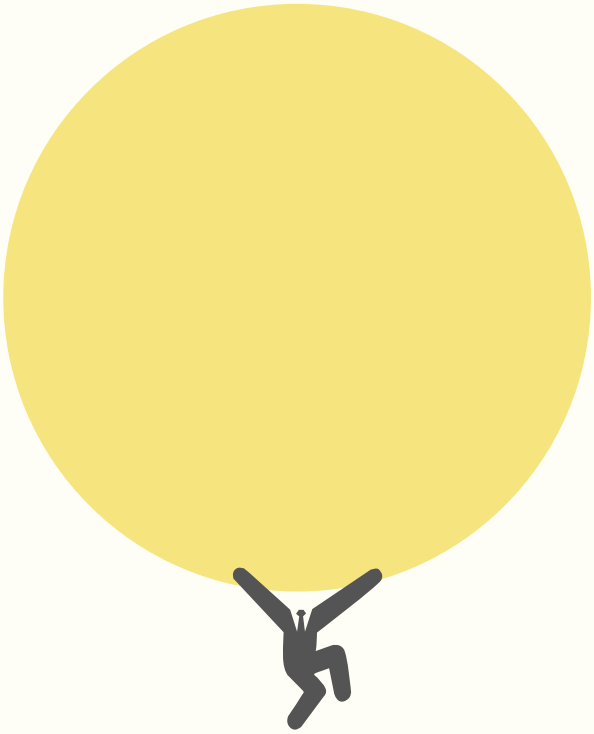
RENEWABLES FIRST

The Great Solar Rush in Pakistan



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Acknowledgements

We gratefully acknowledge the valuable contributions of industry experts, government officials, and partner organizations for making the report “The Great Solar Rush in Pakistan” possible.

Disclaimer

All the information and analysis provided in this document are accurate and to the best of our knowledge and understanding, in case you identify any error, please email: info@renewablesfirst.org

Please cite as:

Renewables First & Herald Analytics, “The Great Solar Rush in Pakistan”, 2024, www.renewablesfirst.org

Contents

Key Insights

- Pakistan is witnessing a rapid increase in solar energy adoption, driven by rising electricity costs and unreliable power supply. Bloomberg reports solar panel imports totaling USD 4.1 billion (B) over four years, with a significant spike in solar panel imports from China in the first half of 2024.

- Trade data for FY24 between China and Pakistan shows coinciding solar panel import values of USD 2.1 B; however, deviations in quantity can be attributed to erroneous enteries at the landing port.

- Despite import restrictions in FY23, solar importers found ways to circumvent limitations. These practices continued even after restrictions eased, supported by the tax-free status of solar equipment and weak customs enforcement.

- Pakistan has become a favorable market for discounted solar panels from China, with prices dropping substantially in FY24.

- The surge in solar adoption is propelled by the drastic increase in electricity tariffs by 155% over three years, creating a substantial shift towards off-grid solar solutions. Notably, the high-consumption residential sector has seen a significant drop in grid electricity demand.

- Pakistan's net metering policy, coupled with falling global solar prices and rising grid electricity costs, has incentivized solar adoption with attractive payback periods. This has led to substantial growth in solar installations, especially in sectors like agriculture and industry.

- Industry experts estimate off-grid solar installations are significantly higher than net-metered ones, driven by consumer demand for reduced grid dependency. Inverter sales and battery storage adoption are on the rise, reshaping Pakistan's energy landscape.

- The industrial sector has embraced solar captive (generation for self-consumption) power plants due to high electricity tariffs and unreliable grid supply, with particular growth in areas like northern Karachi. The agricultural sector is rapidly transitioning to solar power to mitigate escalating electricity costs.

- Therefore, Pakistan's electricity demand has seen a notable decline, prompting a revision in demand projections and necessitating grid modernization to accommodate increasing renewables. Policy reforms and grid strategy recalibration are crucial to ensure system stability.

- The delayed implementation of the Competitive Trading Bilateral Contracts Market (CTBCM) framework poses challenges for deploying substantial solar capacity and meeting growing green energy demand. Combined with projected solar installations, this delay poses technical and economic obstacles for grid management.

- Battery prices are decreasing, accelerating the trend towards solarization. The shift towards battery-based systems could impact demand patterns, highlighting the need for proactive grid adaptation to manage the influx of distributed RE.

- Sustainability of market practices and long-term viability of solar energy in Pakistan remain key concerns. The country's solar transformation, driven by market forces and accessible technology, offers lessons for other developing nations seeking rapid clean energy adoption.

Analyzing the Rise in Solar

The monumental shift in Pakistan's solar demand has garnered global attention

Amid a perfect storm of spiraling electricity costs and chronic power shortages, Pakistan is experiencing an unprecedented transformation in its energy landscape. The nation is witnessing a remarkable surge in solar energy adoption that challenges traditional power structures and heralds a decisive shift toward decentralized energy generation – a dramatic departure from Pakistan's historically centralized energy system.

The scale of this transformation is staggering. BloombergNEF reports that Pakistan imported solar panels worth USD 4.1 B over the past four years, with a substantial 13 GW of panels from China in just the first half of FY2024 (July 23 to June 24).

This surge in imports reflects a fundamental shift in consumer preferences toward distributed power generation. To validate these findings, Bloomberg analyzed Chinese export data showing approximately USD 1.4 B in solar panel exports during early 2024, corroborating their analysis through satellite imagery that reveals expanding solar clusters across Pakistan. Bloomberg projects this momentum to continue, forecasting 10-15 GW of solar deployment in 2024 alone.

The implications of this shift are profound. For a nation with a grid peak demand of 30,000 MW and merely 630 MW of utility-scale solar capacity, this surge in distributed solar adoption will dramatically alter Pakistan's energy system. Most significantly, it positions Pakistan to exceed its 2030 Variable Renewable Energy (VRE) target of 30% total installed capacity within months rather than years – an acceleration that demands immediate attention.

This study examines this transformative development through four critical lenses: verification of Bloomberg's import data claims, analysis of the driving forces behind rapid solar adoption, assessment of implications for Pakistan's evolving power sector, and development of regulatory measures to manage this unprecedented transition.

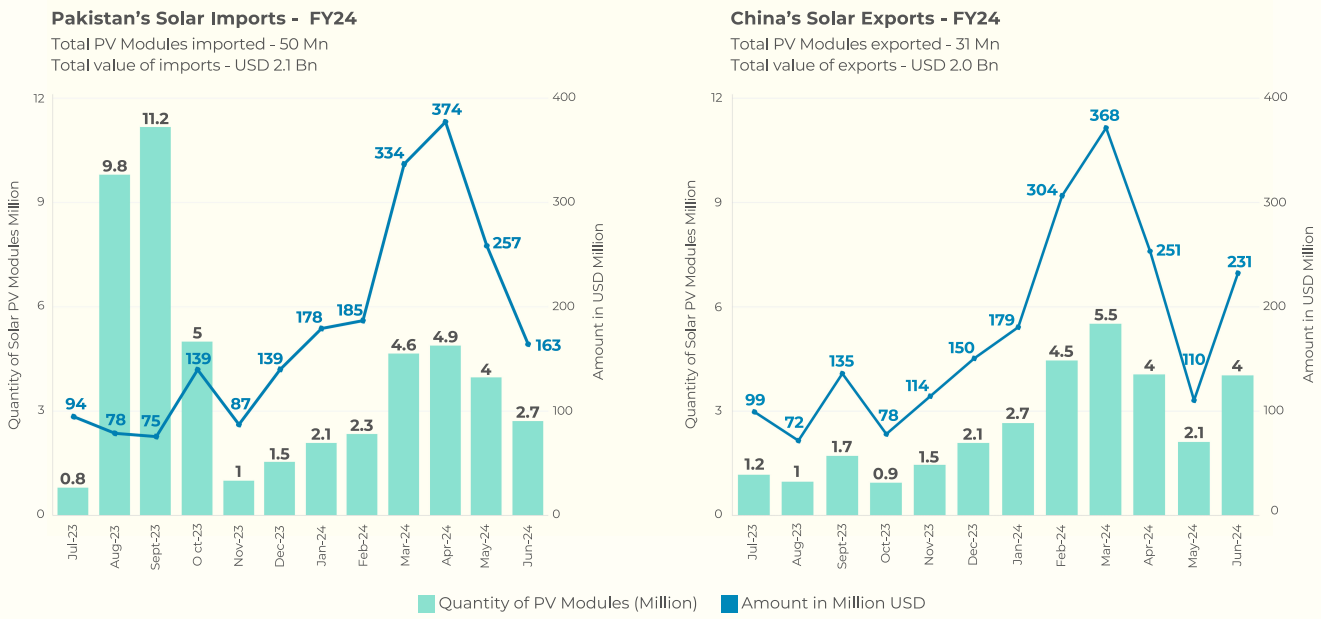
The Bloomberg data and official statistics converge but with some deviations

For FY24, the value of solar panel imports of Pakistan from China approached USD 2.1 B, according to both Chinese export data and Pakistan's import data. For context, the amount is equivalent to Pakistan's two-week import cover and 20% of the State Bank's foreign exchange reserves.

As noted in the Bloomberg analysis, there may be an element of over-invoicing. Anecdotal evidence and channel checks suggest that even after discounting for the over-invoicing element, the quantum of imports remains massive.

Further, China reports module exports of 31 M, whereas Pakistan records it at around 50 M. This difference, experts attribute to multiple factors including potential erroneous entries at the landing port due to human error and/or a deliberate attempt to cover up of for some level of over-invoicing.

Solar PV Trade - FY24 - Comparing Pakistan's Solar Imports with China's Solar Exports



Data Source: Import Data: Pakistan Bureau of Statistics, Renewables First & Herald Analytics Calculations
Export Data : Ember- Climate-China's Solar PV Exports

Over-invoicing remains a reality attached to solar imports as some elements exploit the tax-free status of solar equipment and lax customs inspections. Initially, from mid-2022 to early 2023, government-imposed import restrictions prompted importers to devise ingenious workarounds.

These included establishing shell companies in third countries, leveraging relatives' businesses, and utilizing informal financial networks, often with the complicity of banks, leading to significantly inflated costs.

As these restrictions eased, a new, more direct approach emerged: importers began over-invoicing with the aid of overseas collaborators, effectively channeling substantial funds to offshore accounts.

These workarounds may have come at a higher cost, with some estimates indicating that the price of consignments have doubled due to the involvement of middlemen and the margins taken by banks.

There are indications that personal connections may have played a key role, with a majority of LCs potentially being opened based on favors, and even local branch managers possibly profiting from these transactions.

The Solar Import Process Flow[4]

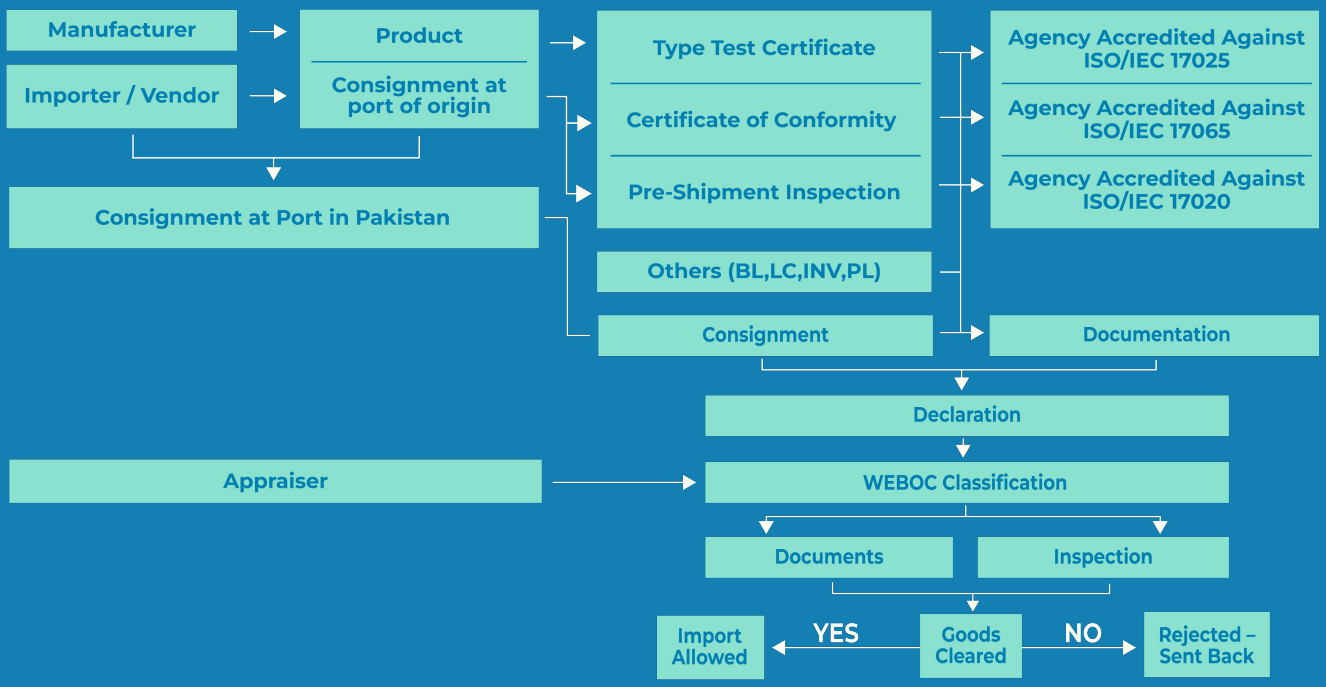
The import process begins with importers placing orders with suppliers or manufacturers. Importers of solar equipment in Pakistan must adhere to Pakistan Standards and Quality Control Authority (PSQCA) standards and ensure manufacturers conduct type tests in accredited laboratories in the country of origin.

Suppliers then ship the equipment to Pakistan, providing necessary documentation including invoices, bills of lading, and LC copies. Importers must retain Certificates of Conformity and Pre-shipment inspection certificates.

Upon arrival, port authorities present the consignment to an appraiser or examiner. The importer submits all required documents to a customs officer, and the vendor declares the consignment according to the Goods Declaration (GD). All documents are then uploaded to WEBOC (Web-Based One Customs).

The customs officer's role involves two primary tasks:

- Document review
- Product inspection and examination



China's supply glut conundrum has led to it flooding in its own backyard

China dominates the global solar manufacturing industry, controlling 80-85% of manufacturing capacity[5]. Years of increased deployment and supportive policy regimes have allowed Chinese manufacturers to achieve economies of scale and technological advancements that have led to a steep fall in the cost of Chinese manufactured solar panels.

The Chinese government ensured that solar consumption was subsidized in the country (until 2021) which meant that the local manufacturers had consistently high level of demand from domestic utility companies. This allowed these manufacturers to scale and ultimately translate those gains into positioning themselves in markets abroad as well.

As western countries, including the US and EU nations, implement anti-dumping regulations on Chinese solar products, Asia has emerged as a significant alternative market. Pakistan, due to its geographical proximity to China and consumers' need for affordable electricity, has become a prime destination for these products. As Chinese solar over-capacity finds its home in the country, solar panel costs in Pakistan have plummeted from 24 cents to 10 cents per Watt in the FY24[6].

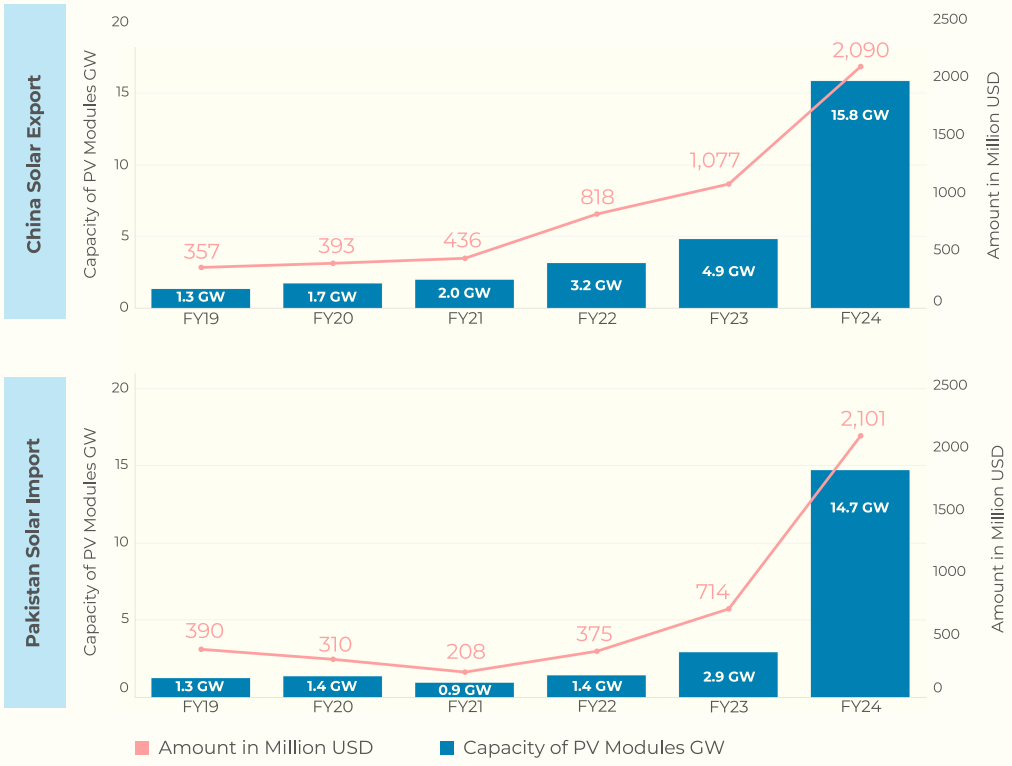
Local EPC companies have voiced concerns about the influx of low quality and counterfeit products into the country. Additionally, weak regulatory enforcement has further enabled this trend . Although Pakistan has implemented SRO 604[7], requiring pre-shipment inspections and certifications, the process is often riddled with loopholes, allowing substandard panels to pass through with minimal scrutiny.

Pakistan's position makes it an attractive target for Chinese manufacturers grappling with oversupply. This influx has led to market saturation in Pakistan, with numerous traders, including those from unrelated industries such as rice and cement, entering the solar market due to the potential for quick profits. This new competition has driven down prices, but also created challenges for established EPC companies, who struggle to compete with traders willing to sell at a loss just to clear inventory.

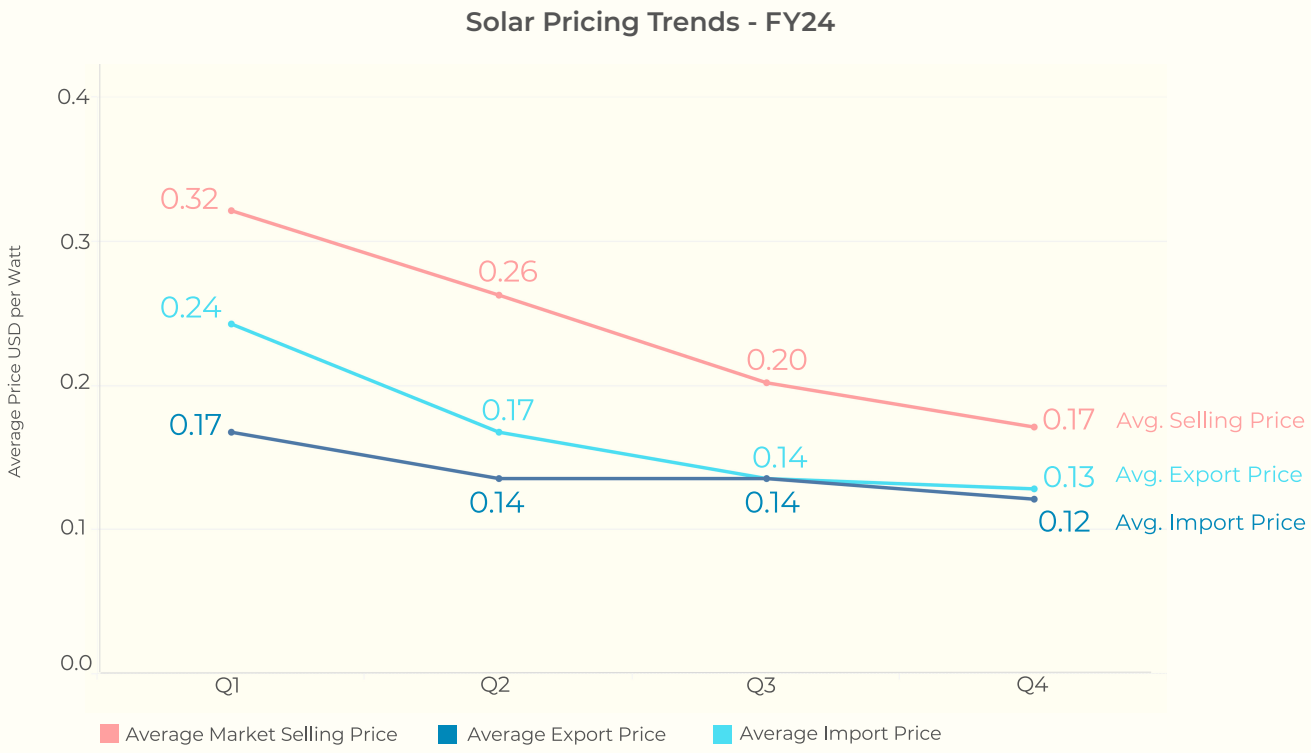
While the China export price of Tier 1 solar panels dropped to around 24 cents per Watt, in Pakistan, prices were as high as 32 cents per Watt, in the middle of 2023. In an ecosystem of shrinking LCs and a market demand stemming from ever-increasing grid electricity prices, solar panel import became a lucrative business for many traders, middlemen and investors with spare change at hand due to the struggling real estate sector. The delta between the import prices and local selling prices also offered lucrative margins for those entering the solar business.

This glut of cheap imported panels resulted in further strengthening the business case of decentralized generation for many consumer classes.

Chinese Solar Exports and Pakistan's Solar Imports Pattern (Year 2019 - 2024)



Data Source: Export: Ember-Climate- China's Solar PV Exports
Imports: Renewables First & Herald Analytics Calculations, Industry and Market Consultations



Data Source: Export: Ember-Climate- China's Solar PV Exports
Imports: Renewables First & Herald Analytics Calculations, Industry and Market Consultations

Demand Side Factors Driving the Shift

The elevated cost of electricity and the resultant subdued electricity demand, substantiates the claims of consumers moving off-grid

Over the past five years, Pakistan's electricity tariffs have followed a largely upward trajectory, with the problem intensifying in the past three years. Multiple factors contribute to this issue.

A knee-jerk reaction to deal with nationwide blackouts in the 2010s led to a rapid deployment of thermal technologies, including imported coal and LNG plants[8]. The nature of contracts with these power plants meant that returns and payments were primarily indexed to the dollar, ultimately leading to a significant hike in electricity costs during the rapid depreciation of the PKR post-2021[9].

Many of these new power plants were financed through foreign investments backed by sovereign guarantees and had a "take or pay" clause enacted. This meant that regardless of electricity generation, these projects would be entitled to significant capacity payments, with the onus of ensuring payment falling on the government.

The problem manifested itself in the shape of an installed capacity of around 45,000 MW, while demand only peaked at 30,000 MW for a short span in the summer[10]. This difference meant that many consumers ended up paying for fixed sovereign obligations without ever consuming the electricity generated by the projects backed by the sovereign.

The crisis has worsened in the past three years, with electricity tariffs surging by more than 155%[11]. This has resulted in a situation where many economic strata have ended up spending more on utilities than even their rental expenditure[12]. Indeed, as Pakistan's GDP grew by 2% in the last two years, its electricity demand on the grid shrank by 10%[13].

While there are discrepancies between various data sources around Pakistan's solar imports, the situation explained above and the statistics to follow provide sufficient grounds to believe that the high cost of grid electricity, averaging 13-14 cents per kWh[14] has led to consumers opting for off-grid cheaper sources like solar; and this trend is unlikely to slowdown any time soon.

Analysis of residential consumer demand over the past five years reveals that the proportion of consumers with demand above 400kWh has gone down from 10% in 2020 to 1% in 2024[15]. This shows that the top tier of consumers has curtailed their demand for electricity and moved off-grid, primarily to solar.

Residential Consumer Demand (% share of consumers with demand)

Category	FY20	FY24
<200kWh	57	89
>400kWh	10	1
Residential Subsidies (PKR B)	239	378

Data Source: PITC Consumer Data, World Bank Staff Calculations,
FY20 Budget in Brief Report, FY25 Budget in Brief Report, Pakistan Development Update 2024

The trend has not stopped here, and more recently, the electricity demand from Pakistan's national grid fell sharply by 17.4% for the month of August 2024 compared to the same period last year[16]. This further underscores the significant shift in consumer behavior and the growing adoption of alternative energy sources in response to rising electricity costs and grid-related challenges.

The net-metering figures also indicate a significant uptake in solarization

Net metering, introduced in 2015 through the Distributed Generation and Net Metering Regulations, has been a crucial driver in promoting solar adoption. These regulations allowed consumers to install small-scale RE systems on their premises, effectively turning them into prosumers.

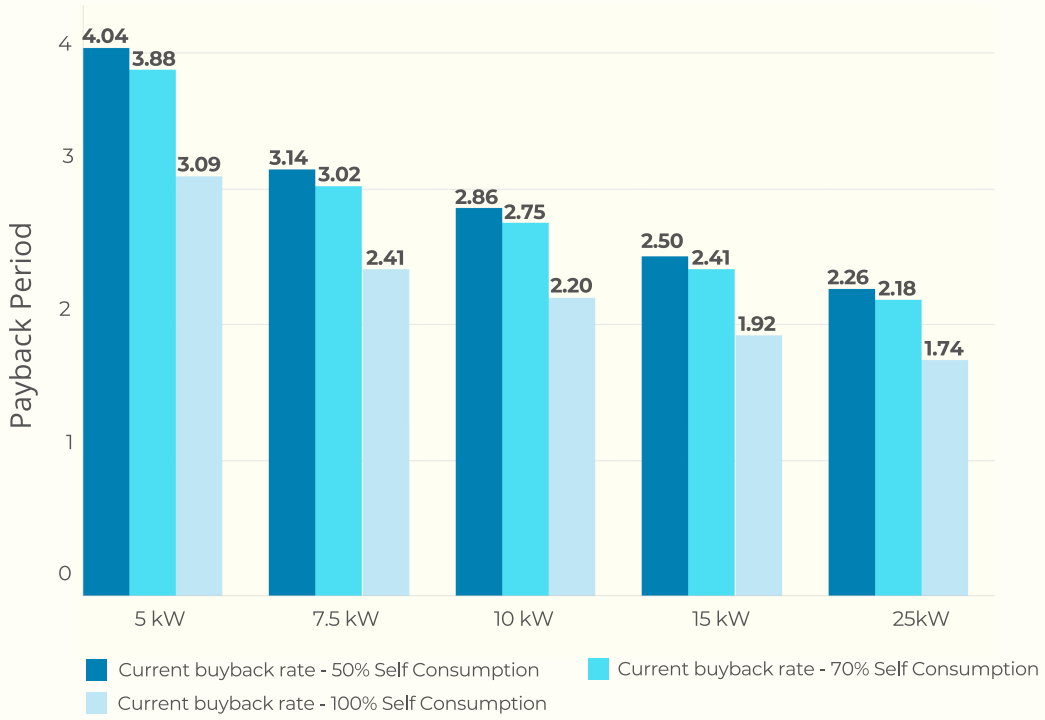
The said policy has undergone several amendments since its inception. Key changes include extending the distribution generation license from three to seven years and exempting systems below 25kW from requiring generation licenses. These modifications have reduced bureaucratic hurdles and made it easier for smaller consumers to participate in solar energy generation.

Further, the economic case for solar installations has dramatically improved over recent years. Global solar panel prices have decreased by 42% in 2023 alone[17], making solar systems more affordable for a broader range of consumers.

Simultaneously, rising electricity tariffs in Pakistan have made grid electricity increasingly expensive, with high-consumption residential consumers paying up to 22 cents per unit[18]. This widening gap between solar costs and grid electricity prices has significantly enhanced the attractiveness of solar investments.

The ability to install up to 1.5 times the sanctioned load under net metering regulations has further improved the financial proposition, with typical investments breaking even in just 2-4 years[19].

Payback Period (Years) for Solar PV Installations (5-25 kW) in Pakistan Under Net-metering



Data Source: IEEFA

Support through concessional financing schemes has also been a key enabler in accelerating solar adoption. The State Bank of Pakistan's Financing Scheme for RE, launched in 2016, offered loans of up to PKR 6 B per project at a fixed 6% interest rate for 12 years. This initiative significantly spurred RE development, financing over 2,600 projects and adding 1,726 MW of renewable capacity by June 2023.

The scheme's success in lowering levelized tariffs through reduced financing costs made RE projects, including solar, more competitive and accessible to a broader range of investors and consumers.

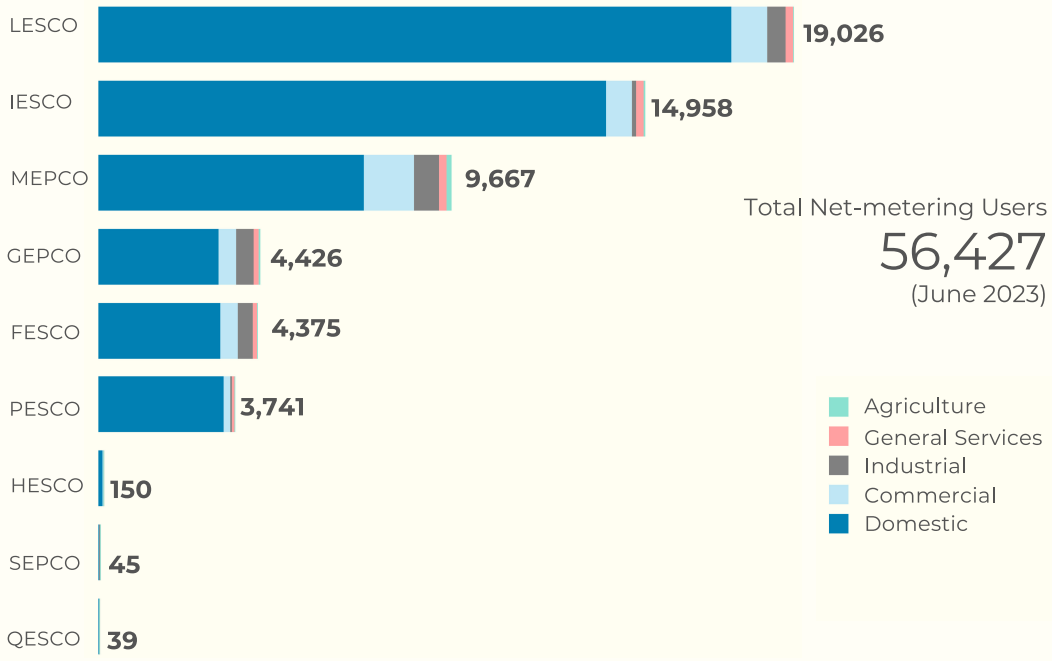
The combined effect of these factors is evident in the rapid growth of solar installations in Pakistan. Since 2022, the amount of net-metered solar PV installations has almost doubled, with 764MW installed in 2023 alone. The first half of 2024 saw an additional 450MW of rooftop solar capacity added to the grid, indicating a continuing upward trend. As of September 2024, Pakistan's on-grid net-metered solar PV capacity reached approximately 3.2 GW[20], with estimates suggesting the actual figure could be significantly higher[21], owing to data lags in reporting as well as unreported addition of panels to existing net metered systems.

This growth is not limited to a single sector but spans across different socioeconomic classes and industries. The industrial sector, particularly textiles, has embraced solar power to reduce costs and meet decarbonization goals. Government initiatives have also promoted solar adoption for public buildings and supported low-consumption households in accessing solar energy.

The robust ecosystem that has developed around solar energy in Pakistan, with over 400 certified solar installers active in the country as of late 2023, primarily serving the industrial sector, further supports this growth trend. While thousands others with formal and informal electrician practices have taken up the installation drive for residential installments.

Even with potential policy shifts from net metering to net billing or gross metering or even a complete do-away of the buyback regime, the economic appeal of solar systems is expected to persist, with break-even periods projected to remain under five years.

DISCO Wise Breakdown of Net-metering Users in Country, June 2023



Data Source: State of Industry Report 2024, Renewables First Calculations

While no official numbers exist for off-grid or standalone solar installations, it remains the biggest destination for Chinese solar panels

The recent surge in off-grid solar installations, inverter and battery sales in Pakistan reflects a complex interplay of market dynamics. The influx of low-cost solar PV panels has attracted a wide array of new entrants, including traders from unrelated sectors like rice and textiles, seeking to capitalize on quick profits[22]. As a result, many of these new players are stockpiling excess inventory, leading to market saturation and intense price competition.

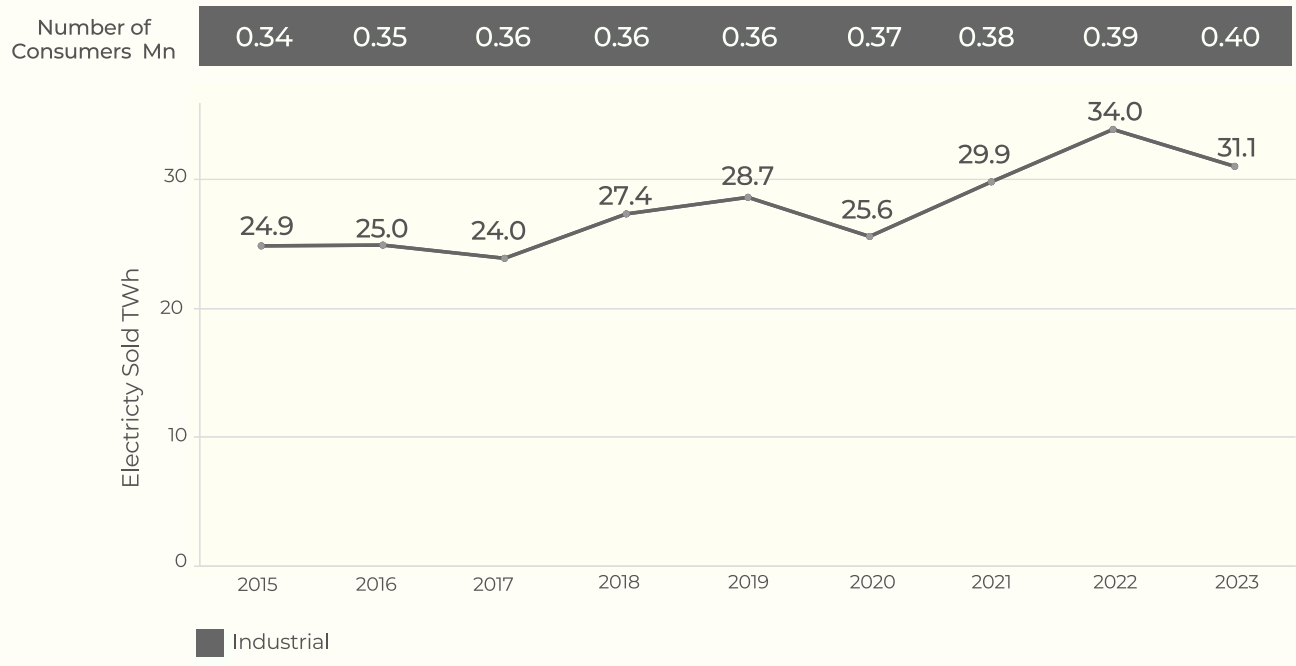
While no official data is available for off-grid installations, experts across the industry including installers opine that the numbers for this will be at least 2-3x the net metered installations, as multiple consumer classes including commercial consumers with day time utilization, domestic consumers with capital to hybridize and install batteries, as well as rural consumers with single-phase connections have widely embraced solar technology to cover their daytime energy requirements, further diminishing reliance on the national grid. Large-scale industrial installations, particularly those exceeding 1 MW in capacity, are also non net-metered.

Inverter sales have also seen a significant increase, with experts estimating that around 6 GW has been installed, yet the inverter stockpiling also continues as its price fell drastically followed by crashing PV prices. The demand for battery storage systems is poised to grow, particularly as the economics of battery deployment improve, allowing for a payback period of just two to three years at competitive tariffs. This shift could fundamentally alter the energy landscape, putting pressure on utility companies and further incentivizing consumers to adopt off-grid solutions.

In pursuit of reliability, affordability and sustainability, the industry is opting for solarization

The industrial sector in Pakistan is increasingly embracing solar solutions, with captive generation (generation for self-consumption) from solar surpassing 1 GW, though experts suggest the actual figure could be significantly higher, potentially reaching between 2-3 GW for the sector . This shift towards solar energy is reflected in the diminishing industrial demand on the traditional power grid which dropped to 31 TWh in FY23, down from 34 TWh in FY22[23].

Industrial Economic Group Electricity Sold in & Number of Consumers



Data Source: NEPRA State of Industry Report

Industrial consumers in Pakistan face electricity tariffs as high as 17 cents (~PKR 50) per unit, a rate that significantly erodes profit margins and competitiveness. This financial burden, coupled with the persistent unreliability of grid power supply, pushed many industries to seek alternative energy sources. Frequent power outages and voltage fluctuations have long been a bane for Pakistani industries, leading to production losses and increased operational costs that further squeeze already tight margins.

Global market pressures have added another layer of urgency to this transition. International buyers, particularly in Pakistan's crucial textile sector, are increasingly demanding products manufactured using RE. This shift in global procurement standards is not just about environmental consciousness; it's becoming a key factor in maintaining export competitiveness. Pakistani industries, especially those integrated into global supply chains, are finding that solar adoption is no longer just an economic decision but a strategic necessity to retain and expand their international market share.

Simultaneously, a new trend is emerging in the north of Karachi, where abundant wind and solar resources have attracted new industries. This area has rapidly become a hotspot for industrial captive solar markets, as businesses seek to capitalize on the region's RE potential.

With agriculture also moving towards solar, another segment is increasingly opting out of the grid

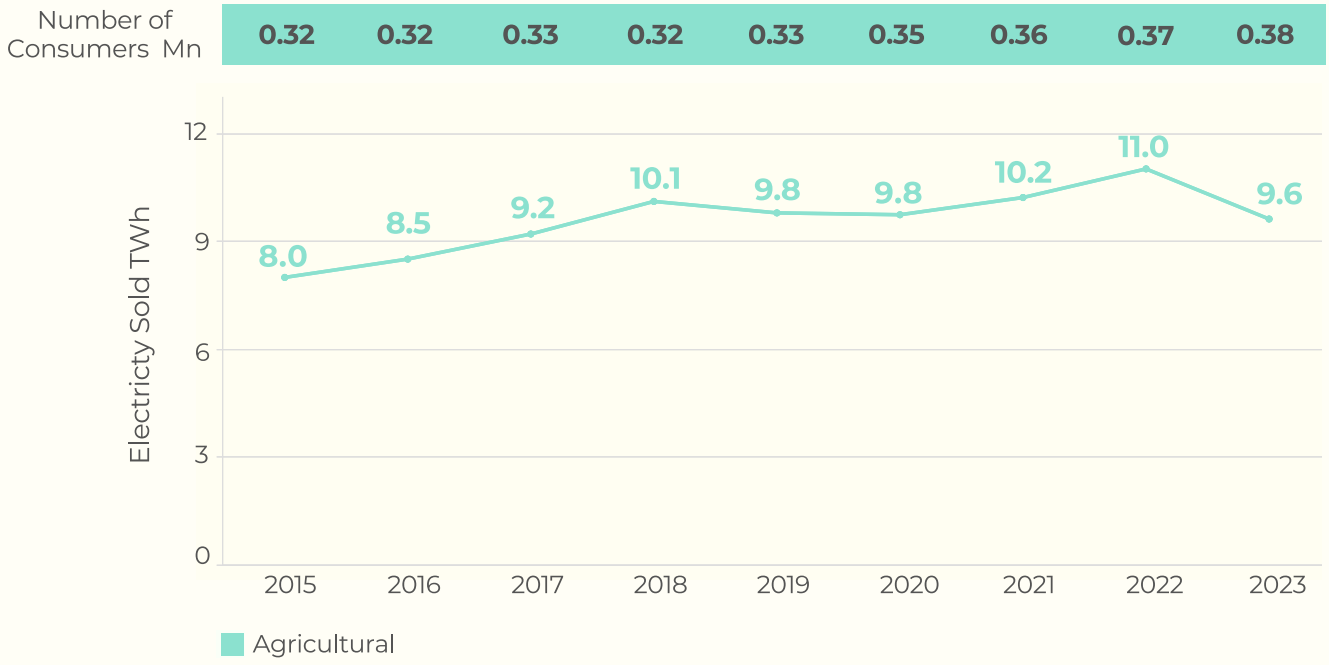
For Pakistan, the agriculture sector contributes about 24% of Gross Domestic Product (GDP) and accounts for half of employed labor force[24]. More than 92% of the country's farming area is classified as arid to semi-arid, highlighting the importance of irrigation in driving this sector forward[25].

Estimates for total number of tubewells installed across Pakistan range from between 1.5 M to 2 M. The government of Pakistan is currently pursuing an aggressive strategy to solarize the tubewells across all provinces of Pakistan, aiming to solarize a 100,000 tubewells in a recent federal drive[26]. Provinces have also enacted similar schemes, aiming at restoring the export competitiveness of Pakistan's irrigation dependent produce.

Industry experts however have noted that the solarization of tubewells is well and truly underway across all of Pakistan. For most installers, agricultural installations have become a prevalent secondary market, indicating an existing robust and growing ecosystem around solar installations in the agricultural sector.

Economic factors are accelerating this transition. While the business case for a transition from expensive diesel fuel to solar power remained strong, the electricity tariff for agricultural tubewells has also seen a dramatic increase of 3x in just one year. Simultaneously, the cost of solar panels has plummeted. This widening gap between grid electricity costs and solar installation costs has made the switch to solar power increasingly attractive for farmers.

Agriculture Economic Group Electricity Sold in & Number of Consumers



Data Source: NEPRA State of Industry Report

The latest electricity price hike for agricultural tubewells is likely to further accelerate the adoption of solar-powered tubewells. This price disparity makes solar energy not just an environmentally friendly option, but an economic necessity for many farmers[27].

Taking an example of Punjab, with a last official count of a total of over 1.2 M tubewells in 2021; assuming an

average installation size of 7.5 kW, if even a quarter of Punjab's tubewells were to be solarized, it would result in approximately 300,000 installations with a total estimated capacity between 2 - 2.5 GW. This represents a significant addition to Pakistan's RE capacity[28].

The trend is not limited to Punjab. As per media reports, an agreement between Balochistan and the federal government to solarize all tubewells connected to QESCO's grid is expected to replace about 300 MW of grid power with solar PV systems. This initiative alone demonstrates the scale of potential solar adoption in the agricultural sector.

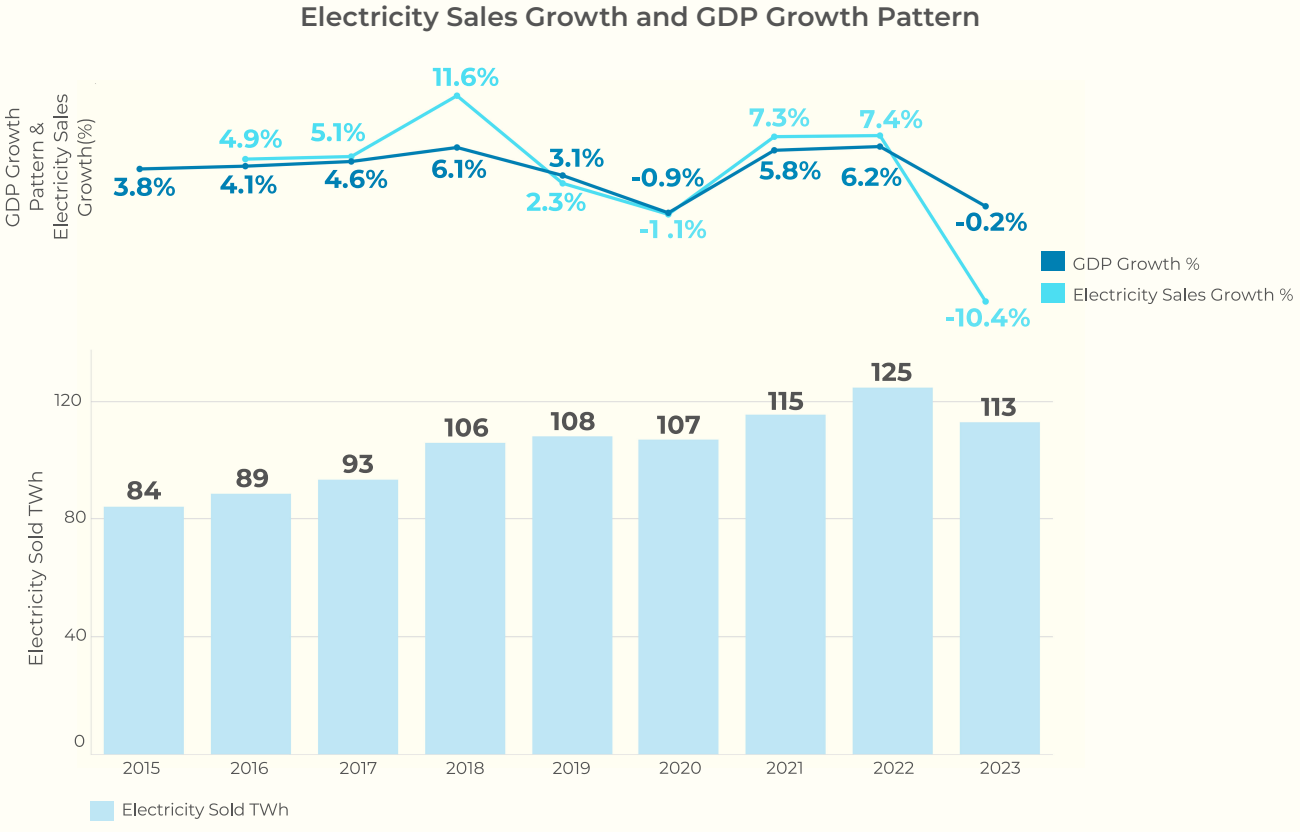
The shift is already having observable impacts on traditional energy consumption patterns. Pakistan State Oil has reported a 30% decrease in diesel sales compared to the past two years[29]. While multiple factors contribute to this decline, the transition of agricultural and industrial demand away from diesel to solar power is a significant contributor.

Future Outlook and Implications

Electricity demand has cliffed for the first time in the past decade and the trend is likely to continue

For the first time in a decade, electricity demand in Pakistan has experienced a significant decline, a trend that appears set to continue. As per IGCEP 2024-34, peak demand dropped by 3.2%. Furthermore, NEPRA's numbers indicate the annual power generation fell by 9.5% from FY22 to FY23 and in FY24, the annual power generation further decreased to 127.2 TWh, down from 129.6 TWh in FY23. This downward trend is also echoed in the first two months of FY25 (July-August), where peak demand fell by 8.9% year-on-year to 18,857 MW, compared to 20,697 MW during the same period last year[30].

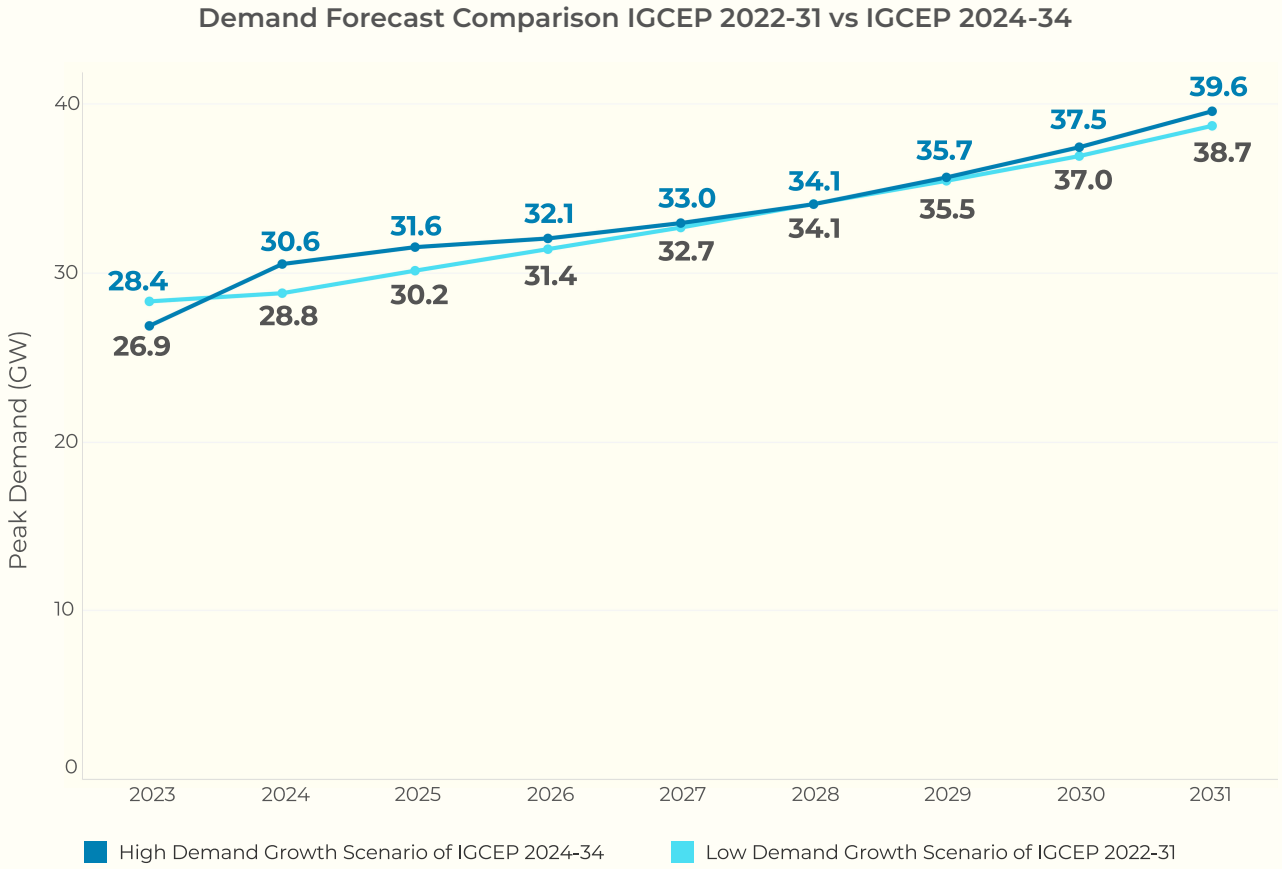
The primary drivers behind this decline include reduced GDP growth fueled by macroeconomic volatility and soaring electricity costs, prompting many industries to abandon grid reliance in favor of captive systems or even to cease operations altogether. This shift is evident in the notable 10.4% decrease in sales of electricity, a phenomenon not witnessed in the past two decades[31]. This downward trajectory is set to persist as escalating electricity prices continue to push consumers away from the grid and towards decentralized energy solutions.



Data Source: NEPRA State of Industry Report, Renewables First and Herald Analytics Calculations

The implications of this shift are profound. The latest iteration of the Integrated Generation Capacity Expansion Plan (IGCEP) 2024-34, Pakistan's annual generation capacity expansion planning document, significantly revises the demand projections downward. The high-demand growth scenario for FY31 (39,608 MW) now closely aligns

with the previous iteration's low-demand growth scenario (38,744 MW)[3233]. This stark reduction underscores the reality of dwindling demand and suggests that the energy sector must recalibrate its strategies to adapt to a fundamentally changed market landscape.

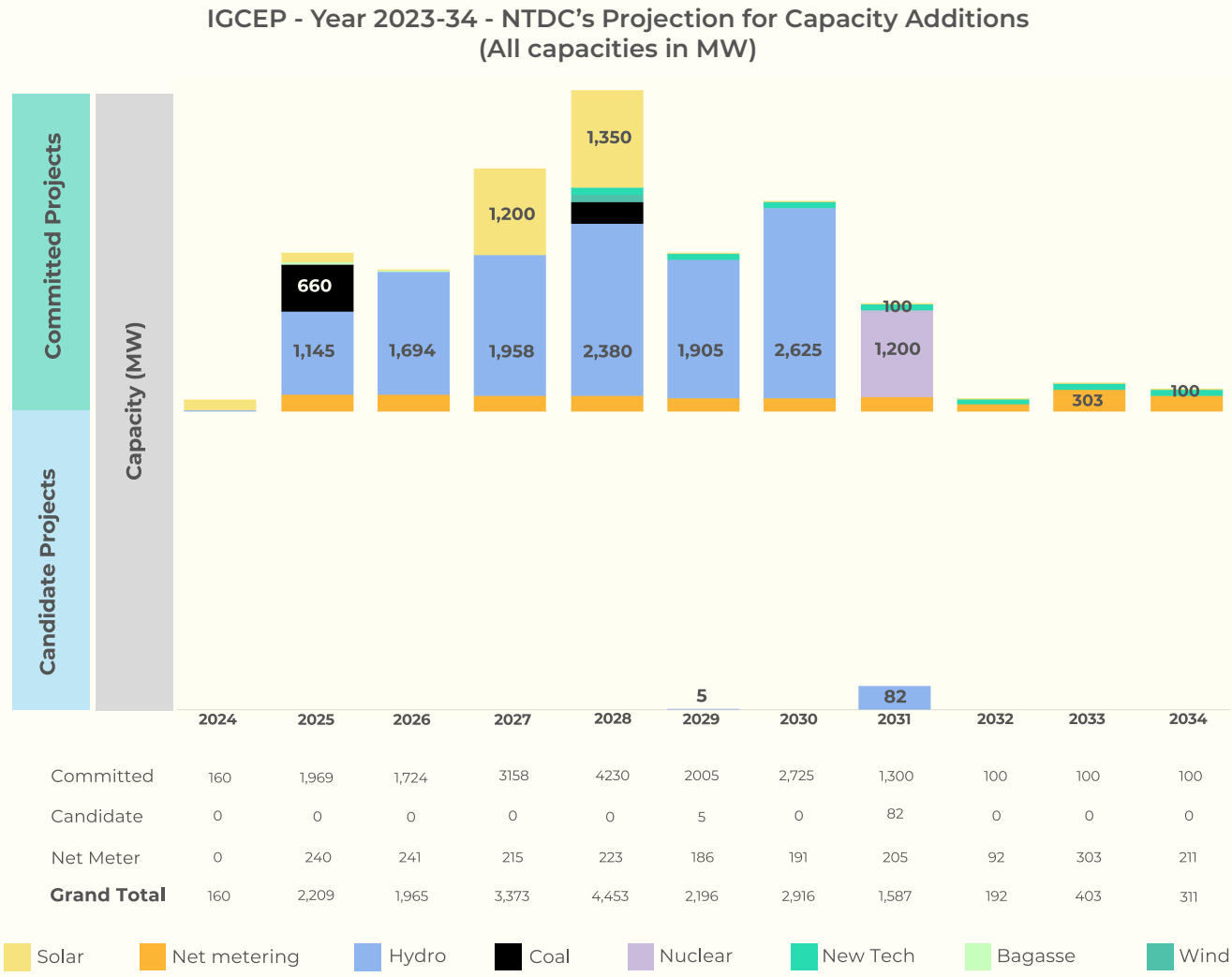


If current trends persist, the power sector's oversupply situation will further exacerbate, leading to increasing financial strain on utilities and greater instability in electricity pricing. Grid contracted capacity through the Independent Power Producers (IPP) mechanism, based on a 'take-or-pay' model, mandates substantial capacity payments irrespective of actual electricity consumption. As rapid adoption of solar PV systems, both grid-connected and off-grid increase, more consumers will generate their own electricity, leading to a diminishing demand for grid power, yet the obligation for capacity payments remains unchanged. As capacity charges constitute a massive 64% of the Power Purchase Price (PPP)[34], this imbalance threatens to worsen as the solar trend accelerates, potentially driving up the per-unit capacity charge as fixed costs are distributed across a shrinking consumer base.

Policymakers will need to reevaluate existing energy strategies, focusing on enhancing efficiency, improving grid connectivity and sustainability rather than merely expanding capacity. In parallel, excess capacity at the grid level will need to be dealt with, through mechanisms such as earlier retirement, contract renegotiation and plant repurposing.

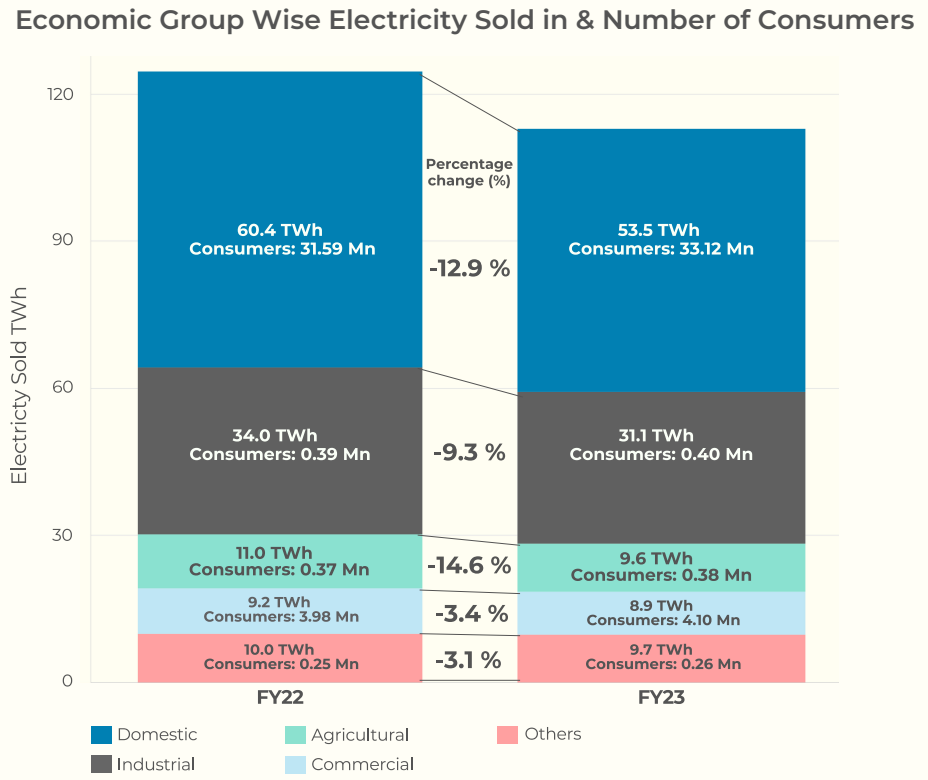
The planning process must adapt to changing demand patterns and move towards a more decentralized system

The energy planning process in Pakistan must evolve to address changing demand patterns and shift towards a more decentralized system. Currently, the country is projected to add 19,765 MW of capacity by 2034, increasing the total installed capacity to 56,046 MW. However, nearly all of these new additions are committed projects (19,518 MW), with only two power plants totaling 87 MW being considered for optimization[35]. This ambitious expansion occurs against a backdrop of under-utilized recent power projects based on Regasified Liquefied Natural Gas (RLNG) and imported coal, where a number of these projects have limited utilization in the next 10 years, of less than 10% as per the IGCEP. The introduction of such additional committed capacity will exacerbate the existing strain on the grid, potentially accelerating its decline.



Moreover, the forthcoming CTBCM is poised to significantly reshape the energy landscape. The existing power market structure in Pakistan follows a single-buyer model, in which CPPA-G as government's agent, functions as solar power purchaser on behalf of Distribution Companies (DISCOS) and facilitates commercial transactions among all the departments of the electricity sector (generation, transmission, distribution etc.). CTBCM is the new market model that will allow trading of electricity between market participants (buyers and sellers) through bilateral contracts. CTBCM allows market forces to determine prices and quantities of electricity traded through bilateral agreements, rather than government participating in the commercial transactions. This shift allows these consumers to bypass the grid, seeking more cost-effective and cleaner power sources to reduce operating costs and fulfill regulatory requirements for emission reductions. As CTBCM enables competition, the financial pressure on DISCOs will rise further. With major consumers exiting the grid, they will no longer be contributing to the cross-subsidies that help maintain lower rates for low-income domestic consumers. This shift will leave the grid primarily serving the domestic sector, which is largely consumptive in nature.

Already, domestic consumers make up 87% of the total number of electricity users, consuming around 44% of the country's electricity sales[36]. However, this consumption is primarily for non-productive activities like heating, cooling, and maintaining lifestyle comforts, as opposed to productive consumption that adds value to the economy. This shift towards a grid dominated by consumptive load will further erode the financial viability of the utility system.



Data Source: NEPRA State of Industry Report

This trend creates a vicious cycle, as the grid loses its most profitable customers, leading to rising electricity tariffs for those left behind; mostly low-income households, least able to bear additional cost burdens, leading to further financial strain on the power sector.

The government's plan to expand the installed capacity through committed projects, coupled with consumers increasingly shifting away from the grid, reduces utility's profitability and accelerates its financial collapse. This cycle of growing financial strain makes it harder for the utility to meet its revenue targets and stay operational. Additionally, provinces are formulating their own plans to promote solar home systems, develop their own grids and even setup decentralized solar parks for specific regions, which will further exacerbate the "utility death spiral".

Furthermore, the growing financial strain could adversely affect ongoing privatization transactions for DISCOs. With a shrinking consumer base and increasing generation costs driven by lower demand, the already slim profit margins are expected to tighten further. This financial instability may deter potential investors, complicating the privatization process and hindering efforts to enhance operational efficiency within the power sector. There is a need to implement dynamic and forward-thinking strategies that not only promote decentralized energy solutions but also reinforce the existing grid infrastructure and grid functions. The urgency for an Integrated Energy Plan (IEP) becomes paramount, as it should seamlessly blend decentralized generation with a resilient centralized grid while facilitating the transition of non-power demand to the upcoming RE sources expected to be integrated into the system. This can be achieved through mechanisms that incentivize self-generation while simultaneously enhancing the grid's capability to integrate these new energy sources effectively. This whole rethink of the concept of a grid is the need of the hour, essential for Pakistan to craft a way out from the utility death spiral.

Opening the electricity market is a key to assimilating the green and affordable electrons in the grid.

The long-awaited CTBCM remains stalled as the key stakeholders struggle to reach consensus on the Use of System Charge (UoSC). The UoSC refers to the fees or charge imposed on the market participants (buyers and sellers of electricity in a competitive electricity market) for utilizing the transmission system to transport electricity. Industrial participants advocate for a market-competitive UoSC, while the government seeks to include the inefficiencies of the legacy power system, such as the capacity costs of underutilized power plants, into the new market. Opening the electricity market could enable the deployment of the stockpiled PV capacity

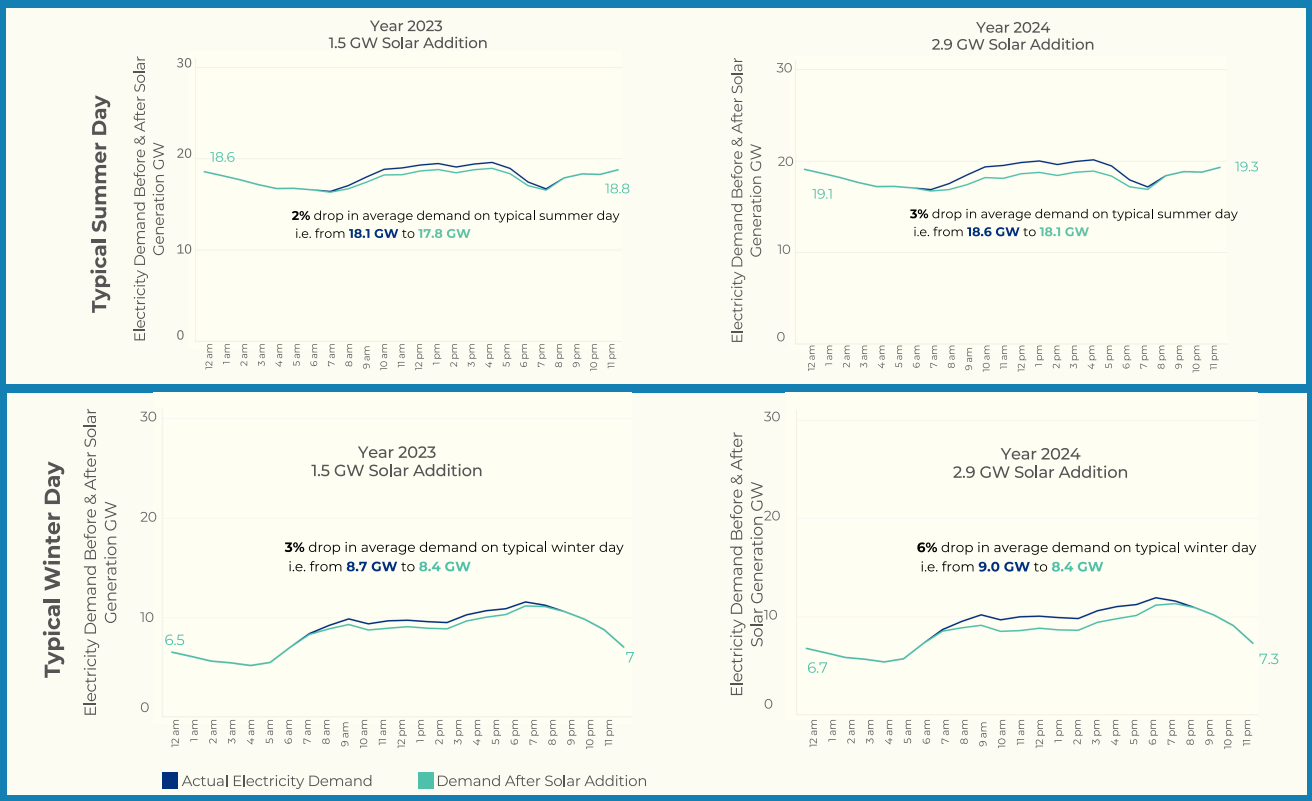
and help reduce electricity costs. The CTBCM will offer pathway for industries and Bulk Power Consumers (BPCs) to directly source electricity from solar and wind generators, providing a vital mechanism for green energy procurement and ensuring competitiveness in regional and global markets.

To illustrate the implications of not opening the market for ancillary services and failing to adopt battery storage solutions and ineffective planning at the grid level, two actual data-based scenarios were explored to highlight the impact of renewable capacity additions for 2023 and 2024.

Actual Data-based Scenarios:

- 2023: 1531 MW (as of December 2023)
- 2024: 2899 MW

Effect of Growing Solar Deployment on Electricity Demand (Scenarios based on actual data)



Data Source: NDTC, Renewables First & Herald Analytics Calculations

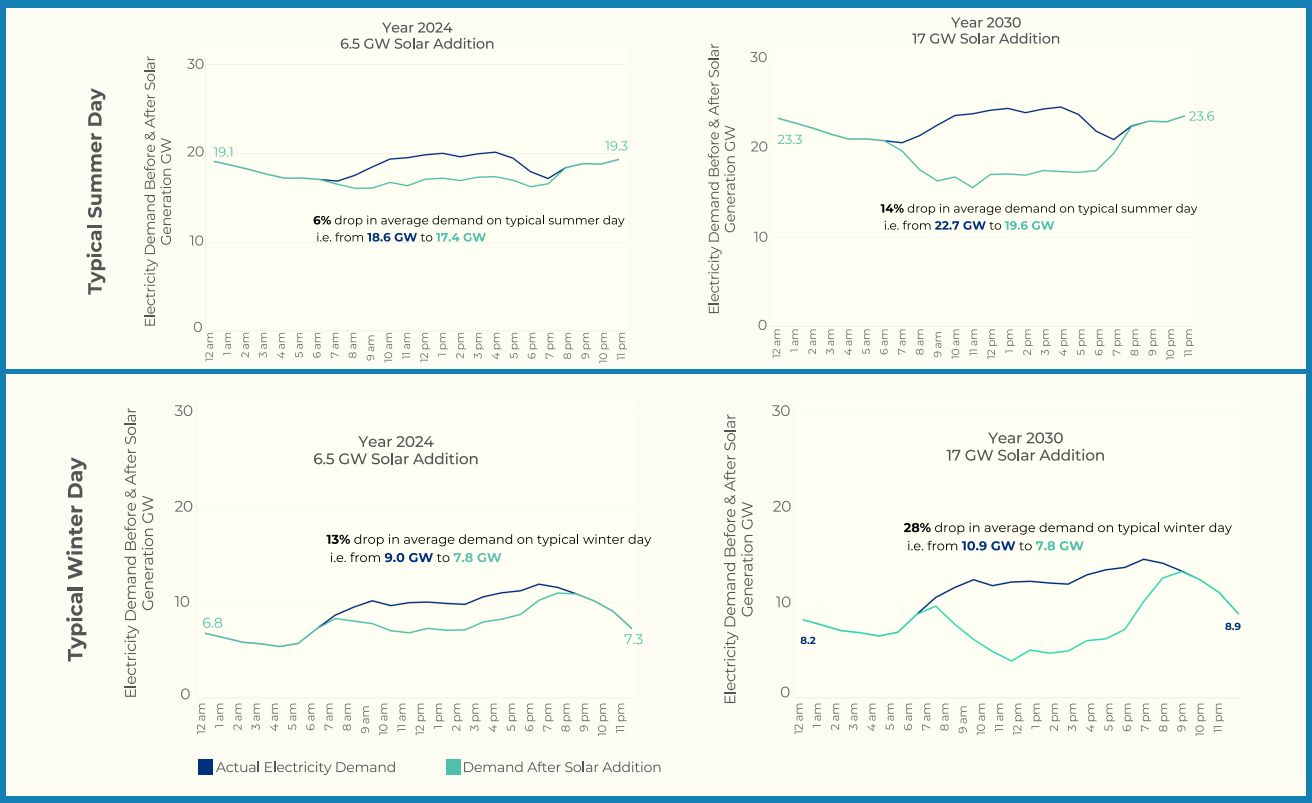
It is evident from the duck curves that the already deployed 2.9 GW till date has considerably impacted the grid demand. The average daily demand for a typical summer day decreased by 2.83%, whereas the drop is more significant for a typical day in winter season, that is 5.88%.

Assumption-based Scenarios

- 2024: 6500 MW
- 2030: 17000 MW

Given that Pakistan has already imported around 17 GW of solar PVs this year, two assumption-based scenarios were also made. In the first scenario, the quantum of already deployed solar PVs based capacity, is assumed to be 6.5 GW in FY 24. In the second scenario, the entire 17 GW is anticipated to be effectively deployed by 2030.

Effect of Growing Solar Deployment on Electricity Demand (Scenarios based on assumptions)



Data Source: NDTC, Renewables First & Herald Analytics Calculations

Assuming the entire 17 GW is installed by 2030, given that 6.5 GW is already operational, leaves 10.5 GW yet to be installed. This could significantly disrupt demand patterns, particularly during the winter months. In the scenario where 6.5 GW is assumed to have been deployed in FY24, the average daily demand drops by 6.36% during a typical summer day, and by 13.19% for a day in winter. Similarly, with 17 GW deployed by FY30, the average daily demand declines by 13.62% during a typical day in summer, and by 28.48% in winter. Demand growth was projected as per the IGCEP 2024-34.

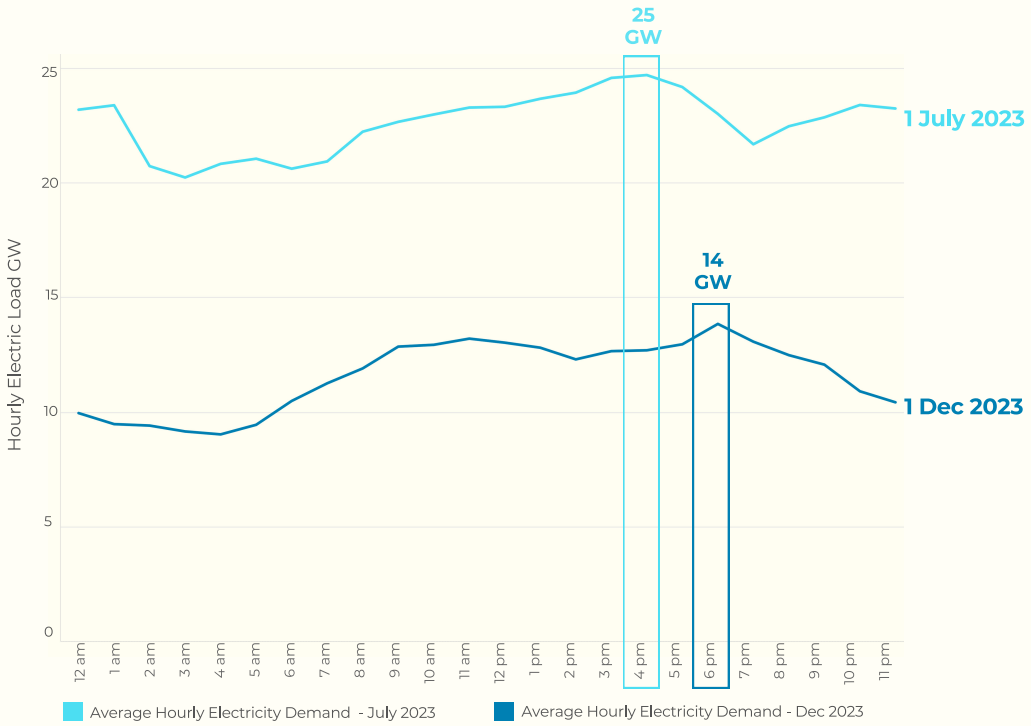
NTDC's demand forecasts indicate minimal growth in winter demand, and the large-scale addition of rooftop solar would likely exacerbate this imbalance. To manage this potential imbalance, it is essential to adopt a proactive approach. Solutions such as enhancing grid flexibility, investing in energy storage systems, and promoting demand-side management can help smooth out the seasonal variations observed.

Integrating ancillary services to enhance grid resilience as more renewables are added at both utility and distributed levels becomes essential as RE shares increase. RE is already the most cost-effective source of power, and any new capacity over the next decade will be renewables-based under least-cost principles, to provide the desired flexibility to a baseload dominant mix. However, the seasonal variations in national demand require grid-level storage solutions to improve plant utilization factors, which in turn will lower overall electricity basket prices. During summers, the total power demand surges to over 29 GW, while in winter, it stands at a comparatively modest 12 GW[37]. As solarization in distributed mode grows and the government continues expanding generation capacity, this mismatch will worsen. With a large share of idle plants during low-demand season, this will drive up capacity costs, making the grid financially unsustainable and leading to higher electricity prices for consumers.

At the grid-level, net-metered installations in residential and commercial sectors, will cause unprecedented levels of energy being fed back into the grid. This bidirectional energy flow can strain an infrastructure originally designed for one-way distribution from centralized power plants, leading to issues like reverse power flow and voltage fluctuations. These technical challenges will be further exacerbated by the uneven distribution of grid capacity across the country (demand in center and production in south and north).

Comprehensive grid modernization is required, including advanced distribution management systems, better weather predictions, load-blocking and demand side management, phase shifters, smart grid technologies for real-time monitoring and control, as well as energy storage solutions like residential batteries. Establishing an ancillary services market is therefore crucial, and the opening of the electricity market under CTBCM remains a key prerequisite for making this happen.

Seasonal Variation in Hourly Demand Typical Summer and Winter Days - Year 2023



Data Source: NTDC, Renewables First & Herald Analytics Calculations[38]

Another key factor which emphasizes the importance of CTBCM for export-based industry is the increase in international regulations and compliance requirements to reduce GHG (greenhouse gas) emissions. For instance, EU's Carbon Border Adjustment Mechanism (CBAM), a policy instrument that imposes a price (carbon tax) on the carbon emissions of certain goods imported to EU, will require Pakistan's export sector to source their electricity from cleaner sources.

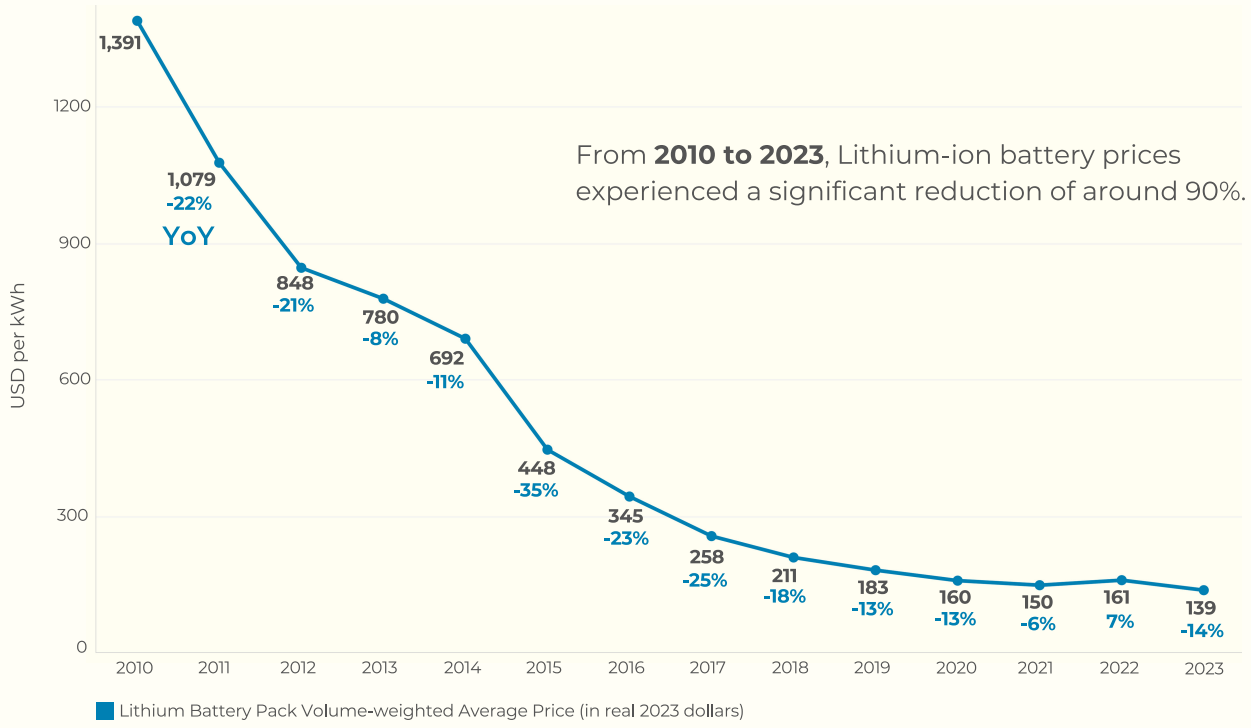
Such global pressures along with major global brands' net-zero commitments along their entire supply chains add further urgency and mandate the industrial businesses in Pakistan to cut down its emissions and procure green electricity. Without access to RE through the grid or their own captive units, these businesses face significant risks, while competing with greener markets of other exporters.

Absorption of renewables by grids is a 'must', not a 'choice' as the lowering battery prices is likely to provide further impetus to the solarization drive.

Absorbing RE into grids is essential, not optional, as falling battery prices are expected to accelerate the solarization trend. The current net-metering regime has reduced the payback period for solar systems on the grid to less than two years, making solar energy highly attractive for consumers. However, some utilities have already stopped net metering in certain areas. This is due to their inability to absorb more renewables into their grid.

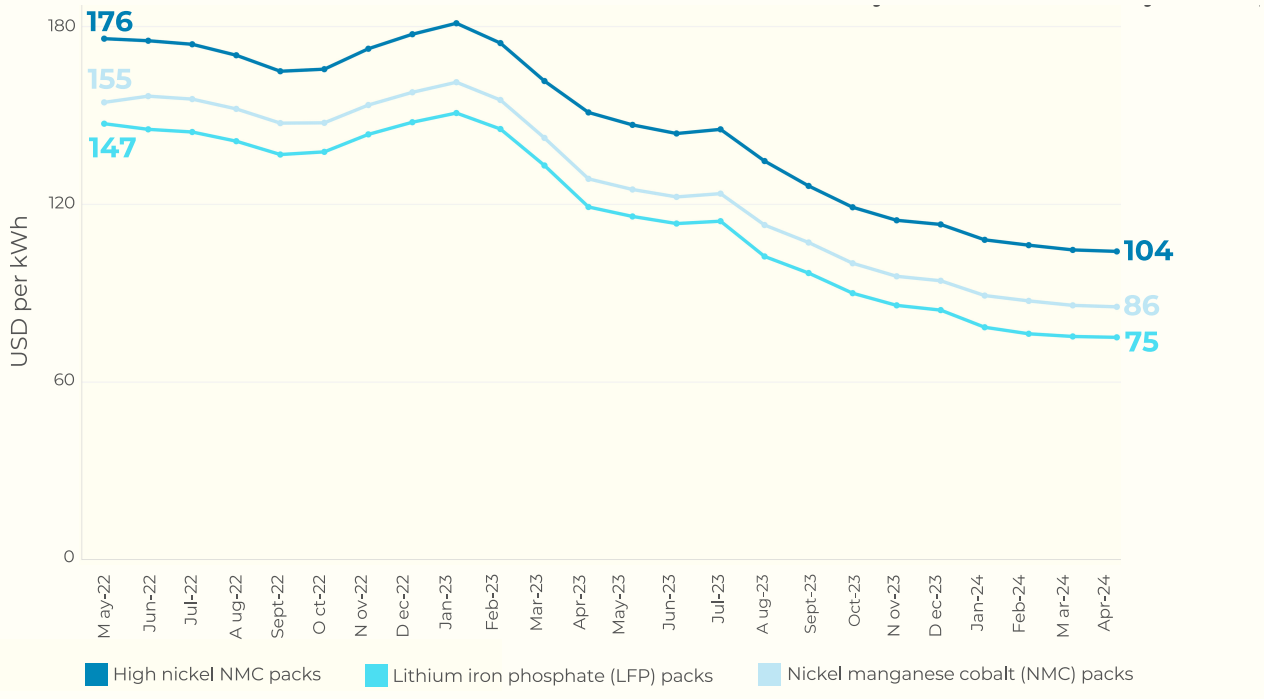
While the government is considering revising net-metering tariffs for longer-term sustainability, there are discussions around moving towards a net billing system, and other changes to reduce or even disincentivize net metering. The rapid decline in battery costs however, adds another layer of momentum to solar adoption. Lithium-ion battery pack prices have fallen dramatically, with a 90% reduction from 2010 to 2023[39], and have witnessed further drops in the past two years, e.g. prices in China alone have decreased from USD 159.4/kWh to USD 88.4/kWh (a drop of 44.5%)[40].

Trend of Lithium-ion Battery Pack Prices Year 2010 - 2023



Data Source: BloombergNEF 2023

Battery Pack Prices in China May 2022 to April 2024



Data Source: BloombergNEF, ICC Battery

DISCOs must proactively prepare their grids for the increasing influx of distributed RE. With battery prices continuing to drop, grid-level adoption is crucial to manage the impact of renewables being added at the consumer level. If net-metering becomes less attractive or is scaled back while battery prices remain low, consumers will increasingly turn to battery-based systems, leading to a significant shift in demand patterns. This could reduce grid demand, driving up capacity payments and increasing the overall electricity basket cost. To avoid these challenges, a forward-looking approach to grid adaptation is essential for integrating RE at scale and ensuring system stability.

A surge of new entrants to the market led to over imports and stockpiling of inventories

An influx of new players into the RE market has led to over-imports and stockpiling, disrupting the sector's stability. A healthy RE transition requires consistent policies, but abrupt measures, such as import bans, have caused market instability. This was evident last year when numerous short-term players entered the market, importing large quantities of solar PV panels to capitalize on immediate gains rather than focusing on long-term EPC businesses. The economic slowdown in Pakistan further pushed traders from sectors like wheat, rice, and textiles to shift their focus toward solar PV imports, particularly after SBP restrictions led to inflated margins in panel trading. These traders offered lower rates to consumers, leading to a stockpile of unsold inventory while undermining established EPC firms, which struggled to compete due to their higher overheads and long-term business models. As a result, there is a growing risk of market volatility, with some traders who bought panels at higher prices now selling at reduced rates to clear excess inventory. Currently, many traders, including newcomers from non-energy sectors, continue to offload these panels at unsustainable prices to remain competitive. While this has introduced short-term pricing competition, it could potentially disrupt market dynamics if not managed carefully. Moving forward, addressing these risks will be critical to ensuring the long-term stability and sustainable growth of Pakistan's RE sector.

Rapid renewable transition remains the often-ignored upside of solar influx

Pakistan's remarkable story of solar adoption over the past year is not just a national success story; it's a microcosm of a broader shift occurring across the Global South. This rapid transition highlights both the opportunities and challenges facing developing nations as they navigate the global energy transition, particularly in the context of utility-scale developments and the race towards decarbonization. As the country failed to offtake any RE project on the grid since 2019, failing to garner interest in recent auctions of a 600 MW solar power project, parallel deployments of a huge magnitude were underway in a decentralized and distributed manner. If this deployment is to be celebrated as a success, the country has a massive task at hand to adapt its grid for greater RE penetration, provision of ancillary services, and a reduction in grid capacity and prices through innovative financing measures, including early retirement, repurposing and renegotiations of operational plants.

The concentration of the solar supply chain in China, often viewed with concern by Western nations, has paradoxically become a boon for developing countries like Pakistan. The availability of affordable solar technology has catalyzed a swift energy transition that might have been impossible just a few years ago. This scenario underscores a crucial point: in the realm of RE, particularly solar, the traditional protectionist measures like tariffs are not only unnecessary but potentially counterproductive. The energy transition demands rapid deployment and accessibility, which the current market dynamics, driven largely by Chinese manufacturing, are delivering. Similar patterns would be expected for the deployment of battery resources, which effectively gives the grid a mere few years to adapt to the future electricity system: decentralized, democratized and distributed.

Reliance on external support and lack of government initiative remains a prominent downside risk

This reliance on Chinese technology however, is not without its complexities. The recent trend of localization efforts in the EU and US, aimed at reducing dependence on Chinese manufacturing, risks increasing prices and potentially slowing deployment for Emerging Markets and Developing Economies (EMDEs). This dichotomy highlights the delicate balance between geopolitical concerns and the practical needs of rapid decarbonization in the developing world. Post Russia-Ukraine conflict, energy systems in developing economies were threatened due to geopolitics and energy independence drives. This has effectively triggered a mass drive to secure energy independence from international and volatile markets, leading to the growth of local and decentralized systems. The case of Pakistan is no different, which had to pass on the exorbitant costs of imported coal and RLNG to its consumers, forcing them to move to alternatives despite having the capacity on the grid to meet their demand effectively.

The market dynamics driving this transition are ruthless and often indifferent to technical or economic perspectives held by traditional energy planners. The adoption of solar technology, driven by its falling costs and increasing efficiency, seems unstoppable – a testament to the power of innovation when aligned with environmental imperatives. As the saying goes, "You can't tax the sun," and this fundamental truth is reshaping energy landscapes across the Global South.

Pakistan's experience demonstrates a crucial lesson: when governments fail to adapt quickly enough, people take charge. The explosive growth of distributed solar in Pakistan, often outpacing official planning and regulatory frameworks, shows the power of individual and community action in driving energy transitions. This bottom-up approach contrasts sharply with the top-down focus often seen in discussions about industrial decarbonization, capital markets, and multilateral development bank financing. For the longest period, discussions of energy transition have centered around utility scale additions, massive decarbonization in industries and mass financing by Multilateral Development Banks (MDBs). What we have as an example from Pakistan, is a model that is driven by the people, taking charge of their energy future, driven by market forces and basic economics.

Instead of sailing against the tide, a more proactive approach is required to accommodate the rapid solarization

Indeed, while much of the global discourse on energy transition centers on these high-level financial and industrial strategies, Pakistan's solar boom suggests that a parallel – and perhaps more impactful – bet should be placed on people and their innate ability to improve their lives when given access to the right tools.

The implications of this rapid solar adoption extend beyond mere energy production. As seen in mature markets like Germany and the Netherlands, the proliferation of distributed energy resources is fundamentally altering the role of the traditional grid. The emergence of ancillary market services and peer-to-peer energy trading platforms suggests that the conventional centralized grid model may be approaching obsolescence in some contexts. Heeding warnings from other developed economies, Pakistan needs to prioritize upgrading its transmission infrastructure to match the geographical disparity between generation and consumption centers, implement advanced grid management systems to handle RE inputs, design electricity markets that provide appropriate price signals for flexible generation and storage, integrate large-scale storage solutions from the outset, and ensure coordinated planning between renewable targets, grid development, and industrial policy.

Preemptive action is required for a resilient and flexible grid capable of accommodating the booming solar potential and envisioning a future for the grid. While load blocking, phase shifting and power curtailment, all seem reasonable solutions in the shorter run, the advent of batteries may effectively condemn the grid to obscurity, without proper planning for RE integration.

This transition is occurring at a breakneck pace, driven by plummeting solar panel prices. This trend is positioning China not just as a manufacturing powerhouse but increasingly as a leader of the Global South in the realm of energy transition. Conversations of a “Marshall Plan” like investment, through the Chinese Belt and Road Initiative are testament of the changing tide of energy leadership in the Asian region and beyond.

Pakistan’s solar saga serves as a testament to the adaptability of consumers in the global south

The swift changes in Pakistan's energy landscape serve as a wake-up call to governments worldwide: adapt swiftly or risk being left behind by market forces. The traditional slow pace of energy policy and infrastructure development is increasingly at odds with the rapid evolution of renewable technologies and their adoption.

For Pakistan and other nations in the Global South, the path forward is evident: embrace and adapt to this new energy paradigm quickly. The benefits of doing so extend beyond mere electricity production, touching on economic development, energy independence, and environmental sustainability. As the world grapples with the urgent need for decarbonization, the experiences of countries like Pakistan offer valuable lessons in how swift, market-driven transitions can occur when barriers are lowered, and people are empowered.

In this new energy world, the Global South, led by the likes of Pakistan, may well leapfrog traditional development pathways, showcasing a model of rapid, distributed, and people-centric energy transition that could inform global strategies for years to come. The message is clear: adapt, and do so soon, for the energy future is already unfolding, with or without government planning.

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