PL Capital
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Power

Sector Update

January 16, 2026

India's power storage at inflection point

India's power storage sector is set for a rapid scale-up as rising RE penetration calls for grid flexibility and stability. Operational urgency is due to expectation of rising evening ramp-up rates of ~25GW/hour on normal days to over 40GW/hour under stress, implying a requirement of 100–160GWh of 4-hour storage to manage net-load shifts from late afternoon to evening. Compared with this, India's installed storage capacity stands at ~6.5GW (~1% of total power capacity) and the Central Electricity Authority (CEA) projects it to increase to 50GW+ by FY30 (~6% of power capacity). Within that, battery energy storage system (BESS) is expected to contribute 50%+ to it at ~208GWh by 2030 (as per CEA). This represents ~Rs2.5trn investment opportunity at current costs. This opportunity spans a broad ecosystem from asset owners to battery cell and pack manufacturers, supported by power electronics suppliers, thermal management providers, EPC players, and upstream battery chemical manufacturers. Currently, over 0.5GWh of BESS capacity is operational and 77GWh is under various stages of construction/bidding. From a returns perspective, standalone BESS projects under the Central Electricity Regulatory Commission's (CERC) cost-plus framework offer stable earnings with 30%+ equity IRR, whereas tariff-based competitive bidding (TBCB) delivers single-digit IRR. Although recent tender results show low headline tariffs, the effective cost of delivered energy rises after accounting for utilization limits (depth of discharge, non-dispatch days), efficiency losses (round trip efficiency), degradation, and charging costs. Adjusting for these factors, the effective cost of energy from BESS rises to Rs6.5–7.5/kWh – higher than coal, but below nuclear power.

- **BESS as the missing link – Mitigating renewables curtailment and enhancing value:** Renewable sources such as solar and wind are low cost but intermittent due to weather and grid limitations. In FY26, India experienced renewable curtailment driven by weak demand and inadequate transmission capacity, unlike FY25 when no curtailment was seen. On certain days, up to 40% of solar generation was curtailed during afternoon, highlighting the growing mismatch between generation and grid absorption. BESS mitigates this by storing surplus power and discharging it during peak-demand or high-price periods (refer Exhibit 4 for the tariff curve). By reducing curtailment, BESS improves capacity utilization, stabilizes revenues, and enhances the long-term bankability of renewable/power projects.

- **Based on ramp, net capacity required is 160GWh+:** India's duck curve is no longer theoretical—midday demand suppression and sharp evening ramps are already reshaping dispatch economics, making BESS grid-critical, rather than optional. Need for flexible power during evening peaks to manage ramp rates ranges from ~25GW/hour on normal days to >40GW/hour under stress conditions. This equates to 100–160GWh of BESS/storage (assuming 4-hour duration) to reliably meet net-load increases during 4:00–8:00 PM. On high-RE and extreme stress days, fast-response, high-power BESS becomes essential as conventional generation may struggle with such steep ramps. Overall, with rising RE penetration and climate-driven demand volatility, BESS has become a core grid-stability asset, not just a balancing tool.

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- **BESS scale-up – From pilot stage to multi-trillion-rupee opportunity:** BESS in India is in the nascent stage with installed capacity of over 0.5GWh, significantly below CEA's projected BESS at ~208GWh by 2030. At current project costs of ~Rs12mn/MWh, this represents a Rs2.5trn investment opportunity by FY30. The wide gap between current capacity and projected demand implies an exponential scale-up, with BESS capacity clocking ~233% CAGR over FY25–30, highlighting the urgency of accelerated storage deployment as renewable penetration increases.

- **Policy tailwinds and falling battery costs:** Lithium-ion battery prices have fallen sharply in recent years, materially improving BESS economics alongside strong government policy support. However, recent reduction in export VAT rebate by China for battery products from 9% to 6% from Apr'26 could marginally increase the project cost of BESS. On the supply side, incentives include the PLI scheme for advanced chemistry cells and equipment, with an aggregate outlay of ~Rs181bn. On the demand side, project viability is supported through VGF and transmission charge waivers. The first VGF program provides Rs37.6bn, covering up to 40% of project capex, supporting 13.2GWh of BESS. A second VGF program for 30GWh, backed by Rs54bn from the Power System Development Fund with ~20% domestic content requirement, has also been approved. Further, co-located BESS commissioned by Jun'28 receive a 12-year ISTS waiver, while non-co-located projects receive a full waiver till Jun'25 followed by a phased reduction.

- **Return in BESS – Higher under CERC framework vs. TBCB:** For standalone BESS projects, CERC's cost-plus framework offers high earnings visibility, providing a post-tax RoE of ~14% with full pass-through of normative O&M costs and battery replacement provisions. Defined technical norms of ≥85% round trip efficiency and ~95% availability, support stable cash flows and can deliver equity IRRs of 30%+ at average tariffs of ~Rs3.8 lakh/MW/month for a 2-hour system. In contrast, under TBCB, returns depend on the bidder's quoted capacity charge, with performance shortfalls, degradation, and financing risks largely absorbed by the developer. As a result, equity IRRs typically compress to 8–10%, even as tariffs settle below Rs2 lakh/MW/month for a 2-hour cycle, arguably insufficient compensation for the higher operational and lifecycle risks relative to CERC's cost-plus regime.

- **BESS tariffs – Low headline prices vs. true cost of delivered energy:** While recent BESS tenders have discovered headline tariffs of Rs2.5–3.0/kWh, these figures materially understate the true cost of delivered energy. In practice, revenues are largely fixed capacity charges spread over limited and uneven annual utilization, as batteries are dispatched mainly during peak stress hours, with many non-dispatch days and depth-of-discharge constraints. Effective utilization is therefore only 70–75%. In addition, ~10% round trip efficiency losses, gradual battery degradation, and charging power costs further inflate delivered energy costs. Adjusting for these factors, the effective cost of energy from BESS rises to Rs6.5–7.5/kWh – higher than coal, but lower than nuclear energy. This highlights the importance of evaluating BESS on system value and capacity economics, rather than on headline energy tariffs.

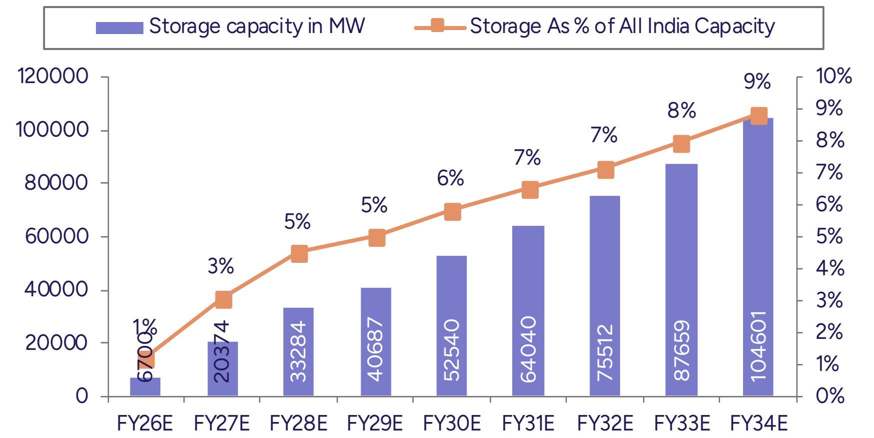
- **BESS ecosystem – Value chain dynamics and key beneficiaries:** BESS ecosystem spans the full value chain, from power developers such as NTPC, ACME Group, and JSW Energy, to equipment and component suppliers. Battery cells, modules and packs account for ~60% of total BESS capex, making cell manufacturers and pack integrators the primary beneficiaries as deployment scales such as Reliance, Ola, Amara Raja, Exide, SPML Infra, Pace Digitek (refer exhibit 9 for list of manufacturer). Power electronics – power conversion systems (PCS) and inverters – account for ~15% of capex; thus players such as Hitachi Energy India, Siemens and ABB India are set to benefit amid rising demand for grid-forming inverters. Thermal management and containerization (~10% of capex) support companies like Amara Raja and Exide, are particularly relevant in India's high-temperature operating environment. Electrical BoP, civil works, and EPC (~10%) benefit infrastructure players such as Sterling and Wilson, Tata Projects, SPML, Prostarm. Additionally, upstream battery chemicals embedded within the ~60% cell capex are a critical value lever, with inputs such as vinylene carbonate, $LiPF_6$ salt, and electrolytes supplied by Gujarat Fluorochemicals and Neogen Chemicals.

Managing India's steepening evening ramp: The case for rapid BESS scale-up

Renewable sources such as solar and wind offer low-cost generation, but remain inherently intermittent due to weather dependence and grid constraints. In FY26, India witnessed RE curtailment driven by weak demand conditions and inadequate transmission capacity, in contrast to FY25 when no curtailment was reported. On certain days, as much as 40% of solar generation was denied grid access during afternoon peaks, underscoring the growing mismatch between generation and system absorption capability.

BESS directly address this challenge by absorbing surplus power and discharging it during peak-demand or high-price windows. By reducing curtailment, BESS improves capacity utilization, smoothens revenues, and materially enhances the bankability and long-term investment value of RE projects.

Exhibit 1: India's storage capacity (BESS + Pumped Hydro) to inch higher



Source: CEA, PL

Exhibit 2: India's BESS operational capacity is miniscule

Project & Location	State/UT	Capacity (MW)	Capacity (MWh)
BESS project at Tata Power-DDL sub-station in Rohini	Delhi	10	10
BESS at Dollygunj & Attam Pahad in South Andaman	Andaman & Nicobar	16	8
Modhera Sun Temple Solar project with BESS	Gujarat	6	19.2
BESS project at Kavaratti	Lakshadweep	0.5	1.4
BESS project at Rajnandgaon	Chhattisgarh	40	120
GSECL Gujarat Solar + Storage Hybrid at Kutch Lignite Thermal Power Station	Gujarat	12	57
SECI 1,200MW Renewable BESS	Karnataka	75	150
SECI RTC 400MW Renewable with BESS	Rajasthan	25	100
BESS in Delhi under TBCB	Delhi	20	40
Total		**205**	**506**

Source: Ministry of Power, PL

Evening ramp volatility makes BESS grid-critical

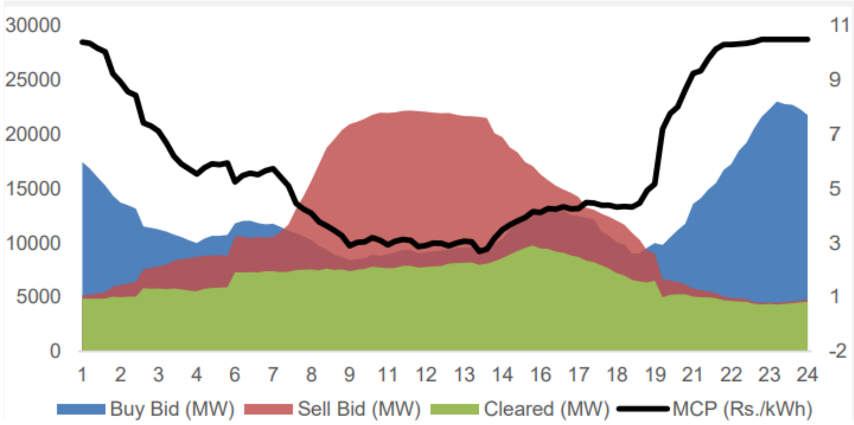
Flexible power is required during evening peak hours to manage ramp rates that jump from ~25GW/hour on normal days to >40GW/hour under stress conditions. In energy terms, this translates to 100–160GWh of BESS/storage (assuming 4-hour duration) to reliably absorb the net-load increase during 4:00–8:00 PM (i.e. 4 hours). On high-RE and extreme stress days, fast-response, high-power BESS becomes critical, as conventional generation alone may struggle to follow such steep ramps. Overall, BESS capacity requirements scale sharply with RE penetration and climate-driven demand volatility, shifting from a balancing role to a core grid-stability asset.

Exhibit 3: Over >40GWh/hour BESS capacity required based on the ramp-up to support the grid

Scenario	Time window	Net load at start	Net load at end	Total ramp	Ramp rate
Typical high-solar day	4:00 PM to 8:00 PM	110–120GW	200–210GW	80–100GW	20–25GW/hour
Extreme stress days (heatwave + low wind)	4:00 PM to 8:00 PM	120–130GW	260–280GW	130–160GW	32–40GW/hour

Source: PL

Exhibit 4: IEX short-term tariff curve from Rs3/kWh to >Rs10/kWh over 4PM to 8PM



Source: IEX

Exhibit 5: NTPC tender for BESS could improve its PLF

Station	State	Installed capacity (MW)	BESS tender (MWh)	FY25 PLF	Increment PLF from BESS
Barauni	Bihar	500	1,000	58.4%	8.3%
Gadarwara Super	Madhya Pradesh	1,600	320	64.1%	0.8%
NTECL–Vallur	Tamil Nadu	1,500	300	65.9%	0.8%
Khargone Super	Madhya Pradesh	1,320	250	64.2%	0.8%
Dadri-II	Uttar Pradesh	1,820	200	62.1%	0.5%
Tanda-II	Uttar Pradesh	1,760	200	69.6%	0.5%
Bongaigaon	Assam	750	150	72.9%	0.8%
Solapur Super	Maharashtra	1,320	150	59.1%	0.5%
Feroze Gandhi Unchahar	Uttar Pradesh	1,550	100	72.3%	0.3%

Source: NTPC, PL

BESS economics in India: Cost-plus stability vs TBCB risk-adjusted returns

For standalone BESS projects, CERC's cost-plus framework offers earnings stability, allowing a post-tax RoE of ~14% with full pass-through of normative O&M expenses and battery replacement provisions. The regulatory construct also specifies technical norms, including ≥85% round trip efficiency and ~95% availability, which together underpin predictable cash flows and can translate into equity IRRs of 30%+ (with average tariffs around Rs3.8 lakh/MW/month for a 2-hour system). In contrast, under TBCB, returns are driven by the bidder's quoted annual capacity charge, with efficiency shortfalls, degradation, and financing risks largely borne by the developer. Consequently, equity IRRs under TBCB typically compress to 8–10%, despite average tariffs settling at sub-Rs2 lakh/MW/month for a 2-hour cycle, arguably modest compensation given the embedded performance and lifecycle risks relative to CERC's cost-plus regime.

Although recent BESS tenders have discovered headline tariffs of Rs2.5–3.0/kWh, these numbers materially understate the true cost of delivered energy. In practice, battery projects are remunerated largely through fixed capacity charges, which must be spread over realistic annual utilization levels. Since batteries are typically dispatched only during peak stress hours—many days see no discharge at all—and daily output is constrained by depth-of-discharge limits, effective annual utilization could be 70–75%. Further, round-trip efficiency losses of ~10%, progressive battery degradation, and the cost of charging power all add to the economics. Taking into account all these factors, the effective cost of energy delivered by BESS comes to Rs6.5–7.5/kWh, which is higher than coal, but lower than nuclear power.

Exhibit 6: CERC draft guidelines on BESS: Covers wide range of aspects

Parameter	Guidelines / norms
RoE	14% base rate
Round trip efficiency	Normative 85% (or actual, whichever is higher)
Auxiliary energy consumption	5% of input charging energy
Availability factor (NAPAF)	90% for integrated with generating stations
Battery useful life / lifespan	12 years' useful life for BESS
O&M charges	O&M = 2% of admitted capital cost; escalated annually @5.25%
Tax treatment	Standard RoE gross-up based on actual tax applies
Interest cost (loan interest)	Based on weighted average rate of loan portfolio.
Debt component (normative D:E ratio)	70:30 (default tariff regulations; not amended)
Interest cost pass-through?	Yes – full pass-through, subject to prudence check and related-party cap
Depreciation	If ESS installed within original scope: Depreciation follows normal generating-station rules If ESS installed in an existing station (after COD): •Depreciation computed using straight-line method based on Appendix-I rates • Any unrecovered depreciation after 12 years (useful life) is spread over the remaining operational life of ESS or the parent station (whichever is higher)

Source: CERC, PL

Exhibit 7: BESS project economics: CERC scores over TBCB

	CERC (RoE 14%)	TBCB
Capacity (MWh)	300	300
Project cost (Rs mn/MWh)	12	12
First year tariff (Rs/MW/month)	4,45,352	1,64,000
First year tariff (Rs/kWh)	7.4	2.7
First year cash PAT (Rs/kWh)	451	17
First year EBITDA margin (%)	91	76
Project cost to annual revenue	4	12

Source: PL Note: Tariff is excluding power for charging, and TBCB is including VGF of 30%

India's BESS scale-up: From pilot stage to multi-trillion-rupee opportunity

India's installed BESS capacity (>1MWh) remains nascent at ~204.5MW / 505.6MWh. In sharp contrast, the CEA projects total energy storage requirement of ~336GWh by FY30 and ~411GWh by FY32. Within this, BESS alone is estimated to account for ~208GWh by 2030 and ~236GWh by 2032. At current project costs of ~Rs12mn/MWh, this translates into a Rs2.75–3.0trn BESS investment opportunity by FY32. The gap between current installations and projected demand implies an exponential scale-up, with BESS capacity growing at an estimated CAGR of ~233% over FY25–30—underscoring the pace at which storage deployment must accelerate as renewable penetration rises and grid flexibility becomes mission-critical.

BESS ecosystem spans the entire value chain—from power developers such as NTPC, Acme, and JSW Energy, to equipment and component suppliers. Battery cells, modules and packs account for ~60% of overall BESS capex, thus positioning cell manufacturers and pack integrators as the primary beneficiaries as deployments scale. Indian players including Reliance, Ola, Amara Raja, Exide and Waaree are well placed to capture volume-led upside as domestic cell manufacturing and system integration ramp-up. The power electronics layer—primarily PCS and inverters—constitutes ~15% of capex, thus benefits companies such as Hitachi Energy India, Siemens India, ABB India, and Servotech Power Systems.Thermal management and containerization, accounting for ~10% of capex, see steady order inflows and these are particularly relevant in India's high ambient temperature conditions. Electrical BoP, civil works and EPC (~10%) benefit infrastructure players such as Sterling and Wilson, Tata Projects, and SPML. Additionally, battery chemicals—economically embedded within the ~60% capex bucket for cells, modules and packs—form a critical upstream layer. Key inputs such as vinylene carbonate, $LiPF_6$ salt, and electrolytes are manufactured by Gujarat Fluorochemicals and Neogen Chemicals. These chemicals directly influence energy density, cycle life, safety, and degradation characteristics, thereby shaping performance lifecycle risk as well as long-term warranty costs.

Exhibit 8: Battery value chain: India aiming for vertical integration

Value chain stage	Description / Scope
Raw material extraction	Mining & refining of lithium, cobalt, nickel, graphite, manganese, aluminum, copper
Material processing & chemicals	Conversion of minerals into battery-grade chemicals such as lithium carbonate, lithium hydroxide
Cell manufacturing	Fabrication of electrodes (cathode + anode), separator, electrolyte, current collectors, cell assembly
Module & pack assembly	Packing cells into modules and packs
Integration (EV / BESS / electronics)	Integrating packs into EVs, BESS, consumer electronics

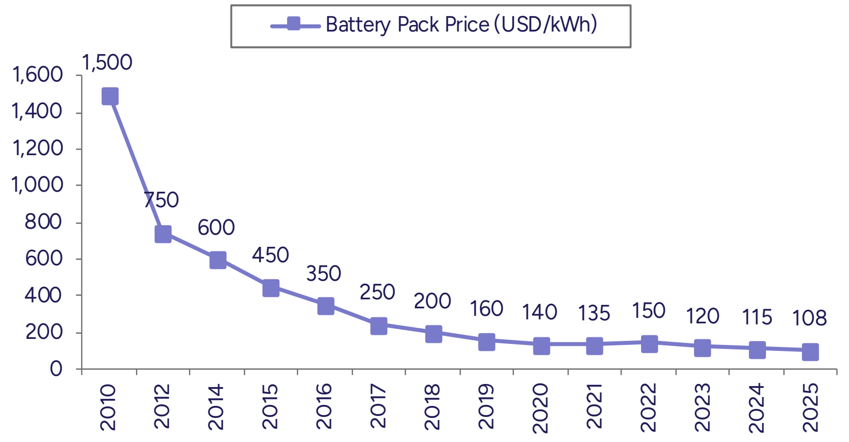
Source: Company, PL

Exhibit 9: BESS value chain: Companies set to benefit

BESS component	Approx. share of capex	Companies (list is not exhaustive)
Battery cells + Modules + Packs	60%	JSW Energy, Reliance, Godawari Power, Hyundai, Ola, Rajesh Exports, Amara Raja, Exide, HBL Power, Waaree Energies, Premier, Vikram , RPLUS, Pace Digitek, Tata Autocom, SPML Infra
PCS / Inverters	15%	Hitachi Energy, Siemens, ABB, Servotech, Pace Digitek, Tata Autocom
Battery management system (BMS) / Control software	5%	Amara Raja, Exide, HBL, Waaree, SPML, Pace Digitek, Tata Autocom, ABB
Thermal management & containerization	10%	Amara Raja , Exide, Luminous, Waaree, Advait, Delta
Electrical BoP + civil works, EPC integration	10%	Sterling and Wilson, Tata Projects, SPML, Prostarm

Source: PL

Exhibit 10: Lithium-ion battery pack prices have fallen over the years



Source: Bloomberg, PL

Note: Battery pack includes cells, BMS, thermal management (cooling), mechanical housing, wiring, sensors, safety electronics

Exhibit 11: Battery PLI given to 4 companies so far

Sr. No.	Beneficiary firms under PLI ACC Scheme	Projected capacity (GWh)	Current capacity (GWh)
1	ACC Energy Storage Pvt Ltd (Rajesh Exports)	5	0
2	Ola Cell Technologies Pvt Ltd	20	1
3	Reliance New Energy Battery Storage Ltd	5	0
4	Reliance New Energy Battery Ltd	10	0
Total		**40**	**1**

Source: Ministry of Heavy Industries, PL

Note: Besides the PLI ACC Scheme applicants, at least 10 manufacturers have announced a cumulative capacity of ~178GWh in the country over the next 5 years, as per the Ministry of Heavy Industries

Exhibit 12: Battery types: BESS utilizes LFP technology

Parameter	Remarks	LFP	NMC
Material composition	Key raw materials used in cathode. Impacts cost volatility, ESG risk, and supply security	Iron, phosphate (no cobalt/nickel)	Nickel & cobalt based
Energy density (Wh/kg)	Amount of energy stored per kg of battery. Higher = more compact system for the same MWh. Important for EVs, less critical for stationary BESS	50–130	120–300
Cycle life (number of cycles)	Number of full charge–discharge cycles before capacity degrades materially (typically 70–80%). Directly drives lifetime economics of BESS	6,000–8,000	3,000–10,000
Calendar life (years)	Maximum usable life in years, regardless of cycling. Important for assets with lower annual utilization	10–20	10–20
Depth of discharge (DoD) tolerance	How deeply the battery can be discharged regularly without accelerating degradation. Higher DoD = more usable energy per installed MWh	High (80–100%)	Moderate (typically lower than LFP)
Thermal stability / safety	Resistance to overheating and thermal runaway. Critical for large grid-scale installations and fire risk management	Very high	Moderate
Round trip efficiency (%)	Percentage of energy recovered after charging and discharging (AC–AC). Higher = lower energy losses	High (85–90%)	High (85–90%)
Degradation behavior	Rate at which capacity fades with cycling and time. Affects replacement cycle and long-term returns	Slower, more predictable	Faster under deep cycling
ESG / supply-chain risk	Exposure to ethical sourcing, geopolitical risk, and commodity price volatility	Low	Higher (cobalt risk)
Cell cost trend	Direction of cell cost over time driven by scale and learning curves	Rapidly declining	Historically lower, but volatile
System-level cost impact	Effect on total BESS capex, including safety systems, cooling, insurance and compliance	Lower system costs	Higher system costs
Best-suited applications	Typical use cases where this chemistry delivers maximum value	Grid-scale BESS, RE firming, peak shaving	EVs, space-constrained storage
Electrolyte	Medium for transporting ions (charged particles) between the anode (negative) and cathode (positive) terminals	Lithium salt	Lithium salt
Cathode	Act as the positive electrode, accepting electrons (reduction) from the external circuit during discharge	LFP	Li-NMC oxides
Anode	Acts as negative electrode, the source of electrons that flow out to power a device during discharge	Graphite (carbon)	Graphite (carbon)

Source: CEA, PL

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Buy	:	> 15%
Accumulate	:	5% to 15%
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