporting industrial infrastructure could reasonably create approximately 2.3 TWh of annual electricity demand, equivalent to a continuous grid load of roughly 263 MW (Figure 11).

Figure 11: Electricity Sale after Smelting Plant



From a power-sector perspective, this demand profile is particularly valuable because mining and metallurgical facilities operate continuously throughout the year with relatively high load factors. Unlike residential consumption, which exhibits pronounced daily and seasonal variation, industrial base-load demand improves utilization of existing generation assets and spreads fixed system costs across a larger volume of electricity sales.

Using the FY25 baseline assumptions adopted throughout this report, Pakistan's power sector currently procures approximately 126,487 GWh annually at a blended Power Purchase Price (PPP) of PKR 23.37/kWh, comprising PKR 1,149 billion in variable energy purchase payments and PKR 1,807 billion in fixed capacity payments. Adding approximately 2.3 TWh of new industrial demand from the Reko Diq mining and metallurgical value chain would increase total electricity sales to approximately 128,787 GWh. At the prevailing variable procurement cost of PKR 9.08/kWh, this additional demand would increase annual variable energy expenditure by approximately PKR 20.9 billion. However, because fixed capacity-payment obligations remain unchanged, the larger sales base would allow these fixed costs to be recovered across a greater volume of electricity consumption.

Under these assumptions, the national blended Power Purchase Price would decline from PKR 23.37/kWh to approximately PKR 23.11/kWh, representing a reduction of approximately PKR 0.26/kWh or 1.1 percent. While modest in percentage terms, this reduction would apply across the entire electricity system and demonstrates the significant fiscal value of attracting large, continuous industrial loads to the national grid.

The long-term opportunity may be even larger. As downstream metallurgical industries expand including copper refining, precious-metal recovery, sulfuric-acid production, rare-earth separation, and other mineral-processing activities annual electricity demand associated with the broader Reko Diq industrial ecosystem could potentially exceed 3–4 TWh. Such growth would further dilute the annual PKR 1,807 billion fixed capacity-payment burden by spreading it across a larger electricity sales base, thereby reducing per-unit system costs and improving utilization of Pakistan's existing generation fleet.

Assuming a future integrated copper smelting and refining complex requires approximately US$2.0 billion in capital investment and generates annual operating margins of US$200–300 million, the indicative simple financial payback period would range between approximately 7 and 10 years. Actual project economics would depend on copper prices, treatment and refining charges, precious-metal recoveries, sulfuric-acid revenues, financing structures, and electricity tariffs. Nevertheless, the development of a domestic mining, smelting, and refining ecosystem centered on Reko Diq would represent one of Pakistan's largest opportunities for creating productive

industrial electricity demand while simultaneously strengthening exports, industrialization, and long-term power-sector sustainability.

Electrification of Cold Chain and Agricultural Tubewells: Implications for Energy Demand and Diesel Displacement

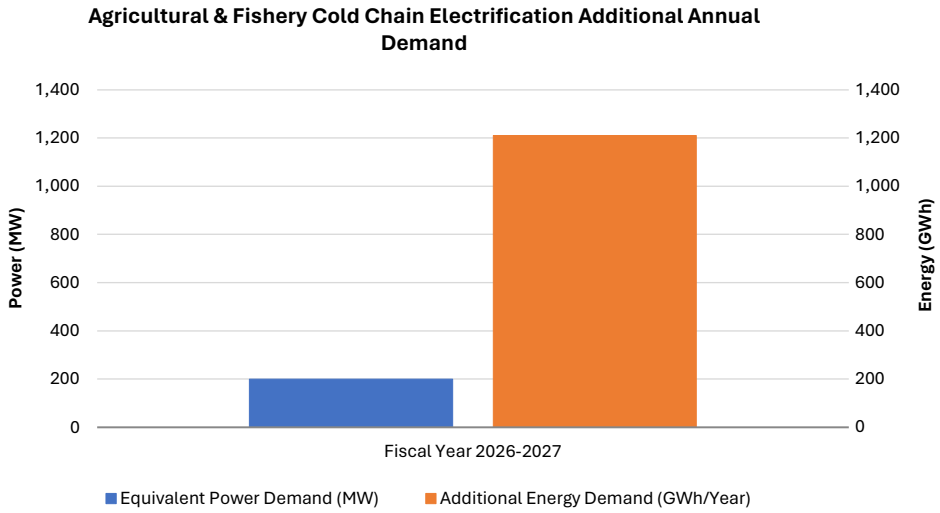
Electrification and energy-efficient modernization of cold storage, ice plants, processing units, and associated cold chain infrastructure in Pakistan's fisheries and agricultural sectors combined with large-scale solarization of diesel-powered agricultural tubewells would introduce a modest increase in grid electricity demand while replacing substantial diesel consumption. This transition addresses critical inefficiencies in the food supply chain, where post-harvest losses remain high (15–40%), irrigation costs are elevated due to diesel dependence, and rural energy access is unreliable. Many facilities currently rely on diesel generators or backup systems, particularly in coastal and off-grid agricultural regions.

Using the FY25 national electricity baseline (total electricity purchased ≈126,487 GWh; variable payment ≈1,149 billion PKR or 9.08 PKR/kWh; capacity payment ≈1,807 billion PKR; average tariff ≈23.37 PKR/kWh), the current energy use profile highlights inefficiencies across both fisheries and agriculture. In the fisheries sector, annual marine catch is approximately 690,600 metric tonnes, with around 82 processing plants consuming 64–147.6 GWh per year (520–667 kWh per tonne). Additionally, nearly 4,000 block ice plants operate at roughly 100 kWh per tonne, many of which are energy-inefficient and rely on diesel during outages. These constraints contribute to post-harvest losses of 15–35%.

In agriculture, annual fruit and vegetable production is approximately 13 million tonnes, yet cold storage capacity remains below 1 million tonnes, leading to losses of 35–40%. Irrigation is heavily dependent on diesel-powered tubewells: out of 1.3 million total units, approximately 1.08 million (83%) operate on diesel, consuming about 3.21 billion litres annually (≈2.7 million metric tonnes). These tubewells irrigate nearly 60% of cultivated land, with irrigation costs reaching approximately PKR 3,000 per acre per cycle, significantly increasing production costs and food prices.

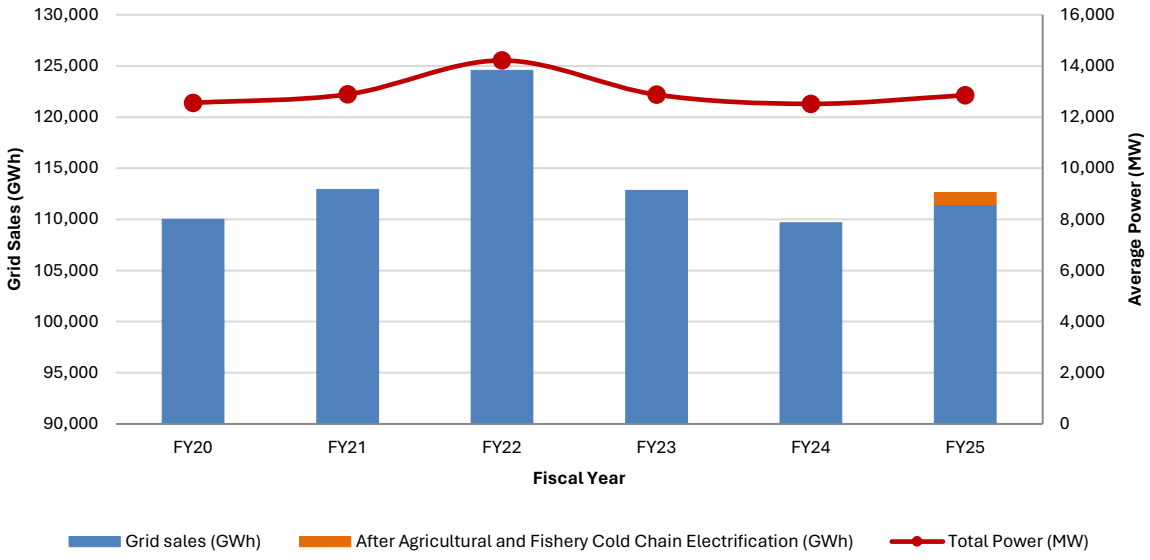
A combined electrification and modernization scenario includes: (i) upgrading and expanding cold chain infrastructure (including improved refrigeration efficiency and scaling storage capacity to 3–5 million tonnes), (ii) replacing diesel-based backup systems with reliable grid electricity, and (iii) solarizing diesel tubewells using dedicated off-grid photovoltaic (PV) systems (typically 10–15 kW per unit). Under this framework, tubewells operate independently of the grid, contributing no additional grid demand while fully displacing diesel use (Figure 12).

Figure 12: Cold Chain and Agricultural Tubewells (Energy Vs Power (70% Assumed Capacity))



The resulting increase in grid electricity demand remains modest. Fisheries cold chain modernization contributes approximately 100–200 GWh annually, while agricultural cold chain expansion adds approximately 800–1,200 GWh. In total, net additional grid demand is estimated at around 1,200 GWh per year, representing approximately 0.95% of current national electricity consumption. This increase is manageable within existing surplus generation capacity and does not require additional capacity payments (Figure 13).

Figure 13: Grid sales After Agricultural and Fishery Cold Chain Electrification



The impact on electricity tariffs is limited but favorable. With an additional 1,200 GWh of demand, total electricity consumption increases to approximately 127,687 GWh. Variable payments rise to around 1,159.9 billion PKR, while capacity payments remain fixed at 1,807 billion PKR. Total system payments reach approximately 2,966.9 billion PKR. As a result, the average per-unit electricity price declines slightly from 23.37 PKR/kWh to 23.24 PKR/kWh, reflecting a reduction of 0.13 PKR/kWh (approximately 0.56%) due to improved utilization of fixed capacity (Figure 14).

Beyond electricity system impacts, the intervention delivers substantial fuel savings and economic benefits. Solarization of 1.08 million diesel tubewells alone eliminates approximately 3.21 billion liters of diesel annually, equivalent to about 2.7 million metric tonnes and roughly US$2.2 billion in avoided fuel imports. Additional savings arise from reduced diesel use in cold chain backup systems. Furthermore, reducing post-harvest losses in agriculture (currently 35–40%) and fisheries (15–35%) translates into significant economic gains through improved product availability, higher export potential, and increased incomes for farmers and fishers. Irrigation costs decline sharply from approximately PKR 3,000 to around PKR 50 per acre per cycle under solar-powered systems, with typical payback periods of 2–3 years.

Importantly, the reduction of approximately US$2.2 billion in the fuel import bill also creates fiscal space for the government. This saving can be partially reallocated toward meeting power sector obligations particularly capacity payments which are a major driver of high electricity tariffs. By easing pressure on public finances and enabling more efficient servicing of fixed capacity costs, this mechanism can further contribute to downward pressure on per-unit electricity prices beyond the direct effect of increased electricity demand (Table 7).

Figure 14: Per Unit Price After Agricultural and Fishery Cold Chain Electrification

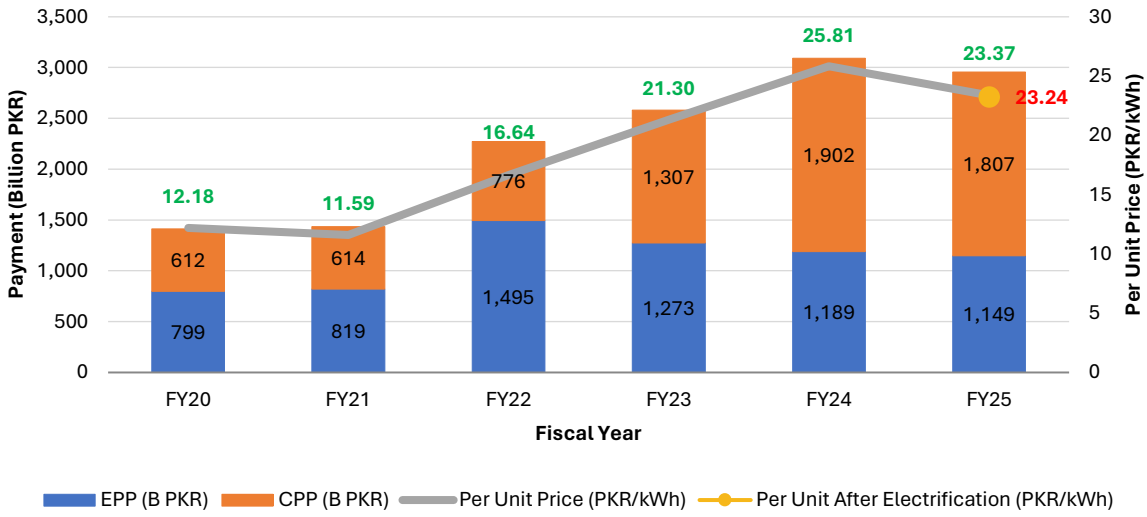


Table 7: Before vs. After: Electrification of Fisheries & Agricultural Cold Chains

Parameter	Before (FY25)	After (Electrified cold chain + solar tubewells)	Change / Impact
Total grid electricity demand (GWh)	126,487	127,687	+1,200 GWh (+0.95%)
Energy (variable) purchase (Bil. PKR)	1,149	1,159.9	+10.9 B
Capacity (fixed) purchase (Bil. PKR)	1,807	1,807	No change (diluted)
Total purchase payment (Bil. PKR)	2,956	2,966.9	+10.9 B net
Per-unit price (PKR/kWh)	23.37	23.24	↓0.13 (–0.56%)
Diesel consumption (cold chain + tubewells)	High (incl. 3.21B litres tubewells)	Substantially reduced	Saved: 3.21B litres/year + cold chain diesel
Post-harvest losses / irrigation cost	High losses; ~PKR 3,000/ acre	Reduced losses; ~PKR 50/acre	Major economic gains

Overall, this intervention demonstrates that targeted electrification of productive sectors, combined with strategic off-grid solar deployment, can deliver high economic returns with minimal stress on the national grid. While the increase in electricity demand is modest, the reduction in diesel consumption is substantial, directly alleviating pressure on Pakistan's fuel import bill and improving energy security. Simultaneously, enhanced cold chain infrastructure reduces food losses and strengthens supply chains, while solar-powered irrigation lowers production costs and supports rural livelihoods.

Importantly, the associated reduction in the fuel import bill particularly from large-scale tubewell solarization creates fiscal space for the government to better service power sector liabilities, including capacity payments. Improved management of these fixed costs can contribute to a reduction in per-unit electricity tariffs (PKR/kWh). Lower tariffs, in turn, can incentivize consumers and businesses currently relying on diesel or off-grid alternatives to shift back toward grid electricity, thereby increasing demand, improving capacity utilization, and reinforcing a virtuous cycle of tariff reduction and system efficiency. This approach complements broader electrification strategies by combining grid-based efficiency gains with decentralized renewable solutions, maximizing both economic and environmental benefits.

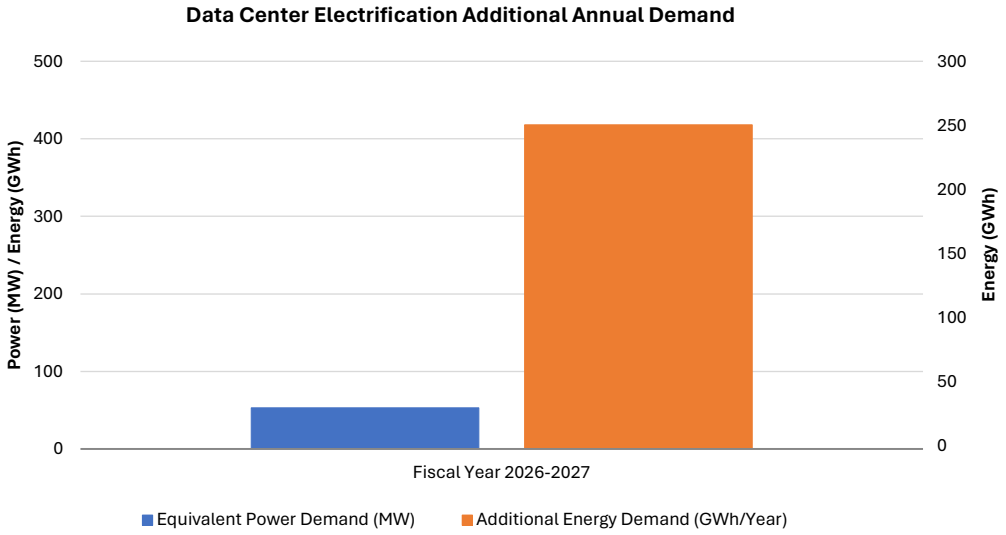
Electrification through Data Centers and Digital Infrastructure Growth

The expansion of advanced digital infrastructure and private-sector data-center investment represents an emerging baseload electrification opportunity capable of improving grid utilization while supporting Pakistan's broader digital-economy objectives. Global hyperscale cloud operators including Google Cloud, Microsoft Azure, Amazon Web Services, and Meta continue expanding across emerging digital markets. Pakistan could potentially position itself as a future regional hosting destination if reliability, policy certainty, and power-quality standards improve sufficiently.

Data centers are particularly valuable electricity consumers because they operate as continuous 24-hour baseload demand with uptime requirements typically exceeding 99.99 percent. This load profile improves utilization of underused generation assets and supports more stable system dispatch compared to highly seasonal or volatile demand segments.

Pakistan's data-center market remains at an early stage of development. Current installed IT load is estimated at approximately 23.5 MW in 2025, with projections indicating growth to approximately 53 MW by 2030 (Figure 15), reflecting strong underlying digital-demand growth driven by cloud adoption, enterprise digitalization, and expanding broadband infrastructure. Existing facilities are concentrated primarily in Karachi, Lahore, and Islamabad and are dominated by Tier III colocation and enterprise-hosting infrastructure. Recent federal policy announcements indicating potential allocation of up to 2,000 MW for AI-computing and digital-load development reflect emerging policy interest in directing surplus generation capacity toward higher-value digital industrial growth.

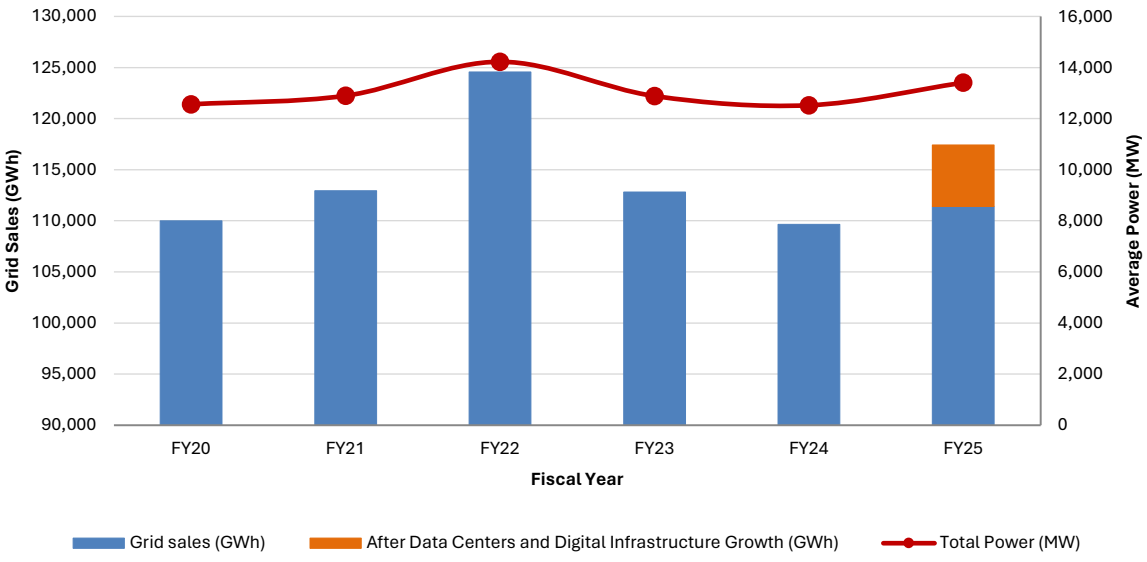
Figure 15: Data Center (Energy Vs Power (90% Assumed Capacity))



Realizing large-scale international investment will depend primarily on addressing electricity reliability and power-quality constraints. Dedicated feeders, special economic-zone infrastructure, transmission redundancy, and industrial-grade service guarantees would be essential prerequisites for attracting major hyperscale deployments.

Under a realistic medium-term scenario, Pakistan could attract approximately 150–400 MW of incremental IT load through a combination of colocation expansion, sovereign-cloud hosting, enterprise digital migration, AI-computing services, and selected international investment. Accounting for cooling and auxiliary infrastructure at Power Usage Effectiveness (PUE) ratios of 1.5–1.8, this would translate into approximately 2,000–6,000 GWh of additional annual electricity demand (Figure 16).

Figure 16: Grid Sales After Data Centers and Digital Infrastructure Growth



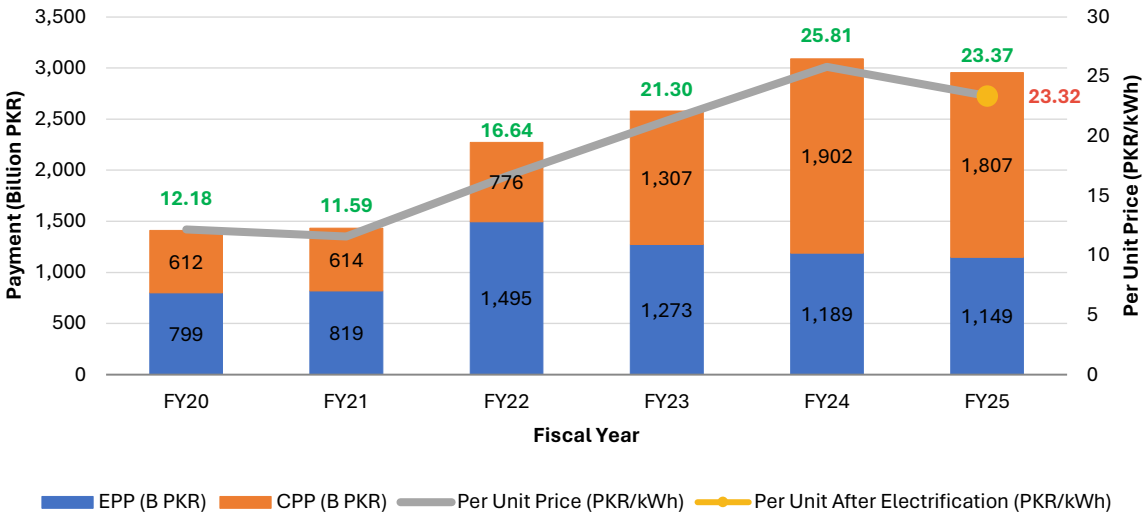
Using Pakistan's FY25 electricity-purchase baseline of approximately 126.5 TWh at an average bulk system cost of PKR 23.37 per kilowatt-hour, this incremental baseload demand could theoretically reduce average bulk power-purchase costs by approximately PKR 0.2–0.6 per kilowatt-hour through improved dilution of fixed capacity payments. Figure 17 illustrates a higher-uptake case of about 10 TWh a year, which would lower the average cost to approximately PKR 22.32 per kilowatt-hour.

Beyond direct tariff effects, successful digital-infrastructure expansion would deliver substantial strategic economic benefits. These include attraction of foreign direct investment, development of cloud-computing ecosystems, expansion of AI-processing capability, creation of high-skilled technical employment, and strengthened digital sovereignty.

Private-sector discussions around pilot computing and digital-processing deployments indicate emerging interest in locating energy-intensive digital infrastructure in regions with competitively priced electricity; however, large-scale deployment remains contingent on reliable industrial-grade power availability.

The principal barriers remain power reliability, voltage-quality consistency, regulatory certainty, and competitive electricity pricing. Accordingly, data-center electrification should be treated as a targeted industrial-demand strategy requiring dedicated infrastructure and selective policy reform rather than a near-term mass-demand intervention.

Figure 17: Per Unit Price After Data Centers and Digital Infrastructure Electrification



De-dieselization of Telecom Towers: Converting Backup Load into Productive Grid Demand

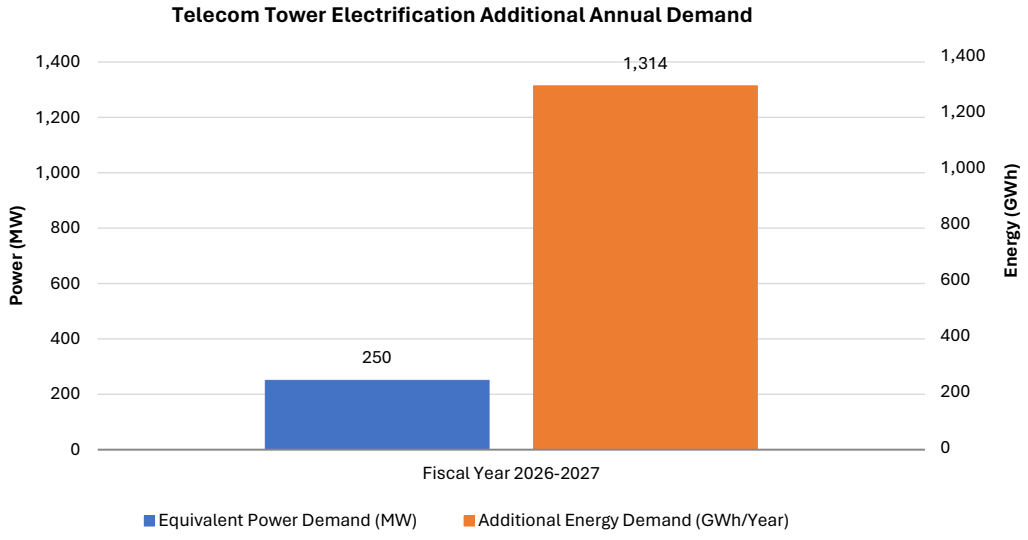
De-dieselization of telecom towers shifting from diesel generators to reliable grid electricity or grid-tied hybrid systems represents a high-impact strategy to increase metered electricity demand while eliminating a major source of diesel consumption in Pakistan. Telecom towers require uninterrupted 24/7 power to sustain network operations, and due to frequent grid outages, operators rely heavily on diesel generators. Converting this backup-dependent system into a stable grid-connected load transforms a costly, imported energy source into productive domestic electricity consumption.

Pakistan currently hosts approximately 58,000 mobile cell sites (58,423 as of June 2025), a number that continues to grow with network expansion and anticipated 5G rollout. These towers consume approximately 350 million litres of diesel annually (a conservative estimate; the Alternative Energy Development Board has put the sector's diesel use as high as 1.2 billion litres a year), making the telecom sector one of the largest single consumers of diesel in the country. This heavy reliance on diesel arises from unreliable grid supply, requiring continuous generator operation to maintain service continuity for about 197 million cellular subscribers.

Using the FY25 national electricity baseline (total electricity purchased ≈126,487 GWh; variable payment ≈1,149 billion PKR or 9.08 PKR/kWh; capacity payment ≈1,807 billion PKR; average tariff ≈23.37 PKR/kWh), telecom towers represent an ideal candidate for electrification due to their steady, non-seasonal, baseload demand profile. Typical tower consumption ranges between 2–5 kW, with an average of approximately 3–4 kW under continuous operation. Assuming efficiency improvements and hybrid integration, the transition to grid electricity would add an estimated 1,300 GWh per year to national demand, equivalent to about 1.03% of current electricity consumption (Figure 18).

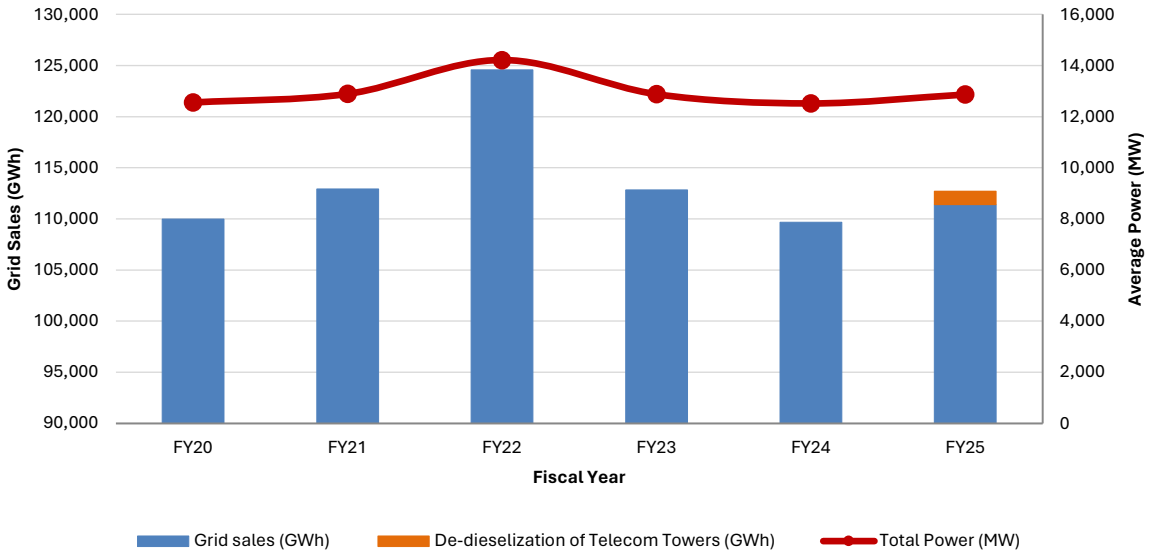
This additional demand can be readily absorbed within Pakistan's existing surplus generation capacity (estimated at 16,000–18,000 MW), without requiring new capacity investments. Importantly, telecom towers provide consistent 24/7 demand, which improves system load factors and enhances utilization of underused generation assets.

Figure 18: Telecom Tower Electrification (Energy Vs Power (60% Assumed Capacity))



The impact on electricity tariffs is modest but positive. With an additional 1,300 GWh of demand, total electricity consumption increases to approximately 127,787 GWh. Variable payments rise to about 1,160.8 billion PKR, while capacity payments remain unchanged at 1,807 billion PKR. Total system payments reach approximately 2,967.8 billion PKR. As a result, the average per-unit electricity price declines slightly from 23.37 PKR/kWh to 23.23 PKR/kWh, reflecting a reduction of 0.14 PKR/kWh (approximately 0.60%) due to improved spreading of fixed costs (Figures 19 and 20).

Figure 19: Grid Sales De-dieselization of Telecom Towers



Beyond electricity system impacts, the intervention yields significant fuel savings and operational benefits. Eliminating approximately 350 million litres of diesel annually (≈290,000–300,000 tonnes) generates direct foreign exchange savings and reduces one of the largest concentrated sources of diesel consumption in the country. These savings also create fiscal space for the government, which can be partially redirected toward servicing power sector capacity payments. This, in turn, can exert additional downward pressure on electricity tariffs (PKR/kWh). Lower tariffs improve affordability and can incentivize further migration of diesel-dependent or off-grid users toward the grid, reinforcing demand growth and improving system efficiency (Table 8).

Figure 20: Per Unit Price After Telecom Towers Electrification

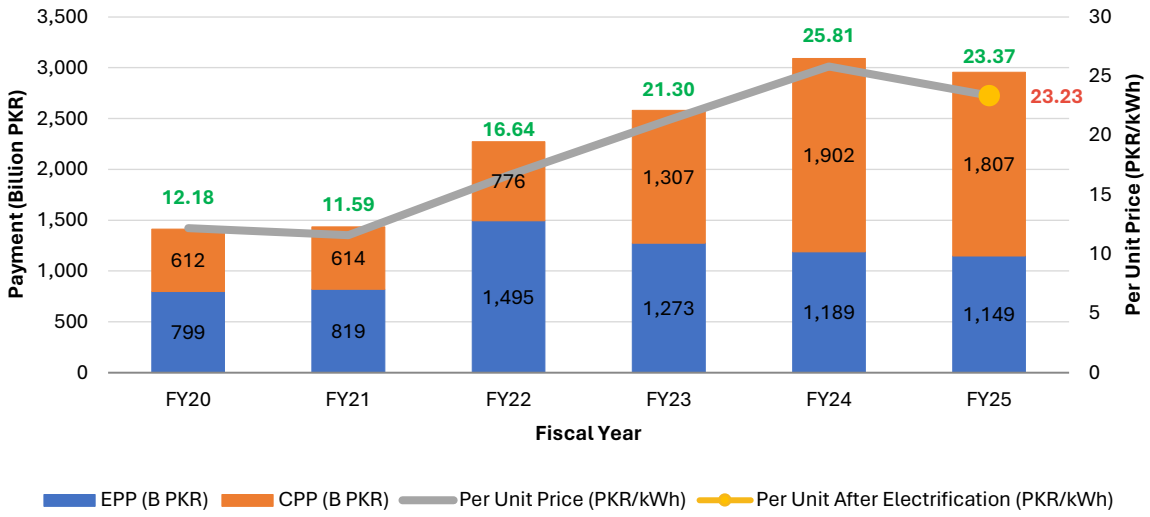


Table 8: Summary — Before vs. After Telecom Tower De-dieselization

Parameter	Before (FY25)	After (Telecom towers electrified)	Change / Impact
Total electricity demand (GWh)	126,487	127,787	+1,300 GWh (+1.03%)
Energy (variable) purchase (Bil. PKR)	1,149	1,160.8	+11.8 B
Capacity (fixed) purchase (Bil. PKR)	1,807	1,807	No change (diluted)
Total purchase payment (Bil. PKR)	2,956	2,967.8	+11.8 B net
Per-unit price (PKR/kWh)	23.37	23.23	↓0.14 (–0.60%)
Diesel consumption (telecom towers)	350 million liters/year	Near zero	Saved: 350M liters/year

Overall, de-dieselization of telecom towers converts a large, inefficient diesel-based backup system into a stable and productive source of grid demand. While the increase in electricity consumption is modest, its baseload nature delivers outsized benefits for system utilization and tariff reduction. At the same time, the elimination of diesel use reduces import dependence, lowers operational costs for telecom operators, and improves network reliability critical for Pakistan's rapidly expanding digital economy.

Electrification of Pakistan Railways Main Lines: Strategic Demand Creation and Long-Term Cost Implications

Electrification of Pakistan Railways' three principal corridors—ML-1 (Karachi–Peshawar, approximately 1,733 km), ML-2 (Kotri–Attock, approximately 1,254 km), and ML-3 (Rohri–Quetta–Taftan, approximately 996 km)-represents one of Pakistan's most significant long-term strategic electrification opportunities. These corridors carry the majority of the country's passenger and freight traffic and therefore offer the highest operational value for phased traction electrification. Their conversion from diesel-based propulsion to electric traction would contribute to national objectives of transport modernization, reduced imported fuel dependence, productive electricity demand creation, and improved utilization of fixed power-sector capacity.

Pakistan's electricity system currently procures approximately 126,487 GWh annually at an average blended system cost of PKR 23.37 per kilowatt-hour, comprising PKR 1,149 billion in variable energy purchase payments and PKR 1,807 billion in fixed capacity payments. This implies a variable energy cost of approximately PKR 9.08 per kilowatt-hour and a fixed capacity burden of PKR 14.29 per kilowatt-hour. Since capacity payments remain largely fixed irrespective of dispatched electricity volumes, productive growth in electricity consumption improves system utilization by spreading these fixed obligations across a larger sales base.

Pakistan Railways currently consumes approximately 350,000 litres of high-speed diesel per day, equivalent to approximately 127.75 million litres annually. Electrification of ML-1, ML-2, and ML-3 would progressively displace the majority of this diesel consumption. Applying a conservative traction-conversion equivalence of approximately 4 kilowatt-hours of electricity per litre of diesel displaced, annual electricity demand created through corridor electrification is estimated at approximately 511 GWh. This would increase national electricity offtake from 126,487 GWh to approximately 126,998 GWh, representing a modest system-wide increase of approximately 0.4 percent.

At prevailing energy purchase rates, this incremental electricity demand would increase annual variable procurement costs by approximately PKR 4.6 billion, raising total annual system expenditure to approximately PKR 2,960.6 billion. Since fixed capacity payments would remain unchanged, the average blended system tariff would decline modestly from PKR 23.37 per kilowatt-hour to approximately PKR 23.31 per kilowatt-hour. This represents an absolute reduction of PKR 0.06 per kilowatt-hour, or approximately 0.26 percent (Figure 21).

While the immediate tariff reduction effect is modest, the broader strategic economic gains are substantially more significant. At a prevailing diesel price of approximately PKR 400 per litre, displacement of approximately 127.75 million litres annually would generate direct fuel-cost savings of approximately PKR 51.1 billion per year. Electric traction also significantly reduces locomotive maintenance and lifecycle operating costs due to lower mechanical complexity, higher drivetrain efficiency, and reduced servicing requirements. Conservatively estimated maintenance savings of PKR 10–16 billion annually increase total direct annual operational savings to approximately PKR 61–67 billion.

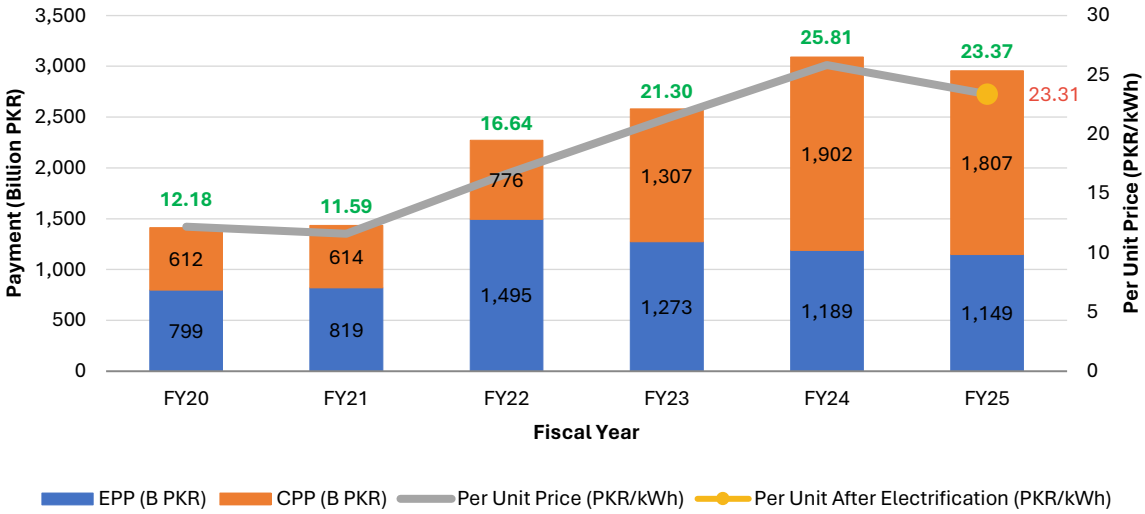
Using an indicative exchange rate of PKR 280 per US dollar, these savings correspond to approximately US$218–239 million annually. Based on the revised officially agreed ML-1 modernization cost of approximately US$6.678 billion, and accounting for electrification-specific systems and phased extension to ML-2 and ML-3—including traction substations, overhead electrification systems, signaling integration, transmission reinforcement, and rolling stock conversion a complete national mainline electrification program would likely require approximately US$8.8–11.0 billion in phased capital expenditure.

Based on annual operational savings of US$218–239 million, the indicative simple financial payback period would range from approximately 37 to 50 years. This extended recovery horizon demonstrates that railway electrification should not be evaluated solely as a short-term financial-return or tariff-reduction intervention. Its principal value lies in strategic infrastructure modernization, reduced foreign exchange exposure to imported petroleum volatility, freight-sector productivity gains, compatibility with higher-speed rail operations, and long-term structural strengthening of both Pakistan's railway and electricity systems.

Key Benefits of Railway Electrification:

- Diesel eliminated on ML-1, ML-2, ML-3 - saving ~127.75 million litres/year
- Per-unit electricity price reduced from 23.37 → 23.31 PKR/kWh (–0.26%)
- ML-1, ML-2, and ML-3 would add roughly 511 GWh of annual electricity demand
- Locomotive maintenance costs reduced by 50–70%
- Travel speeds targeting 160+ km/h on ML-1 upgrades
- Significant foreign exchange savings from fuel import displacement
- ML-1 modernization cost of approximately US$6.678 billion
- Indicative simple financial payback period would range from approximately 37 to 50 years

Figure 21: Per Unit Price After Railway Electrification



From a power-sector perspective, railway electrification introduces a predictable and productive electricity demand profile that improves utilization of underused generation capacity, particularly during off-peak dispatch periods. It also eliminates direct diesel combustion across core freight and passenger corridors, reducing transport-sector emissions and improving local air quality. It is important to recognize that while Pakistan's aggregate generation fleet may absorb this incremental electricity demand, implementation would require substantial corridor-specific infrastructure upgrades, including dedicated traction substations, transmission interconnection reinforcement, overhead catenary systems, rolling-stock replacement or retrofitting, and modernization of operational dispatch and signaling systems. Accordingly, railway electrification should be treated as a phased strategic national infrastructure intervention rather than an immediate tariff optimization mechanism.

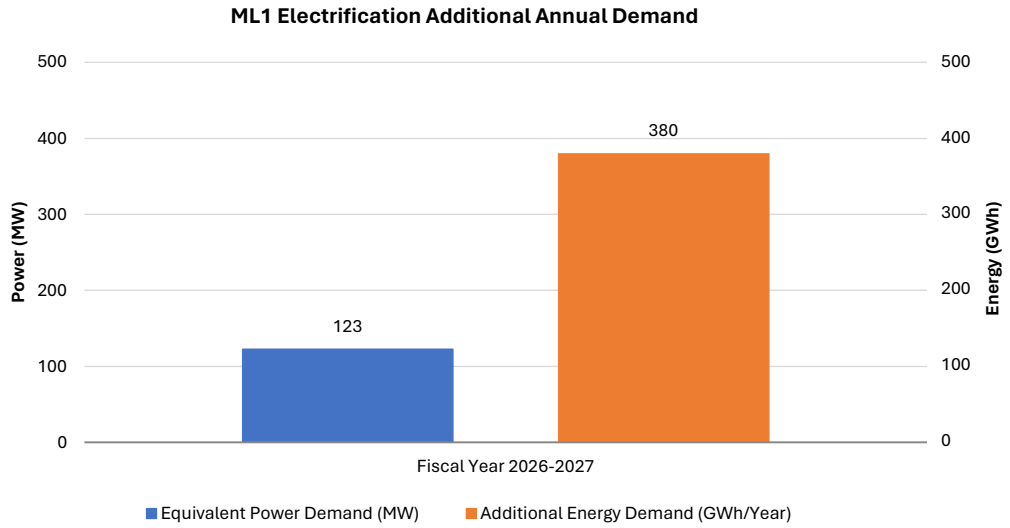
Its strongest justification lies in supporting Pakistan's long-term transport electrification pathway, strengthening national energy security, reducing dependence on imported liquid fuels, and enabling structural modernization of both the transport and electricity sectors. Within a phased national electrification strategy, railway electrification should therefore be viewed as a foundational infrastructure investment with durable economic and systemic benefits rather than a standalone short-term tariff-reduction measure.

While full electrification of Pakistan Railways' ML-1, ML-2, and ML-3 corridors represents a major long-term strategic infrastructure initiative, the electrification of the Karachi–Peshawar Main Line-1 (ML-1) corridor can also be evaluated as a standalone investment focused exclusively on traction electrification infrastructure. This approach excludes broader railway modernization expenditures—including track rehabilitation, dualization, signaling modernization, station upgrades, grade separations, and rolling stock procurement and instead concentrates solely on the fixed electrical systems required for electric train operations.

ML-1 extends approximately 1,726–1,733 km and carries the majority of Pakistan Railways' passenger and freight traffic. The dedicated electrification infrastructure would consist primarily of a 25 kV AC overhead catenary system (OCS), traction substations, sectioning and paralleling stations, transmission interconnections, SCADA and control systems, signaling modifications, and associated grid reinforcements. Railway electrification studies conducted for Pakistan and comparable regional railway systems indicate that the capital cost of fixed electrification infrastructure represents only a fraction of the overall railway modernization cost. Based on available ML-1 electrification assessments and updated cost escalation assumptions, a dedicated electrification investment of approximately US$2.0 billion is considered a reasonable planning estimate.

Pakistan Railways currently consumes approximately 350,000 litres of high-speed diesel (HSD) per day, equivalent to approximately 127.75 million litres annually. Given that ML-1 carries roughly 75 percent of total railway traffic, approximately 95.8 million litres of annual diesel consumption can reasonably be attributed to this corridor. Applying the same traction-conversion factor used throughout this report 4 kWh of electricity per litre of diesel displaced electrification of ML-1 would create approximately 383 GWh of additional annual electricity demand. Under the FY25 baseline variable energy procurement cost of PKR 9.08/kWh, this additional demand would require approximately PKR 3.48 billion annually in electricity purchases (Figures 22 and 23).

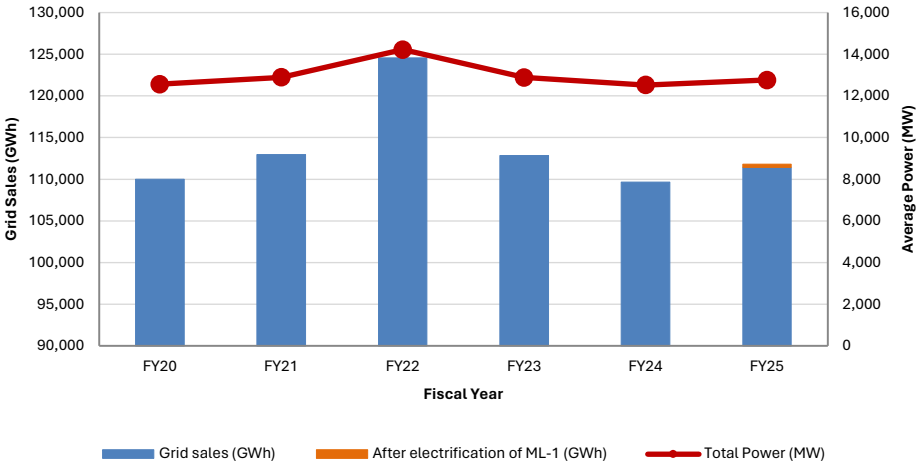
Figure 22: ML1 Electrification (Energy Vs Power (35% Assumed Capacity))



At an assumed diesel price of PKR 400 per litre, displacement of approximately 95.8 million litres of HSD would generate gross fuel-cost savings of approximately PKR 38.3 billion annually. After deducting the incremental electricity procurement cost, net fuel savings amount to approximately PKR 34.8 billion per year. Electric traction also substantially reduces locomotive maintenance and lifecycle operating costs due to lower mechanical complexity, improved drivetrain efficiency, and reduced servicing requirements. Applying a proportional share of the network-wide maintenance savings yields an additional PKR 7.5–12.0 billion annually in operational savings. Consequently, total annual financial benefits generated by ML-1 electrification are estimated at approximately PKR 42.3–46.8 billion per year.

Using the report assumption of PKR 280 per US dollar, these savings are equivalent to approximately US$151–167 million annually. Relative to an electrification-specific capital cost of US$2.0 billion, the resulting simple financial payback period is estimated at approximately 12.0–13.2 years. This recovery horizon is significantly shorter than the payback period associated with the complete ML-1 modernization project and demonstrates that the fixed traction electrification component can be economically justified on its own merits. Beyond direct financial returns, ML-1 electrification would reduce petroleum imports, improve railway operating efficiency, strengthen national energy security, and create a stable source of productive electricity demand capable of improving utilization of existing generation assets.

Figure 23: Grid Sales After electrification of ML-1



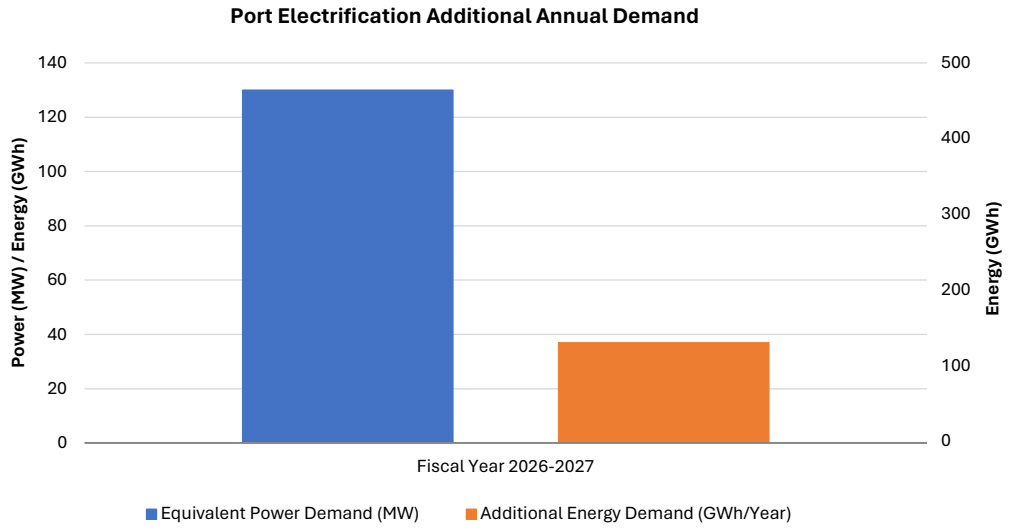
Port Electrification: Productive Electricity Demand

Electrification of Pakistan's two principal maritime gateways Karachi Port Trust (KPT) and Port Qasim Authority (PQA)—represents an important opportunity to expand productive electricity demand while reducing dependence on imported petroleum products. Together, these two ports handle more than 90 percent of Pakistan's international seaborne trade and operate continuously throughout the year, making them among the country's highest-load-factor industrial facilities. Replacing diesel-powered cargo-handling equipment with electric alternatives and introducing shore power (cold ironing) for berthed vessels would simultaneously improve port efficiency, reduce fuel imports, create additional electricity demand, and improve utilization of Pakistan's existing power-generation capacity.

Electrification opportunities at Pakistan's ports fall into two complementary categories. The first involves replacing diesel-powered Rubber-Tyred Gantry (RTG) cranes, reach stackers, forklifts, and terminal tractors with electric or hybrid-electric equipment. The second involves installation of shore power systems that allow ships berthed at port to switch off onboard auxiliary diesel generators and receive electricity directly from the national grid. While terminal electrification primarily generates savings through reduced diesel consumption and lower operating costs, shore power creates an additional source of electricity demand while improving local air quality and providing a new revenue stream for port authorities.

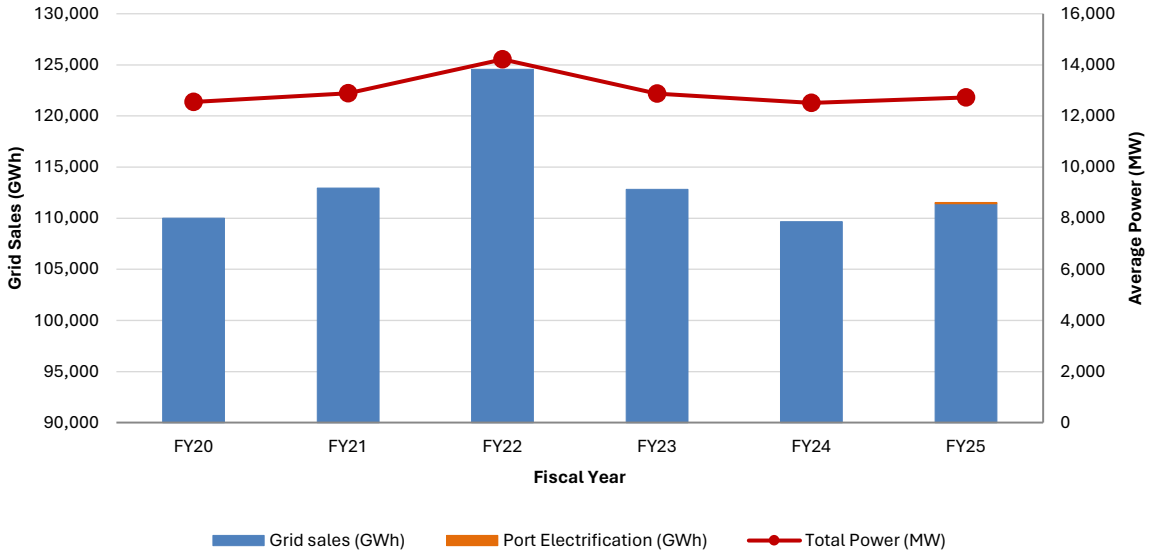
Karachi Port handled a record 54 million tonnes of cargo, approximately 2.65 million TEUs, and 1,943 vessel calls during FY2024–25, a cargo record it surpassed again in FY2025–26 with more than 2,000 vessel calls, while Port Qasim continues to serve as Pakistan's principal bulk cargo, LNG, coal, and industrial port. Combined, both ports are estimated to receive approximately 3,500–4,200 vessel calls annually. Comprehensive operational fuel consumption data for Pakistan’s cargo-handling equipment fleets are not publicly available. However, two grounding data points support a reasoned estimate. First, energy-intensity benchmarks from a detailed four-port U.S. Maritime Administration study show cargo-handling equipment demand of 18–110 kWh per TEU (mean ≈57 kWh/TEU) and shore power demand of 36–81 kWh per TEU (mean ≈51 kWh/TEU) across Baltimore, Port Everglades, Houston, and Seattle. Applying these ranges to Karachi Port’s FY2024-25 throughput of approximately 2.65 million TEU implies a plausible range of 48–292 GWh/year for cargo-handling electrification and 95–215 GWh/year for container-vessel shore power, before adjusting for Pakistan’s currently lower equipment automation and cold-ironing readiness compared to U.S. terminals. Second, the only published primary fuel-consumption data for Pakistani ports from KPT and PQA records analyzed harbour-craft (dredgers, tugs, barges, floating cranes, ferry boats) diesel/petrol consumption of 1,122.60 tonnes at KPT and 722.97 tonnes at PQA in FY2021-22 (equivalent to roughly 1.3 million and 0.85 million litres respectively).

Figure 24: Port Electrification (Energy Vs Power (40% Assumed Capacity))



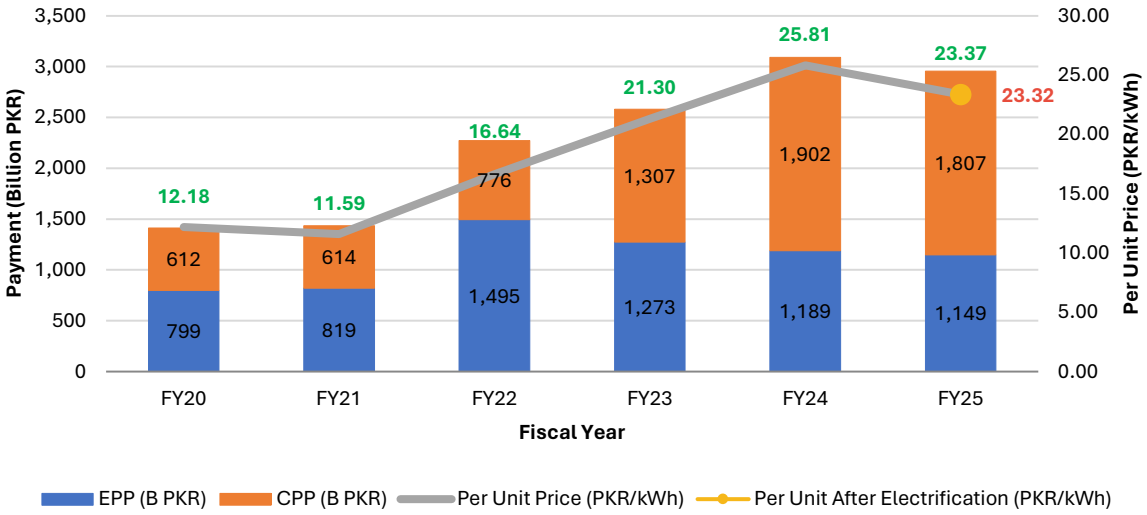
While this covers port-operations craft rather than cargo-handling equipment or vessel auxiliary engines, it confirms that metered, government-sourced port energy data exists in principle and can serve as a baseline for future audits. Reconciling the international per-TEU benchmarks with Pakistan's lower automation intensity and the modest scale shown by the KPT/PQA harbour-craft data, this report adopts a conservative central estimate of approximately 130 GWh/year of additional electricity demand from combined cargo-handling and shore power electrification (range: 70–210 GWh/year), while noting that the upper end of the internationally benchmarked range (up to ~500 GWh/year if U.S.-level shore power uptake were achieved at Karachi Port alone) represents the long-run ceiling once full automation and mandatory cold-ironing policies are implemented (Figures 24 and 25).

Figure 25: Grid Sales After electrification of Ports



Relative to Pakistan's annual electricity injection of approximately 124,000 GWh, full port electrification represents less than 0.2 percent of total national electricity demand. Consequently, the direct impact on the national Power Purchase Price is modest. Applying the same capacity-payment dilution methodology used throughout this report indicates that port electrification would reduce the average PPP by approximately PKR 0.01–0.05/kWh, generating annual system-wide savings of approximately PKR 2–7 billion through improved utilization of existing generation capacity. Although this tariff reduction is relatively small, it demonstrates how productive industrial demand contributes incrementally to reducing the burden of fixed capacity payments (Figure 26).

Figure 26: Per Unit Price After Ports Electrification



The project economics are considerably more attractive from the perspective of port operators. Electrification of cargo-handling equipment is estimated to eliminate approximately 6–10 million litres of High-Speed Diesel annually, depending on the level of deployment a range consistent with applying international cargo-handling energy-intensity benchmarks of 18–110 kWh/TEU (Schenk et al., 2020) to Karachi Port's container throughput, and bounded on the low side by the confirmed order of magnitude of KPT and PQA's own reported harbour-craft fuel consumption of 1,122.60 and 722.97 tonnes/year respectively, the only audited, primary-source fuel data currently published for Pakistan's ports, albeit for a narrower equipment category than cargo-handling machinery. At prevailing diesel prices, eliminating 6–10 million litres translate into approximately PKR 1.2–2.0 billion in annual net operating cost savings after accounting for electricity consumption. Since High-Speed Diesel remains a significant imported petroleum product, these savings also reduce Pakistan's foreign exchange requirements by approximately US$5–9 million annually. Electric equipment further reduces maintenance costs because of its simpler mechanical design, higher drivetrain efficiency, and lower servicing requirements.

Installation of shore power infrastructure produces a different set of economic benefits. Rather than reducing domestic diesel consumption, shore power allows ports to sell electricity directly to visiting vessels, generating additional operating revenue while significantly reducing emissions from auxiliary engines operating at berth. International benchmarks indicate shore power demand of 36–81 kWh per TEU for containerized vessel calls (Schenk et al., 2020), which applied to Karachi Port's container throughput corresponds to the 95–215 GWh/year upper component of the demand range used in this report. Depending on utilization rates and tariff structures, annual revenue generated from shore power services is estimated to range between PKR 0.6 billion and PKR 3.3 billion, while simultaneously improving air quality within Karachi's port area and reducing greenhouse gas emissions.

Achieving full electrification would require investment in both electric cargo-handling equipment and supporting electrical infrastructure. Total investment requirements are estimated at approximately US$115–240 million, with a central estimate of US$180 million, equivalent to roughly PKR 51 billion at an exchange rate of PKR 282 per US dollar. Because cargo-handling equipment is periodically replaced during normal operational cycles, only the incremental cost of selecting electric rather than diesel equipment is considered for the terminal fleet, whereas shore power requires entirely new electrical infrastructure including substations, transformers, frequency converters, and high-voltage berth connections.

Combining the operating savings from terminal electrification with revenues generated through shore power results in an estimated project payback period of approximately 13–18 years, depending on the deployment

scenario. However, the economics differ significantly between the two components. Terminal equipment electrification alone achieves a payback period of approximately 11 years, making it commercially attractive within normal equipment replacement cycles. Shore power infrastructure exhibits a substantially longer recovery period of approximately 20 years and is therefore more likely to require environmental regulation, green shipping incentives, or concessional climate finance to become financially attractive, consistent with international experience.

From a national power-sector perspective, port electrification represents another source of predictable, productive industrial electricity demand that complements other demand-growth strategies discussed throughout this report, including railway electrification, electric vehicles, industrial captive-power conversion, Special Economic Zones, and agricultural electrification. Although the standalone impact on national electricity tariffs is relatively modest because of the size of Pakistan's electricity market, the cumulative effect of multiple productive demand sources can materially improve utilization of existing generation assets while reducing the effective burden of fixed capacity payments.

The principal uncertainties relate to future diesel prices, industrial electricity tariffs, and exchange-rate movements. On data availability, this report's estimates are now anchored to two independent sources: internationally validated per-TEU energy benchmarks from a peer-reviewed four-port U.S. study (Schenk et al., 2020), and Pakistan's only published primary-source port fuel data, drawn directly from KPT and PQA records. The latter, however, covers harbour craft rather than cargo-handling equipment or vessel auxiliary engines, so a genuine gap remains at the equipment level most relevant to electrification investment decisions. Accordingly, the first priority should still be a detailed metered energy and fuel audit at Karachi Port and Port Qasim specifically of cargo-handling fleets and vessel shore-power draw to narrow the current 70–210 GWh range to a single defensible baseline for investment decisions. Electrification should then be implemented in phases, beginning with cargo-handling equipment during routine fleet replacement and subsequently expanding to shore power at the busiest container berths.

Within Pakistan's broader energy transition strategy, port electrification should therefore be regarded as a practical and commercially viable industrial electrification initiative that strengthens energy security, reduces imported fuel consumption, supports environmental objectives, and contributes incrementally to long-term capacity-payment dilution across the national electricity sector.

Combined Electrification Impact: System-Level Analysis

The combined electrification strategy presented in this chapter spanning railway electrification (with ML-1 as the initial priority corridor), public transport electrification through deployment of 5,000 electric buses in Punjab, accelerated electric-vehicle adoption under the National Electric Vehicle Policy, phased gas-to-grid conversion across residential, commercial, and industrial thermal loads, modernization of cold-chain infrastructure and agricultural tubewell systems, telecom tower de-dieselization, and targeted digital infrastructure expansion through data-center development—constitutes a comprehensive multi-sector portfolio approach for increasing productive electricity demand and improving utilization of Pakistan's existing power-sector infrastructure.

Rather than assuming simultaneous full-scale implementation across all sectors, this report advocates a phased portfolio strategy that prioritizes immediate low-cost and high-impact interventions while gradually preparing network infrastructure for larger structural electrification shifts over the medium to long term. This approach reflects practical system realities, including current transmission and distribution constraints, feeder-level reliability challenges, transformer loading limitations, and the need for parallel investment in network modernization.

Using Pakistan's FY25 electricity-system baseline of approximately 126.5 TWh of purchased electricity at an average bulk power-purchase cost of PKR 23.37 per kilowatt-hour, the combined interventions assessed in this study could realistically generate approximately 35–65 TWh of additional productive electricity demand over the next five to seven years under disciplined implementation.

Railway electrification, beginning with the ML-1 corridor and progressing toward phased expansion across the national mainline system, is expected to contribute approximately 300–350 GWh of additional annual electricity demand in the medium term. Although its direct tariff impact is modest estimated at approximately PKR 0.03–0.05 per kilowatt-hour it delivers significant strategic benefits through imported diesel displacement, railway modernization, and long-term transport-sector electrification.

Punjab's planned deployment of 5,000 electric buses could contribute approximately 260 GWh of additional annual electricity demand within the next two to three years. While its immediate system-wide tariff impact remains limited at approximately PKR 0.03–0.05 per kilowatt-hour, this intervention generates important fuel-import savings, reduces urban air pollution, and provides a scalable model for wider public-transport electrification.

The electric-vehicle transition under Pakistan's National Electric Vehicle Policy is expected to become one of the largest new sources of productive electricity demand. Conservative implementation trajectories indicate annual electricity additions of approximately 8–15 TWh by 2030, producing estimated system-wide bulk tariff reductions of approximately PKR 0.8–1.5 per kilowatt-hour. This pathway is primarily privately financed and can scale rapidly provided distribution companies facilitate charging infrastructure deployment and grid interconnection reliability.

Phased gas-to-grid electrification across households, commercial establishments, and selected industrial thermal processes represents the single largest structural demand-growth opportunity. Under practical implementation scenarios, this pathway could generate approximately 15–35 TWh of additional annual electricity demand over a three-to-seven-year horizon. This alone could reduce average bulk power-purchase costs by approximately PKR 1.5–3.1 per kilowatt-hour by spreading fixed capacity obligations across a significantly larger electricity-sales base. However, successful implementation depends on targeted feeder reinforcement, transformer augmentation, and improved service reliability.

Cold-chain modernization and agricultural-energy reform including electrified cold-storage expansion and off-grid solarization of diesel-powered tubewells could contribute approximately 1–1.2 TWh of additional productive electricity demand while simultaneously eliminating substantial diesel consumption. This intervention offers particularly strong economic returns through lower agricultural production costs, reduced post-harvest losses, and improved food-security outcomes, with estimated tariff reductions of approximately PKR 0.10–0.15 per kilowatt-hour.

Targeted data-center development represents an emerging industrial baseload opportunity capable of contributing approximately 3–6 TWh of continuous annual electricity demand over the medium term. This could reduce average bulk power-purchase costs by approximately PKR 0.3–0.7 per kilowatt-hour while supporting foreign direct investment, digital industrialization, sovereign cloud infrastructure, and high-skilled employment growth. However, realization of this opportunity depends heavily on improvements in power quality, transmission redundancy, and regulatory certainty.

Telecom tower de-dieselization offers another high-value near-term intervention. Conversion of tower backup systems from diesel dependence to stable grid-connected or hybrid electricity supply could contribute approximately 1–1.3 TWh of annual baseload electricity demand while reducing imported diesel consumption significantly. This intervention could lower average system costs by approximately PKR 0.10–0.15 per kilowatt-hour while strengthening digital-service reliability across Pakistan's telecommunications sector.

Taken together, these interventions could cumulatively reduce Pakistan's average bulk electricity purchase cost by approximately PKR 3.1–4.9 per kilowatt-hour over the next five to seven years, depending on implementation pace, system-loss reduction, and parallel network reinforcement. This range is obtained by adding the combined 35–65 TWh of new demand to the FY25 baseline while holding capacity payments at PKR 1,807 billion and pricing the additional units at PKR 9.08 per kWh. Simply adding up the sector-by-sector reductions shown in Figure 27 would overstate the combined effect, because each additional unit of demand dilutes a progressively smaller per-unit capacity charge.

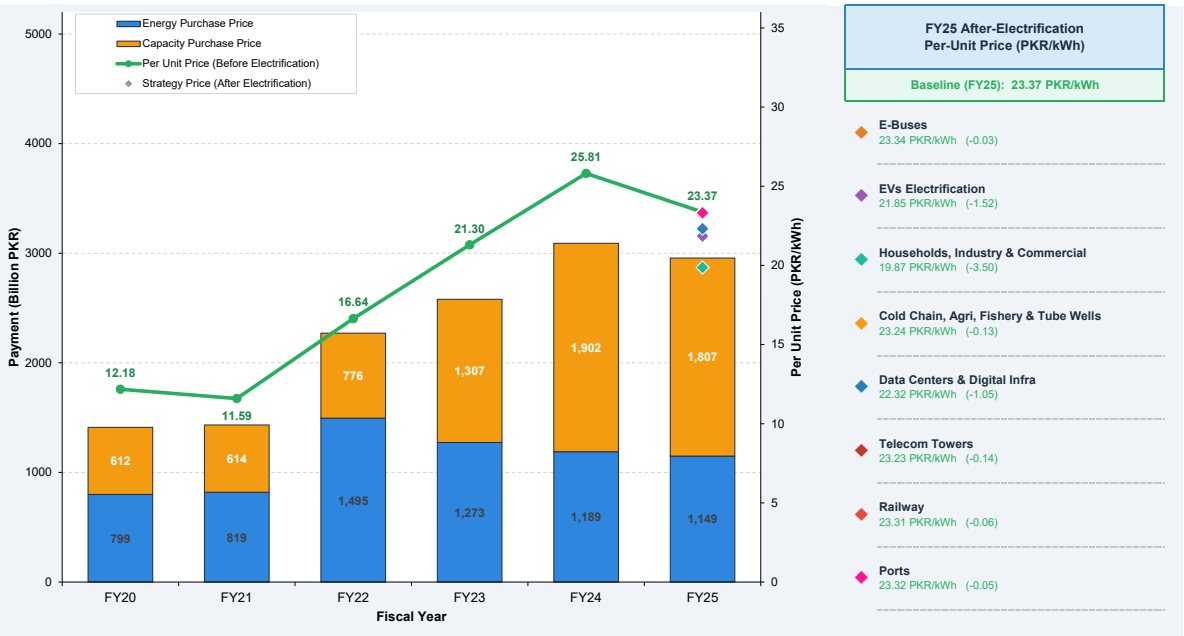
It is important to note that these reductions arise primarily through improved dilution of fixed capacity payments, which currently account for approximately PKR 1,807 billion annually, equivalent to roughly PKR 14–15 per kilowatt-hour under present electricity-purchase volumes. Increasing productive electricity sales spreads this fixed burden across a larger energy base, thereby lowering average system cost.

However, there are structural limits to tariff compression through electrification alone. The theoretical lower bound for bulk power-purchase prices remains constrained by Pakistan's prevailing capacity-payment obligations. Achieving deeper long-term tariff reductions will therefore require parallel reforms in power-purchase agreements, system-loss reduction, distribution-sector efficiency improvements, circular-debt restructuring, and rationalization of subsidy frameworks.

Accordingly, electrification should be understood not as a standalone tariff-reduction instrument, but as a foundational pillar of broader power-sector reform.

If implemented strategically alongside institutional and regulatory reforms, this combined electrification portfolio can transform Pakistan's surplus generation capacity from a persistent fiscal burden into a productive national economic asset lowering electricity costs, reducing imported-fuel dependence, improving industrial competitiveness, strengthening energy security, and enabling long-term structural resilience across the national economy.

Figure 27: Combined Electrification Impact on Electricity Demand and Cost



The combined electrification pathway is expected to generate a substantial yet technically realistic system-wide impact by adding approximately 35–65 TWh of productive annual electricity demand over the next five to seven years, increasing Pakistan's purchased electricity volume from 126,487 GWh to nearly 161,000–191,000 GWh. This increase would improve dilution of fixed capacity payments and reduce the average bulk power-purchase cost from PKR 23.37/kWh to approximately PKR 18.5–20.3/kWh, representing a reduction of roughly 13–21 percent depending on implementation scale. Simultaneously, the transition could displace approximately 2.5–4.5 billion litres of petrol and diesel annually, in addition to 3.21 billion litres of diesel through agricultural tubewell solarization, while reducing dependence on approximately 1,351 MMCFD of natural gas and 2.8 million tonnes of LPG, collectively strengthening energy security, reducing foreign-exchange pressure, and lowering annual carbon emissions by an estimated 8–12 million tonnes of CO_2 equivalent.

Growth & Competitiveness Impact

The reduction in system cost translates into a substantial improvement in industrial tariff competitiveness. The implied reduction in effective industrial tariffs falls in the range of approximately 19 to 26 percent. Such a reduction materially alters the cost structure of Pakistan's export sectors, particularly in electricity-intensive industries where energy costs constitute a significant share of total production costs. The macroeconomic implications of this transformation are considerable. Lower electricity costs improve industrial competitiveness, increase export volumes, and incentivize the shift from captive and fossil-based energy systems toward grid electricity. At the same time, electrification reduces reliance on imported fuels, particularly petroleum products and liquefied natural gas, thereby improving the external balance (Table 9).

Table 9: Macroeconomic Impact Under Full Electrification Realization

Variable	Indicative Impact
Industrial tariff reduction	~19–26%
Export impact	+$7–9 billion
Net FX impact	+$10–14 billion
GDP growth impact	+2.0 to +2.5 percentage points
Inflation impact	–1.8 to –2.8 percentage points
Circular debt improvement	PKR 0.9–1.3 trillion

Source: Authors' estimates using the integrated electricity–macroeconomic growth framework (specified in the Model Specification box in the following section)

The increase in exports reflects both direct and indirect effects. Lower electricity tariffs reduce production costs, enabling firms to price more competitively in international markets, while improved reliability and reduced reliance on captive generation enhance productivity and output. The resulting expansion in export volumes contributes to a stronger foreign exchange position.

The foreign exchange impact is further reinforced by reductions in fuel imports. Electrification of transport, industry, and commercial activity reduces demand for petroleum products, while substitution away from gas and diesel lowers import requirements. Although some of the additional electricity demand is met through generation that carries fuel costs, the net effect remains strongly positive, reflecting the combined impact of export growth and import substitution.

These improvements in external balances translate into reduced pressure on the exchange rate, which in turn moderates imported inflation. Lower electricity tariffs also directly reduce cost-push inflation, particularly in

sectors where energy costs are a key input. The combined effect is a measurable reduction in overall inflation, creating space for more stable monetary conditions.

From a growth perspective, the additive realization case represents a structural shift in the role of electricity within the economy. Instead of acting as a constraint on production, the power sector becomes a driver of expansion. Increased industrial output, higher exports, improved external stability, and lower inflation collectively support an increase in GDP growth of approximately 2.0 to 2.5 percentage points relative to the baseline.

The fiscal implications are equally significant. Higher electricity demand increases billed units and improves revenue collection, while lower per-unit costs reduce the gap between cost and tariff. This combination reduces the need for tariff subsidies and slows, and potentially reverses, the accumulation of circular debt. Under full realization, the improvement in circular debt dynamics is estimated in the range of PKR 0.9 to 1.3 trillion.

Despite these substantial gains, it is critical to interpret these results with caution. The full additive realization scenario represents a technical upper bound. It assumes near-complete electrification across sectors, rapid adoption of new technologies, and the absence of binding infrastructure and institutional constraints. In practice, such a transformation would require sustained investment, significant upgrades to transmission and distribution systems, and coordinated policy action over an extended period.

Integrated Scenario Model of Electricity Demand, Cost Dynamics, and Macroeconomic Impact

The preceding analysis has established that Pakistan's electricity sector is not constrained by the availability of generation capacity, but by the utilization of that capacity. The system is characterized by a large and growing fixed-cost base, primarily in the form of capacity payments that must be recovered irrespective of actual electricity consumption. As a result, the price of electricity is determined not only by the cost of supply, but critically by the volume of electricity over which these costs are distributed.

In such a system, the relationship between demand and cost is non-linear and self-reinforcing. Lower demand leads to higher per-unit costs, which in turn discourage further consumption and accelerate exit from the grid. Conversely, an expansion in grid-served demand increases the denominator over which fixed costs are allocated, thereby reducing average cost and improving affordability. This dynamic lies at the core of Pakistan's current electricity pricing challenge and, equally, at the heart of its potential resolution.

While the section above has demonstrated the scale of electrification possible across different sectors of the economy, those estimates were intentionally constructed using a sector-by-sector additive approach. Such an approach is useful for identifying the full technical potential of electrification, but it does not reflect the constraints under which real-world systems operate. Electrification across transport, industry, households, agriculture, and digital infrastructure does not occur simultaneously, nor does it proceed in isolation across sectors. It is shaped by infrastructure capacity, investment cycles, policy sequencing, and the interaction of economic incentives across the system.

This second framework, therefore, develops an integrated scenario model that translates the technical potential identified earlier into realistic, system-level outcomes. The model is aligned with a broader growth framework underpinning this study, linking electricity demand expansion to tariff dynamics, industrial competitiveness, foreign exchange balances, inflation, and economic growth.

At its foundation, the model rests on a simple accounting identity: total system cost is the sum of capacity payments and variable energy costs, while the average cost of electricity is determined by dividing this total cost by the

volume of electricity purchased by the grid (126.5 TWh in FY2024-25). Capacity payments are largely fixed in the short to medium term, reflecting contractual obligations that do not vary with utilization. Variable costs, by contrast, scale with generation and are influenced by fuel prices, dispatch efficiency, and the composition of the generation mix.

Model Specification: Integrated Electricity–Macroeconomic Framework (Tables 7 to 13)

The framework has three linked blocks. Blocks 1 and 2 are deterministic accounting relationships that can be reproduced from the data in this report; Block 3 converts the resulting change in electricity cost into indicative macroeconomic ranges.

Block 1 – Power purchase cost. For each case s, total power purchase cost is $C(s) = CP(s) + v(s) \times D(s)$ and the average power purchase price is $P(s) = C(s) \div D(s)$, where D(s) is the electricity purchased by CPPA-G (TWh), CP(s) the annual capacity payments (PKR billion) and v(s) the variable (energy) cost per kWh. FY2024-25 baseline: D = 126.487 TWh, CP = PKR 1,807 billion and energy payments of PKR 1,149 billion, giving v = PKR 9.08/kWh and P = PKR 23.37/kWh. For the sector cases in this chapter and in Chapter 2, capacity payments are held at PKR 1,807 billion and each additional kWh is priced at PKR 9.08, so that $P = (1{,}807 + 1{,}149 + 9.08 \times \Delta D) \div (126.487 + \Delta D)$, with ΔD in TWh.

Block 2 – Grid demand and capacity payments by scenario. Scenario demand is $D(s) \approx 126.5 \text{ TWh} + \Sigma\Delta D(i,s) - O(s)$, where ΔD(i,s) is the incremental grid demand from domain i (transport; industry and process heat; households and commerce; agriculture and cold chain; digital and telecom; and the shift from captive generation to the grid) shown in Table 10, and O(s) deducts overlaps between domains, phased adoption and network constraints (6, 20 and 34 TWh in the Partial Recovery, Integrated and Transformation scenarios); the Status Quo assumes continued grid defection, with demand falling to about 122 TWh. Capacity payments CP(s) follow the path assumed for each scenario in Table 11: higher under the Status Quo, and lower under the reform scenarios as plant debt-service periods expire (Table 14) and contracts are renegotiated. The Table 11 averages correspond to variable costs of about PKR 9.4/kWh (Status Quo), 9.0 (Partial Recovery), 8.7 (Integrated) and 8.5/kWh (Transformation), reflecting the generation-mix assumptions of each scenario.

Block 3 – Macroeconomic transmission (indicative). The change in average electricity cost from Blocks 1 and 2 is traced through the five channels described in the preceding section: (i) industrial tariffs, by passing the reduction in the average power purchase price through to industrial consumers, with distribution margins, taxes and surcharges held constant; (ii) exports, through lower production costs in electricity-intensive export sectors and the return of captive load to the grid; (iii) the external balance, as the export gain plus fuel-import savings from electrification; (iv) inflation, through lower cost-push pressure from electricity prices and a more stable exchange rate; and (v) the fiscal position, through higher billed sales and a smaller gap between cost and tariff, which slows the accumulation of circular debt. Block 3 is a reduced-form scenario framework rather than an estimated econometric model, so its results (Tables 7 and 12) are reported as ranges and should be read as indicative orders of magnitude.

Cross-check. The net foreign-exchange impact in Table 7 (US$10–14 billion) is consistent with the export impact (US$7–9 billion) plus fuel-import savings of about US$3–5 billion shown in the sector analyses of this chapter: about US$2.2 billion from solarizing diesel tubewells and US$1–2.8 billion from displacing petrol and diesel in transport.

Under current conditions, with electricity demand at approximately 126 terawatt-hours and capacity payments exceeding PKR 1.8 trillion annually, the system is operating at low utilization. Capacity payments account for over sixty percent of total cost, making the system highly sensitive to changes in demand. Even modest increases in electricity consumption can therefore produce meaningful reductions in average cost, provided that these increases are sustained and concentrated in productive segments of the economy (Table 10).

Table 10: Baseline Power Sector Structure (FY2024–25)

Indicator	Value
Electricity demand	~126 TWh
Capacity payments	PKR 1,807 billion
Energy payments	PKR 1,149 billion
Average cost	PKR 23.37/kWh
Capacity share of cost	~61%

The integrated model incorporates all five domains of electrification identified above: transport, industrial and commercial energy use, household substitution, agriculture and cold chain infrastructure, and digital and telecom systems, while also explicitly accounting for the transition of consumers from captive and off-grid energy sources back to the grid. Each of these domains contributes differently to demand growth, and each is subject to distinct constraints in terms of capital investment, infrastructure readiness, and policy support (Table 11).

Table 11: Mapping of Electrification Domains Across Scenarios

Electrification Domain	Partial Recovery	Integrated Scenario	Transformation Scenario
Transport (EVs, buses, rail)	Limited adoption	Scaled expansion	Large-scale transition
Industry & process electrification	Minimal	Moderate	Deep electrification
Household & commercial substitution	Limited	Partial	Significant
Agriculture & cold chain	Targeted	Expanded	Broad-based
Digital & telecom infrastructure	Early growth	Accelerated	Large-scale
Captive generation → grid shift	Minimal	Moderate	Significant

Source: Authors' growth model mapping

Transport electrification, encompassing electric vehicles, public transport fleets, and railway systems, provides a scalable and relatively early source of demand, particularly in urban and intercity corridors. Digital infrastructure, including data centers and telecom networks, contributes stable, high-utilization loads that improve system load factors. Electrification in agriculture and cold chain systems introduces additional demand while delivering efficiency gains in food systems and irrigation. Industrial and commercial electrification, including the replacement of gas, LPG, and diesel-based systems with electricity, represents the largest technical potential but unfolds more gradually due to capital intensity and operational considerations. Finally, the shift of industrial consumers from captive generation and behind-the-meter solutions back to the grid enabled by improved tariff competitiveness emerges as a critical and often underappreciated driver of demand recovery (Table 12).

Table 12: Incremental Electricity Demand by Domain (TWh)

Domain	Partial Recovery	Integrated	Transformation
Transport electrification	8	15	22
Industry & process electrification	3	12	25
Household & commercial	2	8	15
Agriculture & cold chain	2	4	6
Digital & telecom	4	11	16
Captive to grid shift	2	6	10
Subtotal	21	56	94
Less overlap & constraints	-6	-20	-34
Net increase	~15	~36	~60

Source: Authors' growth model estimates

When these domains are considered in isolation and aggregated mechanically, the resulting technical potential for electrification exceeds 140 terawatt-hours. However, such an outcome assumes near-complete substitution of fossil fuel use across sectors and does not account for overlapping demand categories, phased adoption, or system constraints. Once these factors are incorporated, the realistic medium-term expansion of grid-served demand falls within a range of approximately 50 to 70 terawatt-hours. This implies that roughly forty to fifty percent of the technical potential identified above can be realized within a policy-relevant timeframe, with the remainder representing longer-term structural transformation.

To capture the implications of this demand expansion, the model evaluates four distinct scenarios (Table 13).

Table 13: Electricity Demand and Cost Outcomes Across Scenarios

Scenario	Demand (TWh)	Capacity Payments (PKR bn)	Avg Cost (PKR/kWh)
Baseline	126	1,807	23.37
Status Quo	122	1,950	25.4
Partial Recovery	142	1,750	21.3
Integrated	162	1,550	18.3
Transformation	187	1,350	15.7

Source: Authors' growth model estimates/assumptions

The implications of these scenarios extend beyond the power sector (Table 14).

Table 14: Macroeconomic Impact Across Scenarios

Scenario	Export Impact	FX Impact	GDP Growth	Inflation	Circular Debt
Status Quo	–$1 bn	Weakening	–0.3 to –0.5 pp	Rising	Deteriorates
Partial Recovery	+$1–2 bn	Moderate	+0.5 pp	Slight decline	Stabilizes
Integrated	+$3–5 bn	Strong	+1.0–1.4 pp	Declines	Improves
Transformation	+$6–7 bn	Significant	+2.0 pp	Falls	Reduces materially

Source: Authors' growth model estimates

The contrast between the additive electrification potential presented in the section above and the integrated outcome in this section is, therefore, both intentional and instructive (Table 15).

Table 15: Reconciling Technical Potential and Realistic Outcomes

Metric	Value
Technical potential	140+ TWh
Realistic medium-term expansion	50–70 TWh
Achievable share	~40–50%

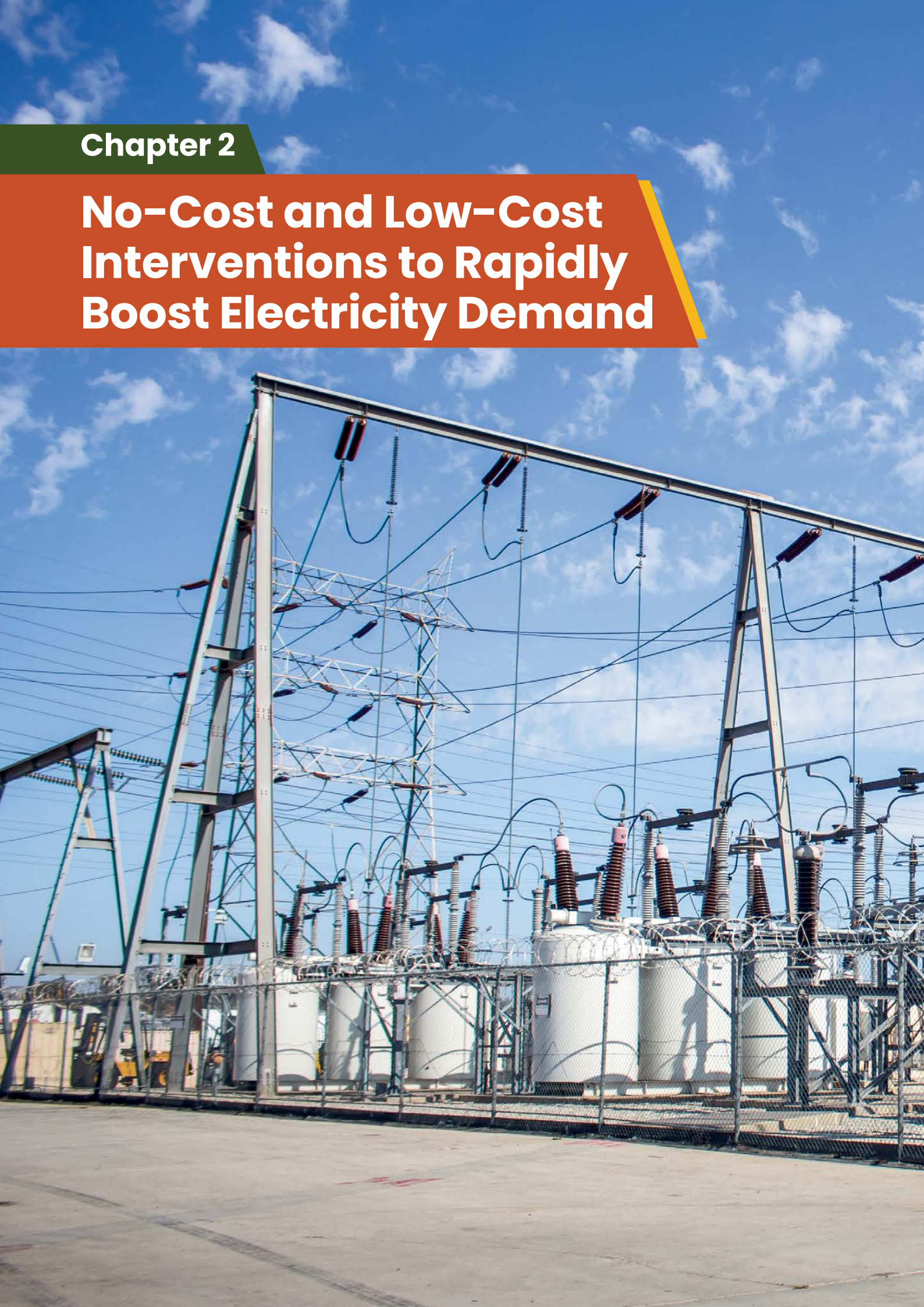
The former defines the scale of opportunity available to the system, while the latter defines the pathway through which that opportunity can be realized under real-world constraints. Together, they provide a comprehensive framework for understanding not only what is possible, but what is achievable.

The central conclusion that emerges is that Pakistan's electricity challenge is not a shortage of supply, but a failure to align demand, pricing, and policy. Electrification, when pursued in a coordinated and economically grounded manner, transforms surplus capacity from a fiscal liability into a productive asset. By expanding demand across transport, industry, agriculture, and digital infrastructure, while simultaneously rationalizing costs and improving system efficiency, the electricity sector can become a driver of competitiveness, growth, and macroeconomic stability.

In conclusion, a coordinated national electrification strategy creates a self-reinforcing virtuous cycle: increased productive demand lowers per-unit electricity costs, and lower tariffs incentivize further adoption of grid electricity. This reduces reliance on imported fuels and diesel-based captive generation, while improving energy security and fiscal stability. By aligning energy policy with transport, agriculture, industry, fisheries, and digital development, Pakistan can achieve a more affordable, efficient, and resilient power system simultaneously advancing economic growth, reducing the import bill, enhancing food security, and delivering environmental benefits.

Chapter 2

No-Cost and Low-Cost Interventions to Rapidly Boost Electricity Demand



Chapter 2

No-Cost and Low-Cost Interventions to Rapidly Boost Electricity Demand

The electrification interventions analyzed in sections 1.1 through 1.7 of this chapter railways, electric buses, private transport, household and industrial conversion, cold chain and agriculture, data centers, and telecom tower de-dieselization each require substantial capital investment, multi-year implementation timelines, and complex coordination across public and private actors. Their aggregate tariff impact is transformative but deferred. Pakistan's power sector, however, also carries a category of high-impact demand-side interventions that require little or no public capital expenditure. These measures do not wait for new infrastructure to be built. They act on latent demand that already exists but is currently suppressed by institutional inertia, regulatory delays, governance failures, and misaligned incentive structures within the distribution system itself.

The governing arithmetic is identical to that established at the outset of this chapter. Pakistan's annual capacity payments to CPPA-G generators stood at approximately PKR 1,807 billion in FY 2024-25, while energy payments added PKR 1,149 billion. These obligations are largely fixed. They do not diminish when grid consumption falls, and they do not increase materially when additional consumers begin using electricity. Since the national grid currently purchases approximately 126,487 GWh annually, the average bulk power cost is PKR 23.37 per kilowatt-hour, comprising approximately PKR 9.08 per kilowatt-hour in variable energy costs and PKR 14.29 per kilowatt-hour in fixed capacity costs. Every additional gigawatt-hour of electricity consumed on the existing grid spreads these fixed obligations across a larger base, reducing the per-unit burden for all consumers. The no-cost and low-cost interventions identified in this section are, in essence, administrative and regulatory actions that unlock this arithmetic without requiring additional capital.

The urgency of this class of intervention is underscored by NEPRA's own performance records. The regulator's Performance Evaluation Reports have repeatedly flagged that non-provision of new connections within prescribed timeframes is a direct contributing factor to lower electricity demand in Pakistan at a moment when installed generation capacity significantly exceeds system load. Consumers willing to connect are being turned away. Industries seeking to expand their electricity intake are encountering transformer constraints and approval backlogs. Solar prosumers who could be induced to increase their daytime grid consumption are instead maximizing export to a grid that does not need the energy. Each of these phenomena represents suppressed demand that can be released without building a single new generator or kilometer of transmission line.

Streamlining DISCO Connection Processes and Transformer Upgrades

Distribution companies should be directed through a binding NEPRA regulatory determination to fast-track new connections and load enhancement requests for electric vehicle charging stations, industrial expansions, cold chain facilities, and commercial electrification conversions. The scale of the connection backlog is not marginal. NEPRA's analysis for FY 2024-25 revealed that approximately 128,096 eligible consumers were denied new connections despite having completed advance payments, representing an unserved latent demand of more than 1,021 megawatts. At a time when the national grid carries surplus generation capacity estimated at 16,000 to 18,000 megawatts, this administrative failure is generating an entirely avoidable cost inflation. Every megawatt of

unserved, paid-up demand that should be contributing to fixed-cost dilution is instead remaining outside the system, leaving existing consumers to bear a proportionally heavier capacity payment burden.

The institutional resistance to rapid connection provision is not technical it is a product of incentive structures in which distribution companies face no commercial penalty for delayed connections and no commercial reward for growing their consumer base. Current delays frequently extend beyond 90 to 120 days for three-phase industrial and commercial connections, despite the NEPRA Performance Standards (Distribution) Rules, 2005 prescribing significantly shorter timeframes (53 days for commercial and 73 days for LT industrial connections). Transformer upgrade requests essential for enabling EV charging infrastructure, electric cooking loads, and industrial electrification are routinely deferred pending cost-recovery decisions that create a circular dependency between investment and the demand growth that would justify investment.

The intervention required is twofold. A mandatory time-bound approval mechanism a maximum of 30 working days for single-phase domestic connections and 45 working days for three-phase commercial and industrial connections, with financial penalties accruing automatically to the consumer account for each day of excess delay would eliminate the institutional tolerance for backlog accumulation that currently characterizes DISCO operations. Simultaneously, transformer upgrades for load enhancement requests from electric vehicle charging stations, industrial facilities, agricultural tubewell electrification, and cold chain installations should be treated as priority items within each DISCO's annual Distribution Investment Plan, recoverable through the regulatory asset base without requiring upfront cost contribution from the applicant. These are administrative reforms. They require a regulatory notification and a governance directive, not capital.

The quantifiable system impact of clearing the existing connection backlog and sustaining timely connection provision going forward is an estimated 500 to 1,500 GWh of additional annual electricity demand. Applied to the FY25 baseline, the midpoint addition of approximately 1,000 GWh would reduce the average per-unit electricity cost from PKR 23.37 to approximately PKR 23.26, a reduction of PKR 0.11 per kilowatt-hour. While this appears modest in isolation, it is entirely additive with the other interventions described in this section, and it establishes the institutional foundation without which larger-scale demand programs cannot function.

Key Outcomes: DISCO Connection Standards Reform

- Eligible consumers with unserved demand: ~128,096; unserved latent load: >1,021 MW (NEPRA FY25)
- Proposed connection standard: 30 days (single-phase); 45 days (three-phase)
- Automatic financial penalties to consumers for delays beyond mandated timelines
- Transformer upgrades for EV, industrial, and agri loads treated as priority regulatory asset base items
- Estimated additional annual electricity demand: 500–1,500 GWh
- Per-unit cost impact (midpoint, +1,000 GWh): 23.37 → 23.26 PKR/kWh (–0.11 PKR/kWh)
- Capital required from public sector: Zero

Policy and Regulatory Facilitation for Electric Vehicles and Charging Infrastructure

Pakistan's New Energy Vehicle Policy 2025-2030, launched in June 2025 under the Ministry of Industries and Production, targets 30 percent of all new vehicle sales to be electric by 2030 and envisages the deployment of 3,000 EV charging stations nationwide. The macroeconomic rationale is compelling: the policy projects cumulative savings of PKR 800 billion over 25 years through reduced petroleum imports, with electricity costs for the charging infrastructure declining from PKR 174 billion to PKR 105 billion annually. Yet as of 2025, Pakistan operates fewer

than 100 publicly accessible charging stations, concentrated in Karachi, Lahore, and Islamabad. The infrastructure gap between the policy ambition and ground reality is almost entirely a function of administrative and regulatory friction rather than market failure.

The National Energy Efficiency and Conservation Authority has established a one-window framework for EV charging station approvals under the Pakistan Electric Vehicles Charging Infrastructure and Battery Swapping Regulations 2024. The framework creates the legal basis for streamlined approvals, cost-effective tariffs, and public-private partnership in infrastructure deployment. The missing element is distribution company implementation. DISCOs have been slow to priorities EV charging connections, have not standardized procedures for shared transformer arrangements, and have not published clear technical guidelines for charging station operators seeking to access the grid.

Mandating DISCOs to process all EV charging infrastructure connection applications within 21 working days, maintaining a publicly accessible live register of pending EVCS applications and approval statuses, and issuing standardized technical connection packages for Level 2 and Level 3 chargers would remove the principal bottleneck to private investment in charging networks. A dedicated off-peak electricity tariff of PKR 18 to 20 per kilowatt-hour for Level 2 and Level 3 chargers operating between 10 PM and 6 AM reflecting the actual marginal cost of surplus generation in off-peak hours would simultaneously incentivize night-time charging, reduce peak demand pressure while improve utilization of the generation capacity that currently sits idle during low-load hours. Each 150-kilowatt DC fast charger operating at 60 percent utilization for eight hours per day generates approximately 262 megawatt-hours of annual electricity demand. Scaling to 1,000 such stations one-third of the 2030 target adds approximately 262 GWh annually; the full 3,000-station network contributes approximately 786 GWh per year of stable, metered grid demand. For the cumulative estimates in this section, a central case of about 520 GWh a year is used. It corresponds to roughly 2,000 fast chargers, or two-thirds of the 2030 target (2,000 × 262 MWh ≈ 524 GWh), midway between the 1,000-charger (262 GWh) and full 3,000-station (786 GWh) cases.

Key Outcomes: EV Charging Infrastructure Facilitation

- NEV Policy 2025-30 target: 3,000 charging stations by 2030; currently <100 nationwide
- NEECA EVCI Regulations 2024 provide legal framework; DISCOs have not implemented priority protocols
- Proposed action: 21-day EVCS connection standard; off-peak tariff PKR 18-20/kWh (10 PM–6 AM)
- Estimated demand addition (1,000 fast chargers at 60% utilization): ~262 GWh/year
- Full 3,000-station NEV Policy target: ~786 GWh/year of stable metered grid demand
- Per-unit cost impact (+520 GWh central case, about 2,000 chargers; cumulative with the connection reform): 23.26 → 23.20 PKR/kWh
- Capital required from public sector: Zero

Optimizing Net Metering and Solar-Plus-Electric Load Synergy

Pakistan's rooftop solar expansion has been one of the most rapid of any country of comparable size. Net-metered solar capacity grew from under 1 gigawatt in June 2023 to approximately 6.1 gigawatts by June 2025, with imports of solar panels reaching 17 gigawatts in 2024 alone making Pakistan one of the world's largest solar markets. Over 283,000 consumers were registered net-metering users by December 2024. The same dynamics that have driven this expansion escalating grid tariffs and falling solar costs have, however, produced a structural problem for the power sector. When consumers offset their grid consumption through solar self-generation, the fixed capacity payment obligation of PKR 1,807 billion remains unchanged. By December 2024, estimates presented to the Economic Coordination Committee showed that net-metered consumers had shifted PKR 159 billion in fixed grid costs onto non-solar consumers, accelerating the very tariff spiral that drove solar adoption in the first place.

The policy response has been to reduce the net metering buyback rate from PKR 27 per kilowatt-hour to PKR 10 per kilowatt-hour (ECC decision of March 2025), and, under NEPRA's Prosumer Regulations 2026, to shift to a net-billing model in which exports are credited at the average energy purchase price rather than at full retail parity. While this adjustment was necessary to arrest the cross-subsidization problem, it addresses only the revenue side of the net metering equation. The demand side the opportunity to convert net-metered solar consumers from net exporters into balanced grid users who also increase their productive daytime grid consumption has not been fully utilized.

A Solar-Plus-Load incentive structure, in which net-metered consumers who simultaneously increase daytime grid consumption through induction cooking, electric water heating, or EV charging receive a discounted grid tariff for their incremental daytime consumption, would convert a regulatory conflict into a demand creation opportunity. Mandatory time-of-use billing for all net-metered consumers above 20 kilowatts with grid tariffs of PKR 12 to 15 per kilowatt-hour during solar production hours between 9 AM and 3 PM would incentivize consumption of surplus solar generation that would otherwise be exported at reduced credit rates, improving both system utilization and individual consumer economics. Additionally, the backlog of over 4,000 pending net-metering applications reported as of mid-2025 should be cleared within 60 days through a directed DISCO processing timeline. Each grid-connected solar installation that also increases daytime load is a net system contributor.

Key Outcomes: Net Metering Reform

- Net-metered solar capacity: 6.1 GW (Jun 2025); 283,000 registered consumers
- Fixed cost shift to non-solar consumers: PKR 159 billion (Dec 2024, NEPRA estimate)
- Proposed Solar Load incentive: discounted daytime grid rate for induction, EV, HVAC loads
- Mandatory ToU billing for net-metered consumers >20 kW: off-peak rate PKR 12-15/kWh
- Pending net-metering backlog (Jun 2025): 4,000+ applications; 60-day clearance directed
- Estimated additional annual demand: 500–1,000 GWh
- Per-unit cost impact (+750 GWh, cumulative): ~23.20 → 23.12 PKR/kWh
- Capital required from public sector: Zero — tariff restructuring only

Targeted Enforcement and DISCO Governance: Linking Discos Performance to Sustainable Demand Growth

Pakistan's eleven public-sector distribution companies represent the single largest institutional barrier to demand growth in the power sector. Their AT&C losses in FY 2024-25 stood at 17.55 percent on average, against a NEPRA-allowed benchmark of 11.43 percent. The excess equivalent to 6.12 percentage points above the permitted level contributed PKR 265 billion in additional costs to the national exchequer and added directly to circular debt accumulation. A further PKR 132 billion was lost through recovery shortfalls. In total, distribution company inefficiency imposed a combined financial burden of PKR 397 billion in a single year. To contextualize this figure: it exceeds the annual development budget of several provinces and approaches the full-year energy payment obligations of some large bilateral power purchase agreements.

The governance failure is structural, not operational. Distribution companies in Pakistan were not designed to grow demand, attract consumers, or optimize cost recovery. They are organized as administrative entities whose primary orientation is cost pass-through rather than commercial performance. There is, as has been noted elsewhere in this report, no sales function in a Pakistani DISCO. The institutional design creates no incentive to reduce connection delays, no commercial reward for expanding the consumer base, and no financial penalty for allowing demand to migrate off-grid. The consequence is that the single class of institutions most capable of

immediately increasing grid electricity demand because they control the physical and commercial interface between the system and its consumers is also the class with the weakest incentive to do so.

Linking DISCO management incentives to demand-growth performance metrics through NEPRA's annual Performance Evaluation Report is the most direct administrative intervention available. Specifically, units-sold growth rate and new connections provisioned within the mandated standard should be added as weighted performance indicators in the annual PER, alongside the existing T&D loss and recovery metrics, and should feed directly into the allowed return determination in subsequent tariff decisions. For government-owned DISCOs, variable management compensation of 10 to 20 percent of total remuneration tied to measurable commercial outcomes including energy sales growth, feeder-level loss reduction, and connection processing timelines introduces the financial stakes necessary to shift institutional behavior. A reduction in AT&C losses from 17.55 percent to 14.55 percent a three-percentage point improvement, representing roughly half the current excess above NEPRA's benchmark would deliver approximately 3,500 GWh of additional billable demand at zero generation cost increase, purely from electricity that is already produced but currently lost in the distribution network.

Key Outcomes: DISCO Governance Reform

- FY25 actual AT&C losses: 17.55% vs. NEPRA allowed 11.43% — excess of 6.12 percentage points
- Financial loss to exchequer from T&D excess + recovery shortfall: PKR 397 billion (FY25)
- Proposed action: Add units-sold growth and connection timelines as weighted NEPRA PER indicators
- Management variable pays (10-20%) linked to measurable commercial KPIs
- 3 percentage-point AT&C improvement → ~3,500 GWh additional billable demand, zero capex
- Per-unit cost impact (+3,500 GWh, cumulative): ~23.12 → 22.75 PKR/kWh (–0.37 PKR/kWh)
- Capital required from public sector: Zero — regulatory directive and governance reform only

Appliance Standards and Consumer Awareness Campaigns

Pakistan's household energy system is characterized by deep multi-fuel dependence that suppresses productive electricity demand. Approximately 22 million household's 58 percent of the national total lack access to piped natural gas and rely on LPG, biomass, or kerosene for cooking. Pakistan's domestic gas supply deficit is projected at approximately 1 billion cubic feet per day according to OGRA's 2025 estimates, with supply interruptions already affecting significant portions of the urban gas-connected population during peak winter demand. The economics of switching from LPG to induction cooking are unambiguously favorable: a household consuming 1.5 LPG cylinders per month at approximately PKR 3,500 per cylinder spends PKR 5,250 monthly on cooking fuel. The equivalent energy demand from an induction cooktop, at a residential tariff of PKR 35 per kilowatt-hour and approximately 1.5 kilowatt-hours per day, costs approximately PKR 1,575 per month a reduction of 70 percent. The financial case is made. What is suppressing conversion is not consumer economics but a combination of awareness gaps, the absence of minimum energy performance standards for induction appliances that would drive down upfront costs, and the administrative friction involved in obtaining a sanctioned load upgrade for the additional electrical load.

The National Energy Efficiency and Conservation Authority, under the NEECA Act 2016, has the statutory mandate to enforce Minimum Energy Performance Standards for electrical appliances. Extending MEPS coverage to induction cooktops and electric water heaters through a federal gazette notification would eliminate low-efficiency appliances from the market, reduce operating costs for consumers who switch, and create the manufacturing scale needed to bring appliance prices down. A coordinated national consumer awareness campaign delivered through DISCO bill inserts, television media, and provincial government platforms quantifying the per-household

financial saving from switching to induction cooking during periods of gas supply disruption would accelerate natural consumer transition at negligible administrative cost. Sanctioned load upgrades for residential consumers adding an induction cooking load should be processed within seven working days at no charge to the applicant, with the cost absorbed into the regulatory asset base.

A shift of 2 percent of Pakistan's 38 million households approximately 760,000 households per year from LPG or biomass to electric cooking generates approximately 416 gigawatt-hours of additional annual electricity demand. Over a three-year programme these compounds to 1,248 gigawatt-hours, while simultaneously reducing LPG imports by approximately 114,000 tonnes annually, with direct foreign exchange savings and a corresponding reduction in the fiscal burden that partially drives public sector capacity payment obligations.

Key Outcomes: Appliance Standards and Gas-to-Electric Switching

- 55.7 percent households lack piped gas; LPG cooking costs PKR 5,250/month vs. PKR 1,575/month electric
- Gas supply deficit: ~1 bcfd (OGRA 2025); urban disruptions already occurring
- NEECA MEPS notification: extend to induction cooktops and electric water heaters
- National awareness campaign through DISCOs and provincial government channels
- 7-day sanctioned load upgrade for induction cooking additions — no cost to applicant
- Annual demand addition (2% HH shift, 760,000 HH): ~416 GWh/year; cumulative 3-year: 1,248 GWh
- LPG imports reduced: ~114,000 tonnes/year; FK savings reinforce capacity payment servicing
- Capital required from public sector: Zero — NEECA notification and awareness campaign

Time-of-Use Pricing to Unlock Off-Peak and Shoulder Demand

Pakistan's current electricity tariff structure applies predominantly flat or slab-based charges without meaningful time differentiation for most consumer categories. This design ignores a fundamental operational reality: the system's surplus generation capacity is not uniformly distributed across the day. During off-peak hours typically 10 PM to 6 AM and shoulder periods in the early morning and mid-afternoon, dispatchable thermal capacity sits largely idle while fixed capacity payments continue to accrue. The marginal cost of supplying an additional kilowatt-hour during these periods is, in effect, only the variable fuel cost of generation, approximately PKR 9.08 per kilowatt-hour, since the fixed capacity obligation is already fully committed. A tariff that communicates this cost differential to consumers would create a direct financial incentive to shift electricity-intensive activities EV charging, water heating, second-shift industrial operations, cold chain refrigeration cycling, and commercial air-conditioning pre-cooling into these low-cost periods, increasing demand precisely when the system most needs it.

The National Electricity Policy 2021 explicitly identifies Time-of-Use tariff implementation as a demand management instrument. NEPRA already offers ToU tariff options for large industrial consumers, establishing the regulatory precedent. Extension to all commercial consumers above five kilowatts sanctioned load, all agricultural tubewell connections, and all net-metered prosumers with off-peak rates between PKR 12 and 15 per kilowatt-hour and peak rates at the prevailing tariff level would shift the price signal into the segments of the consumer base most capable of responding to it. Agricultural tubewell tariffs restructured to incentivize night-time pumping would reduce daytime peak demand pressure while taking advantage of the system's most cost-effective generation windows. A conservative estimate of five percent additional consumption growth from off-peak price incentives, applied to Pakistan's combined commercial and agricultural electricity base, implies approximately 575 gigawatt-hours of additional annual grid demand.

Key Outcomes: Time-of-Use Tariff Reform

- Off-peak generation marginal cost: ~PKR 9.08/kWh (variable only); capacity already committed
- NEP 2021 mandates ToU implementation; NEPRA precedent exists for large industrial consumers
- Proposed extension: all commercial consumers >5 kW; agricultural tubewells; net-metered prosumers
- Off-peak rate: PKR 12-15/kWh (10 PM–6 AM); nighttime tubewell tariff incentive
- Estimated demand addition: ~575 GWh/year from consumption shifting into surplus-capacity hours
- Per-unit cost impact (cumulative): further ~0.06 PKR/kWh reduction
- Capital required from public sector: Zero — NEPRA tariff determination only

Structured Grid Integration of Industrial Captive BESS and Solar Integration

Between 3 and 4 gigawatts of industrial solar capacity installed by factories, commercial buildings, and large consumers across Pakistan's industrial heartland operates as non-net-metered, self-consumption generation, effectively outside the measured grid economy. These consumers have departed the grid for daytime electricity supply. They retain grid connections primarily for backup power, paying minimum fixed charges while consuming negligible grid units during production hours. This represents a form of demand destruction that is structurally separate from net-metered rooftop solar: it is concentrated in the industrial and commercial sector, is growing rapidly as capital costs for industrial PV systems continue to fall, and is invisible in official energy statistics because it does not flow through DISCO metering systems.

The financial consequence for the grid is symmetrical with consumer migration to rooftop solar. Each megawatt of industrial capacity that self-generates during peak solar hours represents demand that does not contribute to fixed-cost dilution. The PKR 1,807 billion capacity payment obligation, shared across a smaller base of remaining grid consumers, results in a proportionally higher per-unit tariff which in turn provides further incentive for industrial consumers to expand their off-grid generation. This is the industrial dimension of the same utility death spiral described in the Introduction and Background of this report.

A structured Grid Participation Programme would offer industrial captive solar operators a guaranteed bilateral off-peak supply contract at PKR 15 per kilowatt-hour for second-shift and night-shift production significantly below the prevailing industrial tariff and competitive with the operational cost of running diesel backup. Operators who commit to night-shift grid consumption in exchange for priority connection guarantees and tariff certainty would shift a portion of their energy demand from daytime self-generation to off-peak grid supply, adding stable, predictable baseload demand during hours of maximum system surplus. This requires no infrastructure investment, only bilateral agreements between DISCOs and major industrial consumers formalized through NEPRA-sanctioned tariff instruments. The estimated demand addition from 20 percent participation in the 3 to 4-gigawatt industrial captive base, operating at 6 hours of night-shift grid supply for 250 days per year, is approximately 1,050 gigawatt-hours annually.

Key Outcomes: Industrial Captive Solar Grid Integration

- Non-net-metered industrial captive solar in Pakistan: ~3,000–4,000 MW (PIDE estimate, 2025)
- Off-grid daytime generation removes demand from fixed-cost dilution base
- Proposed: off-peak grid supply contracts at PKR 15/kWh for second- and night-shift industrial use
- 20% participation rate (700 MW average base) × 6 hrs × 250 days → ~1,050 GWh/year
- No infrastructure required — bilateral agreements through NEPRA tariff instruments
- Per-unit cost impact (+1,050 GWh, cumulative): further ~0.10 PKR/kWh reduction
- Capital required from public sector: Zero

Public Infrastructure Electrification and Street Lighting Modernization Help to Save from Evening Peak

Pakistan operates over 500,000 street lights with a combined sanctioned load exceeding 400 megawatts, the majority running on 80-watt, 125-watt, or 250-watt sodium vapor lamps. Transitioning this inventory to LED technology, which delivers equivalent luminosity at approximately 40 to 50 percent of the power consumption, would reduce total street lighting load by approximately 160 to 200 megawatts. However, the net impact on grid demand depends on the scale of coverage expansion that the efficiency savings enable. Municipal governments that use energy savings to extend street lighting into currently unlit areas an outcome strongly motivated by public safety considerations would see total electricity offtake from the lighting network remain broadly stable or increase modestly as coverage expands. The capital cost of LED conversion, recoverable within two to three years from energy savings, is self-financing from the municipal budget perspective and does not require federal or provincial capital allocation.

The broader public infrastructure opportunity is larger. Pakistan operates approximately 260,000 government schools and over 12,000 public health facilities. A significant proportion of these concentrated in areas of unreliable grid supply operate diesel generators as their primary or backup power source. Directing all new public buildings above 200 square meters to connect to the grid as their primary power source, with battery energy storage for backup rather than diesel generation, converts a diesel-consuming public estate into a stable, metered demand contributor. If 20 percent of public schools approximately 52,000 institutions shifted from diesel primary to grid primary supply at an average connected load of 5 kilowatts for 8 hours per day across 300 school days: 52,000 multiplied by 5 kilowatts multiplied by 8 hours multiplied by 300 days produces 624 gigawatt-hours of additional annual grid demand. Health facilities, which operate more continuously, would add a further material increment. The policy instrument is a federal circular not a capital programme. DISCOs bear the cost of connections through their regulated asset base; the operational savings from eliminating diesel generator costs at each facility justify the transition on purely financial grounds.

Key Outcomes: Public Infrastructure Electrification

- 500,000+ street lights; 400 MW sanctioned load — majority on inefficient sodium vapor
- LED transition: 40-50% energy saving; self-financing within 2-3 years from municipal budgets
- 260,000 public schools; 12,000+ health facilities — many diesel-generator dependent
- Federal circular mandating grid-primary connection for all new public buildings >200 sqm
- 52,000 schools' grid-connected (20% of total) at 5 kW × 8 hrs × 300 days: 624 GWh/year
- No net capital burden to government — DISCO regulatory asset base covers connection costs
- Diesel savings at each facility justify transition on standalone financial basis
- Estimated combined demand addition: ~700 GWh/year

Combined No-Cost and Low-Cost Intervention Impact: System-Level Analysis

The eight interventions described in this section DISCO connection standard enforcement, EV charging facilitation, net metering reform, DISCO governance and AT&C loss reduction, appliance MEPS and gas-to-electric switching, time-of-use tariff extension, industrial captive solar grid integration, and public infrastructure electrification operate on fundamentally different mechanisms from the capital-intensive electrification pathways described in sections 1.1 through 1.7. They do not require new generation capacity. They do not require transmission infrastructure investment. They require regulatory notifications, governance directives, bilateral agreements, and performance-linked management incentive structures. Their cost to the public sector is, in most cases, zero.

Yet their combined system impact is substantial. The aggregate additional annual electricity demand from conservative implementation across all eight interventions is estimated at approximately 8,500 gigawatt-hours annually, rising toward 9,300 gigawatt-hours by year three as household appliance conversion compounds. This represents 7.4 percent of the FY25 national grid purchase volume of 126,487 gigawatt-hours. Because fixed capacity payments of PKR 1,807 billion remain unchanged, this additional demand reduces the per-unit capacity payment burden from PKR 14.29 to approximately PKR 13.3–13.4 per kilowatt-hour. Combined with a modest increase in variable energy payments (priced at the FY25 variable cost of PKR 9.08 per kWh), the average bulk power purchase cost declines from PKR 23.37 per kilowatt-hour to approximately PKR 22.4–22.5 per kilowatt-hour a reduction of about PKR 0.90–0.98 per kilowatt-hour, or approximately 3.9–4.2 percent. Applied to the existing billed consumption base of about 110 terawatt-hours, this reduction delivers approximately PKR 99–108 billion of annual savings to consumers, achieved without any public capital investment. The two volumes are used deliberately. Per-unit costs throughout this report are calculated on the 126.5 TWh of electricity purchased by CPPA-G, because capacity and energy payments are paid on every unit purchased, including units later lost in transmission and distribution; this keeps the payments and the volume on the same basis (the same CPPA-G purchase data) and isolates the capacity-dilution effect from distribution losses, which are accounted for separately at the distribution stage. Consumer savings, by contrast, are calculated on the volume actually billed to consumers, about 110 TWh (NEPRA's State of Industry Report 2025 records grid sales of about 111.5 TWh in FY2024-25), because only billed units carry a tariff payment; the difference of about 16.5 TWh reflects transmission and distribution losses and theft. Applying the same reduction to the full 126.5 TWh purchased would give PKR 114–124 billion, so the savings shown here are conservative.

These measures are best understood as enabling conditions rather than standalone tariff-reduction instruments. Their primary value is in preparing the institutional and regulatory environment for the larger-scale electrification programmes analyzed throughout this chapter. A distribution system that cannot process connections within mandated timelines, cannot align tariff signals with system cost, and cannot incentivize its management to grow demand will frustrate the tariff reduction potential of every gigawatt-hour of railway electrification, EV adoption,

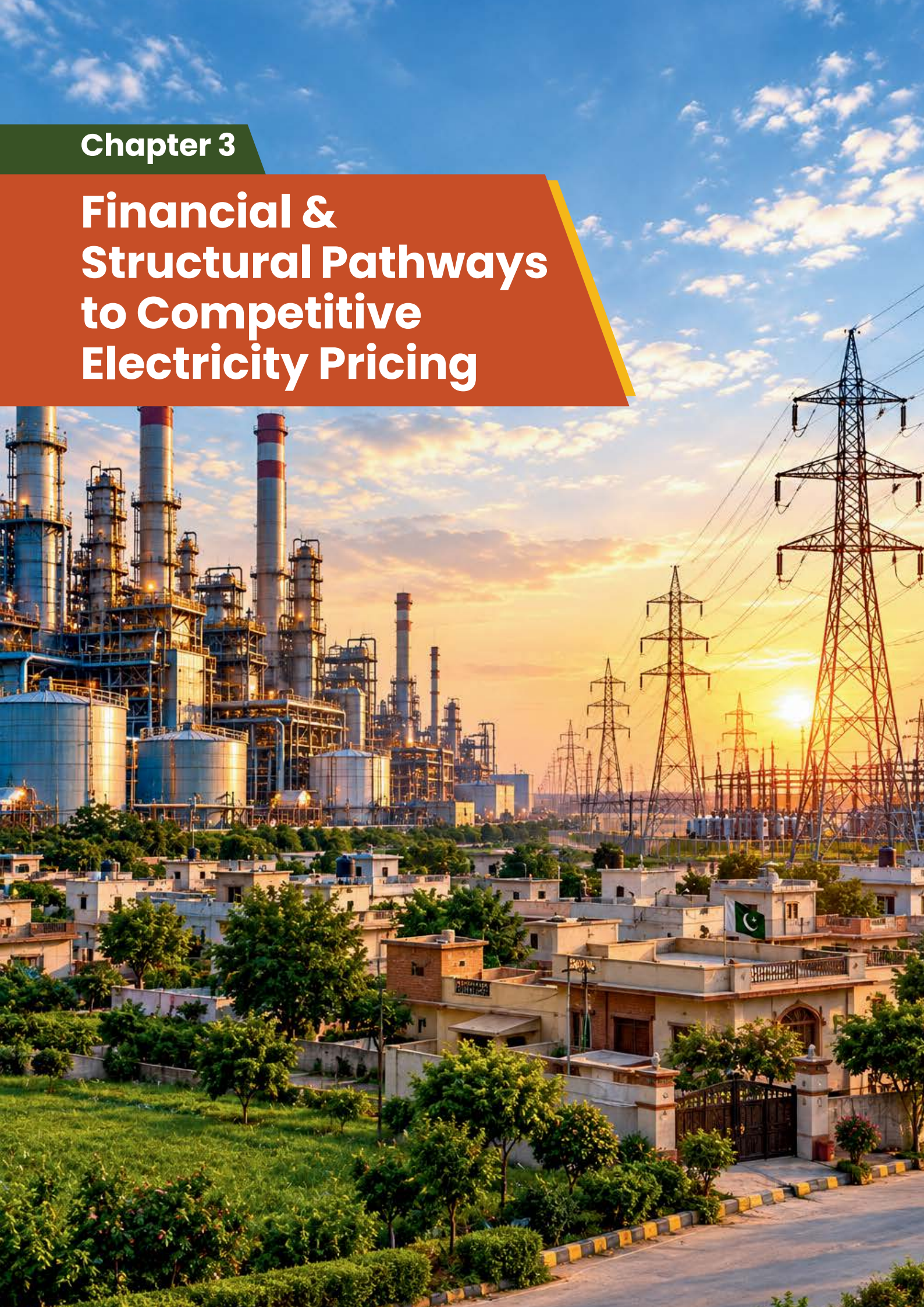
or data center development that policy programmes succeed in adding to the grid. The no-cost and low-cost interventions identified here are, in this sense, foundational. They must precede or proceed in parallel with capital-intensive demand programmes if those programmes are to achieve their potential system-level impact.

The interventions described in this section collectively demonstrate that a meaningful and measurable reduction in Pakistan's average electricity cost can be achieved before a single new power plant is built, before a single kilometer of transmission infrastructure is commissioned, and before a single rupee of public capital is committed. The governing logic is the same throughout this chapter: fixed capacity payments do not diminish when fewer consumers use the grid, but they are diluted when more consumers do. Removing the institutional barriers that are currently keeping willing consumers off the grid delayed connections, misaligned DISCO incentives, inadequate price signals, and administrative inertia in the distribution system releases demand that already exists. That demand, once connected, spreads the fixed cost burden more widely and reduces the per-unit tariff for everyone on the system.

In aggregate, conservative implementation across all eight interventions is projected to add approximately 9,343 gigawatt-hours of annual grid demand, reducing the average per-unit bulk purchase cost from PKR 23.37 to approximately PKR 22.39, a reduction of about PKR 0.98 per kilowatt-hour, delivering approximately PKR 108 billion in annual savings to the existing billed consumer base of about 110 TWh. These measures should therefore be treated as the immediate Phase 1 of Pakistan's demand creation strategy: not because their impact is small, but because they can be initiated through regulatory notifications and governance directives that require no legislative process and no procurement cycle, and whose benefits begin accruing within months of implementation rather than years. The capital-intensive electrification programmes analyzed in sections 1.1 through 1.7 depend, in turn, on the institutional infrastructure that these no-cost and low-cost interventions create.

Chapter 3

Financial & Structural Pathways to Competitive Electricity Pricing



Chapter 3

Financial, Structural, and Policy Pathways to Competitive Electricity Pricing

Financial, Structural, and Policy Pathways to Competitive Electricity Pricing

Pakistan's electricity pricing crisis is not simply a function of high generation costs; it is the outcome of a structure that has priced itself out of both industrial competitiveness and household affordability. Between FY2023 and FY2026, consumption fell by 17 to 45 percent across every residential slab priced above Rs. 33 per kWh, while the lifeline and protected slabs priced below Rs. 22 per kWh grew by about 38 percent in aggregate (Table 3; Figure 28): a market signal that the tariff structure has crossed the threshold of economic viability for most consumers. Because fixed system costs, principally PKR 1,807 billion of annual capacity payments, are borne by those who consume, every reform that adds a consumer or removes an unnecessary cost makes electricity cheaper for everyone already connected. Reform therefore has two jobs: reduce the fixed cost base (the financial and structural pathways) and remove the regulatory, commercial and institutional barriers that keep willing consumers off the grid (the policy reforms). This chapter treats the two together, theme by theme, so that each financial pathway sits beside the policy reform that delivers it, and consolidates both as indicators in Table 19, with the aim of bringing costs within the 6–7 US cents per kWh range that defines industrial competitiveness across peer economies.

Structural and System-Wide Cost Architecture

Comparator economies including Bangladesh, Vietnam, India, and China offer industrial electricity in the range of 7–10 US cents/kWh, whereas Pakistan's industrial tariffs, at 9.13–12.52 US cents/kWh (inclusive of taxes, surcharges, and levies), remain two to three times higher than globally competitive thresholds. A national benchmark of 6–7 cents/kWh, with a long-term target of ~5 cents/kWh and USD 5/MMBTU for gas, must therefore anchor all reform pathways outlined in this chapter (Figure 29).

Figure 28: Estimated Sales 23-26

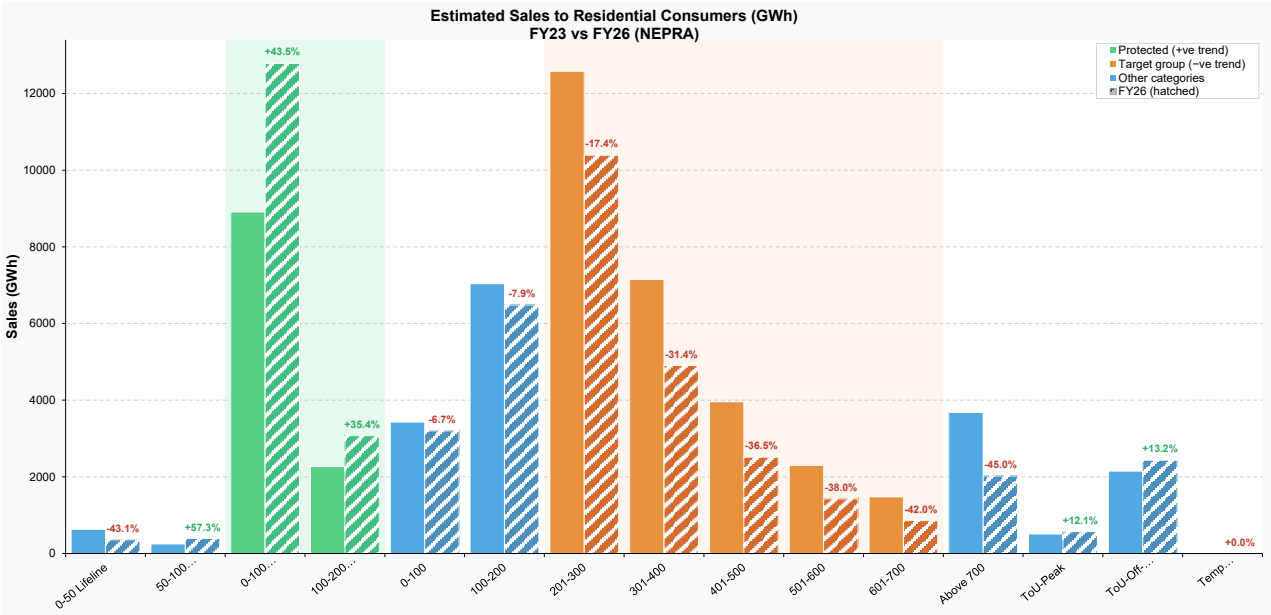
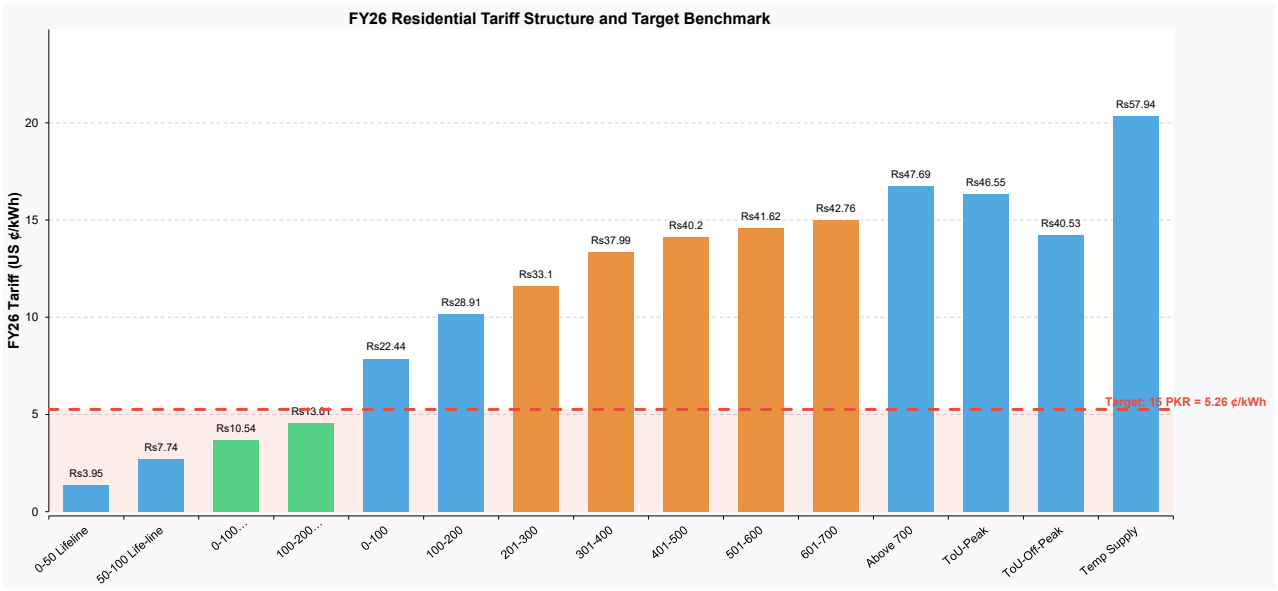


Figure 29: Target Benchmark



The central structural distortion is the scale and rigidity of capacity payments, which constitute the single largest cost component in the system. A substantial share of these payments is front-loaded, reflecting embedded debt servicing obligations within Independent Power Producer (IPP) tariffs. In most cases, particularly for thermal IPPs—this debt component spans approximately 10–12 years from the Commercial Operation Date (COD), after which tariffs decline materially often by 40–60% as only fixed O&M and return on equity remain. This creates a predictable, time-bound pathway for cost reduction that remains underleveraged in current policy design (Table 16).

Table 16: Power Plant Portfolio: Contractual and Loan Expiry Profile (2026 Outlook)

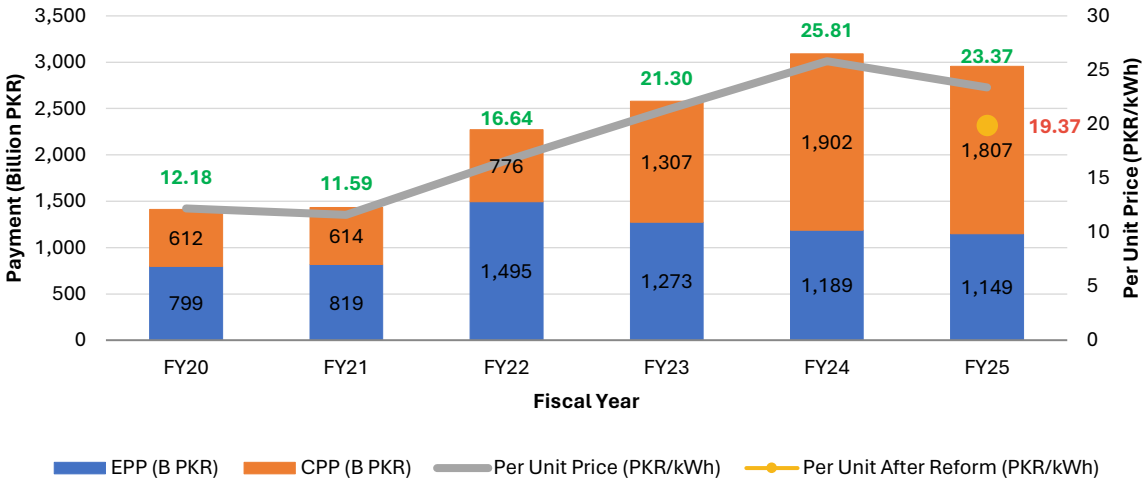
Category	Plant Name	Capacity (MW)	PPA Expiry	Loan Component Expiry
Hydel (Public)	Tarbela, Mangla, Ghazi Barotha	10,000+	Life-based	N/A (Sovereign/Public)
Hydel (IPP)	Karot Hydel (CPEC)	720	2052	2032
	Gulpur Hydel	102	2050	2030
Nuclear	K-2 & K-3 (Karachi)	2,290	2081–2082	2031–2032 *(indicative; sovereign financing)*
	Chashma (C1–C4)	1,330	2030–2047	Expired (C1/C2) / 2027 *(indicative)*
Local Coal	Engro Thar (Phase I)	660	2049	2029
	Lucky Electric	660	2052	2032
	Thar Energy (TEL)	330	2052	2032
Imported Coal	Sahiwal Coal	1,320	2047	2027
	Port Qasim	1,320	2048	2028
	China Power Hub (CPHGC)	1,320	2049	2029
RLNG	Bhikki / Haveli B. Shah	2,410	2048	2027–2028
	Balloki	1,223	2048	2028
Gas	Uch-I / Uch-II	990	2028 / 2039	Expired / ~2024–2026
	Engro Qadirpur	227	2035	Expired *(approx.)*
RFO (Oil)	Hubco (Base Plant)	1,292	2027	Expired
	Lalpir / Pakgen	730	2028	Expired
Renewables	Wind (Jhimpir Cluster)	1,845	2035–2042	2025–2032 *(project-specific)*
	Solar (Quaid-e-Azam)	100	2040	~2025 (indicative)
Bagasse	JDW / Hamza Sugar	150+	2044	2024–2026

Note: Loan expiry estimates are indicative and based on typical financing tenors (10–12 years for thermal IPPs). Actual tariff adjustments depend on plant-specific financing structures, sovereign guarantees, and contractual renegotiations.

A critical inflection point emerges in the 2027–2028 period, when several large baseload plants including imported coal and RLNG-based projects complete their initial debt servicing cycles. This transition is expected to create significant potential for tariff relief, particularly from high-cost thermal assets. In aggregate, an estimated 6–8 GW of capacity is likely to transition into lower-tariff regimes between 2027 and 2029, presenting a narrow but strategic window for tariff rationalization. Without complementary reforms, however, these gains risk being absorbed within existing system inefficiencies rather than translating into end-user price reductions.

Addressing the capacity payment burden requires a structural shift toward variable, performance-linked payment mechanisms, particularly for plants operating below 40% plant load factor, which currently receive full availability payments despite limited dispatch. In parallel, the reclassification of CPEC coal plant capacity payments as sovereign debt service rather than tariff-embedded charges offers a high-impact intervention. This adjustment alone has the potential to reduce tariffs by PKR 3–5/kWh (equivalent to removing roughly PKR 380–630 billion a year of capacity charges from the FY25 purchase base of 126.5 TWh), without requiring additional capital investment (Figure 30).

Figure 30: Structural and System-Wide Cost Architecture Effect on Per Unit Cost of Electricity

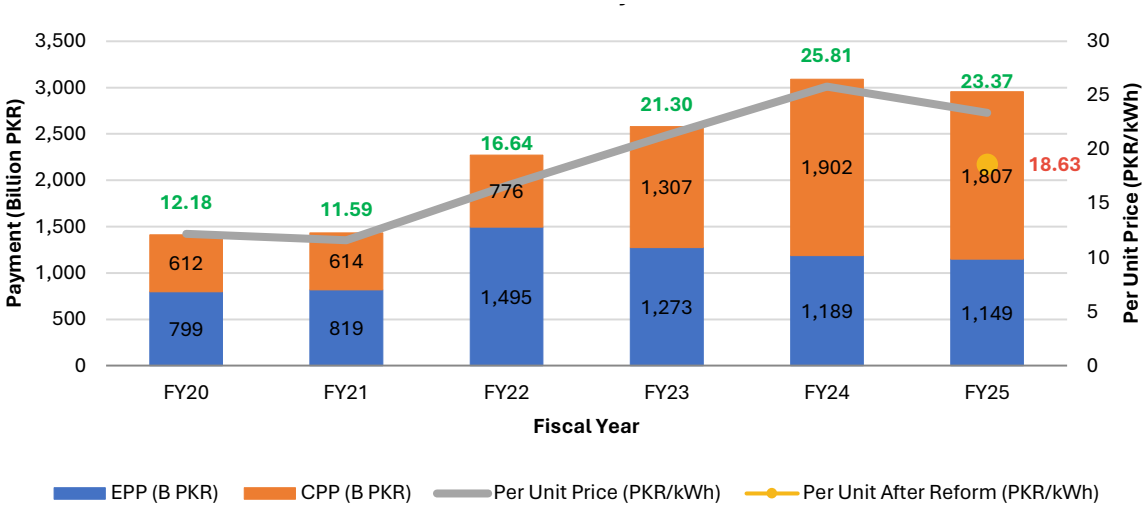


Policy reform: Capacity payments should be (i) converted into variable, performance-linked payments for plants that consistently operate below a 40% plant load factor; (ii) removed from the tariff base for CPEC-era coal plants by reclassifying them as sovereign debt service within the federal budget, which reassigns the obligation to its proper fiscal home rather than eliminating it; and (iii) governed, in future power purchase agreements, by contracted capacity aligned with realistic demand projections, with minimum dispatch thresholds below which full capacity payments are not triggered, an approach that should also be sought in renegotiating existing take-or-pay contracts.

Fiscal Offsets, Leakage Recovery and Government-Owned Capacity

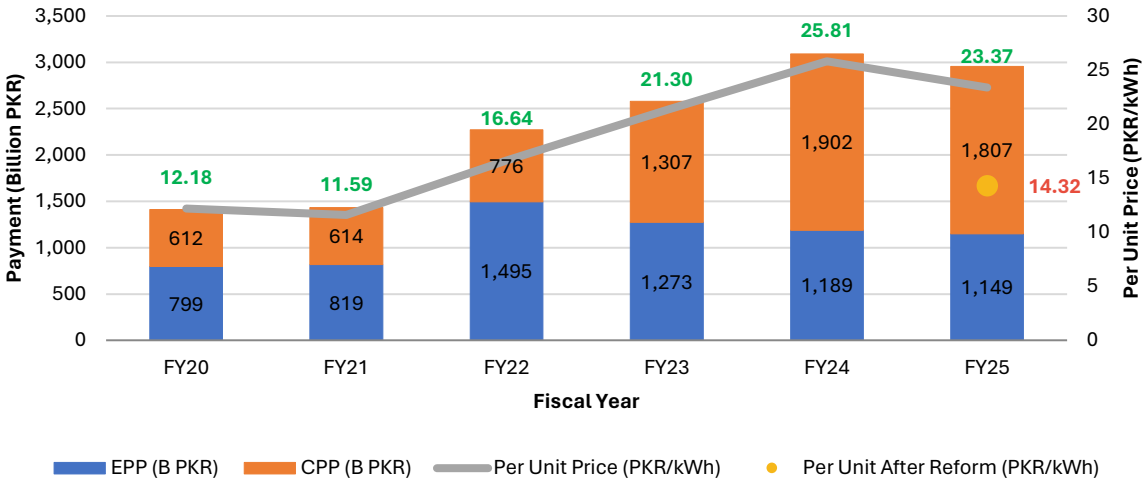
Subsidy reallocation: The government disburses approximately Rs. 1,200 billion a year in subsidies that have been diffuse, poorly targeted and frequently captured by non-intended beneficiaries. Directing Rs. 600 billion of these envelopes to offset capacity payments would leave Rs. 1,207 billion of capacity payments and Rs. 1,149 billion of energy payments, a cost base of about Rs. 2,356 billion spread over 126.5 TWh, or Rs. 18.63 per unit, a reduction of nearly 20% from the current Rs. 23.37 (Figure 31).

Figure 31: Redirecting Government Subsidies and effect on Per Unit cost of electricity



Federal–provincial participation: If provincial governments, notably Punjab and Sindh, which together account for the dominant share of grid load, contribute fiscal resources to offset the remaining Rs. 600 billion of capacity payments, the effective cost falls to about Rs. 9.08 per unit, the Rs. 1,149 billion of energy payments divided across 126.5 TWh (Figure 32). The case rests on direct provincial self-interest, since cheaper electricity raises industrial output, tax revenue and employment, and the compact should be formalized through National Finance Commission alignment, transparent cost-sharing, sunset clauses tied to demand-growth milestones and accountability frameworks that prevent moral hazard.

Figure 32: Federal–Provincial Agreement on Fiscal Participation for Cost Reduction



Recovering theft losses through grid-connected microgrids: Energy theft costs the sector an estimated Rs. 400 billion a year, concentrated in remote, peri-urban and high-loss areas (Figure 33) where enforcement has produced only temporary gains. The recommended design is a franchise-operated microgrid that stays connected to the grid through a single bulk revenue meter, with local solar PV and battery storage for reliability, prepaid or smart meters, and the franchise responsible for billing and collection; fully islanded systems should be limited to remote feeders where grid supply is uneconomic. This is consistent with the demand-dilution logic of this report: stolen units are already inside the 126.5 TWh purchased by CPPA-G but earn no revenue, so converting them into billed units works in the opposite direction to grid exit. An estimated investment of about Rs. 500 billion would pay back in roughly 1.1–1.25 years, and applying the recovered Rs. 400 billion to capacity payments would cut total

cost from Rs. 2,956 billion to Rs. 2,556 billion and the average price from 23.37 to about 20.21 PKR/kWh, a reduction of about 3.16 PKR/kWh (13.5%) that adds to, rather than replaces, the demand-growth effects in Chapters 1 and 2 (Figure 34).

Figure 33: Percent Loses of DISCOs

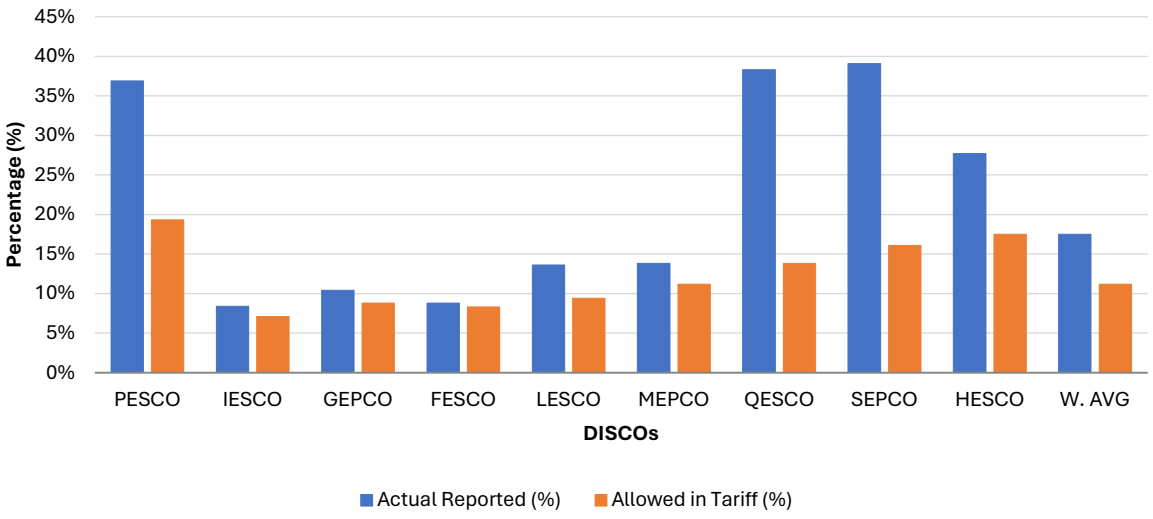
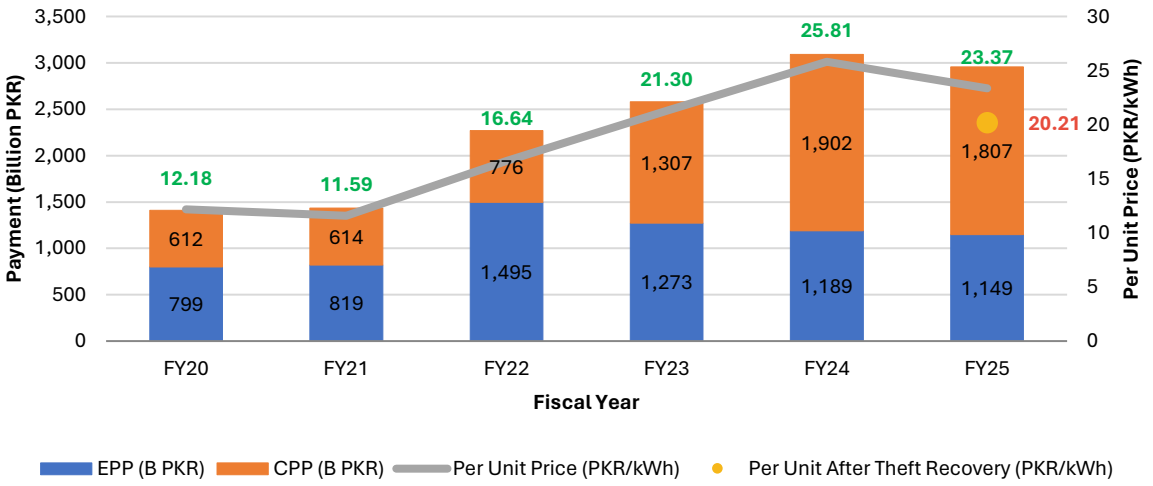
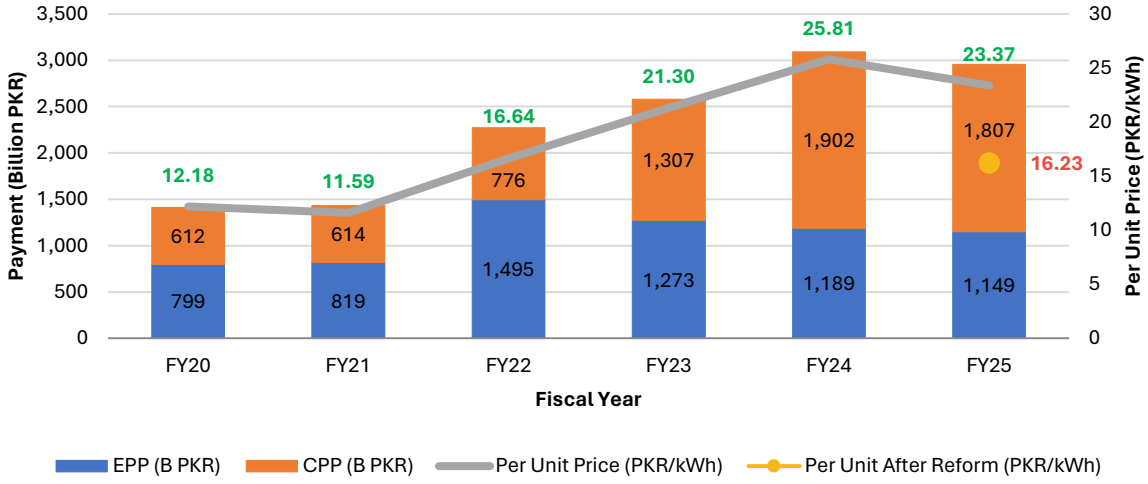


Figure 34: Impact of Electricity Theft Elimination and Capacity Payment Offset on Power Purchase Cost and Per-Unit Tariff (FY25 Baseline)



Government-owned capacity: About 50% of Pakistan's installed capacity is owned or controlled by the government (WAPDA hydel, nuclear plants, GENCOs and government-backed RLNG plants such as Balloki, Haveli Bahadur Shah, Guddu and Nandipur), so a large share of capacity payments is an intra-governmental transfer: about Rs. 903 billion of the Rs. 1,807 billion. Reducing capacity payments by half through PPA renegotiation or cost-based recovery would lower total cost from Rs. 2,956 billion to about Rs. 2,052.5 billion and the average price to roughly 16.23 PKR/kWh, a reduction of about 7.14 PKR/kWh (nearly 30%). Full elimination is not feasible because of debt servicing, sovereign guarantees, fixed O&M and the strategic importance of hydel and nuclear assets, so realistic renegotiation savings of Rs. 400–600 billion, or about 3.2–4.7 PKR/kWh, are the near-term target, complemented by demand growth that spreads fixed costs further (Figure 35).

Figure 35: Per unit cost Reduction After Cut Capacity Payment of 50% Owned Power Plants



Tariff Rationalization, Cross-Subsidy Elimination and Regulatory Reform

Pakistan's electricity tariff is a political settlement rather than a price signal. Approximately PKR 800 to 1,200 billion a year is transferred through it from industrial, commercial and upper-domestic consumers to subsidized categories, principally low-consumption residential users and agricultural tube wells. Industrial consumers pay about PKR 4.06 per kWh (22 percent) more than the recovery rate tariff and commercial consumers about PKR 11.5 per kWh (63 percent) more, so the cross-subsidy alone adds about 1.5 US cents per kWh to what export industries pay, on top of tariffs that are already high compared with the 7 to 10 US cents per kWh in Bangladesh, Vietnam, India and China. The uniform national tariff also ignores locational cost differences, and the residential slab system distorts consumption behavior and encourages informal solutions, including unauthorized generation.

A cost-reflective tariff reform would align charges with the actual cost of service by consumer category. The size of this transfer depends on the benchmark used (estimates by the FPCCI Policy Advisory Board, Unfair Power Tariff for Trade and Industry: The Impact of Cross-Subsidisation, based on FY2020-21 data). Measured against the weighted average tariff (WAT, PKR 16.53/kWh), industrial consumers pay about PKR 44 billion and commercial consumers about PKR 38 billion a year more than their share of cost (about PKR 98 billion together with bulk-supply consumers); set against residential and agricultural shortfalls of about PKR 303 billion and PKR 65 billion, this leaves a system-level shortfall at WAT of about PKR 269 billion. Measured against the recovery rate tariff (PKR 18.32/kWh), the over-payment is about PKR 86 billion by industrial consumers and about PKR 96 billion by commercial consumers annually, or about PKR 181 billion combined. Cost-reflective rationalization would therefore save industry and commerce approximately PKR 82–181 billion a year, depending on the benchmark. Industrial feeders serving established economic zones Sundar, FIEDMC, Hattar, Rashakai, and Port Qasim should be the first to receive tariffs reflecting the actual cost of supply on their feeder, without embedded subsidies for other consumer classes baked into the blended rate.

TARIFF DATA: (FPCCI, FY2020-21) System-level shortfall at WAT (PKR 16.53/kWh): ~PKR 269 billion, i.e. residential (~PKR 303 billion) and agricultural (~PKR 65 billion) shortfalls less ~PKR 98 billion paid above WAT by industry (~PKR 44 billion), commerce (~PKR 38 billion) and bulk supply. Against the recovery rate tariff (PKR 18.32/kWh), industry and commerce over-pay ~PKR 181 billion (~PKR 86 billion and ~PKR 96 billion). Saving to industry and commerce from cost-reflective tariffs: ~PKR 82–181 billion annually, depending on the benchmark.

Policy reform: Cross-subsidies should be eliminated in a time-bound manner and replaced by direct, income-targeted fiscal transfers administered outside the tariff, since subsidies embedded in the tariff benefit every consumer in a category regardless of income and fall hardest on the sectors best placed to drive demand growth. The federal and provincial taxes, surcharges and levies layered onto bills (general sales tax, income tax adjustments and sector-specific levies) should be reviewed and reduced in coordination with NEPRA. Tariffs should become marginal-cost-reflective and location-specific, so that consumers close to generation, such as the Balloki plant in central Punjab, pay less than those served over long distances, and the slab system should be abolished in favor of separate fixed and variable charges, time-of-use pricing that reflects system costs, and income-based subsidies delivered outside the tariff.

NEPRA's regulatory model has come to privilege procedural compliance and input-based control over commercial performance: tariff adjustments take months to process, procurement pre-approvals delay decisions, and micro-managed DISCOs have neither the incentive nor the latitude to behave as commercial utilities. NEPRA should move to output-based regulation, giving DISCOs operational autonomy over routine procurement, resource allocation and tariff application while holding them accountable for verified outcomes: energy sales volumes, AT&C loss trajectories, connection timelines, customer satisfaction and cost efficiency. Permitted revenues should be linked to performance: a DISCO that reduces AT&C losses by 1.5 percentage points a year, grows energy sales by 8 to 12 percent and processes connections within mandated timeframes would earn higher returns, while one that fails would face revenue claw-backs. Faster tariff notifications, lower administrative overhead and lower circular-debt financing costs would follow, and the resulting lower tariffs would stimulate demand.

DISCO Privatization, Connection Access and Governance Reform

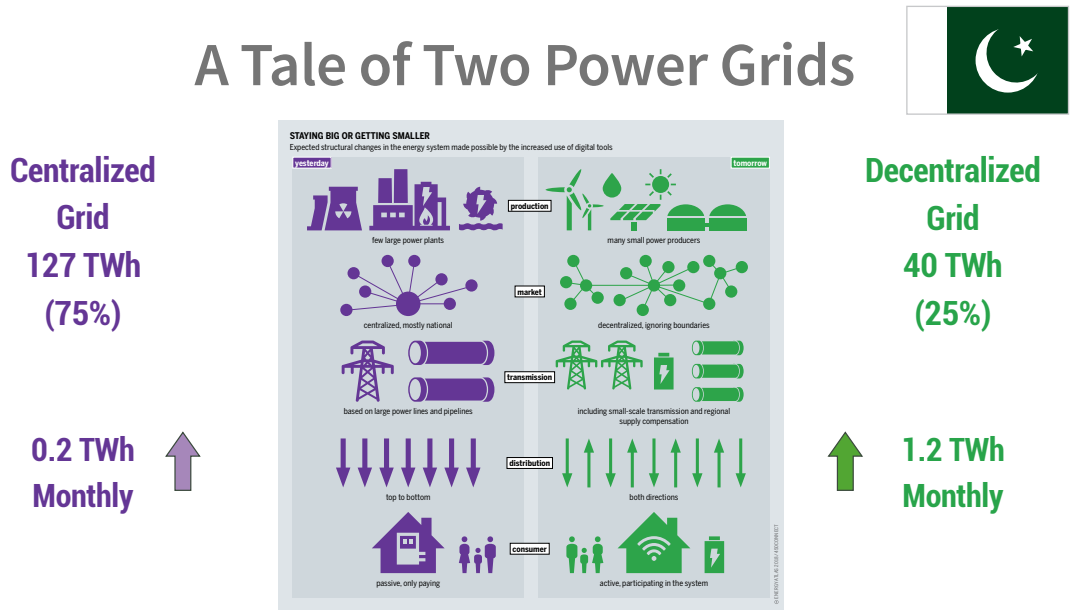
Pakistan's DISCOs are vertically integrated public utilities that were never designed to grow demand: there is no sales department, no function to identify underserved demand or reduce connection friction, and little competitive pressure. A commercially oriented utility puts access first, reliability second and pricing third; DISCOs have inverted this sequence, which suppresses the very demand growth that would lower per-unit costs for everyone. Reform should begin with IESCO and LESCO, the most commercially viable DISCOs given their dense urban load, lower losses and established metering, under five-year distribution licences with publicly committed targets for AT&C loss reduction, reliability, connection processing and sales growth, and with licence revocation as an exercised sanction. For DISCOs that are not immediate candidates, dedicated commercial and sales functions, variable pay of 10 to 20 percent of compensation tied to sales growth, cash collection and feeder-level loss reduction, and franchising of high-loss zones would align incentives with demand growth, while DISCOs should be repositioned as neutral platform operators for distributed energy, prosumers, EV charging and third-party retail supply. A Competitive Trading Bilateral Contract Market (CTBCM) with competitive retail licensing should be carefully sequenced: unrestricted retail competition before the distribution sector is financially sustainable would accelerate the migration of high-value consumers, leave a smaller base to carry fixed costs and require higher wheeling or network charges, so the transition should follow reforms to network pricing, cost recovery and utility revenues.

The most direct way to lower per-unit costs is to connect more consumers. In FY2024–25 about 128,096 eligible consumers who had made timely advance payments were denied new connections, an unserved demand of more than 1,021 MW at a time of surplus capacity. Each of them would have helped spread the Rs. 1,807 billion capacity obligation over a larger base, so the backlog is a self-inflicted cost-inflation mechanism.

Pakistan's grid is growing from centralized to decentralized at a very fast pace. This structural shift is already visible in consumption data: the centralized grid currently accounts for 127 TWh annually, approximately 75 percent of total consumption growing at 0.2 TWh per month. The decentralized segment, driven overwhelmingly by rooftop and distributed solar, now accounts for 40 TWh annually,25 percent of total consumption, and is growing at 1.2 TWh per month, six times the growth rate of the centralized system. The 127 TWh shown for the centralized grid

corresponds to the 126.5 TWh of electricity purchased by CPPA-G that is used throughout this report to calculate the power purchase price. It is about 75 percent, rather than all, of the electricity Pakistan now uses because the remaining 40 TWh is generated behind the meter by rooftop and distributed solar. That supply is never purchased through the grid and carries no capacity payments, so it is correctly excluded from the power purchase price calculation; it is, however, precisely the demand that the reforms in this report seek to bring back to the grid. Independent estimates suggest that the decentralized share may be even larger: Ember and Renewables First (2026) put distributed solar generation at about 51 TWh, or 28 percent of Pakistan's electricity generation, in FY2024-25. The direction of travel is unambiguous: consumers are not waiting for the grid to improve; they are leaving it. This exit is rational. When the centralized grid charges 18–24 cents per kWh and offers unreliable supply, while distributed solar now delivers energy at a levelized cost of 3 cents per kWh in 2025, down from 5 cents in 2022, and battery storage has similarly fallen from 11 cents to 3 cents per kWh over the same period, the economics of self-generation have crossed a threshold that no tariff communication campaign can reverse. The 6–7 cent per kWh competitiveness benchmark that this framework adopts is not an aspiration, it is a ceiling above which consumers will continue to exit the grid in accelerating numbers. The question is no longer whether Pakistan's electricity can be delivered at that cost. The question is whether the institutional reforms required to achieve it will arrive before the centralized system loses the consumer base it needs to remain financially viable.

Figure 36: Tale of Power Grid



Policy reform: Residential connections should be energized within 15 working days of a completed application and industrial connections within 30, with NEPRA imposing financial penalties for each day of delay and DISCOs maintaining a public live demand pipeline updated monthly. For industry, the Sundar Industrial Estate model (a single high-voltage connection at the estate boundary, with internal distribution, metering and billing run by a private operator), together with tax holidays and incentives for SEZs near generation or transmission infrastructure, would speed up load addition. Emerging segments such as EV charging, hyperscale data centers (global data-center consumption is projected to approach 1,050 TWh by 2026), electrified railways and aquaculture represent multi-terawatt-hour demand pools that need preferential supply arrangements, streamlined connection procedures and purpose-designed tariffs.

Governance and circular debt: Circular debt, the cascading chain of payment defaults linking generation companies, fuel suppliers, DISCOs, CPPA-G and the federal government, is the most visible symptom of governance failure: the power sector caused an estimated loss of about PKR 265 billion to the exchequer by the end of FY2024–25, and unpaid obligations accumulate financing charges that re-enter tariffs as a hidden cost. DISCO revenues

should be ring-fenced through an automated central settlement account that distributes collections to generation companies, fuel suppliers and the transmission company according to a pre-determined priority schedule; multi-year tariff frameworks with pre-committed efficiency trajectories should give investors and industrial consumers planning certainty; and DISCO operations should be decentralized to feeder and zone level, with local managers holding real authority over procurement, maintenance and customer engagement, supported by stronger coordination among generation, transmission, distribution and regulatory entities.

Southern Surplus Power, SEZs and North–South Tariff Rationalization

Much of the recently commissioned generation capacity, particularly under CPEC, is concentrated in the south: Port Qasim's 1,320 MW coal plant, the 1,320 MW China Power Hub plant, the Thar coal projects and the Gharo–Jhimpir wind corridor. The 500 kV and 220 kV transmission network have not expanded proportionately, so surplus southern power cannot be evacuated efficiently to northern demand centers, causing underutilization of efficient assets, higher losses and continued reliance on costlier northern generation. Developing large Special Economic Zones around Karachi, Port Qasim, Hub, Gwadar and Thar, targeted at electricity-intensive sectors (steel, chemicals, refining, EV and battery manufacturing, fertilizer, advanced textiles and hyperscale data centers), would create productive demand at the point of supply, improve plant load factors and the viability of CPEC projects, defer transmission reinforcement and support employment and exports.

The SEZ strategy depends on electricity in the south being commercially competitive, but the uniform tariff mandated by Section 31 of the NEPRA Act, 1997 masks regional costs. NEPRA set the National Average Tariff at PKR 33.38 per kWh for FY2025–26, and the federal government budgeted a Tariff Differential Subsidy (TDS) of PKR 249.14 billion (PKR 276 billion in FY2024–25) to bridge the gap between what each DISCO costs to operate and what consumers pay. Allowed T&D losses are 17.55% for HESCO, 16.31% for SEPCO and 13.81% for QESCO against around 8–11% for IESCO, GEPCO and FESCO, and actual losses and recovery shortfalls are considerably worse (Table 18), so efficient northern DISCOs effectively cross-subsidize southern networks. Meanwhile the already-paid-for southern generation (Port Qasim, Thar and the Gharo–Jhimpir wind corridor) has a lower marginal cost than the RLNG-based generation serving the north, yet no consumer or investor sees a price signal reflecting it.

Table 17: Regional DISCO Cost and Efficiency Comparison (FY 2024–25)

DISCO	Region	Allowed T&D Loss (%)	Recovery Rate (%)
IESCO	North (Islamabad)	~9%	~100%
LESCO	North (Lahore)	~10%	~100%
FESCO	North (Faisalabad)	~10%	~100%
GEPCO	North (Gujranwala)	~10%	~100%
MEPCO	South-Central (Multan)	~12%	~100%
HESCO	South (Hyderabad)	~17.55%	~74.80%
SEPCO	South (Sukkur)	~16.31%	~70.20%
QESCO	South (Quetta)	~13.81%	~38.70%

Source: NEPRA DISCO Performance Report FY 2024–25; NEPRA Interim Tariff Determinations FY 2025–26

Policy reform: a two-track framework within the NEPRA Act, 1997 (Section 31(4)) and the National Electricity Policy, 2021. First, a generation-proximity discount: NEPRA should introduce a category-specific industrial tariff for large consumers (above 5 MW) in designated SEZs in Sindh and Balochistan, structured as a discount off the national average tariff and calibrated to the difference between the marginal dispatch cost of southern generation and the national average power purchase price (PKR 27 per kWh for FY2024–25); even a PKR 3–5 per unit discount would create a meaningful location incentive for energy-intensive industry. Second, a performance-linked cost-of-service reform: TDS allocations for HESCO, SEPCO and QESCO should be converted into time-bound Management

Performance Contracts with annual T&D loss reduction targets of 2% a year, minimum collection rates of 85% by FY2027–28 and quarterly penalty-based reviews, with a portion of the subsidy withheld from DISCOs that miss targets and redirected to grid investment in their area. Together, the two tracks give southern industry a tariff that reflects the advantage of southern generation, hold southern DISCOs to the standards that make reliable supply achievable and turn the subsidy from a permanent liability into a time-limited transition instrument.

Battery Storage and Climate Finance

Large-scale Battery Energy Storage Systems (BESS) can lower the effective cost of electricity for large consumers by charging off-peak and discharging at peak. A 100 MW / 400 MWh system costs about USD 100–120 million (USD 250–300 per kWh of usable capacity); with a peak-to-off-peak differential of Rs. 8–12 per kWh, 350–380 cycles a year and 90% round-trip efficiency, a payback of roughly 5–7 years is achievable only when arbitrage is combined with system services such as frequency regulation, operating reserves and deferred network reinforcement: on time-of-use arbitrage alone, revenue of about Rs. 1.0–1.6 billion a year implies a simple payback of roughly 17–33 years. For industrial consumers facing peak tariffs above Rs. 30 per kWh, BESS-enabled peak shaving can reduce effective costs by about Rs. 6–10 per kWh. Because evening surplus capacity is already paid for, the government should also evaluate gradually reducing or abolishing time-of-use peak tariffs for industry to raise consumption and spread fixed costs; this would weaken the arbitrage case, so the long-term business case for BESS should rest on its wider system value.

Climate finance and concessional lending can fund BESS and other demand-enabling infrastructure (rural microgrids, smart metering, grid modernization) at a cost of capital well below domestic commercial borrowing, reducing the capital cost component embedded in tariffs. The Green Climate Fund offers grants and concessional loans for NDC-aligned BESS, microgrid and renewable-integration projects; the Asian Development Bank offers concessional financing for grid modernization, transmission upgrades and storage; and IFC infrastructure bonds and first-loss guarantees are estimated to unlock PKR 2 to 4 of private capital for every PKR 1 of IFC support. The government and CPPA-G should establish a coordinated BESS deployment programme on this basis, and allocate about 0.5 percent of CPPA-G's annual procurement budget to a Power Sector Research, Development and Demonstration (RD&D) Fund for AI-based dispatch optimization, smart grid management, demand response and next-generation storage.

Summary: Financial Pathway to Competitive Electricity Costs

The reforms presented in this chapter constitute a coherent and sequenced financial management strategy not a collection of isolated policy measures. Each intervention addresses a specific structural distortion in the current cost architecture, and their cumulative impact, implemented in coordinated sequence, creates a credible pathway from Pakistan's current electricity cost of Rs. 23.37 per unit to a competitive target range of Rs. 14-19 per unit. The following table (Table 18) summarizes the financial trajectory of the proposed reform pathway.

Table 18: Financial Trajectory of the proposed reform pathway full realization

Reform Stage	Reduction of Cost (PKR/unit)
Baseline (FY 2024–25)	Rs. 23.37
Federal Subsidy Reallocation (Rs. 600 bn to capacity payments)	Rs. 4.7
Provincial Fiscal Participation (full CP absorption)	Rs. 9.08
Government IPP Netting Mechanism (~50% CP offset)	Rs. 6–7
BESS, Microgrid Deployment & Locational Tariff Reform	Target: Rs. 5–6

This trajectory is achievable within a realistic policy and implementation timeframe. The federal subsidy reallocation and IPP netting mechanism can be implemented through administrative and accounting measures without requiring legislative change or new capital. Provincial fiscal participation requires intergovernmental negotiation but has strong self-interest alignment on both sides. Microgrid deployment and BESS procurement involve capital expenditure with clearly defined and short payback periods, making them commercially bankable with appropriate concessional support. Tariff reform and privatization require regulatory redesign but build upon existing institutional frameworks.

Consolidated Financial and Policy Reform Matrix

Table 19 consolidates the financial and structural pathways and the policy reforms of this chapter into a single set of indicators, theme by theme, together with the expected directional impact on per-unit electricity cost. The reforms are interdependent and mutually reinforcing; implemented in a coordinated and sequenced manner, their combined effect is substantially greater than the sum of individual measures.

Table 19: Consolidated financial and policy reform indicators

Reform Theme	Financial / Structural Indicator	Policy Reform Indicator	Expected Impact on Per-Unit Cost
Capacity payments	• PKR 1,807 bn a year of fixed payments (about 61% of the power purchase bill) • Debt component of thermal IPP tariffs ends 10–12 years after COD; 6–8 GW moves to lower-tariff regimes in 2027–29 • Plants below 40% load factor still earn full availability payments	• Performance-linked payments for plants below 40% plant load factor • Reclassify CPEC coal capacity payments as sovereign debt service in the federal budget • Align future PPAs with demand; minimum dispatch thresholds in take-or-pay contracts	• Estimated reduction of PKR 3–5/kWh from CPEC reclassification • Fixed cost base transferred out of the tariff
Fiscal offsets (federal and provincial)	• About Rs. 1,200 bn a year of diffuse subsidies • Rs. 600 bn redirected to capacity payments: Rs. 23.37 to Rs. 18.63 per unit • Provincial absorption of the remaining Rs. 600 bn: about Rs. 9.08 per unit	• Budget reallocation of subsidies to capacity-payment relief • NFC-aligned federal–provincial compact with sunset clauses tied to demand-growth milestones	• Rs. 4.7/unit (federal reallocation) and Rs. 9.08 (full capacity-payment absorption), as shown in Table 17
Government-owned IPP capacity	• About 50% of installed capacity is state-owned or controlled • About Rs. 903 bn of capacity payments flows back to government-owned assets	• Net off or restructure through PPA renegotiation or cost-based recovery • Full elimination not feasible (debt service, sovereign guarantees, fixed O&M)	• Rs. 6–7/unit at about 50% offset (Table 17) • Rs. 3.2–4.7/unit on realistic savings of Rs. 400–600 bn
Energy theft and microgrids	• About Rs. 400 bn a year of theft losses • Rs. 500 bn microgrid investment pays back in about 1.1–1.25 years	• Franchise-operated, grid-connected microgrids with solar PV, storage and prepaid or smart meters • Islanded systems only for remote feeders where grid supply is uneconomic	• About 3.16 PKR/kWh (13.5%) when recovered revenue offsets capacity payments • Adds to the demand-growth effects in Chapters 1 and 2
Tariffs and cross-subsidies	• PKR 800–1,200 bn a year transferred through the tariff • Industry pays about PKR 4.06/kWh (22%) and commerce PKR 11.5/kWh (63%) above the recovery rate tariff	• Time-bound elimination of cross-subsidies; income-targeted transfers outside the tariff • Rationalize federal and provincial taxes, surcharges and levies • Location-specific, cost-reflective tariffs; abolish the slab system	• Estimated PKR 82–181 billion annual savings for industry and commerce (against the weighted average and recovery rate tariff benchmarks respectively) • Removes demand-suppression distortion

Reform Theme	Financial / Structural Indicator	Policy Reform Indicator	Expected Impact on Per-Unit Cost
Regulation (NEPRA)	• Slow tariff adjustments and prior-approval procurement add delay and financing costs	• Output-based regulation: DISCO autonomy, accountability for sales, AT&C losses and connection timelines • Performance-based revenue: higher returns for 1.5 pp a year AT&C reduction and 8–12% sales growth; claw-backs for failure	• Indirect reduction through lower administrative costs and reduced circular debt financing charges
DISCO privatization and retail market	• No sales or commercial function in DISCOs; high technical and commercial losses • Early retail competition would push high-value consumers off the grid	• Begin with IESCO and LESCO under five-year licenses with public targets • Franchise high-loss zones; variable pay of 10–20% tied to sales and collection • Sequence CTBCM after distribution-sector financial reforms	• Higher sales volumes spread fixed costs across more units; lower per-unit recovery requirement
Connection and access	• 128,096 eligible consumers (more than 1,021 MW) awaiting connection in FY2024–25 • Grid shifting from centralized to decentralized: 127 TWh on the grid vs 40 TWh behind the meter	• Connect within 15 (residential) and 30 (industrial) working days, with NEPRA penalties and a public demand pipeline • Replicate the Sundar model; preferential supply for EV charging, data centers and railways	• Immediate demand expansion; fixed capacity costs shared across a broader consumer base
Southern surplus and North–South tariffs	• Surplus southern CPEC generation constrained by transmission • TDS of PKR 249.14 bn in FY2025–26; allowed T&D losses of 13.81–17.55% in QESCO, SEPCO and HESCO (Table 18)	• SEZs at Karachi, Port Qasim, Hub, Gwadar and Thar for energy-intensive industry • Generation-proximity discount of PKR 3–5/unit for large SEZ consumers • Convert TDS into performance contracts (2% a year loss reduction; 85% collection by FY2027–28)	• Better plant utilization and lower delivered cost; deferred transmission reinforcement
Circular debt governance	• Estimated PKR 265 bn loss to the exchequer by end-FY2024–25 • Financing charges re-enter tariffs as a hidden cost	• Ring-fence DISCO revenues through an automated central settlement account • Multi-year tariff frameworks; decentralize DISCOs to feeder and zone level	• Removes the hidden financing cost layer; reduces tariff volatility
Storage and climate finance	• 100 MW / 400 MWh BESS costs about USD 100–120 mn; 5–7-year payback only with system services (17–33 years on arbitrage alone) • GCF, ADB and IFC instruments (PKR 2–4 of private capital per PKR 1 of IFC support)	• Coordinated BESS programme using ADB concessional finance and IFC first-loss guarantees • RD&D Fund at 0.5% of CPPA-G's procurement budget	• Replaces high-cost domestic financing; lowers the capital cost component of supply cost per unit • Peak shaving of Rs. 6–10/kWh for industrial consumers

Taken together, these measures represent a structural transformation of Pakistan's power sector from a high-cost, subsidy-dependent, institutionally fragmented system to a competitive, demand-driven, and financially self-sustaining electricity market capable of supporting Pakistan's long-term industrialization and economic development objectives.

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