kcm NETWORK

K C Mehta & Co LLP
Chartered Accountants

kcm Lens

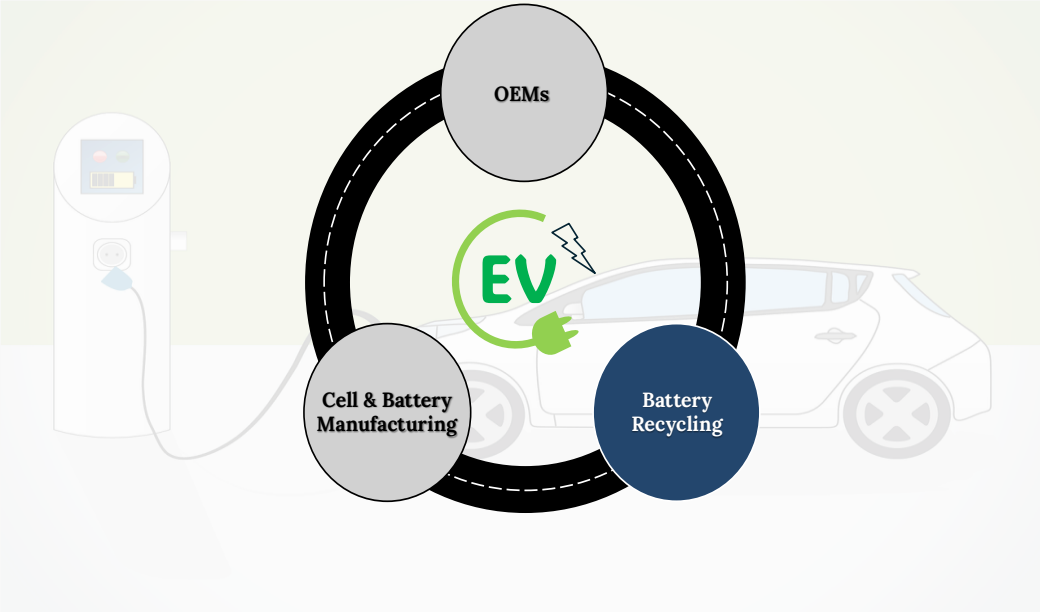
EV Series – Volume 3

EV Battery Recycling

May 2025

Introduction

kcmLens is a series of publication from KCM, offering sector specific insights. Under this series, we pick one sector, outline the value chain of that sector, and offer a deep dive analysis through the Lens of each segment of the value chain. This publication helps in developing a holistic understanding of the entire sector. The idea is to not only collate insights and updates on a particular sector for the readers, but to also present important takeaways from K C Mehta & Co LLP on that sector.



We launched our first **kcmLens** series, **The EV Series,** in July 2024. The EV series involves analysis of the EV value chain which primarily includes following segments: the Original Equipment Manufacturers (OEMs), the Battery & Cell Manufacturers and the Battery Recyclers (deliberately ignoring mining, extracting, and refining segments of the value chain to focus on the **EV loop**).

After our first publication on EV OEMs and the second on Cell & Battery Manufacturing, we are pleased to present the third and final publication in our EV ecosystem series focused on EV Battery Recycling. This edition delves into why battery recycling represents India's best path to securing critical minerals, given the country's limited natural resources and mining infrastructure. It explores current opportunities and challenges in the battery recycling space, recycling technologies, evolving competitive landscape, government policies aimed at promoting recycling, and strategies adopted by key players in the sector.

Together, these three publications provide a comprehensive view of the evolving EV landscape in India.

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Let's pick up the thread from Series #2, we saw how lithium and cell chemistry drive battery efficiency and value. Yet true ecosystem strength comes from closing the loop; after battery formulation to manufacturing, it's the recycling stage that secures critical materials, minimizes environmental impact, and guarantees long-term resource availability.

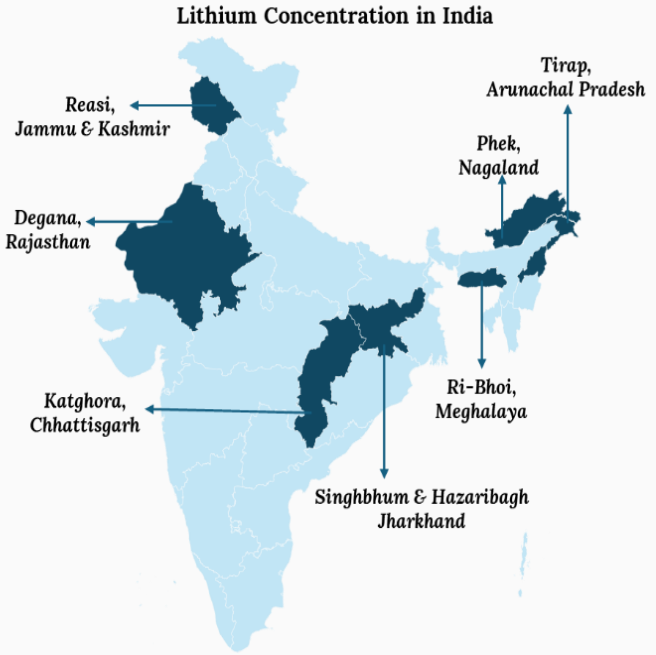
By integrating robust recycling at every stage of the value chain, we power the EV revolution sustainably and future-proof it.
Let's uncover how!

Securing India's Critical Minerals: How?

Why Mining in India isn't Taking Off?

Mining in India: Low Yield, High Cost, Long Lead Time

- Upon initial analysis of the mine, it was found that from India's lithium reserves only ***60 grams of lithium can be extracted after mining 1 tonne of ore.***
- Mined lithium ore is converted into Lepidolite concentrate and that is refined into battery grade lithium.
- To make Lepidolite concentrate ***in India*** it costs ***$500/ton*** vs. its market price of ***$209/ton***, making mining ***economically unviable.***
- For making battery grade lithium, refining needs to be carried out and India does not have any refining capability.
- India would have to export the mined ore to China for refining resulting in high logistics cost.



If not mining, how can India ensure sustainable supply of lithium?

Source: the KEN

Securing India's Critical Minerals: How?

Dying Batteries can help India move towards self sufficiency

End-of-Life battery

Second Life

- Batteries still have usable capacity (~70–80%).
- Extends battery life by several years before final recycling.

Recycling

- When battery health is too degraded to reuse.
- Supports a circular economy by feeding recovered materials into new battery production.

Goal

- Maximize resource efficiency
- Minimize environmental impact

Securing India's Critical Minerals: How?

Coverage

Are dead batteries always dead? Giving them a second life...

How it Works?

Assessment & Grading- *Battery health & usability* → ***Refurbishment & Re-engineering*** *into standardized modules or racks* → ***Repurposing –*** *Energy Storage and Backup Power*

Why it Matters?

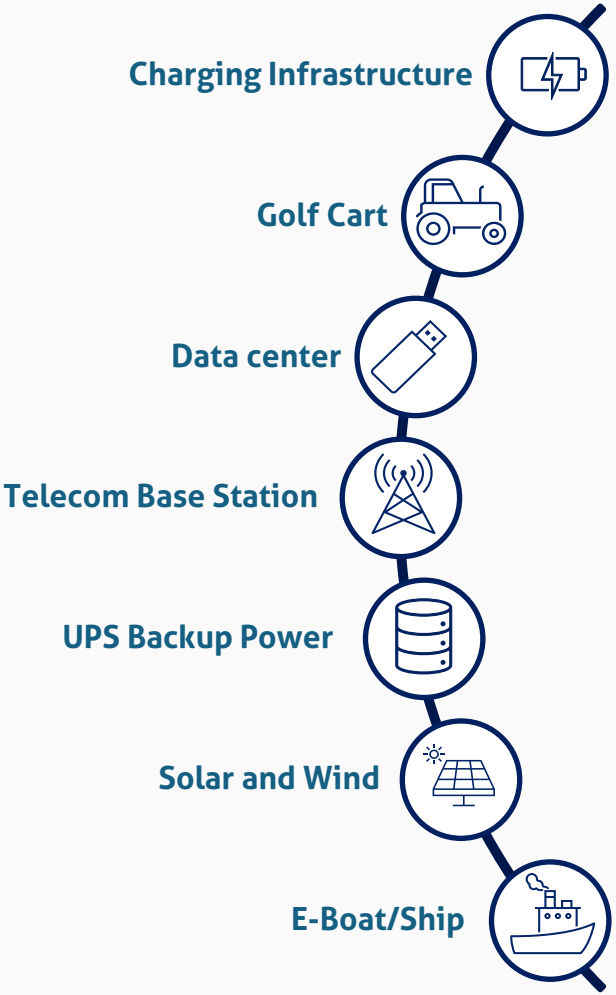
- Extends battery lifespan and reduces e-waste.
- Supports sustainability and a circular economy.
- Significantly reduces dependency on raw material mining.

Why are the Challenges?

- Very high costs.
- Regulatory hurdles and lack of standardized processes.
- Safety risks due to battery degradation.

Future Outlook

- AI-driven battery diagnostics for better efficiency.
- Increased demand for second-life batteries in energy storage.



What happens when batteries can't be Reused, they enter the recycling domain!

Securing India's Critical Minerals: How?

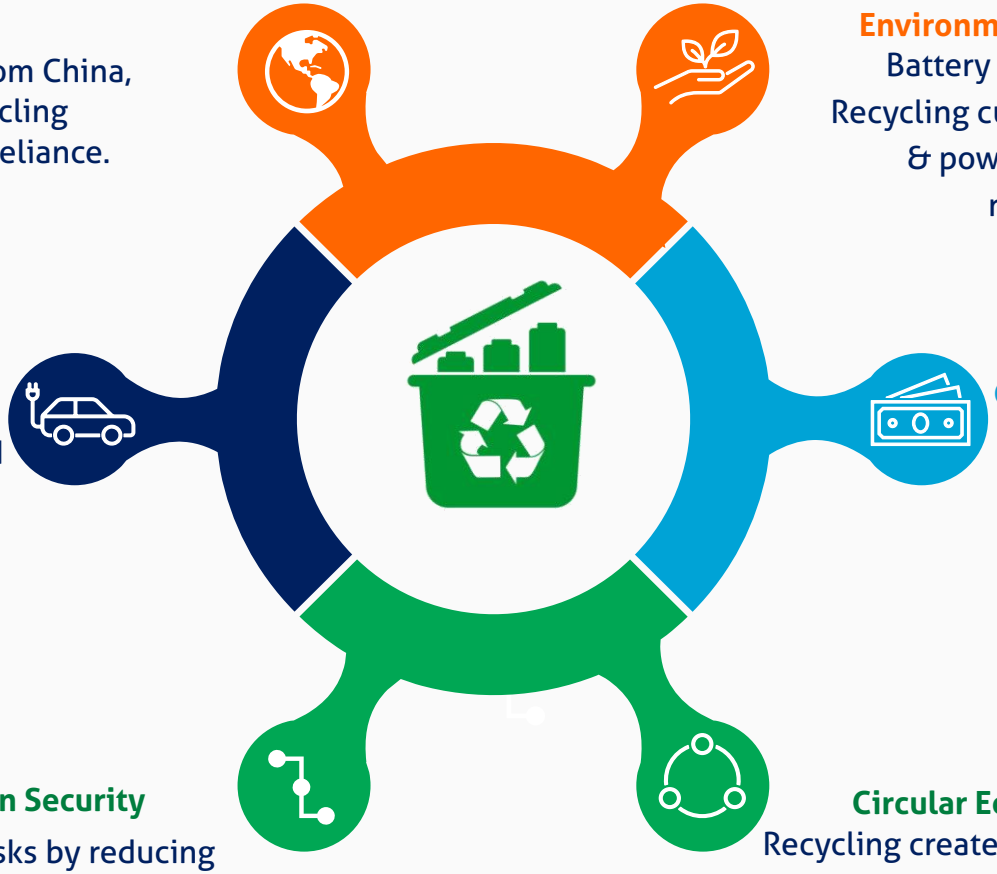
Why Recycling is the Future...

Reducing Import

India imports 90% of its lithium from China, Australia & Argentina, but recycling domestically will reduce foreign reliance.

Environmental, Sustainable & Social Win

Battery waste causes toxic pollution. Recycling cuts landfill waste, CO_2, and water & power usage, deforestation and resettlement of locals.



Meeting Growing EV Demand

India's EV market expected to exceed 50 million by 2030 with recycling ensuring steady lithium supply.

Cost Reduction & Economic Viability

Recycling cuts raw material costs for the OEMs and makes EVs more affordable for the consumers.

Strengthening Supply Chain Security

Recycling mitigates geopolitical risks by reducing reliance on imports and creating a domestic lithium reserve.

Circular Economy & Resource Efficiency

Recycling creates a closed-loop system, boosting EV sustainability and India's net-zero goals.

Recycling powers the next charge

Batteries Reborn: A Circular Economy in Action

1. Battery Recyclers

Battery Recyclers collect and dismantle end-of-life batteries to produce a ***"black mass,"*** which is a mixture of valuable metals.

2. Metal Extractors

Using chemical or thermal processes, ***they extract high purity lithium*** and other metals from the black mass.

3. Pre - CAM Producers

Further, the extracted metals are converted into ***Precursor Cathode Active Materials (Pre-CAM)***, a compound essential for battery production.

6. EV OEMs

Integrating the rejuvenated cells into new battery pack assemblies, for serial EV production, ***closing the loop & cutting demand for virgin inputs.***

5. Cell & Battery Manufacturers

Utilizing CAM along with anode materials, they ***produce battery cells*** and assemble them into complete battery packs.

4. CAM Manufacturers

They refine Pre-CAM into ***Cathode Active Materials (CAM)*** that are used in fabricating battery cells.

Let's find out what black mass is and how it holds the power to revolutionize the EV battery industry.

Recycling powers the next charge

Black Mass: Battery's Hidden Powerhouse

Black mass, derived from recycled EV batteries, is rich in essential minerals like ***lithium, cobalt, nickel, manganese and graphite*** —vital for EVs, energy storage, and electronics.

These materials are in the form of ***oxides, carbonates, or other compounds***, depending on the battery chemistry and the processing method.

EV Battery Pack | **Cell Phone Battery Pack** | **1 Metric Tonne (MT) of Black Mass**

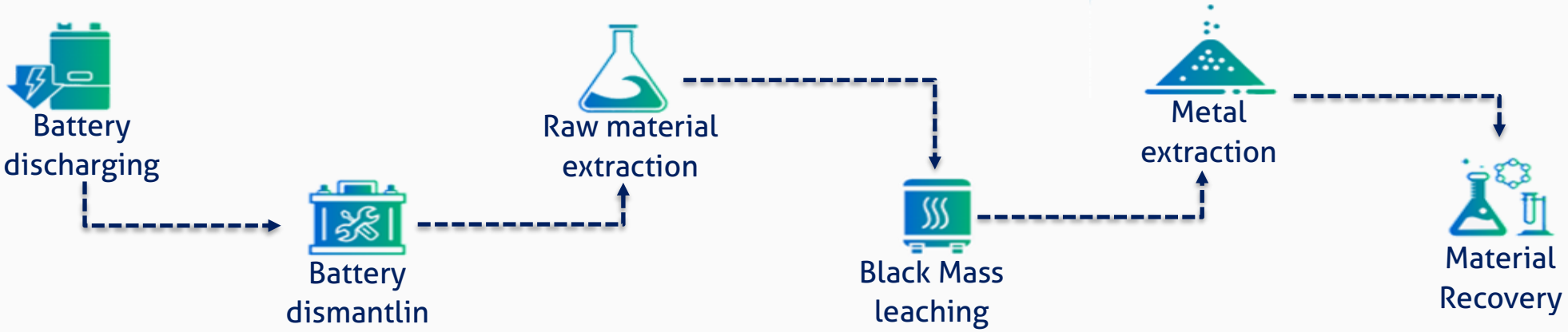
A typical ***EV battery pack weighs 454kg*** and ***yields 40–50%*** of black mass, equating to ***181.6– 227kg of black mass per pack***. Similarly, a standard cell phone battery (3300mAh) ***weighs 48g and yields 21 g– 26g of black mass.***

Takeaway: It is necessary to identify **Black Mass's role as a Strategic Resource in building a circular EV economy**, and to restrict its exports completely to boost local refining and resource sovereignty.

Let's explore how recycling, can shape a more sustainable future through streamlined process workflows & enhanced recovery.

Recycling powers the next charge

Closing the Loop – The End-to-End Battery Recycling



Metal Extracted	Typical Recovery Rate (%)
Lithium	89-95
Cobalt	90-99
Nickel	90-99
Manganese	89-99
Copper	90-95

- Black mass ***captures over 90 % of a battery's critical metals*** in one concentrated stream.
- Technology choice, plant scale, and feed-chemistry mix can ***swing overall recovery by ±10 %.***

Let's explore the techniques for battery recycling & delve into efficiency and commercial analysis of each method.

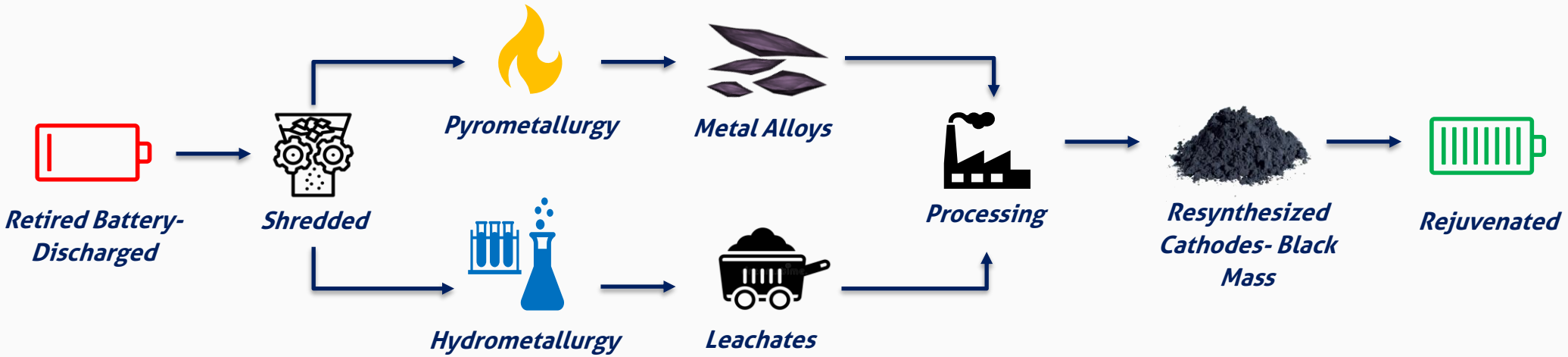
Battery Recycling Techniques

Coverage

How is recycling carried out today...

Inside the Process: Thermal vs. Chemical Recycling Routes

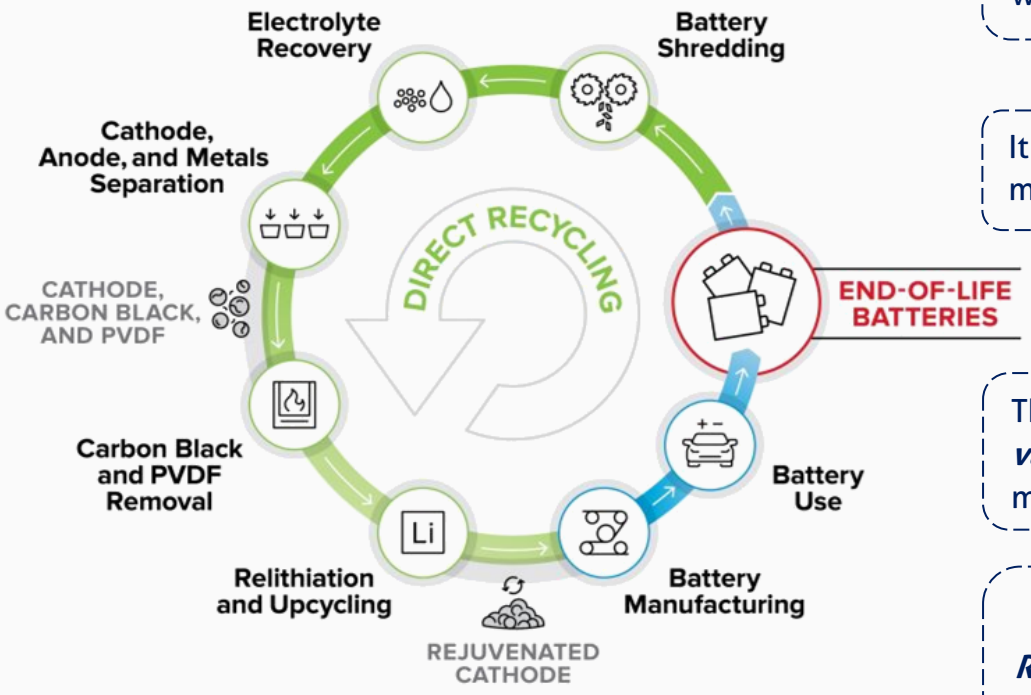
- ***Pyrometallurgy*** is a high-temperature process used to recover metals from used materials - like EV batteries - by burning, smelting, or roasting them.
- ***Hydrometallurgy*** is an advanced chemical extraction process that uses aqueous solutions typically acids or bases to leach (dissolve) metals from solid materials (i.e., battery components in our case).



Takeaway: The choice depends on energy use, environmental concerns, and metal type, ***with hydrometallurgy preferred for eco-friendliness and pyrometallurgy for handling larger volumes.***

Battery Recycling Techniques

... and what does the future look like



Direct recycling (a.k.a. Direct Cathode Recycling) is an innovative process that aims to recover, regenerate and reuse battery components without breaking them down into individual elements.

It ***preserves and refurbishes the original structure of components*** of mainly the cathode.

The regenerated active materials from direct recycling are ***usually more valuable*** compared to elemental products from other two recycling methods.

Process Workflow

Raw chemicals/ minerals from used battery → reusable cathode, slashing energy, cost, waste and complexity while delivering ≥95% recoveries in one streamlined flow.

Battery Recycling Techniques

Coverage

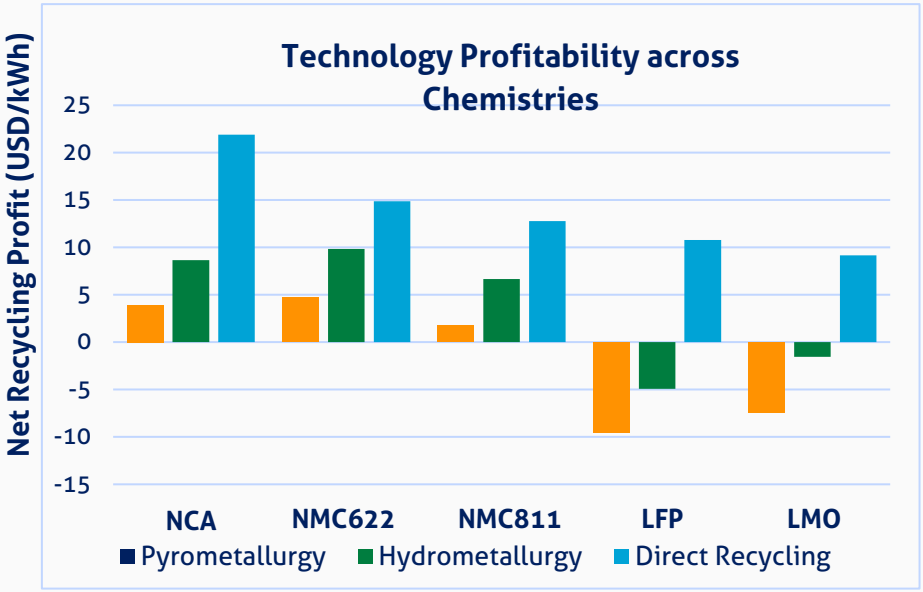
Which recycling method is most suitable

Aspects	Pyrometallurgy	Hydrometallurgy	Direct Recycling
Process Type	Thermal *(high-temperature smelting)*	Chemical *(acid/base leaching)*	Physical and chemical *(component recovery & refurbishment)*
Temperature	Very high (1000–1500°C)	Low to moderate (<200°C)	Low
Material Recovery	Co, Ni, Cu (Li often lost in slag)	Li, Co, Ni, Mn	Preserves and reuses cathodes and other intact materials
Lithium Recovery	Low	High	High
Energy Usage	High	Moderate	Low
Environmental Impact	Higher (emissions, energy use)	Lower (controlled chemical use)	Lowest (minimal waste and emissions)
Best For	Mixed battery chemistries, large volumes	Efficient metal recovery from sorted batteries	Uniform chemistries, maximizing material value
Cost Effectiveness	High	Low	High

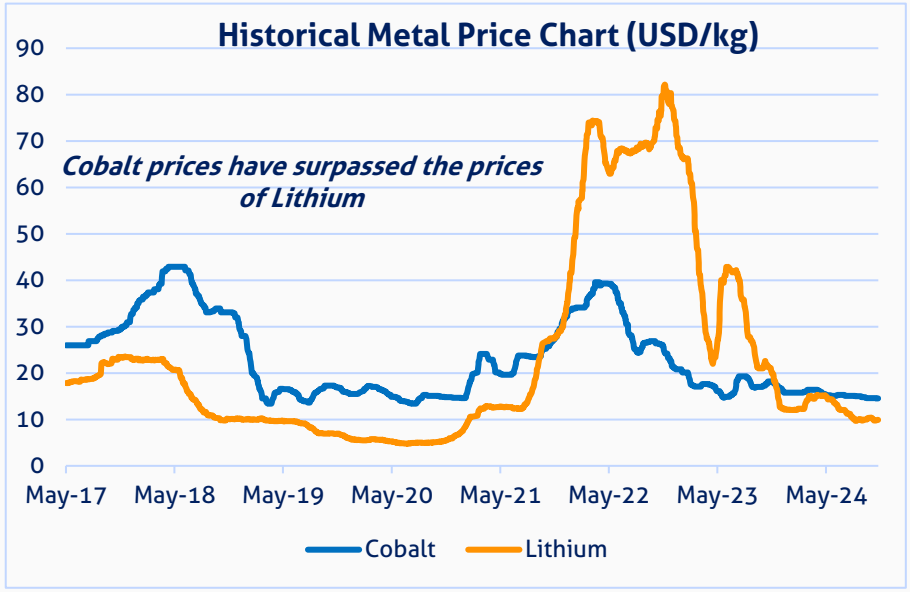
Takeaway:
Hydrometallurgy is recognized as the most promising method for adoption in India's recycling ecosystem, due to its technical efficiency and compatibility across various battery chemistries. In contrast, ***direct recycling*** is still at the pilot stage, with its cost-effectiveness highly dependent on the quality, volume, and consistency of the battery feedstock.

Battery Recycling Techniques

How cell chemistries and technology impact



Source: WRI India



Why is pyrometallurgy underperforming?

- **Poor metal recovery and forcing additional downstream leaching** or simply writing off value.
- **Extreme energy intensity:** smelting black mass requires sustained furnace temperatures > 1500 °C, driving very high utility bills (electricity & natural gas).
- **High maintenance & consumables:** frequent refractory lining replacements and flux additions hike both OpEx & consumables burdens.

Economic Drivers of Battery Chemistry & Recycling

- Recycling profitability depends on **value of metal recovered and processing costs**.
- Nickel chemistries fetch **higher prices**, NMC811 at $103/kWh vs. $60/kWh for LFP due to their **cobalt content.**
- **Nickel chemistries** are readily available in the market. Thus, recyclers are scaling up capacity to leverage economies of scale & boost long-term profits.

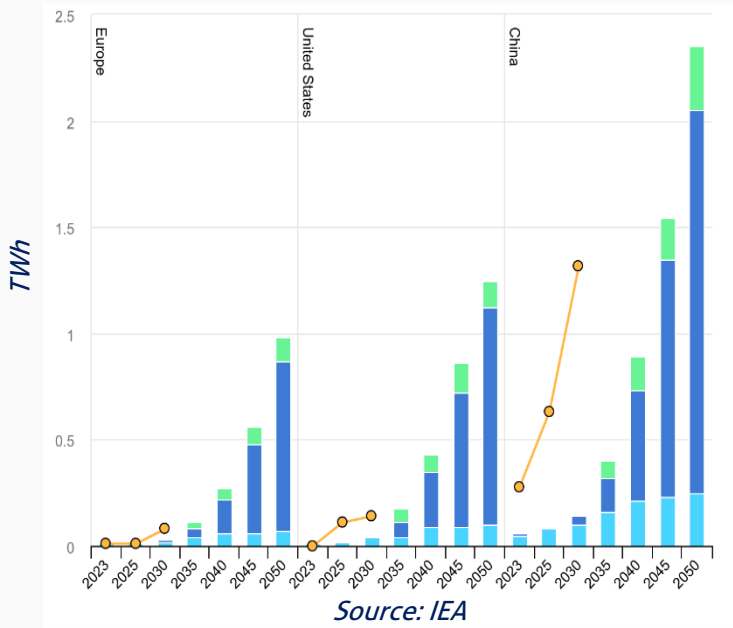
Market Trends & Growth Catalysts

China Dominates the Recycling Race

Global Outlook (2023):

- ***China*** has 5 times more recycling capacity than available feedstock, leading to just 20% utilization.
- The feedstock availability and domestic capacity is roughly equal, say balanced for ***Europe***.
- In ***United States,*** the domestic capacity only meets 25% of the available feedstock.
- In ***India,*** there is a severe deficit as capacity only meets 5% of the feedstock. Even in 2030, India's then domestic capacity can only process 25% of the feedstock.

China's overcapacity positions it well to handle rising global exports, considering their respective domestic undercapacity.



Source: IEA

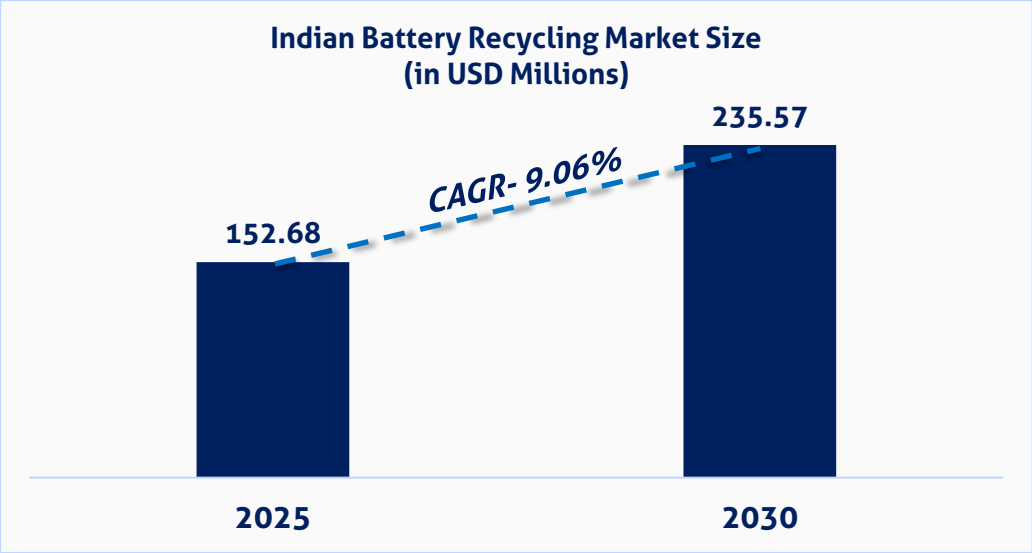
Takeaway:

China's ***early strategic subsidies, clear regulations, massive capacity, integrated supply chain, cutting-edge technology, & strong market economics*** combine to keep its battery-recycling industry years ahead of global rivals.

Considering the facts and capabilities, recycling is the best bet for India to ensure resource sovereignty for critical minerals. Let's dive deep into the opportunities that exist in the battery recycling space

Market Trends & Growth Catalysts

How India is catching up



Source: Mordor Intelligence

Key Challenges

- *Fragmented Collection Network*
- *High Capex & Long Payback*
- *Evolving Chemistries*
- *Low Volumes in Early Years*
- *Environmental & Safety Risks*

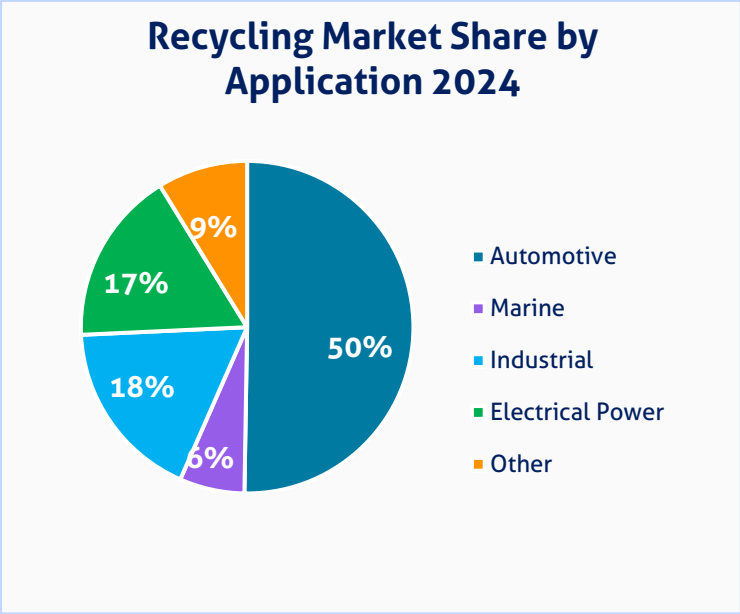
Market Opportunities:

- ***High and volatile prices*** for lithium, cobalt, and nickel make recycling economically attractive as a supply hedge.
- India's historic ***export of black mass is being curbed***, which will ***shift volume toward domestic refining***, boosting market size locally.
- ***Automobile OEMs goals to use recycled materials*** drive back-end demand for recycled materials.
- Projections from NITI Aayog highlight a potential reservoir of ***128 gigawatt-hours of recyclable batteries in India by 2030***, majority of which will come from EVs.

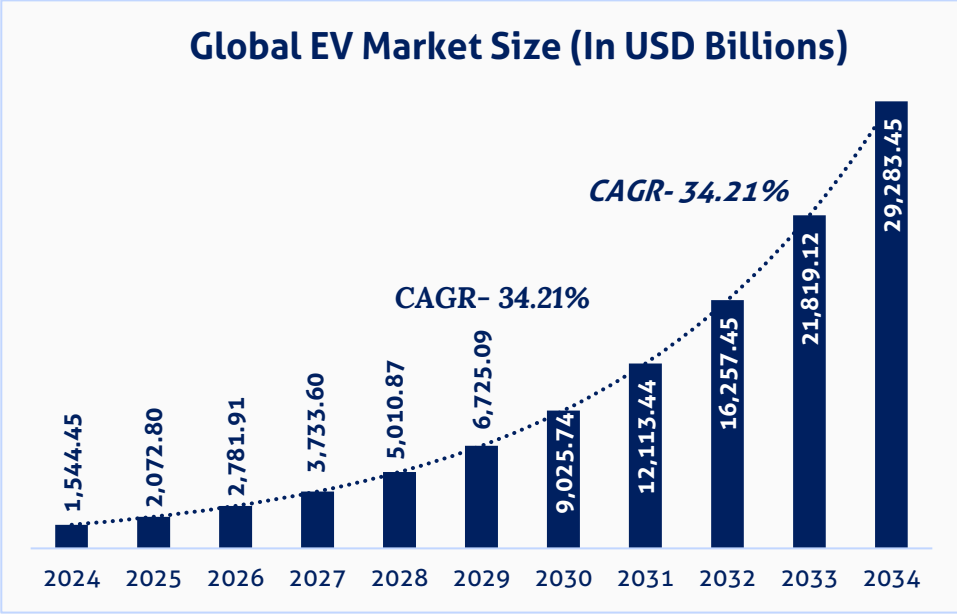
Battery waste from EV sector will increase 6-fold by 2040 and will be 10-fold by 2050.
Let's find out how EVs would be driving majority of the battery recycling market.

Market Trends & Growth Catalysts

EVs fuel the demand surge globally



Source: Maia Research



Source: Towards Automotive

Growth Drivers

- EV batteries account for 50.26% of the total lithium-ion battery supply for recycling, making them the primary source of end-of-life batteries and a key driver of the recycling industry.
- The Electric 2 & 3-Wheeler market guarantees a consistent influx of end-of-life batteries for recycling as the battery life usually ranges between 3-5 years only.
- An 8-year battery life among Electric 4- Wheeler ensures durability, yet rising EV adoption drives a constant supply of used batteries for scalable recycling.
- Bus & Truck batteries lasting 10–12 years provide premium recycling and second-life energy storage opportunities.

Market Trends & Growth Catalysts

Indian Government's Actions to Propel EV Battery Sustainability

- **RECEIC Launch:** India introduced the Resource Efficiency and Circular Economy Industry Coalition (RECEIC) under its G20 Presidency for global sustainability.
- **Mission LiFE Campaign:** The Ministry of Electronics and Information Technology transferred Li-ion battery recycling technology to nine industries and start-ups.
- **Circular Economy Promotion:** The initiative supports research commercialization and the adoption of a circular economy for battery waste.

The **Battery Waste Management Rules, 2022** (BWMR, 2022) by the Government of India set guidelines for managing battery waste, including lithium-ion batteries. Key provisions include:

- **Extended Producer Responsibility (EPR):** OEMs are mandated to collect and recycle waste batteries they introduce into the market.
- **Registration Requirements**: Producers, recyclers, and refurbishes must register with the Central Pollution Control Board (CPCB) through an online portal
- **Prohibition of Landfilling and Incineration**: Direct disposal of waste batteries via landfilling or incineration is prohibited; they must be recycled or refurbished.
- **Reporting Obligations:** Registered entities must submit annual returns detailing the quantities of batteries collected and recycled to the CPCB.

Market Trends & Growth Catalysts

How Global Government Policies Enable Battery Sustainability

United States

The **U.S. Department of Energy (DOE)** funds battery recycling research through the Battery Recycling Prize and supports efficient recycling processes via the Batteries Recycling Program.

European Union

- **EU Circular Economy Action Plan (CEAP):** Promotes sustainability with a focus on EV battery recycling.
- **EU Battery Regulation (2020):** Aims for 65% recycling of EV batteries by 2030.
- Supports initiatives like the European Battery Alliance to boost local battery production and recycling.

South Korea

- **Battery Recycling Act:** South Korea mandates the recycling or repurposing of EV batteries under strict regulations.
- **Recycling Infrastructure Investment:** The government funds high-tech recycling facilities and supports companies like LG Chem and Samsung SDI.
- South Korea encourages research on advanced recycling technologies, including using bacteria to extract valuable metals.

Japan

- **Battery Recycling Law (2001):** Japan mandates the collection and recycling of EV batteries through its Home Appliance Recycling Law.
- **Automaker Collaboration:** Japan encourages automakers like Toyota and Panasonic to improve EV battery recyclability through incentives.

Takeaway: While India has laid down a policy encouraging recycling, enforcement, in terms of navigating ground level difficulties such as supply chain formalization and black mass export loopholes, is still lacking.

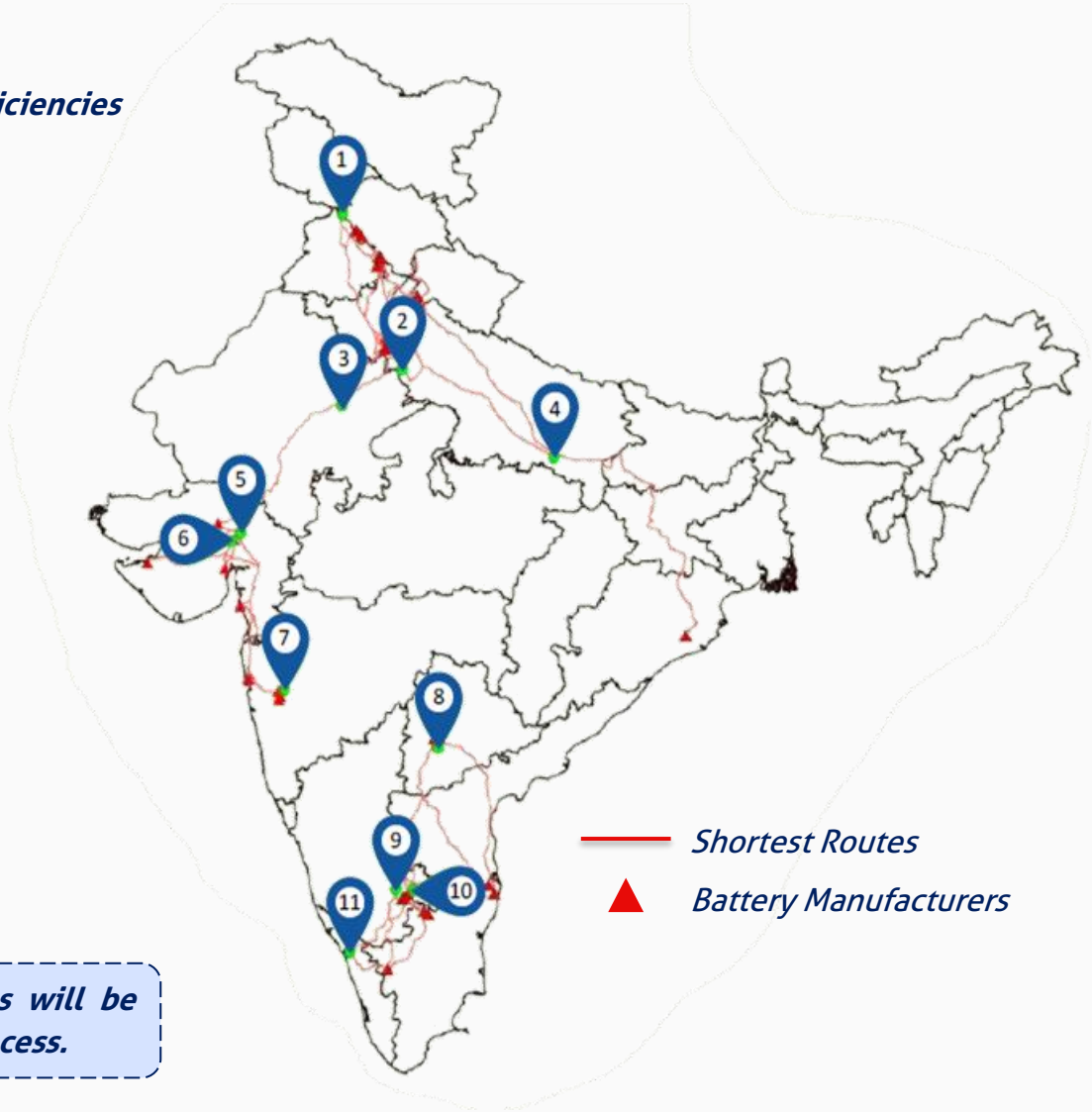
Market Trends & Growth Catalysts

Coverage

Emerging recycling supply chain landscape in India

Key Locations Aligned with Supply Chain and Logistics Efficiencies

1. Industrial Area Kandrori Phase I, Himachal Pradesh
2. Industrial Area Kosi Kotwan-Extension II, Uttar Pradesh
3. Industrial Area Mahindra World City, Rajasthan
4. Naini Industrial Area, Uttar Pradesh
5. DICDL Industrial Area, Gujarat
6. Sanand Industrial Area, Gujarat
7. Industrial Area Khed City, Maharashtra
8. E-City SEZ, Ranga Reddy, Telangana
9. Industrial Area Dobbaspet, Karnataka
10. KIADB Devanahalli, Karnataka
11. KSIDC, Kerala



To power circularity, 11–113 New Recycling Facilities will be required by 2030 which would streamline the entire process.

Innovators & Industry Titans

India is not only reducing recycling dependency...

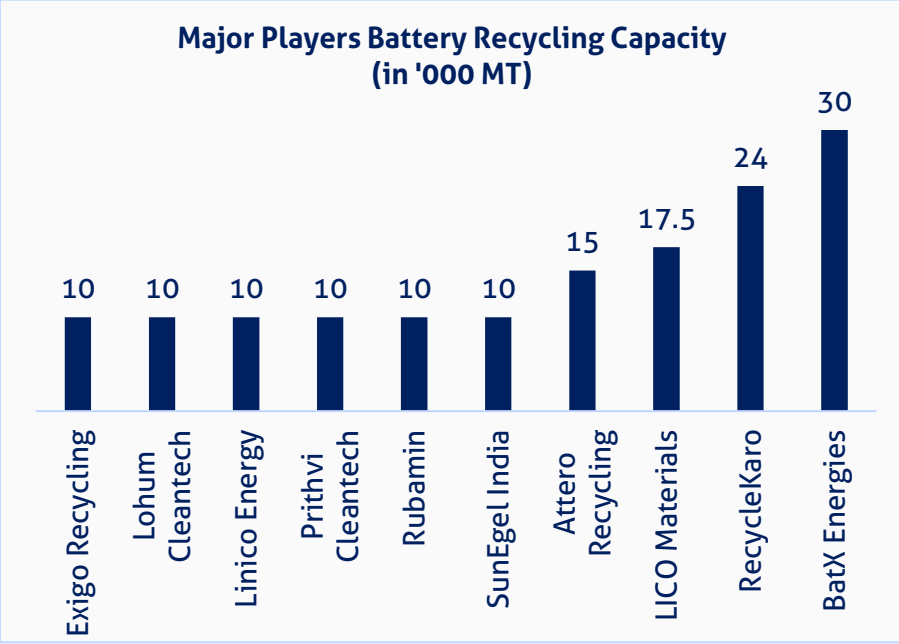
Export-Loss Paradox: India exports ***80% of its Black Mass production*** for processing due to nascent processing facilities domestically, ***majority of which goes to China***, resulting in forfeited critical materials and foreign exchange.

The Way Forward: Investing in local refining infrastructure positions India for resource sovereignty and elevates its role as a global battery recycling leader.

Significant Industry Moves

- **Rubamin Private Limited,** a leading metal recycler, based out of Gujarat, successfully started operations of its state-of-the-art 10,000 MT battery recycling plant. The plant, with zero-waste facility, was inaugurated by the Hon'ble Chief Minister of Gujarat.

- **Tata Chemicals** completed its pilot project, in its facility based in Mumbai recovering Lithium, Cobalt, Nickel, and Manganese at purity levels of 99%. They plan to recycle 500 MT of Li-ion batteries.



Innovators & Industry Titans

...but also bridging the complete EV battery supply chain gap

India currently relies heavily on imports for Cathode Active Materials (CAM), with ***China dominating 90% of the global supply.***

To reduce import dependency and bridge supply chain gaps, India is developing domestic Pre-CAM and CAM manufacturing under Aatmanirbhar Bharat and the PLI Scheme to build a self-reliant EV battery ecosystem.

First Movers

VIDYUTA

Vidyuta Materials, powered by Lohum Cleantech, is engaged in Pre-CAM and CAM manufacturing in Noida, with a 200 MT (~150 MWh) pilot plant and plans for a 10 GWh facility in Tamil Nadu by 2030.

ALTMIN

Altmin Pvt Ltd, in partnership with International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), has launched a 10 MW pilot CAM plant in Hyderabad with plans to scale up to a 10 GWh.

Upcoming Capacities

Himadri
Himadri Speciality Chemical Ltd

Himadri Specialty Chemicals Ltd is building a facility to produce 200,000 MT p.a. of LFP CAM, with capital outlay of ₹4,800 crore over 5–6 years.

SUDEEP
ADVANCED MATERIALS

Sudeep Advanced Materials Pvt Ltd is building a 30-acre hub to produce 100,000 MT/year of Pre-CAMs by 2026.

Takeaway: Creation of CAM and pre-CAM supply chain in India is a major positive step for the upcoming lithium-ion cell manufacturing landscape in India and reduce dependence on Chinese imports. This boost in cell manufacturing will eventually boost the demand for

Innovators & Industry Titans

Driving Profitability in the Industry

Economies of Scale & Automation

Scaling up capacity & automating disassembly, sorting, & processing operations significantly reduce per-unit & labor costs.

Technology Innovation

Investing in advanced, energy-efficient recycling technologies help in preserving valuable metal structures and reduces energy consumption.

Second Life Applications

Recyclers boost profits by recovering valuable metals and repurposing used batteries for second life uses like stationary storage.

Strategic Partnerships

Collaborations with the Automakers & OEMs ensures securing long-term supply contracts and help drive market demand for recycled materials.

Let's uncover the game-changing potential of Strategic Partnerships!

Innovators & Industry Titans

Ensuring robust supply chain through Strategic Partnerships

To establish a circular economy for lithium-ion batteries, automakers and OEMs across sectors, including consumer electronics, are partnering with recyclers to sustainably source critical materials, and secure future supply chains.

Some of the veteran Recyclers have established closed loop recycling contracts with the respective companies listed below:

Attero Recycling has tie-ups with almost ***90% of Automobile OEMs*** in India like,

TOYOTA, MG, HYUNDAI, TATA MOTORS

It also has tie-ups with prominent companies in the ***consumer electronics*** industry like,

SAMSUNG, LG, Whirlpool CORPORATION, Godrej, acer, oppo, vivo

Recyclekaro has established its expertise in recycling the batteries used in ***E-2 Wheelers*** and boasts its partnerships with,

BAJAJ, ATHER, Hero

Lohum Cleantech has entered collaborations with industry giants like,

GLENCORE — To supply specialty chemicals for EV Batteries.

Mercedes-Benz — To supply second life-battery modules.

Final Overview

Coverage

Electrifying India: The Complete EV Value Chain

EV Series #1

Indigenous OEMs are leading India's EV industry, but high upfront costs, mainly due to expensive batteries, remain a major barrier to adoption.

Reducing battery costs is crucial for growth.

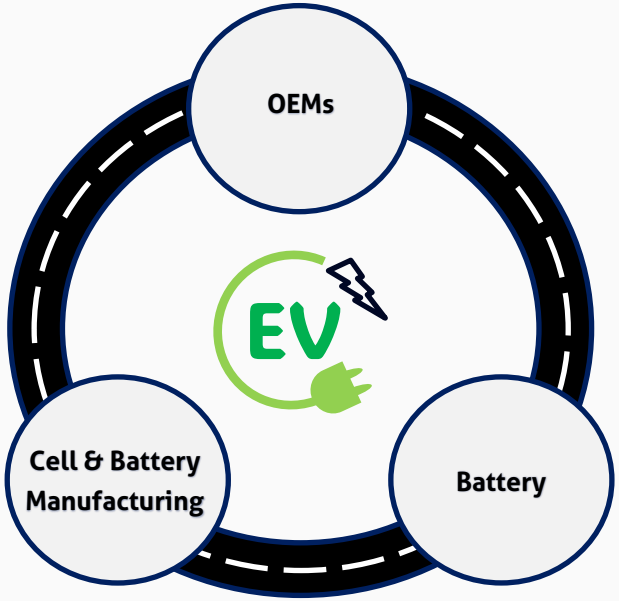
EV Series #2

India's EV cell manufacturing is gaining traction with GWh-scale up in progress, but reliance on imported lithium and China's dominance over key minerals highlight key gaps.

Strengthening domestic capacity and scaling battery recycling are essential to reduce dependency and build a resilient ecosystem.

EV Series #3

India is addressing the need for resource security by building its battery recycling ecosystem, with growing investments in Pre-CAM, CAM, and black mass recovery by **shifting from black mass exports to closing the loop indigenously** on critical materials and enabling a circular EV economy.



India is stitching together a full-stack EV ecosystem, from domestic OEM & cell manufacturing to achieving upstream material circularity through recycling, bridging the gap between ambition and autonomy.

India's EV Supply Chain though still evolving, will be poised, well-equipped & well- positioned to realize this vision.

About kcmLens

kcmLens is a special publication prepared by the Strategic Advisory team at K C Mehta & Co LLP. This publication is intended to provide deep dive into the value chain of a particular industry. The idea is to provide the reader an end-to-end understanding of a particular industry through the Lens of each segment of the value chain of that industry. This would act as a ready reference for professionals, who seek to understand their client's business and as an update document for business leaders for tracking recent developments in their industry.

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