Policy Brief

Opportunities for **Virtual Power Plants (VPPs)** in Pakistan

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Abbreviations & Acronyms

AMI	Advanced Metering Infrastructure
BISP	Benazir Income Support Programme
CBAM	Carbon Border Adjustment Mechanism
CPPA-G	Central Power Purchasing Agency Guarantee Limited
CTBCM	Competitive Trading Bilateral Contract Market
DERs	Distributed Energy Resources
DISCOs	Distribution Companies
ICT	Information and Communication Technology
IGCEP	Indicative Generation Capacity Expansion Plan
ISMO	Independent System Market Operator
RECs	Renewable Energy Credits
NEPRA	National Electric Power Regulatory Authority
NTDC	National Transmission & Despatch Company
VPPs	Virtual Power Plants
VPPAs	Virtual Power Purchase Agreements
VRE	Variable Renewable Energy
TSEP	Transmission System Expansion Plan

Executive Summary

Pakistan's power sector is undergoing a structural transformation driven by the rapid and decentralized expansion of rooftop solar and other distributed energy resources (DERs). This growth has largely been a consumer-led response to high electricity tariffs, supply unreliability, and broader macroeconomic pressures. This policy brief advocates the strategic adoption of Virtual Power Plants (VPPs) as a critical solution for Pakistan's transforming power sector. VPP is a cloud-based network aggregator including DERs, such as rooftop solar, Battery Energy Storage Systems (BESS), and flexible demand into a single, dispatchable power plant to provide energy, capacity, and grid support services. VPPs can shift from passive and unmanaged injections into the grid to active system resources that flatten peak demand, mitigate the evening ramp, defer costly network investments, and reduce reliance on expensive imported thermal generation. For Pakistan, where capacity overhang and demand volatility coexist, VPPs offer a practical mechanism to convert distributed generation into system-wide flexibility.

This policy brief establishes VPPs within Pakistan's evolving regulatory and market context, particularly the forthcoming Prosumer Regulations and the transition toward a Competitive Trading Bilateral Contract Market (CTBCM). Without explicit recognition of aggregation and flexibility services, CTBCM risks reinforcing the limitations of the centralized single-buyer model in a nominally competitive setting. Learning lessons from international case studies such as China, Australia, and Europe, the brief demonstrates that VPPs are no longer experimental concepts but proven system solutions capable of operating at scale. These experiences emphasize key policy recommendations for Pakistan by formally integrating VPPs into national planning documents like the Indicative Generation Capacity Expansion Plan (IGCEP), Transmission System Expansion Plan (TSEP), the design of a DER-ready CTBCM, and utilizing VPPs to enhance the carbon competitiveness of exports facing mechanisms like the EU's Carbon Border Adjustment Mechanism (CBAM). The proposed pathway aims to unlock the systemic value chain of DERs into a strategic VPP for a cleaner, more reliable, and economically competitive power system.

1. Introduction

Pakistan's power sector is transforming with the rapid integration of Variable Renewable Energy (VRE) resources, including roof-top solar systems by households, commercial and industrial consumers, with net-metered solar capacity reaching during the last five years of around 47 GW from January 2020 to August 2025 (Sun, Y., 2025). Among all types of consumers, a silent rooftop solar revolution is underway, driven by consumers seeking relief from high tariffs and frequent outages. On the contrary, this huge surge is also creating technical, financial, and regulatory concerns regarding traditional grid infrastructure and fiscal challenges. This distributed energy resources (DERs) boom presents an exceptional opportunity to restructure the national grid. The government, in response to declining demand on the national grid, is attempting to disincentivize net metering by tightening regulations and introducing additional restrictions on new connections under the forthcoming Prosumers Regulations 2026. However, this approach overlooks the substantial system-wide value of distributed generation in Pakistan. The country's electricity demand, particularly from the industrial sector, remains structurally suppressed rather than saturated. In this context, grid-connected distributed energy resources offer a significant opportunity; they can stimulate productive demand, enhance system flexibility, reduce network losses, and improve overall economic efficiency. Rather than being viewed as a threat to utilities, distributed generation, when appropriately integrated, can serve as a strategic asset for Pakistan's power sector. This policy brief explores the strategic pathways for the development of Virtual Power Plants (VPPs) as a foundational tool to integrate DERs, unlocking better grid flexibility and creating a prosumer-centric approach to provide cleaner and cheaper electricity for export-competitive industries.

VPPs are cloud-based networks that aggregate and optimize the capacity of diverse DERs from rooftop solar, batteries, and flexible demand from households and businesses, functioning as a single dispatchable power plant. For Pakistan, this model can directly compete with the core challenges of reduced peak demand stress, deferring the grid infrastructural upgrades, and integrating VRE resources with efficient grid stability. The concept of VPPs can turn millions of prosumers into a new revenue stream for Distribution Companies (DISCOs) while disseminating power into the national grid with critical balancing services.

Moreover, this brief analyzes the potential of VPPs within Pakistan's evolving policy context, including the ongoing prosumer regulations issued by the NEPRA and the impending CTBCM, which aims to create a competitive wholesale power market. It also considers external drivers like the EU's Carbon Border Adjustment Mechanism (CBAM), which will tax carbon-intensive imports, making Pakistan's industrial exports less competitive unless they are powered by cleaner energy. VPPs can directly contribute to greening the industrial power mix. Therefore, to grasp this opportunity, Pakistan must adopt a proactive policy framework for VPPs by establishing a national VPP roadmap and pilot programs under the CTBCM and prosumers frameworks. In parallel, Pakistan’s long-term planning documents, particularly the Indicative Generation Capacity Expansion Plan (IGCEP) and the Transmission System Expansion Plan (TSEP), must evolve to recognize VPPs and aggregated DERs as strategic assets for capacity planning, grid reliability, and investment optimization. Therefore, to discuss the overall potential of VPPs in Pakistan, this policy brief explores the pathways and opportunities of VPPs in Pakistan, including the following major objectives:

- To highlight key barriers and opportunities for the implementation of VPPs.
- To develop a national VPP framework with supportive policies and market mechanisms.
- To provide technical recommendations for creating economic opportunities for prosumers while promoting cleaner, export-competitive energy.

2. What is a Virtual Power Plant (VPP)?

A Virtual Power Plant (VPP) is a portfolio of distributed energy resources (DERs) such as rooftop solar, batteries, flexible loads, and demand-response assets, managed via an advanced cloud network to function collectively like a dispatchable power plant. For example, hundreds of rooftop solar panels, home batteries, and controllable air conditioners across a city. Instead of operating independently, these DERs are connected to a central cloud-based platform that monitors their energy generation and storage in real-time, forecasts their availability, and combines them collectively to supply power or grid services, much like a conventional power plant. During periods of high demand, the VPP might dispatch stored energy from batteries and adjust smart loads to balance supply and demand, increasing grid stability while maximizing renewable energy use.

2.1. Core Components of VPP:

- **Distributed Energy Resources (DERs):** DERs are the building blocks of the VPP, which include;
    - **Generation:** Rooftop solar panels, small wind turbines.
    - **Storage:** Home and commercial battery systems.
    - **Flexible Demand:** "Smart" appliances (water heaters, air conditioners, industrial processes) that can reduce or shift their electricity use for a short period without major disruption.

- **Information and Communication Technology (ICT):** ICT utilizes the Internet-of-Things technology, including smart meters, and secure internet connections to gather real-time data from all DERs, forecast energy needs, and send dispatch signals.
- **Aggregator:** The company or entity that manages the VPP, signs up participants, and interfaces with the electricity market or grid operator.

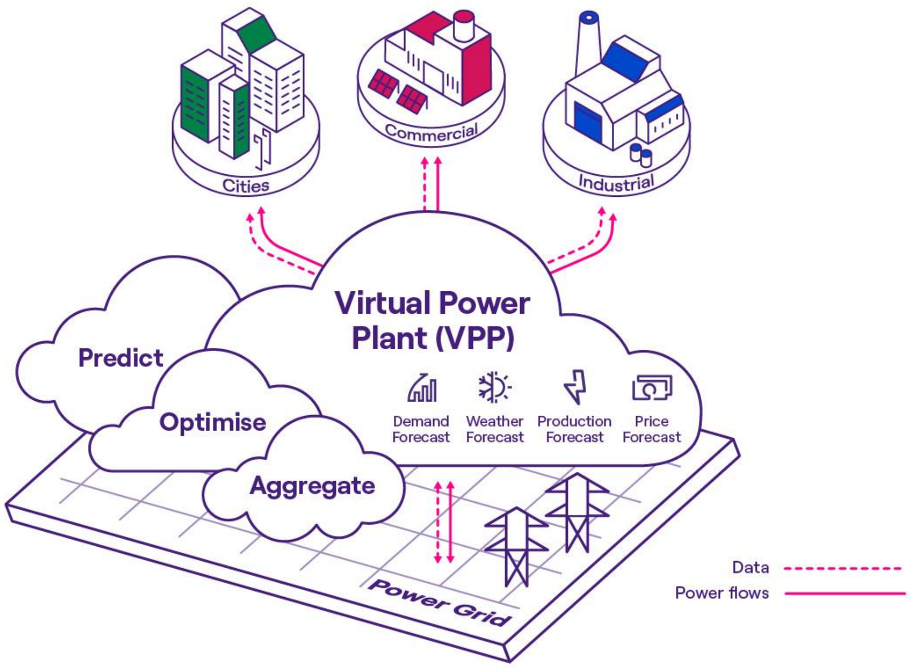

Figure 1: Working mechanism of VPP

2.2. Types of VPPs:

- **Supply-side VPPs:** Aggregate distributed generation assets (e.g., solar, wind) to act as a single, dispatchable power plant, providing energy and capacity to wholesale markets to enhance grid reliability.
- **Demand-side VPPs:** Manage and adjust flexible consumer loads to perform demand response, balancing the grid by reducing or shifting electricity use during peak periods, with value created in energy markets.
- **Hybrid VPPs:** Integrate both generation assets and flexible demand (often with storage), offering maximum grid flexibility to provide advanced services like frequency regulation while strategically optimizing revenue across multiple market opportunities.

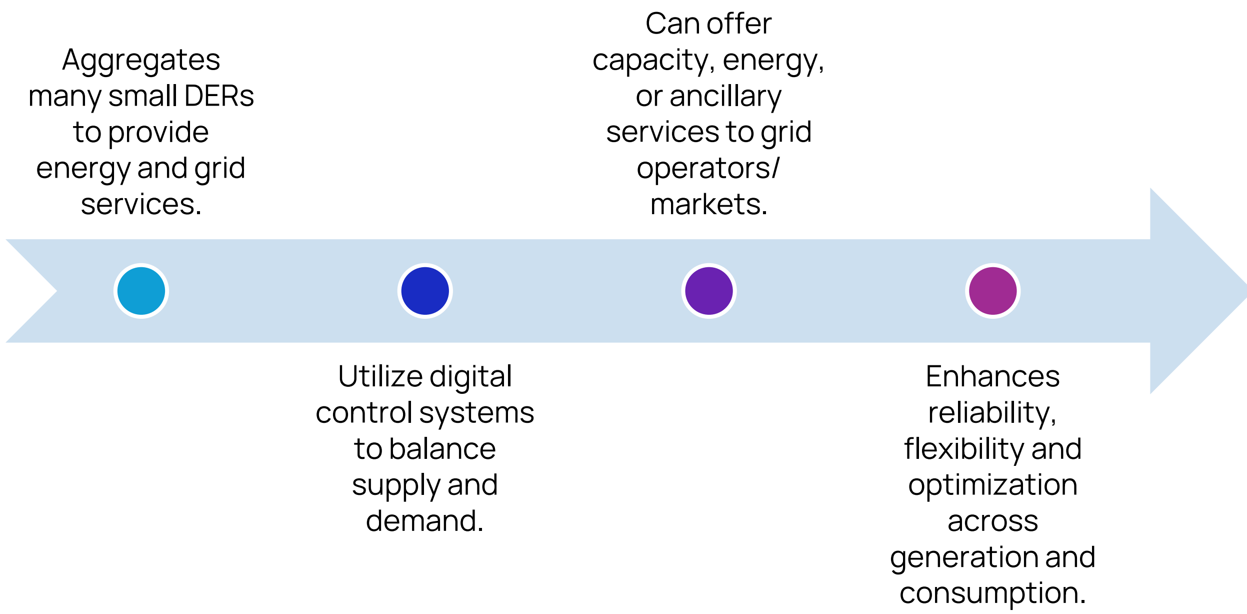

Figure 2: Core benefits of VPP

3. Why Pakistan Needs a VPP Framework?

Pakistan's rapid growth of DERs, particularly rooftop solar and battery storage, alongside evolving regulatory reforms such as the Prosumer Regulations and the CTBCM, creates both an opportunity and a necessity for a VPP framework. A structured VPP policy would allow the aggregation of these resources to enhance grid stability, reduce peak load stress, and optimize renewable energy integration, while also providing financial incentives to prosumers. Given the technical, regulatory, and market challenges currently limiting DERs utilization, a national VPP framework would provide a clear roadmap for pilot programs, licensing, and market participation. For this purpose, key enabling factors and challenges are discussed in the next sections.

3.1. Enabling Factors and Opportunities

- **Rapid Distributed Solar Deployment:** Pakistan's net-metered rooftop solar has grown exponentially, reaching 16.6 GW in 2024 and reaching 15.4 GW by August 2025, as consumers pursue cost savings and reliability (Sun, Y., 2025). This creates an appropriate asset for VPP aggregation, particularly in the commercial and industrial sectors where load profiles are significant and predictable.
- Regulatory Evolution:
    - **Forthcoming Prosumer Regulations (2026):** Recently, NEPRA expedited the initial draft for Prosumer Regulations in December 2025 with foundational legal

recognition for net-metering and gross-metering, allowing prosumers to connect to the grid and be compensated for excess generation.

  - **Competitive Trading Bilateral Contract Market (CTBCM):** This market reform is pivotal. It intends to move away from a single-buyer model to a competitive wholesale market where multiple buyers and sellers can trade power. A well-designed CTBCM must create a market platform where VPPs can participate by selling energy, capacity, or ancillary services.

- **Aligning IGCEP and TSEP with VPPs:** IGCEP and TSEP are the planning documents for generation and transmission system expansion. Therefore, to ensure cost-effective and resilient power, the concept of VPPs should be aligned as an emerging flexibility. As Pakistan's current energy mix shifts toward higher penetration of distributed and VREs, both planning documents must recognize the role of aggregated DERs in reducing peak demand, deferring network investments, and providing ancillary services. Integrating VPP concepts into IGCEP and TSEP would support more accurate demand forecasting, optimize generation and transmission planning, and strengthen grid reliability while enabling a smoother transition to a decentralized and cleaner energy system.
- **Grid Functional Challenges:** It was observed in variable demand patterns, which stressed grid stability and reliability and created pressures on DISCOs due to reduced grid energy sales and financial imbalances. Moreover, the proposed reforms from net-metering to net billing, reducing buyback rates, and shortening contract terms create an imbalance of the active prosumers with grid cost recovery. Therefore, VPPs can play a significant role in pushing this surplus capacity, which not only reduces marginal fuel costs but also avoids transmission losses, capacity deferral benefits, and climate vulnerabilities.
- **International Trade & Carbon Policy Pressures:** The EU's CBAM, currently in its transitional phase, will impose a carbon cost on imports of cement, iron, steel, aluminum, fertilizers, electricity, and hydrogen. For Pakistani exporters in these sectors, demonstrating a lower carbon footprint is becoming a commercial imperative. Accessing power from a VPP that aggregates renewable energy can be a key strategy to achieve this.

The Evening Ramp Case - A Clear Signal for BESS & VPPs Market

The rooftop solar revolution, dominated by domestic consumers seeking relief from high tariffs and frequent outages, has unintentionally exposed the structural inconsistencies in the national grid. The grid faces severe and predictable daily stress known as the "evening ramp". Recently, the generation data of 15th October 2025, was presented by the Independent System Market Operator (ISMO) to NEPRA, revealing a drastic deviation in generation requirements, as shown in Figure 3.

Figure 3: Generation Pattern (15th Oct 2025) Source: (NEPRA, Dec 9, 2025)

From Figure 3, it can be observed that during daytime (Hours 11-13), the demand drops to approximately 9.5 GW, largely due to high solar generation. On the contrary, as the sun sets, the residential and commercial demand increases by over 15.8 GW (NEPRA, Dec 9, 2025). This creates a delta of around 6.3 GW ramp in just a few hours, forcing the system to rely on expensive imported thermal plants to bridge the gap, driving up costs and emissions. The problem with the evening ramp is the perfect business case for BESS and VPPs. In this case, a VPP can aggregate thousands of distributed rooftop solar systems along with grid-scale BESS, enabling an opportunity for BESS to discharge stored solar energy from midday hours directly into the evening peak, providing instantaneous power to flatten the ramp in terms of valley filling, reduce reliance on thermal plants, and lower overall system costs.

3.2. Key Barriers and Challenges

- **Regulatory Gaps:** Current prosumer rules focus on energy export (kilowatt-hours) but do not recognize or value the grid services (e.g., frequency regulation, voltage support, peak shaving) that VPPs can provide. There is no clear licensing or classification for VPPs as market entities.

- **Infrastructure and Technical:** The grid at the distribution level often lacks the Advanced Metering Infrastructure (AMI) and bidirectional communication capabilities required for real-time VPP operation. Cybersecurity for a decentralized grid is also a growing concern.
- **Financial and Market:** The lack of standardized valuation and payment mechanisms for grid services discourages investment in VPP software and aggregation. Utilities may perceive VPPs as a threat to their traditional business model.
- **Awareness and Capacity:** There is limited understanding among policymakers, utilities, and potential prosumers about the concept, benefits, and operation of VPPs.

4. International Success Stories of VPPs

International experiences from China, Australia, and Europe highlight the transformative potential of VPPs in balancing supply and demand, integrating renewables, and providing grid services. Pakistan can draw lessons from these successful models, such as China's large-scale IoT-enabled VPP, Australia's residential battery aggregation, and Europe's cross-border renewable coordination to design a tailored framework that enhances system flexibility, improves efficiency, and accelerates the transition to a cleaner, more resilient energy sector.

4.1. China (The Jiangsu VPP)

The Jiangsu VPP in eastern China, operated by State Grid Jiangsu since 2017, is one of the world's largest VPPs and a key part of China's Internet Plus Grid strategy. It uses Internet of Things technology to balance electricity supply and demand by controlling loads such as lighting, air conditioning, and distributed energy resources like wind and solar, including the option of controlled shutdowns if needed. According to estimates, around 43 million household air conditioners could generate power of nearly 2.6 GW Shaw, V. (2025, January 16).

4.2. Australia (Ausgrid Power2U)

The Australian government recognized the potential of VPPs, leading to the Ausgrid Power2U initiative in partnership with Reposit Power. This program established a VPP by integrating batteries into approximately 233 private homes across 170 suburbs in Sydney, the Central Coast, and the Hunter region of New South Wales. Reposit Power, utilizing its expertise in intelligent demand-side management, provides the necessary ICT to connect DERs to the VPP. Moreover, the participating customers can earn income through Reposit by responding to flexibility requests. (Hill, J., 2019).

4.3. Europe (The REstable project)

The REstable project (2016–2019) was a German, French, and Portuguese initiative aimed at improving grid stability across Europe's largest synchronous grid by coordinating renewable energy-based system services. It designed and tested a VPP that could control many DERs to provide primary and secondary control power for Transmission System Operators (TSOs), demonstrating that renewable-based VPPs can match or exceed conventional power pools in reliability. The project gained high visibility, winning the German–French Innovation Award, and highlighted the potential of international, renewable-focused VPPs in supporting a Europe-wide transition to clean energy. (Baes, K., & Carlot, F., 2018).

5.Policy Recommendations and Way Forward

The following policy recommendations outline key actions required to enable the development and large-scale deployment of VPPs in Pakistan.

Establish an Integrated Economic Planning Architecture for the Power Sector

Pakistan's power-sector challenges increasingly stem from fragmented decision-making rather than purely technical constraints. To address this, a permanent "Integrated Energy–Industry–Fiscal Planning Council" at the cabinet level should be established to align generation and transmission planning with fiscal realities and industrial competitiveness objectives. This body should formally integrate IGCEP and NTDC transmission planning with CPPA-G procurement decisions, NEPRA's tariff-setting framework, the Ministry of Finance's fiscal risk management, and the trade and industrial strategies of the Ministry of Commerce and the Ministry of Industries.

In practical terms, the council should be mandated to produce an annual "Electricity–Economy Consistency Statement" that explicitly links electricity demand forecasts with industrial clustering and export targets, maps capacity additions and retirements against fiscal exposure from capacity payments and foreign exchange indexation, aligns DER and VPP growth with distribution-level investment planning, and connects carbon-intensity trajectories with export market access under CBAM. Crucially, this framework must treat electricity demand as a policy lever rather than a passive outcome, explicitly planning for industrial load reactivation and electrification as the principal escape route from the capacity-payment trap. This matters because Pakistan's power crisis is fundamentally a coordination failure, between tariffs that suppress demand, rigid procurement that locks in excess capacity, and industrial policy that remains disconnected from energy realities. A standing council would impose joint accountability for economic outcomes rather than siloed compliance.

Reframe the Planning Objective: From "Least-Cost Supply" to "Least-Cost System and Economy"

The prevailing emphasis on least-cost generation has delivered nominally cheap capacity but economically expensive outcomes. Planning criteria must therefore be updated so that NTDC, CPPA-G, and NEPRA evaluate investment and procurement options based on system-wide value and economy-wide impacts, not merely levelized costs of electricity. This requires embedding a mandatory System Value Stack within planning processes, one that explicitly prices avoided transmission and distribution losses, deferred or avoided network capital expenditure, reduced fuel imports and foreign exchange pressure, improved reliability through lower outage costs, the value of ancillary services such as frequency and voltage support, and carbon competitiveness through an implicit CBAM shadow price for export-oriented sectors.

Once institutionalized, this value stack should be reflected consistently in IGCEP iterations and CTBCM market design. Resources such as VPPs that deliver peak relief, localized voltage support, and emissions reductions should be valued for the full bundle of services they provide rather than assessed narrowly on energy output alone. Put differently, if the grid is an orchestra, planning must judge performance by whether the system stays in tune, not merely by how loudly individual instruments play.

Stop Treating Prosumer Growth as Leakage; Treat it as a Dispatchable National Asset

The rapid expansion of prosumers has often been framed as revenue leakage for utilities, prompting blunt regulatory responses aimed at suppressing net metering. This perspective is economically counterproductive. Policy should instead pivot toward integrating distributed energy resources through VPPs as a national flexibility resource. Rather than constraining prosumer participation, regulators should formalize a licensed VPP aggregator category with clearly defined rights and obligations, including eligibility to bid aggregated energy into the CTBCM, participation in ancillary services and flexibility markets, and standardized settlement and performance accountability mechanisms.

Complementing this, a Grid Services Tariff should be introduced to compensate DERs and VPPs for measurable grid services, such as peak shaving, frequency regulation, and voltage support, rather than remunerating them solely for exported kilowatt-hours. From an economic planning perspective, the logic is straightforward: when water scarcity emerges, governments do not ban private wells; they regulate, meter, and integrate them into water security. Electricity should be treated no differently.

Align Tariff Reform with Industrial Competitiveness and Fiscal Sustainability

Tariff reform is central to reconciling power-sector viability with economic growth. The existing political economy of tariffs, characterized by heavy cross-subsidization and volumetric cost recovery, has undermined both utility finances and industrial competitiveness. This structure should be replaced with a two-part tariff regime that separates fixed network cost recovery from energy consumption, combined with targeted subsidies delivered through fiscal channels rather than electricity prices. Such an approach would stabilize DISCO revenues even as self-generation expands, while preventing further erosion of grid demand.

Cost-reflective network charges, whether capacity-based or demand-based, should apply equitably to all connected users, including prosumers, to ensure fair recovery of fixed costs. At the same time, social protection objectives should be met through targeted cash transfers linked to BISP databases, rather than by embedding distortions into industrial tariffs. For export-oriented sectors, dedicated industrial decarbonization tariffs should be introduced, offering discounted time-of-use rates conditional on verified low-carbon supply, either through VPP-backed electricity or certified renewable sources, and paired with efficiency benchmarks to prevent rent-seeking. The net effect is a virtuous alignment: utilities regain financial stability, industry accesses cheaper and cleaner power, and the budget ceases to hemorrhage through hidden quasi-fiscal deficits.

Make CTBCM DER-Ready from Day One

If the CTBCM is designed solely around incumbent generators, it risks becoming competitive in name only. To support broader economic objectives, CTBCM rules must explicitly accommodate multi-seller participation, including VPPs and aggregators, from inception. Aggregation should be recognized as a first-class market activity, enabling distributed resources to participate on equal footing with centralized plants.

Beyond energy trading, the market should introduce additional products, including capacity and flexibility instruments tailored to seasonal and peak-hour needs, ancillary service procurement for frequency and voltage support, and, where technically feasible, signals for congestion and losses at the distribution level. Fast-tracking standardized contract frameworks for VPP-to-industry supply, particularly in export corridors, would further ensure that CTBCM contributes directly to industrial competitiveness rather than merely reshuffling existing transactions.

Prioritize Distribution-Level Grid Modernization Where DER Density Is Highest

Investment priorities must shift from an indiscriminate expansion of transmission infrastructure toward targeted modernization of distribution networks in areas with high DER penetration. AMI with two-way communication, feeder automation, voltage regulation equipment, and upgraded protection systems are essential enablers for VPP integration and loss reduction. As the grid becomes more decentralized, robust cybersecurity and data governance standards are no longer optional but integral to system resilience.

From an integrated planning perspective, these investments should be treated as both loss-reduction and fiscal risk-mitigation measures. By reducing technical and commercial losses, lowering procurement needs, and easing capacity-payment pressures, distribution modernization delivers return well beyond the power sector. Private participation can be mobilized through performance-based contracts, allowing utilities to remunerate vendors from verified improvements in losses and service quality rather than upfront capital expenditure.

Use VPPs as a CBAM Competitiveness Instrument

As carbon regulation increasingly shapes global trade, power-sector planning must be explicitly linked to export competitiveness. Building “Green Power Corridors” for CBAM-exposed sectors, such as cement, steel, fertilizers, aluminum, electricity, hydrogen, and indirectly textiles, should become a strategic priority. This requires establishing a national green electricity traceability system, including certificates or guarantees of origin compatible with international buyer requirements.

Exporters should be enabled to source power from VPP-backed renewables through green bilateral contracts, wheeling and third-party supply arrangements, and CTBCM products designed specifically for clean power procurement. Incorporating a CBAM shadow price into planning decisions would help prioritize flexibility and renewable investments where export value at risk is highest. In effect, CBAM acts as an external auditor of Pakistan’s power mix, and VPPs offer a scalable means to green supply without waiting for decade-long mega-project timelines.

Link Capacity Payments Reform to Demand Activation and Flexibility Procurement

Addressing the capacity-payment burden requires a deliberate shift from passive renegotiation toward an active strategy combining retirement, flexibility, and demand activation. Least-efficient thermal plants should be prioritized for early retirement or repurposes into synchronous condensers, grid support nodes, or storage and flexibility hubs.

At the same time, system flexibility should be procured competitively, allowing VPPs to compete directly with peaking plants and network expansion as providers of reliability.

Demand reactivation must complete this triad. Industrial load restoration programs, combining time-of-use pricing with reliability guarantees, can convert suppressed demand into productive consumption, improving capacity utilization and spreading fixed costs over a larger sales base. This approach tackles the capacity trap at its root rather than treating it as an accounting problem.

Build National Capability: Institutions, Standards, and Human Capital

The transition toward DER integration and VPP deployment must be treated as an institutional reform agenda rather than a collection of isolated pilots. Establishing a National DER and VPP Center of Excellence, jointly supported by NEPRA, NTDC, DISCOs, universities, and industry, would provide a focal point for standards development, technical guidance, and policy learning.

Building capacity within utilities and regulators is equally critical. Mandatory training programs should be instituted for DISCO planning teams, covering hosting capacity analysis, DER forecasting, VPP dispatch and settlement mechanisms, and cybersecurity and data governance. Without this institutional depth, even well-designed policies risk underperformance at the implementation stage.

Sequenced Implementation Roadmap

Effective reform requires disciplined sequencing. In the immediate term, within the first 12 months, regulators should approve the VPP aggregator license category, authorize pilot programs, select two to three pilot zones combining export corridors with high-DER feeders, and define initial ancillary service products and settlement mechanisms. Over the medium term, spanning one to three years, AMI deployment and feeder automation should be scaled in DER hotspots, CTBCM products enabling VPP participation should be launched, and green traceability systems introduced to support exporter procurement. In the longer term, over three to five years, these initiatives should culminate in a national VPP deployment framework with clear capacity targets and full integration of flexibility markets and distribution-level locational signals, embedding DERs and VPPs permanently into Pakistan's power-sector architecture.

Introduce Virtual Power Purchase Agreements (VPPAs) as a Market Enabler for Renewable Energy and Industrial Competitiveness

To accelerate renewable energy investment for industries to meet green and clean procurement mandates, Pakistan should formally introduce and enable Virtual Power

Purchase Agreements (VPPAs). A VPPA is a financial contract that allows renewable energy developers (such as a wind or solar farm) and buyers (such as an organization or an export-oriented industry) to transact without the physical transfer of electricity. The buyer obtains environmental benefits under Renewable Energy Certificates (RECs) without directly purchasing the electricity from the renewable facility. This mechanism dissociates clean energy consumption from location, enabling industrial consumers in Punjab to financially support a solar farm in any area of Sindh or Balochistan and claim its environmental benefits, meeting international standards such as CBAM. NEPRA should establish a national RECs with robust tracking and verification to ensure environmental attributes are credible and tradable. This also opens an opportunity for CTBCM design to create standardized RECs for VPPAs, allowing bulk power consumers and VPP aggregators to participate. This will help private investment for utility-scale renewables by providing a stable revenue stream for developers, while simultaneously giving Pakistani exporters a critical tool to prove the low-carbon provenance of their energy, enhance global competitiveness, and attract green investment.

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