

1.0 RESEARCH PROPOSITION

Beyond Energy Arbitrage

Assessing the incremental value of BESS ancillary services in India

A battery creates value through electricity delivered and capability retained. Reserve participation is worthwhile only when additional receipts compensate for the energy opportunity surrendered and the costs of delivery.

This self-contained study tests one battery under alternative commitments. It examines available capability, incremental economics and the evidence required before a modelled service becomes an accepted operating proposition. All profiles and commercial fees are illustrative. [1]

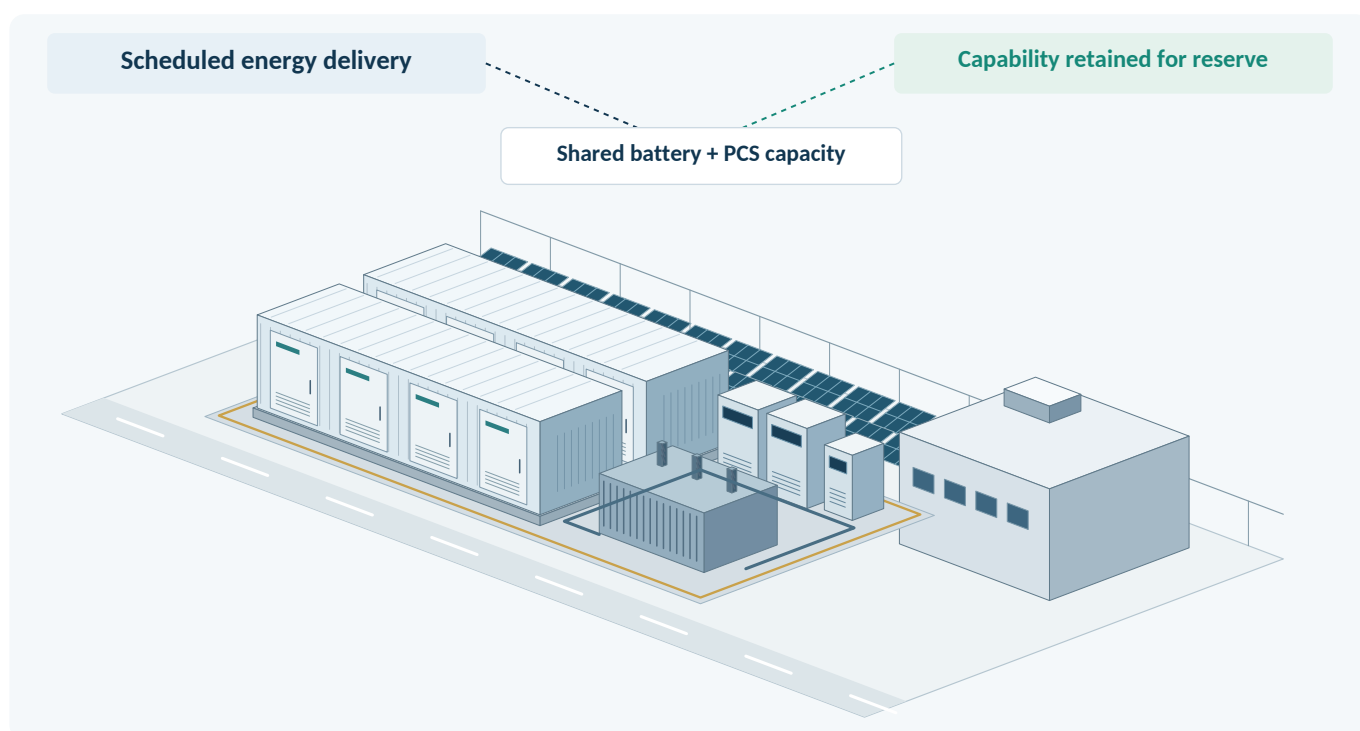


Figure 1.1 Original equipment illustration. Both uses share the same physical installation; no client site is represented.

1.1 Three dimensions of a deliverable commitment

Power | MW

Change from the scheduled operating point.

Energy | MWh

Delivery sustained within usable SOC limits.

Evidence

The requested change must be demonstrated.

ILLUSTRATIVE STUDY CONFIGURATION

2 MW / 4 MWh

Battery rating

1 MW each way

One symmetric bundle

1 hour

Full-activation screen

15 minutes

Economic interval

Choose commitments that add net value within the battery's physical limits.

[1] Firstgreen independent-study workbook v2.0: Study_Design, Inputs, Sources. Independent means standalone analysis, not third-party assurance. Illustrations are conceptual, not equipment specifications.

2.0 STUDY DESIGN AND PARTICIPATION

Define the service before calculating the revenue

Capability, participation rights and payment entitlement are separate tests.

The same 2 MW / 4 MWh battery, synthetic price day and feeder-head valuation boundary apply to every operating case. The study uses a hypothetical symmetric reserve contract—not an Indian tariff. A feasible schedule does not establish market access or payment entitlement. [1]

2.1 Where is value measured?

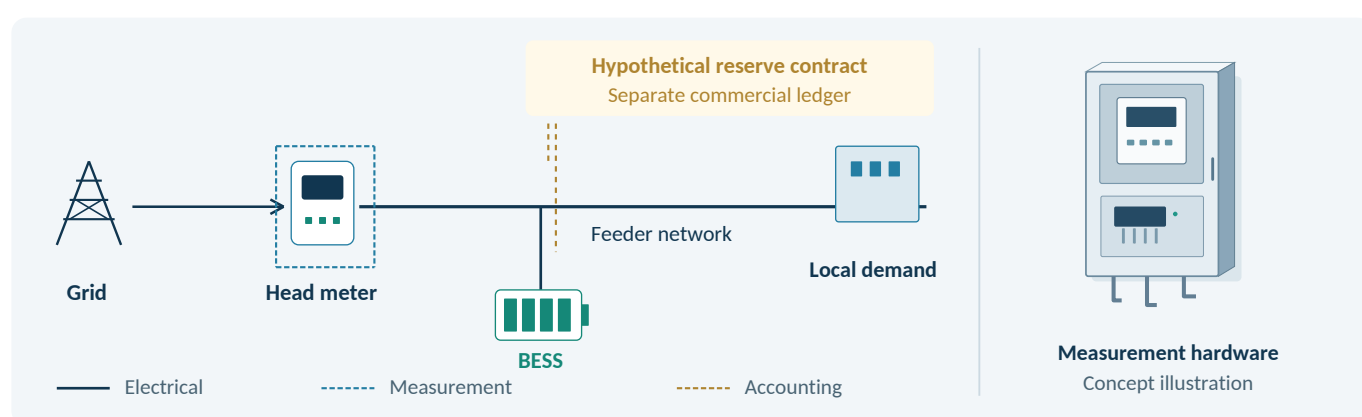


Figure 2.1 Common feeder-head valuation includes a fixed 3.5% loss allowance. Not battery-terminal merchant revenue.

2.2 Four rule-based comparisons; one physical battery

Scenario	Operating assumption	Question tested
R0 Energy only	Price-threshold energy schedule	Reference operating value
R1 Reserve ready	Fixed windows; no activation	Value sacrificed to be ready
R2 Activated	Same windows; up/down calls	Activation and recovery
R3 Stress	Long calls; derating; comms loss	Shortfall and its cost

Separate benchmark: optimised energy only versus energy plus optional hourly reserve. Both know the full synthetic price day; neither includes activation. [1]

2.3 Selected Indian reference provisions

SRAS | Secondary reserve

Minimum response 1 MW. Respond within 30 s; full obligation within 15 min; sustain for at least the next 30 min. [2]

TRAS | Tertiary reserve

Provide the service within 15 min; sustain for at least the next 60 min. Separate participation conditions apply. [2]

Payment boundary: the assumed ₹1,000/MW/h availability fee and activation adders are not the Indian settlement calculation.

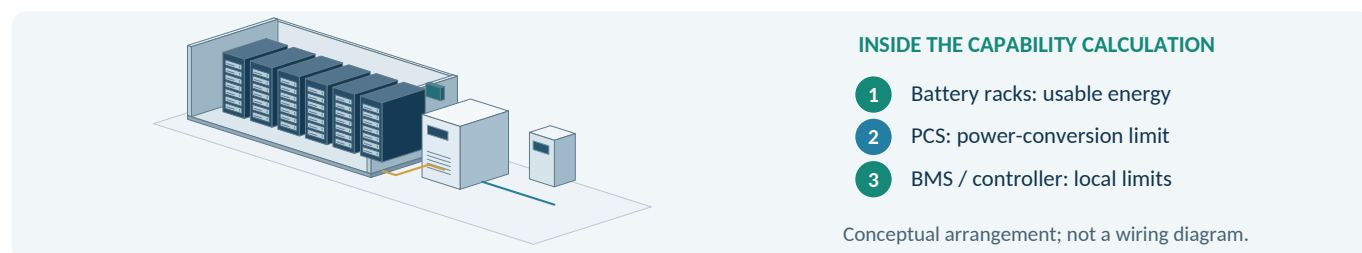
[1] Workbook: Study_Design, Inputs, Eligibility. [2] CERC Ancillary Services Regulations, 2022, regs 7 and 14. Dated source text carried forward; later orders and current applicability require review.

3.0 PHYSICAL CAPABILITY

Available reserve is not nameplate power

Baseline operation, state of charge (SOC) and duration constrain the commitment.

Reserve is a change from the accepted operating baseline. Upward response can include reducing charging; downward response can include reducing discharge. The smaller directional capability limits the symmetric bundle. [1]



3.1 Available reserve | zero baseline, one-hour screen

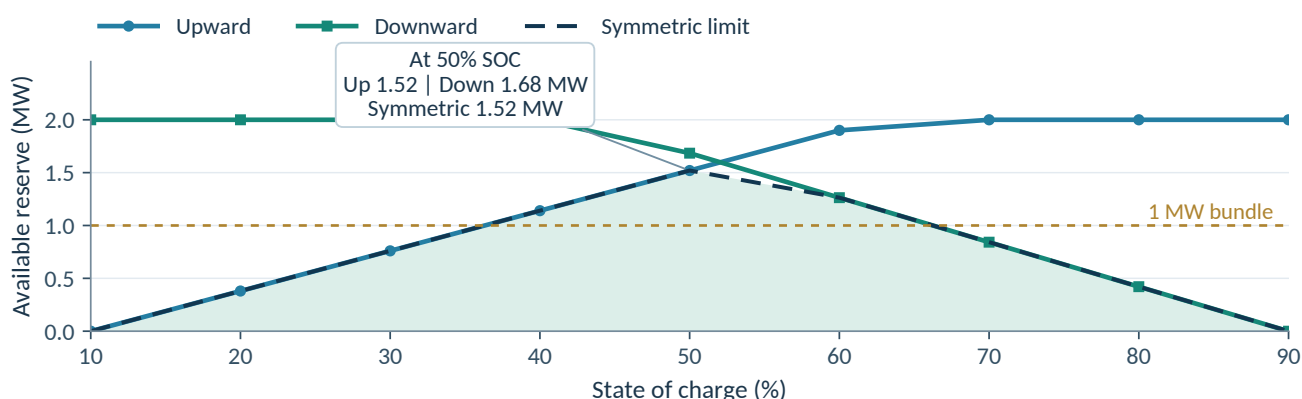


Figure 3.1 Shading shows the smaller directional capability—not an added quantity. Sampled SOC values; no market or network qualification is implied. [1]

3.2 Staying ready changes the operating trajectory

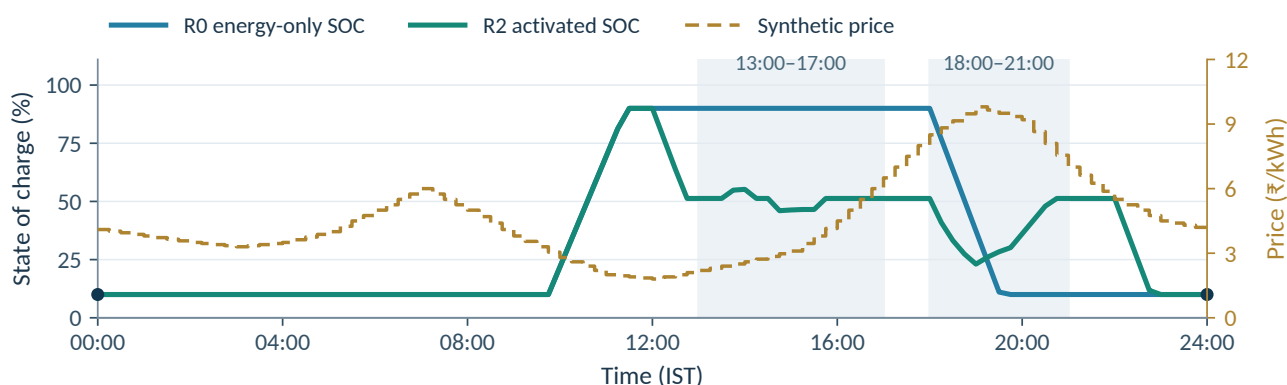


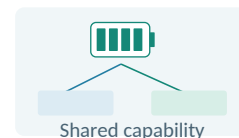
Figure 3.2 SOC at interval boundaries; initial and terminal SOC both 10%. Shaded windows are fixed reserve commitments. Price is synthetic. [1]

Practical limit: 2 MW rated – 1.5 MW discharge = 0.5 MW instantaneous upward headroom.

[1] Workbook: Reserve_Envelope, Inputs, R0_Energy_Only, R2_Activated, Report_Charts. BMS: battery-management system. Conceptual power and control paths are distinct; no AC-network or protection study.

4.0 INCREMENTAL ECONOMICS

More service income can still mean less net value



Compare added fees with energy value sacrificed and costs incurred.

Fixed reserve commitments earn fees but sacrifice more energy value than those fees replace. Selective participation needs an equally optimised comparator. A negative scenario does not reject every reserve opportunity. [1]

4.1 R2 waterfall | ₹12,738/day below rule-based R0

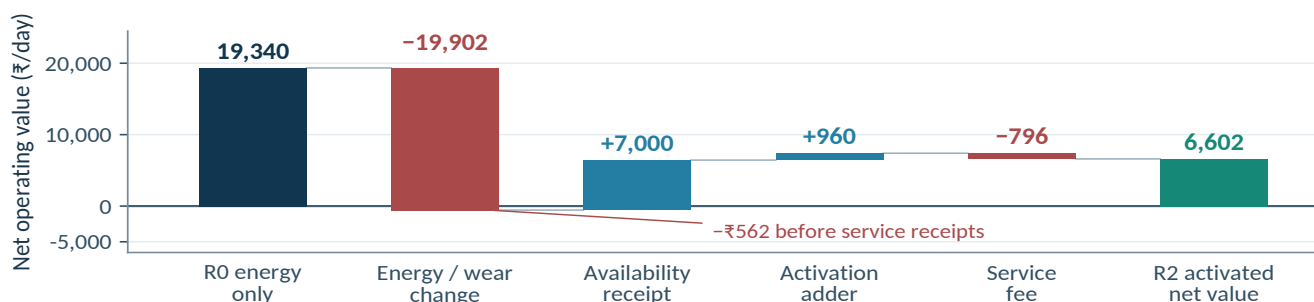


Figure 4.1 Energy/wear change already includes opportunity cost. Before new integration capex and fixed opex; generic fees are not Indian settlement. [1]

4.2 SELECTIVE PARTICIPATION | FROZEN BENCHMARK

Optimised energy only

₹26,693/day

Energy + optional reserve

₹27,737/day

Isolated reserve increment

+₹1,044/day

Same perfect price knowledge; no activation. Three hours of 1 MW reserve, not 3 MWh discharged. New capex and fixed opex excluded. [1]

4.3 Incremental NPV | required fee and paid availability

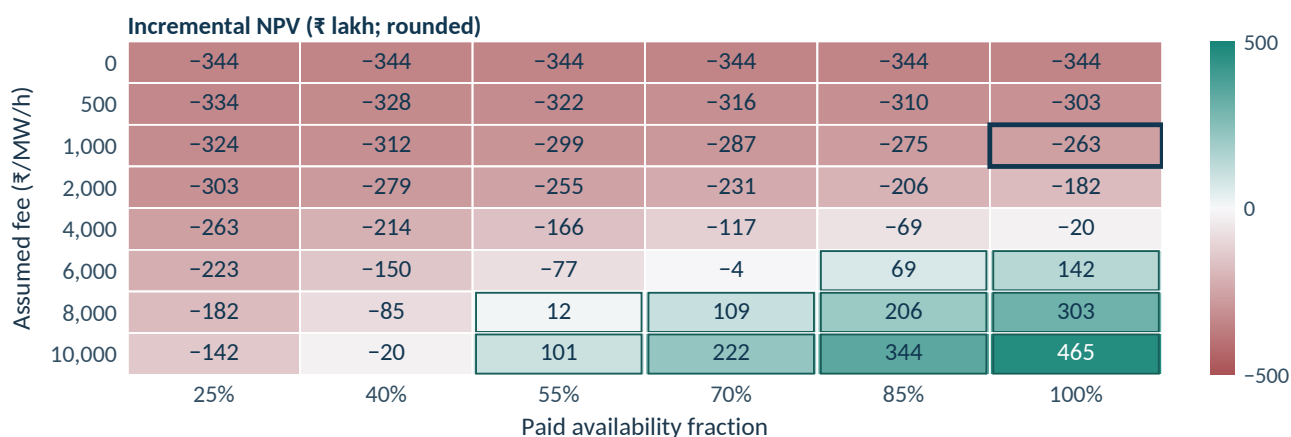


Figure 4.2 Base: -₹263.0 lakh. Paid availability differs from the separate 75% capture factor. R2 dispatch, calls and other costs stay fixed. Discrete fee scenarios; no interpolated frontier. [1]

Incremental break-even: about ₹4,251/MW/h—a required hypothetical fee, not a market price. New costs: ₹5 lakh capex and ₹1.5 lakh/year fixed opex.

[1] Workbook: Comparison, Opt_Benchmark, Economics, Sensitivities. Screen: 10 years, 10% discount, 300 days/year. Existing BESS investment excluded from the incremental decision, not assumed free; no whole-project bankability claim.

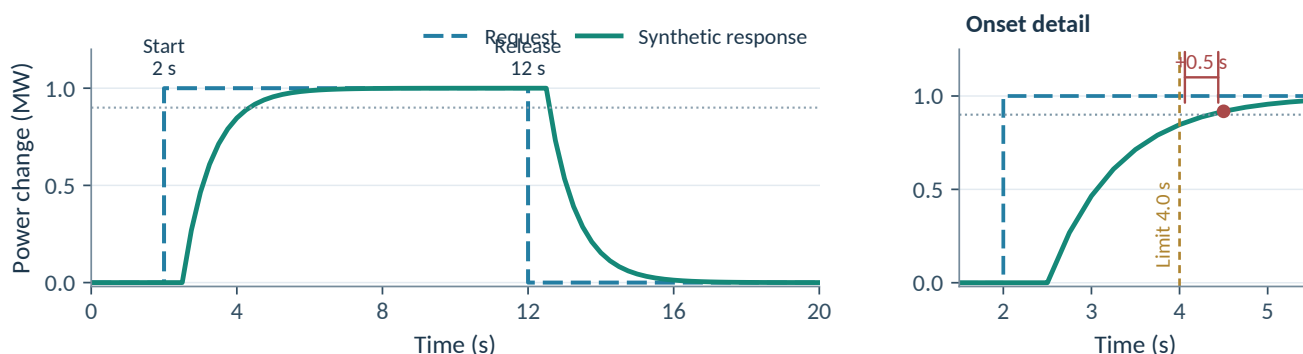
5.0 VERIFICATION AND IMPLEMENTATION

From calculated capability to verified delivery

Accepted evidence and clear authority make an operating proposition credible.

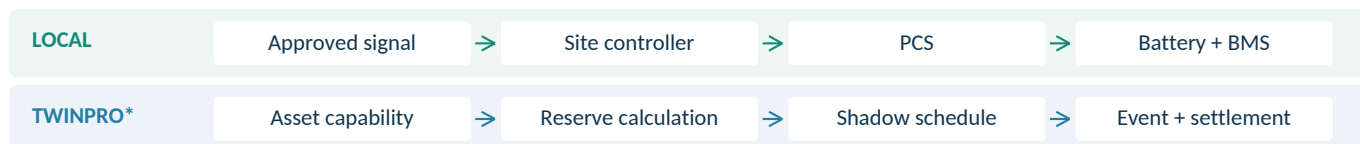
Numerical checks, synthetic response performance, technical qualification and commercial approval are separate tests. The study's modelled service needs accepted, time-aligned operating evidence before a delivery claim can be made. [1]

5.1 Measure the response against the request



Exceeds internal demo limit. First 90% crossing is 4.5 s absolute: 2.5 s after the request, or 0.5 s beyond the internal limit. Synthetic samples—not field data or service qualification. [1]

5.2 Keep fast control local; connect supervisory evidence



*Proposed supervisory/evidence application. Read-only and shadow operation; no browser/cloud fast-control or protection path. [1]



SUPPLIED PRESENTATION VISUAL

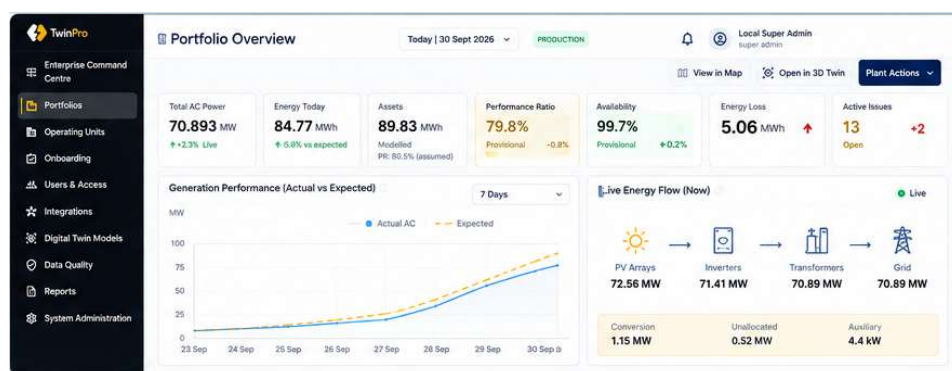


Figure 5.1 Enlarged original portfolio view from the supplied TwinPro presentation. Interface context, not proof of live ancillary-service operation. [3]



FIELD RECORD

Asset identity
Timestamp
Complete event
Independent review

Presentation illustration; not pilot evidence. [3]

Stress test: R3 retains 1 MWh undelivered activation. Synthetic—not a real incident. [1]

PILOT | Establish trust → Reconcile records → Test in shadow mode | Written acceptance before release

Firstgreen: engineering, due diligence, financial modelling and storage advisory. [4]

[1] Workbook: Response_Demo, TwinPro_Requirements, Pilot_Data, Eligibility. [3] Supplied TwinPro presentation, pp. 5, 7. [4] Corporate credentials, pp. 4–5. U 26/6, DLF Phase 3, Gurugram 122002 | info@firstgreen.co