RMI CLIMAKE

India EV Battery Circularity Investment Outlook



Why This Deck, and How to Use It



Why we embarked on this

- India's EV adoption is accelerating, with more than 2 million EV sales in 2024. Battery demand is projected to reach 1,080 GWh by 2050.
- This deck focuses on lithium-ion batteries from EVs, projected to account for 80%–90% of India's lithium-ion battery demand. Retirements stay small through 2030 (~10 GWh/year), then rise to ~300 GWh/year by 2040 and 800+ GWh by 2050, mostly from commercial fleets. This is where investment opportunity will concentrate.
- Circularity (collection, diagnostics, second life and recycling) is essential to secure minerals, reduce emissions, and create jobs.
- Although investor interest is strong, investment opportunities remain early-stage and unstructured; this deck identifies how capital can move from pilots to scale.
- This deck aims to close that gap by defining key metrics and benchmarking India versus global leaders.



How this resource is most useful

- A primer for investors, policymakers, and industry.
- Offers a common vocabulary (metrics, baselines, risks, opportunities) and helps prioritise investment areas by showing where the most significant gaps and advantages lie.
- Economic opportunity: India's battery circularity system could unlock over ₹75,000 crore in profit by 2050 from second-life repurposing, recycling, and wider co-benefits.
- Policy tailwinds: India is placing growing emphasis on critical mineral security, backed by strong policy momentum.
  - In September 2025, the Union Cabinet approved a ₹1,500 crore incentive scheme for critical mineral recycling — underscoring both urgency and opportunity.
  - The National Critical Mineral Mission, announced in the 2024–25 Union Budget, sets a bold agenda to secure long-term mineral supply and build a globally competitive battery value chain.

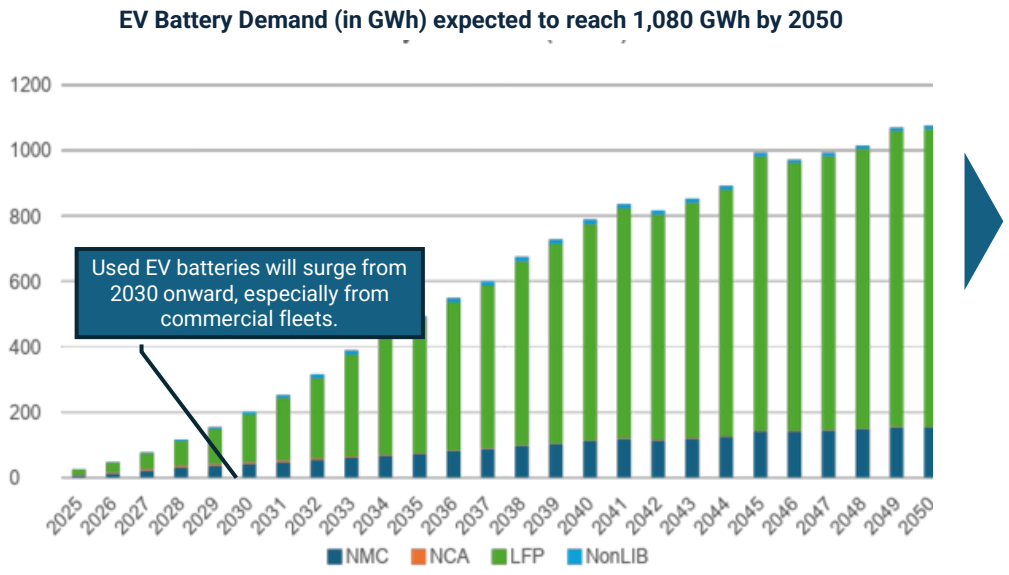


What this deck covers

- **Circularity Ecosystem:** A primer on the four pillars of battery circularity: **collection and logistics** (feedstock security); **diagnostics** (how data yields bankability of second-life assets); **second life** (deployment and additional value capture); and **recycling** (mineral recovery and efficiency).
- **Benchmarks and Value:** Comparison of global benchmarks and best practices (EU, China, and the United States) with India's current capabilities and performance.
- **Market Opportunity:** Size of India's battery circularity market, including the relative economics and value potential of repurposing and recycling.
- **Investment Landscape:** Where capital has been raised across the circularity ecosystem; the types of investors and lenders involved; and the forms of capital best suited to different ecosystem actors.
- **Capital Needs:** Capital required to scale the ecosystem, the financing instruments needed at different stages, and the roles different investor types can play.

EV Battery Demand Will Exceed 1,000 GWh by 2050 — Circularity Is the Unlock

EVs are expected to account for over 80% of India's lithium-ion battery demand by 2035



Domestic opportunity



₹75,000+ crore

By 2050, more than 800 GWh/year of end-of-life batteries in India could unlock over ₹75,000 crore in circularity profit from collection, repurposing, and recycling.

Global play



India's recycling costs are one-third to one-fifth of EU levels, positioning it as a low-cost recycler for global EV and storage supply chains.

Repurposing leadership



With cost advantages and early pilots, India can be the first market to scale battery repurposing.

Stacked value



Repurposing extends battery life, preserves recycling value, and creates broader **economic and environmental benefits**.

Investment opportunity exists, but scale requires feedstock aggregation, warranty frameworks, and blended finance.

Note: This analysis focuses on EV battery demand as it is projected to account for 80%–90% of total lithium-ion battery demand

Source: RMI analysis; industry interviews

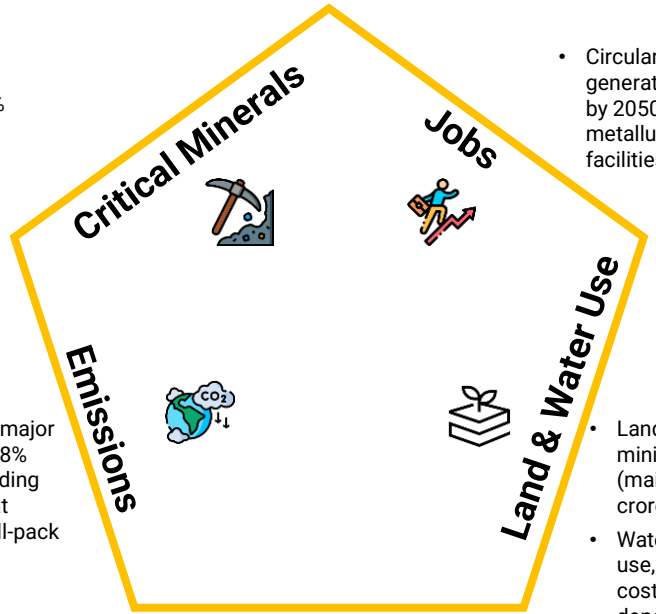
Circularity Secures Minerals, Reduces CO_2, and Creates Jobs

India

- By 2050, recycling could supply 41% of lithium demand and 48% of nickel and cobalt demand, reducing import dependence.[a]
- Leading Indian recyclers claim >90% recovery rates.[b]

Global benchmarks

- EU benchmark (law): 95% Co/Ni/Cu & 80% Li by 2031; 90% Co/Ni/Cu & 50% Li by 2027.[c]
- Technical best practice (studies): >90% Ni/Co, ~70–90% Li recovery achievable in optimised hydrometeorology lines.[1]



India

- Circularity activities projected to generate 106,000 full-time jobs by 2050 (recycling and metallurgical recovery facilities).[a]

Global benchmarks

- EU Battery Regulation impact assessment (2020): ~200,000 jobs by 2040 supported across collection, recycling, and repurposing.[f]

India

- Circularity can avoid 2.9 million tonnes of CO_2 by 2050 compared to virgin mining/processing.[a]

Global benchmarks

- Global recyclers report major CO_2 reductions — 50–98% lower emissions depending on whether measured at process, material, or full-pack level (Celltech, Altilium, Infinitev).[e]

India

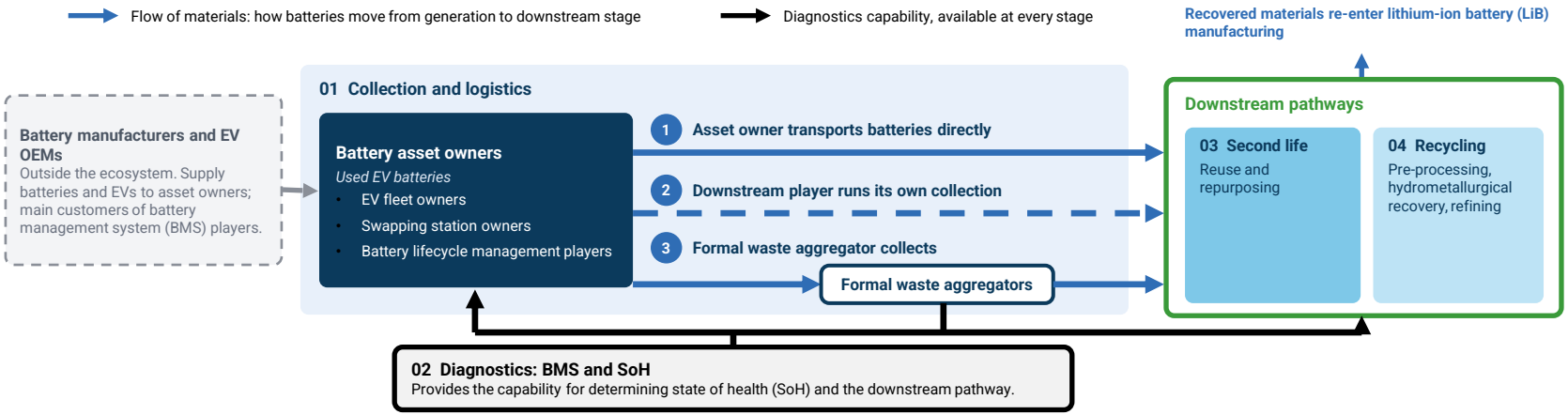
- Land use: recycling avoids mining-related land disturbance (mainly copper), valued at ₹860 crore by 2050.[a]
- Water use: recycling adds water use, modeled as a ₹172 crore cost by 2050 (technology dependent).[a]

Global benchmarks

- Land: EC *Critical Raw Materials Resilience* report notes reduced pressure on biodiveristy and land >90% recovery (EC 2020).[g]
- Water: Hydromet processes use 20–30% less water than conventional refining.[h]

Note: 1. Recovery rates vary by process and feedstock. EU law targets 90% Co/Ni/Cu and 50% Li by 2027, rising to 95% and 80% by 2031. Optimized hydrometallurgical lines achieve >90% Co/Ni and ~70–90% Li recovery.
Source: a. RMI Analysis; b. Company statements and press releases: Lohum (2024); Attero (2023); c. Regulation (EU) 2023/1542 (recovery targets); d. MDPI 2025 – *Material and Energy Flow Analysis of Hydrometallurgical Lithium-Ion Battery Recycling*; Springer 2025 – *Recycling of Lithium-Ion Batteries: A Review of Hydrometallurgical Advance*; e. Company disclosures (Celltech 2022; Altilium 2023; Infinitev 2023); f. European Commission (2020), *Impact Assessment on the Proposal for a Battery Regulation*; g. European Commission (2020), *Critical Raw Materials Resilience Report*; h. ScienceDirect (2023), *Comparative Analysis of Hydrometallurgical and Pyrometallurgical LiB Recycling Processes.*

How the EV LiB Circularity Ecosystem Works



	01 Collection & logistics	02 Diagnostics	03 Second life	04 Recycling
Definition	Systems through which battery asset owners, downstream players, and formal aggregators collect end-of-life batteries and move them downstream via warehouses, aggregation hubs, and transport vehicles.	Tools and protocols to assess a battery's SoH, state of charge (SoC), and safety.	Reusing EV batteries in similar applications or repurposing them for second-life use (e.g., stationary storage or microgrids).	Processing retired batteries to extract critical minerals (Ni, Co, Li, Cu, etc.).
Purpose	Secure feedstock for second life and recycling.	Data and tools to determine whether a battery is reused or repurposed (still usable in its form) or recycled (too degraded/damaged).	Extend battery life and capture additional value before recycling.	Feed recovered materials back into domestic or global battery supply chains.
Relevance	The bigger and more reliable the collection network, the larger the market for second-life applications and material recovery.	Standardised, trusted diagnostics are critical to make second-life assets bankable.	Keeping a battery in its original form captures the greatest value, as there is a significant gap between the price of a functional battery and that of scrap.	Reduces dependence on imports and creates a stable, long-term materials business.

Note: Informal collectors and aggregators still dominate end-of-life battery flows in India. They are not shown because they fall outside the financing focus of this report. The diagram shows the routes batteries can take, not the volumes flowing through each.

Collection and Logistics Move Batteries Downstream and Need Their Own Financing

01 Collection and logistics

Example Companies

BATTERY ASSET OWNERS

Own packs through their first life and decide where they go next

Battery Smart: India's largest battery-swapping network for two- and three-wheelers (2W/3W), enabling large-scale aggregation and traceability of used batteries.

SUN Mobility: Interoperable battery-swapping infrastructure for 2W/3W and light commercial vehicles, with centralised ownership supporting reuse and recovery.

Turno: EV marketplace and battery-financing platform for 3W, offering buy-back and resale of used EVs.

FORMAL AGGREGATORS AND PLATFORMS

Consolidate end-of-life batteries for authorised recyclers

Karo Sambhav: Formal end-to-end recycling platform for multiple waste streams; EV lithium-ion batteries is a focus area at pilot stage, with a view to scale as volumes increase.

Recykal: Digital platform managing EPR compliance and linking producers, aggregators, and authorised recyclers.

DOWNSTREAM PLAYERS WITH THEIR OWN COLLECTION

Recyclers or second-life players running their own reverse logistics

BatX Energies: Manages a full reverse logistics chain and original equipment manufacturer (OEM) take-back partnerships to reduce feedstock cost volatility.

Context

Battery asset owners hold end-of-first-life packs in bulk. They include EV fleet owners, swapping station owners, and battery lifecycle management players that own or finance packs, track their health, and manage buy-back or resale. Because they own and track their batteries, they are the most reliable source of feedstock, and their volumes will surge from 2030, especially from commercial fleets.

Methods and means

Batteries reach downstream players in three ways. Asset owners transport them directly to second-life players or recyclers. Vertically integrated recyclers, such as Attero, run their own collection through reverse logistics and OEM take-back partnerships. Formal waste aggregators collect, store, and consolidate them.

Technicalities

Battery collection requires safe handling, storage, and transport of high-voltage and potentially damaged batteries. Battery condition, chemistry, pack design, and state of charge can affect packaging, storage, transport, and handling requirements, making aggregation more complex than conventional material collection.

Why this matters

Low-cost, reliable feedstock is key: recyclers with steady scrap access can sustain margins and stay competitive. Control over feedstock, rather than access alone, determines margin stability. Feedstock security depends on bringing the informal sector into the fold.

Note: Companies spotlighted here are representative of India's most visible and scaled early movers across each pillar, selected for their relevance, innovation, and data availability. The information on Karo Sambhav is based on stakeholder consultation. **Source:** RMI Analysis; company statements.

Diagnostics Startups Are Early-Stage but Enable Bankability of Second-Life Markets

02 Diagnostics

Example Companies

BatteryOK: Develops AI-powered battery diagnostics, providing ultra-fast direct-current internal resistance (DCIR) testing and predictive SoH/SoC analytics for EV fleets.

Vecmocon: Builds advanced telematics and analytics systems for EVs, providing real-time health and performance data.

Altergo: Battery-intelligence software enabling diagnostics, asset tracking, and predictive maintenance across fleets.

Exponent Energy: Bengaluru-based manufacturer of rapid-charging battery packs and chargers, with a proprietary BMS stack that enables precise SoH tracking and fast charging for commercial EVs.

Nicola Tech: An electric-vehicle battery analytics platform offering advanced diagnostics and electronics to optimise li-ion battery health.

igrenEnergi: Intelligent battery management systems for electric vehicles and energy storage, using power electronics and artificial intelligence for real-time monitoring.

Fawkes Energy: Battery intelligence company developing diagnostics and health monitoring to assess battery performance and residual value across EV and energy storage applications.

Context

Diagnostics determine whether a used battery is reused, repurposed, or recycled, and give buyers and lenders the confidence to put a value on it. They serve battery asset owners, aggregators, and downstream players alike.

Methods and Means

Battery health can be assessed through two primary approaches. BMS-based diagnostics draw on battery management system data collected over time, such as voltage, current, temperature, and charging history, to estimate performance; OEMs often have primary access to these data. Rapid diagnostics use point-in-time physical measurements, such as voltage and impedance, to assess battery condition. Both approaches assess battery health and performance in different ways.

Technicalities

SoH is a common metric used to estimate a battery's remaining performance, often expressed as a percentage: existing capacity over rated capacity. Its reliability depends on the data and method used, and the same SoH can represent different levels of degradation and risk.. Translating SoH into remaining life and residual value therefore requires confidence in how it was derived.

Why This Matters

Diagnostics reduce uncertainty around a battery's remaining performance, helping allocate batteries to their highest-value use, avoid costly misallocation, and build confidence in residual value and second-life investment.

Note: Companies spotlighted here are representative of India's most visible and scaled early movers across each pillar, selected for their relevance, innovation, and data availability. BMS refers here only to the state-of-health diagnostic functions of a battery management system. **Source:** RMI Analysis; AVILOO.

Second Life Extends Battery Value Before Materials Are Recycled

03 Second Life

Example Companies

REUSE

Inverted Energy: Delhi-based lithium-battery manufacturer producing packs for mobility and stationary storage as well as testing second-life reuse of recovered modules.

Pi Beam: Chennai-based light-EV manufacturer integrating internet of things (IoT)-based battery-monitoring systems and exploring reuse of smaller EV packs for last-mile and micro-storage applications.

REPURPOSING

Nunam: Social enterprise repurposing used EV batteries into stationary and solar-powered community energy systems in India.

Statiq: EV-charging-network operator piloting stationary energy-storage systems built from repurposed EV batteries at its fast-charging hubs.

Infinite Cycle: Developer of second-life energy storage systems from EV batteries for residential consumers, businesses, and municipalities.

RECYCLERS WITH SECOND-LIFE LINES

Lohum, BatX, peakAmp, NavPrakriti: Recyclers that also operate second-life lines.

Context

Repurposing reconfigures retired EV batteries for a new use, most often in stationary storage, solar, and microgrids. Reuse keeps a battery in a similar application after refurbishment, such as when smaller EV packs are redeployed for last-mile mobility. Keeping a battery in its original form captures the greatest value, as there is a significant gap between the price of a functional battery and that of scrap.

Methods and Means

Augmenting a battery for second life may require refurbishment or reassembly before redeployment. Repair replaces failed cells or components; refurbishment includes BMS recalibration, software resets, and firmware updates; and reconfiguration adjusts modules or packs to meet the voltage, capacity, and physical requirements of the new application. The extent of this work depends on battery condition.

Technicalities

Batteries degrade differently depending on ageing, operating conditions, and use. Assessing degradation is essential to determine a battery's safety and remaining performance and whether the cost of repurposing is justified by its remaining value.

Why This Matters

By 2050, India will retire nearly 800 GWh of EV batteries annually, most of which are viable for second-life use. At full market maturity, repurposing could generate more than ₹19,500 crore in annual profits.

Note: Companies spotlighted here are representative of India's most visible and scaled early movers across each pillar, selected for their relevance, innovation, and data availability. **Source:** RMI Analysis (2025)

Recycling Is Scaling Rapidly; Feedstock and Battery-Grade Recovery Will Shape Competitiveness

04 Recycling

Example Companies

Attero: India's largest e-waste and lithium-ion recycler, operating hydrometallurgical facilities targeting approximately 11,000 tonnes/yr of Li-ion capacity by 2025.

Lohum: Integrated recycler and refiner running closed-loop operations for Li-ion batteries; produces battery-grade nickel, cobalt, and lithium salts reused in new cells.

BatX Energies: Hydrometallurgical recycler extracting cobalt, nickel, and lithium from end-of-life batteries; scaling modular plants towards approximately 10,000 t/yr capacity.

ACE Green Recycling: Developer of zero-emission recycling technology for both lead-acid and Li-ion batteries; building plants in India and the United States.

Metastable Materials: Bengaluru deep-tech recycler using solvent-free processes with >90% material-recovery efficiency (company claim).

NavPrakriti: Provider of lithium battery recycling, refurbishment, and metal refining services through collection, dismantling, and hydrometallurgical extraction.

Context

Batteries are discharged, dismantled, and shredded into black mass, a metal-rich powder. India's domestic capacity is concentrated in shredding and pre-processing, and much of the recovered black mass is exported for further processing, which creates value leakage.

Methods and Means

- **Hydrometallurgy** (commercial today): leaches black mass with acids to recover lithium, nickel, cobalt, and manganese at recovery rates of 80%–98%, and fits India's LFP and NMC mix.
- **Direct recycling** (cathode-to-cathode) (R&D / pilot, medium-term upside): restores the cathode instead of breaking it down into metals, uses the least energy and generates the least waste, but needs standard packs and battery data.
- **Pyrometallurgy** (mature, not optimal): smelting at 1,500°C loses lithium, is poorly suited to LFP, and is energy-intensive and polluting.

Technicalities

Refining converts black mass into high-purity, battery-grade chemicals such as Li_2CO_3, $NiSO_4$, and $CoSO_4$ that re-enter cell manufacturing. Without domestic refining capacity, much of India's recovered material is exported for reprocessing, leaving new cell manufacturing import-dependent.

Why This Matters

By 2050, recycling could meet 41% of India's lithium demand and 48% of its nickel and cobalt demand, making it a strategic domestic source of critical minerals and reducing reliance on imports.

Note: The companies spotlighted here represent India's most visible, scaled early movers across each pillar, selected for their relevance, innovation, and data availability. In this report, we treat recyclers as carrying out all of these activities. Source: RMI Analysis (2025); Industry Interviews

Collection: Formalising Feedstock Is the First Unlock

01 What's relevant?

Key metrics to track

- Collection rate (% of EoL batteries captured)
- Cost per kg/kWh
- Informal vs. formal collection

02 The gold standard

Global benchmarks

- EU Battery Regulation targets for light means of transport: 51% by 2028 and 61% by 2031.[a]
- EU achieved 46.5% collection in 2022; targets of 63% by 2027 and 73% by 2030.[b]
- Logistics cost: €0.5–€1.5/kg (EU); US$2–US$4/kg (US).[b]

03 India's baseline

India's numbers today

- Formal collection: <20% (2025), though overall scrap recovery (formal + informal) already exceeds 80%.
- RMI projects formal collection could reach 90% by 2040 as informal networks are integrated into compliant systems.

04 Risk

Key barriers

- 80%–90% of scrap is still collected through informal channels.
- Multiple intermediaries add mark-ups and reduce price transparency.

05 Opportunity

Investable upside

- Reverse-logistics platforms connecting informal collectors to formal recyclers (e.g., Lohum, BatX) can unlock investable scale and lower feedstock costs.

Source: a. Regulation (EU) 2023/1542 — *Battery and Waste Battery Regulation*, Official Journal of the European Union (July 2023); b. European Environment Agency (EEA) — *Battery Waste Statistics 2023*; EU Commission Progress Report on Waste Targets

Diagnostics: Bridging Information Asymmetry and Increasing Liquidity in Used Battery Markets

01 What's relevant?

Key metrics to track

- SoH accuracy in field vs. lab
- Test speed and cost
- Standardisation

02 The gold standard

Global benchmarks

- British Car Auctions provides EV Battery Health Grading (A–E + SoH) using third-party diagnostics (AVILOO).[a]
- AVILOO Flash: Three-minute SoH test that certifies a battery's grade (approximately €1–€2/kWh).[b]
- DEKRA Quick Test: 15-min diagnostic for capacity and safety assessment.[c]

03 India's baseline

India's numbers today

- Startups (BatteryOK, Exponent, Fawkes) are piloting diagnostics and partnering with lenders and insurers to translate battery-health data into commercially relevant measures of residual value and risk.
- Battery Aadhaar can help develop battery intelligence; depicting a used battery's remaining value depends on its power output, delivery duration, operating conditions, and the confidence with which these can be assessed.

04 Risk

Key barriers

- Lack of standardised diagnostics limits lenders' ability to underwrite second-life value.
- Common diagnostic methods and reporting requirements can bridge the existing information asymmetry.

05 Opportunity

Investable upside

- Rapid SoH diagnostic tools that deliver lab-grade accuracy in minutes could make used batteries bankable.
- With industry-led grading and SoH-linked warranties, lenders could underwrite second-life value.

Source: a. BCA (UK) EV Battery Health Grading (AVILOO); b. AVILOO FLASH (3-min); c. DEKRA (15-min)

Second Life: Unlocking Arbitrage Opportunities From Scrap

01 What's relevant?

Key metrics to track

- Value recovered from used batteries beyond their scrap value (residual value gain).
- Additional charge–discharge cycles achieved through second-life use.
- Market penetration of repurposed batteries in stationary and commercial applications.

02 The gold standard

Global benchmarks

- EU repurposed packs resell at 60%–70% of the value of new packs, with more than 2,000 additional cycles demonstrated in second-life use.[a]
- China targeted more than 10 GWh of repurposed capacity by 2025.[b]

03 India's baseline

India's numbers today

- Mostly pilots; less than 1 GWh of capacity.
- Repurposed packs resell at almost 30% discount versus new. Based on the market's willingness to pay.
- Costs: Primary cost inputs are the cost of used batteries and reassembly cost estimated at US$28/kWh, declining with learning.

04 Risk

Key barriers

- Uncertain usable energy capacity and short or absent warranty coverage (~3 years) limit buyer and lender confidence.[1]

05 Opportunity

Investable upside

- Second-life batteries represent a value recovered from what would otherwise be scrap, offering a clear residual value gain. RMI estimates a repurposing margin of +/- 18% for EV-to-stationary-storage batteries.

Note: 1. Energy potential refers to the remaining deliverable energy in repurposed batteries, which varies by State of Health and application.
Source: a. Circular Energy Storage (2023), IEA Global EV Outlook (2023, 2024); MIIT (2022); b. IEA Global EV Outlook (2024)

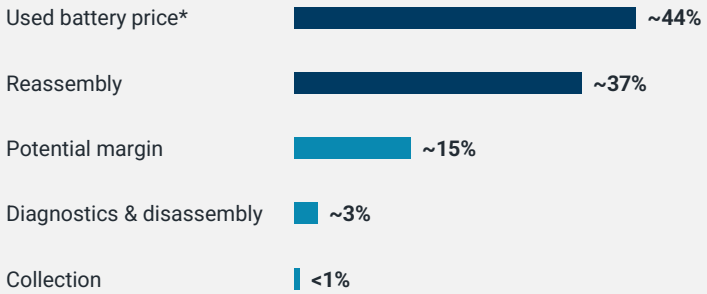
The Economics of Second Life Repurposing

The unit economics come down to one question. *Can repurposed batteries compete with new batteries on price and performance?* Used batteries must still meet customer performance requirements. However, degradation often means systems need to be oversized to provide the same usable energy over time, increasing effective costs. Buyers are also less willing to pay for used batteries, so repurposed systems must be priced below new alternatives. This discount could narrow as testing, certification and market confidence improve.

Four cost components. Used battery price is what repurposers pay owners for used EV batteries. Collection moves batteries from retirement to reprocessing. Its cost varies widely and depends on contracts and whether the repurposer also recycles. Diagnostics and disassembly involve testing battery condition to determine whether repurposing is viable, followed by dismantling the packs. Reassembly covers repair, refurbishment, and reconfiguration into a usable second-life system.

Monitoring economic trends. Market uptake depends on buyer confidence in the quality and safety of repurposed batteries. Supply depends on EV adoption and effective collection and reverse logistics. New battery costs set the price benchmark. A new pack costs ~$108/kWh in 2025 and is expected to fall to ~$54/kWh by 2040, so repurposed systems must compete on price and performance.

Share of repurposed pack price, 2025 (~$75/kWh)



*Price paid to a battery asset owner for a used battery, including the need to oversize systems to meet power-throughput demands.

Source: RMI analysis; shares approximated from the RMI repurposing cost breakdown, 2025

Recycling: Feedstock, Recovery Efficiency, and Battery-Grade Mineral Purity Will Shape Competitiveness

01 What's relevant?

Key metrics to track

- **Recovery rate:** Percentage of each metal (Li, Ni, Co, Cu) extracted from processed feedstock.
- **Black mass yield:** Percentage of input battery converted into metal-rich powder.
- **Purity level:** degree to which recovered metals meet battery-grade quality.
- **Refining integration:** in-house capability to refine black mass into battery-grade salts.

02 The gold standard

Global benchmarks

- EU Regulation 2023/1542 mandates recovery rates of 95% for Co/Ni/Cu and 80% for Li by 2031.[a]
- Best hydrometallurgical recycling achieves >90% Ni/Co and 70%–90% Li.[1, b]

03 India's baseline

India's numbers today

- Industrial players: Attero, Lohum, BatX, ACE, Metastable.
- Estimated total cost: approximately US$2,550/tonne (including operating and feedstock costs), or ₹210–₹220/kWh.[c]

04 Risk

Key barriers

- India's current recovery claims are largely self-reported.
- Limited refining capacity constrains production of battery-grade materials.

05 Opportunity

Investable upside

- Scale hydrometallurgical recycling, which is particularly effective for LFP batteries, to match global recovery efficiency and reduce import dependence.[2]
- India's recycling costs are between one-third and one-fifth of EU levels, driven by lower labour costs, more flexible regulation, and growing domestic processing capacity.

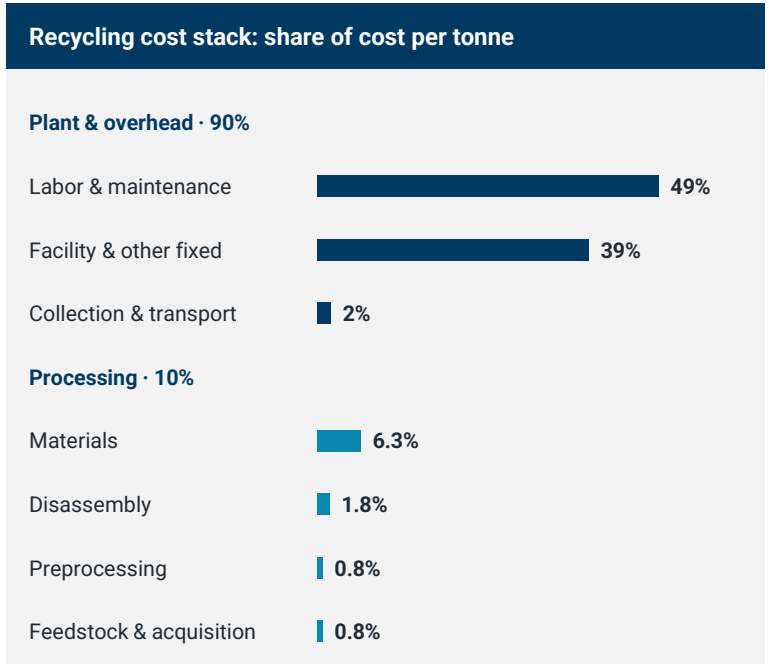
Note: 1. The EU's mandated recovery targets are forward-looking (2031). Current best-in-class recyclers achieve recovery rates of over 90% for Ni/Co and approximately 70%–85% for Li. 2. Hydrometallurgy uses aqueous leaching and solvent extraction to recover metals with high purity and low emissions, suitable for lithium-rich chemistries.
Sources: a. Regulation (EU) 2023/1542; b. MDPI (2025); Springer (2025); c. RMI Analysis (2025)

The Economics of Battery Recycling

Recycling is a scale business. Plant and overhead costs (labour, maintenance and facilities) make up about 90% of the cost per tonne and don't fall when volumes do, so profitability depends on running plants at high, steady throughput. End-of-life batteries are a relatively low-cost input, but securing supply is the harder problem. Collection and logistics networks determine whether a plant reaches the volumes it needs.

Feedstock drives profitability. Plants must secure sufficient feedstock at competitive cost. Vertical integration and long-term OEM contracts improve supply visibility and margin stability, whereas larger volumes spread fixed costs and raise operating efficiency. For investors, the business model rests as much on feedstock aggregation as on processing technology.

Recovery and material quality set revenue. Revenue depends on recovery rates and commodity prices. Recovered materials must meet stringent specifications to re-enter battery manufacturing. Battery-grade purity is therefore a prerequisite for higher-value markets, whereas recovery efficiency determines how much value each battery yields.



Second Life Unlocks Significant Additional Value While Preserving Recycling Potential

₹58,700+ crore
Annual second life repurposing profit by 2050

~800 GWh
EV batteries retired each year by 2050

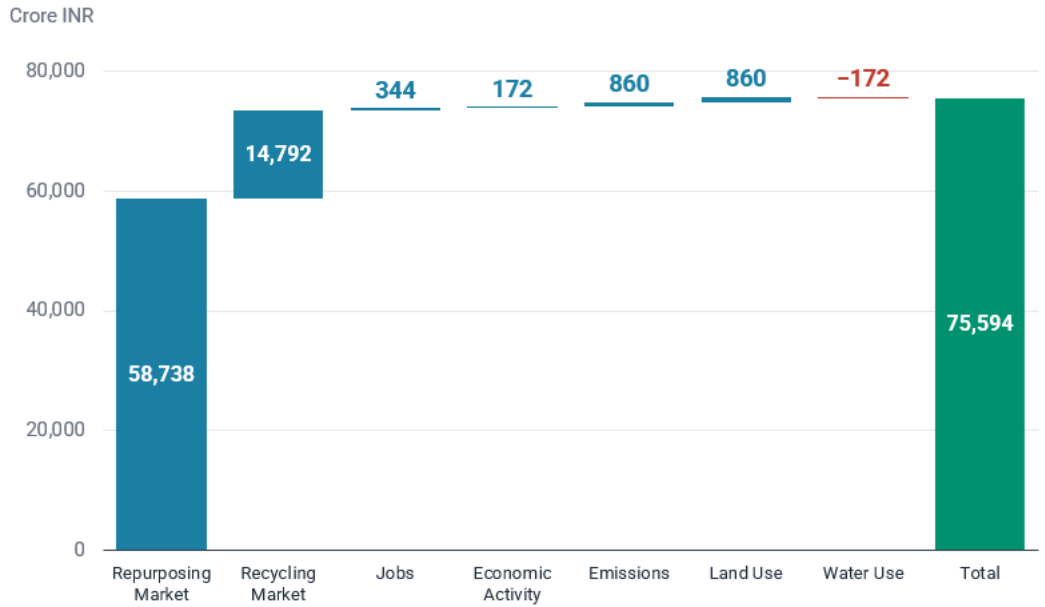
~80%
of retired batteries could be eligible for second life

Dual value creation at different times

- **Repurposing:** ₹58,700+ crore profit.
- **Recycling:** ₹14,800 crore from the same batteries, but years later, when second life ends.
- **Co-benefits:** jobs, GDP contribution, and environmental savings (emissions, land, water) further boost system value.

Repurposing adds to, not substitutes, recycling value.

India's circular battery system could unlock over ₹75,000 crore in profit, as repurposing creates an additive value layer on top of recycling, making circularity a stacked opportunity



Source: RMI analysis (2025)

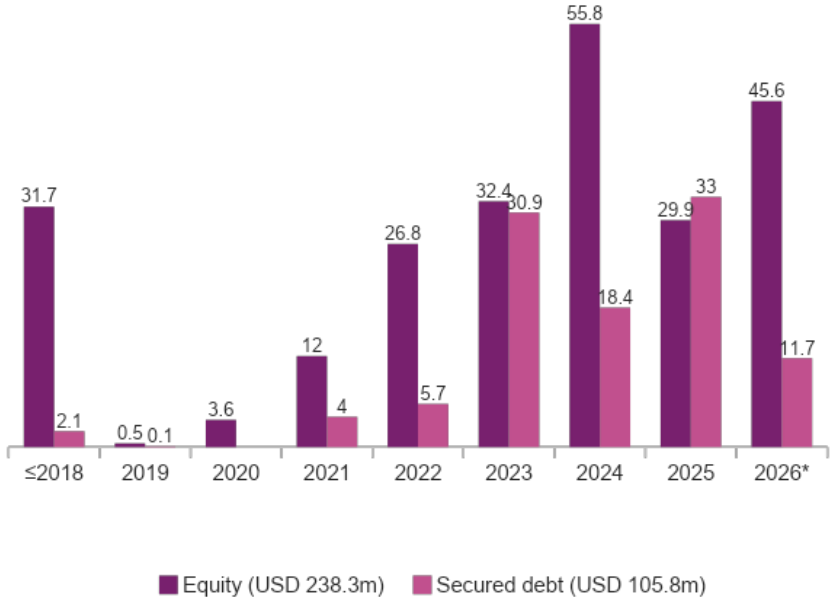
Financing Circularity Requires Both Debt and Equity Capital

Financing circularity requires both debt and equity capital. Across the ecosystem, US$344.1 million has been tracked across the value chain: US$238.3 million in equity over 53 rounds and US$105.8 million in secured debt over 66 loans to 14 companies.

Equity funds early-stage technology risk and provides leverage: lenders subsequently lend against the equity base and the plants and receivables it helps build. Of the total equity raised, 80% has been raised since 2022. Nine rounds of US$10 million or more account for nearly two-thirds of the total, while the typical round is approximately US$1.6 million.

Debt funds capital expenditure, asset-heavy requirements, and working capital needed to scale and operate. Almost all of it has come since 2023, once recyclers had plants and receivables. The typical loan is approximately US$0.6 million. A single US$23.4 million loan to Attero accounts for more than one-fifth of the total. Debt financing was close to equity financing in 2023 (US$30.9 million against US$32.4 million) and overtook it in 2025 (US$33.0 million against US$29.9 million). This coincided with operating recyclers beginning to borrow against their plants.

Combined Debt and Equity Financing by Year



Note: Labels show USD m raised in each year. Debt is secured borrowing registered with the Registrar of Companies. *2026 is year to date. Source: analysis of company filings.

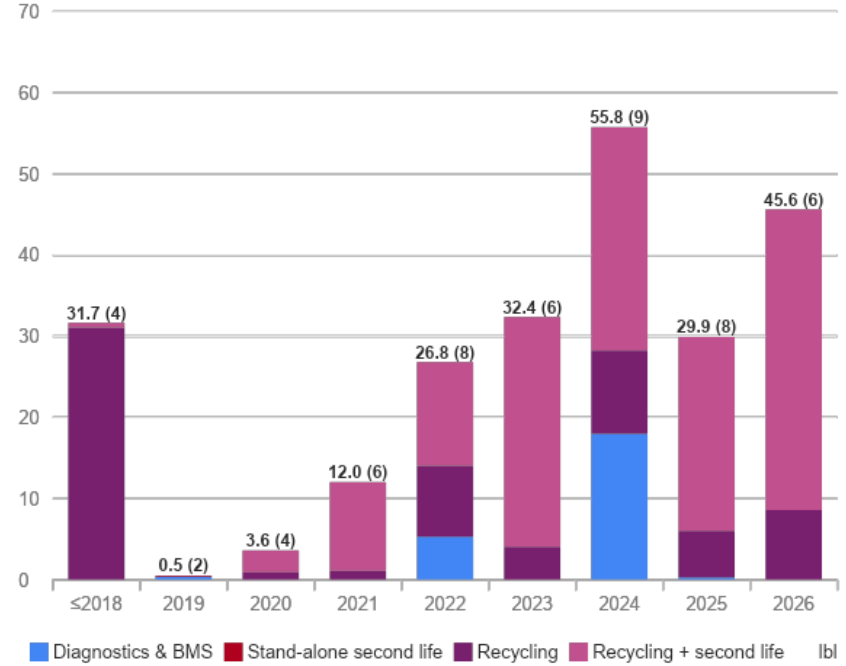
Equity Investment Trends

Most equity capital has gone to recyclers. They raised US$214.2 million, representing 90% of all equity raised, with Lohum alone accounting for US$124 million. Lohum, BatX, and peakAmp, which also run second-life lines, together raised US$143.7 million. Recyclers without a second-life line, led by Attero and RecycleKaro, raised a further US$70.5 million.

Second-life, meanwhile, is taking shape within these recyclers and among battery asset owners that already own packs. The four stand-alone second-life players have collectively raised a single US$0.1 million round.

Diagnostics and BMS sit apart from the rest. The segment has raised US$24.0 million across five rounds, mostly in 2022 and 2024. The entire disclosed amount has gone to one company, Vecmocon.

Equity by year · USD m (number of rounds) · total USD 238.3m



Note: Bar labels show equity raised in USD m; the figure in parentheses is the number of equity rounds. "Recycling + second life" shows recyclers that also run second-life lines; this section counts both recycling series as recycling.

Debt Financing Trends

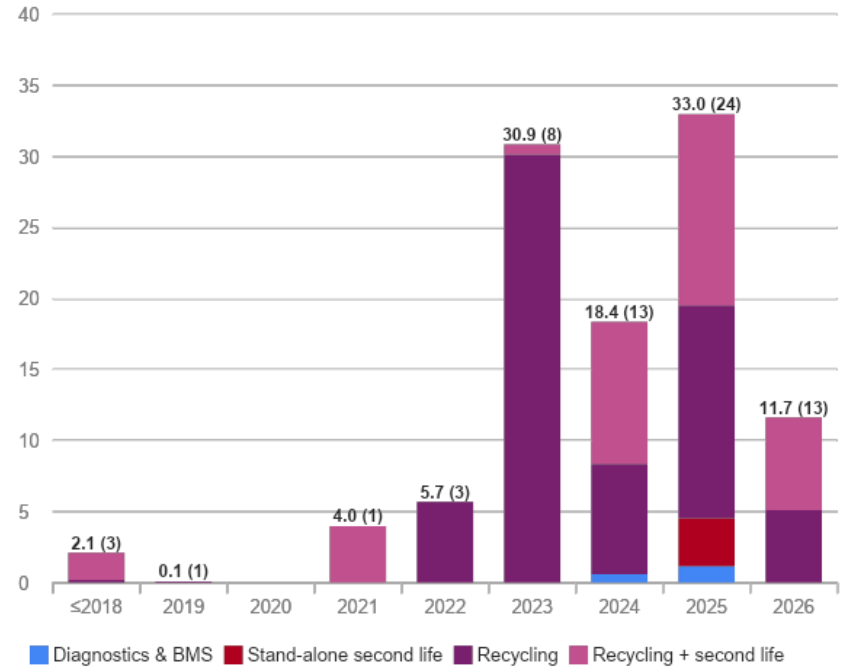
Debt has followed equity and is concentrated in operating recyclers. Loans are secured against the company as a whole, and the businesses are diversified across recycling, refining, second-life packs, and, in Attero's case, e-waste. The borrowing shows that lenders are comfortable with established recyclers. It does not show how much has gone into new battery-recycling capacity.

Almost all of this lending has gone to recyclers: USD 100.7m, 95% of all debt. Attero and Lohum alone account for two-thirds of it.

Second life has barely drawn on debt. The only loan to a stand-alone second-life company is a single USD 3.4m bank loan to Lico. Without a proven way to price used packs, lenders have little to underwrite.

Diagnostics and BMS have the least debt of all, because their capital needs sit in technology and deployment rather than physical assets. The segment needs little debt beyond working capital.

Secured debt by year · USD m (number of charges) · total USD 105.8m



Note: Bar labels show secured debt in USD m; the figure in parentheses is the number of charges, i.e. secured loans registered against the borrower with the Registrar of Companies. "Recycling + second life" shows recyclers that also run second-life lines; this section counts both recycling series as recycling.

How Equity Players Fund EV Battery Circularity

Angel Investors Go Beyond Initial Investments
Angels and family offices, crucial first investors in innovation, remain invested beyond seed. They led 19 rounds worth US$52.3 million, including all five of Recyclekaro's Series A rounds and Poonawalla Vision Fund's US$24.0 million Series C investment in Lohum.

Venture Capital Backs Scale, Not First Plants
Most venture capital firms favour technology-first, asset-light models over capital expenditure-heavy businesses. Of the US$136.1 million deployed across 56 funds (57% of total equity), most backed recyclers operating at scale. Lohum alone secured US$83.0 million.

Climate Funds Make Complex Investments, but Selectively
Climate funds are crucial for high-potential, technologically complex investments, but they have been selective in the sector. One example is Circulate Capital's US$7 million investment in ACE Green.

Development Finance Institutions (DFIs) Have Yet to Find Their Catalytic Role Here
Circularity needs smaller tickets than DFIs are accustomed to leading, so their participation has been limited; the only DFI-led round was a 2010 deal by the International Finance Corporation (IFC) in Attero.

Lead investor type	Number of investors	Diagnostics & BMS	Second life	Recycling	Total
VC & growth PE	56	5.9	–	130.2	**136.1 (21)**
Family offices & angels	83	0.1	–	52.2	**52.3 (19)**
Climate & impact funds	9	18.0	–	7.0	**25.0 (4)**
Corporates	10	–	0.1	12.7	**12.8 (3)**
DFIs	2	–	–	8.3	**8.3 (1)**
Accelerators & incubators	7	–	–	3.8	**3.8 (5)**
Total equity	**167**	**24.0**	**0.1**	**214.2**	**238.3 (53)**

Note: Columns 3–6 show equity raised in USD m, grouped by the type of investor that led the round. Figures in parentheses in the Total column are the number of rounds led. Recycling includes recyclers that also run second-life lines.

How Debt Lenders Are Funding EV Battery Circularity

Debt has not yet found its scale
Debt is what scales climate businesses, and it is widely available once a sector is mainstream and profitability is established. Battery circularity is only getting there: secured debt totalled US$105.8 million, less than half the equity raised. Of the 66 borrowings recorded, 58 date from 2023 onwards, when recyclers began commissioning plants. This underscores the sector's recent emergence at scale.

Banks lend against assets, not ideas
Private, public-sector, and foreign banks account for 15 of the 32 lenders and hold 42 of the 66 charges, almost all of which relate to operating recyclers.

NBFCs write the larger tickets
As projects grow, domestic lenders demonstrate their ability to provide larger loans. NBFCs are the largest source of debt, accounting for US$47.1 million across 17 charges. One of these is a US$23.4 million loan to Attero.

Specialist lenders are missing
EV financing went mainstream once dedicated EV financiers and NBFCs entered alongside banks. Circularity has no equivalent yet, whereas NBFC lending has been concentrated in a few large loans to recyclers.

Lead lender type	Number of lenders	Diagnostics & BMS	Second life	Recycling	Total
NBFCs	12	–	–	47.1	**47.1 (17)**
Private banks	6	0.6	3.4	35.8	**39.7 (26)**
Foreign banks	2	–	–	9.7	**9.6 (5)**
Government lenders	4	1.2	–	4.2	**5.4 (6)**
Public-sector banks	7	–	–	3.8	**3.9 (11)**
Corporates*	1	–	–	0.1	**0.1 (1)**
Total secured debt	**32**	**1.7**	**3.4**	**100.7**	**105.8 (66)**

Note: Columns 3–6 show secured debt in USD m, grouped by lender type. Figures in parentheses in the Total column are the number of charges (secured loans registered against the borrower). Recycling includes recyclers that also run second-life lines. Figures may not sum due to rounding.

** Includes leasing companies for second-life batteries*

Each Segment Needs Different Capital

Segment	Stage today	Capital needed	Capital available today	Funding gap	Who should step in
Second-life companies	**Pilot**	VC equity for pilots; growth equity and capex debt for lines; working capital; financing for batteries offered as a service	Stand-alone players: USD 0.1m equity, a USD 2.6m grant and a USD 3.4m bank loan. Recyclers fund their own second-life lines	High: little dedicated equity or debt so far; capital needed to scale beyond pilots	Climate funds, DFIs and grants for pilots; battery asset financiers for service fleets; NBFCs as partners once production flines are proven
Second-life battery users	**Emerging**	Asset financing when users buy batteries; little financing need when they lease	Little dedicated lending to buyers yet; most batteries are placed as a service	High: lending to second-life battery buyers is yet to develop	NBFCs and leasing companies, once track record and standards exist, as for new EV batteries
Recyclers	**Growth for black-mass processing; early for high-quality refining**	Capex debt and equity for plants (first plants ~USD 10–15m); working capital for feedstock and receivables; first-of-a-kind and R&D capital for battery-grade refining, especially LFP	USD 214.2m equity and USD 100.7m secured debt, concentrated in Lohum, Attero and Recyclekaro	Moderate: capital is concentrated, but newer plants lack long-tenor debt	Banks for profitable players; NBFCs for the rest; DFI and blended capital for first plants; VCs and climate funds for new refining processes
Diagnostics (tech layer)	**Early commercial**	R&D expenditure and cash/liquidity burn until profitable; small working capital (receivables only, no inventory)	USD 24.0m equity and USD 1.7m debt, nearly all to one company (Vecmocon)	Low: capital goes into R&D and deployment, not physical assets	Grants and angels early; VCs and climate funds; strategic corporates

Reading the table: beyond one-off capex for production lines and plants, the batteries themselves are the largest asset to finance, following the model used for new EV batteries. Diagnostics needs less capital, but requires wider adoption.

Second-Life Batteries Start as a Service and Move to Purchase as Track Record Builds

Near-term focus: battery as a service. Second-life battery applications are at an early stage and must demonstrate reliability and performance at scale. Second-life companies fund deployments and retain batteries on their balance sheets using asset finance or equity. They repay loans using income from lease rentals and service fees.

As a track record builds, purchasing becomes an option. With an established performance history and standards, users will purchase batteries financed by NBFCs and leasing companies, as they do with new EV batteries.

What this means for capital: As the segment matures, battery financing will shift from second-life companies to users as track records improve and operations scale.

Who Finances the Batteries Today and Later

Near Term — Battery as a Service: The Second-Life Company Finances the Batteries

Capital providers	→ Asset finance or equity →	Second-life company	→ Service/ lease →	Second-life user
Battery asset financiers (NBFCs, lessors) and equity		Owns and deploys the batteries		C&I, MSME, telecom, rural; pays a service fee

As track record builds, purchase: the user finances the batteries

Second-life company	→ Sale →	Second-life user	← Loan / lease ←	Capital providers
Sells graded batteries with a warranty		Buys and owns the battery		NBFCs and leasing companies

What helps the shift to purchase

- **Standards:** Battery Aadhaar and a common SoH method help lenders value used batteries.
- **Warranties and buy-backs:** SoH-linked warranties give buyers and lenders confidence.
- **Blended capital:** DFIs and climate funds can share risk on early portfolios.

Strengthening the Whole Value Chain Unlocks Each Segment's Opportunity

Each segment depends on the others. Diagnostics provide the battery data others rely on. Second-life companies and recyclers need a steady supply of graded batteries and buyers for their output. Lenders need trusted data and predictable volumes.

Capital works best when it moves together. Growth capital for second life and recycling, first-of-a-kind capital for refining, and battery financing and adoption capital for diagnostics reinforce one another.

Standards are the common thread. A common battery health standard lowers the cost of capital across the value chain.

What Each Segment Unlocks for the Next

Diagnostics & BMS trusted battery health data at every stage lets lenders and buyers price used batteries

Second-life companies	Second-life battery users	Recyclers and refiners
Turn graded packs into storage batteries, extending their value before recycling.	Use batteries as a service today; buy them with NBFC finance as track record builds.	Recover materials at end of life and supply domestic manufacturing.

What strengthens the whole chain

- **Standards:** Notify Battery Aadhaar and a BIS/ARAI state-of-health method.
- **Data access:** OEM sharing of BMS data gives second-life companies, lenders and recyclers the battery history they need to evaluate viable second-life batteries.
- **Formal feedstock:** Take-back contracts and EPR bring batteries into formal second-life and recycling channels.
- **Coordinated capital:** Equity, asset financing, blended and adoption capital, deployed together.

Note: BMS refers here only to state-of-health diagnostic functions. Source: RMI analysis; stakeholder consultations.

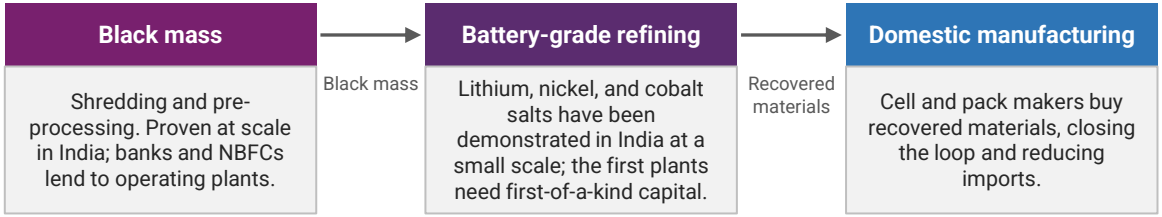
Domestic Refining Is the Next Opportunity for India's Recyclers

Recyclers have attracted the most funding. They have built shredding and black-mass capacity in India, attracting US$214.2 million in equity and US$100.7 million in debt. Not all of this capital has gone to battery recycling: some recyclers also operate second-life lines and are active in other segments, such as e-waste.

Scaling to refining is a next-stage opportunity. Although the technology is proven, commercial-scale refining into battery-grade materials is nascent in India. This creates an opportunity to capture more domestic value as demand for critical raw materials grows.

What this means for capital: The first refining plants will need first-of-a-kind capital. New processes, particularly for LFP batteries, are still early-stage and will rely on R&D funding and venture capital. Operating plants also need working capital for feedstock.

How Recycling Captures Value in India



Lohum opened India's first battery-grade lithium refinery in 2025, with an annual lithium carbonate capacity of approximately 1,000 tons.

What helps it scale

- **Assured feedstock: F**ormal collection, EPR, and take-back contracts with fleet operators give plants steady volumes.
- **Offtake:** Long-term agreements with domestic cell and pack manufacturers for recovered materials.
- **Policy support:** The ₹1,500 crore critical mineral recycling incentive scheme and the National Critical Mineral Mission.
- **Blended capital:** DFIs and climate funds alongside banks and NBFCs for first refining plants.

Call to Action: Three Opportunities That Define Capital Needs in Battery Circularity

The market is moving from pilots to scale. Recyclers have drawn most capital so far. However, the wider ecosystem must strengthen to scale battery circularity. The next wave of financing must reach second-life applications, refining, and diagnostics adoption to unlock scale and opportunities.

Each opportunity has natural capital providers. Climate funds, DFIs, and growth equity for second-life companies; NBFCs and leasing companies for battery users; DFIs and blended capital for refining; and grants and VCs for diagnostics.

Three Takeaways for Funders and Financiers

Scaling diagnostics adoption will unlock downstream capital ADOPTION CAPITAL	Diagnostics needs relatively little capital, but its tools need to be adopted at scale by fleets, second-life companies, lenders, and recyclers. Trusted battery health data enables lenders to price used batteries and unlocks second life and recycling.
Finance second life end to end: from capacity to usage GROWTH AND ASSET FINANCE	Second-life companies are emerging but need to establish a track record. They need equity for pilots, capital expenditure debt for production lines, and financing for batteries they offer as a service. As they build a track record, users will buy batteries through NBFCs and leasing finance.
Build domestic refining capacity REFINING CAPITAL	Black-mass recycling is established, but India relies largely on imports for battery-grade chemicals. First refining plants and new processes for LFP batteries need DFI and blended capital alongside banks and NBFCs.

Capital Is Concentrated in Recycling; Providers Need to Extend Into the Other Segments

Capital remains concentrated in recycling. Recyclers draw the broadest base: angel investors and VCs for equity, banks and NBFCs for debt. Diagnostics attracts selective VC and climate fund investment; second-life companies and battery users remain largely unserved.

Expansion requires providers to enter new segments. Climate funds, DFIs, and VCs can back second-life companies; NBFCs and leasing companies can finance second-life batteries; DFIs and blended capital can fund first refining plants; grants, VCs, and strategic corporate investment can fund diagnostics.

Capital provider	Diagnostics & BMS	Second life	Second-life battery users	Recycling
EQUITY AND GRANTS				
Grants	Opportunity Area	2.6 (1) ▲		0.5 (2)
Accelerators & incubators				3.8 (5)
Angels & family offices	0.1 (1)			**52.1 (17)**
VC & growth PE	5.6 (2) ▲	Opportunity Area		**130.2 (18)**
Climate & impact funds	**18.0 (2)** ▲	Opportunity Area		**7.0 (2) ▲**
DFIs		Opportunity Area		**8.3 (1) ▲**
Corporates	Opportunity Area	0.1 (1) ▲	Opportunity Area	**12.7 (2)**
DEBT				
Government lenders	1.2 (1)			**4.2 (5) ▲**
NBFCs & private credit		Opportunity Area	Opportunity Area	**47.1 (17) ▲**
Commercial banks	0.6 (1)	3.4 (1)		**49.3 (40)**

Note: Figures are USD m of equity, grants or secured debt; figures in parentheses are the number of rounds or grants (equity) or charges (debt). Recycling includes recyclers with second-life lines.

▲ Present today, but needs to participate further

Opportunity area: absent today, but needed

Mapping Investor Instruments to Circularity Needs

Early-stage sectors and business models → *Late stage*

	Angels and family offices	Climate and impact funds	VC and growth PE	NBFCs and private credit	DFIs and government lenders	Corporates	Commercial banks
What to Bet On	*Bet on what's next:* early-stage diagnostics, second-life pilots, new refining processes (especially for LFP), and software or IP that could become standards.	*Bet on what's technologically complex:* validated diagnostics, second-life pilots and new refining processes with strong climate impact.	*Bet on what scales:* proven recyclers and repurposers positioned to expand processing volumes and improve capacity utilisation, consolidating India's fragmented market.	*Bet on what's backed by assets:* recycling plants, second-life production lines and battery fleets offered as a service; as a track record builds, loans and leases to users buying second-life batteries.	*Bet on what builds systems:* DFIs typically prefer larger investments (~US$30 million–US$50 million) and replication-stage projects with secured feedstock and offtake. First commercial recycling and refining plants are the natural fit; blended vehicles can also support second-life pilots.	*Bet on what secures supply:* mineral recovery through closed loops, take-back partnerships, second-life pilots that secure future feedstock, and strategic stakes in diagnostics. Financial institutions can also take strategic stakes and offer finance leases to second-life battery users.	*Bet on what cash flows:* operating recycling and refining plants with secured offtake, steady feedstock, and high utilisation. Second-life companies once production lines are proven.
Gap (What's Missing)	Angels and family offices led 19 rounds worth US$52.3 million, mostly into recyclers, but their patient, strategic approach needs to extend to the rest of the ecosystem.	Climate funds led only four rounds involving diagnostics companies and recyclers; their participation has to expand beyond early-stage innovation to funding and de-risking initial commercialisation.	Growth capital has gone to a few winners: VC and growth PE investors led rounds worth US$136.1 million (57% of equity), mostly into Lohum. PE-driven consolidation of smaller recyclers and repurposers has yet to begin.	NBFCs are the largest source of debt (US$47.1 million across 17 charges), concentrated in a few loans to recyclers, including US$23.4 million to Attero. Battery fleets and second-life users are yet to be financed effectively.	Largely absent: one DFI-led equity round (IFC in Attero, 2010) and USD 5.4m from government lenders. Few proof points yet for concessional loans, guarantees or blended structures. Largely absent: one DFI-led	Few OEMs have long-term purchase agreements or equity stakes ensuring that their end-of-life batteries re-enter formal circular streams.	Banks have lent US$53.2 million, almost all to operating recyclers. Second life has received one US$3.4 million bank loan, and diagnostics has received US$0.6 million.
Potential Instruments	Patient equity, convertibles, and revenue-based financing for early pilots.	Early-to-growth equity, blended capital, and first-loss tranches alongside DFIs.	Growth equity, buyouts, or mergers that integrate smaller players into large-scale platforms.	Asset finance, equipment and working-capital loans, finance leases, and private credit.	Concessional loans, first-loss capital, blended finance, and viability gap funding for recycling and refining infrastructure.	Strategic equity (minority stakes or joint ventures), long-term offtake agreements, advance purchase contracts, and issuance of green bonds to finance circular infrastructure.	Term loans, project finance, working-capital lines, and green bonds.
Why It Matters	Angels and family offices fund early technology risk in diagnostics, second-life pilots, and new refining processes.	Climate funds take technology risk that mainstream VC avoids and help crowd in DFIs and lenders.	PE is needed to industrialise and consolidate fragmented operators into efficient large-scale players.	NBFCs move faster than banks on new asset classes, as they did for EVs, and can finance second-life batteries first.	DFIs and blended vehicles help bankable first commercial plants reach financial close, crowding in private lenders through concessional loans and guarantees.	OEM contracts secure inflows of end-of-life batteries, underwriting feedstock volumes so other investors can step in.	Expanding recycling and repurposing plants requires large-scale debt financing to mainstream the sector.

Glossary and Acronyms

Acronym	Meaning
BMS	Battery Management System – electronics that monitor battery health and safety
CAPEX	Capital expenditure – upfront investment in facilities and equipment
Co/Ni/Cu	Cobalt, Nickel, Copper – key metals in batteries
EoL	End-of-Life – batteries retired from first use
EPR	Extended producer responsibility
LiB	Lithium-ion Battery
IRR	Internal Rate of Return – measure of investment profitability
kWh	Kilowatt-hour – unit of energy
LFP	Lithium Iron Phosphate – India's most common EV battery chemistry
NCA	Nickel Cobalt Aluminium– a high-energy battery chemistry
NMC	Nickel Manganese Cobalt – a widely used EV battery chemistry
NBFCs	Non-Banking Financial Companies – lenders outside traditional banks
OEM	Original Equipment Manufacturer – vehicle or battery producer
OPEX	Operating Expenditure – recurring costs to run a facility
RUL	Remaining Useful Life
TAM	Total addressable market
SoC	State-of-Charge, how much energy is left in a battery
SoH	Remaining capacity over rated capacity, common measures of battery condition

Term	Meaning
Black Mass	Powder containing valuable metals recovered from shredded batteries
Closed Loop	System where recovered materials re-enter the same supply chain (e.g., OEM recycling back into new packs)
Learning Rate	Percentage cost reduction with every doubling of cumulative production or throughput
Residual Value	Value of a battery after its first-life use
Repurposing	Reconfiguring EoL EV batteries for second-life use (e.g., stationary storage)
Recycling Efficiency/Recovery Rate	Percentage of metals and/or materials recovered during recycling
Refining Integration	Ability to refine black mass in-house into high-purity, battery-grade materials
Second-Life Battery	EoL EV battery used in another application (e.g., grid storage)
Traceability	Ability to track a battery's life cycle through data and standards

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