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Pakistan's Solar Rush
Beyond the Hype

Six Monthly Energy Monitor - June 2025

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INTRODUCTION

In the midst of a severe energy crisis, Pakistan's solar boom has been hailed globally as a success story. The narrative of this "solar revolution" is largely driven by the exponential rise observed in solar photovoltaic or PV imports, with China as the dominant supplier, positioning Pakistan as the world's third-largest destination for Chinese solar exports. As per Ember data[1], a cumulative capacity of about 50GW has been exported into the country by China since 2017(see Figure 1). Contrary to this impression of a solar boom happening in Pakistan, however, the deployment of solar PV at "utility scale" - large-scale energy projects, such as solar or wind farms, generating a significant amount of electricity for the power grid - has been almost stagnant over the past years (see Figure 2). Total utility scale solar currently stands at 680 MW as per the latest *State of Industry Report 2024*, even as the

Solar PV Capacity Exported by China (GW)

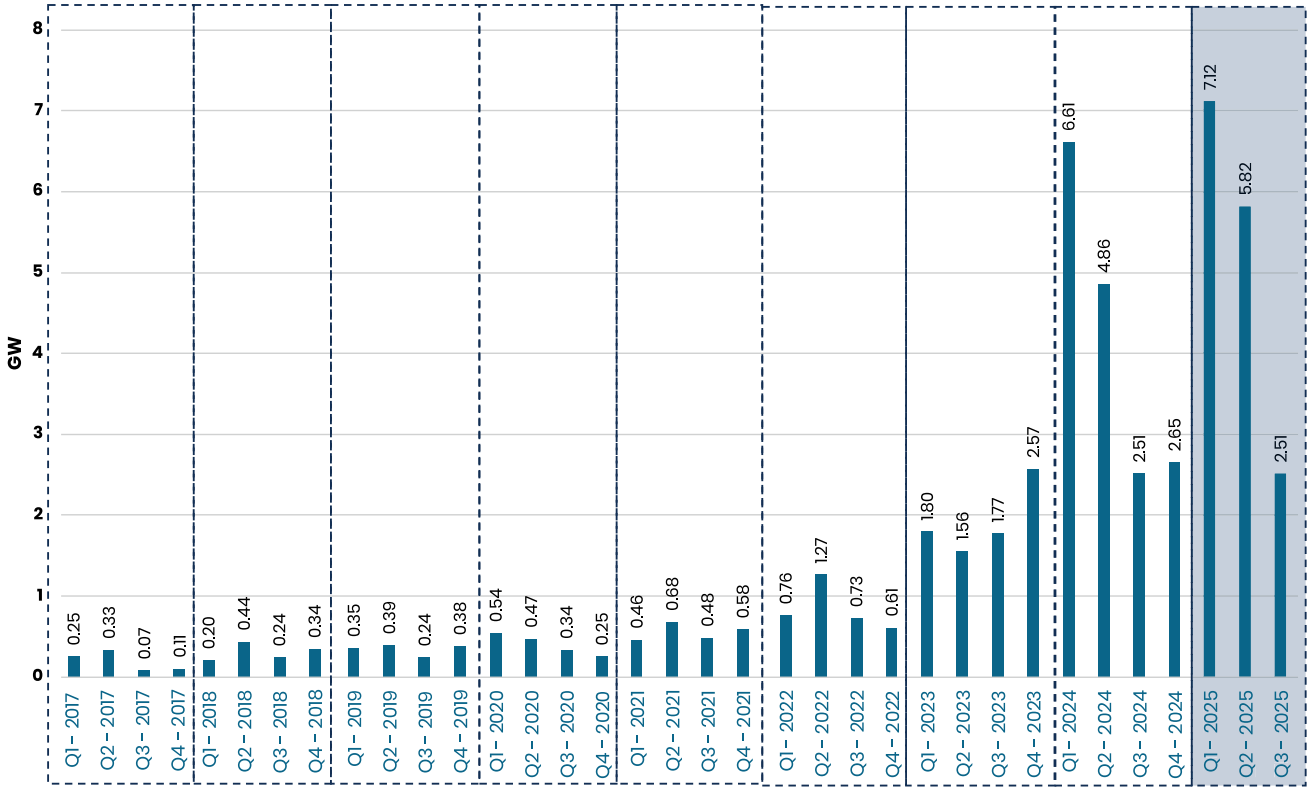

Figure 1: Solar PV capacity exported to Pakistan by China

1. https://ember-energy.org/data/chinas-solar-pv-export-explorer/#dataset

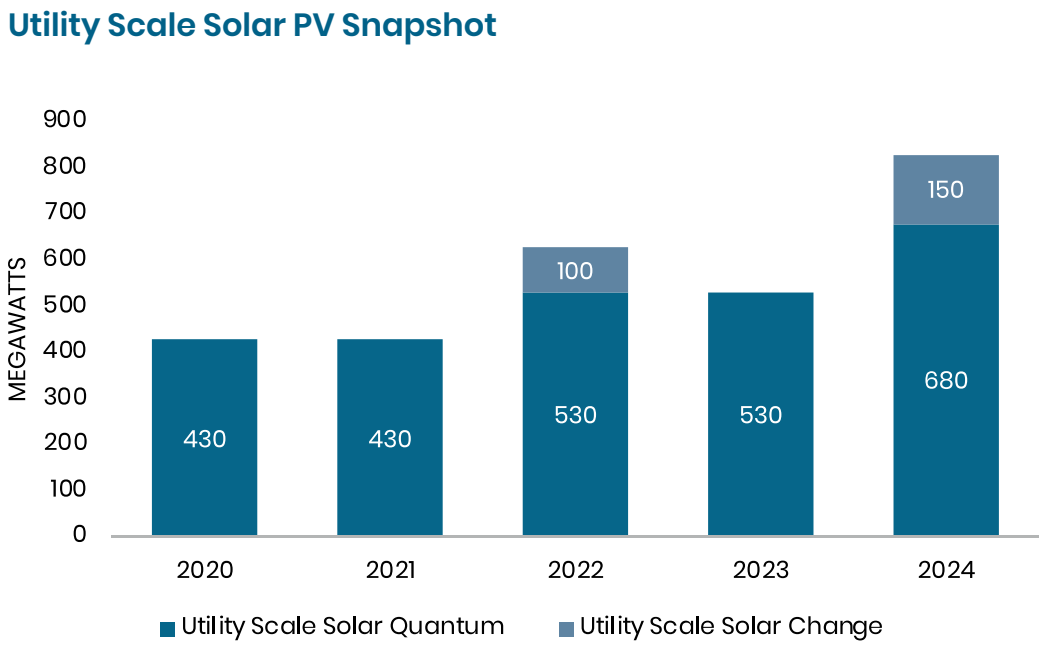

Figure 2: Pakistan›s utility scale solar PV capacity

the utilization of decentralized solar PV systems is rapidly increasing across different sectors including the residential sector, commercial, industrial, and agriculture sectors. In these sectors, the adoption has been both through net-metered systems allowing consumers to feed excess electricity back into the grid, and through behind-the-meter systems, used directly by adopters/ installers without any interaction with the grid. However, the only verifiable numbers of solar PV adoption at a decentralized level exist at the scale of net metering. As per the data from the *State of Industry Report 2024*, the electricity imports from the net-metered systems show a steep rise (see Figures 4 and 5), while, the pending applications capacity for net metered systems stood at over 58MW as per the same report. However, the current net-metered capacity across the country is stated to be over 6GW as reported in a consultation session with the Private Power and Infrastructure Board on 16th April 2025. This net-metered capacity is about 3 times the reported cumulative net-metered capacity of about 2.498GW in 2024, and far beyond the capacity of pending net-metering applications in 2024.

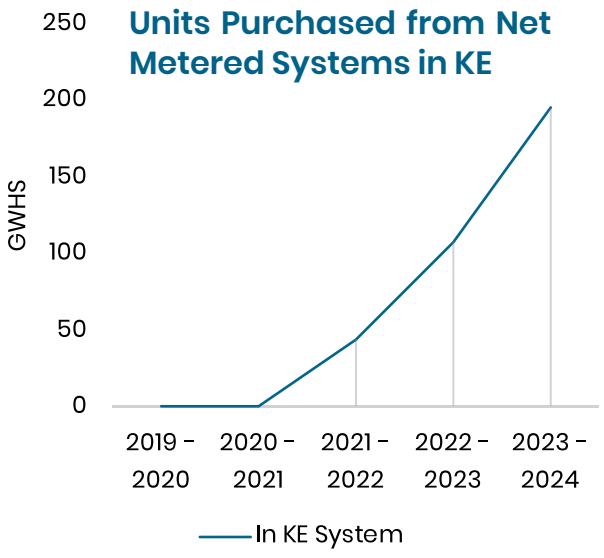

Figure 3: Units imported into KE system from net--metered system

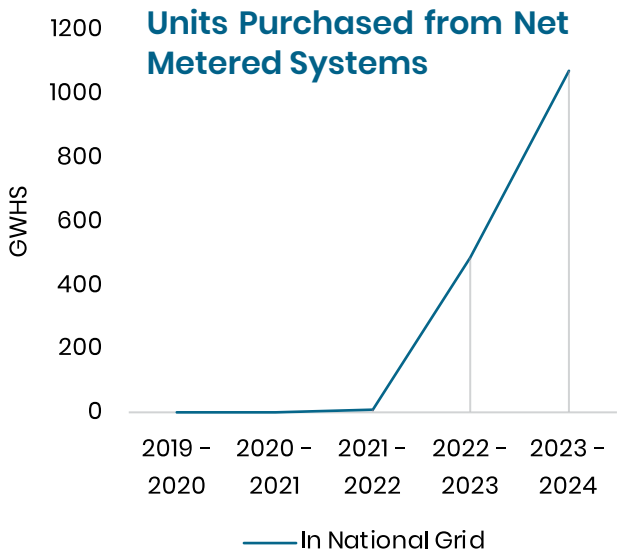

Figure 4: Units imported into national grid system from net--metered system

This net-metering expansion is happening across all consumer categories, with residential sector consumers claiming a lion's share of solar PV adoption, closely followed by the commercial sector such as businesses and offices, and finally the public infrastructure like government buildings and hospitals.

Net Metering Consumers By Type

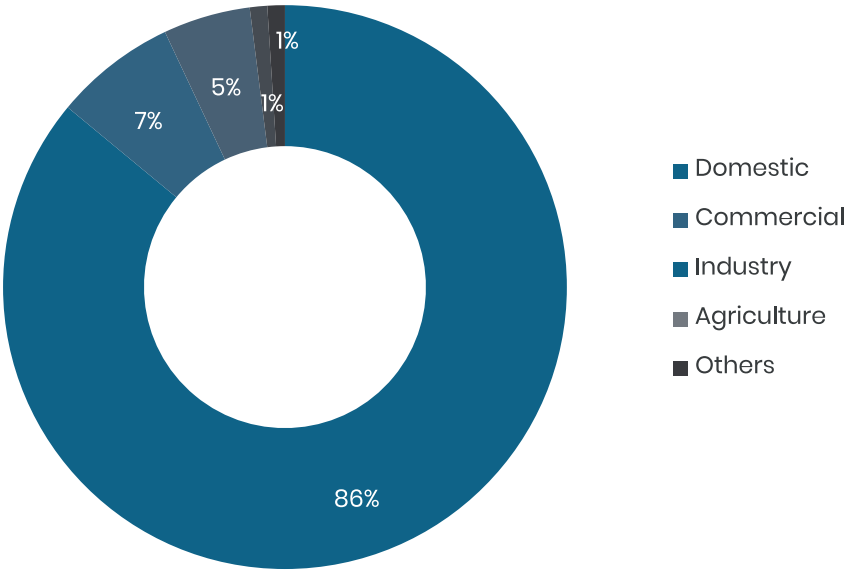

Figure 5: Net-metering consumers by type as of June 2024 (State of Industry Report 2024)

From the solar PV imports and government published net metering data and trends, it becomes apparent that the solar revolution is real and taking place. However, there is a delta of over 43 GW of solar PV that has been imported but nothing verifiable can be stated about its adoption. There have been estimates of solar adoption by researchers and sector analysts, but nothing that can be verified. The following Figure 6 represents this lack of information.

Distribution of Imported SolarPV

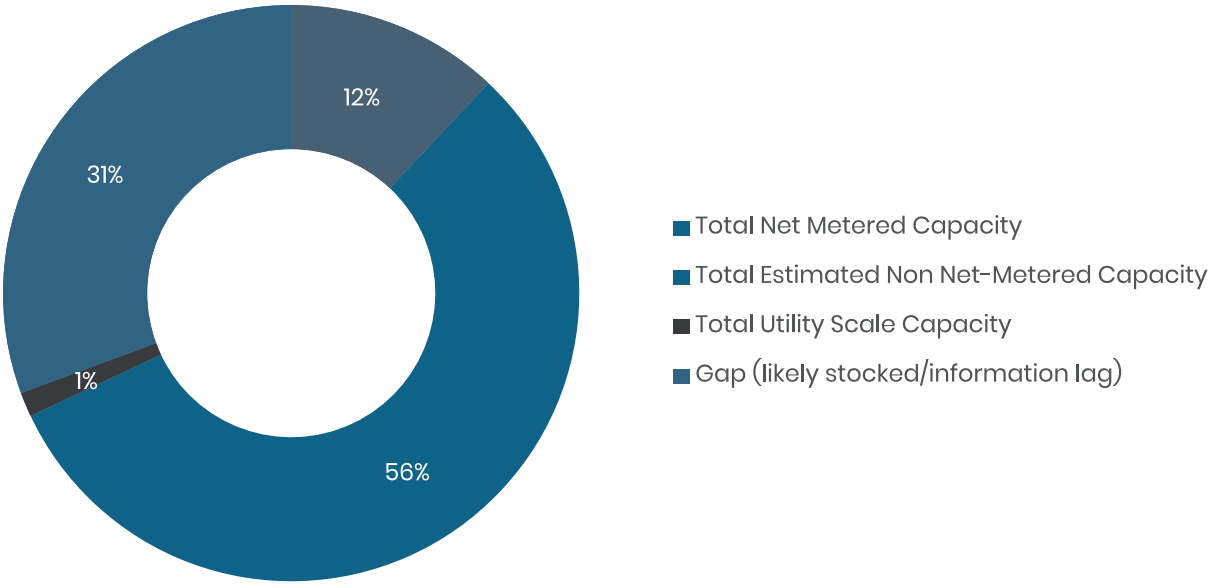

Figure 6: Solar PV imports vs. verifiable solar PV adoption

This discrepancy, or gap, suggests that a significant, unknown portion of solar capacity remains unaccounted for, possibly indicating a widespread off-grid use, unreported installations, or stockpiling of solar equipment yet to be deployed. Evaluating this unknown solar capacity is vital to accurately assess Pakistan's renewable energy progress, ensure effective energy planning, and address potential inequities in access to sustainable energy sources, especially in rural areas. It also clarifies the economic and environmental impacts of energy sources such as reduced use of fossil fuel and carbon emissions to ensure better resource allocation and policy decisions. However, before tackling the scale and implications of unaccounted solar, it is important to first examine the broader dynamics of electricity demand and supply. This monitoring report therefore limits its scope to assessing the current status of the power sector, providing the baseline against which future solar adoption and its impacts can be better understood.

This huge gap of 43 GW could be reconciled in the following forms:

- Solar PV installation not selling solar electricity back to the grid (behind-the-meter installations)
- Solar PV installations with where grid is inaccessible (off-grid installations)
- Solar PV inventories yet to be deployed

It is important to understand and reconcile this data gap in order to:

- Gauge the country's progress towards a renewable energy led sustainable path
- Ensure realistic demand projections and energy expansion planning
- Address any inequalities resulting from decentralized solar surge

It will further help clarify the broader economic and environmental implications—such as reductions in fossil fuel dependence and carbon emissions—thereby supporting better informed policy and investment decisions. However, before the scale and impact of this unaccounted capacity of solar PV can be meaningfully analyzed, it is essential to first examine the overarching dynamics of electricity demand and supply. **Accordingly, this energy report confines its scope to assessing the current status of Pakistan's power sector, establishing a baseline from which future trends in solar adoption and their implications can be more effectively understood.**

BASELINE ASSESSMENT OF ENERGY LANDSCAPE IN PAKISTAN

Pakistan's energy landscape is undergoing a profound shift, marked by a surprising and consistent decline in overall energy demand despite a steadily growing population, and exponential increase in net-metered solar PV systems. The critical question, however, is whether this decline in energy demand is primarily driven by the rapid expansion of solar adoption, rising tariffs, declining reliability of grid supply, subdued economic activity, or a combination of these factors. This analysis delves into the dynamics of grid energy sales, the role of solar power in meeting demand, and the factors contributing to the shifts in energy consumption.

The analysis will further support our work on reconciling the gap between solar PV imports and on-ground adoption of solar energy, enabling us to discuss implications for a just energy transition, energy access, affordability, and sustainability.

Methodology

We have relied on publicly available secondary datasets to analyze energy consumption trends, electricity demand growth, shifts in patterns in response to technological, political, and socioeconomic parameters. To better understand distributed generation trends, we also held consultations with key stakeholders.

This section describes the adopted methodology in detail.

Secondary Data Sources

The adoption of grid-connected solar systems was assessed using ***the NEPRA State of Industry Reports and National Transmission & Distribution Company's (NTDC's) Power System Statistics Reports***. These sources provide official statistics on installations registered under net metering, reflecting the formally documented portion of the solar market in Pakistan.

To capture behind-the-meter installations in the domestic sector, especially where no official records exist as in the case of behind-the-meter system, national census datasets (*Pakistan Household Census*) for 2017 and 2023 which provide statistics on household-level energy use were analyzed, including the number of households using solar for lighting. Through these census reports, trends of reliance on different energy sources were also identified. Overall, these provided a reliable basis for estimating small-scale, decentralized solar adoption, but one that is limited to the residential (household) sector and levels.

We have carried out the analysis of secondary datasets at three levels of electricity consumption constituting National, Provincial and Sectoral levels, to understand demand growth patterns across all the identified key categories.

Stakeholder Consultations

To better understand the findings from secondary research, and gain first hand perspective of the key energy sector stakeholders, targeted consultations were carried out. These engagements were conducted through a mix of focused group discussions and informal interviews, aimed at capturing institutional perspectives, operational realities, and policy considerations influencing solar deployment in Pakistan. The consultations also explored grid-level challenges, policy drivers, and sectoral solar PV adoption dynamics.

Stakeholders engaged included:

- 3 major Distribution Companies (DISCOs) – representing diverse service areas across Punjab, KPK and Sindh
- Government agencies involved in energy regulation and policymaking
- Private sector actors, including distributed solar installers and suppliers
- The Pakistan Solar Association and other energy sector experts

Areas of focus during engagements:

DISCOs were specifically consulted to understand:

- Strains on grid and reverse power flow issues from distributed solar generation
- Their estimates of solar PV installations either net-metered or not-net-metered within respective service areas

Government agencies and private actors were engaged to understand:

- The validity of solar PV imports data and corresponding installation records
- Off-grid and behind-the-meter (BTM) solar PV adoption patterns
- Technological advancements and outlook for market developments

SECONDARY DATASETS ANALYSIS

Nationally, the sales of electricity from the grid have registered a declining trend recently. During the Covid-19 years, there were considerable efforts to boost the struggling economy, which we see reflected in the positive growth rates until fiscal year 2021-2022. However, there is a marked decline in sales from the grid since.

Electricity Consumption (TWhs) vs. Sales Growth (%)

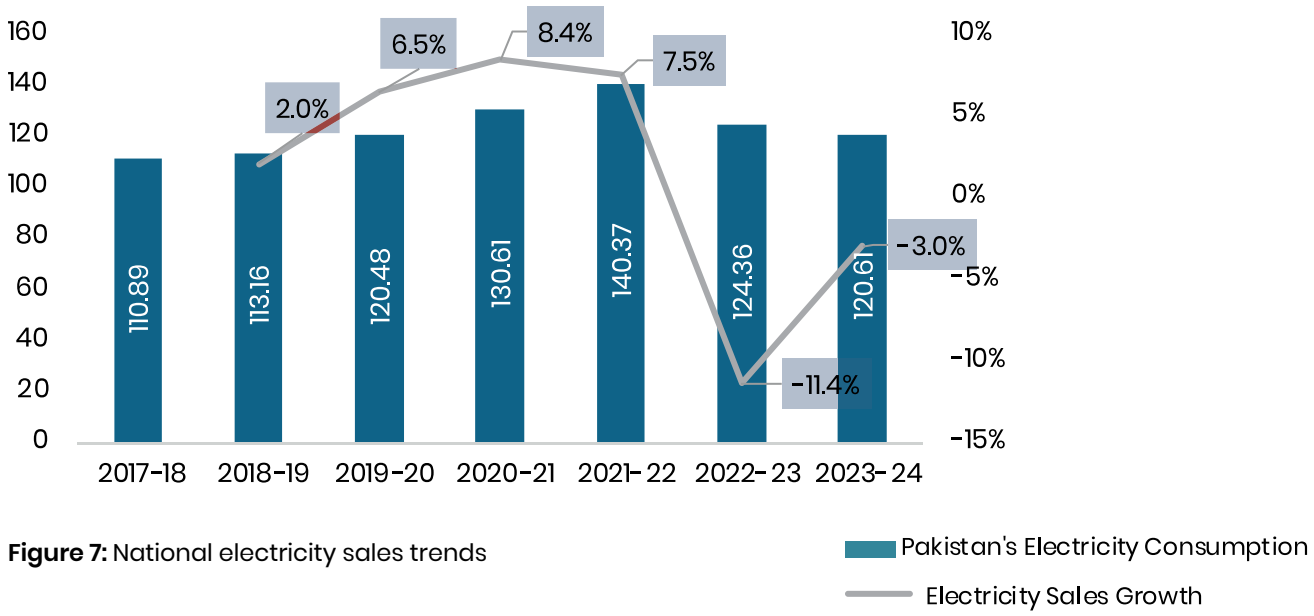

Figure 7: National electricity sales trends

The decline in electricity sales coincides with a rise in net-metered installed capacity. While the installed capacity for net-metering has continued to grow over years, its growth rate has slowed down since 2021 even when solar imports have increased.

This raises a critical question: Does the decline in growth indicate a shift toward behind-the-meter or off-grid solar installations that remain undocumented in official datasets?

Net Metering Installed Capacity/MW

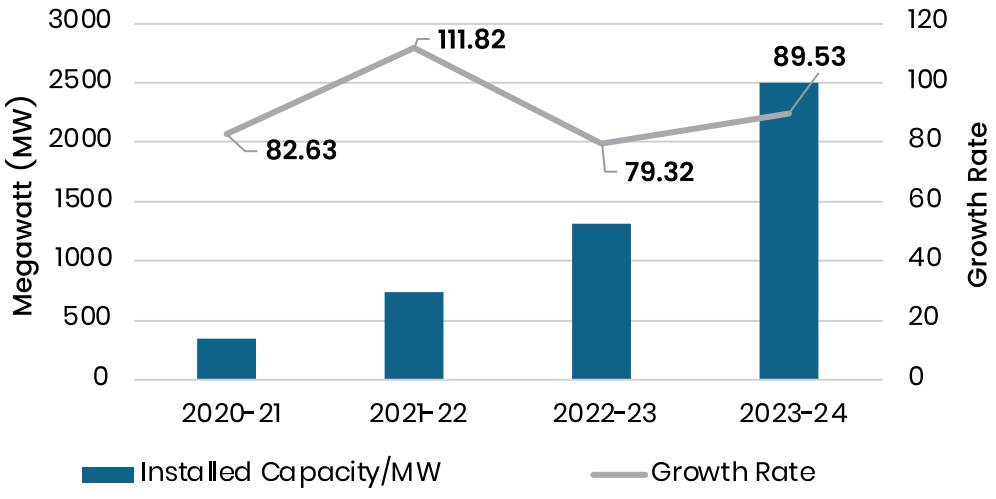

Figure 8 Net-metering trends

At the provincial level, the total electricity consumption shows an increasing trend from 2019-20 to 2021-22, where it reaches the cumulative peak of 140.4 TWhs (terawatt hours). However, from 2022 onwards, the total electricity consumption decreases and reaches the lowest 121 TWhs in 2023-24. This trend (bell-shaped curve) is seen in all provinces reflecting the decreasing demand for grid. The same trend is evident across all distribution companies as shown in the following figures.

Provincial Electricity Consumptions (GWhs)

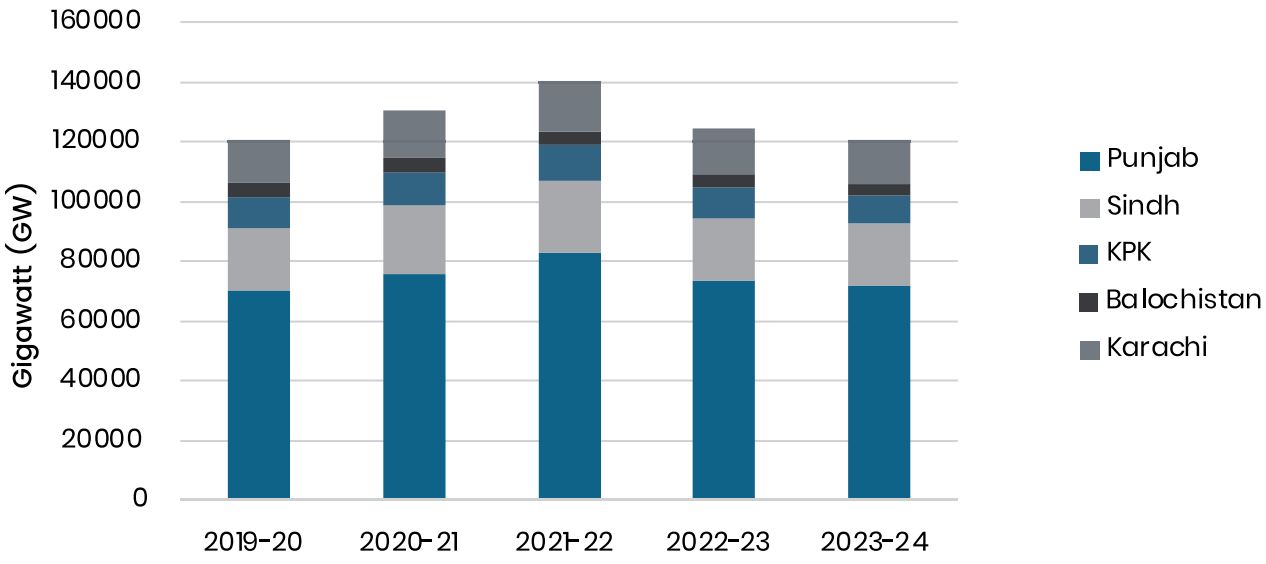

Figure 9: Provincial electricity sales trends

DISCO-wise Electricity Consumption (GWhs)

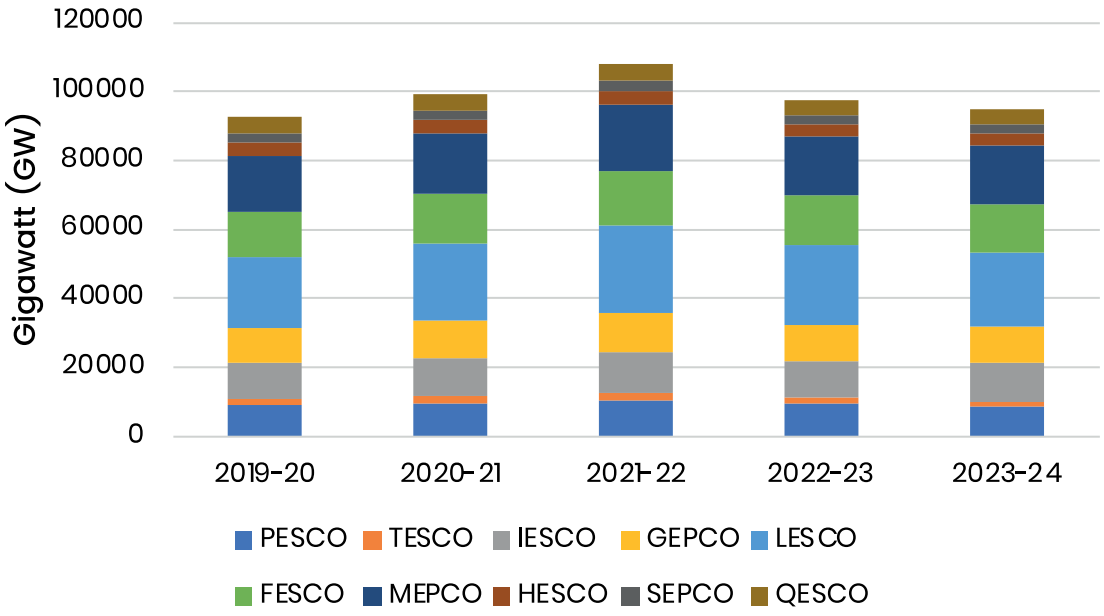

Figure 10: DISCO wise electricity sales trends

Punjab Electricity Sales (GWh) vs. Growth Rate

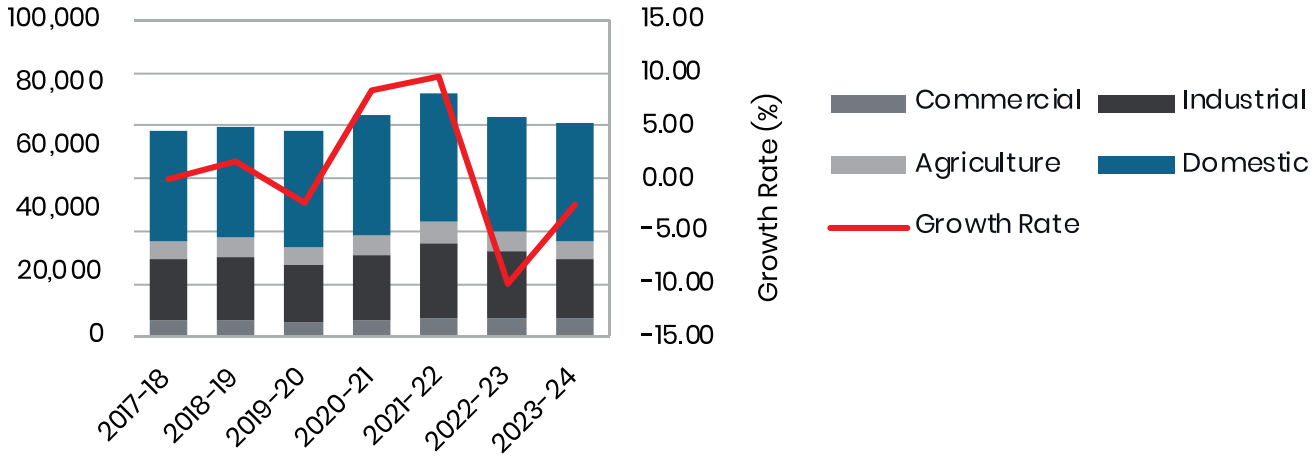

Figure 11 Punjab electricity consumption trends

Sindh Electricity Sales (GWh) vs. Growth Rate

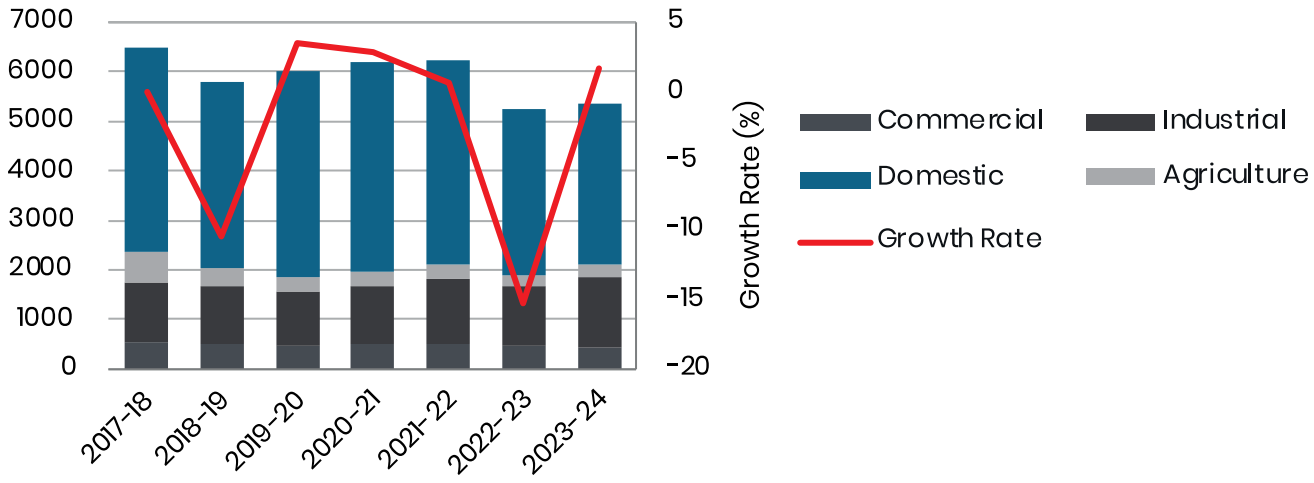

Figure 12 Sindh electricity consumption trends

KPK Electricity Sales (GWh) vs. Growth Rate

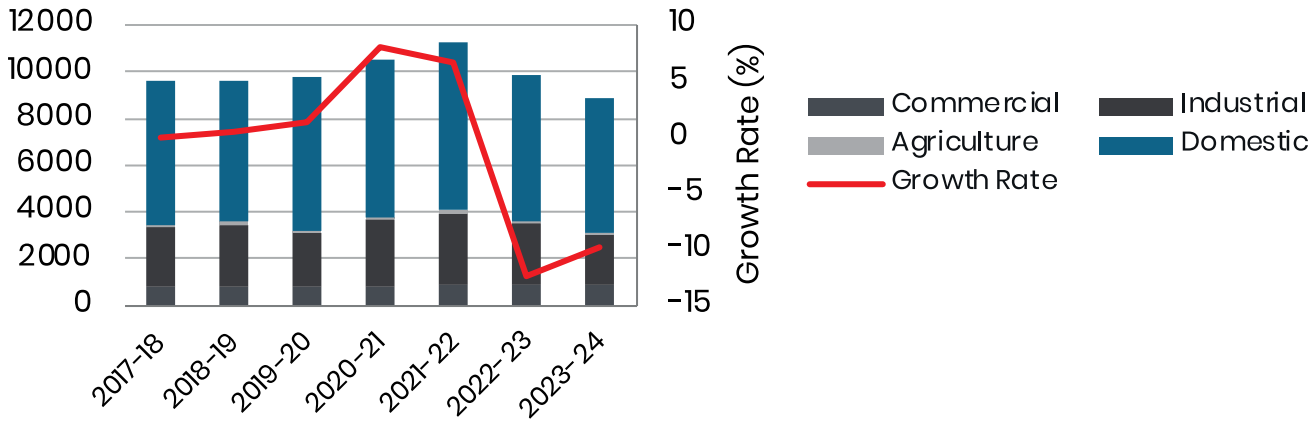

Figure 13 KPK electricity consumption trends

Balochistan Electricity Sales (GWh) vs. Growth Rate

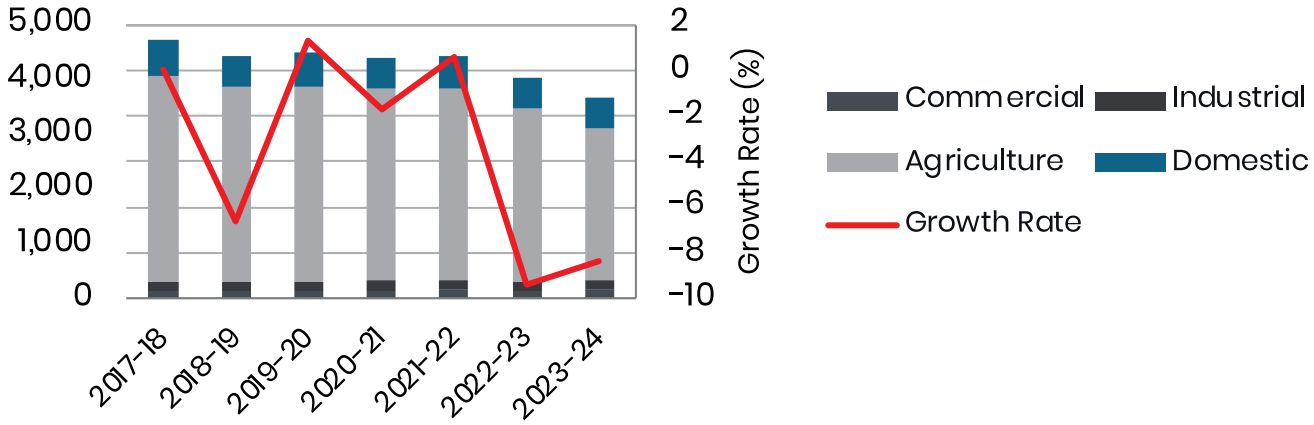

Figure 14 Balochistan electricity consumption trends

These graphs for provincial electricity sales also depict a declining trend. However, certain variations can be observed looking at sectoral trends within each province. For example, in Balochistan, where unconventional electricity sales for agricultural use dominate, as opposed to the domestic use, a declining trend in sales is seen. However, industrial electricity sales in Sindh are experiencing an increase. Whereas, in Khyber Pakhtunkhwa (KPK) province, commercial electricity sales are somewhat consistent. Looking at these numbers, we see a constant decline in demand from consumers. The decline is associated with multiple factors, as highlighted ahead.

Sectoral Analysis

Domestic Sector

At the domestic level, a two-tiered analysis has been carried out. The first tier drew on available datasets from the State of Industry Reports, focusing on consumer numbers, electricity consumption

and the net metering trend across the sector. The second-tier analysis considered each household as a single consumer, using household data from the Pakistan Bureau of Statistics along with estimates of the share of households adopting solar PV.

Reviewing the numbers for domestic consumers in the *State of Industry Report*, one witnesses an increase in consumer base, rising from approximately 25 million in 2018–19 to nearly 35 million in 2023–24. However, the increase in the domestic consumer base could be attributed to population growth, social mobility, or a combination of both. In comparison, the domestic consumption increased from 45,590 GWh in 2018–19 to peak at 52,406 GWh in 2021–22, before falling sharply by 13 per cent in 2022–23 to 46,153 GWh. A modest recovery is observed in 2023–24, with consumption reaching 47,143 GWh, though it remains below the 2021–22 peak. This overall represents the lack of trust in the grid, where consumers are becoming part of the grid but not fully meeting their energy needs from it. This is illustrated by the decline in household electricity consumption in recent years, particularly after 2022.

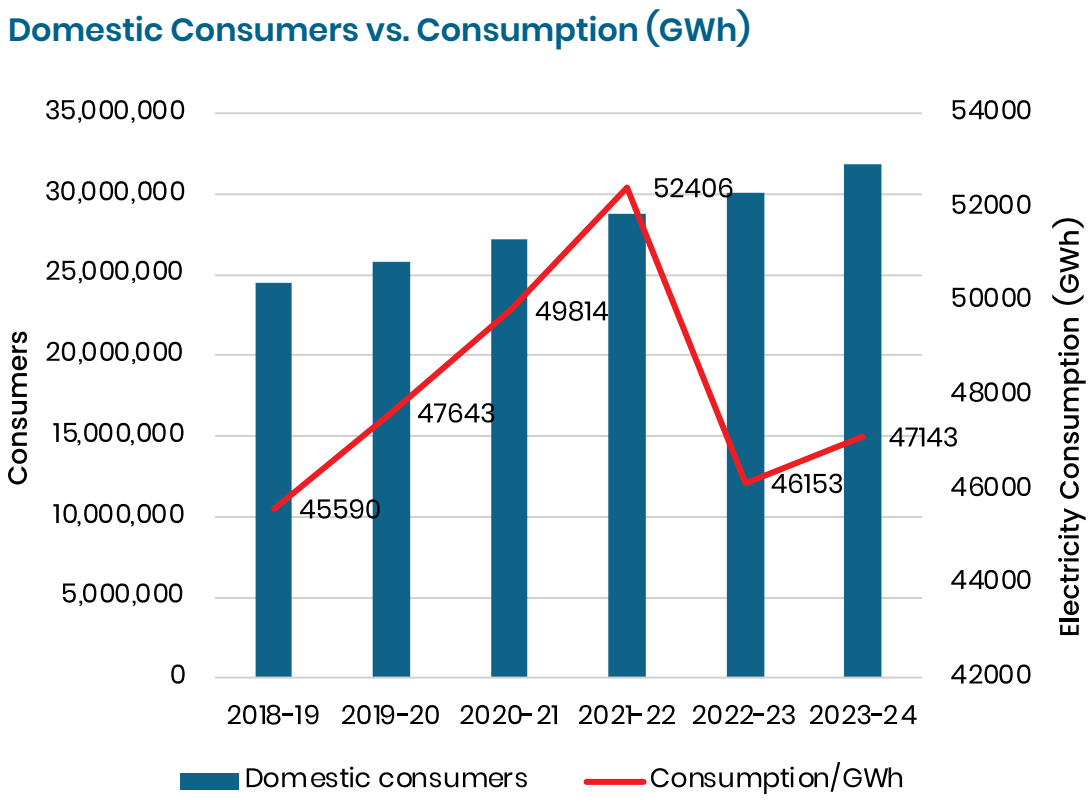

Figure 15 Domestic sector consumption trends

Net Metering Consumer Trend in the Domestic Sector

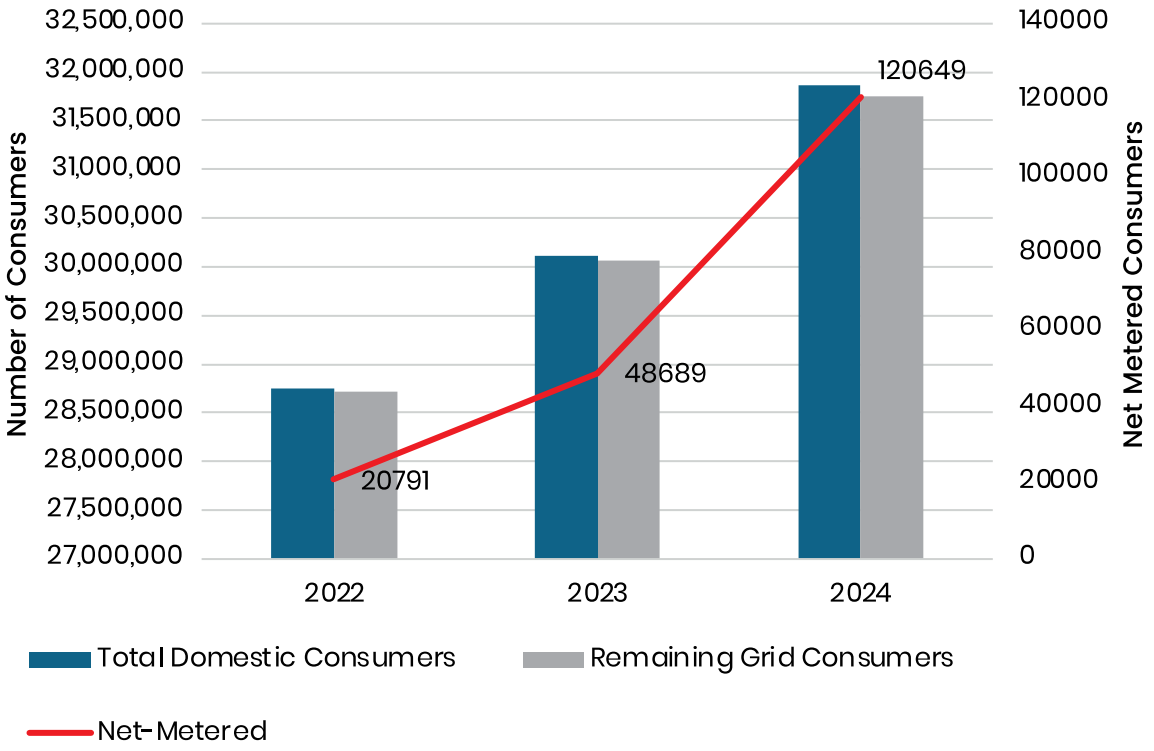

Figure 16 Domestic sector net-metering installation trends

Similarly, if one looks at the net metering trends, one observes a sharp rise in the net-metered domestic consumers from 48,689 consumers in 2023 to 120,649 consumers in 2024 - with the net-metered capacity mounting from to 2400MW in 2024 as per the State of Industry reports. However, if we compare the total domestic net-metered consumers to those reflected in the 2023 household census consumers, there is a huge difference. This denotes that net-metered domestic consumers do not have a significant impact on the grid.

In 2023, the Pakistan Bureau of Statistics (PBS) conducted a national population and housing census, which included detailed questions on the sources of household lighting. Among the listed options, solar energy was explicitly captured as a response category. This addition provided a unique opportunity to map the percentage of penetration of solar technology at the household level across provinces and regions. By analyzing the total 7 per cent solarized households out of the total 38 million census figure, we roughly estimated the solar quantum installed at the domestic level. We gained insights into the extent of documented solar adoption, identified regional disparities, and compared official figures with available net metering trends. The detailed analysis is given in the last section of this monitor where we integrated these datasets with the stakeholder insights. In doing so, this analysis aims at developing a critical understanding of how much of Pakistan's solar revolution is visible in household-level statistics, and where significant gaps in data and equity may still exist.

Number of Households vs. Households with Solar

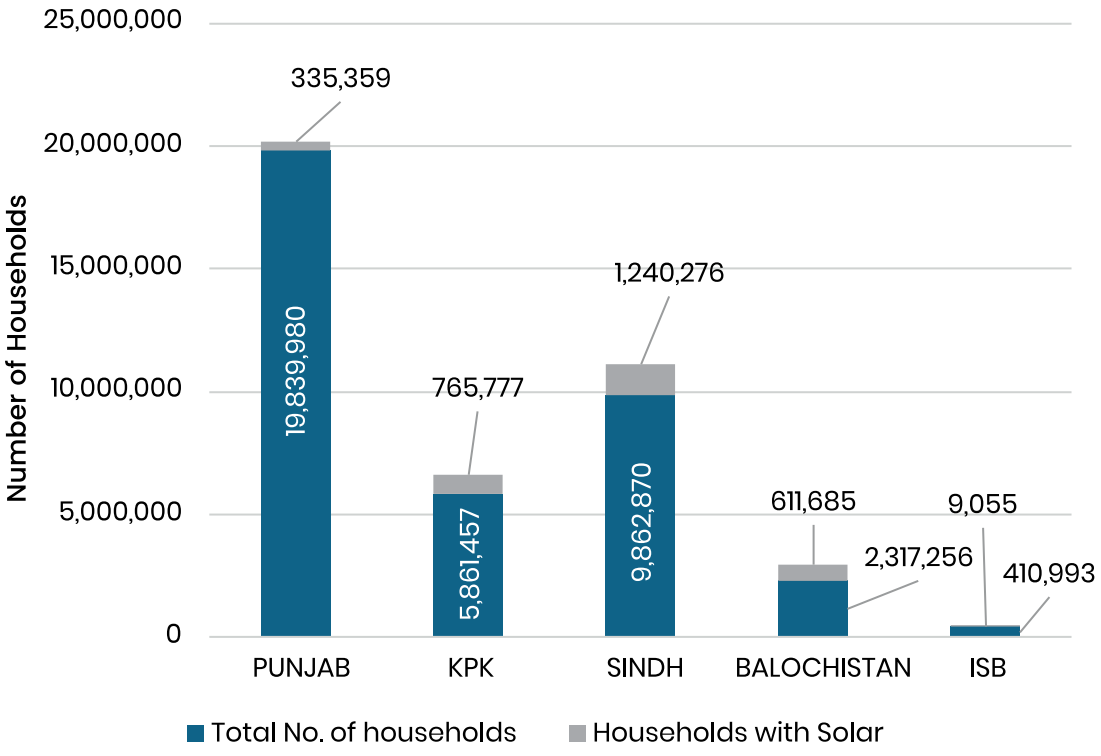

Figure 17 Households with and without solar across provinces - Pakistan Bureau of Statistics population census 2023

Figure 17 presents the distribution of total households and those adopting solar PV across provinces and Islamabad as per the PBS census 2023. Punjab accounts for the largest number of households (19.8 million), with approximately 335,359 reported to have installed solar systems. Sindh follows with 9.86 million households, of which around 1.24 million use solar—the highest absolute adoption among all regions. KPK has 5.86 million households, with 765,777 on solar, while Balochistan, with 2.31 million households, shows 611,685 solar adopters. Islamabad has a comparatively small base of 410,993 households, with 9,055 using solar PV.

The key questions that emerge are how just and equitable this distribution is, what the income profile of these households looks like, what size and quality of solar systems they possess, and whether their shift to solar has been driven primarily by unreliable grid supply or other factors—questions that will be addressed through our field survey.

DISCO-wise Solar adoption

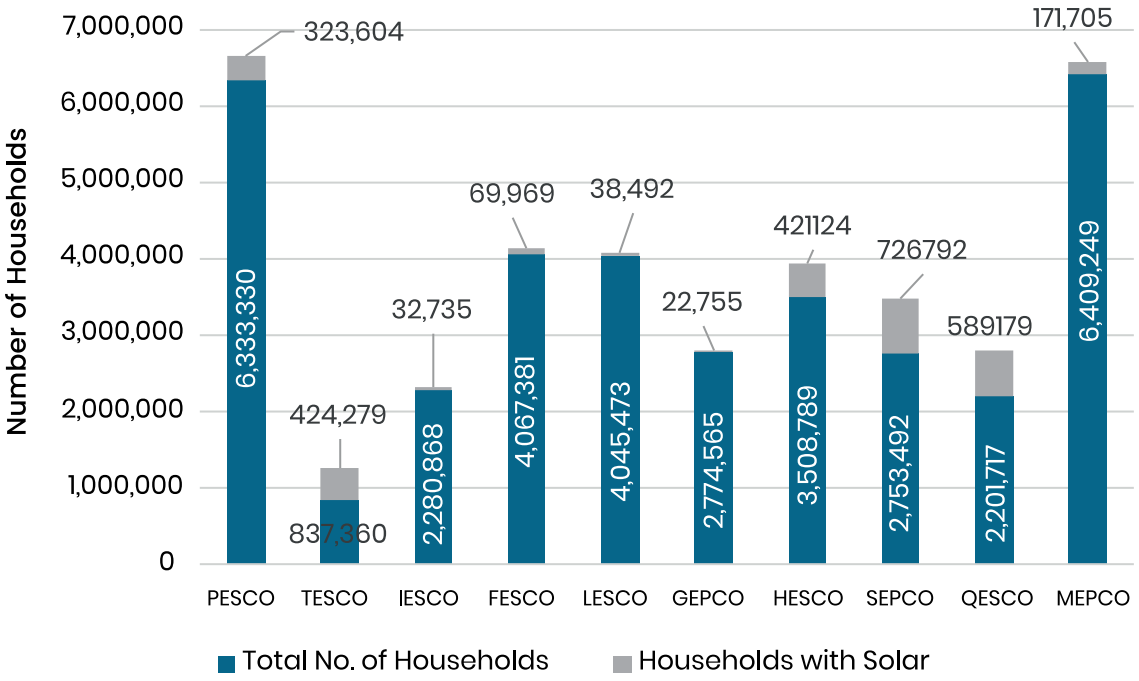

Figure 18 Households with and without solar across DISCOs - Pakistan Bureau of Statistics population census 2023

The chart illustrates the number of households with and without solar across various DISCOs, based on PBS data. Overall, total households vary widely by region, with MEPCO (6.4 million) and PESCO (6.3 million) having the largest bases, while TESCO (2.28 million) and QESCO (2.2 million) represent the smaller ones. Solar adoption, however, shows significant regional variation. SEPCO has the highest number of solar households (726,792), followed by HESCO (421,124) and PESCO (323,604). QESCO (589,179) and MEPCO (171,705) also report sizable adoption, while IESCO (69,969) and LESCO (38,492) show relatively low uptake despite having large household bases.

The questions which need to be addressed from the above illustration are related to LESCO and IESCO which serve one of the most developed urban regions of Pakistan. Yet, the number shows relatively low solar PV adoption. Also, if solar adoption is truly concentrated in urban areas, or do these regions simply have fewer systems but larger, better-equipped installations—perhaps because reliable grid supply in this region reduces the incentive for wider solar PV uptake?

Commercial Sector

Commercial Consumers & Consumption (GWh)

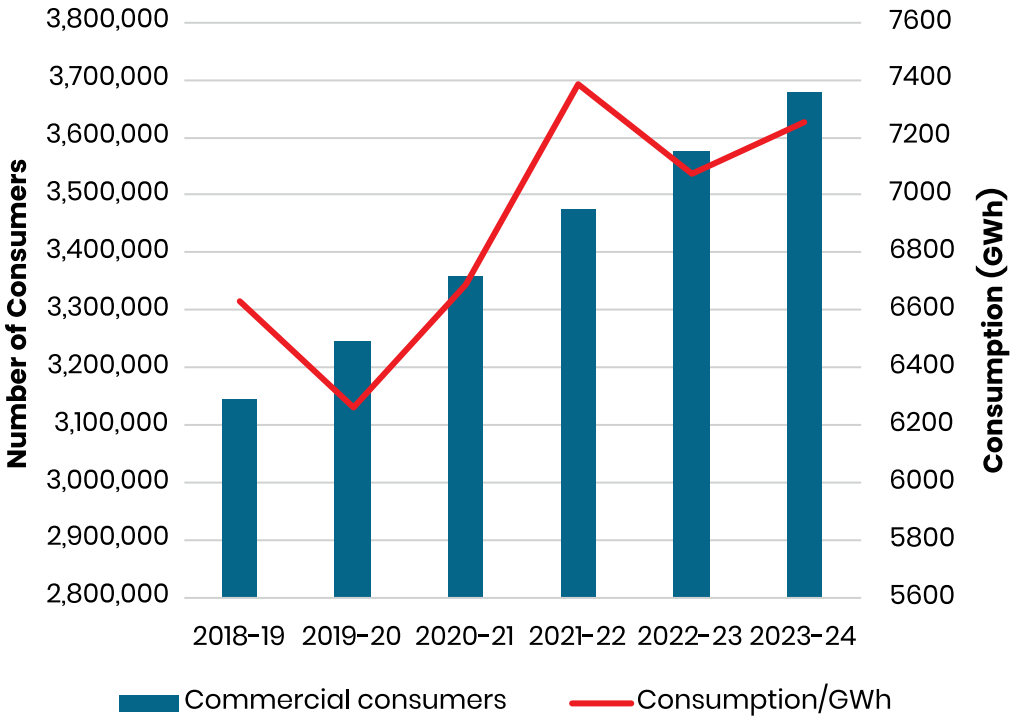

Figure 19 Commercial sector consumption trends

Net Metering Trend in Commercial Sector

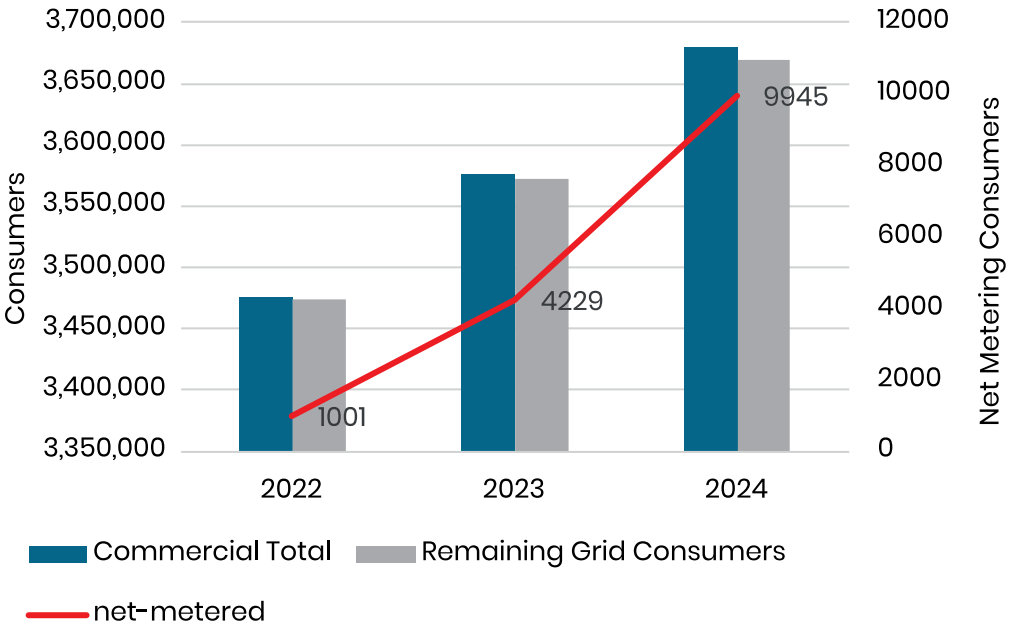

Figure 20 Net-metering consumers trends across commercial sector

From the above graphs, it can be observed that for the commercial sector consumers, there is a sharp rise in the net-metered consumers from 4229 in 2023 to 9945 in 2024. However, when we see this number in comparison with total commercial consumers (approximately 380 million consumers), the net-metered consumers are relatively insignificant i.e., 0.002 per cent.

The data suggests very negligible net-metered consumers, but the question that arises here is how many solar systems have been installed behind the meter.

Industrial Consumers

Industrial Consumers & Consumption (GWh)

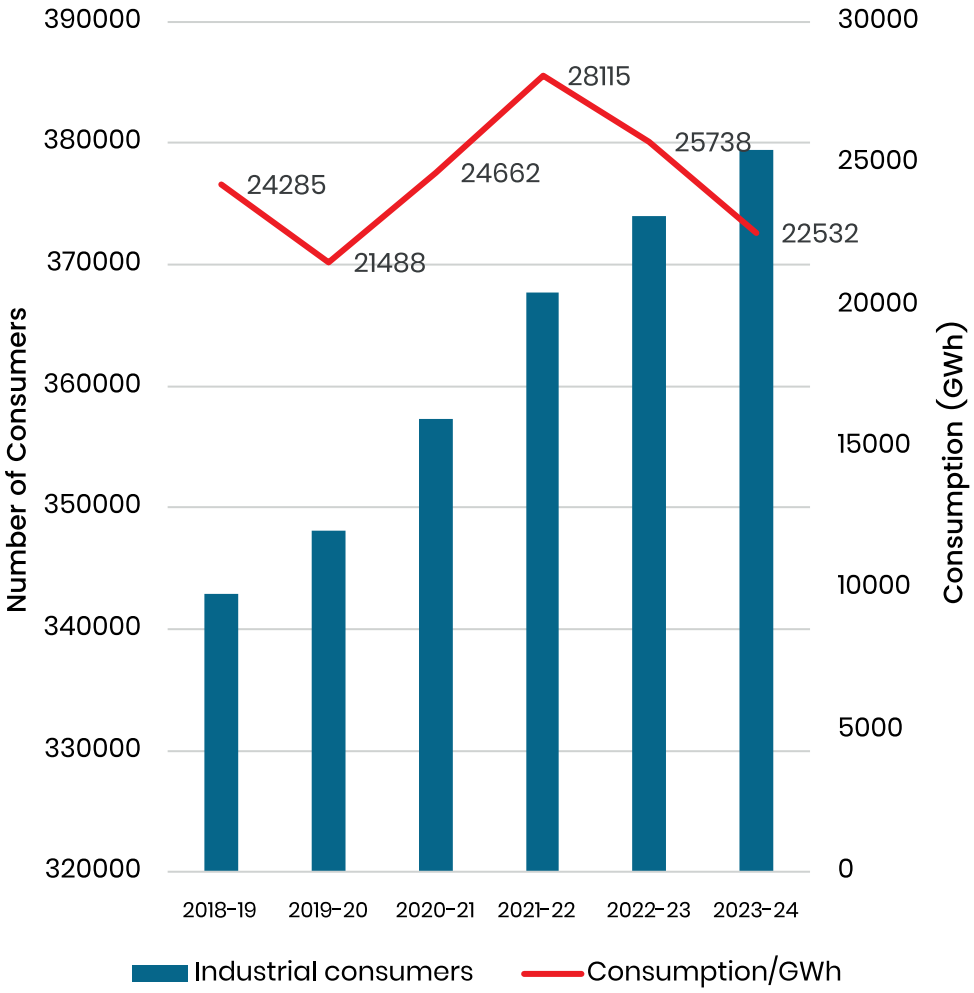

Figure 21 Industrial sector consumption trends

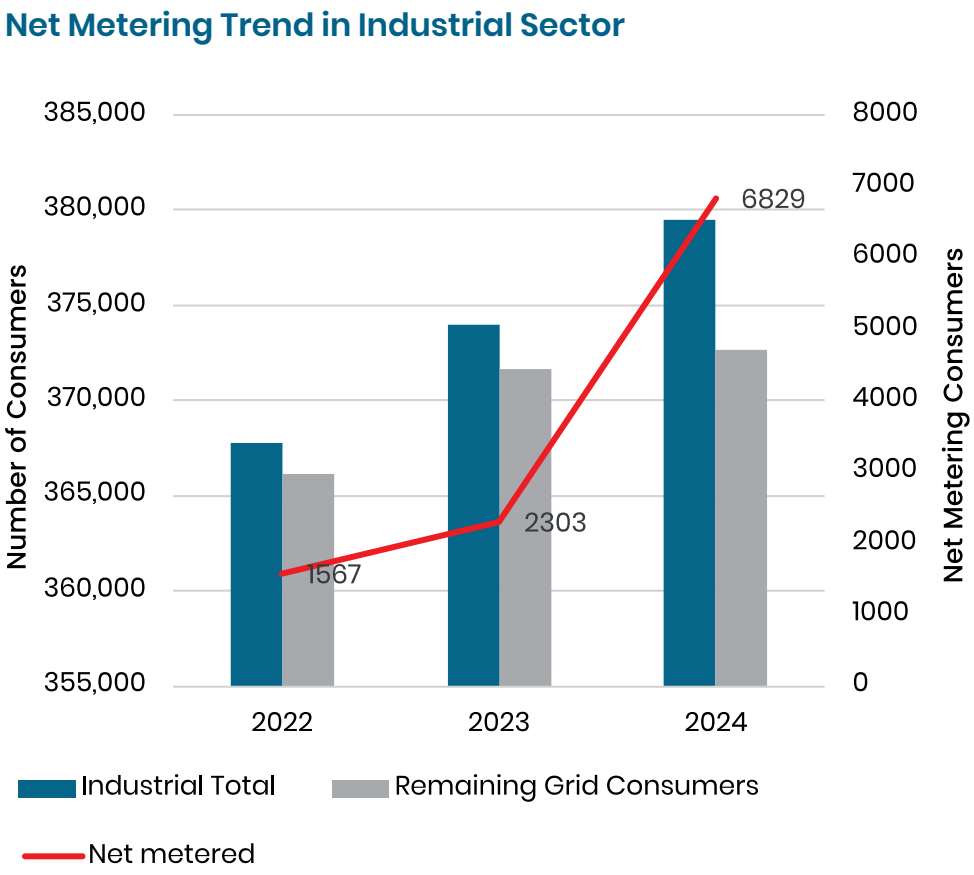

Figure 22 Net-metering consumers trends across Industrial sector

Figure 22 above shows the trend of net-metering adoption among industrial electricity consumers from 2022 to 2024. While the total number of industrial consumers has grown gradually over the period, there has been a notable increase in the number of net-metered consumers—from 1,567 in 2022 to 6,829 in 2024. This reflects a growing shift toward self-generation through solar power in the industrial sector.

However, a large majority of industrial consumers remain classified as "Remaining on Grid", as shown in red. It is important to note that the status of these remaining on-grid consumers is unclear—we do not know how many of them have installed behind-the-meter solar systems without formal net metering arrangements, nor to what extent they continue to rely on grid electricity versus self-generation.

Agricultural Consumers

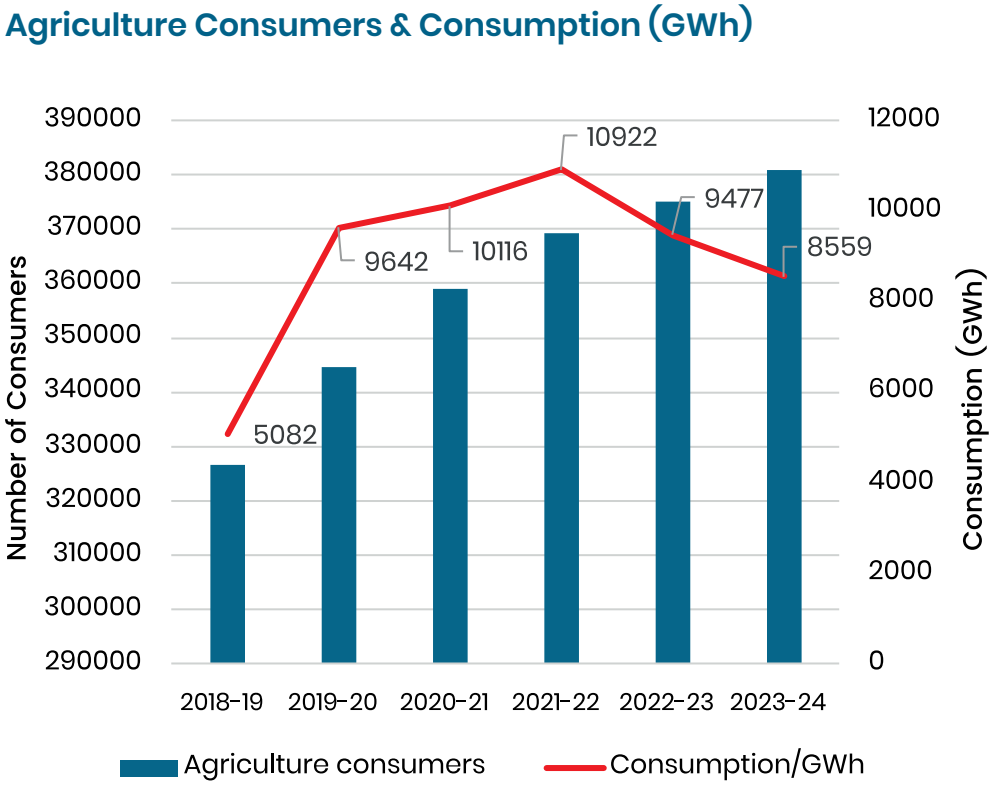

Figure 23 Electricity consumption trends agriculture sector

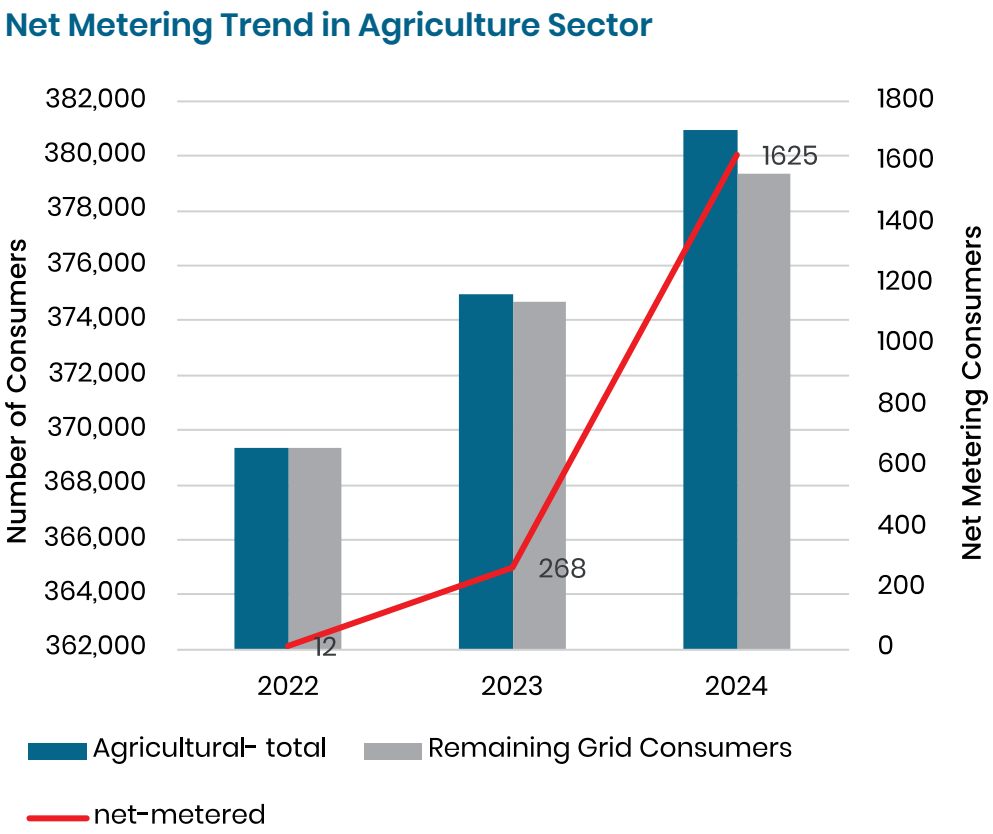

Figure 24 Net metering consumer trends across agricultural sector

The above graph shows the electricity consumption trends among agricultural consumers over the last three years. As seen from the net metering trends, a stark increase of 134 per cent is witnessed in the last 3 years. However, the total agricultural consumers in 2024 were 380,000, whereas net-metered solar consumers were only 1625 i.e. 0.004 per cent which is a very small portion of the total. Whereas, the remaining on-grid agricultural consumers include both non-solar as well as solar-based non-net-metered consumers. It is important to note here that a large part of agricultural consumers is not grid connected but solarized (through solar tube wells); however, the data for this is unavailable.

POSSIBLE FACTORS OTHER THAN SOLAR DRIVING THESE TRENDS

Having examined the growth rate trends, the next important area is to understand the structural issues influencing the electricity demand. Are systemic failures a major reason for these shifts or are there other macroeconomic indicators?

Systemic Failures

The demand–supply gap in Pakistan's power sector is not a new phenomenon, and it has continued to adversely affect the sector for years. This gap is not driven by demand alone, but is also closely tied to transmission and distribution constraints, which undermine the reliability of electricity supply. Despite the country achieving nearly 99 per cent electrification, many regions still experience significant daily load-shedding and low voltage levels, highlighting persistent inefficiencies in ensuring dependable access to power. The following tables show the official datasets from the distribution performance report of NEPRA for the year 2024.

Table 0-1: Faults Rates in distribution lines across DISCOs

Name	Total Length of Distribution System (km)	Total No. of Faults	Fault Rate (No. of Faults/ km)
PESCO	90,996.80	149,934	1.65
IESCO	60,068.55	175,779	2.93
GEPCO	47,010.00	153,521	3.27
FESCO	83,148.31	94,853	1.14
LESCO	51,767.99	272,314	5.26
MEPCO	51,948.27	32,782	0.63
QESCO	73,158.32	102,599	1.40
SEPCO	41,831.33	33,100	0.79
HESCO	47,461.59	66,035	1.39
K-Electric	42,169.00	136,115	3.23

Table 0-2:Average load-shedding hours across DISCOs		
Name of DISCO	**Reported Figures of Average Daily Load Shedding (Hours)**	**Actual Load Shedding Being Monitored by NEPRA**
PESCO	11.0	> 10 hours as per AT&C
IESCO	2.5	2 to 3 Hours
FESCO	0.22	2 to 3 Hours
GEPCO	0	2 to 3 Hours
LESCO	0.5	2 to 3 Hours
MEPCO	0.7	2 to 3 Hours
QESCO	10.0	> 10 hours as per AT&C
SEPCO	2.3	> 8 hours as per AT&C
HESCO	10.6	> 8 hours as per AT&C
K-Electric	8.52	6 to 8 Hours

From the consumer's perspective, the tables highlight how persistent supply-side challenges in Pakistan's power sector—energy not served, frequent system faults, and prolonged load-shedding—have directly shaped their experience. Consumers have faced years of unreliable supply, with sharp price spikes in unserved energy, frequent technical faults especially in certain distribution companies, and daily outages often longer than officially reported. This unreliability eroded trust in the grid and reduced effective demand, as households and businesses either cut back on consumption or shifted toward alternatives such as solar and backup generators. However, the decline in demand cannot be explained by supply issues alone nor can it be solely attributed to solar revolution—broader macroeconomic pressures such as rising electricity tariffs, inflation, and reduced purchasing power have also significantly constrained affordability, further suppressing consumption.

Macroeconomic Trends Shaping Electricity Use

An unusual drop in total electricity sales has been registered over the last two years in a row. This period has also seen the country importing 17 GW of solar panels [2], equal to nearly one-third of its total capacity. As a result, both industrial and residential consumers have reduced their reliance on the national grid. And yet, this is not the only reason for the fall. Broader economic problems — including weak growth, high inflation, and political instability — have also played a central role in lowering demand.

2. https://ember-energy.org/latest-insights/global-electricity-review-2025/

Economic Downturns and Electricity Demand

Pakistan's economy has grown at a very slow pace in recent years, with negative growth especially after 2020. During the pandemic lockdowns, economic activity came to a standstill, and GDP growth turned negative. This reduced industrial electricity demand, but household use increased as people stayed home, more than offsetting the decline in industry and pushing overall consumption upward.

The picture changed in fiscal year 2022–23, when electricity consumption dropped steeply by around 10 per cent at the same time as economic growth again turned negative. The fall coincided with intense political instability and a balance-of-payments crisis that left the country on the edge of default. Although default was narrowly avoided in 2023 through a $3 billion Stand-by Arrangement with the IMF, these wider macroeconomic pressures weighed heavily on demand. Thus, while the spread of solar systems was an important factor, reflected in the fall in both household and industrial grid consumption during fiscal year 2023, the contraction cannot be understood without considering the weak economic fundamentals that were suppressing electricity use at the same time.

Electricity Growth Rate & GDP Growth Rate

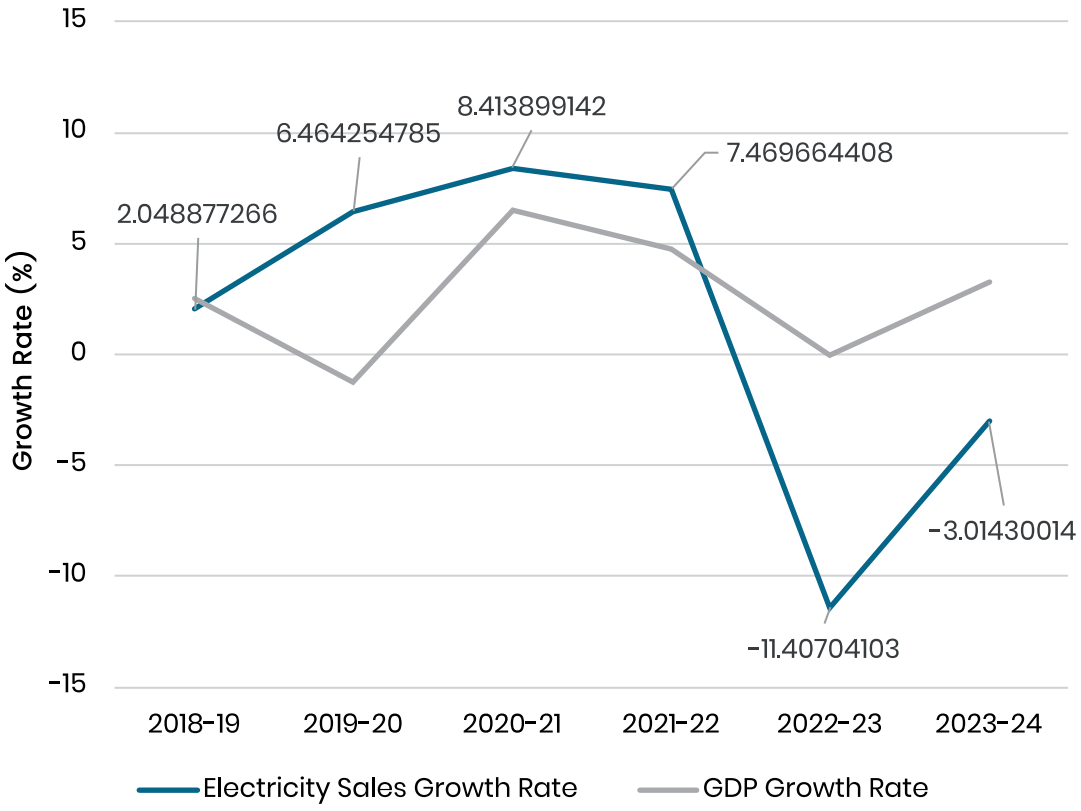

Figure 25 Electricity sales growth vs the GDP

Inflation, Unemployment, and Affordability

Affordability strongly affects electricity demand. When energy prices rise, electricity consumption tends to decline as households and businesses cut back to manage higher costs. Moreover, since energy is a fundamental input to practically every other sector of the economy, price hikes also feed into broader inflation, which reduces household real income. With less purchasing power, families often limit electricity use to essentials, further driving down demand.

This is precisely what has happened in Pakistan. Since 2021, electricity prices have surged by 155 per cent[3] as the government first started cutting subsidies to improve its chances of an IMF loan. In a country where 40 per cent of the population lives below the poverty line, this has made electricity unaffordable for many. Past inflation trends confirm this link: Between 2017 and 2021, inflation was under 10 per cent; electricity remained relatively affordable, and demand held steady. But when inflation jumped to 19.9 per cent in 2022 and peaked at 30.8 per cent in 2023, real incomes fell sharply, forcing both households and industries to cut back on power use.

Inflation and Unemployment across Pakistan

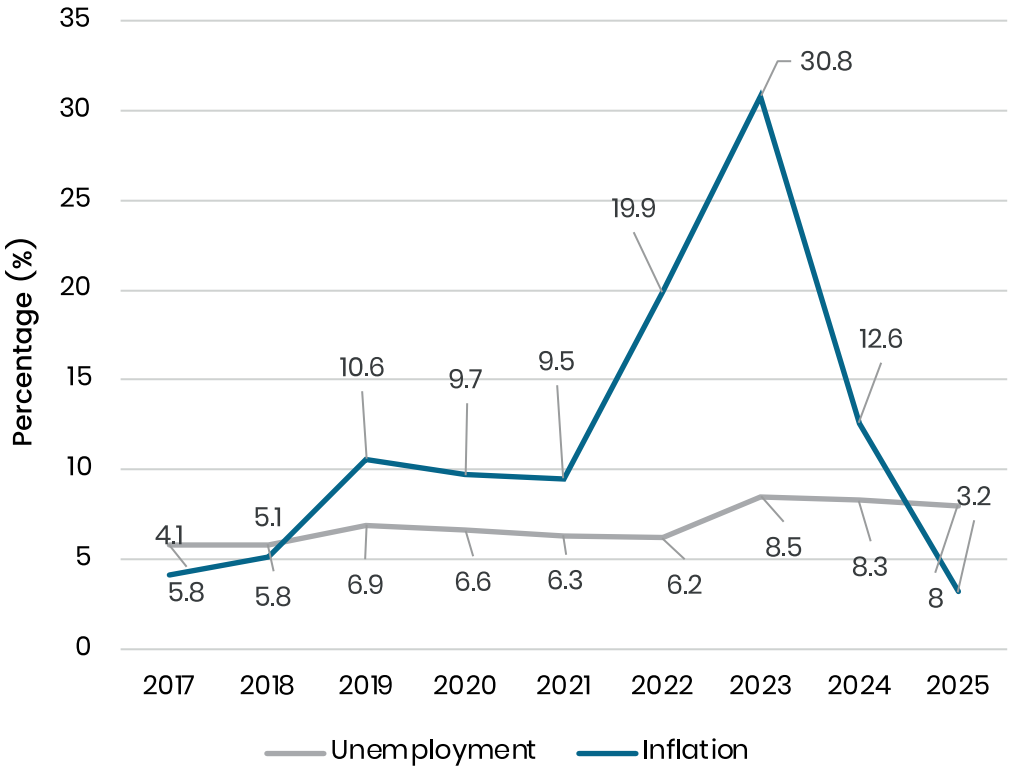

Figure 26 Inflation and unemployment trends across Pakistan

3. https://www.bloomberg.com/news/articles/2024-08-13/it-can-cost-more-to-power-a-house-than-rent-it-in-pakistan?embedded-checkout=true

Unemployment adds to this pressure. When more people are out of work, incomes fall, and fewer households can afford steady electricity use. In the last three years, unemployment rose above 8 per cent, during which time electricity demand has consistently declined.

Open Economy Effects

External economic conditions have also affected electricity demand. A falling exchange rate makes imported fuels more expensive, pushing up electricity generation costs and raising prices for consumers. This not only reduces electricity demand but also hurts the competitiveness of exports, especially in electricity-intensive industries. As exporters cut back production, their power use falls, further depressing demand. The recent Energy Yearbook report highlights a notable production cutback, with most major players in the industrial sector showing contractions in their output over the past few years.[4]

The Pakistani Rupee has lost almost half its value, from about PKR 150 per USD in mid-2021 to nearly PKR 300 per USD. Since imported fuels make up 40 per cent of the power mix[5], this has driven generation costs sharply higher. At the same time, Pakistan's trade position has weakened. Imports rose much faster than exports, pushing the trade deficit to a record $48.4 billion in 2021–22. This imbalance reflects both the rising cost of imported goods, particularly fuel, and weaker performance on the export side, which is tied to slower economic activity. Export-oriented industries that rely heavily on electricity, such as textiles and sports goods, faced higher costs and declining competitiveness, forcing them to cut back production. As these sectors scaled down, their electricity use fell sharply, further reducing overall demand.

Trade Deficit

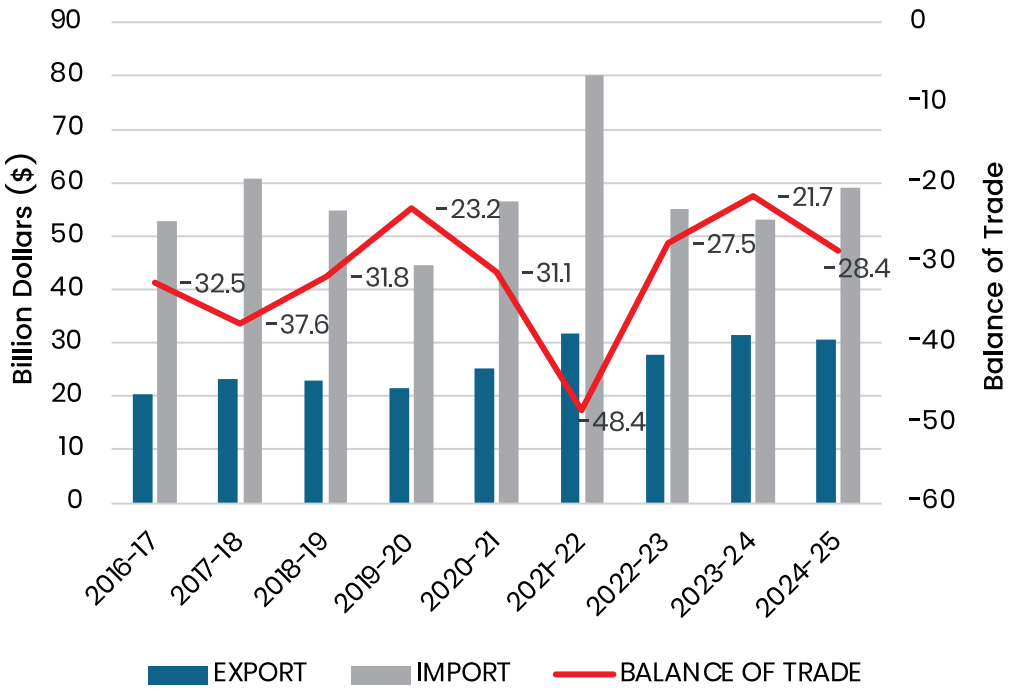

Figure 27 Trade deficit sourced from the State Bank of Pakistan annual reports

4. https://file.pide.org.pk/uploads/book_power-sector.pdf
5. https://www.finance.gov.pk/survey/chapter_25/3_Manufacturing_and_Mining.pdf

The textile sector illustrates how these pressures combine with longer-term structural challenges. Climate change has drastically reduced cotton yields[6], making it harder for the industry to maintain past levels of output. With lower raw material availability, many factories have operated below capacity, which has directly reduced their power consumption. Taken together, currency depreciation, a widening trade deficit, and climate-driven declines in key industry output have all contributed to weaker industrial activity and, by extension, to the persistent fall in electricity demand.

There is also a structural shift in how exporters use electricity. Global brands are pushing suppliers to go green as part of their net-zero commitments. For example, Khwaja Masood Akhtar, CEO of a major football manufacturer for Adidas, told the Financial Times that his factory planned to shift fully to solar.[7] Similar moves are expected across other industries as brands push for clean energy in supply chains, which will reduce demand for grid electricity even further in the future.

Public records present mixed indicators. Electricity demand growth has been steadily declining, and while statistics point to a rise in solar installations, the question remains: How accessible is this solar capacity across income groups? Systemic failures continue to undermine reliable supply, while macroeconomic pressures—such as unemployment, inflation, and declining incomes—are trying the purchasing power of citizens. Before turning to ground-level evidence on equity and accessibility in our next monitor we will first examine stakeholder perspectives and assess the domestic demand quantum based on their underlying assumptions.

6. https://pu.edu.pk/images/journal/geography/pdf/6_V78_No2_2023.pdf
7. https://www.ft.com/content/69e4cb33-3615-4424-996d-5aee9d1afe19

STAKEHOLDERS' PERSPECTIVE

Data-driven research, complemented by informed stakeholder perspectives, is essential for developing a holistic understanding of any subject matter. Accordingly, we conducted a series of detailed consultative sessions involving multiple stakeholders i.e., DISCOs, governmental agencies, the Pakistan Solar Association, and civil society organizations. These sessions enabled us to both share our preliminary findings and gather critical feedback on the pace, scale, and challenges of solar adoption in Pakistan.

Distribution Companies (DISCOs)

DISCOs estimate that solar penetration is advancing at a rate of approximately 130 MW per month nationwide, mainly through small-scale, behind-the-meter systems. Over the last six months, solar adoption has accelerated, with many consumers even willing to pay a premium for faster installation. Furthermore, some DISCOs noted that per-connection energy demand has risen—domestic use has increased by around 25 per cent, mainly due to behind-the-meter systems not captured under net metering. One DISCO reported a 17 per cent drop in industrial demand, with 12 per cent attributed to solar adoption, based on their sensitivity analysis. In contrast, utility-scale solar projects take at least 10 months to implement—revealing a clear mismatch between rapid rooftop solar growth and the slow pace of grid planning and reinforcement.

DISCOs currently lack real-time monitoring mechanisms for net metering (NM), making it hard to track installations and their grid impact. Estimates suggest that about 25 per cent of NM systems have illegal extensions. The authorities recommend that to account for this, a 25 per cent buffer should be added to the total NM capacity. In DISCOs with high NM penetration, especially in urban areas, reverse power flow and the duck curve are causing problems especially during shoulder months (September, October, February and March). Reported by a DISCO representative, in one of the affluent areas, substations saw a 5 MW draw at midnight and 7 a.m., but by noon, solar generation flips this to a reverse flow of -15 MW, a 20 MW swing in just three hours, deeply stressing the grid. The 220 kV substation began experiencing overloads, prompting National Power Construction Corporation system operators to start isolating 132 kV circuits to stabilize voltage levels.

Moreover, there is no system for testing or validating the actual wattage of individual solar panels, raising further reliability concerns. The unchecked expansion of solar installations has enabled vendors to cut corners by using poor-quality components, undermining the safety and sustainability of solar systems. DISCOs raised concerns about safety and quality, estimating that 10 per cent of installed solar systems use substandard equipment. While high-quality branded inverters are available, the market is increasingly dominated by locally made inverters that don't meet performance standards. Additionally, the use of substandard mounting structures by some vendors to increase profit margins has resulted in serious safety incidents. Vendors are often unwilling to reduce profit margins, even in risky conditions — as seen during windstorms in LESCO areas, where poorly installed systems collapsed.

The widespread use of low-quality, behind-the-meter systems is harming consumer interests — similar to the unchecked spread of inefficient, non-inverter air-conditioners in rural areas. A clear pricing gap exists between registered vendors and informal "desi" vendors, often reflecting differences in equipment quality.

Government Agencies

Similar concerns were raised by other government entities, who highlighted the operational and planning challenges posed by the rising level of solar integration into the grid. Nationally, Pakistan is facing extreme load fluctuations due to rapid solar uptake. The duck curve as mentioned by the DISCOs was a common problem raised by the government agencies as well. It was mentioned that at around 7 a.m., demand stands at about approximately 14,000 MW but drops to just 6,000 MW by noon — far below the previous year›s minimum of 6,993 MW. Demand then rises back to 13,000 MW within the next three hours. This sharp mid-day drop forces system operators to take costly measures: Shutting down 12 high-voltage lines, curtailing hydropower output, and ramping down wind and nuclear generation. Gas turbines, normally used during peak hours, are being run during off-peak periods to stabilize the grid. These actions add operational complexity and cost, especially with baseload plants not designed for rapid adjustments.

This cost of grid management accumulates and is eventually passed on to consumers through tariff adjustments approved by the regulator. In FY 2024, this cost was PKR 55 billion which went up from PKR 18 billion the previous year. In FY 2025, the government expects this figure to rise to PKR 100 billion. To reduce the exposure to the volatile electricity prices, and unreliable electricity supply consumers are turning to solar to shift their partial electricity demand. In the last three years, there has been an increase of 155 per cent in the electricity prices domestically. Similarly, Non-Project Missed Volume (NPMV)[8] penalties increased from PKR 2 billion to PKR 40 billion. All of these factors lead to about 50 per cent of the average household's disposable income being spent on electricity bills—compared to the global average of just 10 per cent.

Some of the distribution companies claim that the behind-the-meter quantum of installed solar is 3 times that of net-metered quantum.

Pakistan Solar Association

The Pakistan Solar Association (PSA) underscores that solar adoption in the country has been organic in nature. The catalyst for the scale-up of rooftop solar in Pakistan is the unreliable and expensive electricity. Different categories of consumers are choosing different adoption pathways: affluent urban households, large commercial users, and some industrial units are opting for net metering to avail long-term bill savings through export credits, while middle-income households and small commercial users are increasingly installing behind-the-meter systems to reduce electricity costs without engaging in the formal regulatory process.

In response to the government's reform plan of net metering, PSA highlighted that any reform to the net metering policy must be rooted in comprehensive, real-time data infrastructure. The current solar integration landscape suffers from fragmented data, leading to reactive policymaking and inconsistent regulatory actions. PSA strongly recommends the establishment of a centralized energy data platform that captures real-time rooftop solar generation, load trends, storage usage, and demand-supply analytics. Without such data, energy planning remains disjointed and unreliable.

In response to the government's proposal to transition from net metering to net billing, PSA proposes a reformed framework that maintains consumer incentives while addressing grid stability and equity concerns. Key recommendations include:

8. NPMV represents the potential energy that a power plant could have produced but didn›t, leading to financial losses for the plant

- Preserving unit-to-unit adjustment during off-peak hours, ensuring simplicity and fairness without imposing financial strain on distribution companies (DISCOs).
- Eliminating the buyback of excess off-peak energy exports beyond netting, to discourage oversizing of systems and mitigate grid saturation during low-demand periods.
- Extending peak hours for solar users from 4 to 6 hours (5pm–11pm) to promote energy storage and reduce peak-time grid reliance.

Overall, PSA's position is that a well-calibrated, data-informed net metering reform—complemented by both consumer and utility-scale storage—can balance the needs of consumers, DISCOs, and the grid, while maintaining momentum toward clean energy adoption

ESTIMATE OF SOLAR QUANTUM AT THE HOUSEHOLD LEVEL

Based on our stakeholder analysis, and secondary datasets collected from the 2023 census, we developed a set of informed assumptions to estimate the actual scale of domestic solar adoption in Pakistan. While official statistics capture the growth of net-metering, a much larger segment of the market remains undocumented in utility records—namely, behind-the-meter installations.

Net Metering

As of December 2024, the cumulative capacity of net-metering installations in Pakistan has reached 4,124 MW (4.1 GW)[9]. A sectoral breakdown of this capacity is shown in Table 1.

Table 0-3: Net metering share as of December 2024

Sectors	Percentage Share	Total Capacity Share 4124 MW
Residential	50%	2,062 MW
Industrial	36%	1,484.64 MW
Commercial	9%	371.16 MW
Agriculture	1%	41.24 MW
General Services	4%	164.96 MW

According to the Pakistan Bureau of Statistics (PBS) 2023 survey, approximately 2.96 million households reported using solar energy as a source of lighting. Assuming an annual growth rate of 15 per cent in solar adoption, the number of households using solar energy is projected to have increased to 3.91 million by June 2025. [10]

From the estimated 3.91 million solar-using households, excluding those registered under net metering (0.28 million), the number of households with behind-the-meter solar installations is approximately 3.63 million.

9. https://tribune.com.pk/story/2534262/new-net-metering-policy-how-long-will-it-take-to-recover-the-solar-system-cost
10. https://www.brecorder.com/news/40329650/solar-showdown-the-untold-power-play-behind-pakistans-energy-revolutioni

Estimating Household System Sizes

Conservative estimates suggest that the typical size of solar home systems in Pakistan ranges from **3 kW to 7 kW**, depending on household income and energy demand. Categorizing households into income groups with corresponding adoption shares provides the following distribution:

Table 0-4: Categorization of income groups

System Size	Adoption Share	Rationale
3 kW	40%	Lower- to middle-income homes; enough for fans, lights, and a fridge
5 kW	45%	Standard middle-income homes with ACs and kitchen loads
7 kW	15%	Higher-income households

Applying the estimated adoption shares to the 3.63 million behind-the-meter households suggests that approximately 1.45 million households have installed 3 kW systems, 1.63 million households have installed 5 kW systems, and 0.55 million households have installed 7 kW systems. This distribution corresponds to a total behind-the-meter capacity of nearly 16 GW. In comparison, grid-connected net-metering capacity currently stands at 4.1 GW, indicating that the behind-the-meter solar market is substantially larger and underscoring the significant scale of self-generation occurring outside formal regulatory and utility records.

CONCLUSION

Pakistan's solar journey stands at a critical crossroads — caught between the promise of clean, decentralized energy and the challenges of fragmented data, inequitable access, and grid instability. The evidence presented in this monitoring report shows that while the country's solar imports and rooftop installations have expanded rapidly, the benefits of this growth are not evenly distributed. A vast portion of the installed capacity remains undocumented, primarily in the form of behind-the-meter systems concentrated among middle- and higher-income households and commercial users. Meanwhile, low-income and rural communities, which face the highest energy insecurity, continue to lag behind in adoption due to affordability barriers and lack of supportive financing mechanisms.

The findings also reveal that the apparent decline in national electricity demand cannot be attributed to solarization alone. It reflects a complex interplay of factors including economic stagnation, inflationary pressures, rising tariffs, and declining industrial output, all of which have constrained consumption and reshaped demand patterns. Systemic inefficiencies in grid reliability, frequent outages, and policy uncertainty have further eroded public trust in the centralized power system, accelerating the shift toward self-generation. However, this uncoordinated transition risks deepening inequalities and creating operational stresses on an already fragile grid.

Moving forward, the solar boom must evolve beyond import statistics and isolated rooftop success stories. A coordinated, data-driven policy framework is urgently needed—one that integrates real-time monitoring of distributed generation, promotes quality assurance in installations, and ensures that solar adoption extends equitably to underserved regions. The government, regulators, and industry must collaborate to build a balanced energy ecosystem where solar growth complements grid stability rather than undermines it.

Our next monitoring report will focus on closing the data gap identified in this report by estimating the approximate deployment figures for both on-grid and off-grid solar systems. It will quantify the unaccounted solar capacity and provide a clearer picture of Pakistan's actual solar landscape—bridging the divide between imports, installations, and equitable access to clean energy.