

PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS

Policy View point: NO. **87: 2026**

From Battery Procurement to Integrated Energy Planning in Pakistan

Authors

Dr. Rubina Ilyas
Research Economist, PIDE

Dr. S. M. Naeem Nawaz
Professor of Economics/ Director (MPL), PIDE

Bilal Aftab
Staff Economist, PIDE

Executive Summary

Pakistan's electricity system is being reshaped by rooftop solar, falling grid sales, and increasingly unaffordable tariffs. The Integrated System Plan (ISP) 2025-35 proposed 600 MW/1,500 MWh of battery storage costing US$900-910 million. NEPRA approved the plan but excluded this package because system optimization had not established its cost and value. Batteries can shift solar generation, support frequency, relieve network constraints and protect industrial demand. Their value depends on location, operating conditions and alternatives. The proposed package primarily addresses frequency support and requires comparison with resources providing equivalent reliability. Consumer batteries also warrant assessment, subject to availability and controllability. The economic question is whether storage delivers greater lifetime net benefits than feasible alternatives. Financial returns, system savings and national economic benefits require separate assessment. Lower fuel use may not reduce contractual obligations or tariffs. Appraisal must include losses, degradation, replacement, financing, and end-of-life costs, avoid double counting, and compare avoided fuel imports with equipment imports and financing obligations. Storage decisions should integrate rooftop solar, grid planning, tariffs, CTBCM, contractual obligations, and industrial demand. Priorities are hourly and locational evidence, transparent appraisal, and competitive service pilots. Procurement should specify buyers, funding, performance, and risk allocation. The Power Division should coordinate this work, supported by system planners, DISCOs and CPPA-G, with NEPRA reviewing appraisals and tariff implications. Safety, recycling and funded decommissioning arrangements should be specified before procurement. Expansion should depend on independently verified performance, demonstrated net economic value and financial sustainability. These conditions would make storage investment responsive to Pakistan's reliability, affordability and wider economic needs.

1. Introduction

Pakistan's electricity consumers are rapidly becoming electricity producers. By March 2026, registered net-metering capacity had reached 7,319 megawatts (MW) and was included within Pakistan's total installed generation capacity of 49,651 MW. Between July-March FY2025 and July-March FY2026, the household share of consumption fell from 49.6 percent to 47.5 percent, which the government attributes to tariff-driven shifts to alternative sources and conservation (Finance Division, 2026, pp. 244-245).

In February 2026, the National Electric Power Regulatory Authority (NEPRA) replaced net metering with net billing for new prosumers under the NEPRA (Prosumer) Regulations, 2026. Electricity a prosumer buys from its

Distribution Company (DISCO) is billed at the applicable tariff, while exported electricity is credited at the national average energy purchase price (NEPRA, 2026c, Regulation 14). As this price covers only energy costs and excludes capacity payments (Yousuf, 2026), exported solar is worth less than the grid electricity it replaces, creating an incentive to consider storing surplus solar, subject to storage losses and lifetime costs.[1] Prosumers with contracts signed before 9 February 2026, however, keep the earlier net-metering terms until their agreements expire, subject to the amendment's exception for material modification changing the facility's maximum electrical output (NEPRA, 2026e).

If storing solar makes sense for a household, does it also make sense for the grid, and if so, where, how much and at what cost? The Integrated System Plan (ISP) 2025-35 proposed a phased Battery Energy Storage System (BESS) package of 600 MW of power capacity and 1,500 megawatt-hours (MWh) of storage (500 MW/1,200 MWh in 2025-29 and 100 MW/300 MWh after Chashma-5 nuclear plant integration), costing around US$910 million including a 30 percent allowance for installation, logistics and contingencies (NEPRA, 2026a, submitted IGCEP, Section 5.4 and Table 5-2).[2] MW measures the rate at which the battery can deliver power, while MWh measures the energy it can store. On average, the proposed package could discharge at full power for 2.5 hours. The submitted plan primarily sizes this package for fast frequency support during low-load conditions and major generation contingencies (NEPRA, 2026a, submitted IGCEP, Section 5.4). Its economic value should therefore be tested against alternatives delivering the same reliability service.

NEPRA approved the ISP but excluded the BESS package, highlighting that "its cost has not been incorporated in the generation optimization exercise" of the Independent System and Market Operator (ISMO) (NEPRA, 2026a, sec. E(xvii), pp. 28-29). This is not a verdict that storage lacks value; it is a refusal to commit consumer-funded or tariff-recoverable investment before its economic justification is established. For the BESS package to be reconsidered, NEPRA requires a comprehensive technical and economic analysis covering optimal sizing, duration, technology, siting, system-reliability needs, congestion management, costs and benefits, and the effect of consumer-level BESS.[3]

In September 2026, NEPRA made co-located BESS mandatory in the first wheeling auction: solar and wind projects qualify only if their BESS firm capacity is at least 10 percent of their renewable firm capacity. NEPRA called this a proportionate market-development and project-risk-management measure, treating mandatory co-location as a transitional arrangement. This requirement does not by itself establish the optimal size or location of storage, or a net saving for consumers. Higher project returns and lower system costs must be assessed separately (NEPRA, 2026b, paras. 5.3-5.7 and Annexure A).[4]

This Policy Viewpoint argues that Pakistan should procure battery storage for clearly defined services, with payment linked to verified performance. Pakistan's policy gap is not the absence of battery proposals; it is the absence of an integrated framework linking storage with rooftop solar, locational grid needs, tariffs, CTBCM, fuel and capacity contracts, and industrial demand. Without this framework, investment may add costs without addressing the constraints that justify it. Its scope covers utility-scale and behind-the-meter BESS and the evidence required to establish their technical need, financial viability, and economic justification. As such, it does not prescribe a national storage target or select battery chemistry. Any decision regarding BESS would require reliable information on where solar and storage are connected, timing and length of grid flexibility needs, and what costs storage can actually avoid under current contracts and settlement rules. The evaluation should consider alternative options for providing the same service in terms of life-time cost and benefit, and separate the returns to the individual, the system and the national economy. The sections that follow examine the services batteries provide, the information such decisions require, the conditions under which savings reach consumers, and how procurement and performance verification can support transparent investment decisions.

1.Yousuf (2026). The incentive to store is not a finding of financial viability; losses, foregone exports and lifetime storage costs must also be considered.

2.NEPRA (2026a), submitted IGCEP, section 5.4 and Table 5-2 (printed p. 25). Authors' calculations: 1,500 MWh / 600 MW = 2.5 hours, assuming the full stated energy capacity is usable, the battery starts fully charged, and rated power is maintained. The two phases imply 2.4 and 3.0 hours respectively. These are nominal energy-to-power ratios; usable AC duration can be lower because of state-of-charge limits, conversion losses, reserve commitments and degradation.

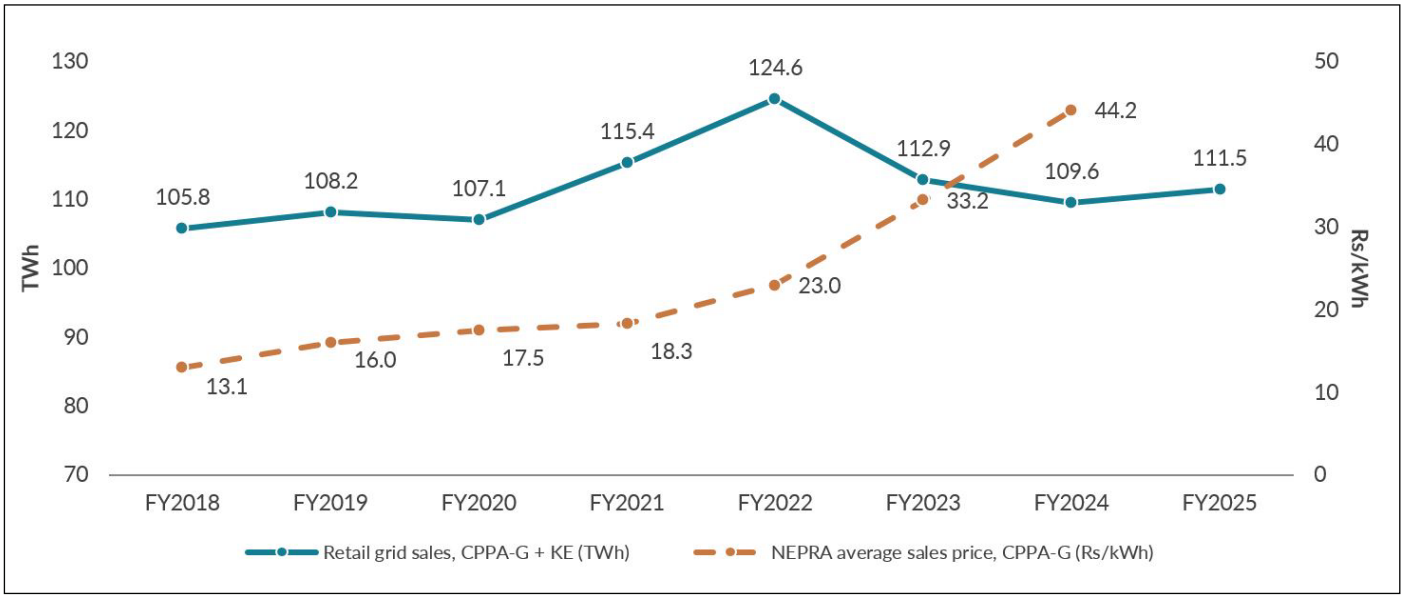
3.NEPRA (2026a), determination, section E(xvii), printed pp. 28-29. The regulator describes the investment as US$900 million, while the appended submitted IGCEP Table 5-2 totals US$910 million; the range reflects these two reported figures, rather than an independently estimated uncertainty interval.

4.NEPRA (2026b, paras. 5.3-5.7 and Annexure A). The requirement uses certified firm capacity rather than renewable nameplate MW; certification accounts for inverter capacity, duration and availability as applicable.

2. Solar Has Moved Ahead of the Grid

Grid electricity sales have stopped growing. Retail sales by DISCOs and K-Electric Limited (KE) peaked at 124.6 terawatt-hours (TWh) in FY2022 before falling to 111.5 TWh in FY2025. Over the same years, NEPRA's average sales price for the Central Power Purchasing Agency (Guarantee) Limited (CPPA-G) system almost doubled, from PKR 23.03 per kilowatt-hour (kWh) to PKR 44.15 per kWh between FY2022 and FY2024 (Figure 1) (NEPRA, 2022, 2023, 2024, 2025).[5] The rise in prices alongside lower sales after FY2022 does not establish causation because economic activity, electricity outages, extreme weather, and conservation all affect sales. Falling grid purchases also do not necessarily imply lower total electricity use where consumers increasingly generate their own electricity.

Figure 1: Retail Grid Sales and Average Sales Price in Pakistan



Source: Authors' calculations based on NEPRA (2022, 2023, 2024, 2025). Sales cover FY2018-FY2025; the published price series covers FY2018-FY2024. The FY2025 CPPA-G price is reported as not published in Table 55 of the 2025 report and is therefore omitted from the price series.

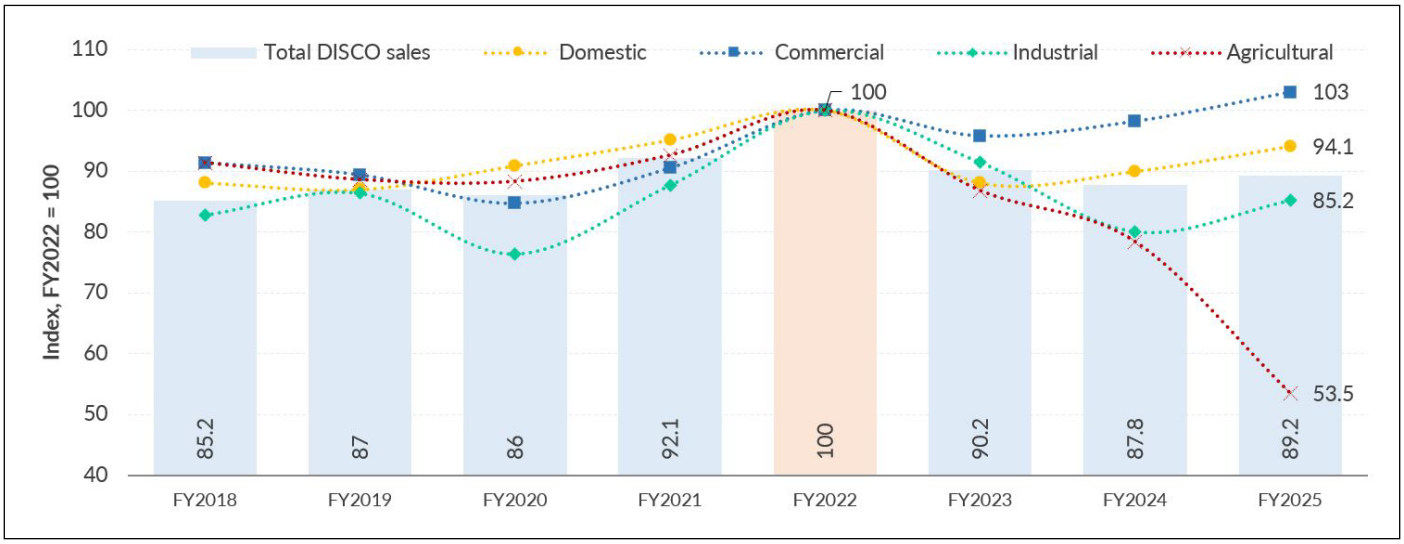
More recent partial-year data, from the Pakistan Economic Survey 2025-26, indicate that electricity consumption increased by about 3.8 percent during July-March FY2026. However, this is not directly comparable with the full-year sales series presented in Figure 1. The disaggregated analysis reveals a more specific pattern (Figure 2). DISCO sales to agricultural consumers fell by about 47 percent between FY2022 and FY2025. Likewise, industrial sales dropped by 15 percent during the same period. Domestic sales fell by 6 percent from FY2022, although the last two fiscal years show a recovery; compared with FY2018, domestic sales were 6 percent higher in FY2025. Notably, commercial sales increased by around 13 percent between FY2018 and FY2025, despite a modest 3 percent increase since FY2022 (NEPRA, 2022, 2023, 2024, 2025). The government attributes the fall in agricultural consumption partly to changes in irrigation and a switch to solar alternatives (Finance Division, 2026, p. 245).[6]

As grid sales fall, capacity, network and administrative costs do not decline automatically. When largely fixed costs are recovered from fewer billed units, the cost per remaining unit rises. This can reinforce the incentive for households, farms and firms to invest in their own solar and batteries, while consumers unable to make that investment carry a larger share of the system's costs. Storage policy therefore affects not only dispatch, but also the financial sustainability and distributional fairness of the grid.

5.NEPRA (2022, 2023, 2024, 2025), main electricity statistics tables; authors' calculations. Sales combine CPPA-G/DISCO retail sales and KE retail sales, converted from GWh to TWh by dividing by 1,000. The price covers CPPA-G only, so the geographic bases differ. FY2019 price uses the subsequently reported value of PKR16.00 in the 2023 report; FY2024 price is PKR44.15 in the 2025 report. FY2025 CPPA-G price is not published and is omitted; no interpolation is made.

6.Finance Division (2026), Table 14.3, p. 245. The reported consumption growth is recalculated as (83,143 / 80,111 - 1) × 100 = 3.7846 percent, rounded to 3.8 percent. The table's comparative total is used because the accompanying narrative prints a different denominator. These figures do not measure unrecorded behind-the-meter generation.

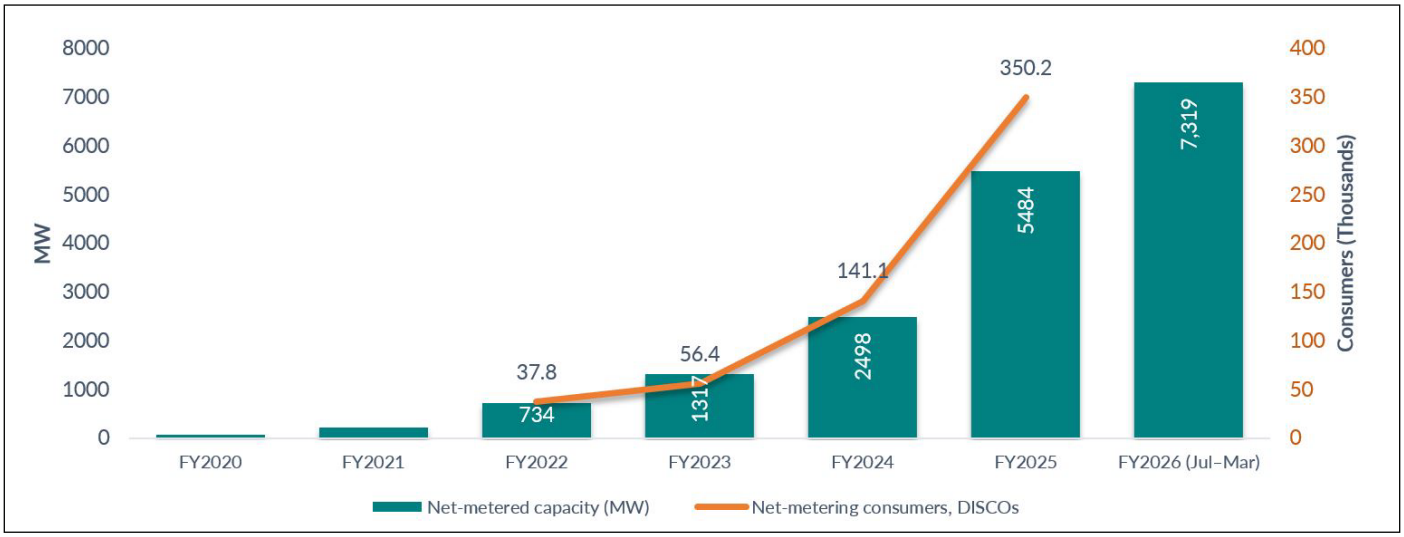
Figure 2: DISCO Sales by Consumer Category



Source: Authors' calculations based on NEPRA (2022, 2023, 2024, 2025). The index sets each category's FY2022 sales equal to 100. FY2025 endpoints: total 89.2; domestic 94.1; commercial 103.0; industrial 85.2; agricultural 53.5. Calculation: each index equals annual category sales divided by that category's FY2022 sales, multiplied by 100; values are rounded to one decimal place. The bars exclude KE.

The rapid expansion of rooftop solar must also be considered before storage investment decisions are made. NEPRA reported that registered net-metered capacity increased to 5,484 MW in FY2025 from 86 MW in FY2020. The number of DISCO net-metering consumers increased from roughly 38,000 in FY2022 to more than 350,000 in FY2025 (Figure 3) (NEPRA, 2020, 2021, 2022, 2023, 2024, 2025).[7] Registered net-metered capacity captures only part of Pakistan's distributed solar deployment. Satellite-based estimates suggest that total capacity is substantially higher once systems outside the net-metering framework are included (TransitionZero & Policy Research Institute for Equitable Development, 2025).[8]

Figure 3: Registered Net-Metered Solar Capacity and DISCO Net-Metering Consumers



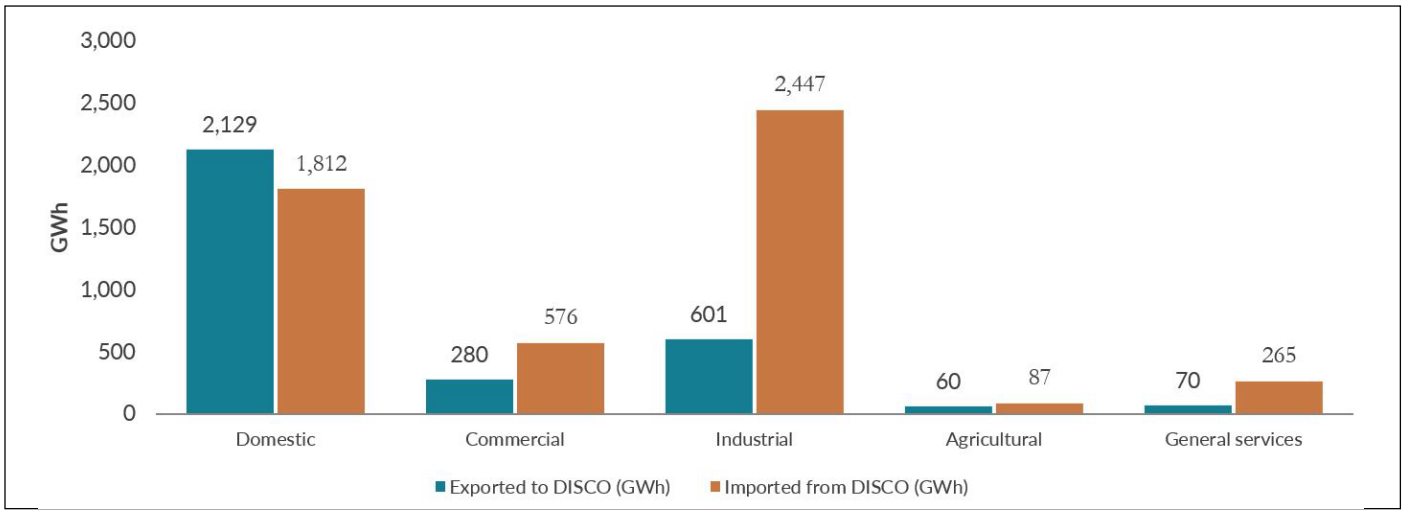
Source: Authors' calculations based on NEPRA (2020, 2021, 2022, 2023, 2024, 2025) and Finance Division (2026). FY2026 capacity is the stock reported at the end of March 2026; the consumer-count series is available through FY2025.

7.NEPRA (2020, 2021, 2022, 2023, 2024, 2025). The capacity series combines reported licensing and installed-capacity totals with differing coverage and is indicative, rather than a harmonized measure of commissioned AC capacity. FY2022 and FY2023 capacity values are reconstructed from the 2024 report's total of 2,498 MW, subtracting annual additions of 1,181 MW and then 583 MW. DISCO consumer counts exclude KE and are rounded to thousands; FY2026 capacity is a March observation, not a full-year outcome.

8.TransitionZero and Policy Research Institute for Equitable Development (2025). Their estimate combines satellite imagery with survey evidence and includes systems outside net metering; its coverage and estimation method differ from administrative capacity records.

In FY2025, domestic net-metering consumers exported approximately 316 GWh more electricity than they imported. In contrast, commercial and industrial prosumers remained net importers, purchasing approximately 297 GWh and 1,845 GWh more from the grid than they exported, respectively (Figure 4) (NEPRA, 2025, Section 5.10, pp. 83-85).[9] Since sunlight is a prerequisite for solar exports, annual net exports alone do not establish that a household can meet its demand at night or during cloudy periods without the grid. NEPRA's annual aggregates do not show when electricity flows in each direction, although timing is critical for a storage decision.

Figure 4: Exports and Imports of DISCO Net-Metering Consumers by Category, FY2025 (GWh)



Source: Authors' calculations based on NEPRA (2025).

3. What Batteries Can Do, and What They Cannot

The International Energy Agency (IEA, 2019) defines power system flexibility as the capacity to manage variations and uncertainty in electricity supply and demand reliably and cost-effectively across different timescales. Batteries are one of several sources of power-system flexibility; other options include grid reinforcement, demand-side management and more flexible operation of existing power plants.[10] Therefore, any storage proposal should be assessed against such alternatives, and its value evaluated by the service it is procured to provide (Table 1).

Table 1: Battery Services and Pre-Procurement Evidence

Service	What the battery does	Evidence needed before procurement
Energy shifting	Stores low-cost electricity, such as midday solar, and releases it in higher-cost hours	Hourly costs and marginal generation; round-trip efficiency; degradation and cycling assumptions; which generation is displaced
Frequency response	Injects or absorbs power within seconds of a disturbance	Required response speed and duration; telemetry and performance tests
Capacity adequacy	Supplies output during hours of system stress	Timing and length of scarcity hours; usable energy, recharge opportunity and availability when called; contribution to reliable capacity
Congestion relief	Relieves an overloaded line or transformer at a specific location	Loading data for that node; cost of the network alternative
Backup and resilience	Supplies protected load during outages	Cause, frequency and duration of outages; protected load; usable duration and recharge; value of avoided interruption
Voltage and reactive-power support	Injects or absorbs reactive power to help keep local voltage within limits	Node-level voltage data; inverter capability; connection and grid-code requirements
Grid-forming and black-start capability	Establishes voltage and frequency or helps restart a defined part of the system	Restoration plan; system-strength study; testing protocol; protected charging source

Source: Adapted from Bowen et al. (2019) and the International Renewable Energy Agency (IRENA, 2019).

9.NEPRA (2025, sec. 5.10, pp. 83-85). Calculations use the TOTAL DISCOs gross export and import columns and exclude KE. Annual net flows do not establish hourly surplus, charging opportunity or firm capacity. Reported kWh are divided by one million to obtain GWh. Domestic net exports equal 2,128.492 minus 1,812.007, or 316.484 GWh; commercial and industrial net imports equal 296.754 and 1,845.492 GWh. Values in the text are approximate; the arithmetic is used because the report's printed net column is inconsistent with its gross-flow columns.

10.International Energy Agency (2019). https://www.iea.org/reports/status-of-power-system-transformation-2019

The specification must follow the service. A battery sized for seconds of frequency response is not automatically suitable for several hours of evening energy shifting. Procurement should therefore state round-trip efficiency, usable state-of-charge range, expected cycles, degradation, augmentation, availability, response time, and the performance test against which payment will be made. Pending the availability of hourly dispatch and network data, the potential applications of BESS in Pakistan include locational congestion relief and network support, evening energy shifting, fast frequency response, industrial reliability and capacity adequacy. Their priority must be determined by service requirements, location, costs, and available alternatives. Where multiple services are combined, the appraisal must account for constraints on power, stored energy, and availability, while ensuring that overlapping benefits are not counted twice (Bowen et al., 2019).

A preliminary Pakistani planning example illustrates the difference a defined service can make. For Gwadar, the Power Division, along with the Private Power and Infrastructure Board (PPIB), carried out a preliminary sizing analysis to solarize 24 water-pumping stations and a desalination plant, proposing 9.7 MW of solar photovoltaic (PV) capacity coupled with 18.26 MWh of BESS, with estimated annual savings of PKR 987 million and an expected payback of 2.7 years (Finance Division, 2026, p. 247). These are preliminary estimates for the combined solar and battery configuration; they do not establish the battery's incremental return.[11] By contrast, ISMO's modelling for the wheeling auction revealed that the 10 percent co-located BESS requirement would reduce system-level curtailment by only 1.1 percentage points for solar and 0.3 percentage points for wind, with a negligible effect on marginal prices (NEPRA, 2026b, paras. 3.2-3.5 and 5.3).[12] Hence, the battery's service, the site, and the load all must be known before it is sized. The latter results describe a particular modelled auction configuration, while the Gwadar estimates concern a specific combined project; neither can be generalized to all storage investment.

4. Information Before Investment

NEPRA's requirements for a technical and economic study are, in effect, a list of missing information. Addressing these gaps requires data for the location and hour at which storage creates value (Table 2).

Table 2: Information a Storage Decision Requires

Information	Question it answers	Main holder
Rooftop solar and consumer batteries by feeder and transformer	Where is daytime surplus created, and where are local limits close?	DISCOs; ISMO; NGC
Hourly demand and net load by DISCO and grid node	When does the evening ramp begin, and how steep is it?	DISCOs; ISMO
Dispatch, curtailment and ramping records	Which plants would a battery displace, and when?	ISMO
Network loading and constraints	Where could storage defer a line or transformer upgrade?	National Grid Company of Pakistan Limited (NGC); DISCOs
Contract terms and costs	Which costs are avoidable under existing contracts?	CPPA-G; Power Division
Tariff, contract and settlement rules	Will an avoided system cost become a cash saving and reach consumers or industrial buyers?	NEPRA; CPPA-G; ISMO; Power Division

Source: Authors' analysis. PPIB (2023) is used for the institutional succession of AEDB.

Rooftop solar must first be mapped by location, and DISCOs already hold part of this information. Under the NEPRA (Prosumer) Regulations 2026, DISCO must decline additional distributed generation once the capacity connected to a distribution transformer reaches 80 percent of its rating (NEPRA, 2026c, Regulation 3(5)). Since August 2026, DISCOs are allowed to approve systems of 25 kilowatts (kW) or below without obtaining NEPRA's concurrence (NEPRA, 2026d).[13] A DISCO should therefore be able to map, transformer by transformer, the total rooftop solar capacity connected to it and how close that capacity is to the 80 percent

11.Finance Division (2026), p. 247. The source reports preliminary savings and a payback for the combined 9.7 MW PV/18.26 MWh BESS configuration. It does not disclose the detailed load profile, counterfactual supply cost, efficiency, discount rate, degradation or replacement assumptions, or separate the battery's incremental benefit. The figures are reproduced as reported and are not independently validated investment estimates.

12.NEPRA (2026b), paras. 3.2-3.5 and 5.3. The first 400 MW auction configuration implies about 40 MW of certified BESS firm capacity and, subject to duration requirements, about 160 MWh. The model reports modest curtailment reductions and negligible marginal-price effects; reliability benefits were not quantified. Project returns should not be interpreted as measured system savings.

13.NEPRA (2026d). The exemption concerns NEPRA's concurrence; DISCO approval and applicable interconnection requirements remain necessary.

The Prosumer Regulations govern distributed generation but do not establish a dedicated framework for registering and coordinating consumer batteries (NEPRA, 2026c, reg. 2(1)(ix) and Schedule I). Storage data are therefore also needed to assess the contribution of consumer-level BESS. NEPRA itself cautions that, given the potentially huge deployment of consumer-level BESS, the requirement for grid-level BESS may change materially and may even become redundant (NEPRA, 2026a, sec. E(xvii), pp. 28-29).[14] Unless behind-the-meter batteries are registered, neither their size nor their operation can be incorporated into the planning. Consumer storage can substitute for utility storage only where its location, operating schedule, availability and controllability meet the relevant service. Uncoordinated household backup capacity cannot automatically replace frequency response or network support.

The ISP considered three demand-growth scenarios and adopted the low-growth case as its reference, projecting peak demand to rise from 26,950 MW in 2025 to 35,521 MW by 2035 (NEPRA, 2026a, pp. 20-21). The Chairman's additional note identified substantial differences among the demand projections submitted by ISMO, the DISCOs and CPPA-G, and recommended their reconciliation (NEPRA, 2026a, Additional note of the Chairman, p. 2). However, annual peak-demand projections alone are insufficient to assess storage requirements. The same report also cited ISMO's estimate of a 12,000 MW decline in daytime demand, which is roughly equal to the combined output of must-run plants. (NEPRA, 2026a, Additional note of the Chairman, p. 1). Assessing storage needs therefore requires hourly load and dispatch data to identify periods of solar curtailment, the timing and magnitude of the evening ramp, and the generating plants available to meet it. ISMO also reported that these operational challenges were becoming more significant (NEPRA, 2026b, paras. 3.7 and 5.6).

NEPRA recorded its displeasure at ISMO's disclaimer of responsibility for the accuracy, integrity, and completeness of the data used in the ISP. The note of the Member (Tariff and Finance) records that about 640 MW of KE renewable projects, competitively auctioned in late 2024, were left out of successive drafts of the plan despite NEPRA's repeated queries; one was optimized only after ISMO re-ran it with corrected data (NEPRA, 2026a, sec. E(v) and Additional note of Member [Tariff and Finance]). NEPRA's own State of Industry Report FY2025 also prints a domestic net-export figure of 199 GWh, while its export and import columns imply 316 GWh (NEPRA, 2025, sec. 5.10).[15] Thus, any storage decision based on flawed data would inherit its errors.

5. From Battery Operation to Tariffs and the Economy

A battery can lower consumers' bills only when the avoidable system costs it displaces exceed its total additional costs and the resulting net savings are passed through to consumer tariffs. The chain has five links, and each must hold (Figure 5). The least certain links are whether a physical displacement becomes an avoidable cost and whether the avoided cost becomes an actual cash saving. This is the financial pathway. National economic appraisal must also recognize reliability and environmental benefits that do not immediately become cash savings, and distinguish them from transfers between consumers, utilities and government (Asian Development Bank [ADB], 2017).[16]

Figure 5: From Battery Operation to Consumer and Fiscal Savings

Battery action	Physical effect	Cost avoided	Cash saving	Consumer and fiscal effects
Charges when electricity is abundant; discharges or stands by when the system needs support	Reduces peak generation, start-ups, losses or congestion; improves reliability	A fuel purchase, new plant, network upgrade or outage loss is genuinely displaced	Contracts and settlement rules allow the avoided cost, after added storage costs, to become a net cash saving	Verified net cash savings reduce consumer tariffs, payment arrears or fiscal exposure, subject to settlement and pass-through rules

Source: Authors' analysis.

14.NEPRA (2026a), determination, section E(xvii), printed pp. 28–29. The statement on potential substitution by consumer batteries is conditional, not a quantified finding that utility storage is redundant.

15.Authors' calculation from NEPRA (2025, sec. 5.10): domestic net exports = (2,128,491,520 − 1,812,007,474) / 1,000,000 = 316.484 GWh. The printed net column shows 198.959 GWh and is not used. Commercial and industrial differences are likewise recalculated from gross flows; no independent reconciliation of the source's underlying records is claimed.

16.Asian Development Bank (2017). Financial appraisal measures project cash flows; national economic appraisal measures incremental resource benefits and costs. Domestic taxes, subsidies and transfers are not automatically new national resource benefits. Financial appraisal may include debt-service flows; economic appraisal should not add financing principal or interest to resource costs already valued and discounted.

Pakistan's power purchase cost has two parts. These include an energy component covering fuel and variable costs, and a capacity component covering fixed costs, returns, and debt servicing (NEPRA, 2025; Yousuf, 2026). A battery that stores cheap midday solar and releases it in the evening can reduce fuel-burning generation and its energy costs where charging losses and the displaced generation make this worthwhile. Any emissions benefit likewise depends on the charging source and the generation displaced. In the short run, however, the capacity component generally does not fall simply because dispatch falls. Under long-term power purchase agreements (PPAs) with independent power producers (IPPs), capacity obligations depend on contractual availability and other terms rather than energy dispatch alone. Contract-specific obligations, guarantees, and termination or renegotiation costs must therefore be examined.[17] Over time, storage can lower generation capacity costs if it avoids a new plant or enables an economically justified retirement or renegotiation. Network investment deferral is a separate potential saving.

This distinction also applies to wheeling: charges should recover attributable network and legacy capacity costs so that these costs are not shifted to grid-dependent consumers, but they should not be set so high that competitive supply and storage cease to provide meaningful industrial relief. For consumer-owned batteries, the chain is shorter. Under net billing, a household's operating savings depend on the avoided retail tariff, foregone export credit, storage losses, degradation, and operating costs (Bowen et al., 2019; NEPRA, 2026c).[18] Investment viability additionally depends on capital expenditure, financing, replacement, and utilization. A positive private saving can nevertheless shift costs onto other consumers. Because fixed capacity and network costs are recovered mainly through the per-unit price, households that buy fewer units from the grid contribute less to them, leaving consumers without solar or storage to pay more. A private saving is therefore not necessarily a system-wide or national saving. Network charges, legacy stranded-cost recovery and time-varying energy charges should be stated separately and allocated transparently. Any shift towards fixed or demand charges must account for their effects on low-use and vulnerable consumers. Lower annual purchases do not establish a lower contribution to the system peak.

Table 3: Channels from BESS to Consumers and the Economy

Economic channel	Potential benefit	Condition required	Risk if absent
Electricity tariffs	Lower fuel, capacity or network cost	The cost is avoidable and the saving passes through settlement and tariff rules	Battery cost is added while the displaced obligation remains
External account	Lower net foreign-exchange demand	Lifetime avoided fuel imports exceed imported equipment, augmentation, replacement and foreign financing charges; near-term financing needs are disclosed	Gross fuel savings are mistaken for net foreign-exchange savings
Circular debt and fiscal exposure	Lower subsidy need and payment arrears	Cash costs and revenue recovery improve, rather than only accounting dispatch	New availability payments deepen fixed obligations
Industrial competitiveness	Fewer interruptions, steadier voltage and lower peak cost	Storage addresses the actual cause and duration of interruptions at an industrial node; performance and avoided losses are measured	Industry pays for a system asset without receiving better service
Investment efficiency	Deferred generation or network capital	The counterfactual project is credible and can actually be deferred	Storage duplicates infrastructure already committed
Distributional equity	More reliable service without shifting costs to non-adopters	Tariff design allocates fixed costs fairly and protects vulnerable users	Consumers without solar and batteries bear a rising share of fixed costs

Source: Authors' analysis.

17.NEPRA (2025); Yousuf (2026). Payment avoidability is contract-specific. Availability terms, guarantees, termination costs and contract amendments must be reviewed before cash savings are claimed.

18.Authors' calculation framework, informed by Bowen et al. (2019) and NEPRA (2026c). For one kWh delivered to the household from otherwise exportable solar, operating saving = $T - E/\eta - c$, where T is the marginal avoidable retail charge at discharge, E is the export credit at charging, η is AC-to-AC round-trip efficiency ($0 < \eta \leq 1$), and c is degradation plus variable operating cost per delivered kWh. It assumes adequate solar surplus, household demand at discharge and no change in fixed charges; taxes or tariff blocks are included only where actually avoidable. Foregone export is zero only if the solar would otherwise be curtailed. Capital, financing and replacement require a separate lifetime appraisal; degradation and replacement must not be counted twice. No numerical tariff or efficiency assumption is imposed here.

The external-account test must be made on a net basis. Avoided fuel imports should be compared over the project life with imported battery cells, power-conversion equipment, augmentation, replacement and foreign financing charges. The timing of equipment imports, foreign loan inflows and subsequent debt service should be reported separately. Net foreign-exchange savings may therefore be smaller than the gross reduction in fuel imports. A project may reduce net foreign-exchange requirements over its life while increasing near-term financing needs. Imported equipment and the loan principal financing that equipment must not be counted twice as economic costs. Likewise, avoided fuel expenditure and the associated reduction in fuel imports describe the same underlying saving and must not be added as separate benefits.

The industrial test is equally practical. At a constrained industrial node, benefits should be measured in terms of fewer outage minutes, improved voltage quality, avoided production losses and more dependable export delivery. These outcomes make the economic case understandable without requiring detailed knowledge of battery chemistry. The appraisal must establish the cause and duration of interruptions, since short-duration storage cannot resolve prolonged energy shortages or commercial disconnections. Project financial viability, system cost savings and national economic benefits should be reported separately. Discounted lifetime benefits and costs should be compared with those of the best feasible alternative providing an equivalent service, including losses, degradation, augmentation, replacement, connection and decommissioning costs (Asian Development Bank, 2017). Sensitivity analysis should cover demand, utilization, fuel prices, exchange rates, financing costs and consumer-battery adoption.[19]

6. Transparent and Competitive Procurement

Official cost assumptions for storage vary widely. Dividing the proposed investment of US$900-910 million by 1,500 MWh gives an implied package cost of about US$600-607 per kWh (NEPRA, 2026a, Table 5-2).[20] This is a package-level ratio, not a battery-pack price or a levelized cost of stored electricity. The submitted plan explicitly adds 30 percent for installation, logistics, and contingencies; other cost components should be disclosed rather than assumed. ISMO's financial model for the wheeling auction assumes US$125 per kWh for co-located BESS (NEPRA, 2026b, para. 3.4).[21] The two values cannot support a precise cost-gap conclusion until their scope, duration, location, performance, and financing assumptions are reconciled.

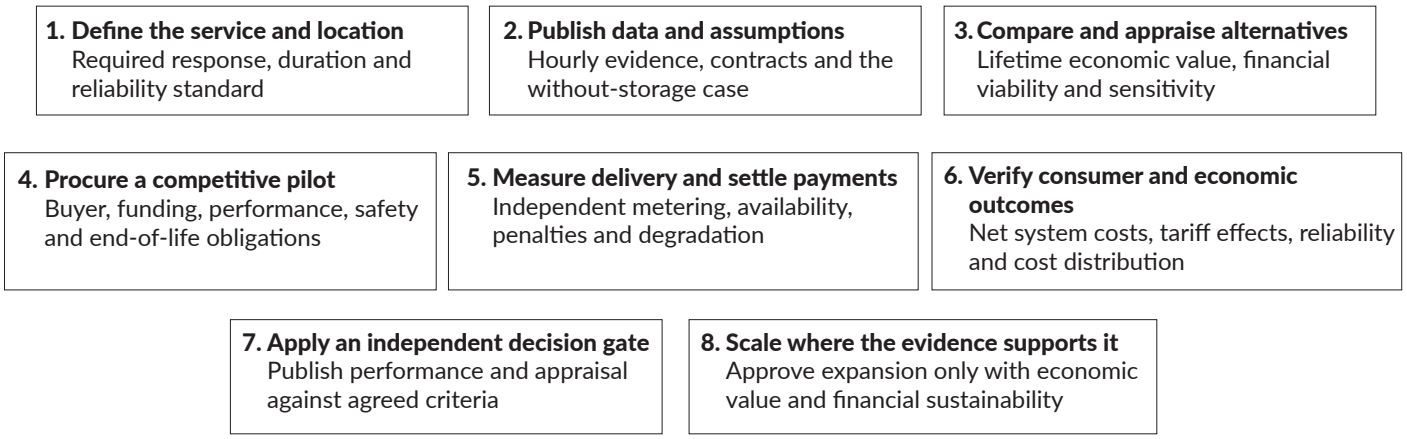
In this regard, NEPRA has set useful procedural safeguards. For the wheeling auction, it required ISMO to publish its financial model before issuing the first request for proposals (RFPs), kept all technologies competing on bid value alone, and directed ISMO to report on the batteries' costs, utilization, availability, and charging behavior before any further requirement is set (NEPRA, 2026b, paras. 5.4, 5.6-5.7). The same principles should govern any utility-scale storage procurement (Figure 6), informed by international practice (Table 4). The service contract must identify the buyer and funding source, dispatch rights, performance verification, penalties and allocation of degradation and replacement risk. Availability payments may be justified for reliability, but must remain linked to an identified service and enforceable performance obligations.

19.See Asian Development Bank (2017), sections II.B, III and VI-VII, for the distinction between financial and economic appraisal, the treatment of opportunity costs and the use of sensitivity analysis. The variables identified here are proposed for applying that framework to BESS in Pakistan. This Policy Viewpoint does not calculate a project-level NPV or quantify tariff, fuel-import or national economic savings.

20.Authors' calculations using NEPRA (2026a), submitted IGCEP Table 5-2: 1,500 MWh = 1,500,000 kWh; US$900–910 million / 1,500,000 kWh = US$600-606.67/kWh, rounded to US$600–607/kWh. The table's US$700 million base plus a 30 percent allowance of US$210 million equals US$910 million. The denominator is stated energy capacity, not annual discharged energy. The ratio does not establish usable capacity, scope comparability, project financing cost or levelized storage cost.

21.NEPRA (2026b), para. 3.4: US$0.125 million/MWh equals US$125/kWh. Reported model assumptions include a 25-year project life; a BPC sale price of PKR24/kWh indexed to CPI or 20 percent below grid tariff, whichever is lower; wheeling charges of PKR7.24/kWh for B-3 and PKR6.86/kWh for B-4; and recovery of curtailed energy. These are ISMO model assumptions, not verified market prices or complete battery replacement assumptions.

Figure 6: Evidence-Led Storage Procurement and Scale-Up Process



Source: Authors' analysis, informed by ADB (2017), Bowen et al. (2019), NEPRA (2026b) and the cases in Table 4. If performance or appraisal criteria are not met, redesign or discontinue the project; expansion should not be automatic.

Table 4: International Experience with Storage Procurement and Market Design

Jurisdiction	What was procured	Design feature	Lesson for Pakistan
Great Britain (GB)	Dynamic Containment: fast frequency response after a sudden loss of generation or demand	Open to all technologies; frequent auctions with published results; performance monitoring of providers	Define the product first, then let batteries compete for it
India	4,000 MWh of BESS by 2030-31, with viability gap funding of up to 40 percent of capital cost	Developers selected through competitive bidding; supported capacity later raised to 13,200 MWh within the same budget as costs fell; the 2025 report specifies lower support of 30% of capital cost or the monetary ceiling, whichever is lower	Competition reveals prices and stretches public money
South Australia	Hornsdale Power Reserve expansion, including grid-forming capability and frequency-control services	Performance-tested services, staged expansion and independent reporting	Start with a measurable service, publish performance and expand only after evidence is available
California, USA	Solar-plus-storage under a net-billing tariff with time-varying export values	Export credits reflect time and system value; storage is encouraged to serve the evening peak	Align consumer batteries with system needs while protecting consumers who cannot invest

Source: National Energy System Operator (NESO, n.d.); Press Information Bureau (2023, 2025); Australian Renewable Energy Agency (ARENA, 2025); California Public Utilities Commission (CPUC, 2022).

The contexts vary, but the pattern holds. Great Britain established a fast-frequency product prior to batteries competing for it. India applied competitive bidding and modified support as observed costs came down.[22] South Australia expanded an operationally proven resource by adding grid-forming capability. California tied customer storage to time-varying system value. The implication for Pakistan is to articulate the service, expose the price to competition, measure delivery, and scale only when the evidence is public.

7. Safety and End of Life

Batteries carry thermal-runaway risks that must be managed through design, installation, and testing. International standards exist for this purpose: International Electrotechnical Commission (IEC) 62619 sets safety requirements for industrial lithium batteries, IEC 63056 covers lithium batteries in electrical energy storage systems, and UL 9540A provides a test method for thermal-runaway fire propagation (IEC, 2020, 2022; UL Solutions, n.d.).[23] NFPA 855 adds system-level requirements for siting, separation, ventilation,

22.Press Information Bureau (2023, 2025). The initial scheme envisaged support up to 40 percent of capital cost. The April 2025 update expanded supported capacity to 13,200 MWh and specified INR4.6 million/MWh or 30 percent of capital cost, whichever is lower. It also reported that no project had achieved financial closure in FY2024–25; scheme allocations should not be interpreted as commissioned capacity.

23.International Electrotechnical Commission (2020, 2022); UL Solutions (n.d.). IEC 63056 and IEC 62619 specify battery safety requirements; UL 9540A is a test method and does not, by itself, establish complete system compliance.

detection, suppression, and emergency planning (National Fire Protection Association [NFPA], 2026). The Prosumer Regulations already require grid-connected inverters to meet UL 1741 (NEPRA, 2026c, Regulation 9(5)), but contain no comparable requirement for batteries. Import rules, connection approvals, and tenders should reference battery safety standards explicitly. Each project should also have an emergency-response plan agreed with local fire services, incident reporting, cyber-security controls, and insurance adequate for the identified risk.

Lithium-ion batteries contain materials that can create environmental and safety risks if they are improperly handled at the end of their useful life. Recycling them at scale requires safe dismantling and chemistry-specific recovery processes at the end of battery life, with technical and economic challenges documented in the literature (Harper et al., 2019). Where collection is left to informal markets, the consequences can be serious: the World Health Organization (WHO) documents harmful lead exposure from informal recycling of used lead-acid batteries (WHO, 2017). Lithium-ion and lead-acid batteries are different waste streams and should not be conflated; the lead-acid evidence shows why chemistry-specific collection, transport and recycling rules must be established before informal handling takes hold. The European Union (EU) has assigned responsibility in law: its Batteries Regulation sets recycling-efficiency targets for lithium-based batteries of 65 percent by 2025 and 70 percent by 2030, coupled with lithium-recovery targets of 50 percent by 2027 and 80 percent by 2031 (European Commission, 2026; European Parliament & Council of the European Union, 2023, Annex XII).[24]

Pakistan's National Hazardous Waste Management Policy 2022 adopted a life-cycle approach to hazardous waste but requires effective federal and provincial coordination, enforcement capacity, and an actionable implementation plan (Ministry of Climate Change, 2022). Before batteries are deployed at scale, responsibility for take-back and decommissioning should be assigned to importers, suppliers, and project owners, and formally written into procurement contracts.

8. Recommendations

1. Establish a shared information baseline

The Power Division should coordinate a common dataset on rooftop solar and consumer batteries at feeder and transformer level, with DISCOs maintaining connection records and ISMO and NGC integrating them into system and network planning. The initial solar records should draw on DISCO approvals under the Prosumer Regulations. This should be integrated with hourly demand, dispatch and curtailment data. Behind-the-meter batteries should be registered at installation, including their location, capacity and relevant operating characteristics. NEPRA should specify a minimum reporting template, privacy safeguards and a route for aggregators to submit operating data without exposing individual consumers.

2. Complete NEPRA's storage study transparently

ISMO should consider storage as part of the least cost optimization and systematically evaluate it against demand response, network upgrades and flexible generation. The study should also test how storage interacts with CTBCM settlement, tariff design, fuel commitments, capacity-payment obligations and industrial load. The assumptions used, the structure of the model, scenarios, and the results should be made available for independent evaluation and public comment prior to investment decisions. The Power Division should oversee delivery, with CPPA-G supplying contractual and settlement information and NEPRA reviewing the appraisal before tariff-recoverable investment is approved. The study should compare discounted lifetime costs and benefits at equivalent reliability standards and disclose sensitivity results.

24.European Parliament and Council of the European Union (2023, Annex XII); European Commission (2026). Recycling efficiency concerns the mass of waste batteries processed; material-recovery targets concern recovery of specified materials. These are distinct measures with different deadlines.

3. Design procurement around services

Procurement should specify the required service, location, duration, and performance standards rather than a particular technology. All technically qualified resources must be given the chance to compete, and payments must be based on verified availability and performance. Before any broader deployment, initial pilots at specific constrained nodes should be evaluated independently. Each pilot should pass published decision gates for cost, availability, response, degradation, safety, and the value of the service actually delivered. The designated procuring entity should identify the service buyer and funding source, while NEPRA should require independent verification and published performance reports. Mandatory co-location should be reviewed against this evidence. Failure to meet service or economic decision gates should trigger contract remedies and prevent automatic scale-up.

4. Distinguish consumer savings and national economic benefits

All storage appraisals must specify which fuel, capacity or network costs a battery would avoid under current contracts, the added lifetime cost of storage, and how the net saving would affect system costs or tariffs. They should separately report financial returns, system savings and national economic benefits, including reliability and environmental effects where these can be substantiated. Time-of-use pricing should also provide incentives for consumer batteries that demonstrably reduce evening peak demand. Results should be reported in terms readers can test: the tariff effect in PKR/kWh, net foreign-exchange saving after imported equipment and financing, any change in subsidy or circular-debt exposure, industrial outage minutes avoided, and the distribution of costs between battery owners and other consumers. Tariff reform should separate network and legacy cost recovery from energy charges, protect vulnerable consumers and reward reductions during actual constrained hours rather than annual grid purchases alone.

5. Assign safety and end-of-life responsibility upfront

Battery safety requirements should be included in importation, installation, and grid connection criteria. Take-back, recycling, decommissioning, and disposal should be clearly defined in the contract before commissioning a battery. The contract should also assign emergency-response duties, incident disclosure, cyber-security, insurance and the financial security required for end-of-life obligations. Federal and provincial environmental authorities should specify compliance and reporting requirements, while project owners and suppliers should provide funded take-back and decommissioning arrangements. The procuring entity should verify this financial security before commissioning.

9. Conclusion

Pakistan does not need to choose between batteries and caution. It must define the intended service and location of each battery and evaluate its benefits against credible alternatives. NEPRA's ruling presents an opportunity to establish that evidence first by determining where solar and storage are already deployed, measuring when and where the grid requires flexibility, making assumptions and modelling clear, and enabling batteries to bid for services that are clearly defined. Storage procured on that basis can reduce the cost of reliable electricity where it demonstrably provides value. The economic test is simple to state, even if it is demanding to prove: after losses, degradation, contracts, financing and imported equipment are counted, the battery must provide greater net economic value than the best feasible alternative delivering the same service, while remaining financially sustainable and allocating costs fairly. Tariff savings and fiscal relief should be claimed only where the relevant cash savings and pass-through arrangements are demonstrated. Without defining the service it delivers or the cost savings it provides, battery storage purchased as a stand-alone piece of equipment can become another fixed cost for an already costly power system.

References

Asian Development Bank. (2017). Guidelines for the economic analysis of projects. https://doi.org/10.22617/TIM178607-2

Australian Renewable Energy Agency. (2025, April 30). Hornsdale Power Reserve upgrade. https://arena.gov.au/projects/hornsdale-power-reserve-upgrade/

Bowen, T., Chernyakhovskiy, I., & Denholm, P. (2019). Grid-scale battery storage: Frequently asked questions (NREL/TP-6A20-74426). National Renewable Energy Laboratory. https://doi.org/10.2172/1561843

California Public Utilities Commission. (2022, December 15). CPUC modernizes solar tariff to support reliability and decarbonization. https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-modernizes-solar-tariff-to-support-reliability-and-decarbonization

European Commission. (2026, September 11). Waste batteries: Commission finds recycling targets remain fit for purpose. https://environment.ec.europa.eu/news/waste-batteries-recycling-targets-remain-fit-purpose-2026-09-11_en

European Parliament & Council of the European Union. (2023). Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries. Official Journal of the European Union, L 191, 1–117. https://eur-lex.europa.eu/eli/reg/2023/1542/oj/eng

Finance Division. (2026). Pakistan economic survey 2025–26 (Chapter 14, Energy). Government of Pakistan. https://www.finance.gov.pk/survey/chapter_26/14_Energy.pdf

Harper, G., Sommerville, R., Kendrick, E., Driscoll, L., Slater, P., Stolkin, R., Walton, A., Christensen, P., Heidrich, O., Lambert, S., Abbott, A., Ryder, K., Gaines, L., & Anderson, P. (2019). Recycling lithium-ion batteries from electric vehicles. Nature, 575(7781), 75–86. https://doi.org/10.1038/s41586-019-1682-5

International Electrotechnical Commission. (2020). Secondary cells and batteries containing alkaline or other non-acid electrolytes: Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems (IEC Standard No. 63056:2020). https://webstore.iec.ch/en/publication/29224

International Electrotechnical Commission. (2022). Secondary cells and batteries containing alkaline or other non-acid electrolytes: Safety requirements for secondary lithium cells and batteries for use in industrial applications (IEC Standard No. 62619:2022). https://webstore.iec.ch/en/publication/64073

International Energy Agency. (2019). Status of power system transformation 2019: Power system flexibility. OECD Publishing. https://doi.org/10.1787/7c49400a-en

International Renewable Energy Agency. (2019). Innovation landscape brief: Utility-scale batteries. https://www.irena.org/publications/2019/Sep/Utility-scale-batteries

Ministry of Climate Change. (2022). National hazardous waste management policy 2022. Government of Pakistan. https://mocc.gov.pk/SiteImage/Misc/files/National%20Hazardous%20Waste%20Management%20Policy%202022.pdf

National Electric Power Regulatory Authority. (2020). State of the industry report 2020. https://nepra.org.pk/publications/State%20of%20Industry%20Reports/State%20of%20Industry%20Report%202020.pdf

National Electric Power Regulatory Authority. (2021). State of the industry report 2021. https://nepra.org.pk/publications/State%20of%20Industry%20Reports/State%20of%20Industry%20Report%202021.pdf

National Electric Power Regulatory Authority. (2022). State of the industry report 2022. https://nepra.org.pk/publications/State%20of%20Industry%20Reports/State%20of%20Industry%20Report%202022.pdf

National Electric Power Regulatory Authority. (2023). State of the industry report 2023. https://nepra.org.pk/publications/State%20of%20Industry%20Reports/State%20of%20Industry%20Report%202023.pdf

National Electric Power Regulatory Authority. (2024). State of the industry report 2024. https://nepra.org.pk/publications/State%20of%20Industry%20Reports/State%20of%20Industry%20Report%202024.pdf

National Electric Power Regulatory Authority. (2025). State of the industry report 2025. https://nepra.org.pk/publications/State%20of%20Industry%20Reports/State%20of%20Industry%20Report%202025.pdf

National Electric Power Regulatory Authority. (2026a, September 11). Determination of the Authority in the matter of approval of the Integrated System Plan 2025–35. https://nepra.org.pk/licensing/Licences/ISMO/2026/GPP-15%20Determination%20of%20Approval%20of%20ISP%2011-09-2026%2018654-82.PDF

National Electric Power Regulatory Authority. (2026b, September 4). Determination of the Authority in the matter of the proposed amendments to the wheeling auction process submitted by ISMO. https://nepra.org.pk/licensing/Licences/ISMO/2026/NCM-13%20ISMO%2004-09-2026%2018273-89.PDF

National Electric Power Regulatory Authority. (2026c, February 9). National Electric Power Regulatory Authority (Prosumer) Regulations, 2026 (S.R.O. 251(I)/2026). https://nepra.org.pk/Legislation/3-Reg/3.35%20NEPRA%20%20Prosumer%20Regulations%202026/NEPRA%20Prosumer%20Regulations%20(SRO%20251(I)2026)%2009-02-26.PDF

National Electric Power Regulatory Authority. (2026d, August 6). Notification S.R.O. 1330(I)/2026: Amendment to the NEPRA (Prosumer) Regulations, 2026. https://nepra.org.pk/Legislation/3-Reg/3.35%20NEPRA%20%20Prosumer%20Regulations%202026/SRO%201330(I)-2026%20Dated%2006-08-2026.pdf

National Electric Power Regulatory Authority. (2026e, April 2). Notification S.R.O. 547(I)/2026: Amendment to the NEPRA (Prosumer) Regulations, 2026. https://nepra.org.pk/Legislation/3-Reg/3.35%20NEPRA%20%20Prosumer%20Regulations%202026/S.R.O%20547(1)%202026%20notification%20amendment%20in%20NEPRA%20(Prosumer)%20Regulations%2002-04-2026.PDF

National Energy System Operator. (n.d.). Dynamic services (DC/DM/DR). https://www.neso.energy/industry-information/balancing-services/frequency-response-services/dynamic-services-dcdmdr

National Fire Protection Association. (2026). Standard for the installation of stationary energy storage systems (2026 ed., NFPA 855). https://www.nfpa.org/codes-and-standards/nfpa-855-standard-development/855

Press Information Bureau. (2023, September 6). Cabinet approves viability gap funding for development of battery energy storage systems. Government of India. https://www.pib.gov.in/PressReleasePage.aspx?PRID=1955112

Press Information Bureau. (2025, April 3). Viability gap funding for battery energy storage systems. Government of India. https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2118325

Private Power and Infrastructure Board. (2023). Private Power and Infrastructure Board (Amendment) Act, 2023. https://www.ppib.gov.pk/legislation/PPIB-Amendment-Act-2023-1.pdf

TransitionZero & Policy Research Institute for Equitable Development. (2025, October 28). Shedding light on Pakistan's distributed solar revolution. https://www.transitionzero.org/shedding-light-on-pakistans-distributed-solar-revolution

UL Solutions. (n.d.). UL 9540A test method for battery energy storage systems (BESS). https://www.ul.com/services/ul-9540a-test-method

World Health Organization. (2017). Recycling used lead-acid batteries: Health considerations. https://www.who.int/publications/i/item/9789241512855

Yousuf, M. U. (2026). From net metering to net billing: Insights from Pakistan's 2026 prosumer regulatory reform. Next Energy, 13, Article 100871. https://doi.org/10.1016/j.nxener.2026.100871

Follow us



PIDEpk



PIDE Islamabad



PIDE Official

Visit our Website

pide.org.pk