ENERGY ECONOMY NEXUS FOR INDUSTRIALIZATION IN THE AGE OF GEOPOLITICAL CRISIS

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Pakistan's current energy-industrial dilemma is best understood not as a conventional supply shortage, but as a temporal and structural mismatch embedded within its generation mix. The RLNG-dependent segment of the power system, though accounting for approximately 13.7 percent of total generation, carries a disproportionate fiscal and operational weight. In CY2026, RLNG-based generation of 17,675 million units translates into a power purchase burden of Rs 511 billion, nearly 17.4 percent of the total system cost, with fuel costs alone exceeding Rs 20 per kWh. This asymmetry is critical. RLNG is not merely another fuel; it is the marginal price setter, and therefore, the anchor of industrial electricity tariffs.

The geopolitical disruption of supply routes through the Strait of Hormuz converts this structural dependence into an immediate systemic risk. A full-quarter disruption eliminates nearly 8,800 GWh of dispatchable generation while continuing to impose take-or-pay capacity charges of roughly Rs 140 billion. The fallback options within the merit order, primarily imported coal and furnace oil, are both costlier and equally exposed to global price volatility. Substitution, therefore, is not a neutral adjustment. It simultaneously contracts supply and increases the marginal cost of electricity by approximately Rs 17 per kWh. The result is a dual shock transmitted through tariffs and load shedding, particularly during evening peak hours.

This is where Pakistan's power system's technical architecture becomes decisive. Over the past two to three years, an estimated 10 to 18 GW of distributed rooftop solar has emerged, effectively creating a parallel generation system. During daylight hours, this fleet offsets 3,500-4,000 GWh of grid demand in a summer quarter, absorbing a substantial share of the RLNG shortfall. However, solar generation is inherently intermittent and ceases entirely at sunset. The critical vulnerability lies in the 7 PM to 6 AM window, where demand remains high due to residential cooling, industrial operations, and agricultural loads, but supply reverts entirely to thermal generation. In the absence of RLNG, this window becomes the locus of system stress, leading to load shedding and an emergency reliance on expensive fuels.

The absence of battery energy storage systems in Pakistan's grid architecture transforms this temporal mismatch into a structural constraint. At present, Pakistan has effectively zero operational grid-scale or distributed battery storage capacity. This means that surplus solar generation during the day cannot be shifted to meet evening demand. From a systems engineering perspective, this is equivalent to operating a two-period electricity market without intertemporal arbitrage. The system is forced to overproduce in one period and underdeliver in another, with no mechanism to smooth the imbalance.

The industrial implications of this are profound. Industries require not only affordable electricity but also predictability and continuity of supply. RLNG-based generation historically provided this flexibility due to its relatively fast ramping characteristics. In its absence, and without storage, the system loses its ability to provide firm power. This introduces what can be termed "temporal unreliability," where electricity is available but not when needed. For industrial processes, particularly in textiles, chemicals, and light manufacturing, such interruptions translate into higher operating costs, reduced capacity utilization, and lower export competitiveness.

The case for battery energy storage, therefore, is not ancillary; it is foundational. From a technical standpoint, deploying 2 to 3 GW of grid-scale battery storage at key transmission nodes such as Lahore, Faisalabad, Multan, and Karachi can fundamentally alter the system's dynamics. Assuming a four-hour storage duration, this translates into 8 to 12 GWh of dispatchable capacity, sufficient to cover a significant portion of the evening peak deficit. More importantly, storage enables the conversion of non-dispatchable solar energy into firm capacity. This effectively replaces the role previously played by RLNG, but without the associated fuel price volatility and foreign exchange exposure.

The economics of such deployment are equally compelling. The Rs 35 billion quarterly burden of idle RLNG capacity charges alone is sufficient to service the debt of a $1.5 billion battery storage program within two years. This reframes storage not as an additional cost but as a reallocation of existing inefficiencies. Moreover, the levelized cost of storage, when integrated with solar, is increasingly competitive with imported fuel-based generation, particularly under conditions of elevated global energy prices.

At a technological level, the choice of battery chemistry becomes critical. Lithium-ion batteries, while currently dominant, present supply chain risks due to the concentration of lithium, cobalt, and nickel resources. Sodium-ion batteries offer a viable alternative, particularly for stationary storage applications. Their lower energy density is less relevant in grid-scale deployments, where space constraints are minimal. More importantly, sodium-ion technologies rely on more abundant, geographically dispersed raw materials, thereby reducing exposure to global supply bottlenecks. From an industrial policy perspective, this creates an opportunity for localized manufacturing. The production process, involving cathode and anode fabrication, electrolyte formulation, and cell assembly, can be integrated with existing chemical and manufacturing industries in Pakistan.

The strategic relevance of sodium-ion batteries extends beyond energy storage. It enables the development of a domestic industrial ecosystem around energy technologies. This includes upstream industries such as chemical processing and materials engineering, as well as downstream applications in electric mobility and distributed energy systems. By anchoring storage manufacturing domestically, Pakistan can reduce its import dependency not only on fuels but also on critical technologies.

Firstly, Pakistan must initiate a fast-track deployment of grid-scale battery energy storage systems, prioritizing nodes with high load density and solar penetration. This requires regulatory recognition of storage as a distinct asset class, with appropriate tariff mechanisms that allow cost recovery through capacity payments and ancillary service markets. Without such regulatory clarity, private sector participation will remain limited.

Secondly, the policy framework should incentivize the integration of distributed storage with rooftop solar. Introducing time-of-use export tariffs of Rs 25-30 per kWh for evening discharge can transform existing solar installations into dispatchable assets. This effectively crowds in private investment into storage, reducing the burden on public finances while enhancing grid stability.

Thirdly, Pakistan should develop a targeted industrial policy for sodium-ion battery manufacturing, focusing on technology partnerships, local value addition, and export potential. This includes establishing pilot manufacturing facilities, investing in research and development, and aligning standards with international benchmarks. The objective should be to position Pakistan not merely as a consumer of storage technologies but as a producer within the emerging global value chain.

The RLNG crisis has exposed a deeper structural issue within Pakistan's energy system. The problem is not the absence of capacity but the absence of flexibility. Battery energy storage provides that flexibility, enabling the system to bridge the temporal gap between generation and demand. More importantly, it offers a pathway to align energy security with industrial development. The choice before Pakistan is not whether to adopt storage technologies, but rather how to do so in a way that reinforces its industrial base.

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