

STARTUPS AS CATALYSTS OF ENERGY TRANSITION

A focused assessment of battery storage, AI-enabled grid services and distributed energy solutions in India — impact and implications for South Asia



Battery storage & flexibility



AI-enabled grid services



Distributed energy platforms

Aakanksha Mishra | PhD Researcher, Bayes Business School, City St George's, University of London

Rajib K | Executive Director, IRADe



1. Research Question and Analytical Boundaries

Which startup-led energy solutions in India have the strongest potential to move from innovation and pilots to commercially scalable deployment — and under what ecosystem conditions?

Included

BESS & flexibility
AI-enabled forecasting/optimisation
DER, aggregation & energy-service
platforms

Assessed Through

Technology readiness
Economics & capital needs
Regulatory fit
Customer/procurement access
Replicability & regional transfer

Outside Core Scope

Broad treatment of EVs, hydrogen, carbon
management and all climate-tech categories;
these remain contextual rather than
separately evaluated.

2. Theoretical Grounding

Four lenses from innovation and strategy research explain why energy startups scale differently from software startups.

● Profiting from innovation

Teece (1986); Gans & Stern (2003)

Startups rarely own the complementary assets energy innovation needs: grid access, operating data, customers, balance sheet. When those assets are held by incumbents, cooperation (partnering, licensing, acquisition) beats competition.

→ Customer access · H3

● Cleantech finance & the valley of death

Gaddy et al. (2017); Ghosh & Nanda (2010)

VC is built for short-cycle, asset-light bets. Hardware and infrastructure startups need patient, larger capital that sits between VC and project finance, so a 'missing middle' appears at the first commercial project.

→ Capital intensity · Unit economics · H1

● Technological innovation systems

Hekkert et al. (2007); Bergek et al. (2008)

Markets for new energy technologies are formed by policy and procurement design (tenders, VGF, tariffs, market rules), not by cost declines alone. Entry and funding should respond to these market-formation events.

→ Regulatory & market fit · H2

● Institutional voids & granularity

Khanna & Palepu (1997); Wilson et al. (2020); Malhotra & Schmidt (2020)

Weak counterparties and missing market institutions raise the cost of capital and stall projects. Small, modular, standardised technologies learn faster and cross institutional borders more easily than lumpy assets.

→ Replicability · H4, H5

Together these lenses yield the six-dimension Scale-Readiness Framework and the five hypotheses on the next slide.

3. Five Testable Hypotheses

Each hypothesis is anchored in established theory and maps onto one dimension of the Scale-Readiness Framework.

H1

Capital intensity & the ‘missing middle’. The more project capital a model needs, the lower its odds of moving from early-stage VC to growth capital — and the more its scale-up depends on non-VC money (DFIs, strategic corporates, project debt).

Theory: Gaddy et al. (2017); Ghosh & Nanda (2010)

Framework: Capital intensity

H2

Policy-made markets. Startup entry and funding in a domain rise after discrete market-design events (VGF, ancillary-service rules, PM Surya Ghar), not simply after technology costs fall.

Theory: Technological Innovation Systems — market formation (Bergek et al., 2008)

Framework: Regulatory & market fit

H3

Complementary assets. Startups with an early anchor partner that owns complementary assets (DISCOM, grid operator, large industrial buyer, strategic investor) are more likely to reach a first commercial project; for digital models, acquisition by an incumbent is the modal route to scale.

Theory: Teece (1986); Gans & Stern (2003); Doblinger et al. (2019)

Framework: Customer access

H4

Counterparty & institutional quality. BESS and DER deployment clusters in states with financially stronger DISCOMs and clearer state regulation; weak counterparties raise the cost of capital and stall projects after award.

Theory: Institutional voids (Khanna & Palepu, 1997); project-finance counterparty risk

Framework: Unit economics · Regulatory fit

H5

Granular, segment-specific transfer. Granular, standardised, software-heavy models travel across South Asia more readily than lumpy grid-scale assets — and transfer follows each neighbour’s regulatory strengths, segment by segment.

Theory: Granularity (Wilson et al., 2020); design complexity (Malhotra & Schmidt, 2020)

Framework: Replicability

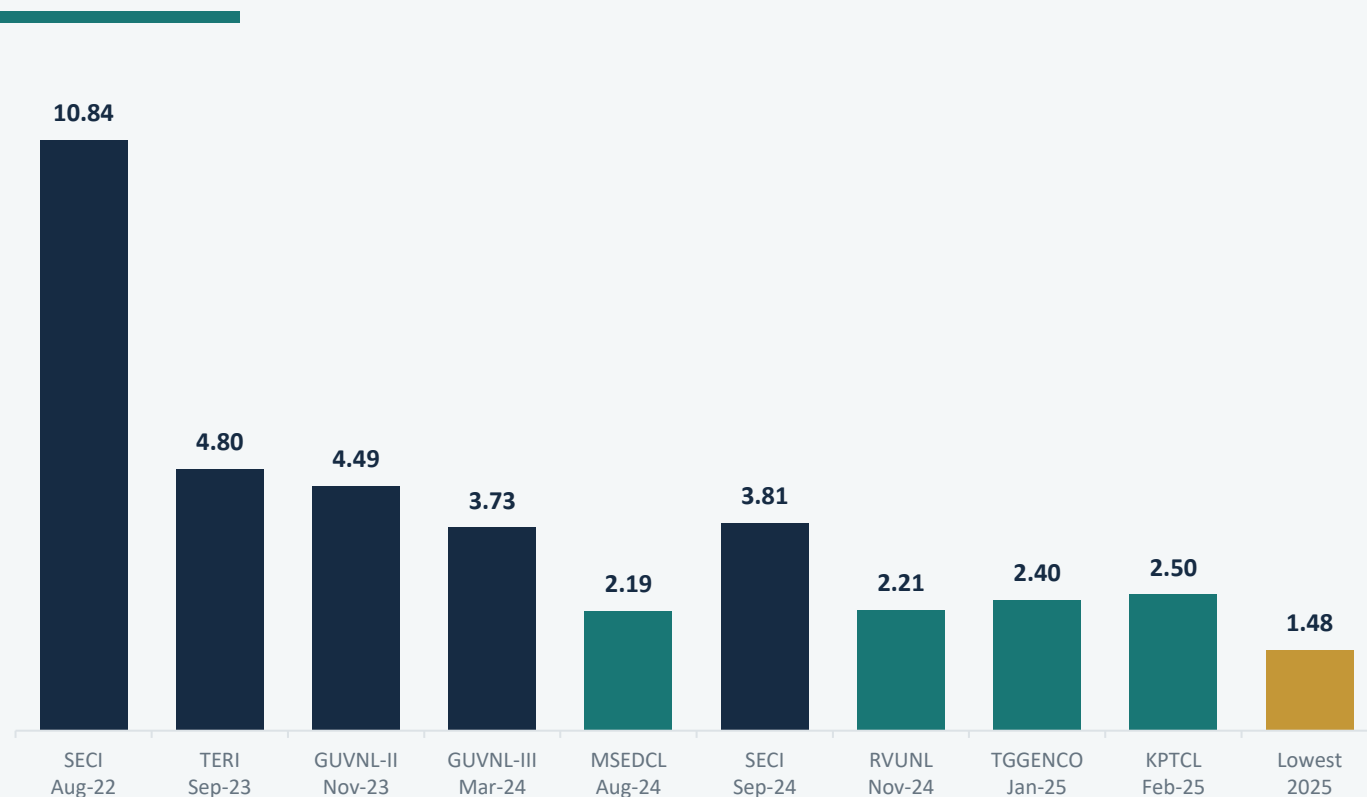
4. From Scores to Measures: Operationalising the Framework

Each 1–5 judgement on the comparison slide is replaced by observable indicators drawn from named datasets.

Dimension	Measurable indicator(s)	Candidate data source
Technology readiness	TRL coded from disclosures; months of field operation; certification (BIS/CEA); patent family counts (CPC Y02E)	Company filings & press; CEA BESS portal; Lens.org / PATSTAT
Unit economics	Discovered tariff vs. cost benchmark; gross margin; payback / savings share	IEEFA–JMK tender tracker; Mercom; CMIE Prowess / MCA filings
Capital intensity	Capex per MW or site; share of funding from debt/DFI vs. VC equity; asset on vs. off balance sheet	Tracxn / PitchBook / Venture Intelligence; MCA21 financials
Regulatory & market fit	Number of value streams a model can legally earn (arbitrage, SRAS/TRAS, capacity); state rule index	CERC & SERC orders; Grid-India ancillary reports; IEX data
Customer access	Anchor partnerships (MoU, pilot, strategic equity); months from pilot to first contract; buyer concentration	Press releases (Factiva); DISCOM pilot lists; tender award lists
Replicability	States / countries of operation; repeat contracts per customer; RISE sub-scores of target markets	Company websites & filings; World Bank ESMAP RISE

5. Preliminary Evidence 1 — BESS: A Policy-Made Market with an Execution Gap

Discovered tariffs in India's standalone 2-hour BESS auctions, ₹ lakh per MW per month (VGF-backed auctions in teal).



-86%

fall in the lowest 2-h tariff, 2022 → 2025

10.4 GW

standalone BESS awarded in 2025 alone

1.8 GWh

grid-scale BESS actually installed (Mar 2026)

53.7%

of 2025 capacity won by firms with little or no BESS experience

~75%

of awarded 2-h capacity judged 'at risk': tariff below cost

Reading: procurement design created the market (H2); the winners are balance-sheet developers, not VC-backed startups (H1); viable bids cluster in a few state auctions — Karnataka, Tamil Nadu, Telangana, Gujarat (H4). The startup opportunity lies in the layers around the asset: BMS/EMS, optimisation, O&M analytics.

Sources: IEEFA (Apr 2025) standalone storage market report; IEEFA-JMK (May 2026) viability of BESS tariffs discovered in 2025; energy-storage.news (Aug 2022); pv magazine India (Sep 2024).

6. Preliminary Evidence 2 — Nine Indian Cases, Coded Against the Framework

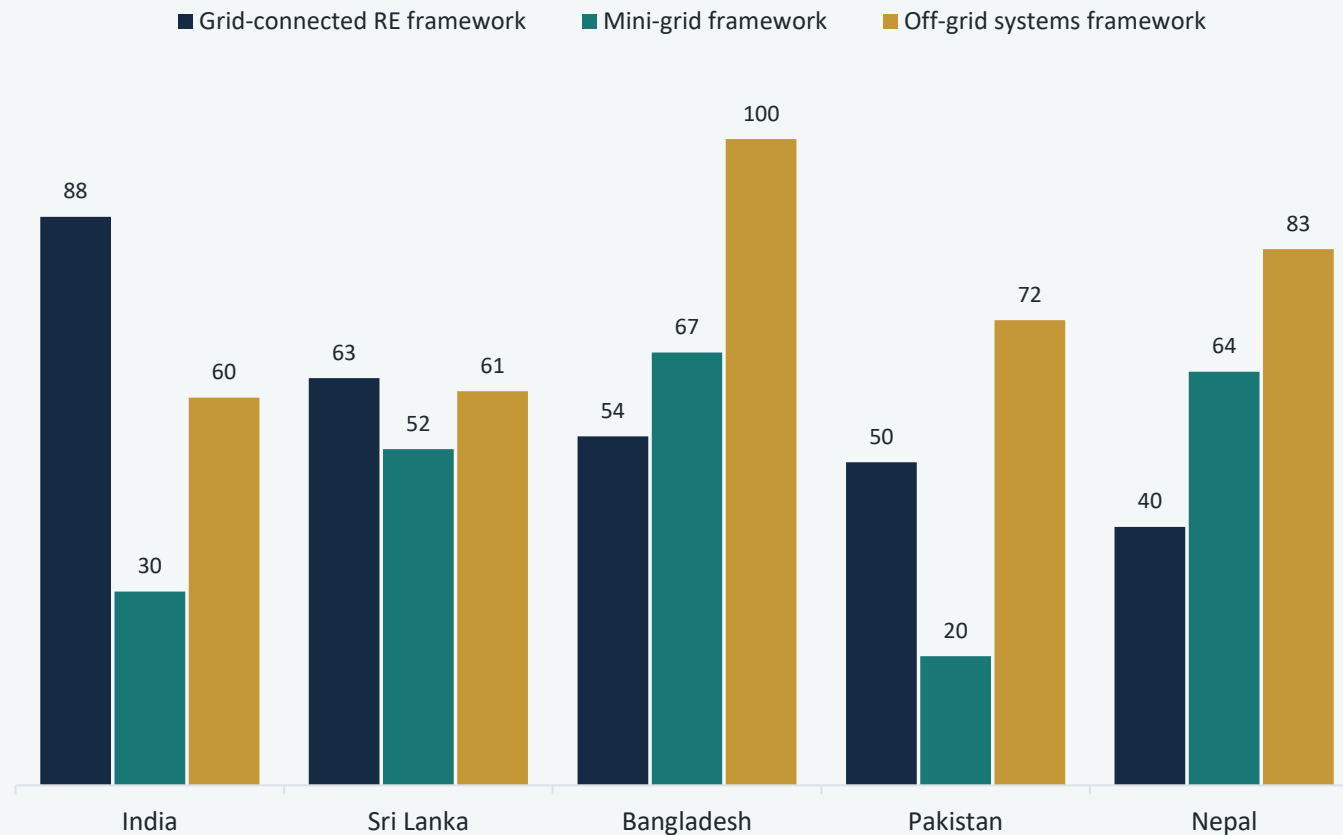
Named cases replace ‘illustrative models’. Public sources only; n = 9, so this shows patterns, not statistical tests.

Case	Domain / model	Capital (public)	Stage reached	Scale route / anchor	Signals
Log9 Materials (2015)	Battery cells & packs — hardware	~US\$75m equity + venture debt	Stalled; NCLT insolvency (Nov 2025)	VC-funded cell manufacturing; LTO cells lost to cheaper LFP	H1 (–)
Offgrid Energy Labs (2018)	Zinc-based stationary storage	US\$15m Series A (Sep 2025)	Pilot → 10 MWh demo plant	Strategic corporate lead (Archean Chemicals)	H1, H3
Zenatix (2013)	IoT / AI energy management, buildings	VC → acquired	Replication: 2,500+ buildings	Acquired by Hero Electronix (2018), then Schneider Electric (2024)	H3
Bidgely (2010)	AI analytics SaaS for utilities	US\$77m by 2021	Utility contracts incl. Indian private DISCOMs	Sells into DISCOM smart-meter data	H3
SolarSquare (2015)	Residential rooftop solar, D2C	>US\$100m (Series C, Jun 2026)	Portfolio: ~50,000 homes	PM Surya Ghar subsidy demand; asset owned by household	H2, H1
Smart Joules (2014)	Energy efficiency as a service	~US\$27m equity + debt	Replication across hospitals, hotels	Pay-as-you-save; anchor Apollo Hospitals; ADB investor	H3, H1
Fourth Partner Energy (2010)	C&I solar + storage (RESCO)	US\$275m from IFC/ADB/DEG (2024)	Portfolio: 1.5 GW operating	Grew into an IPP on DFI capital; also Sri Lanka, Bangladesh	H1, H5
Husk Power (2008, Bihar)	Solar mini-grids	US\$103m Series D (2023): \$43m equity + \$60m debt	200+ mini-grids, India & Nigeria	DFI equity & debt; two-thirds of new funds to Africa	H1, H5
Contrast: 2025 BESS auction winners	Grid-scale BESS developers	Balance sheet / project finance	10.4 GW awarded in 2025; 1.8 GWh installed in total	10 of top-15 awardees were new entrants: EPC & industrial firms	H1

Pattern: cases that reached scale either kept the asset off their own balance sheet (SolarSquare) or raised DFI/infrastructure capital (Fourth Partner, Husk). Digital cases scaled through incumbents (Zenatix, Bidgely). The VC-funded manufacturing case failed (Log9).

7. Preliminary Evidence 3 — Transferability Is Segment-Specific

World Bank RISE regulatory scores (0–100): India leads on grid-connected renewables; its neighbours lead on off-grid and mini-grid rules.



● Grid-scale models travel badly

BESS and utility-procured services meet weaker grid-RE rules next door. RISE also finds no counterparty creditworthiness mechanism in Sri Lanka or Bangladesh, so bankability is the binding constraint.

● Distributed models may find better rules abroad

Bangladesh (100) and Nepal (83) score far above India (60) on off-grid rules, so DER and off-grid startups may face friendlier regimes than at home.

● Revises the paper's claim

Not 'India → neighbours with adaptation', but transfer that depends on segment × regulatory fit (H5). Firms already follow this: Fourth Partner in Sri Lanka and Bangladesh; Husk chose Nigeria.

Source: World Bank ESMAP, RISE country profiles (latest edition, 2021–22 data): 'Electricity-sector renewables', 'Mini-grids framework', 'Off-grid systems framework' sub-indicators. Bhutan not scored in RISE.

8. Empirical Test Plan

What will be run, on what data, and what would count as evidence against each hypothesis.

	Design	Unit & data	Evidence against the hypothesis
H1	Stage-transition (survival) model: time from Series A to growth round / first commercial project, by capital-intensity class	~300–500 Indian energy startups, 2010–26: Tracxn / PitchBook / Venture Intelligence + MCA financials	Hardware firms progress as fast as software firms, or scale on VC alone
H2	Event study / interrupted time series around VGF (Sep-23, Jun-25), ancillary-services regulations (2022), PM Surya Ghar (Feb-24); control for LFP cell prices	Monthly startup foundings & deals by domain; tender volumes (IEEFA–JMK, Mercom)	No break in entry or funding after policy events once cost trends are controlled
H3	Logit / Cox models on hand-coded partnership events (MoU, pilot, strategic equity, acquisition)	Press releases (Factiva), DISCOM pilot lists, acquisition records	Anchor partnership has no link with reaching first commercial project
H4	State panel: rooftop installs per household, BESS awards & clearing tariffs on DISCOM grade, AT&C loss, payment delays	PM Surya Ghar portal; PFC Integrated Ratings (13th–14th); PRAAPTI; SERC orders	Deployment is unrelated to DISCOM health (e.g., subsidy design dominates)
H5	Cross-country comparison of Indian firms' foreign operations by model granularity × RISE segment score	Company disclosures; RISE; ADB / World Bank project databases	Expansion does not follow segment-level regulatory fit

Alongside: 15–20 interviews (startups, DISCOMs, investors, regulators) to recalibrate the 1–5 scores. Failed and stalled firms (Tracxn ‘deadpooled’) are sampled on purpose to limit survivorship bias.

Appendix — Theory and Data References

Theory

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Data & evidence

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- Case sources: Inc42 (Log9, Zenatix, Smart Joules, Bidgely); Entrepreneur India (SolarSquare); Saur Energy (Offgrid Energy Labs); IFC (Fourth Partner); TechPoint Africa (Husk).
- Firm-level databases for the next phase: Tracxn, PitchBook, Venture Intelligence, CMIE Prowess, Lens.org / PATSTAT.

THANK YOU