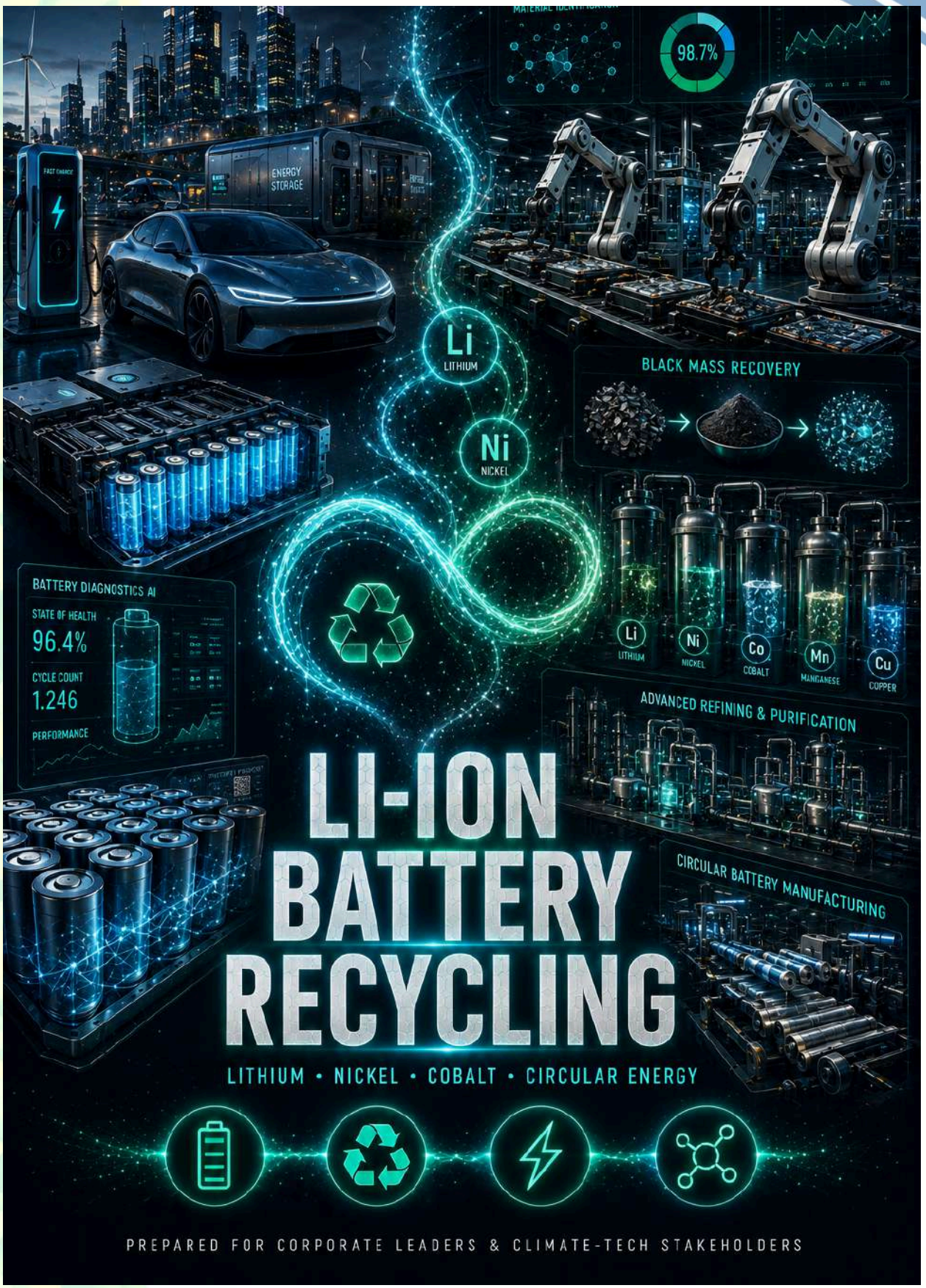
98.7%
ENERGY STORAGE
Li
LITHIUM
Ni
NICKEL
BLACK MASS RECOVERY
BATTERY DIAGNOSTICS AI
STATE OF HEALTH
96.4%
CYCLE COUNT
1.246
PERFORMANCE
Li
LITHIUM
Ni
NICKEL
Co
COBALT
Mn
MANGANESE
Cu
COPPER
ADVANCED REFINING & PURIFICATION
CIRCULAR BATTERY MANUFACTURING
LI-ION
BATTERY
RECYCLING
LITHIUM • NICKEL • COBALT • CIRCULAR ENERGY
PREPARED FOR CORPORATE LEADERS & CLIMATE-TECH STAKEHOLDERS

Waste Management
Li-ion Battery Recycling

This section provides key inputs on Li-ion Battery Recycling Opportunities for corporate leaders.

Opportunity Snapshot: Li-ion Battery Recycling

Recovery of valuable materials (lithium, nickel, cobalt, copper) from used EV and industrial batteries

Market Signal

- India currently **imports most battery materials** ; recycling as domestic source to tackle demand
- Strong policy push via **Battery Waste Management Rules** (EPR for batteries)
- **Annual Market size by 2030:** 3000 - 4000 ₹ Cr

What Makes or Breaks It?

- **Access to battery scrap** (OEM tie-ups, fleet partnerships, EPR contracts)
- **High recovery rates** (>90% for key metals via hydro processes)
- Safe handling, dismantling, and compliance with hazardous waste norms

Why It Matters NOW?

- **Raw material security** (reduce dependence on imports)
- **High value recovery** (30–50% of battery value)
- ESG and circular economy push from OEMs

Well Aligned Opportunity for

- **Battery and EV ecosystem players**
- **Metal recycling and chemical companies**
- **Startups specializing in recycling technologies**

Key Challenges

- **Limited feedstock today** (EV battery volumes still ramping)
- **Collection and reverse logistics complexity**

Business Model

- Partner with OEMs for end-of-life battery collection (EPR compliance)
- Set up recycling plants near EV clusters
- Focus on high-value recovery (Li, Ni, Co)

Introduction and Business Case

With India's EV and storage markets scaling rapidly, end-of-life batteries are becoming both a waste challenge and a resource opportunity. Li-ion battery recycling addresses two problems at once: preventing hazardous landfill waste and securing critical minerals such as Li, Co, Ni, Mn and graphite that India currently imports.

Recycling enables circular supply chains, helps OEMs comply with the Battery Waste Management Rules 2022 and EPR mandates and supports the growth of EVs and energy storage by lowering raw material dependence.

Li-ion recycling thus represents a significant, growing business opportunity in India.

Market Potential for Li-ion Battery Recycling in India

Year	Market Size (₹ Cr)	Drivers
2025	500-700	Early EV and electronics battery replacements; pilot recycling plants scaling.
2030	3,000-4,000	Surge in EV adoption; large volumes of end-of-life 2W/3W and grid BESS batteries.
2040	15,000-20,000	Mass replacement of 4W EV packs + stationary storage systems; closed-loop ecosystem matures.

Market Segments and Applications

Segment	Applications	Business Model	Key Drivers
EV Battery Recycling (End-of-Life)	Recovery of Li, Ni, Co, Mn from retired EV packs	contracts + material sales	Rapid growth of EV retirements
Battery Manufacturing Scrap Recycling	Recycling of gigafactory production scrap	Fee-for-service + material offtake	High-value scrap and immediate volumes
Hydrometallurgical Recycling	Chemical recovery of battery metals	Technology licensing + processing fees	Higher recovery rates and lower emissions
Direct Recycling to Cathode Materials	Conversion to pCAM or CAM	Material sales at battery-grade specs	Reduce cost and carbon vs. virgin mining
Mechanical	Shredding,	Processing fees +	Scalable feedstock

Pre-Processing & Black Mass Production	separation, black mass output	black mass sales	preparation
Closed-Loop Recycling for OEMs	Recycling tied directly to battery manufacturing	Long-term supply contracts	Supply-chain security and ESG commitments
Battery Collection & Reverse Logistics	Safe transport, dismantling, storage	Collection fees + recycling contracts	Regulatory requirements and safety
Stationary Storage & Industrial Battery Recycling	Grid and industrial energy storage systems	Project-based contracts	Growth of stationary storage deployments
Low-Carbon & ESG-Optimized Recycling	Recycling with verified low emissions	Premium material pricing	OEM carbon footprint reduction targets
Second-Life & Pre-Recycling Processing	Testing, repurposing before recycling	Asset resale + recycling	Value maximization before material recovery

Typical Project Capacities & Investments Required in India

Project Type	Typical Capacity	Indicative CapEx (₹ Cr)	Notes
Pilot dismantling + pre-processing line	500-1,000 TPA (packs/cells)	12-25	Safe discharge, manual/semiauto dismantling, basic shredding.
Regional collection + dismantling hub	5,000-15,000 packs/yr	5-12	EPR-driven intake; triage + logistics consolidation.
Pre-processing (industrial shred + separation)	3,000-8,000 TPA (input batteries)	25-45	Produces black mass + Cu/Al fractions.
Hydrometallurgical refinery (black-mass to salts)	5,000-15,000 TPA (black mass)	80-160	Recovers Li, Co, Ni, Mn salts; >90% recovery targets.
Integrated recycling plant (pack-in → salts-out)	~10,000 TPA (battery input)	150-250	End-to-end: discharge → shred → refine; bankable offtake.
Direct-recycling R&D line	200-500 TPA (black mass)	15-30	Cathode relithiation; early-stage, high upside.

Underlying Technologies & Processes

Element	Options	Key Traits
Pre-processing	Manual/automated dismantling, discharge, shredding	Ensures safe handling, separates modules & packs.
Recovery route	Hydrometallurgy (leaching + precipitation)	High recovery rates (>90%), scalable, lower energy.
	Pyrometallurgy (smelting)	Robust, tolerant of mixed chemistries; less selective.
	Direct recycling (cathode re-lithiation)	Preserves material structure; promising but at R&D stage.
Materials recovered	Cobalt, nickel, manganese, lithium, graphite, copper, aluminium	Feedstock for new cells; offsets import dependence.

Key Challenges

Challenge Area	Key Issues	Business Impact	India Specific	Strategic Implications
Feedstock Availability & Timing Mismatch	Limited end-of-life batteries currently available at scale	Underutilized recycling capacity and uncertain revenue streams	EV market still maturing; majority of batteries yet to reach EOL	Need diversified feedstock sources (manufacturing scrap + imports)
Collection Logistics & Reverse Supply Chain Complexity	Fragmented battery ownership and informal recycling sector	High collection costs and inconsistent feedstock quality	Unorganized sector dominance; lack of standardized collection infrastructure	Strong partnerships and structured take-back systems required
Technology Selection & Process Economics	Choice between hydrometallurgical, pyrometallurgical, or hybrid recycling methods	Capex intensity and uncertain recovery yields impacting profitability	Rapid evolution in battery chemistries (LFP vs NMC) affecting economics	Flexible processing technologies and modular design important
Policy, Compliance &	EPR norms evolving;	Increased operational	India-specific battery waste	Early compliance capability and

Safety Regulations	handling hazardous materials requires strict compliance	costs and licensing complexity	rules; safety risks in transport/storage	safety infrastructure critical
Commodity Price Volatility & Geopolitical Dependencies	Revenue linked to recovered metals (lithium, nickel, cobalt)	Profitability sensitive to global metal price fluctuations	Import dependency for raw materials; global battery supply chain dynamics	Hedging strategies and diversified offtake agreements needed

Prominent Players in the Indian Market

Company / Entity	Project Details
Attero Recycling	India's largest Li-ion recycler; hydro-metallurgical recovery of cobalt, nickel, lithium; exports refined materials.
Lohum Cleantech	Second-life + recycling; reuses EV cells for stationary storage, then recycles; scaling to multi-GWh capacity.
Metastable Materials	Bengaluru-based startup using carbothermal reduction process for high recovery yields.
ACE Green Recycling	Developing modular, low-emission recycling plants in India and abroad.
Gravita India	Expanding from lead-acid into Li-ion recycling; leveraging global refining footprint.
Exigo Recycling	Delhi NCR-based recycler offering collection, dismantling and recycling services.
E-Parisaraa	Early e-waste recycler; piloting small-scale Li-ion recovery lines.

Innovation Perspectives

Innovation	Business Opportunity	For Senior Management
Closed-Loop Battery Material Platforms	Recycling integrated directly with cell manufacturing	Locks in long-term offtake and strategic partnerships
Direct-to-Cathode Recycling Technologies	Skip metal refining and go straight to CAM/pCAM	Structural cost advantage over traditional recycling
Battery	Subscription or long-term	Recurring revenue and lower

Recycling-as-a-Service	service contracts	customer friction
Low-Carbon & Traceable Battery Materials	Verified low-CO_2 recycled materials with digital traceability	Enables premium pricing and OEM ESG alignment
Gigafactory Scrap Monetization Platforms	Dedicated, on-site or near-site recycling solutions	Immediate cash flow and deep OEM integration
Global Battery Reverse-Logistics Networks	End-to-end collection, dismantling, and compliance platforms	Control of feedstock determines long-term scale
AI-Driven Battery Sorting & Diagnostics	AI to classify chemistry, state-of-health, and reuse potential	Higher recovery rates and operational efficiency
Second-Life-First Business Models	Repurpose before recycling to maximize asset value	Expands value pool beyond raw materials
Recycling-Linked OEM Financing Models	Pre-funded recycling tied to future material supply	Secures scale ahead of competitors
Regulatory-Adaptive Recycling Platforms	Systems that adapt to regional EPR and reporting rules	Turns regulation into a competitive moat

Concentric & Satellite Opportunities

- Urban collection & reverse logistics networks: FPOs and startups building last-mile aggregation systems for used EV and consumer batteries.
- Dismantling & pre-processing facilities: Safe discharge, sorting and module separation units co-located with auto clusters for supply efficiency.
- Black mass refining & precursor manufacturing: Intermediate plants producing battery-grade salts for domestic cathode and cell manufacturers.
- Battery testing & triage services: Secondary markets for grading and redeploying partially viable packs into energy storage or low-demand uses.
- Digital traceability & compliance systems: Blockchain-based EPR and material-tracking platforms ensuring transparency across the recycling value chain.
- Recycled-material certification & trading: Platforms linking recyclers and cell makers through verified carbon-credit and circular-material exchanges.
- Lithium precipitation reagents: Manufacture and supply oxalic acid/selective chelators for 99% Li2CO3 recovery.

Key Takeaway for Senior Management

Takeaway	Details
Battery recycling is strategic materials infrastructure, not waste management	• Recycling secures lithium, nickel, cobalt, manganese, copper, and graphite—critical inputs for EV and storage scale-up • ***Examples****:* closed-loop supply to cell manufacturers; recycled metals offset import volatility
Feedstock control is the single biggest determinant of returns	• Technology matters, but predictable volumes matter more • ***Sub-components****:* manufacturing scrap, fleet EV EoL packs, stationary storage, consumer electronics • **Competitive advantage:** derive through long-term feedstock contracts, reverse-logistics design, utilization certainty and lower unit costs competitors can't easily replicate

Technology choice defines recovery rates, costs, and customer acceptance	• Advanced processes materially outperform basic shredding
	• ***Examples****:*
	  ○ **Hydromet:** high recovery & purity
	  ○ **Direct recycling:** cathode value preservation (emerging)
	  ○ **Pyromet:** simpler, lower selectivity

Compliance, traceability, and quality are becoming market entry barriers	• OEMs and regulators demand certified, auditable recycling • ***Sub-components****:* EPR compliance, battery passports, digital chain-of-custody, ESG audits • **Recommended innovation focus:** digital traceability and certification by design

Next Steps for Corporate Leaders

Li-ion battery recycling is becoming strategically important as EV penetration, stationary storage, and consumer electronics drive rapid growth in end-of-life (EOL) and production scrap volumes. Closed-loop recycling pathways (hydrometallurgical, pyrometallurgical, and direct recycling) enable recovery of critical minerals such as lithium, nickel, cobalt, and graphite, reducing supply chain exposure and embodied emissions. Regulatory frameworks, Extended Producer Responsibility (EPR), and OEM circularity goals are accelerating ecosystem build-out, while economics depend on material mix, collection efficiency, and technology maturity.

This could be an attractive climate tech opportunity for industries and firms in specific sectors and industries keen on catering to this fast growing market.

Connect with Team EAI to know more about this opportunity and take your corporate's initial steps. Send a note to consult@eai.in or talk to Muthukrishnan - 9952910083