A DEEP DIVE INTO BATTERY ENERGY STORAGE SYSTEM

Climate Angels

India's Largest Early Stage Climate Focused Angel Fund

ABOUT GOMASSIVE

GoMassive is working towards building a Global Climate Innovation Network uniting founders, investors, corporates, government bodies, and policymakers through symbiotic partnerships. It empowers founders to build and scale their ventures with a comprehensive suite of solutions, from fundraising to post-investment management.

WHAT WE DO?

INVESTMENTS

Climate Angels — SEBI Catogery-1 Angel AIF

PORTFOLIO

beco, PRAAN, INDRA EVERYTHING WATER., MATTER, solar square

ACCELERATOR

go massive earth network — Awarding pilots and grants for early-stage Climate Tech startups

PARTNERS

UN environment programme, THE INCUBATION NETWORK, IFC, aws, AMPLUS SOLAR

CSR & GRANT

massive earth foundation — On-ground execution of complex projects in hard to abate sectors

DONORS

ALLIANCE TO END PLASTIC WASTE, giz, TARA

RESEARCH

massive earth foundation — Research in Electric Mobility, Circular Economy and Air Pollution

PARTNERS

agnii, WRI INDIA

EVENTS

massive earth foundation — Massive Earth Summit, Waste NXT, Mobility NXT and NXT by Climate Angels

SPONSORS

Paytm, ÖSTARA ADVISORS, RUPAREL REALTY, INVEST INDIA, AXIS BANK

ABOUT CLIMATE ANGELS

Climate Angels is a SEBI regulated Cat-1 Angel fund focused on creating a sustainable future by exclusively investing in companies working on Pollution Reduction and Climate Change. We invest in startups working on Agriculture, Clean Mobility, Water, Waste, and Built Environment (Clean & sustainable cities). We have invested in a total of 20 companies till date.

Since its launch in 2021, Climate Angels has invested in 24 climate-tech startups, supporting visionary founders who are building innovative, scalable solutions to combat climate change. Through early-stage capital and strategic guidance, Climate Angels is accelerating the development of breakthrough technologies aimed at addressing the world's most urgent environmental challenges

PORTFOLIO COMPANIES

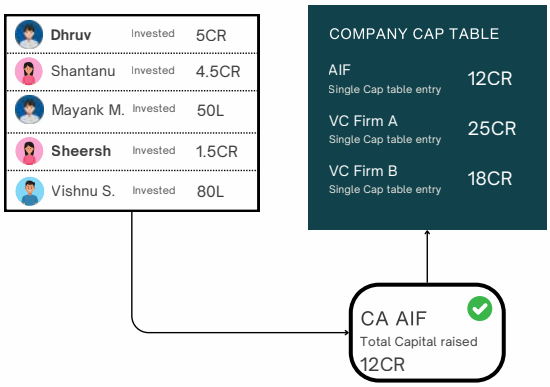
GOMASSIVE SUITE OF SERVICES

GoMassive is working towards building a global Climate Innovation Network uniting founders, investors, corporates, government bodies, and policymakers through symbiotic partnerships.
It empowers founders to build and scale their ventures with a comprehensive suite of solutions, from fundraising to post-investment management.

1. Fundraising Solutions

RUV (Roll up Vehicle)

- As a founder, you can easily create a funding round on the platform and share it with committed investors like friends, family, and angels.
- The deal page is also visible to fund managers and syndicates on the platform for review.
- Through RUV, the entire raise is consolidated into a single cap table entry.



Climate Angels & Syndicate

- Raise through Climate Angel Investors.
- Leverage your proprietary investor network to raise capital, or choose to access the GoMassive capital network, enabling investments through deal-specific special purpose vehicles (SPVs).

GOMASSIVE IB

- Access to a global network of VCs, Corporates and Impact Investors
- Offers end-to-end support across Fundraising (Seed to Growth Stages), Corporate Finance & Structuring, Valuation, Market Strategy, and Investor Relations & Pitch Advisory.

GOMASSIVE SUITE OF SERVICES

2. POST INVESTMENT TOOLS

Captable Management tool

Real-time cap table updates with scenario analysis for future rounds and transparent equity distribution insights.

Employee Stock Option Management

Manage employee stock options with ease and accuracy

MIS Updates to Investors

Share regular updates on company performance with investors

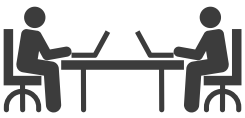
3. ADDITIONAL SERVICES

GoMassive Community

Becoming a part of the GoMassive community, invites to climate events and community programs

Mentor Connect

Guidance and support through 1:1 mentorship sessions while you build your business



Co-Working Spaces

GoMassive partners with leading coworking spaces like WeWork, Springhouse, and 91Springboard to offer the best coworking solutions across India.

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EXECUTIVE SUMMARY

India's grid produces too much cheap solar during the day and too little affordable power in the evening. BESS is the only technology that can profitably bridge this gap — storing ₹1–2/kWh electricity at noon and selling it at ₹8–10/kWh at 6pm. The arbitrage is structural, growing, and policy-anchored. The blocker is not technology — it is the financial weakness of the entities that must sign the contracts.

FIVE STRUCTURAL FINDINGS

The demand mandate is non-negotiable

India's grid cannot absorb its renewable energy targets without 236 GWh of storage. This is not a policy aspiration — it is an operational necessity embedded in the National Electricity Plan.

The supply gap is severe

India has installed approximately 0.5 GWh (FY2025 E) against a 236 GWh target — less than 0.25% of what is needed. The deployment trajectory must accelerate by 100× in seven years.

China dependency is a strategic vulnerability

Approximately 85% of LFP cell supply is China-controlled. Every MW of BESS deployed in India today deepens this dependency. Localisation is years away from meaningful scale.

Revenue models remain structurally fragile

Merchant arbitrage economics only crossed viability in FY2024 for the first time. Many potential revenue streams — ancillary services, demand response, grid services — remain underdeveloped or nascent.

DISCOMs are the critical chokepoint

The financial health and payment reliability of India's electricity distribution companies is the single most important risk factor for any BESS investment. Without a solvent, reliable offtaker, no revenue model is bankable.

KEY CONCEPTS

Concept	Definition	Why It Matters for Investment
MW (Power Capacity)	Rate of energy flow — how fast the battery can charge/discharge	Determines revenue capacity in ancillary/frequency markets
MWh (Energy Capacity)	Total energy that can be stored	Determines arbitrage duration and capacity payment scale
Duration (hours)	MWh ÷ MW — how long a battery can discharge at full power	2-hour systems earn highest IRR in India today; 4-hour for firming
Round-Trip Efficiency (RTE)	Energy out ÷ Energy in (typically 85–92% for LFP)	Directly impacts arbitrage profitability — losses reduce margin
Depth of Discharge (DoD)	% of capacity actually usable (typically 90% for LFP)	Higher DoD = more energy available = better economics
Cycle Life	Number of charge/discharge cycles before capacity degrades to 80%	Determines asset life, augmentation schedule, and warranty cost
Levelised Cost of Storage (LCOS)	Total lifecycle cost per kWh of electricity delivered	The key benchmark — must be below market price spread to be viable

Short-Duration vs Long-Duration Storage

Today's commercial sweet spot in India is 2-hour LFP systems for price arbitrage and grid services. India's NEP-14 planning horizon increasingly requires 4-hour systems for renewable firming. Long-duration storage (8+ hours, flow batteries, iron-air) remains pre-commercial at scale. Investors should focus on the 2–4 hour window as the near-term deployment reality.

WHY DO WE NEED ENERGY STORAGE?

From the Storage Imperative to BESS

WHY DO WE NEED ENERGY STORAGE?

The electrical grid operates under a constraint that has no parallel in any other commodity market: at every instant, the quantity of electricity generated must precisely equal the quantity consumed. Surplus electricity cannot be warehoused; deficits cannot be drawn from inventory. The consequence of imbalance is grid frequency deviation — too much generation pushes frequency above 50 Hz, too little pulls it below — and sustained deviation triggers cascading disconnections and, at the extreme, system-wide blackouts.

For the century in which coal, gas, and hydro dominated electricity generation, this balance was maintained through dispatchable generation: plants whose output could be raised or lowered in response to demand. Storage was unnecessary because supply could follow demand. The energy transition has broken that assumption.

THE FUNDAMENTAL MISMATCH PROBLEM

Solar panels generate maximum output between 10 am and 4 pm on sunny days. Peak electricity demand in residential and commercial sectors occurs between 6 pm and 10 pm, when air conditioning runs, meals are cooked, and industrial processes operate peak shifts. The structural gap between peak generation and peak consumption — typically 6 to 12 hours — cannot be bridged by renewable generation alone. Wind output is similarly intermittent and often inversely correlated with demand patterns.

The numbers make the challenge concrete. By end-2024, global solar PV installed capacity exceeded 2,200 GW — a figure that was considered an ambitious 2030 target as recently as 2020. Wind added a record 117 GW in 2023 alone. Every incremental percentage point of variable renewable generation in a grid requires a corresponding increment of flexibility resource — either storage, demand response, or flexible generation — to maintain stability. No grid that aspires to 50% renewable penetration can achieve it without storage as a foundational infrastructure layer.

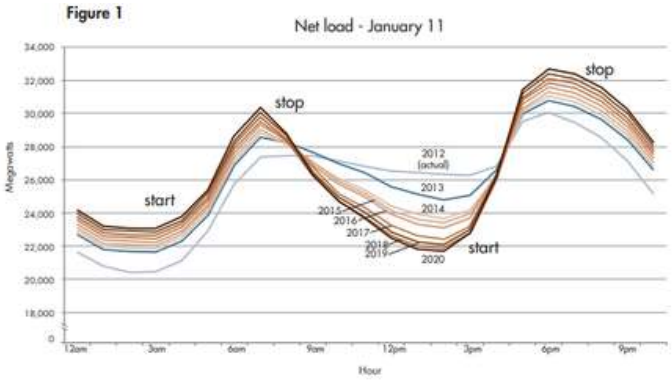
THE CORE CONSTRAINT

Supply and demand in electricity cannot be mismatched, even briefly. Storage converts the temporal mismatch between when renewables generate and when consumers need power from a grid stability problem into a commercial arbitrage opportunity.

THE DUCK CURVE: GRID PHYSICS MADE VISIBLE

The duck curve is the most useful visual representation of the storage imperative. It plots net electricity demand — total consumption minus renewable generation — against time of day. In a system with significant solar penetration, the curve develops a characteristic shape: a belly of suppressed net demand during peak solar hours, and a steep evening neck as demand surges when solar output collapses.

Figure 1



California's grid operator CAISO first published the duck curve analysis in 2013 as a forecast for 2020. By 2017, the curve had already been exceeded. By 2023, California was curtailing solar output — literally switching off solar panels — because the grid had more electricity than it could absorb, while simultaneously running gas peaker plants three hours later to meet the evening surge. Annual curtailment costs in California exceeded $500 million in 2023.

India entered duck curve territory in 2022 and has deepened rapidly. By mid-2025, midday prices on the IEX Day-Ahead Market regularly fell to between zero and ₹0.30/kWh on high-solar days. Evening peaks persistently hit the ₹10/kWh regulatory ceiling. The midday-to-evening spread, which averaged ₹2.5/kWh in 2019, reached ₹7.5/kWh by June 2025 — a 17% compound annual growth rate. This is a structural consequence of rising solar penetration meeting an inflexible thermal fleet, not a seasonal variation.

₹0-0.3/kWh	₹10/kWh	17%/yr	May 2025
India: midday price 2025 *Near-zero on high-solar days*	**India: evening price 2025** *Hits regulatory ceiling 1 in 6 hrs*	**Price spread growth rate** *2019–2025, compound annual*	**Grid reserve failure** *Upward + downward simultaneously*

GRID SERVICES THAT STORAGE MUST REPLACE

The storage imperative extends beyond daily price arbitrage. Coal and gas plants provide a suite of grid services — beyond simple energy supply — that are critical to system stability and must be replaced as those plants retire.

FREQUENCY REGULATION

As generation and load vary second by second, grid frequency deviates from 50 Hz. Coal and gas plants provide primary frequency response through governor action — automatically adjusting output as frequency changes. As thermal plants retire, this response must be provided by other resources. Batteries can respond in under 30 milliseconds, several orders of magnitude faster than any thermal plant. India's Secondary Reserve Ancillary Services (SRAS) market, launched by GRID India in 2023, creates a revenue mechanism for this service — paying BESS operators approximately ₹0.50/kWh for dispatch accuracy exceeding 95%.

SPINNING RESERVE

The grid requires capacity that can increase output within 10–30 seconds following a sudden generation loss. This spinning reserve was traditionally provided by thermal plants operating below their rated capacity. Batteries provide this service without consuming fuel, with sub-second response, and with no wear cost per activation — making them structurally superior to thermal spinning reserve on every economic dimension

BLACK START CAPABILITY

Following a widespread blackout, the grid cannot be restored without resources that can start without external power and provide a reference voltage around which other generators synchronise. Batteries are ideal black-start resources: they can energise a section of grid instantaneously from stored energy, requiring no fuel supply, no warm-up period, and no external power reference. As coal plants retire, battery black-start capability becomes critical grid resilience infrastructure.

TRANSMISSION CONGESTION MANAGEMENT

Batteries located at congested points in the transmission system can absorb local surpluses during off-peak hours and inject power during peaks, deferring or eliminating costly transmission upgrades worth hundreds of crore per circuit-kilometre. This grid deferral value — recognised under CERC's regulated asset value framework — represents a revenue stream that is independent of wholesale electricity prices and therefore provides uncorrelated diversification for BESS portfolio returns.

THE INDIA-SPECIFIC IMPERATIVE

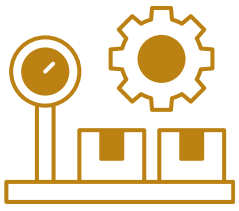
India's storage requirement combines the universal pressures of the energy transition with several India-specific factors that make the urgency greater and the commercial opportunity larger than in most comparable economies.

Speed of renewable deployment: India has deployed renewable capacity faster relative to GDP than any other major economy. The 500 GW non-fossil target by 2030 implies adding approximately 50 GW per year — a pace that creates grid flexibility challenges at each incremental megawatt, without the decades-long ramp that allowed Western grids to build flexibility mechanisms gradually.

Thermal fleet inflexibility: India's coal fleet, which provides approximately 50% of total generation, is predominantly composed of large supercritical units with technical minimum loads of 55–65% of rated capacity. These plants cannot be ramped down sufficiently to accommodate midday solar surpluses without risking equipment damage. The grid operator is therefore forced to curtail solar rather than reduce coal output — an operationally and economically perverse outcome that will only intensify as solar capacity grows.

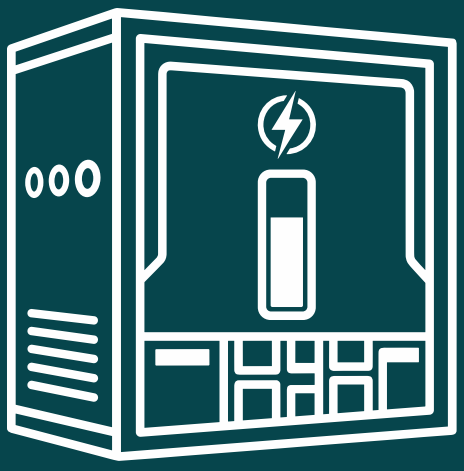
Industrial scale: India has over 600,000 MW of grid-connected commercial and industrial load. The behind-the-meter storage opportunity — helping industrial consumers reduce peak demand charges and shift consumption to off-peak periods — is enormous in scale and largely untapped. High-tension consumers pay ₹8–12/kWh on peak tariff bands with demand charges of ₹200–600/kVA/month, creating a strong economic incentive for on-site storage that requires no wholesale market participation.

Policy mandate: India's National Electricity Plan (NEP-14) mandates 47 GW / 236 GWh of BESS by FY2031-32. Energy Storage Obligations require DISCOMs to procure storage equivalent to 4% of their renewable energy by FY2030. This is mandated procurement, not discretionary demand — an unusual combination of structural necessity and regulatory compulsion that creates a floor under investment activity.



WHAT ARE THE ENERGY STORAGE OPTIONS?

A landscape of five fundamental categories, from pumped hydro to hydrogen



WHAT ARE THE ENERGY STORAGE OPTIONS AVAILABLE?

When confronted with the storage imperative, the first analytical step is to understand the full landscape of technologies available. Energy can be stored in several fundamentally different physical forms, each with distinct characteristics, costs, and appropriate applications. Before this report focuses on Battery Energy Storage Systems, it is analytically necessary to map the complete option set and understand why each technology is — or is not — suited to India's primary storage requirement: firm, modular, rapidly deployable 2-to-8-hour storage deployed at significant scale by 2032.

Category	Primary Form	Duration Range	Response Time	Round-Trip Efficiency	Maturity
Mechanical	Kinetic / Potential energy	Minutes – weeks	Seconds – minutes	70–85%	Mature (PHS); Niche (CAES, flywheel)
Thermal	Heat or cold	Hours – days	Minutes – hours	15–70% (varies)	Mature (CSP); Emerging (others)
Electrochemical	Chemical potential (batteries)	Minutes – 12 hours	Milliseconds	80–95%	Commercial scale (Li-ion, flow)
Chemical	Energy-dense molecules (H_2, NH_3)	Days – seasonal	Hours (H_2 turbine)	25–42%	Pre-commercial at grid scale
Electrical	Electrostatic / Magnetic field	Seconds – minutes	Milliseconds	90–98%	Mature (supercapacitors); Niche (SMES)

MECHANICAL STORAGE

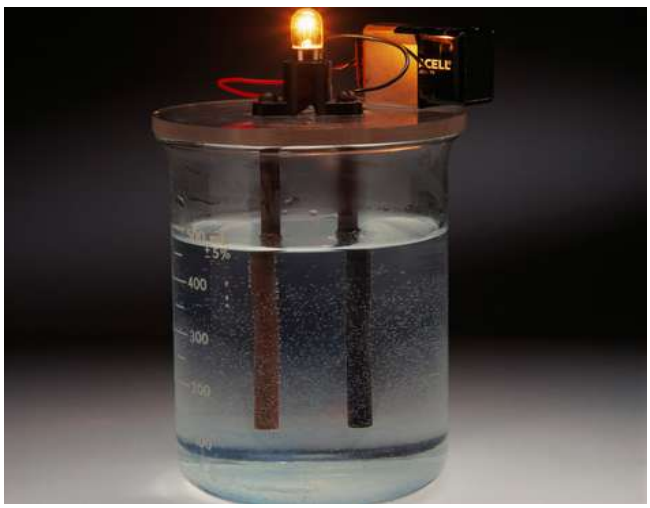
Mechanical storage converts electrical energy into kinetic or potential energy. Pumped hydro — moving water uphill using surplus electricity and releasing it through turbines on demand — is the world's dominant storage technology, accounting for more than 85% of all installed grid-scale storage capacity globally. Flywheels store kinetic energy in rotating masses. Compressed air stores electricity as pressurised gas in underground caverns.

THERMAL STORAGE

Thermal storage captures electrical energy as heat or cold. Molten salt storage, deployed at Concentrated Solar Power plants, retains heat at 560–600°C for dispatch after dark. Ice storage uses off-peak electricity to freeze water for cooling buildings during peak demand. Phase change materials enable smaller-scale thermal buffering for industrial and building applications.

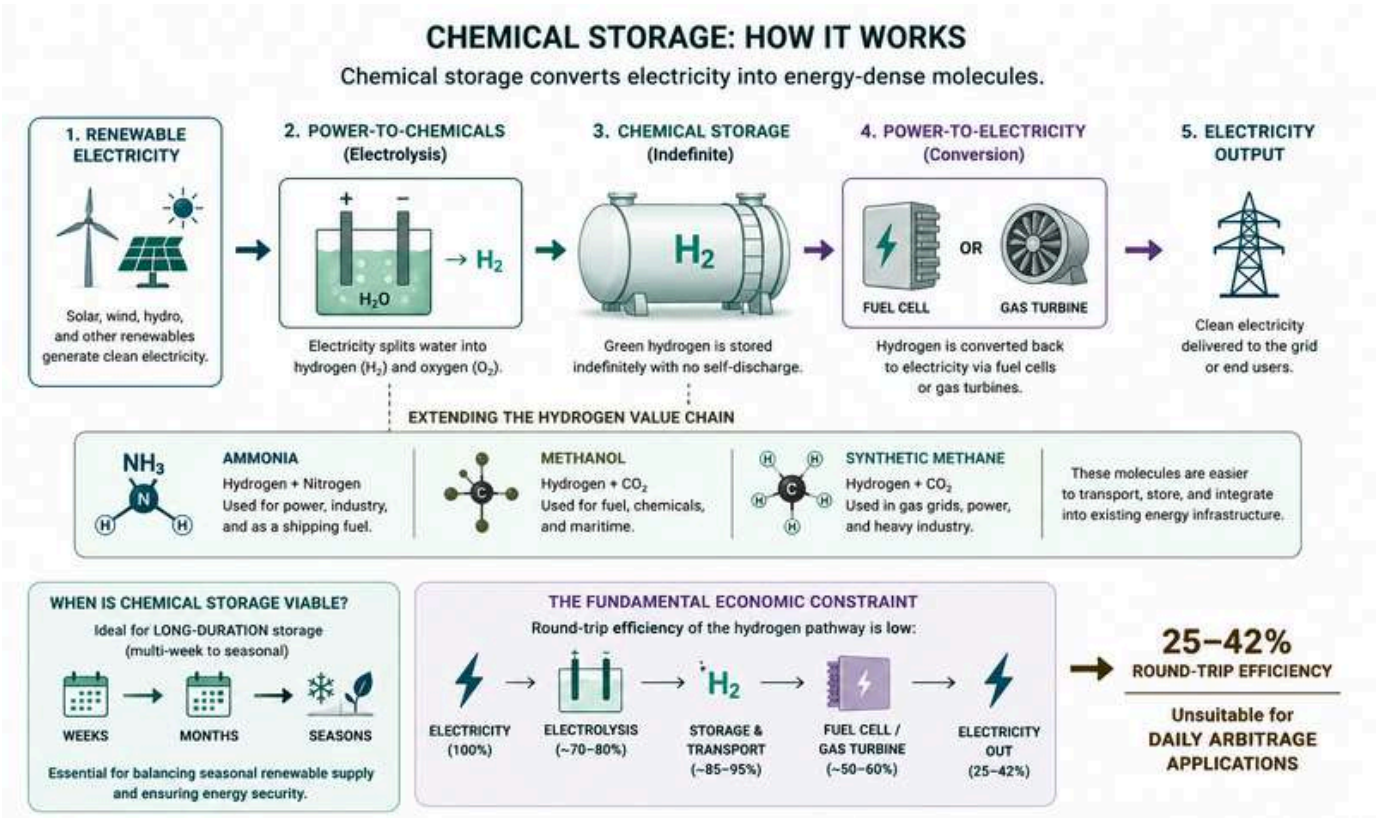
ELECTROCHEMICAL STORAGE (BATTERIES)

Batteries convert electrical energy into chemical potential energy stored in electrodes and electrolytes. The category encompasses dozens of chemistries — lithium-ion in multiple variants, sodium-ion, lead-acid, flow batteries, sodium-sulfur — each with different characteristics for energy density, cycle life, safety, and cost. Lithium Iron Phosphate (LFP) has become the dominant chemistry for grid-scale applications globally, accounting for approximately 67% of all deployed storage by 2024.



CHEMICAL STORAGE: HYDROGEN AND POWER-TO-X

Chemical storage converts electricity into energy-dense molecules. Green hydrogen, produced by electrolysing water using renewable electricity, can be stored indefinitely and converted back to electricity through fuel cells or gas turbines. Ammonia, methanol, and synthetic methane extend the hydrogen value chain. Chemical storage is the only viable option for multi-week or seasonal storage at scale — but the round-trip efficiency of the hydrogen pathway (25–42%) is a fundamental economic constraint that makes it unsuitable for daily arbitrage applications.



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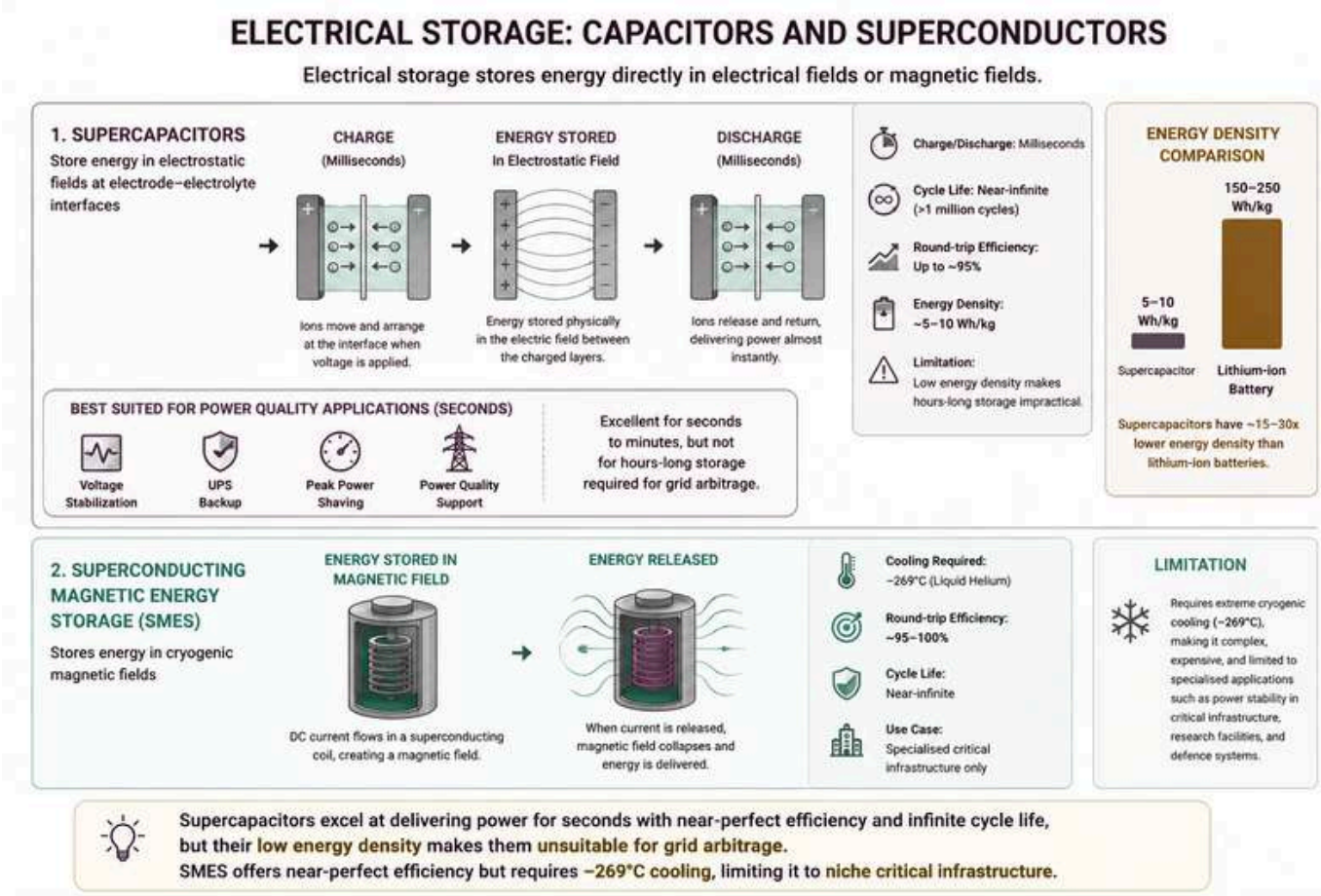
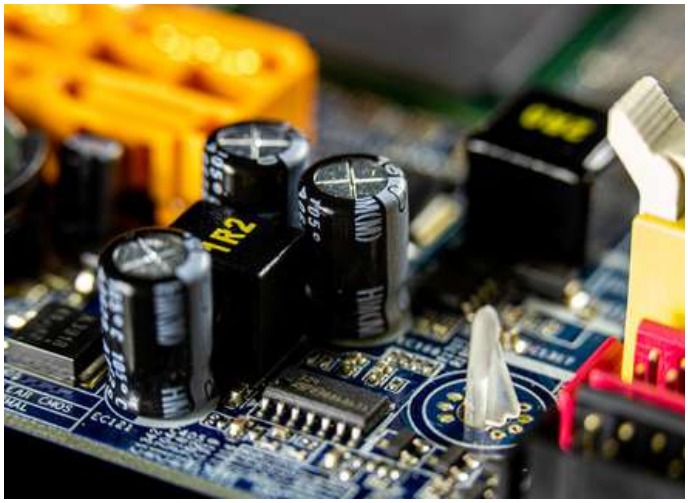
ELECTRICAL STORAGE: CAPACITORS AND SUPERCONDUCTORS

Supercapacitors store electrical energy directly in electrostatic fields at electrode-electrolyte interfaces. They charge and discharge in milliseconds with near-infinite cycle life and round-trip efficiencies approaching 95%. Their fundamental limitation is energy density: a supercapacitor stores approximately 5–10 Wh/kg versus 150–250 Wh/kg for lithium-ion batteries, making them suitable for power quality applications measured in seconds, but impractical for the hours-long storage that grid arbitrage requires. Superconducting Magnetic Energy Storage (SMES) stores energy in cryogenic magnetic fields with near-perfect efficiency but requires cooling to −269°C, limiting it to specialised critical infrastructure applications.





WHAT IS

BESS

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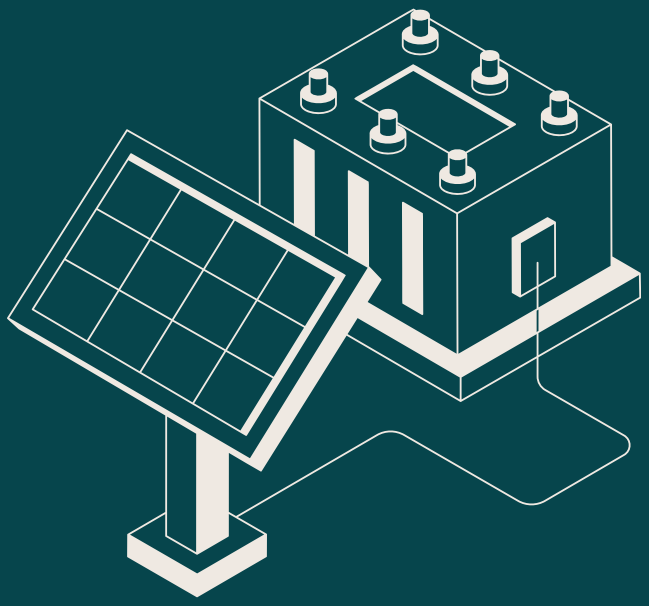
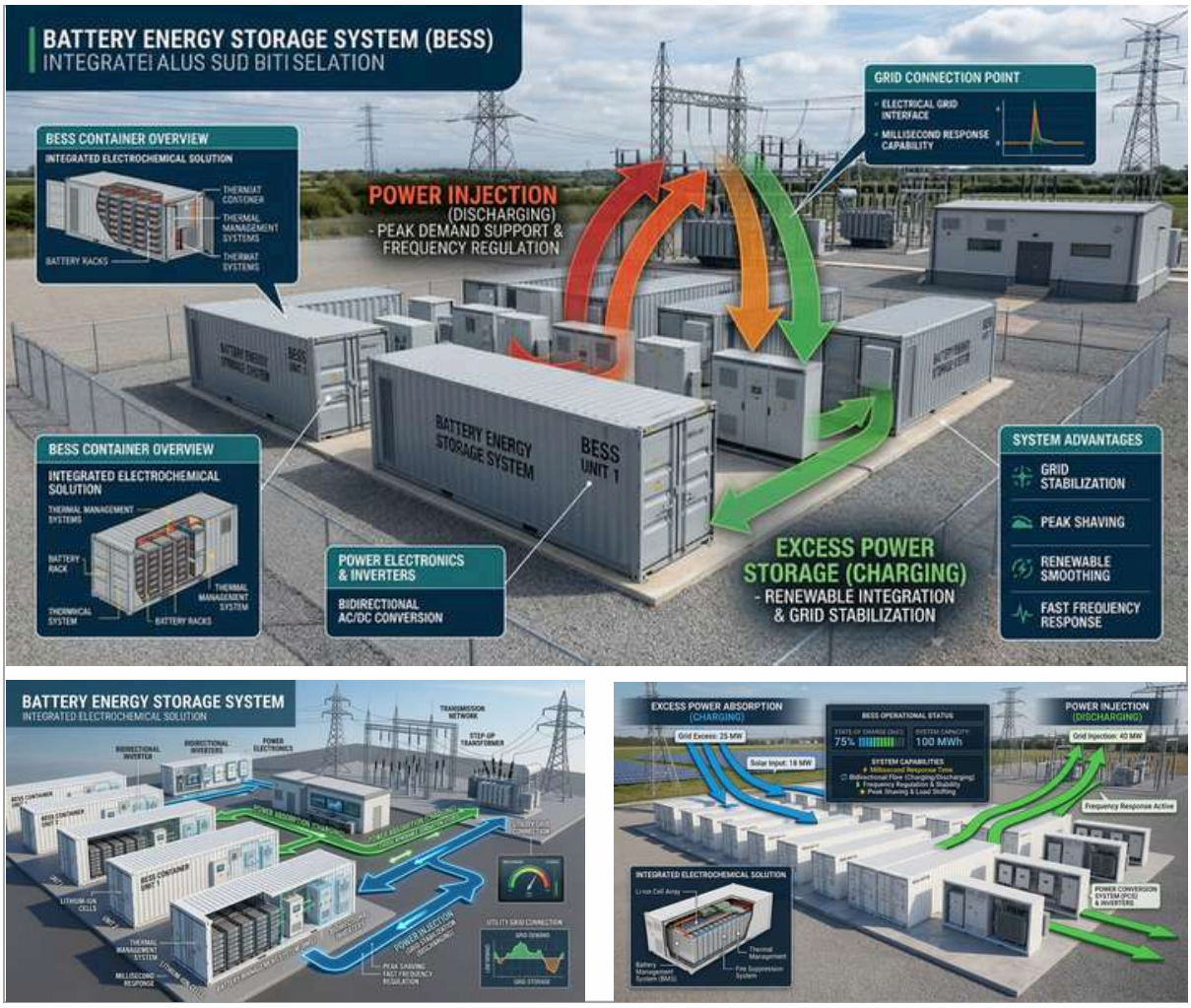


PRIMER: WHAT IS BESS?

A Battery Energy Storage System (BESS) is an integrated electrochemical solution that stores electrical energy and delivers it back to the grid or connected loads on demand. Unlike conventional generation assets, BESS enables bidirectional energy flow, allowing it to rapidly absorb excess electricity and discharge it within milliseconds when required.



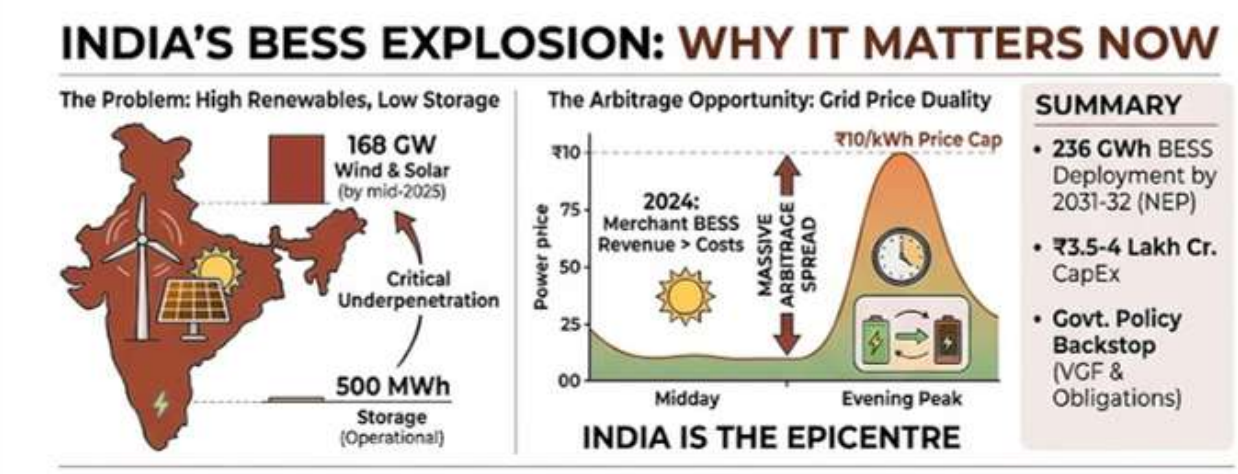
By storing energy during periods of low demand or high renewable generation and releasing it during peak demand or supply shortfalls, BESS enhances grid flexibility, reliability, and resilience. As renewable energy penetration increases, BESS plays a critical role in enabling a stable, efficient, and decarbonized power system.

WHY DOES IT MATTER NOW?

India added 168 GW of solar and wind by mid-2025, yet storage remains critically underpenetrated at just 500 MWh operational. As solar floods midday grids and pushes prices to near zero, while evening demand spikes to the ₹10/kWh price cap, the arbitrage spread for batteries has never been wider. For the first time in 2024, merchant BESS revenues exceeded annualised costs.

Why India is the epicentre?

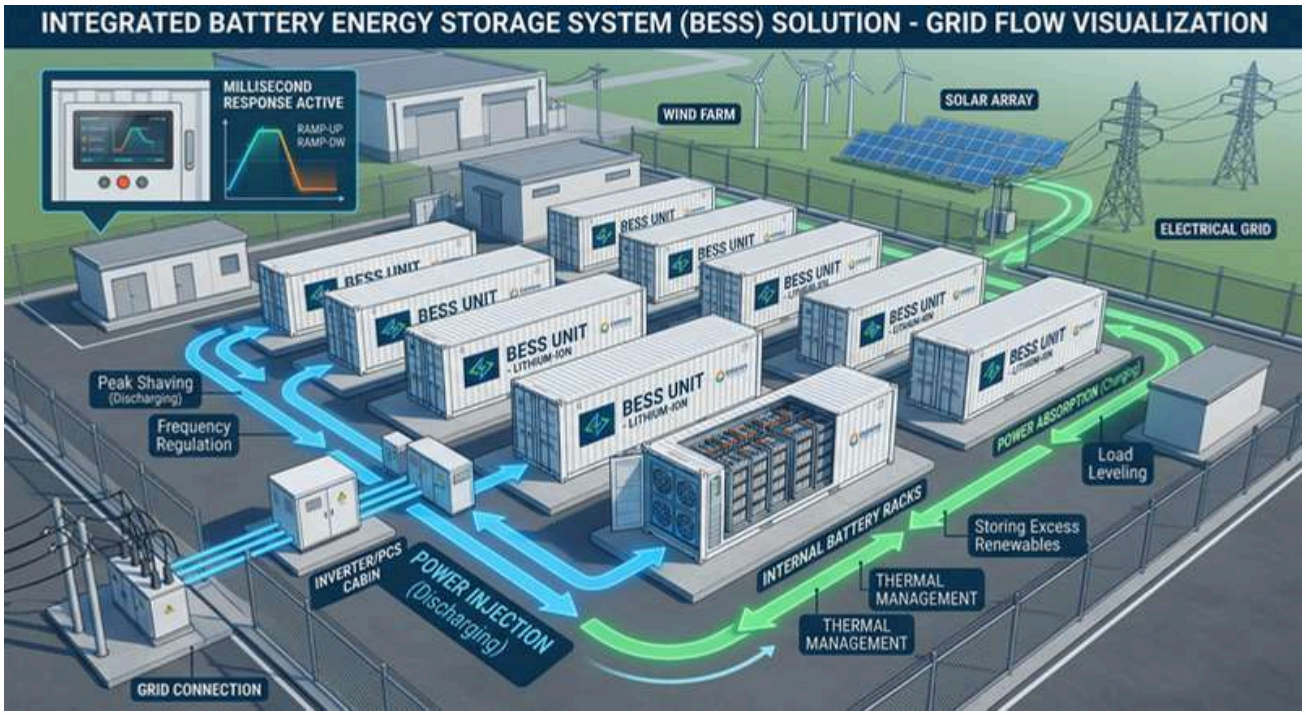
India must deploy 236 GWh of BESS by 2031-32 per its own National Electricity Plan — starting from near zero. That is a ₹3.5–4 lakh crore capital requirement over seven years, with virtually no domestic supply chain, a government backstop via Viability Gap Funding, mandatory Energy Storage Obligations on distribution companies, and a power exchange price structure that is structurally ideal for battery arbitrage.



Core Components

- **Battery cells (the electrochemical heart)**: Arranged into modules and racks. The dominant chemistry today is Lithium Iron Phosphate (LFP) for utility-scale applications due to its safety, cycle life (3,000–6,000+ cycles), and falling cost.
- **BMS**: The electronic brain monitoring cell voltage, temperature, and state-of-charge to prevent overcharge, over-discharge, and thermal events.
- **PCS**: Converts DC battery output to AC grid power and vice versa. A critical bottleneck for project economics and grid code compliance.
- **Thermal management**: Liquid or air cooling to maintain optimal operating temperature and prevent thermal runaway — the most critical safety variable.
- **EMS/SCADA**: The operational intelligence layer that schedules charge/discharge based on price signals, grid instructions, and battery health. This is where the most defensible software value sits.
- **Safety systems**: Enclosures, gas detection, suppression systems. Subject to NFPA 855 and UL 9540 standards globally; India is developing analogous requirements.

1) Roland Berger Report



Energy Storage Estimations for MV/LV Grid (MWh)

Estimates	2019	2022	2027	2032
Generation (GW)				
Thermal	209	NA	NA	NA
Hydro	43	NA	NA	NA
Nuclear	6	NA	NA	NA
Solar	26	107	244	349
Ground Mounted Solar	24	68	148	206
RTPV	1.5	40	98	144
Connected to EHV	14	34	66	94
Connected to MV	11	35	84	112
Connected to LV	2	40	98	144
Wind	35	NA	NA	NA
Small Hydro	4.5	NA	NA	NA
Biomass & Biopower	10	NA	NA	NA
Peak Load (GW)	192	333	479	658
Energy (BUs)				
Annual Energy Requirements	1192	1905	2710	3710
Storage Recommended (MWh)				
Battery for LV Grid	241	5908	14617	21484
Battery for MV Grid	1054	3482	8393	11191
Total Storage (MWh)	**1295**	**9390**	**23010**	**32675**
Approximate (GWh)	**1 GWh**	**10 GWh**	**24 GWh**	**33 GWh**

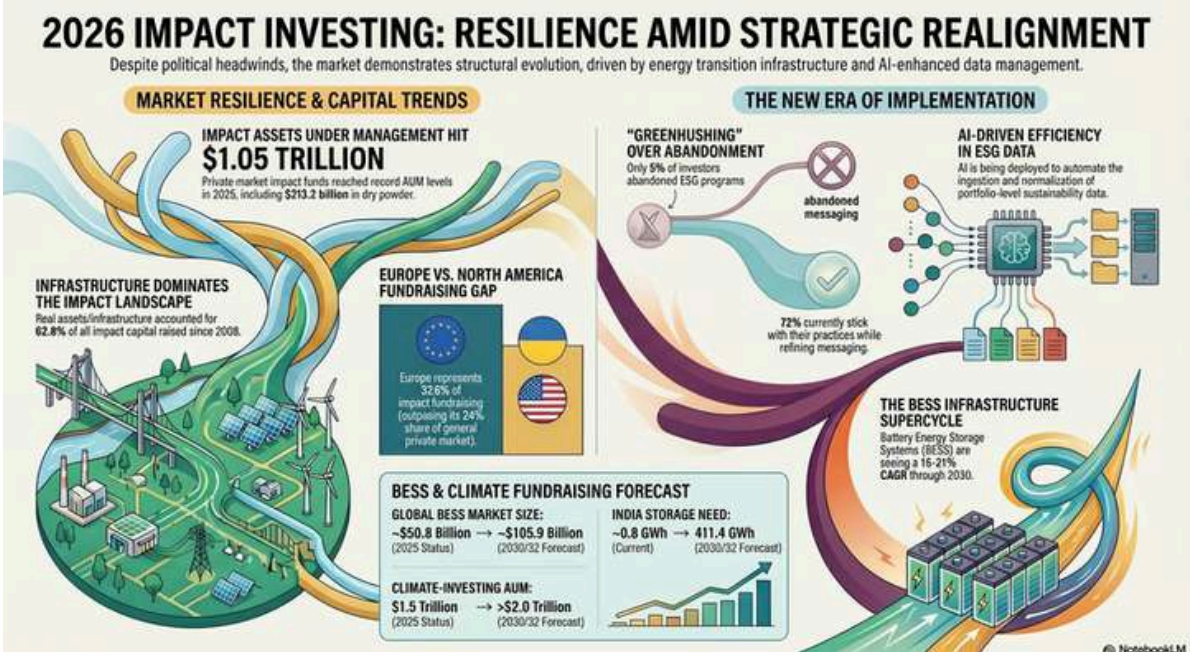
WHY GRID

NEEDS BESS

WHY GRIDS NEED BESS

As solar and wind capacity expands, grids face the "Duck Curve" problem—midday solar overproduction followed by an evening demand surge when solar output drops. BESS addresses this via:

- **Renewable Integration:** Buffering supply-demand mismatches to turn intermittent power into "firm" dispatchable energy.
- **Frequency Regulation:** Maintaining system stability within milliseconds as coal plants retire.
- **Grid Modernization:** Replacing services previously provided by dispatchable thermal plants.
- **Peak Shaving:** Reducing grid stress and peak demand charges by shifting loads.



India's grid is no longer a smooth demand-supply curve. It is an increasingly volatile, duck-shaped intraday profile driven by solar. BESS is not optional infrastructure — it is the essential flexibility layer.

1) Roland Berger Report

WHY GRIDS NEED BESS

WHAT BESS CAN DO THAT COAL CANNOT

Grid Service	Coal/Hydro	BESS	India Revenue Mechanism
Peak Shaving	Slow to ramp	Millisecond response	IEX DAM arbitrage
Frequency Regulation	Minutes to respond	Sub-second (<30 sec SRAS)	SRAS / TRAS ancillary market
Renewable Firming (FDRE)	Must stay on 24×7	Stores excess, releases on demand	Long-term PPA or hybrid tender
Black Start	Requires external power	Can self-start grid restoration	Reliability premium / mandated
Transmission Deferral	Cannot reduce congestion	Absorbs local surplus, defers upgrade	Regulated asset value / tariff
Demand Charge Management	N/A (industrial / C&I)	N/A (industrial / C&I)	Behind-the-meter energy savings

The comparison highlights the unique operational and commercial advantages of Battery Energy Storage Systems (BESS) over conventional coal or hydro-based generation assets. Unlike traditional plants, which are often slow to ramp and dependent on continuous operation, BESS delivers near-instantaneous response capabilities, making it highly effective for modern grid support services such as peak shaving, frequency regulation, renewable firming, black start support, and transmission deferral.

WHY GRIDS NEED BESS

THE INTERMITTENCY PROBLEM

Solar and wind generate electricity only when the sun shines and the wind blows. In India, solar now contributes 7.4% of annual generation — but during peak solar hours, it contributes 30–50% of instantaneous supply.

This creates:

- Midday price crashes
- Evening price spikes
- Growing daily spread

The Duck Curve Reality

India has moved firmly into 'duck curve' territory — the characteristic shape of net demand (total demand minus solar output) where the belly dips at midday and the neck rises sharply in the evening. This shape creates structural demand for storage that charges during the belly and discharges during the neck. As solar penetration continues to grow, the curve deepens.

The Flexibility Gap

India's existing grid flexibility relied on coal plants being dispatchable. But as solar floods midday hours, coal plants are forced to back down to or near their technical minimum load — which means they cannot absorb more surplus. By evening, when demand spikes, plants that were at minimum load cannot ramp up fast enough to meet demand surges. This creates simultaneous downward reserve gaps at noon and upward reserve gaps at night.

On May 26, 2025, both upward and downward spinning reserves were inadequate simultaneously — downward reserves near zero for five consecutive midday hours, upward reserves at zero for three hours at night. These are now systemic, not anomalous, events.

1) Roland Berger Report

THE TIME DIMENSION — THE DUCK CURVE

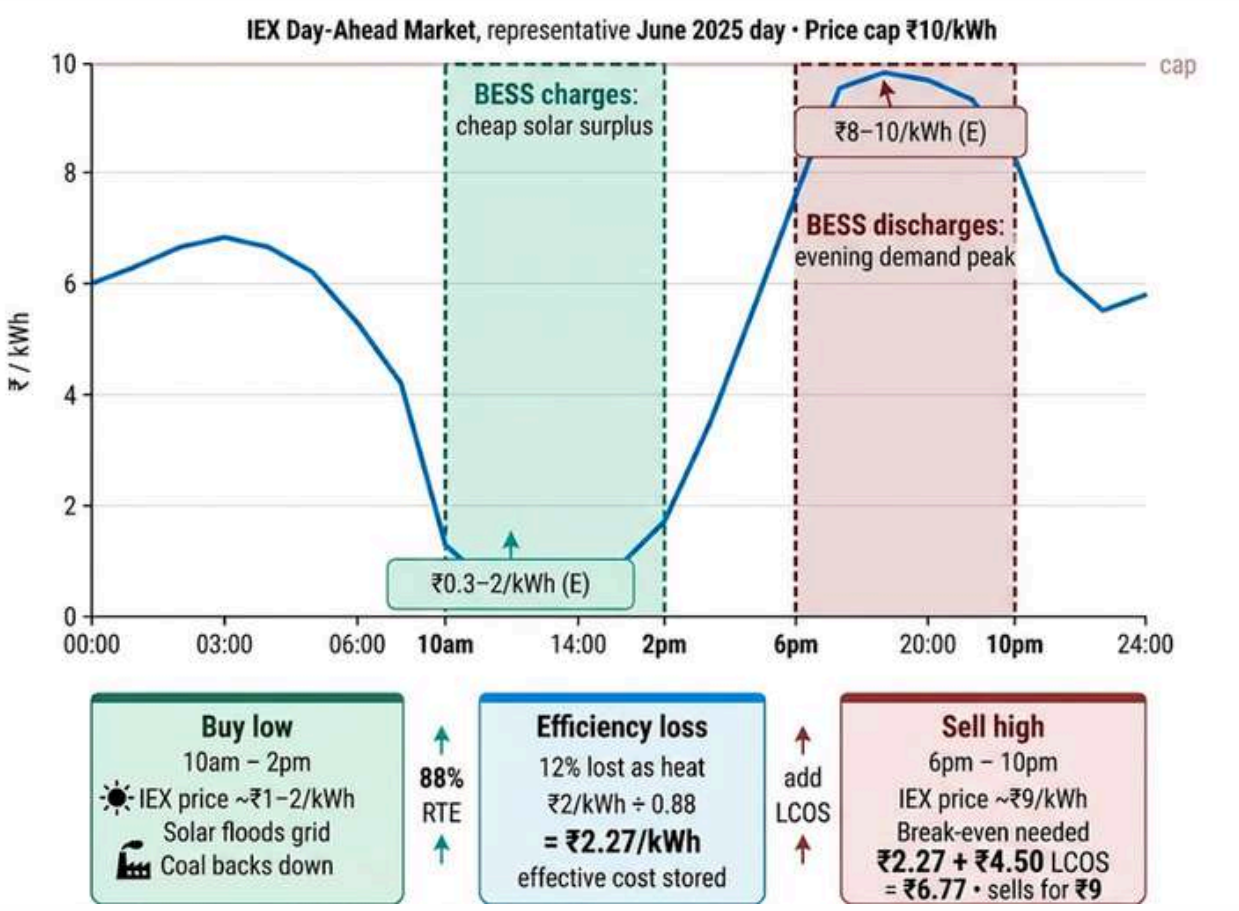
The 'duck curve' describes the intraday shape of net demand (total demand minus solar output). As solar penetration grows, the belly deepens (midday oversupply) and the neck steepens (rapid evening ramp). India is now firmly inside the duck curve — and it will get deeper every year as more solar is added.

Time Window	Grid Condition	IEX DAM Price (June 2025)	What Is Happening
Midnight – 6am	Base load; thermal dominant	₹3–5/kWh	Coal and gas setting marginal price; low demand
6am – 9am	Demand rising; solar starting	₹4–6/kWh	Morning industrial load; solar beginning to contribute
9am – 2pm (PEAK SOLAR)	Solar surplus; thermal backing down	₹0.30–2.00/kWh (E)	Solar oversupply; thermal at minimum technical load; prices crash
2pm – 5pm	Solar declining; demand rising	₹2–5/kWh	Transition window; grid tightening
5pm – 7pm	Solar gone; demand peak begins	₹6–9/kWh	Rapid supply shortfall as solar disappears simultaneously with demand peak
7pm – 11pm (PEAK DEMAND)	No solar; maximum demand	₹8–10/kWh (at cap E)	Thermal at full output; still insufficient; expensive gas/imports set price
11pm – midnight	Demand easing	₹4–6/kWh	Returning to base conditions

WHY DOES IT MATTER NOW?

THE TIME DIMENSION — THE DUCK CURVE

The arbitrage: A BESS charges at **₹1–2/kWh** during peak solar **(10am–2pm)** and discharges at **₹8–10/kWh** during evening peak **(7pm–10pm)**. After round-trip efficiency losses **(~88% for LFP)** and system costs **(LCOS ~₹4.5/kWh)**, the net margin per cycle is approximately **₹2–4/kWh**. At 1.2 cycles/day, this is a structurally profitable business — for the first time ever in FY 2024.



1) Roland Berger Report

WHY DOES IT MATTER NOW?

THE NUMBERS: PRICE SPREAD IS GROWING STRUCTURALLY

The arbitrage: A BESS charges at ₹1–2/kWh during peak solar (10am–2pm) and discharges at ₹8–10/kWh during evening peak (7pm–10pm). After round-trip efficiency losses (~88% for LFP) and system costs (LCOS ~₹4.5/kWh), the net margin per cycle is approximately ₹2–4/kWh. At 1.2 cycles/day, this is a structurally profitable business — for the first time ever in FY2024.

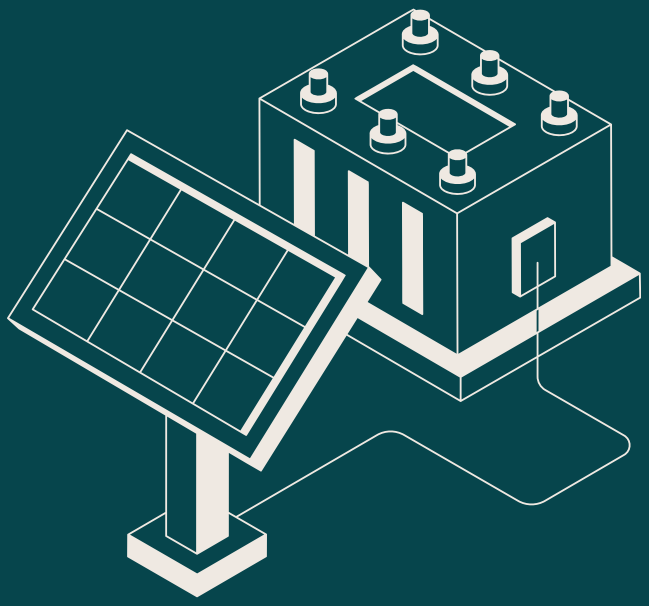
Year	Avg Midday Price June (₹/kWh)	Avg Evening Peak June (₹/kWh)	Daily Spread (₹/kWh)
2019	₹3.5	₹5.0	₹2.5
2021	₹3.0	₹6.2	₹3.2
2022	₹2.5	₹8.0	₹5.5
2023	₹2.8	₹8.5	₹5.7
2024	₹2.0	₹9.0	₹7.0
2025 (E)	₹1.2	₹9.5	₹7.5 (E)
2030 (P)	₹0.5–1.5 (P)	₹8–10+ (P)	₹7–9 (P)

Source: IEX DAM historical data; Ember 'Age of Storage' report (August 2025). 2025 figures are estimates (E); 2030 are projections (P).

The arbitrage spread has tripled from ₹2.5/kWh (2019) to ₹7.5/kWh (2025 E). This widening is structural — driven by increasing solar penetration crashing midday prices and inflexible coal sustaining evening peaks. The trend will continue as more solar is added.

GLOBAL MARKET

A STRUCTURAL MEGATREND



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India's Largest Early Stage Climate Focused Angel Fund

GLOBAL MARKET OVERVIEW

India is not pioneering BESS — it is entering a market that has already been de-risked at a technology and business-model level globally, but where local supply, finance, and regulatory infrastructure is still nascent. This is the classic early-mover opportunity in a proven sector.

Global Market Scale

Global Scale
Exceeded 200 GWh annually by 2024, growing at 50%+ per year. The IEA projects cumulative global BESS deployment of 1,500+ GWh by 2030.

Cost trajectory
Lithium-ion battery pack prices fell to a record low of $139/kWh in 2024 (BNEF), down from $1,500/kWh in 2010 — a 90% reduction in 14 years.

US/Europe
The US Inflation Reduction Act and Europe's REPowerEU created massive BESS deployment waves, validating business models and attracting infrastructure capital at scale.

Australia
The South Australia big battery and subsequent projects validated merchant BESS economics at a national scale — a direct precursor for India's market structure.



What India Can Learn from Mature Markets

The most important global lesson is revenue stacking: BESS assets that combine energy arbitrage, ancillary services, and capacity payments consistently outperform single-stream assets. The UK capacity market, Australia NEM, and US ERCOT all demonstrate that well-designed market structures can deliver 15–25% IRRs on storage. India's regulatory trajectory is now following the same path.

Why India Is Different — and Larger

India's opportunity is structurally larger than most markets because: (1) the renewable buildout is faster and at greater scale relative to GDP than any comparable economy; (2) the grid is still insufficiently flexible; (3) government procurement creates large, visible demand via tenders; and (4) the C&I behind-the-meter market is nascent and huge, with 600,000+ MW of grid-connected industrial consumers facing high and volatile tariffs.

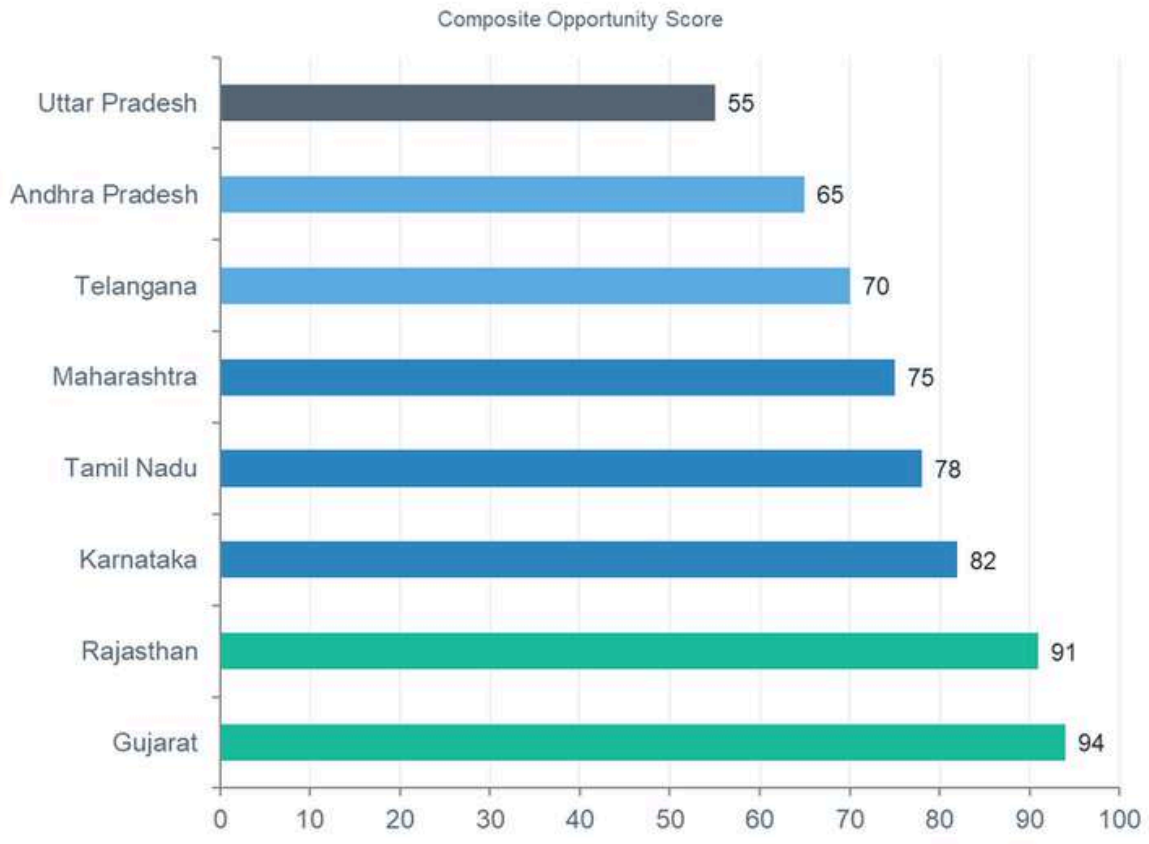
GLOBAL MARKET OVERVIEW

The global BESS market is entering a massive deployment phase. In 2025, installations reached 74 GWh, nearly triple the previous year.

Source	2025 Market Size	2030E Market Size	CAGR
Markets and Markets	$50.81B	$105.96B	15.80%
Research And Markets	$13.7B	$43.4B	21.30%
McKinsey (Statzon)	$8.8B	$49.3B (2032E)	~24%

Regional Leaders: Asia-Pacific holds the largest share (42.2% in 2024) and the highest projected CAGR (36.1%), followed by North America (~30%) and Europe (~25%).

State-by-State BESS Opportunity Index in India

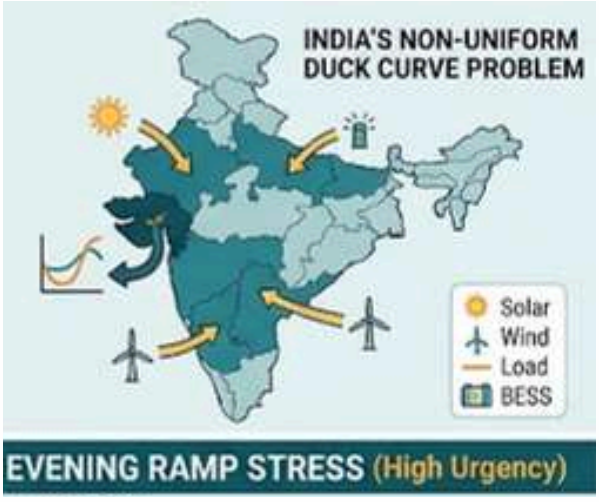


Source: Composite index based on: RE capacity (MNRE data), DISCOM tendering, grid frequency reports (GRID India), industrial load (CEA)

REGIONAL BESS URGENCY

The duck curve problem is not uniform across India. Severity depends on solar penetration, industrial load profile, and grid interconnectedness. This creates a state-by-state investment map.

State / Region	Grid Stress Type	Specific Dynamics
Gujarat	Deep duck curve	Highest solar penetration; GUVNL already tendering; midday prices near ₹0 in summer 2025
Rajasthan	Curtailment + duck	Largest solar potential; curtailment growing; SECI tenders active
Karnataka	Evening ramp stress	Hydro + solar mix; steep evening ramp as solar drops; industrial load
Andhra Pradesh	Data center + RE load	Growing data center cluster (Vizag); high reliability demand; solar heavy
Tamil Nadu	Wind variability	Coastal wind intermittency; TANGEDCO demand growing; EV adoption rising
Maharashtra	C&I peak demand	Largest industrial load; MSEDCL peak procurement challenge; data centers
UP / Bihar	Supply deficit	Chronic shortage states; high afternoon demand even as solar grows; load-shedding



THE SECTORAL DIMENSION

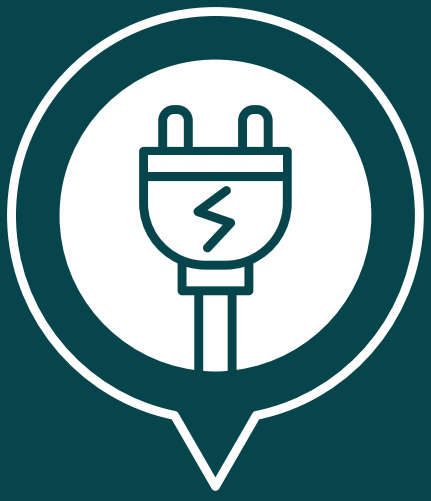
The duck curve problem is not uniform across India. Severity depends on solar penetration, industrial load profile, and grid interconnectedness. This creates a state-by-state investment map.

Sector	Load Profile	Storage Opportunity	Market Size (E)
Industrial / Manufacturing	High daytime baseload + sharp evening peak; predictable schedule	Peak demand reduction; shift consumption to cheap midday solar; avoid demand charges	₹600+ Cr/year addressable (E)
Data Centers	24×7 near-constant load; >99.9% uptime requirement; high reliability premium	UPS replacement + arbitrage; solar+BESS for RE100 commitments; demand charge management	₹200+ Cr/year addressable and growing fast (E)
Commercial / Retail	Morning-evening peaks; weekend variations	Demand charge reduction; peak shaving	₹300 Cr/year addressable (E)
Telecom Towers	~7 lakh towers; diesel dependent; DG cost ₹20–30/kWh	Solar+BESS replacing diesel; ~₹15/kWh saving per tower	₹3,000–5,000 Cr total capex opportunity (P)
EV Charging Depots	Concentrated demand spikes at depot charging windows	BESS buffer reduces peak demand charge; enables fast charging without grid upgrades	₹1,000+ Cr/year by FY2028 (P)
Agriculture / Rural	Pump load: 6–8 hr demand windows; irregular	Solar+BESS microgrids replacing DG; PM-KUSUM alignment	Large government-backed opportunity; scheme-dependent

Telecom towers represent the largest single CapEx opportunity (₹3,000–5,000 Cr) due to diesel replacement economics. Data centers and EV depots are the fastest-growing segments. Industrial C&I offers the most immediate behind-the-meter opportunity.

DISCOMS AND REVENUE

UNCERTAINTY



DISCOMS AND REVENUE UNCERTAINTY

DISCOMs are the single most important risk variable in India's BESS market. The technical and economic case for storage is clear — but without a creditworthy, contractually reliable buyer for storage output, no amount of policy support converts the opportunity into bankable investment

What the DISCOM Problem Actually Is

India has 28 states and ~50 electricity distribution companies (DISCOMs). They are the monopoly retailers of electricity to end consumers and the primary procurement counterparty for new generation and storage capacity. For a BESS investor, the DISCOM is the entity that signs the contract and makes the payments. The problem: most DISCOMs are financially distressed in ways that make them unreliable long-term contract partners.

DISCOM Financial Metric	National Situation (FY2024 E)	Why It Matters for BESS
Aggregate losses (net, after subsidy)	~₹40,000–60,000 Cr/year (E)	DISCOMs lose money on operations; payments to new contracts are at risk
Aggregate Technical & Commercial (AT&C) losses	~16–18% national average (E)	~1 in 6 units of electricity produced is lost or unpaid; reduces revenue
Average cost of supply vs avg revenue gap	₹0.50–1.00/kWh gap in many states (E)	Selling below cost of procurement; structurally unviable without subsidy
Dues payable to generators (outstanding)	~₹1.5–2.0 lakh Cr (E)	Already not paying existing generators; new BESS contracts face same queue
States with investment-grade DISCOM credit	~4–5 states (Gujarat, HP, some NE states)	Most DISCOMs are sub-investment-grade; cannot support project finance PPA
Annual state government subsidies required	₹70,000–90,000 Cr/year nationally (E)	Government must bail out DISCOMs every year; politically driven; unreliable

1) Roland Berger Report

Most DISCOMs are chronically loss-making with ₹1.5–2 lakh Cr in unpaid generator dues. Only 4–5 states have investment-grade DISCOMs. This makes the majority of BESS contracts structurally unbankable without sovereign backstop or SECI intermediation.

WHY DISCOMS WILL NOT SIGN LONG-TERM PPAS

The DISCOM problem manifests specifically as an unwillingness — or inability — to sign long-term BESS procurement contracts at prices that make projects bankable. There are five reasons:

What the DISCOM Problem Actually Is

POLITICAL TARIFF
MANAGEMENT

State governments control retail electricity tariffs for political reasons. Raising tariffs to cover the cost of new storage capacity faces voter resistance. DISCOMs cannot pass through the full cost of BESS to consumers.

SHORT PLANNING
HORIZONS

DISCOM management changes with state government elections (every 5 years). A 12–15 year BESS contract signed by one government may be challenged or restructured by the next. There is no institutional continuity.

EXISTING DEBT
BURDEN

DISCOMs already carry legacy debt from renewable energy PPAs, generator dues, and bank loans. Adding BESS capacity tariff obligations worsens their balance sheet and is resisted by DISCOM finance teams.

LOW RETAIL TARIFFS
CREATING A CAP

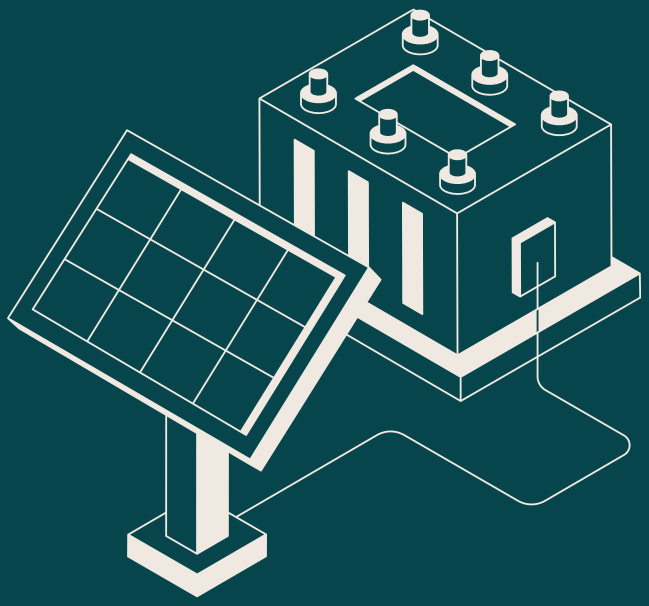
If a DISCOM procures BESS at ₹4.5L/MW/month (Gujarat benchmark) but can only collect ₹5–6/kWh from consumers, there is limited headroom to absorb storage costs without subsidy top-up.

REGULATORY
UNCERTAINTY

State electricity regulatory commissions (SERCs) must approve tariff pass-through for storage procurement. Some SERCs have disallowed or delayed approvals, creating additional uncertainty for DISCOM procurement decisions.

TECHNOLOGY

LANDSCAPE



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TECHNOLOGY LANDSCAPE

Technology risk is the first question investors ask about BESS. The short answer: for utility-scale and C&I applications in India today, LFP lithium-ion is the bankable choice. Everything else is either a niche, a future bet, or a risk to avoid at angel stage.

The LFP vs NMC Decision

Parameter	LFP (Lithium Iron Phosphate)	NMC (Nickel Manganese Cobalt)
Energy Density	Lower (~150 Wh/kg)	Higher (~250 Wh/kg)
Cycle Life	3,000–6,000+ cycles	1,500–3,000 cycles
Thermal Stability	Excellent — no thermal runaway below 270°C	Moderate — runaway risk above 150°C
Cost (2025)	~$70–80/kWh cell	~$90–110/kWh cell
Safety	Industry benchmark for stationary storage	Higher risk — more safety systems required
Cobalt Dependency	None	High — geopolitical supply risk
India Suitability	✓ Strong — utility, C&I, grid-scale	Limited — EV applications only

Verdict: LFP dominates India's utility-scale BESS. Investors should require LFP unless there is a specific reason for alternatives.

Emerging Technologies: Future Bets

Sodium-ion (Na-ion): Promising due to no lithium requirement. CATL and BYD commercialising. Cost parity with LFP possible by 2027–28. Worth watching at seed stage.

Flow batteries (Vanadium Redox VRFB): Ideal for 6–12 hour storage. Independent power/energy scaling. High upfront cost but long lifespan (20+ years). Niche application today — viable for long-duration tenders.

Solid-state batteries: High density, safer — but still pre-commercial for utility scale. Horizon: 2030+. Not relevant for near-term angel deals.

Sodium-sulfur (NaS): High temperature operation. NGK (Japan) has deployed at scale. Limited commercial availability in India.

1) Roland Berger Report

TECHNOLOGY LANDSCAPE

What Technology Risk Actually Means for Investors

The real technology risk in BESS is not chemistry failure — LFP is mature and proven. The risks are: (1) thermal management execution, where poor cooling leads to battery fires; (2) BMS software quality, where poor cell balancing accelerates degradation; and (3) PCS reliability, where inverter failures create availability penalties under project contracts. Investors should diligence these as engineering and operational risks, not chemistry risks.

Comparison of Key Chemistries:

Chemistry	Share (2024)	Cycle Life	Best Application
Lithium-Ion (LFP)	66.70%	3,000–6,000	Grid-scale, Utility, C&I
Lithium-Ion (NMC)	~20%	1,000–3,000	EV integration, Residential
Flow Batteries	~4%	10,000+	Long duration (8-12 hrs)
Sodium-Sulfur	~3%	2,500–4,500	Grid firming

The 2024 global chemistry breakdown makes the investment decision straightforward. LFP has captured two-thirds of all deployed energy storage capacity through a decade of compounding advantages in safety, cost, and cycle life that no competing chemistry has matched at utility scale. NMC's remaining share is migrating toward EVs and residential applications, making it a poor fit for India's high-utilisation daily-arbitrage model. Flow batteries and sodium-sulfur together hold under eight percent of the market — both remain constrained by cost, complexity, or operational limitations that prevent near-term scale in India. For Climate Angels, this table functions as a simple filter: any India BESS deal not built on LFP requires explicit justification, and any thesis predicated on an alternative chemistry displacing LFP before 2030 should be treated with scepticism.

1) Roland Berger Report

THE COST CURVE

ECONOMICS

COST CURVE AND ECONOMICS

Battery costs have declined 80% since 2015. India's BESS revenues from market participation have grown fivefold in the same period. 2024 was the first year revenues exceeded annualised costs. The economics are no longer marginal — they are compelling.

The Historic Cost Decline

Year	BESS Levelised Cost (India, ₹M/MWh)	Merchant Revenue Potential (₹M/MWh)	Status
2015	₹7.9M	₹0.5M	Unviable — 15× cost vs revenue
2018	₹5.2M	₹0.8M	Unviable — 6× cost vs revenue
2020	₹3.8M	₹1.2M	Pre-commercial — improving
2022	₹2.6M	₹2.0M	Near breakeven — momentum building
2024	₹1.7M	₹2.4M	✓ VIABLE — revenues exceed costs for first time
2025	₹1.5–1.6M	₹2.7M (projected)	Strong — IRR 17–24% achievable
2030 (proj.)	₹1.0–1.2M	₹3.0M+ (forecast)	Highly attractive — market deepening

Source: Ember BattMan model and IEA Batteries and Secure Energy Transitions report. These are annualised metrics over a 10-year asset life.

1) Roland Berger Report

COST CURVE AND ECONOMICS

The economic viability of BESS has been revolutionized by a dramatic decline in battery costs. Lithium-ion battery prices fell from $1,000/kWh in 2010 to $139/kWh in 2023—an 86% reduction. In India, turnkey project costs decreased by 40% in 2024 alone. Lower costs are driving a self-reinforcing cycle of manufacturing scale and further price reductions.

NREL 2025 Global Utility-Scale 4-Hour System Costs

2024 Cost	2030 Cost	2035 Cost	2050 Cost
$334/KWH	$279/KWH	$243/KWH	$178/KWH

The last five years have confirmed two simultaneous truths. Battery costs have continued to decline structurally, especially as stationary storage shifted toward LFP chemistry, but system economics remain sensitive to non-cell costs and to utilization assumptions. NREL's ATB states that stationary storage is now primarily represented by LFP and highlights that a substantial share of cost reductions comes from the battery pack while BOS, installation, and other non-pack costs fall more slowly. That is why project developers can see battery pack prices fall while all-in EPC or delivered LCOS declines less sharply.

For global utility-scale 4-hour systems, the clearest high-confidence benchmark in the sources reviewed is NREL's 2025 update. The report uses $334/kWh as the 2024 overnight capital cost for a complete 4-hour system, with mid-case values of $279/kWh in 2030, $243/kWh in 2035, and $178/kWh in 2050. By construction, these are complete system costs, not cell-only costs. Near-term uncertainty remains large: NREL notes that some literature sources still implied cost increases up to about 10% by 2026, while others implied declines up to about 23%, which is a useful reminder that battery pricing is still cyclical despite its long-run downward trend.

COST CURVE AND ECONOMICS

For operating assumptions, NREL's selected values are conservative enough to be useful for underwriting. The report adopts 15 years of life, 85% round-trip efficiency, zero VOM, and FOM equal to 4% of the $/kW capacity cost for a 4-hour battery, explicitly noting that this FOM assumption is meant to cover performance maintenance and roughly aligns with one cycle per day. NREL also warns that if the asset cycles materially more often, the selected FOM may no longer be sufficient to offset degradation. That is one of the most important practical sensitivities in BESS modeling: high gross revenue can be offset by higher augmentation and throughput-related wear.

OPERATING ASSUMPTIONS

- 15-year life
- **85%** round-trip efficiency
- 4% FOM of capacity cost

For India, the most useful official cost signal in the public domain is not a tender quote but the implied planning-level capital intensity embedded in the Ministry of Power's National Framework. Dividing the official BESS fund requirement by the official BESS energy requirement implies roughly ₹1.63 crore/MWh for the 2022-27 period and about ₹1.41 crore/MWh for 2027-32. Using a simple assumption of ₹84/$, those figures are about $194/kWh and $167/kWh, respectively.

These are inferred planning averages, not EPC offers, but they are directionally consistent with global cost compression and are much more useful for Indian screening than legacy headline estimates from 2022-23

COMPARATIVE BENCHMARK (INDIA)

₹1.63 crore/MWh($194/kWh) | 2022-27

₹1.41 crore/MWh($167/kWh) | 2027-32

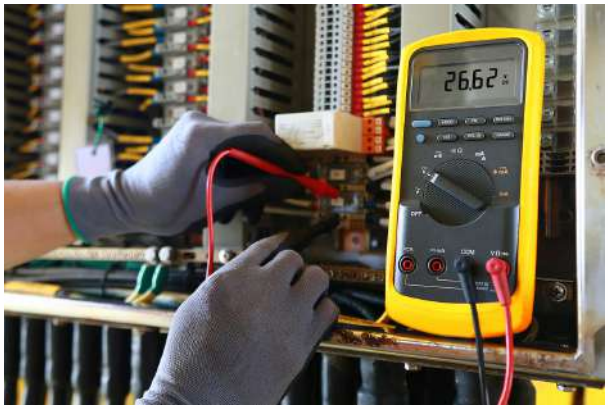
NEAR-TERM UNCERTAINTIES

Literature ranges suggest potential cost variations from +10% to -23% due to supply chain fluctuations, material costs, and policy changes.

COST CURVE AND ECONOMICS

What Drives Project Economics

- **Capital cost (Capex):** Currently ₹1.4–2.0 Cr/MWh for 2-hour systems in India. VGF reduces effective capex by ₹46 lakh/MWh. Getting below ₹1.6 Cr/MWh is the target for strong economics.
- **Cycling utilisation:** India's VGF guidelines assume 572 cycles/year (roughly 1.5 cycles/day). Real merchant projects achieving 1.2–1.6 cycles/day are the base case.
- **Round-trip efficiency:** Every 1% of RTE loss costs approximately ₹0.03–0.05/kWh of arbitrage margin. LFP at 88–92% RTE is the baseline.
- Price spread capture: Not all of the DAM spread is capturable — transaction timing, battery constraints, and market competition reduce capture to 60–80% of the theoretical maximum.
- **Augmentation reserves:** LFP degrades ~2–3% per year of usable capacity. A 10-year project must budget for capacity augmentation. This is a material cost that some models understate.
- **Interest rate environment:** At 70% debt financing at 11% (India infrastructure debt cost), leverage dramatically amplifies equity returns but also risk. The base case equity IRR of 34% (at base unlevered 17.6%) collapses to -13.5% in the bear case.



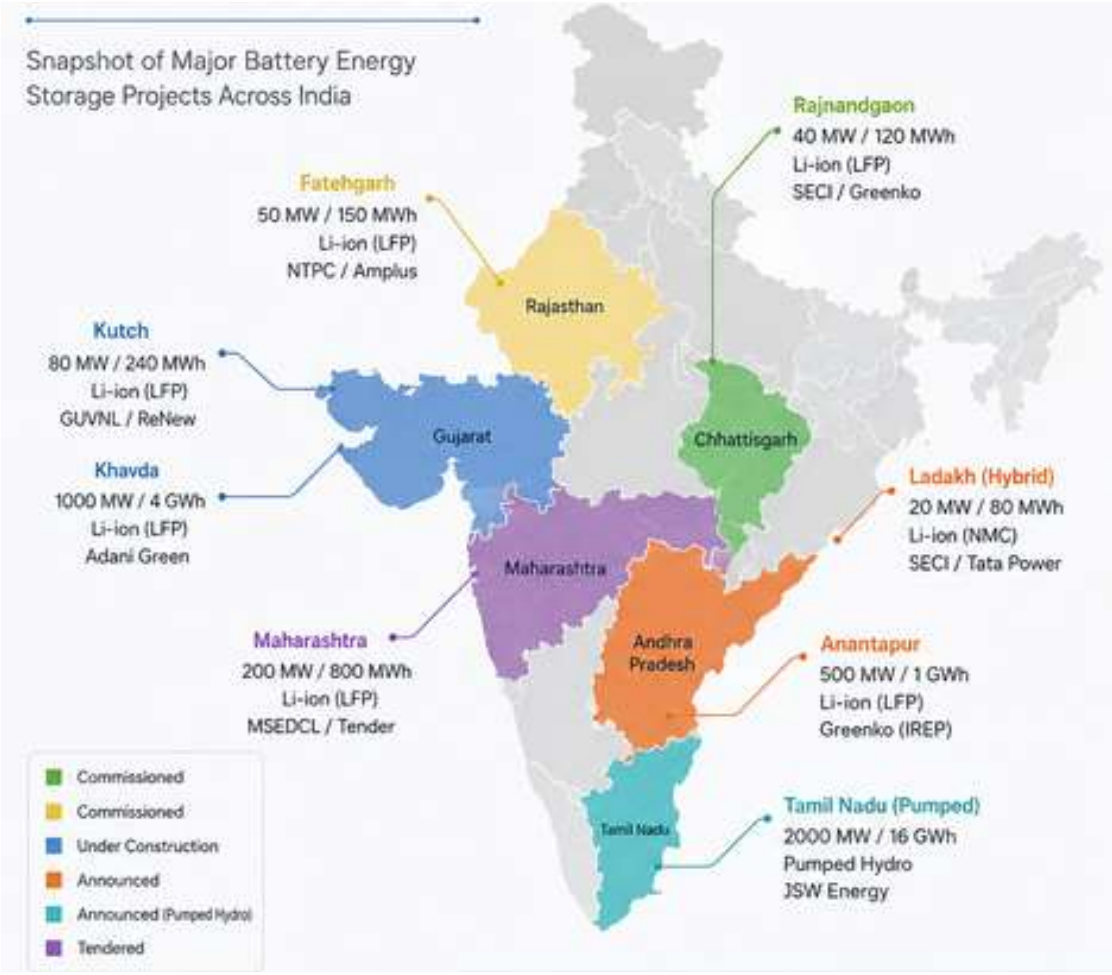
SUPPLY

LANDSCAPE

CURRENT DEPLOYMENT STATUS

PROJECT	CAPACITY	TECHNOLOGY	DEVELOPER	STATUS
Rajnandgaon, Chhattisgarh	40 MW/120 MWh	Li-ion (LFP)	SECI / Greenko	Commissioned
Fatehgarh, Rajasthan	50 MW/150 MWh	Li-ion (LFP)	NTPC / Amplus	Commissioned
Kutch, Gujarat	80 MW/240 MWh	Li-ion (LFP)	GUVNL / ReNew	Under Construction
Ladakh (Hybrid)	20 MW/80 MWh	Li-ion (NMC)	SECI / Tata Power	Under Construction
Anantapur, AP	500 MW/1 GWh	Li-ion (LFP)	Greenko (IREP)	Announced
Khavda, Gujarat	1000 MW/4 GWh	Li-ion (LFP)	Adani Green	Announced
Tamil Nadu (Pumped)	2000 MW/16 GWh	Pumped Hydro	JSW Energy	Announced
Maharashtra	200 MW/800 MWh	Li-ion (LFP)	MSEDCL / Tender	Tendered

Total Commissioned: ~0.5 GWh | **Under Construction:** ~0.4 GWh | **Announced Pipeline:** ~21 GWh



SUPPLY CHAIN DEPENDENCIES

India's BESS ambitions face critical supply chain bottlenecks across raw materials, cell manufacturing, and system integration. The table below maps key dependencies, current domestic capability, and risk levels.

COMPONENT	PRIMARY SOURCE	DOMESTIC STATUS	RISK LEVEL
Lithium Carbonate	Australia, Chile, Argentina	No domestic mining; 100% imported	HIGH
Graphite (Anode)	China (70% global)	Limited processing capacity	HIGH
LFP Cathode Material	China (85% global)	Pilot plants only (Amara Raja)	HIGH
Cell Manufacturing	China, South Korea	5 GWh planned (Reliance, Ola)	MEDIUM-HIGH
Battery Management Systems	US, Europe, China	Emerging (Lohum, Log9)	MEDIUM
Power Conversion Systems	China, Europe	Growing domestic (ABB, Siemens India)	MEDIUM
EPC & Integration	Domestic + Global	Strong capability (Tata, L&T, Sterling)	LOW
Thermal Management	China, Japan	Limited; mostly imported	MEDIUM-HIGH
Separator Films	China, Japan, Korea	No domestic production	HIGH
Electrolyte	China (80% global)	Small-scale R&D only	HIGH

Key Insight: 80%+ of critical battery materials are sourced from China, creating significant geopolitical and logistics risk for India's 236 GWh target.

India is largely an assembly and deployment market for BESS, not a manufacturing one. Every project today is overwhelmingly dependent on Chinese cells, Chinese cathode material, and Chinese or Korean power conversion equipment. This is not a short-term gap — it is a structural dependency that will persist for 5–8 years even with aggressive PLI execution.

STRATEGIC SUPPLY CHAIN RISK MATRIX

Detailed risk assessment of India's BESS supply chain dependencies with strategic mitigation timelines.

DIMENSION	CURRENT SITUATION	STRATEGIC RISK	MITIGATION TIMELINE
LFP cell supply	~85% global supply from China (CATL, BYD, Gotion, EVE)	Supply disruption, price manipulation, export restriction	5–8 years for India domestic scale (P)
Lithium processing	~65% of global Li processing in China	Choke point on raw material even if mined elsewhere	Diversification underway; Australia/Chile alternatives
Cathode material (LFP)	~90% cathode manufacturing in China	Price and availability controlled upstream	India PLI for ACC; early stage
BMS chips / components	Heavy dependency on US/Taiwan chips via Chinese integrators	Secondary sanctions risk; chip export controls	Difficult — semiconductor localization >10 years away
Equipment pricing	Chinese PCS/inverters 20–35% cheaper than Western alternatives	Race-to-bottom pricing; but risks in quality and warranty	Maintain supplier diversification; avoid single-source
India PLI status	₹18,100 Cr ACC PLI scheme; Ola, Rajesh Exports, Reliance NE won bids	Execution risk; scale still years away	First meaningful domestic cell output: FY2027–28 (P)

Strategic Implication: India cannot achieve energy storage sovereignty without 5–10 years of sustained industrial policy. Near-term BESS deployment will remain China-dependent regardless of PLI outcomes.

SECURING THE UPSTREAM: INDIA'S OVERSEAS LITHIUM STRATEGY

India remains heavily dependent on imports for lithium and battery raw materials, and the concentration of that dependency is the structural backdrop against which its recent supply-chain moves must be read. China dominates every downstream stage that matters: it controls an estimated 65–70% of global lithium refining capacity, the majority of cathode production, and the dominant share of cell manufacturing. India, by contrast, has very limited domestic lithium production and almost no refining capacity, which makes lithium security a strategic concern for both the electric vehicle and battery storage sectors. Recognising this exposure, India has begun taking concrete steps to diversify supply away from China through overseas mineral partnerships and acquisitions.

ARGENTINA

India's most significant lithium deal. The most concrete development to date came in January 2024, when India's state-owned Khanij Bidesh India Ltd. (KABIL) signed an agreement with Argentina's state-owned CAMYEN for the exploration and development of five lithium brine blocks in Catamarca Province. This marked India's first overseas lithium exploration and mining project. The agreement covers five brine blocks spanning approximately 15,700 hectares, with exclusive exploration rights granted to KABIL and commercial exploitation rights available upon successful discovery and development. KABIL began exploration activities in October 2024, with deeper exploration following, and the Indian government has indicated that commercial production could begin around 2029, subject to exploration results. The asset positions India, for the first time, as a direct participant in upstream lithium rather than a pure importer.

AUSTRALIA

A strategic critical-minerals partnership. India and Australia have strengthened cooperation on critical minerals through the India–Australia Critical Minerals Investment Partnership and broader trade and economic engagement. Australia holds some of the world's largest lithium resources and is already a major producer, and Indian policymakers increasingly view it as a key long-term source of lithium concentrate. Unlike the Argentine project, however, the Australian relationship has not yet produced a headline government-owned mine acquisition, and remains at the stage of partnership and private-sector investment discussion rather than secured supply.

SECURING THE UPSTREAM: INDIA'S OVERSEAS LITHIUM STRATEGY

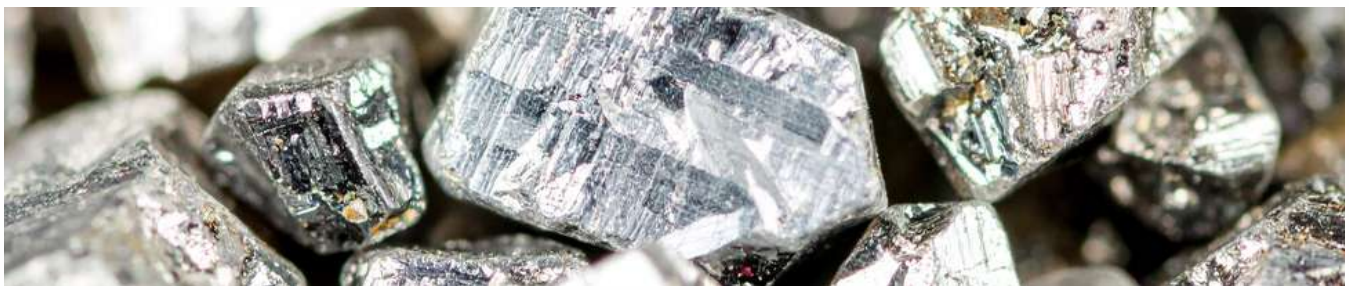
Chile and the Lithium Triangle. India has also been evaluating opportunities in Chile, a major producer and part of the "Lithium Triangle" alongside Argentina and Bolivia. KABIL is reported to be assessing prospects in Chile and other Latin American jurisdictions, though the Argentine blocks remain India's most advanced overseas lithium asset by some distance.

BRAZIL AND CANADA

Beyond South America and Australia, the Indian government has indicated that it is examining critical-mineral investment opportunities in Brazil and Canada. These are part of a broader diversification strategy aimed at reducing reliance on a single dominant supplier, but they remain exploratory rather than committed.

THE LIMIT OF THE STRATEGY

For an investor, the important nuance is that these initiatives improve resource security without resolving India's deeper vulnerability. Securing lithium ore or brine from Argentina or Australia addresses only the raw-material end of the chain; it does nothing to close the gap in refining and battery-materials processing, where China retains a commanding global position. Even with diversified ore sources, India must still build domestic refining, cathode, and cell-manufacturing capacity before it can claim meaningful supply-chain independence — and that capacity, as noted elsewhere in this report, is several years from operating at the scale the storage build-out requires. Overseas mineral acquisition is therefore best understood as a necessary first move rather than a solution: it secures the input, but the chokepoint remains downstream.



KEY CHALLENGES

IN BESS

CHALLENGE 1 — WEAK AND EVOLVING REVENUE MODELS

Most BESS projects in India today cannot point to a clearly bankable, diversified revenue stack. The revenue models are real but fragile — dependent on regulatory frameworks that are still being built, market structures that are nascent, and price dynamics that are inherently uncertain.

THE ARBITRAGE CONSTRAINT

Energy arbitrage — buying cheap midday and selling expensive evening — is the merchant model's foundation. The economics became viable for the first time in FY2024 when daily price spreads in the IEX DAM consistently exceeded the Levelised Cost of Storage (LCOS). However, this viability is fragile:

- **Price cap suppression:** India's ₹10/kWh DAM price cap limits the upside of arbitrage. In liberalised markets (Australia, UK), price spikes of $500–2,000/MWh during scarcity create very high arbitrage margins. India's cap structurally limits the merchant model's ceiling.

- **Capture rate erosion:** As more BESS is deployed, each additional asset competes with others for the same arbitrage opportunity. Markets with high BESS penetration (South Australia, California) show declining arbitrage margins over time. India is 5–7 years from this problem, but it is not avoidable.

- **Low base electricity prices:** India's average DAM clearing price (outside peak hours) is ₹3–5/kWh — low by international standards. This constrains the denominator of arbitrage economics.

- **Single-stream dependency risk:** Projects designed around arbitrage alone are vulnerable. The UP BESS tender (₹6.45/kWh contracted) and Gujarat benchmark (₹4.5L/MW/month) provide revenue certainty — but contracted projects at these rates are dependent entirely on DISCOM payment reliability.

Case study — UP BESS Tender (2024): Uttar Pradesh NEDA awarded 1 GW / 4 GWh of BESS at ₹6.45/kWh. This is India's largest standalone BESS tender to date. The tariff implies acceptable economics for the developer — but UPNEDA/UP DISCOM payment track record is a significant credit risk. The project's IRR depends entirely on timely and full payment over a 15-year contract period. This is the DISCOM problem in microcosm.

CHALLENGE 2 — THE DISCOM PROBLEM

The financial health of India's distribution companies (DISCOMs) is the single most important structural risk in the entire BESS investment landscape. A BESS contract is only as good as the entity obligated to pay for it — and India's DISCOMs are chronically financially distressed.

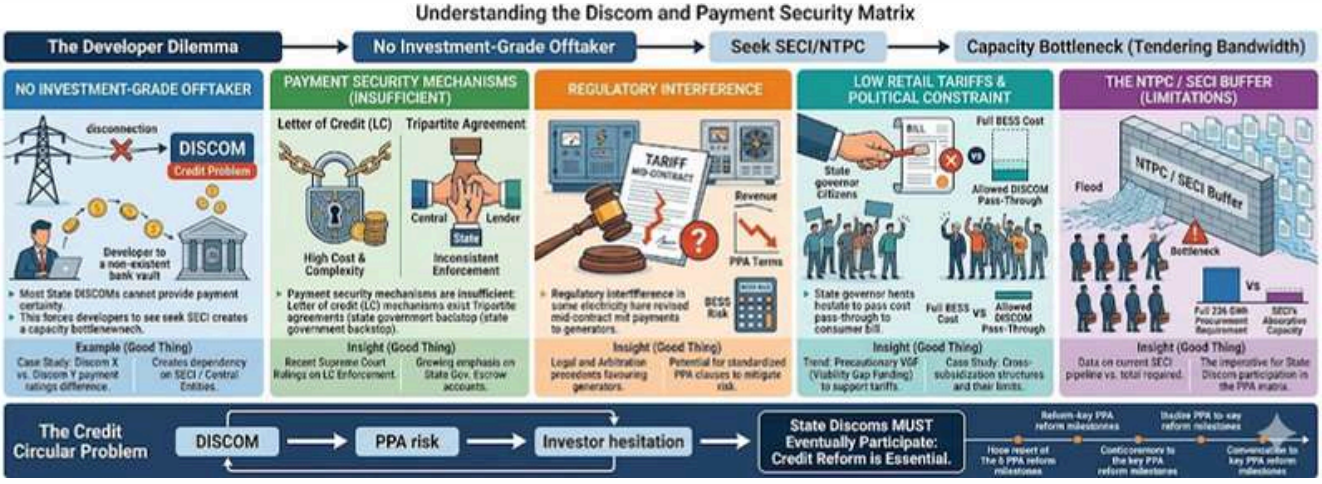
THE FINANCIAL HEALTH OF INDIA'S DISCOMS

DISCOM FINANCIAL METRIC	CURRENT SITUATION	TREND	IMPLICATION FOR BESS
Aggregate Technical & Commercial (AT&C) losses	~16–18% national average (FY2024 E)	Slowly improving from 22%+ in 2015	Every unit of AT&C loss is revenue not collected; erodes payment capacity
Aggregate payable to generators (dues)	~₹1.5–2.0 lakh Cr outstanding (E)	Persistent structural problem	BESS contracted payments compete with already-unpaid generators
Average cost of supply vs average revenue	Gap of ~₹0.50–1.00/kWh in many states (E)	Widening in some states	DISCOMs structurally lose money on every unit sold in many states
State government subsidy dependence	Most DISCOMs require annual state bailouts to survive	Structural	Political risk: new state government can cut subsidies; DISCOM defaults
UDAY scheme outcomes	UDAY (2015–2020) reduced debt but did not fix fundamentals	Reforms incomplete	RDSS (2021) next reform attempt; outcomes still uncertain
Credit ratings	Majority of DISCOMs unrated or below investment grade	Stable to deteriorating	Project debt cannot be raised against DISCOM offtake without sovereign guarantee

WHY DISCOM WEAKNESS KILLS BESS BANKABILITY

For a BESS project developer seeking project finance, the offtaker's credit quality is not a secondary concern — it is the primary bankability determinant. Project finance lenders assess Debt Service Coverage Ratio (DSCR) against expected cash flows. If the offtaker cannot reliably pay, there are no reliable cash flows, and therefore no bankable project.

1. **No investment-grade offtaker:** Most state DISCOMs cannot provide investment-grade payment certainty. This forces developers to seek SECI (central government) as the offtaker — which is better but creates a capacity bottleneck in SECI's own tendering bandwidth.
2. **Payment security mechanisms are insufficient:** Letter of credit (LC) mechanisms exist but add cost and complexity. Tripartite agreements (state government backstop) are available but inconsistently enforced.
3. **Regulatory interference:** State electricity regulators in some states have revised tariffs mid-contract or applied disallowances that reduce effective payments to generators. BESS projects face the same risk.
4. **Low retail tariffs create political constraint:** State governments hesitate to pass through the full cost of BESS procurement to consumers via retail tariff increases — creating a structural limit on how much DISCOMs can pay for contracted storage capacity.
5. **The NTPC / SECI buffer:** Central government-backed entities (NTPC, SECI, SJVN) provide a credible offtaker alternative. But they cannot absorb the full 236 GWh procurement requirement. The math requires state DISCOMs to eventually participate — which circles back to the credit problem.



The DISCOM problem is not a risk to model around — it is the central structural constraint of India's BESS market. Any investment thesis that does not explicitly address offtaker credit quality is incomplete.

CHALLENGE 3 — REGULATORY AND MARKET STRUCTURE GAPS

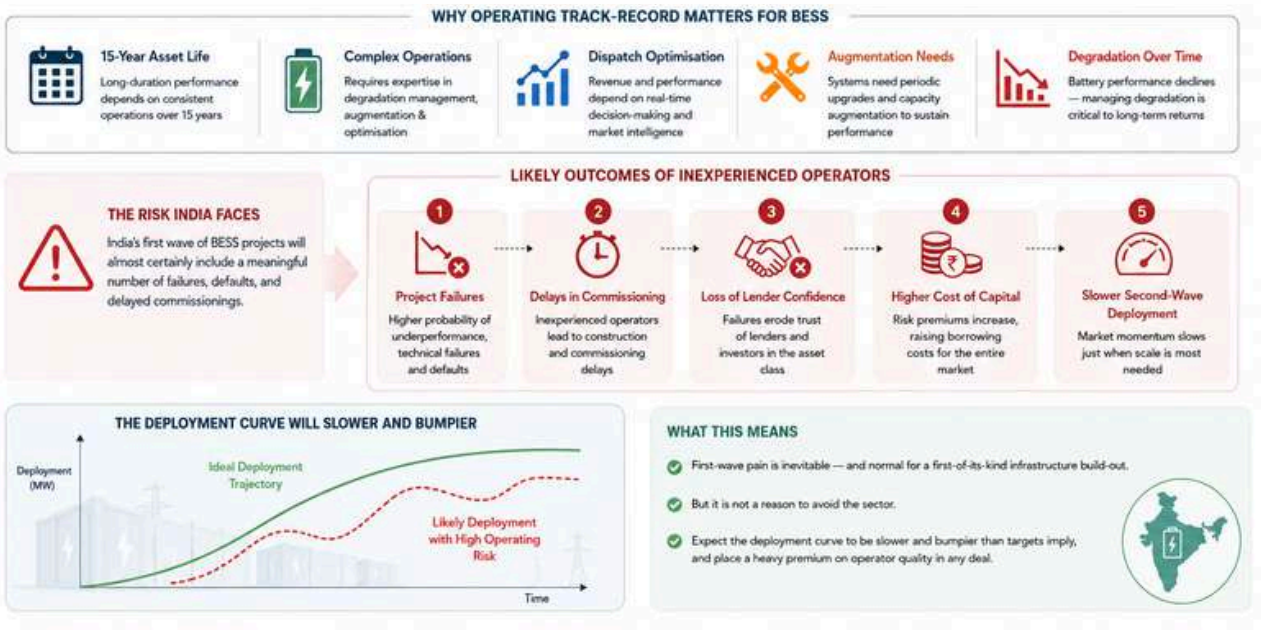
India has made significant regulatory progress on BESS (VGF, ESO, ISTS waivers, SRAS). But critical gaps remain in the market architecture that prevent BESS from realising its full economic potential.

REGULATORY GAP	CURRENT STATUS	IMPACT	REQUIRED ACTION
No capacity market or capacity payment mechanism	India has no formal capacity market; storage earns only on energy delivered	BESS cannot monetise its availability value; limits project economics	CERC consultation on capacity markets ongoing; no timeline confirmed
Ancillary services market depth	SRAS operational but small; TRAS still in design; RRAS being phased out	Ancillary revenue only 15–20% of total stack; insufficient standalone	TRAS market design must be finalised with bankable payment rates
State-level inconsistency	Each state has different storage rules, tariff treatment, and open access policy	Developers cannot apply uniform business models across states; fragmentation increases cost	National framework (MoP 2023) helps but state implementation lags
No standard for behind-the-meter storage	No national framework for C&I storage installation, tariff treatment, or net metering for storage	C&I market cannot scale without clear rules on bill impact and grid interaction	CERC and state regulators need harmonised C&I storage regulations
RPO/ESO enforcement	Renewable Purchase Obligation enforcement varies significantly by state	ESO (storage component) may face same weak enforcement; mandated demand may not materialise	CERC / state regulators must ensure ESO is enforced with penalties
Market coupling and real-time signals	India's power market structure fragments price signals across DAM, RTM, and bilateral markets	BESS dispatch optimisation is sub-optimal without integrated real-time market signals	CERC market design reforms needed; convergence of market segments

CHALLENGE 4 — OPERATING TRACK-RECORD RISK

BESS is a 15-year infrastructure asset being deployed largely by developers with zero operating history in storage. The winners of India's early tenders include names that no serious infrastructure-finance desk would recognise — entities whose experience is in construction or unrelated sectors, not in operating an electrochemical asset across a decade and a half of degradation, augmentation, and dispatch optimisation. The report identifies speculative bidding but does not follow the thread to its logical end.

That end is this: India's first wave of BESS projects will almost certainly include a meaningful number of failures, defaults, and delayed commissionings. When they occur, they will damage lender confidence and set back second-wave deployment — raising the cost of capital for the disciplined operators precisely when the market needs them most. This is a normal feature of a first-of-its-kind infrastructure build-out, not a reason to avoid the sector, but it is a reason to expect the deployment curve to be slower and bumpier than the targets imply, and to place a heavy premium on operator quality in any deal.



CASE STUDIES

REAL TENDER ANALYSIS

CASE STUDY A: UP BESS TENDER — ₹6.45/KWH (2026)

News EV+Storage

SAUR ENERGY INTERNATIONAL

UPPCL Awards 375 MW BESS Tender to KCC Buildcon, Agastya Energy, MKC Infra

The tender for a 4-hour, 1-cycle BESS under VGF Tranche 2 was awarded Rs. 6.45/kWh to Rs. 6.46/kWh to three of the 11 companies that bid for the project. UPPCL had issued the tender for this project in September and awarded the bids after seven months.

Company	Capacity Awarded	Tarrif Rate
KCC Buildcon Private Limited	187.5 MW	Rs. 6.45/unit
Agastya Energy Industries	62.5 MW	Rs. 6.45/unit
MKC Infrastructure Ltd (MKC Green Energy)	187.5 MW	Rs. 6.46/unit

KCC Buildcon PVT. LTD. Dedication to Quality | Agastya | MKC Foundation for the Future

Among the winning bidders, companies like KCC Buildcon Private Limited won the 187.5 MW Battery Energy Storage Project (BESS, and Agastya Energy Industries Pvt Ltd (Agastya Green Energy) won the 62.5 MW BESS project, both won the project at Rs. 6.45/unit. Whereas MKC Infrastructure Ltd (MKC Green Energy) secured it for Rs. 6.46/unit for a 187.5 MW BESS Project.

Other companies that bid for the project include Coal India, NLC India Renewables, MB Power (Madhya Pradesh), Stockwell Energy Vall Five, RKC Infra Built Energy Vault Five Private Limited, Avaada Energy, Ayana Renewables, and Gallantt Ispat.

CASE STUDY A: UP BESS TENDER — ₹6.45/KWH (2026)

ABOUT THE TENDER

Uttar Pradesh has issued its latest Battery Energy Storage System (BESS) tenders under VGF Tranche 2. Uttar Pradesh Power Corporation Limited (UPPCL), through its large-scale BESS tender for **375 MW / 1500 MWh**, has specified a minimum bid size of 250 MWh, i.e., 62.50 MW × 4 hours.
Developers are required to arrange charging power for the BESS project from renewable energy sources and design the system to provide a maximum of 4 hours of discharge capacity. The project is supported by Viability Gap Funding (VGF) under the Power System Development Fund (PSDF).

This tender enables the allocation of over 50% of the capacity under VGF Tranche 2. With this, around 15.5 GWh of capacity under the VGF scheme has now been tendered. States such as Rajasthan and Gujarat, along with Maharashtra, have already issued cumulative bids of 4 GWh, while Andhra Pradesh has issued 2 GWh, and Uttar Pradesh now adds 1.5 GWh.

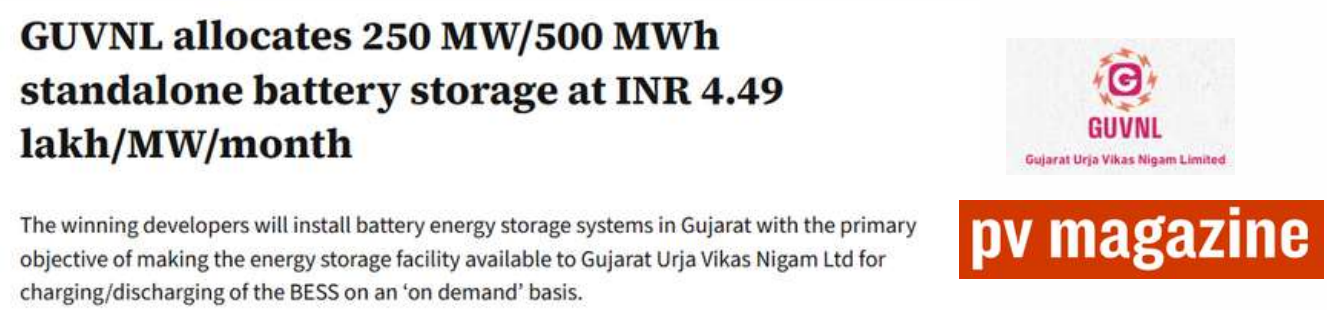
BID DYNAMICS AND MARGIN COMPRESSION

The ₹6.45/kWh tariff in the UP tender represents a significant compression from the theoretical revenue ceiling. Analysis of the bid dynamics reveals a familiar pattern in India's renewable energy tender market:

- **Multiple bidders competed aggressively:** Reports indicate 5–7 qualified bidders with tariffs ranging from ₹6.45 to ₹7.80/kWh, suggesting the winning bid may not fully price in project risk.
- **L1 discovery drives race to the bottom:** India's lowest-bid-wins (L1) auction design creates incentives to bid at the margin of viability, assuming optimistic CapEx, optimistic cycles, and reliable payment — none of which is guaranteed.
- **No risk premium for DISCOM credit quality:** The winning tariff appears to embed no premium for UPCL's weak payment track record, which is a significant analytical gap.

The UP tender illustrates both the opportunity (large-scale, government-backed demand) and the risk (DISCOM payment uncertainty; margin compression). The project is likely viable if — and only if — payment security mechanisms are enforced. For investors, this is a case where deal structure (payment security mechanism, LC, escrow) matters as much as tariff level.

CASE STUDY B: GUVNL GUJARAT — ₹4.48–4.49 LAKH/MW/MONTH (FY2024)


GUVNL allocates 250 MW/500 MWh standalone battery storage at INR 4.49 lakh/MW/month

The winning developers will install battery energy storage systems in Gujarat with the primary objective of making the energy storage facility available to Gujarat Urja Vikas Nigam Ltd for charging/discharging of the BESS on an 'on demand' basis.

GUVNL
Gujarat Urja Vikas Nigam Limited

pv magazine

Gujarat Urja Vikas Nigam Ltd (GUVNL) has concluded its 250 MW/500 MWh standalone battery energy storage tender at a tariff of INR 4.49 lakh (around $5,429)/MW/month—58% lower than INR 10.8 lakh/MW/month tariff discovered in SECI's 500 MW/1000 MWh auction in 2022. Gensol won 70 MW by quoting the lowest bid of INR 448,996/MW/month. IndiGrid secured the balance 180 MW at INR 449,996/MW/month.

The winners will install battery energy storage systems totaling a capacity of 500 MWh (250 MW x 2 hrs) in Gujarat, with the primary objective of making the energy storage facility available to GUVNL for charging/discharging of the BESS on an "on demand" basis. The projects are to developed on a build-own-operate (BOO) model.
GUVNL shall enter into a battery energy storage purchase agreement with the successful bidders.

The BESS shall be charged by drawing power from GETCO and inject power into the GETCO network per the dispatch instructions issued by SLDC in consultation with GUVNL. GUVNL will provide the required power for charging the BESS considering the minimum system efficiency under the agreement.
The developers will make the BESS available for two operational cycles per day, i.e., two complete charge-discharge cycles per day.

PARAMETER	DETAIL
Issuing authority	Gujarat Urja Vikas Nigam Limited (GUVNL)
Tender specification	250 MW / 500 MWh standalone BESS; 2-hour duration; grid-connected
Awarded tariff	₹4.48–4.49 Lakh/MW/month (capacity-based; not per kWh)
Contract duration	12 years
Offtaker	GUVNL (Gujarat's state utility — among India's strongest financially)
Why this matters	India's first large standalone BESS tariff discovery; sets national benchmark

Gujarat's tender is the national benchmark. Its combination of capacity-based tariff, strong DISCOM credit, and supportive policy creates 16–20% IRR — materially better risk-adjusted return than UP's 12–16% with weak offtaker. Gujarat is the reference state for BESS investment underwriting.

75% OF BATTERY STORAGE PROJECTS BELOW VIABILITY BENCHMARKS

Aggressive bidding, collapsing tariffs and rising supply-chain costs squeeze project economics across India's 2-hour standalone BESS market

75% battery storage projects below viability benchmarks

SAURAV ANAND
New Delhi, May 26

INDIA'S RAPIDLY EXPANDING battery energy storage sector is coming under mounting financial and execution stress. Nearly 75% of the country's allocated two-hour standalone battery storage capacity in 2025 falls below viability benchmarks as aggressive bidding, collapsing tariffs and rising supply-chain costs squeeze project economics.

According to a new report by JMK Research and the Institute for Energy Economics and Financial Analysis (IEEFA), standalone Battery Energy Storage System (BESS) tariffs fell as low as ₹1.48 lakh per MW per month for two-hour systems in 2025, significantly below the benchmark viability tariff of ₹2.3 lakh per MW per month.

"Nearly 75% of allocated 2-hour BESS capacity falls into the at-risk viability category, indicating a major gap between discovered tariffs and actual project costs," the report titled Viability of standalone battery energy storage tariffs discovered in 2025 said.

India allocated around 10.4 GW of standalone BESS capacity in 2025. Cumulative energy storage tendered capacity surged more than 13 times from 6.8 GW in 2018 to 90.7 GW by 2025. Standalone storage tenders accounted for over 71% of total storage capacity tendered during the year, with standalone BESS projects making up around 60% of this capacity.

The report said the rapid fall in tariffs was increasingly diverging from actual project costs and execution realities.

Between 2022 and 2025, average standalone BESS tariffs declined by nearly 79.6%, while battery pack prices fell only 36.5% during the same period, exposing developers to rising cost pressures and weak project returns. "Tariff reduction accelerated sharply in the second half of 2025," the report said, adding that several large-scale tenders were awarded at "very low prices, suggesting speculative bidding behaviour".

The stress is beginning to spill into financing and project execution. The report said implementation delays ranging from nine to 18 months could continue because of challenges related to financial closure, procurement and commissioning.

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75%
BESS capacity at risk
Below viability benchmarks

₹1.48L
Lowest tariff discovered
Per MW/month (2-hr system, 2025)

₹2.3L
Viability benchmark
Minimum needed per MW/month

79.6%
Tariff decline 2022–25
vs 36.5% decline in battery costs

Tariffs fell 79.6% between 2022–2025 — while battery pack prices fell only 36.5%. Developers are being squeezed between auction-driven price compression and real-world cost inflation

KEY FINDING	DETAIL FROM REPORT
Tariff vs benchmark gap	Standalone BESS tariffs fell as low as ₹1.61 lakh/MW/month for 2-hour systems in 2025 — significantly below the benchmark viability tariff of ₹6.3 lakh/MW/month identified by the report
Scale of the problem	India allocated ~18.4 GW of standalone BESS capacity in 2025; cumulative energy storage deployed capacity surged from 5.0 GW (2018) to 90.7 GW (2025) — 53+ growth
Standalone dominance	Standalone storage accounted for 75% of total storage capacity tendered in 2025, with standalone BESS projects making up ~90% of this season
Tariff cost divergence	Between 2022 and 2025, average standalone BESS tariffs declined by 79.6%, while battery pack prices fell only 36.5% — squeezing developers to a widening cost-revenue gap
Speculative bidding	Multiple developers quoted tariffs well below any feasible cost floor, suggesting speculative bidding behaviour — developers bidding below their own cost floor to win volume
Execution consequences	Implementation delays of 6 to 18 months expected due to financial distress, failures, procurement difficulties, and commissioning bottlenecks
Tariff acceleration	Tariff reduction accelerated sharply in the second half of 2025 — the problem is worsening, not stabilising

INDIA BESS

ECOSYSTEM

SEGMENT 1 : SODUIM- ION BATTERIES

Sodium-ion is the most strategically important alternative chemistry for India. It eliminates lithium dependency, tolerates India's high ambient temperatures better than LFP, and has domestic raw material supply. Four India-based players are developing Na-ion technology at various stages of maturity.

GOODENOUGH ENERGY

Company	Qood ENOUGH
Segment	Sodium-ion battery systems and energy storage
Focus	Na-ion BESS systems designed for distributed and grid-scale storage in Indian operating conditions
Why Relevant	Takes a systems-level approach — complete BESS units built around Na-ion, not just cell or chemistry R&D; bridges lab to deployment
Strategic Fit	India-specific design for high ambient temperatures; domestic material sourcing aligned with import substitution goals
Stage	Early-stage product development; pre-commercial scale
Key Differentiator	Full-stack integration of Na-ion chemistry into deployable storage products, not just cells
Key Risk	Technology maturity relative to CATL Na-ion already at commercial stage; domestic scale-up timeline uncertain

GoodEnough Energy occupies a rare position in India's sodium-ion landscape: rather than developing chemistry in isolation, it is building complete storage systems around Na-ion cells, targeting the moment when the technology is ready to deploy rather than waiting to license IP. India's extreme heat and import dependency on lithium give this company a context-specific value proposition that no Chinese manufacturer can replicate domestically. The key question is timing — whether its product matures ahead of, or behind, CATL's commercially available Na-ion reaching the Indian market at scale.

KPIT TECHNOLOGIES

Company	KPIT
Segment	Sodium-ion innovation and indigenous battery technology
Focus	Automotive technology and software company pursuing Na-ion R&D as a strategic adjacency to its EV battery systems work.
Why Relevant	Brings credible engineering depth and automotive industry relationships to a chemistry where India needs technical talent above all.
Current Status	R&D and IP development stage; not yet at commercial product
Key Differentiator	Engineering capability and automotive OEM relationships; Na-ion could enter EV and stationary supply chains simultaneously.
Key Risk	Core business distraction; battery commercialisation requires dedicated focus that a services company may not sustain

KPIT Technologies represents India's established technology sector entering the battery chemistry space — a pattern that could accelerate commercialisation significantly given the engineering talent and customer access it brings. Its Na-ion work is credible precisely because battery electronics and automotive software are adjacent to what it already does. The investment risk is not technical but organisational: whether KPIT treats this as a core product line or a strategic R&D experiment will determine whether it produces a deployable technology or a set of patents.

NAXION ENERGY

Company	Naxion Energy
Segment	Sodium-ion BESS for distributed storage
Focus	Commercialising sodium-ion storage systems specifically for distributed and behind-the-meter applications in India
India Strategic Angle	Founded on an India-first Na-ion thesis; domestic sodium abundance and heat tolerance are core to the value proposition, not add-ons
Target Market	Distributed C&I and rural/semi-urban energy storage where reliability and cost matter more than energy density
Current Status	Early-stage startup; moving from concept to pilot deployments
Key Risk	Very early stage; requires both technology and commercial validation simultaneously with a small team

Naxion is the most focused Na-ion player in India's ecosystem — built around a single thesis rather than entered as an extension of an existing business. Its distributed storage focus is strategically sound because the C&I and semi-urban markets it targets are least well served by large utility-scale LFP imports and most sensitive to cost and heat tolerance. At this stage it requires capital patient enough to absorb the technology de-risking phase, but the potential for a first-mover moat in a genuinely large market is real.

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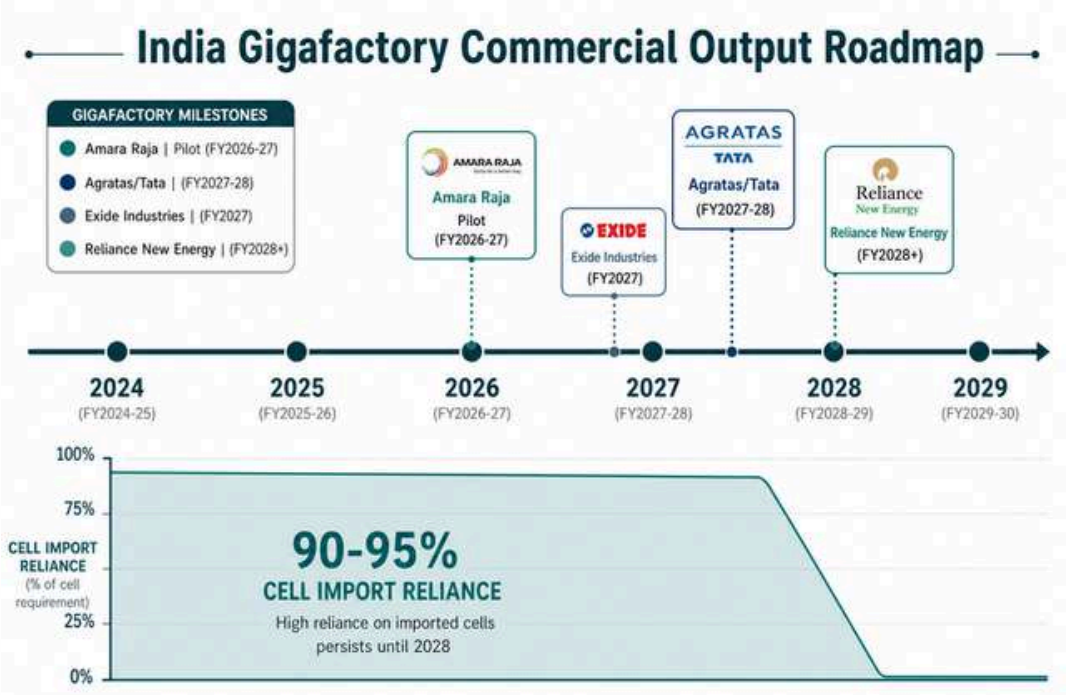
UNIGRID

Company	UNIGRID™ Na-ion
Segment	Sodium-ion R&D and pre-commercial development
Focus	University-linked Na-ion research being transitioned to commercial application; materials and cell chemistry focus
Current Status	R&D stage; academic-to-commercial transition in progress
Key Differentiator	Academic IP base with differentiated insights in electrolyte formulations for Na-ion; potential for novel chemistry contributions
Key Risk	Academic pace vs. startup execution speed; needs a manufacturing bridge partner to reach commercial scale

Unigrid sits at the earliest end of the commercialisation spectrum — a university spinout in the process of becoming a company. Its relevance to this report is as a signal of India's emerging technical capacity in Na-ion chemistry rather than as a near-term deployment player. Early capital here is primarily an IP and talent bet, with a 5-to-7 year horizon before any contribution to BESS deployment at scale.

SODIUM-ION PLAYERS — COMPARATIVE OVERVIEW

Across the four Na-ion players, a clear maturity gradient emerges. GoodEnough Energy is the highest-priority engagement because it has moved beyond chemistry research into systems integration — the stage at which investment capital creates the most leverage. Naxion follows closely with a commercially focused thesis. KPIT is relevant as a technology development partner rather than a primary investment target. Unigrid represents the very earliest stage of the pipeline. Taken together, these four companies confirm that India has genuine domestic capacity in Na-ion — it is not purely dependent on CATL and BYD commercialisation — but the ecosystem is still early enough that first-mover capital is consequential.



SEGMENT 2 : CELL MANUFACTURING & GIGAFACTORIES

Cell manufacturing is the most capital-intensive segment of the BESS value chain. India's PLI scheme (₹18,100 Cr) is the primary demand driver. Four major players are building or planning gigafactories — but all face the challenge that Chinese manufacturers operate at 10× the scale with 30–40% lower costs.

AGRATAS (TATA GROUP)

Company	agratas A TATA Enterprise
Segment	Battery manufacturing — Tata Group's dedicated cell platform
Focus	Large-scale battery manufacturing capacity in India; positioned as Tata's response to global gigafactory investment trends
Scale Ambition	40–50 GWh target (P); cell production timeline FY2027–28; investments announced in India and the UK
Technology Bet	LFP for stationary storage; NMC for EVs; multiple chemistry openness
Competitive Moat	Tata Group balance sheet; relationships with Tata Motors (EV) and Tata Power (grid); brand credibility
Key Challenge	Battery manufacturing is not Tata's core competency; technology partnerships essential; Chinese cost structure is hard to match.

Agratas matters to this report not as an investment opportunity but as an enabling condition. If Tata's battery manufacturing ambition executes at even half its stated scale, it creates a credible domestic cell source that reduces the China dependency that currently runs through every BESS project in India. Its relevance to early-stage investors is indirect: a functioning Agratas supply chain makes the downstream software, integration, and services plays more investable by reducing supply chain risk for their customers.

SEGMENT 2 : CELL MANUFACTURING & GIGAFACTORIES

AMARA RAJA ENERGY & MOBILITY

Company	AMARA RAJA
Segment	Cell manufacturing — India's most advanced lithium-ion cell development effort
Focus	Transition from legacy lead-acid business toward lithium-ion via the Giga Corridor project in Telangana
Giga Corridor	Near Tirupati, Andhra Pradesh; Phase 1 targeting ~5 GWh; full scale 16+ GWh (P)
Production Linked Incentive Status	PLI awardee; first Li-ion cell output expected FY2026–27 at pilot scale
Technology	LFP for stationary and 2W EV; exploring Na-ion as next-generation transition
Key Differentiator	Operational battery manufacturing track record (lead-acid); OEM relationships with 2W manufacturers; south India location

Amara Raja is the most credible domestic cell manufacturing effort in terms of near-term deliverability, largely because it is not starting from zero — it has battery manufacturing infrastructure, customer relationships, and institutional knowledge of electrochemical production. The transition from lead-acid to lithium-ion is non-trivial but not unprecedented. For the BESS ecosystem, Amara Raja's Giga Corridor is the most likely near-term source of domestically manufactured cells — and its exploration of Na-ion as a second-generation chemistry makes it a company to track closely through 2026 and 2027.

SEGMENT 2 : CELL MANUFACTURING & GIGAFACTORIES

EXIDE INDUSTRIES

Company	EXIDE INDUSTRIES LIMITED
Segment	Cell manufacturing — established battery incumbent entering lithium-ion
JV Partner	Leclanche SA (Switzerland) — provides Li-ion technology; Exide provides manufacturing infrastructure and India market access
Current Status	JV formalised; facility planning in Ahmednagar, Maharashtra; commercial production timeline FY2027 (P)
Technology	NMC for EVs; potential LFP for stationary storage via Leclanche's technology stack
Key Differentiator	Century-old battery brand; nationwide distribution network; Leclanche's European technology credentials
Key Challenge	JV execution risk; Leclanche is a smaller player with limited scale vs CATL/BYD; Exide's institutional mindset is still lead-acid

Exide's approach — acquiring European Li-ion technology through a JV rather than developing chemistry indigenously — reflects a pragmatic if slower path to the gigafactory era. The Leclanche partnership provides credibility, but Leclanche's own scale limitations mean this route does not produce a world-competitive cost structure. Exide's real strategic asset is its distribution network and brand trust across India's battery market, which matters more for the C&I behind-the-meter segment than for utility-scale BESS where procurement is centralised.

SEGMENT 2 : CELL MANUFACTURING & GIGAFACTORIES

RELIANCE NEW ENERGY

Company	Reliance NEW ENERGY
Segment	Integrated energy storage — vertically integrated clean energy ambition
Acquisition	Reliance acquired Netherlands-based Lithium Werks (LFP technology developer) for proprietary cell IP and manufacturing know-how
Scale Ambition	₹75,000 Cr+ green energy investment; 50 GWh+ gigafactory ambition (P); Jamnagar as the manufacturing hub
Vertical Integration	Aims to control solar panels, electrolyzers, fuel cells, and batteries — the most ambitious vertical stack of any Indian industrial
Current Status	Planning and land acquisition stage; significant manufacturing scale unlikely before FY2028 (P)
Key Challenge	Limited technology manufacturing track record; Lithium Werks is pre-scale; global competitiveness extremely difficult

Reliance's entry into battery manufacturing is significant not because its execution is assured — it is not — but because Reliance's capital strength means that if it commits seriously, the scale it can reach dwarfs any other Indian player. The Lithium Werks acquisition was the clearest signal of genuine technological intent rather than announcements alone. For ecosystem investors, Reliance as a potential future anchor customer for electrolytes, cathode materials, and manufacturing software is a more reliable use of the relationship than betting on the gigafactory itself at this stage.

CELL MANUFACTURING PLAYERS — COMPARATIVE OVERVIEW

Company	Scale Target	PLI Status	Earliest Output	Technology Bet	Key Constraint
Agratas (Tata)	40–50 GWh (P)	Not PLI; self-funded	FY2027–28 (P)	LFP + NMC	Not Tata's core competency
Amara Raja	16+ GWh (P)	PLI awardee; compliant	FY2026–27 pilot	LFP + exploring Na-ion	China cost competition
Exide Industries	~6 GWh (P)	Not PLI route	FY2027 (P)	NMC / LFP via Leclanche	JV execution; Leclanche scale
Reliance New Energy	50 GWh+ (P)	PLI awardee	FY2028+ (P)	Multiple chemistries	Execution track record

All four cell manufacturers are at least two to three years from meaningful commercial output, and none currently produces cells at a cost that competes with Chinese manufacturers. The common thread is that each is approaching cell manufacturing from a different legacy position — a conglomerate, a battery incumbent, a distribution company, and an industrial giant — and each will need to solve the same core challenge: converting balance sheet capital into process chemistry expertise. For the BESS investment thesis, the most relevant near-term implication is that India will continue to deploy 90-95% imported cells through 2028, and supply chain diversification remains essential for any project underwriting

SEGMENT 3 — BATTERY MATERIALS, CHEMICALS AND SUPPLY CHAIN LOCALISATION

Battery materials — cathode precursors, electrolytes, lithium salts, and separators — are the most import-dependent layer of India's BESS supply chain. Approximately 90% of electrolyte solvents and cathode materials are imported, predominantly from China. The four companies in this segment are attempting to address this vulnerability from different angles. They represent the earliest and least-covered part of India's battery ecosystem.

NEOGEN CHEMICALS

Company	NEOGEN IONICS LTD.
Segment	Battery materials — specialty chemicals and electrolytes for lithium-ion batteries
Focus	Listed specialty chemicals company pursuing battery electrolyte chemicals as a strategic growth area; produces lithium
Why Relevant	Electrolyte localisation is critical for India's battery independence; existing chemistry infrastructure and listed status provide
Current Status	Active in specialty chemicals; battery-specific electrolyte production at development / early commercial stage
Strategic Fit	Reduces dependency on Chinese electrolyte imports (~90% currently imported); aligned with PLI and Aatmanirbhar Bharat goals
Key Differentiator	Existing fluorine chemistry and lithium compound expertise; manufacturing infrastructure already in place

Neogen Chemicals is the most institutionally established player in India's battery materials space, which matters because credibility and capital access are the first two requirements for scaling chemistry manufacturing. Its significance to this report is partly as a direct company and partly as a proof point: a SEBI-listed, profitable specialty chemicals business has made a strategic decision to enter battery electrolytes, which validates the market opportunity in a way that a startup's roadmap cannot. For investors tracking the electrolyte localisation space, Neogen is the benchmark to assess pure-play startups against.

SEGMENT 3 — BATTERY MATERIALS, CHEMICALS AND SUPPLY CHAIN LOCALISATION

ALTMIN

Company	ALTMIN
Segment	Battery materials — cathode active material development
Focus	Developing cathode active materials and upstream battery material processing in India; focused on LFP and NMC cathode synthesis
Why Relevant	Cathode material represents 30–40% of total cell cost; India has near-zero domestic production; ALTMIN addresses the highest-value import substitution opportunity in the battery chain
Stage	Early-stage R&D to pilot; backed by strategic investors with materials industry connections
Key Differentiator	Focus on the highest-value, most import-critical material in the entire battery value chain
Key Risk	Chinese players have 10+ years of process optimisation advantage; scale-up capital requirement is significant

ALTMIN operates in the most commercially significant gap in India's entire battery supply chain. Cathode active material is where the highest proportion of cell cost originates and where India is most completely dependent on Chinese supply. The company's early-stage status means the technology risk is real — cathode synthesis is chemically demanding and process-intensive — but it also means that an investment now enters before the space becomes crowded. If any domestic cell manufacturer reaches meaningful scale by 2027-28, ALTMIN will be among the first domestic cathode suppliers they need.

SEGMENT 3 — BATTERY MATERIALS, CHEMICALS AND SUPPLY CHAIN LOCALISATION

MOLSYNTH

Company	
Segment	Battery chemicals — electrolytes and lithium salts
Focus	Electrolyte formulation and lithium salt synthesis for lithium-ion batteries; complements Neogen in the battery chemistry ecosystem
Why Relevant	Electrolyte is one of the most technically complex battery inputs; domestic formulation capability reduces import dependency and enables India-specific customisation
Key Differentiator	High-temperature electrolyte formulations for India's ambient conditions — generic Chinese electrolytes are not optimised for 45°C operation
Stage	Early-stage; R&D to pilot production
Key Risk	Addressable market is small today as Indian cell manufacturing is pre-scale; Molsynth is dependent on gigafactory ramp-up to create domestic demand

Molsynth's strategic insight — that electrolytes need to be reformulated for India's heat rather than imported as designed for temperate climates — is technically sound and commercially underdeveloped. Standard LFP electrolytes are optimised for operating temperatures between 15 and 35 degrees Celsius; India's deployment environments regularly reach 42 to 48 degrees. Higher ambient temperatures accelerate electrolyte decomposition, reduce cycle life, and increase safety risk. A domestically developed high-temperature formulation addresses this directly. The constraint is demand timing: Molsynth's customers do not yet exist at commercial scale in India.

SOLVING FOR BESS

THE BANKABILITY AGENDA

How India can create revenue certainty despite distribution-sector weakness

SOLVING FOR BESS IN INDIA

Every preceding chapter of this report establishes the same conclusion from a different angle: the technology is proven, the economics crossed the viability threshold in 2024, the policy framework is among the most comprehensive of any emerging market, and the grid physically cannot function at 50% renewable penetration without storage. And yet operational BESS in India sits at roughly 0.5 GWh against a 236 GWh target. The barrier is not what most observers assume.

The most useful reframing of the India storage challenge is to stop calling it a "DISCOM problem" and start calling it a bankability problem. The question that actually determines whether a project gets built is not "are distribution companies financially healthy?" — they are not, and will not be for years — but rather: **how can government and developers create revenue certainty despite that weakness?**

The Central Insight

Lenders do not finance tariffs — they finance certainty of payment. Every effective BESS solution in India therefore works by relocating, guaranteeing, or diversifying the revenue away from the weakest link in the chain. Bankability, not technology or even headline tariff, is the variable that unlocks the 236 GWh build-out.

THE CHALLENGE–SOLUTION MATRIX

The distribution sector's weaknesses translate into specific, identifiable impacts on storage projects — and each impact has a corresponding solution lever. Setting them side by side converts a vague sense of risk into a structured agenda that policymakers, developers, and investors can each act on.

Read down the right-hand column and a pattern emerges: almost every solution does one of three things — it makes the revenue more certain (guarantees, central procurement), it makes the cost lower so less revenue is needed (VGF, subsidies), or it makes the price signal sharper so storage earns more without subsidy (time-of-day tariffs, ancillary markets). These three mechanisms — certainty, cost reduction, and price-signal sharpening — are the structural foundations of everything that follows.

THE CHALLENGE–SOLUTION MATRIX

Challenge	Impact on BESS	Potential Solutions
Political interference in tariffs	DISCOMs cannot fully recover storage costs from consumers	Cost-reflective tariffs; targeted subsidies instead of blanket tariff suppression; pass-through mechanisms for storage procurement
Short-term planning horizon	Reluctance to sign 10–20 year BESS contracts	Mandatory long-term resource adequacy planning; storage procurement targets; integrated resource planning
Existing debt burden	Weak creditworthiness and payment delays	State guarantees; payment security funds; central-government-backed tenders
Low retail tariffs	Limited ability to absorb additional storage cost	Time-of-day tariffs; peak pricing; demand-response programmes; gradual tariff rationalisation
Regulatory uncertainty	Investors demand higher returns, raising project cost	Clear storage regulations; long-term ancillary-service markets; stable procurement frameworks

WHAT INDIA IS ALREADY DOING: THE WORKAROUNDS

The Indian government has, in effect, conceded that waiting for distribution companies to become financially healthy would take too long to meet the 2032 storage targets. Rather than gating storage deployment on distribution reform, it has built a set of workarounds that create bankability around the weak link. Five are already operational or substantially in place, and an investor assessing any India BESS opportunity should understand exactly what each one does to the risk profile of a project.

CENTRALISED PROCUREMENT THROUGH SECI AND NTPC

Rather than relying on individual state distribution companies as counterparties, central entities such as the Solar Energy Corporation of India (SECI) and NTPC Limited aggregate storage demand and run tenders on behalf of multiple states. This is arguably the single most important near-term solution. SECI, as a central government entity, provides a creditworthy counterparty that lenders treat very differently from a financially stressed state DISCOM. The benefits compound: stronger counterparty credit, standardised contract terms across projects, and materially improved lender confidence and therefore lower cost of capital. The practical limit is scale — SECI and NTPC can credibly backstop a meaningful tranche of the national requirement, but the larger balance must eventually flow through state-level offtake, which is precisely why the other mechanisms remain necessary.

VIABILITY GAP FUNDING (VGF)

Battery storage produces system-wide benefits — grid stability, deferred transmission investment, reduced curtailment — that a single project's revenue contract does not fully capture or monetise. Viability Gap Funding bridges that gap with a capital grant: under the operational scheme, up to ₹46 lakh per MWh or 30% of project capital cost, whichever is lower. The effect is threefold — it reduces the upfront capital a developer must finance, it allows developers to bid lower tariffs while preserving returns, and it makes storage procurement more affordable for distribution companies that cannot pass high costs to consumers. VGF has become the primary policy instrument for accelerating standalone BESS deployment, improving project IRR by an estimated 3–5 percentage points.

PAYMENT SECURITY MECHANISMS

This is where the bankability framing becomes most concrete. Lenders care far less about the headline tariff than about the reliability of getting paid on time. India's storage procurement framework therefore increasingly incorporates payment security instruments: escrow accounts that ring-fence DISCOM payments, letters of credit covering several months of dues, explicit state government guarantees, and central payment security funds. Each instrument directly reduces the perceived counterparty risk that would otherwise inflate the cost of debt or block financial closure altogether. For an investor, the presence and quality of these mechanisms is a primary diligence item — a project with a robust payment security package and a weak offtaker can be more bankable than a project with a stronger offtaker and no security.

CREATING ADDITIONAL REVENUE STREAMS

A battery becomes dramatically easier to finance when its return does not depend on a single distribution-company contract. India's market structure increasingly allows a single asset to stack revenue across peak shifting (energy arbitrage on the IEX Day-Ahead Market), frequency regulation and ancillary services (the SRAS market, live since 2023), congestion relief, and capacity support. Instead of one revenue line exposed to one weak counterparty, the developer assembles a diversified portfolio of income streams — some merchant, some contracted, some regulated. This revenue stacking is how most mature BESS markets, from the UK capacity market to Australia's NEM to US ERCOT, reached commercial viability, and it is the structural condition the India report repeatedly identifies as essential to sound underwriting.

TIME-OF-DAY (TOD) TARIFFS

India's electricity prices have historically failed to reflect the true time-varying cost of supply. Time-of-Day tariffs correct this by raising prices during the evening demand peak and lowering them during solar-rich daytime hours. The elegance of this solution is that it increases the economic value of storage without any direct subsidy — a battery that charges cheaply at midday and discharges into an expensive evening peak simply earns more as the price differential widens. As ToD tariff structures roll out across commercial and eventually residential consumers, they sharpen the very price signal that makes storage arbitrage profitable, doing through market design what would otherwise require fiscal support.

WHY THE WORKAROUNDS MATTER MORE THAN THE REFORM

Each of these five mechanisms shares a single design logic: none of them requires distribution companies to first become financially healthy. They create bankable revenue around the weak link rather than waiting to repair it. This is why India's storage market can scale on a 2032 timeline that distribution-sector reform alone could never support.

PRIVATE-SECTOR MODELS THAT BYPASS DISCOM RISK

Beyond government reform and policy workarounds, the market itself is producing business models that reduce or eliminate dependence on distribution companies altogether. For early-stage and venture investors specifically, these private-sector models are often more attractive than utility-scale infrastructure projects, because they sidestep the weakest counterparty in the system and substitute customers with stronger credit profiles and clearer willingness to pay.

COMMERCIAL & INDUSTRIAL (C&I) STORAGE

Large industrial and commercial customers present a fundamentally better counterparty than most distribution companies. They face significant demand charges (₹200–600/kVA/month) and high peak tariffs (₹8–12/kWh), they require reliable backup power, and — critically — many have stronger credit profiles and faster payment behaviour than financially stressed state DISCOMs. A battery installed behind a creditworthy manufacturer's meter earns its return directly from that customer's electricity savings, with no exposure to distribution-company payment risk at all. This is why a growing number of developers regard C&I behind-the-meter storage as the most attractive near-term growth segment, and why the India report identifies it as the closest thing to a venture-scale BESS opportunity available today.

RENEWABLE-PLUS-STORAGE PPAS

Rather than selling storage as a standalone product, developers increasingly co-locate batteries with solar or wind generation and sell a superior product: firm, dispatchable, round-the-clock renewable power under a long-term Power Purchase Agreement. India's Firm and Dispatchable Renewable Energy (FDRE) framework is the policy vehicle for this model, and it is the fastest-growing tender category in the market. The commercial insight is subtle but important — the customer is not buying “storage,” they are buying reliability and schedulability. This reframing makes the value proposition far easier to sell and finance, because it is priced against the value of firm power rather than against a storage cost line that a distribution company struggles to justify to its consumers.

ENERGY-AS-A-SERVICE (EAAS) MODELS

The Energy-as-a-Service model removes the customer's capital barrier entirely. Instead of selling a battery, the developer sells an outcome — peak shaving, guaranteed backup power, or power quality services — under a multi-year service contract, typically taking a share of verified savings. The customer commits no upfront capital; the developer retains ownership of the asset and the recurring revenue. This lowers the adoption barrier dramatically for C&I customers and creates the sticky, recurring revenue base that venture investors prize. The defensible moat in this model is not the hardware but the dispatch software and the customer energy data that compounds with every deployed system — the same EMS-software thesis the India report identifies as the highest-priority venture white space.

BATTERY ENERGY STORAGE SYSTEM

INVESTMENTS

INVESTMENTS: GLOBAL

KEY STATISTICS

420+ Companies

38 Acquisitions

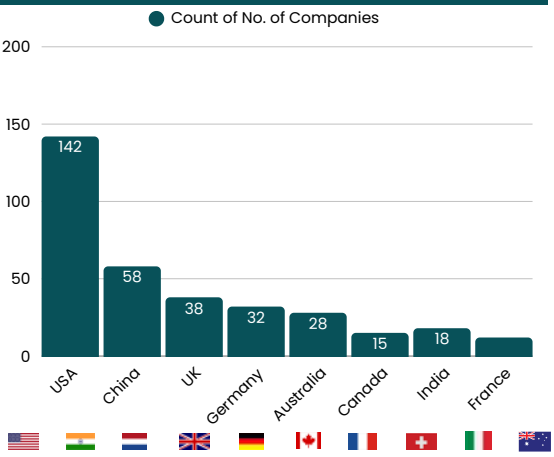
$18.4B Total Funding

$45M Median Valuation

0 Active Unicorns

$8.2M Median Round Size

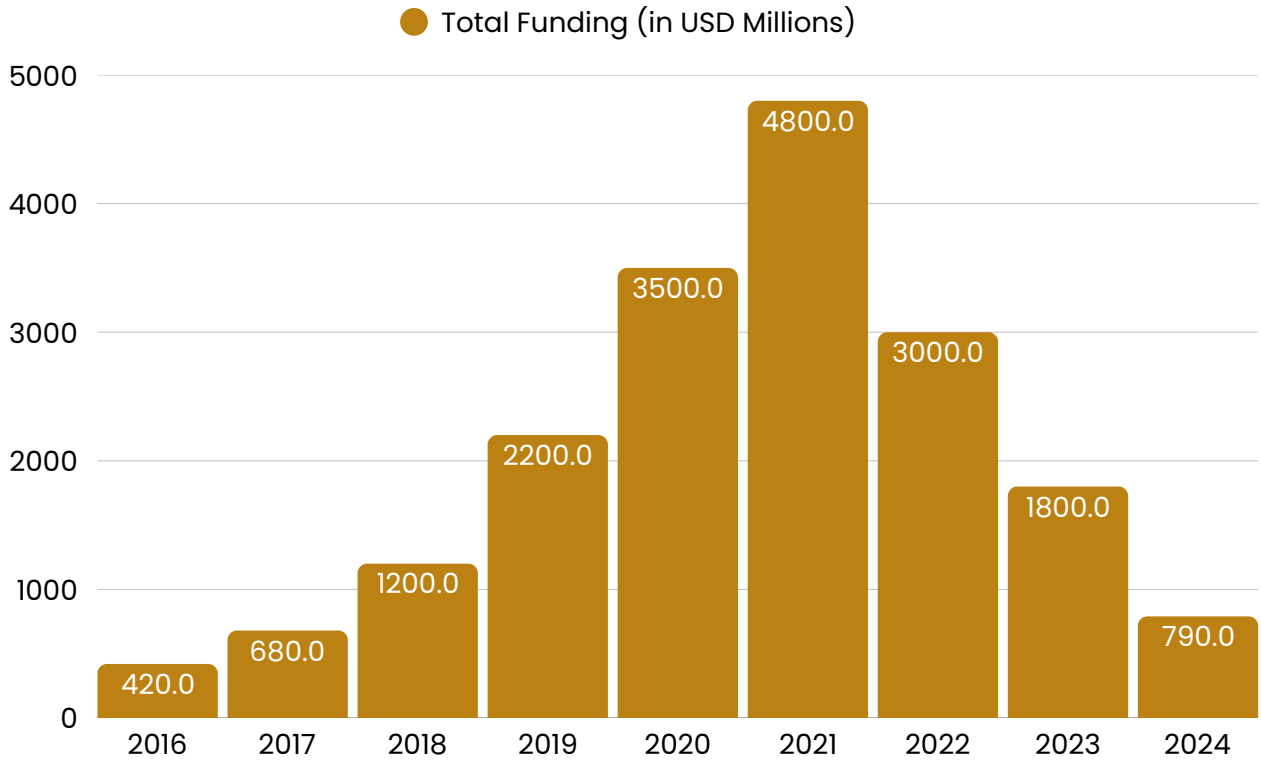
TOP GEOGRAPHIES



Source: Tracxn

Note: *Data represents VC, angel, and institutional investment in India-incorporated BESS technology, recycling, and integration startups (2016–2025). Conglomerate capex (Tata, Reliance, JSW) and government project finance excluded. Stage distribution approximate. Compiled from Crunchbase, press releases and public sources.*

TOTAL FUNDING



Breakthrough Energy · SoftBank Vision Fund · BHP Ventures · TotalEnergies · Energy Impact Partners · Prelude Ventures · Shell · Temasek Holdings

INVESTMENTS: INDIA

KEY STATISTICS

42 Companies

18 Funded Companies

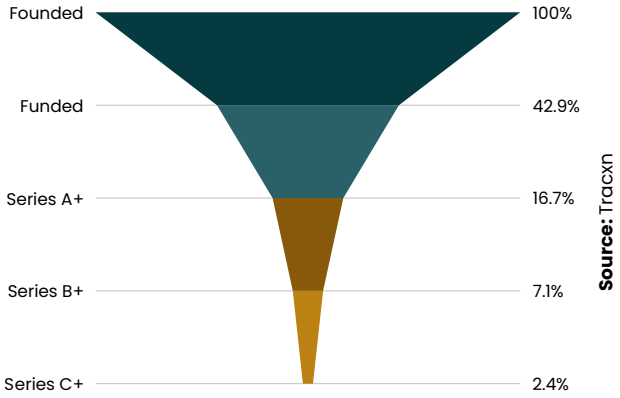
$98.4M Total Funding

$68M Funding in Last 2 Years

0 Active Unicorns

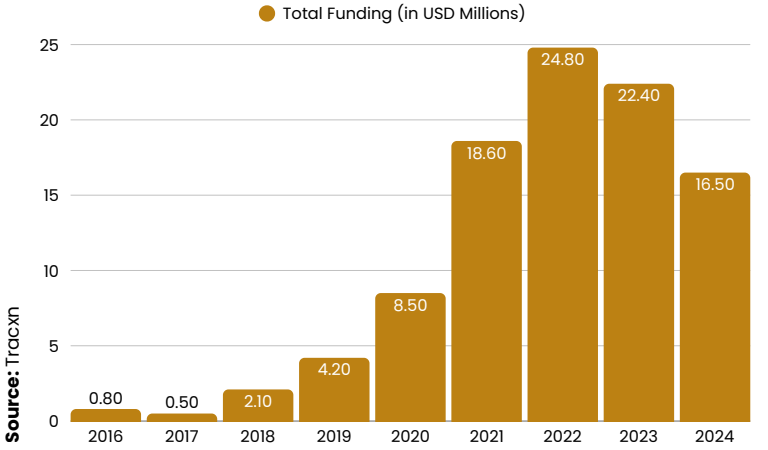
$2.8M Median Round Size

COMPANIES BY CURRENT STAGE



Note: *Data covers VC, growth equity and corporate venture investment in BESS technology, integration, and software companies globally (2016–2024). Project finance and infrastructure construction capex excluded. Compiled from BNEF, Wood Mackenzie, Crunchbase, IEA, and public sources. Most large players (Fluence, Stem, ESS Inc) IPO'd via SPAC in 2021–22, explaining 0 active unicorns.*

TOTAL FUNDING



INVESTORS

AVAANA

kalaari capital

Shell Ventures

BLUME

IFC

Climate Angels

CONCLUDING STATEMENT

The primary barrier to BESS deployment in India is not technology maturity but revenue certainty. The most effective solutions therefore focus on improving project bankability — through centralised procurement, payment security mechanisms, viability gap funding, market-based pricing signals, and the development of diversified revenue streams that reduce dependence on financially stressed distribution companies. This framing shifts the discussion from 'DISCOM weakness' to the more actionable question of how to create financeable storage assets despite DISCOM constraints.

For the investors, this reframing is not merely rhetorical — it is the basis of a deal-selection discipline. Back projects routed through SECI or NTPC offtake, or backed by robust payment security packages. Require diversified revenue stacking rather than single-stream dependency. Favour C&I, EaaS, and FDRE models that substitute creditworthy customers for distribution-company risk. And treat the headline tariff as only one input among several, subordinate to the question that actually governs whether capital can be deployed safely: is the revenue bankable? In India's storage market, that question — not technology, not policy ambition, not even cost — is the one that separates the projects that get built from the 75% of tendered capacity that may never reach financial close.

Sources: Ministry of Power National Framework for Energy Storage; MoP Viability Gap Funding Scheme Guidelines (May 2024); CERC / GRID India SRAS framework; SECI and NTPC tender documentation; CEA National Electricity Plan (NEP-14); industry analysis of DISCOM creditworthiness and payment security mechanisms. May 2026. Policy details should be verified against the latest government notifications.

THE CLIMATE ANGELS BESS WEBINAR

WHAT THE EXPERTS SAID

BESS WEBINAR

THE CLIMATE ANGELS BESS WEBINAR: WHAT THE EXPERTS SAID

To pressure-test the conclusions of this report against the people building, financing, and regulating storage in India, Climate Angels convened a live expert panel — "Where is the Money to be Made in BESS?" The session drew over 200 registrations and ran as a free-flowing, deliberately unscripted debate across the full value chain: cells, system integration, software and dispatch intelligence, project finance, and grid services. What follows is a synthesis of that conversation and the conclusions an investor should carry away from it.

200+	5	3	236 GWh
Registrations	Expert panellists	Viewpoints: startup, corporate, policy	The number under debate

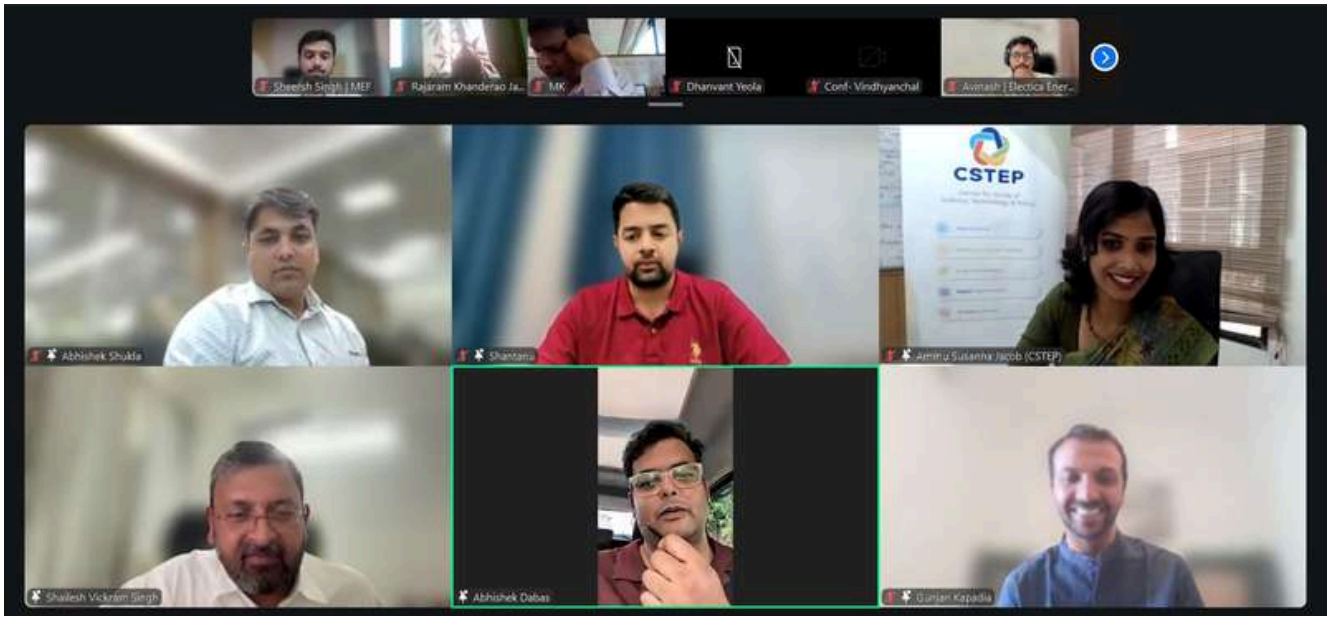
THE PANEL

The panel was assembled to bring deliberately different vantage points to the same question — an early-stage investor, two founders building at opposite ends of the chemistry spectrum, a policy researcher, and a representative of one of India's largest renewable developers. The disagreements between them are where the most useful signal sits.

Panellist	Affiliation	Perspective Brought
Shantanu Chaturvedi	Transition VC	Early-stage climate VC; the deep-tech and sub-component investor view
Gunjan Kapadia	Sthyr Energy	Founder building zinc-air long-duration storage; the alternative-chemistry view
Abhishek Shukla	ReNew	Battery storage strategy at a leading IPP; the large-developer view
Dr Ammu Susanna Jacob	CSTEP	Energy storage research lead; the policy and grid-system view
Abhishek Dabas	Axon BESS	Founder in C&I and distributed storage; the on-ground product view

WHERE THE VALUE ACCRUES: A GENUINE DISAGREEMENT

The opening question — if you could invest in only one layer of the BESS stack for the next decade, which would it be? — produced no consensus, and that itself was the finding. The panel split along the lines of where each participant sits in the value chain. The VC favoured sub-components and IP — cells, power conversion systems, inverters, charge controllers — on the logic that a containerised full system cannot out-compete Chinese imports, but a differentiated component can. The large developer argued for vertically integrated system integration as the point of maximum value capture, while conceding that not every integrator makes money and that the integrator must be backward-tied to cells. The policy researcher pointed to software and dispatch intelligence as the layer where storage actually earns its keep supporting the grid. The C&I founder argued for the product itself — hardware and software together, customised to Indian conditions.



The most candid moment came from the chemistry founder, who stated plainly that on lithium-ion cell manufacturing, India has “missed the bus” — and that for domestic players, the software and integration layers are where near-term value realistically sits, even as the country must eventually build its own cell and component capacity. This honest concession, from a manufacturer, aligns directly with this report’s own conclusion that commodity cell manufacturing is not a venture opportunity and that the defensible value sits in software, services, and differentiated chemistry.

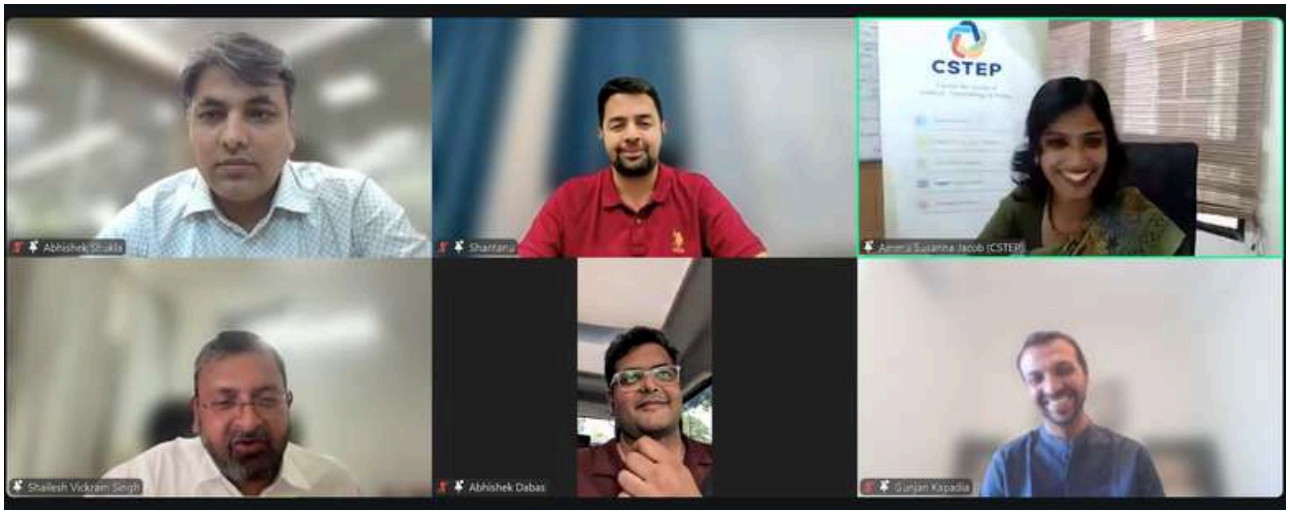
ONE CHEMISTRY WILL NOT WIN

Asked whether the market would move from LFP to alternative chemistries such as zinc, the founder of the zinc-air company gave a counter-intuitive answer: it will not, and it should not. There is no single application and no single winning technology. LFP will dominate short-duration storage — perhaps 30 to 50% of the market; redox flow and other chemistries will serve longer durations; and zinc-air and similar approaches will address the longest, including seasonal storage and diesel-generator replacement for data centres. The systems will coexist. This maps to the report's own technology-landscape framing: LFP as the bankable default, with alternative chemistries occupying defensible niches rather than displacing it wholesale.

THE ECONOMICS: TARIFFS HAVE FALLEN FASTER THAN COSTS

On revenue, the panel was unambiguous and it echoed the single most important warning in this report. The developer noted that discovered tariffs have fallen below roughly ₹2 lakh per MW per month — levels that look unsustainable — and drew the crucial distinction the report also insists on: it is the tariffs being discovered that are unreasonable, not the underlying system prices, because battery prices have not fallen anywhere near as fast as the tariffs have. Some developers who won tenders at these aggressive numbers will struggle to deploy good systems and meet their contractual obligations over the asset's life.

> **"Everyone assumes BESS prices will only go down. That is the worst assumption one can make."**
> **— Abhishek Shukla, ReNew**



THE ECONOMICS: TARIFFS HAVE FALLEN FASTER THAN COSTS

The policy view reinforced the caution from a different direction: the procurement frameworks exist — FDRE, co-location, round-the-clock supply — and storage is now recognised as an asset under the electricity rules, but with under 1 GWh genuinely operational and roughly 35 GWh under construction, the real operating challenges will only surface once that capacity comes live. The market's foundations exist; its operating track record does not yet. (One panellist noted deployment may already be ahead of the widely cited sub-1 GWh figure, with large systems accounting for the bulk — a reminder that even the baseline numbers are still settling.)

THE CHINA QUESTION AND INDIA'S EDGE

On supply-chain dependency, the developer was blunt: for a 100–200 MWh system there is no real alternative to Chinese supply on price, China sets the floor price, and India takes it — there is no counterweight in the short term. But the panel identified a genuine Indian edge in the places China is structurally unsuited to serve. China builds for global scale and does not customise, does not service, and does not maintain. Customisation of smaller systems, real service and maintenance, and engineering tailored to Indian weather, usage, and grid conditions were all cited as defensible moats — precisely the white spaces this report flags as venture-appropriate. The chemistry founder added the strongest version of the supply-security argument: by sourcing roughly 96% of materials domestically, an India-first chemistry sidesteps the import dependency entirely.

"China does very well at millions of identical units, but where even a little customisation is needed, that is where China does not even want to enter. Customisation, service, and design for Indian conditions can each be a moat."
— Shantanu Chaturvedi, Transition VC

THE SMALLER-SYSTEM AND C&I OPPORTUNITY

A recurring theme was that the behind-the-meter and C&I opportunity is large and under-discussed. The on-ground founder gave a vivid example: a commercial customer exporting 98% of solar during the day for ₹2.09/kWh while paying ₹10/kWh in the evening — a problem only storage solves. In states such as Maharashtra, time-of-day spreads on commercial high-tension connections already reach ₹7–8/kWh, making peak-shaving arbitrage viable even without solar and even without any backup requirement. The recurring caution: every site is different, so these are product-and-design businesses, not EPC businesses, and that site-specificity is itself the barrier to entry.

Key Takeaways from the Panel

A recurring theme was that the behind-the-meter and C&I opportunity is large and under-discussed. The on-ground founder gave a vivid example: a commercial customer exporting 98% of solar during the day for ₹2.09/kWh while paying ₹10/kWh in the evening — a problem only storage solves. In states such as Maharashtra, time-of-day spreads on commercial high-tension connections already reach ₹7–8/kWh, making peak-shaving arbitrage viable even without solar and even without any backup requirement. The recurring caution: every site is different, so these are product-and-design businesses, not EPC businesses, and that site-specificity is itself the barrier to entry.

01

The Value Layer is Contested, Not Obvious

No panellist agreed on where value accrues — sub-components, integration, software, and product each had a champion. The lesson for investors: there is no single "right" layer, and the obvious answer (whoever builds the batteries) is most likely wrong.

02

India has lost lithium-ion cell manufacturing

Even a battery founder conceded India "missed the bus" on commodity LFP cells. Near-term domestic value sits in software, integration, services, and differentiated chemistry, not in competing with Chinese cell scale.

03

Tariffs have fallen faster than costs

The panel independently confirmed the report's central economic caution: discovered tariffs below ~₹2 lakh/MW-month are unsustainable, system prices have not fallen proportionately, and some tender winners will struggle to deliver. "Prices will only fall" is the most dangerous assumption in the market.

04

No single chemistry wins; applications segment the market

LFP dominates short duration; flow and alternative chemistries serve longer durations; zinc-air and similar target seasonal and DG-replacement use cases. The technologies coexist — a portfolio reality, not a winner-takes-all race.

05

India's Edge Is Where China Won't Go

China sets the floor price on large systems and India has no near-term counterweight. The defensible Indian opportunities are customisation, genuine service and maintenance, India-conditions engineering, and domestically-sourced alternative chemistries.

06

The C&I and small-system market is large and real

Time-of-day spreads of ₹7–8/kWh already make C&I peak-shaving viable in leading states, with or without solar. These are site-specific product businesses — and that site-specificity is the moat.

07

Software, dispatch, and VPP are the emerging frontier

Across startup, corporate, and policy voices, the dispatch-intelligence and aggregation layer — ultimately the virtual power plant — was repeatedly named as where new value and new players will emerge, supported by regulation favouring indigenous EMS and BMS.

08

BESS is a financial instrument, not a backup

A persistent customer misconception is that storage equals backup power. The panel was clear: BESS is primarily a financial-optimisation asset — arbitrage, peak-shaving, demand-charge reduction — and educating the market on this will take time, as it did with solar.

The Panel's Verdict, and the Report's

The webinar closed on a deliberately provocative question — what is everyone getting wrong about BESS? The answers, taken together, form the most honest one-line summary of this report's thesis: prices will not only fall; the supply-chain and security risk is underweighted; cheap batteries alone do not create value without the market design to monetise them; and India is thinking too small, both in market ambition and in strategic patience. **The opportunity is real, but it rewards the disciplined and the strategic, not the optimistic.**

> **"Cheap batteries can create deployment, but we need proper market design so that we create value for the battery — because batteries are dispatchable, and that value has to be paid for."**
> **— Dr Ammu Susanna Jacob, CSTEP**

India needs a vast build-out of storage the grid cannot function without; the economics are turning but remain fragile and widely mispriced; and the durable opportunity lies less in the obvious, capital-intensive layers than in the software, services, alternative chemistries, and India-specific engineering that the entire sector requires. The panel, drawn from across the industry, did not contradict the report. It confirmed it — and reminded every investor that in a market this early, the difference between the deals that succeed and the majority that will not comes down to discipline, patience, and a clear-eyed view of where value genuinely accrues.

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