

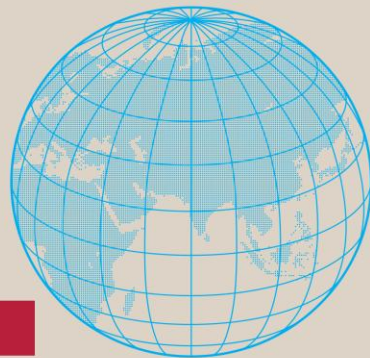
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Battery Circularity in India—A Billion-Dollar Long-Term Opportunity

The Case of EV Batteries

Shyamasis Das

Kartik Nair



CSEP RESEARCH

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Highlights

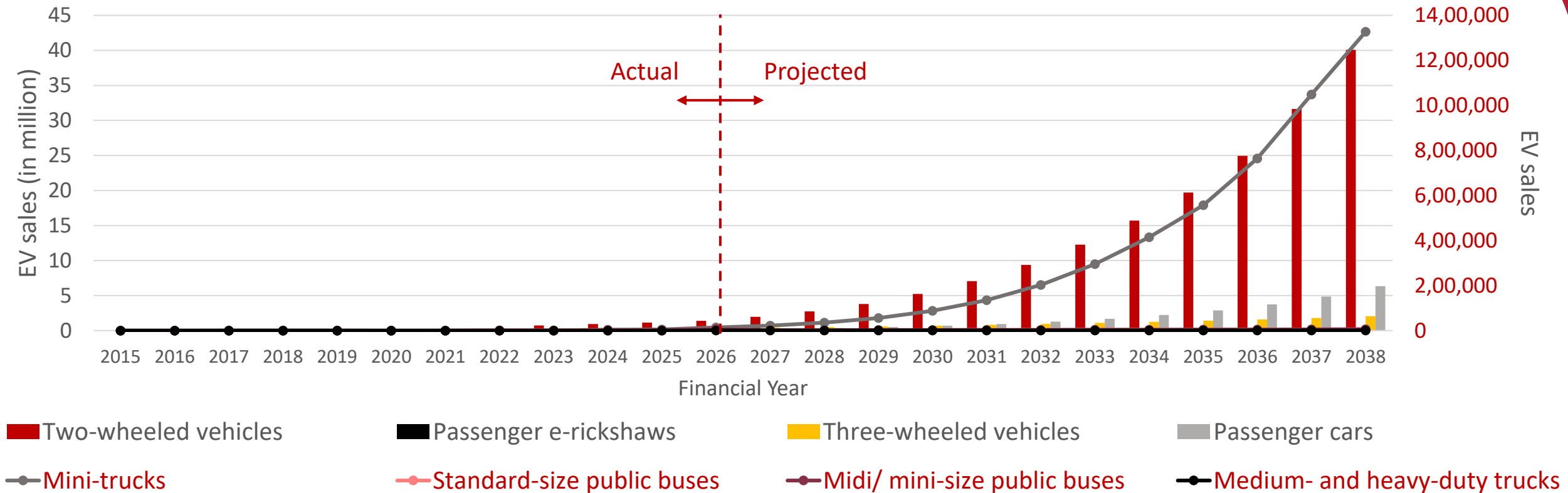
Shyamasis Das

Fellow, CSEP

October 2026

India's EV Growth Story... Each Vehicle Powered By A Battery

- EV transition is racing ahead, with ~ 8 million EVs added between FY 2016–17 and FY 2025–26.
- There is a **lot of headroom** for EV market to grow further. EV share of total vehicle sales is in single digits.

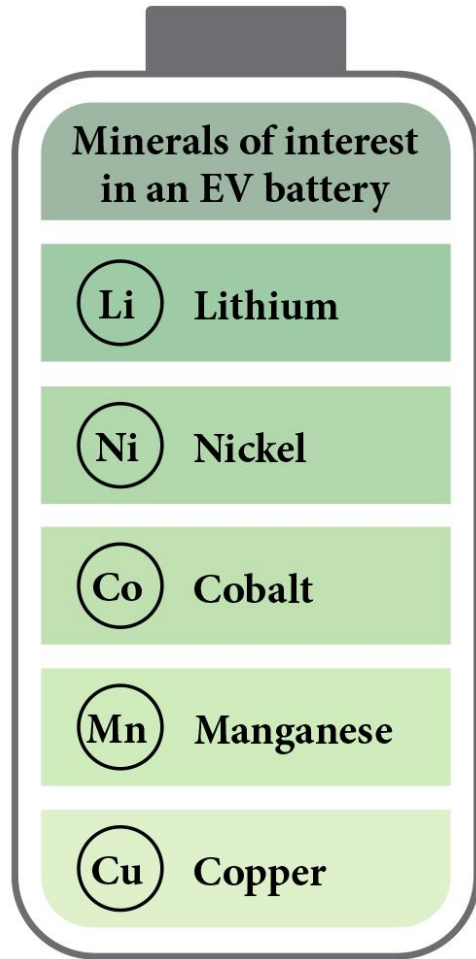


Note:

- Actual EV sales data have been sourced from Vahan dashboard of MoRTH.
- Projection of sales excluding buses and trucks are based on projected penetration rates as per the [KPMG analysis](#). Existing govt. plans have been considered for the bus segment. E-trucks have been projected using moving average of recent sales.

What is at stake for India to manage end-of-mobility-life EV batteries?

Battery Circularity—An Emerging Opportunity For India



- Retired batteries pose a growing **waste-management challenge**, but also creates **opportunities** based on sound **circularity practices**.
- **Repurposing** used LiBs for other applications helps **extend** the **useful life of batteries**. **Recycling EoL** LiBs allows **recovering** and **reusing embedded** valuable **minerals**.
- India potentially faces **supply and economic risks** given its **mineral import dependence** and the current **geographic concentration** of mineral supply chains (refer to next slide).
- Even with limited domestic LiB cell manufacturing capacity, **battery minerals recovery** is a **strategic imperative**. It allows India to export recycled minerals and develop in-house mineral-processing capability.
- Spent LiBs from **EVs** are envisaged to constitute **bulk of used-battery stream** in India.*

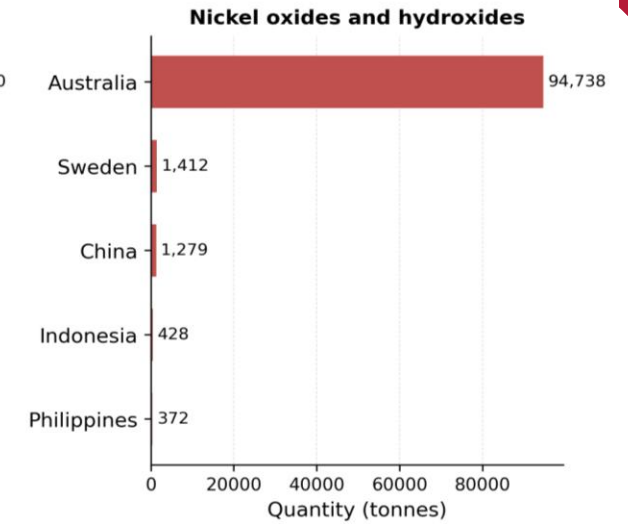
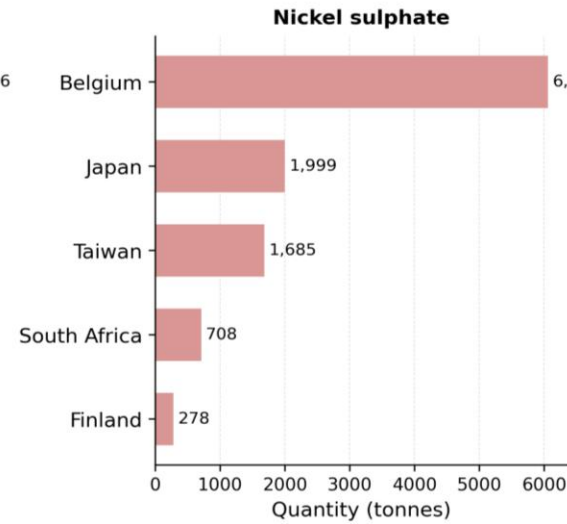
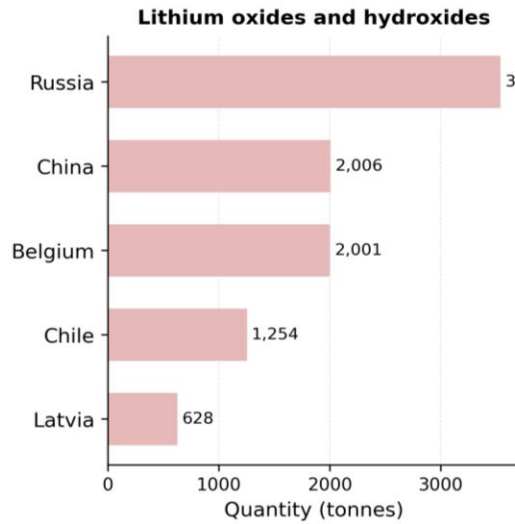
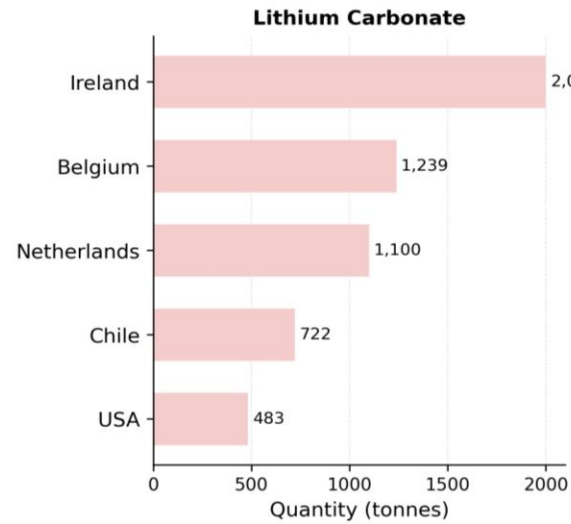
EV battery circular economy helps secure supply chain and serves sustainability objectives.

*Due to controlled operating conditions that help maintain battery health, the first life of LiBs in stationary energy storage is likely to be longer.

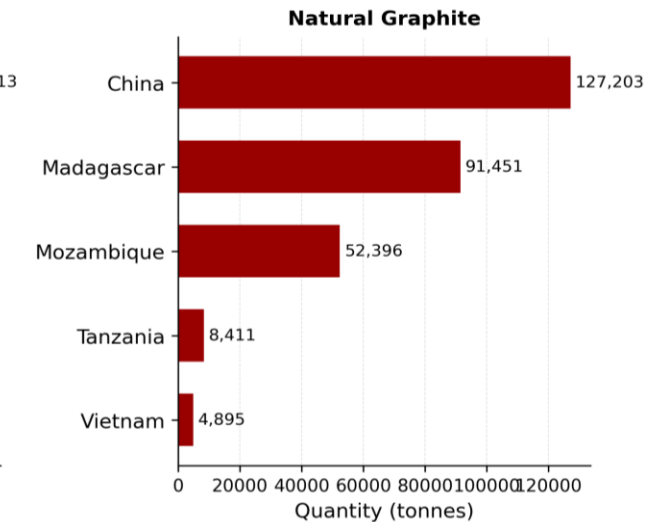
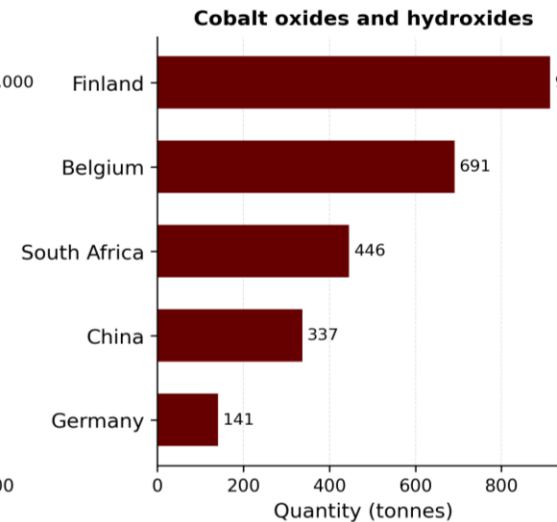
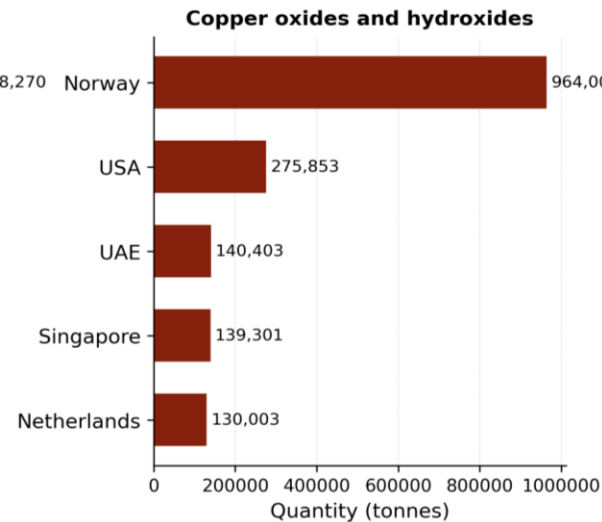
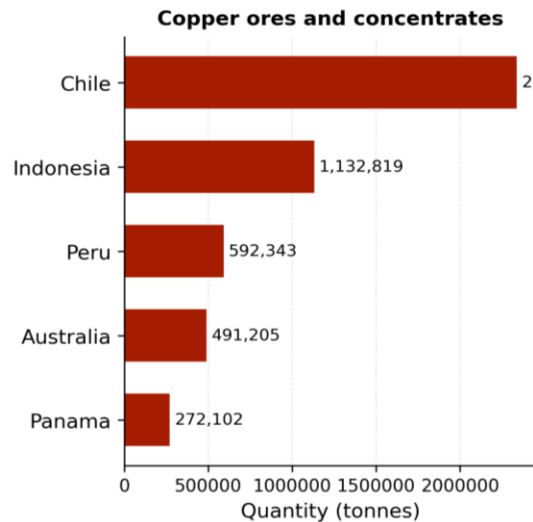
Acronyms: LiB (lithium-ion battery); EoL (end of life)

India's Imports Of Battery Minerals By Source Countries

2019 - 2024



Even with limited LiB cell making capacity, India has a substantial import exposure for battery minerals.



Why Is This Research Important?

- It is essential for India to have a clear **understanding** of the **scale of opportunity** for **battery circular economy**.

This research demystifies some critical unknowns like:

How many **tonnes of critical minerals** could potentially be **recovered** from the growing EV battery stock?

How does the **economic value** of this resource **evolve over time**?

Is the **economic opportunity** of “mining” the minerals **secular**?

How much can EV battery recycling **contribute** to meeting **future mineral demand** of the country?

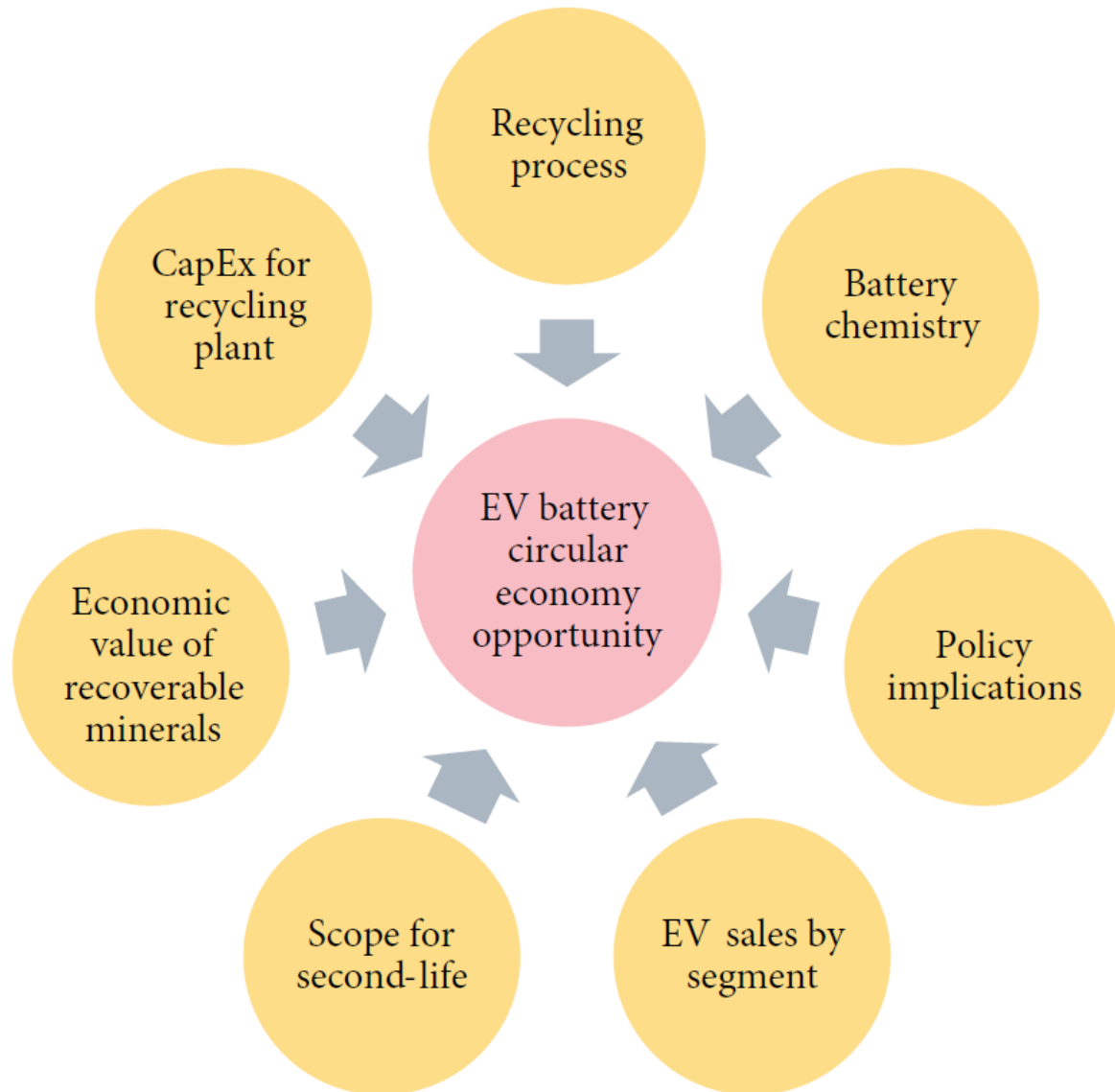
Why will a **targeted approach** to accessing, collecting, handling and managing EoL batteries be **important**?

What **infrastructure** and **investments** are needed to avoid a wasted opportunity?

Are all **circular economy opportunities** across the battery value chain equally **scalable**?

What are the **10 key interventions** needed to **strengthen** India’s battery circularity **ecosystem**?

Multidimensional Approach To Assess EV Battery Recycling



Acronym: CapEx (capital expenditure)

Scope of the study:

- It considers **time horizon** up to **FY 2040–41**.
 - The **period** is long enough to get a judicious **medium-to long-term view** of the sector with **reasonable confidence**.
- The assessment **does not include** LiBs deployed at **swapping stations** and **lead-acid batteries** present in EV stock.

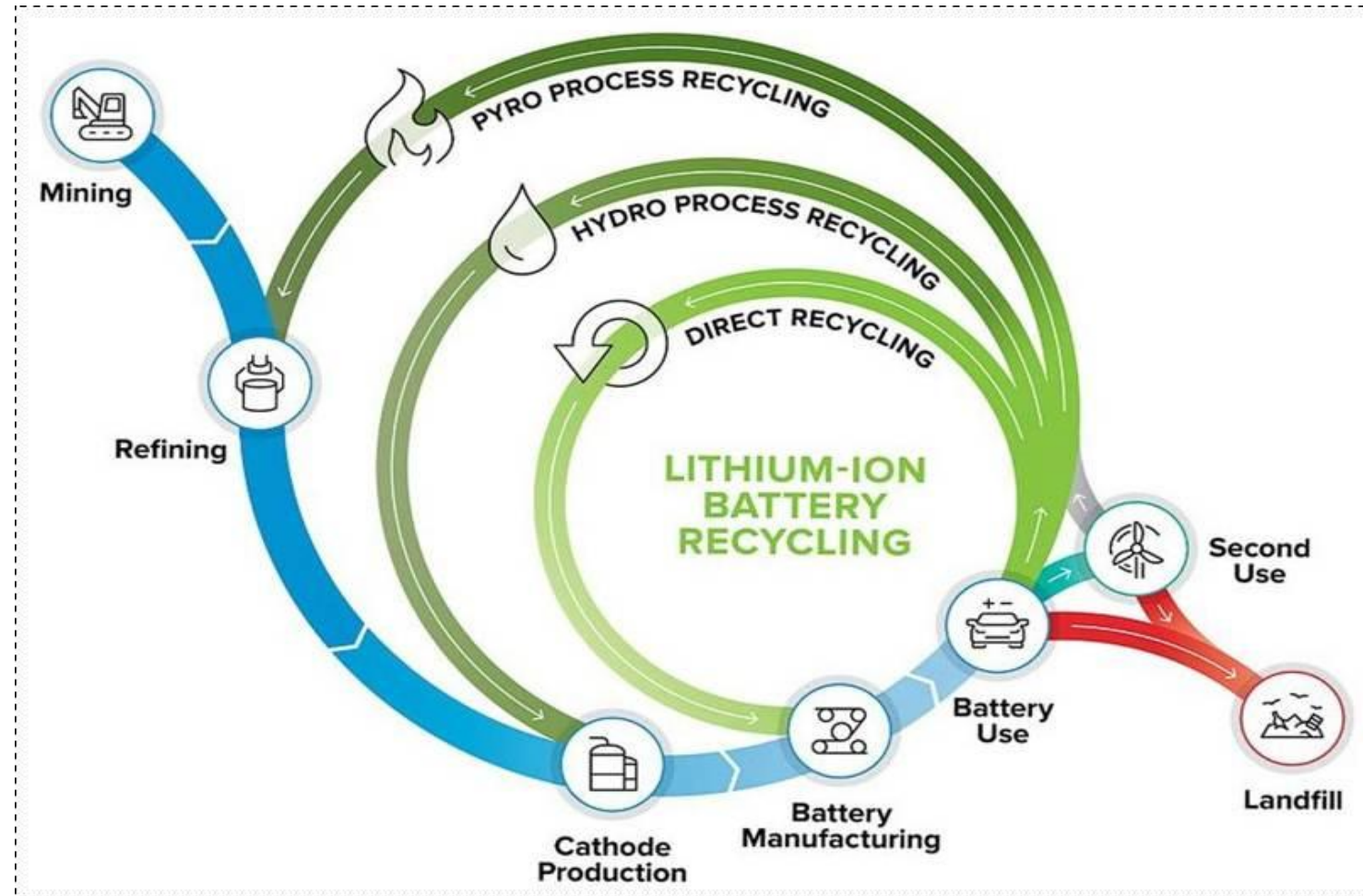
USP of the research:

- **Segment-specific approach** to reflect **differences in battery characteristics** and **useful lives**.
- **Linking of EoL LiB flows**, including possible repurposing, with **material recovery** and associated requirements.
- **Transparent** assumptions and an assessment **framework** amenable to **periodic updates**.

Multiple Circularity Pathways Exist

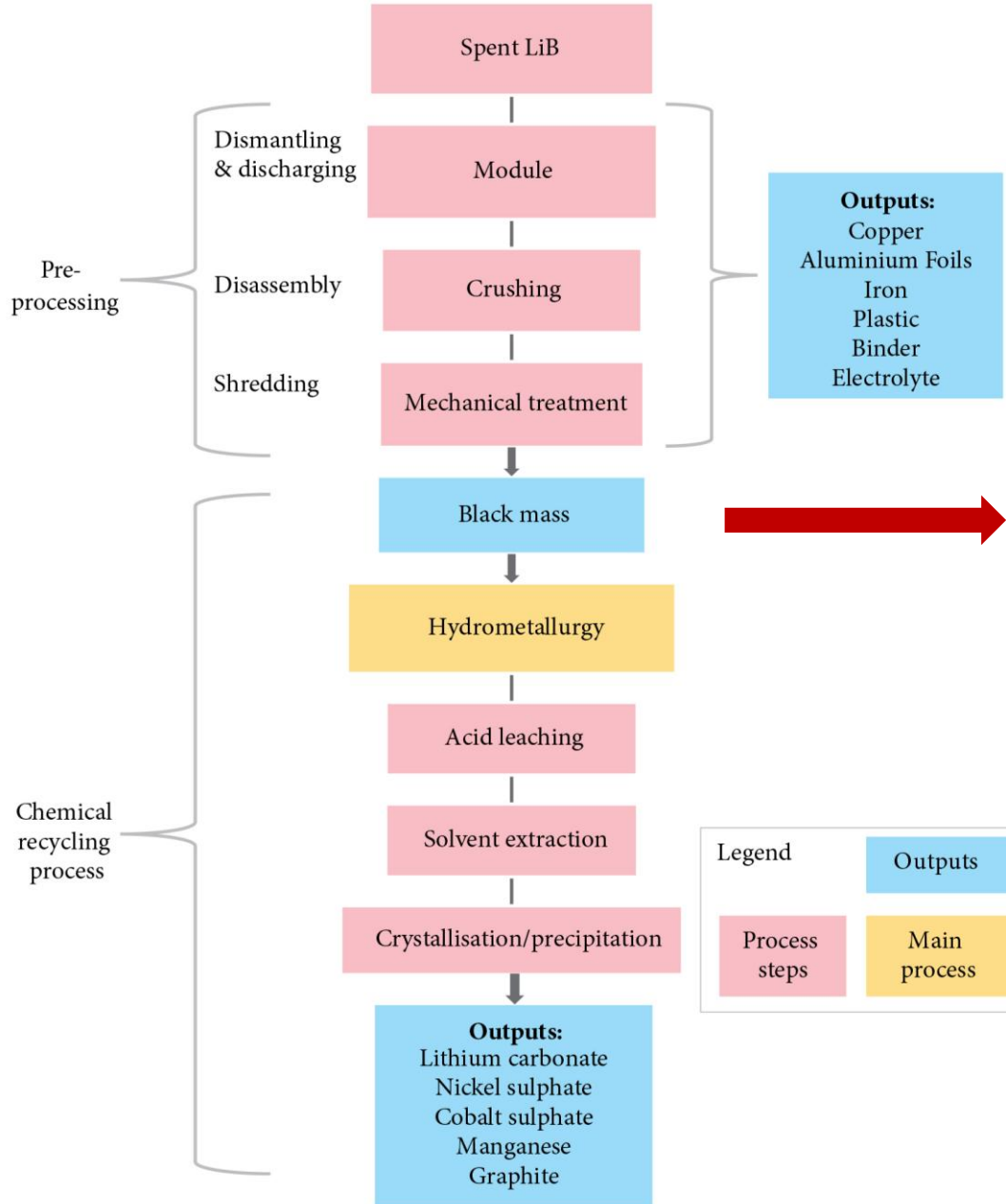
- A battery that enters recycling stream can be processed through **different techniques**.
- These include **pyrometallurgy**, **hydrometallurgy**, and **direct recycling**.
- They **differ** in technical **complexity**, **recovery profile**, associated **costs**, and recycled **mineral grades**.
- **Hydrometallurgy** is currently the **dominant** recycling technique for mineral recovery from spent LiBs.

EV Battery Circularity Pathways



Hydrometallurgy Currently Anchors Minerals Recovery

Key Steps in Hydrometallurgy



- It involves **metal recovery** from **black mass** by means of leaching, precipitation, solvent extraction, ion-exchange resins, and bioleaching.

Black mass serves as the intermediate process feedstock. It is produced once EoL batteries undergo shredding and separation during the pretreatment stage. It represents about 40% to 50% of the dry weight of an EV battery. It has varying compositions depending on the chemistries of the spent batteries.

Indicative Mineral Recovery Rates in Hydrometallurgy *

Mineral	Li	Ni	Co	Mn	Cu
Recovery rate (%)	90%	99%	99%	95%	99%

*Global benchmark

Existing Policies Give A Headstart To EV Battery Circularity

Battery Waste Management Rules, 2022	Critical Mineral Recycling Scheme 2025
Sets framework for collection, refurbishment and recycling of waste batteries.	Promotes recycling-based recovery of critical minerals from spent LiBs, e-wastes, and other eligible scraps.
Places producer responsibility at the core through EPR obligations.	Provides ₹1,485 crore indicative outlay to support 270 kt processing capacity.
Considers vehicle-specific minimum mobility life for EV battery recycling compliance.	Covers two beneficiary groups: Group A (large, established) and Group B (small, new / start-up).
Links EV battery collection targets to batteries placed in the market earlier.	Requires actual mineral recovery/ extraction; players producing only black mass not eligible.
Mandates minimum recovery of EV battery materials and minimum recycled content in new EV batteries.	Offers support through CapEx reimbursement and sales-linked OpEx support.

Battery Aadhaar guidelines (draft)

- Proposes unique battery IDs, QR codes and server based dynamic data to enable battery lifecycle traceability.
- Intends to support second-life use, regulatory compliance, and efficient recycling.

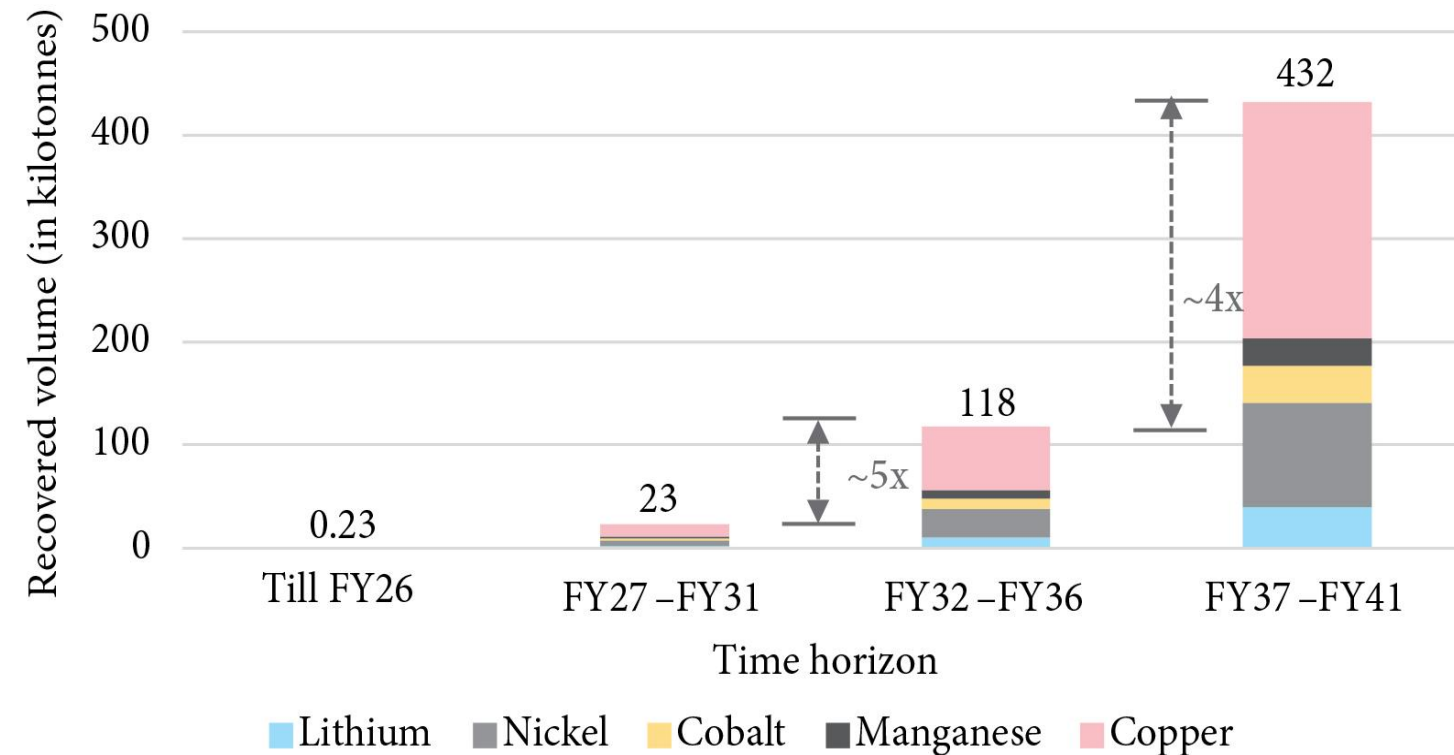
How Is The EV Battery Recycling Opportunity Assessed?

1	Collation of annual EV sales (FY2015 to FY2026)	Actual EV sales compiled for each vehicle segment using Vahan dashboard data.
2	Projection of EV sales	EV sales for different segments projected based on expected penetrations.
3	Estimation of battery capacity introduced into circulation	EV sales multiplied by battery pack size to estimate annual battery stock entering use (changes in pack capacity over the time considered).
4	Allocation of battery stock by chemistry type	Battery capacity introduced into circulation split into LFP, NMC and NCA+Others using segment specific chemistry and mineral intensity factors.
5	Consideration of minimum mobility life	Minimum mobility life assigned to each vehicle segment based on provisions in BWMR and relevant secondary literature.
6	Evaluation of EoL battery availability	Possible opportunity of repurposing of batteries considered for certain segments.
7	Estimation of battery mass available for recycling	EoL battery capacity by chemistry type converted into battery mass based on chemistry specific energy density.
8	Assessment of mineral recovery opportunity till FY2041	Recovery rates and technology shares applied to estimate recoverable mineral quantities.
9	Economic valuation of recoverable minerals	Value of recovered minerals estimated based on current market prices.
10	Estimation of required recycling capacity and investment	Projection based on recycling opportunities till FY 2040-41.

Stakes for India to “Mine” EV Batteries Over the Next Decades

Tonnes Of Opportunity For Mineral Recovery

Projected Recoverable Mineral Volumes from EoL EV Batteries



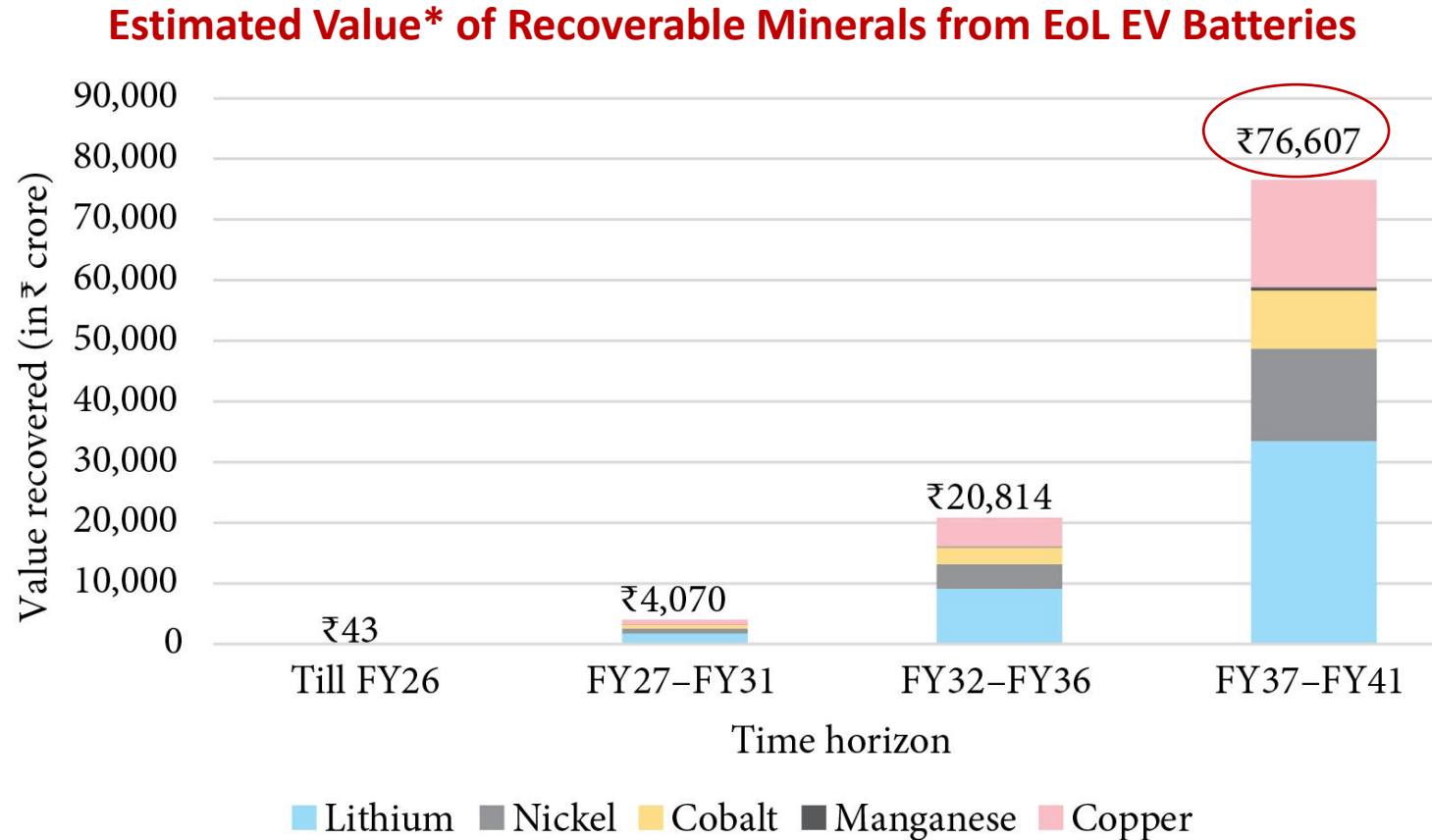
- India's EV battery recycling opportunity remains **limited in near term** but is projected to **rise quite sharply post-2030**.
- Copper** accounts for the **largest share of recovered battery minerals by quantity** across the assessment horizon.

Recycling opportunity will be driven not only by precious critical minerals but also by bulk minerals.

Economic Value Of Recycling Driven By Critical Minerals

* At current market values

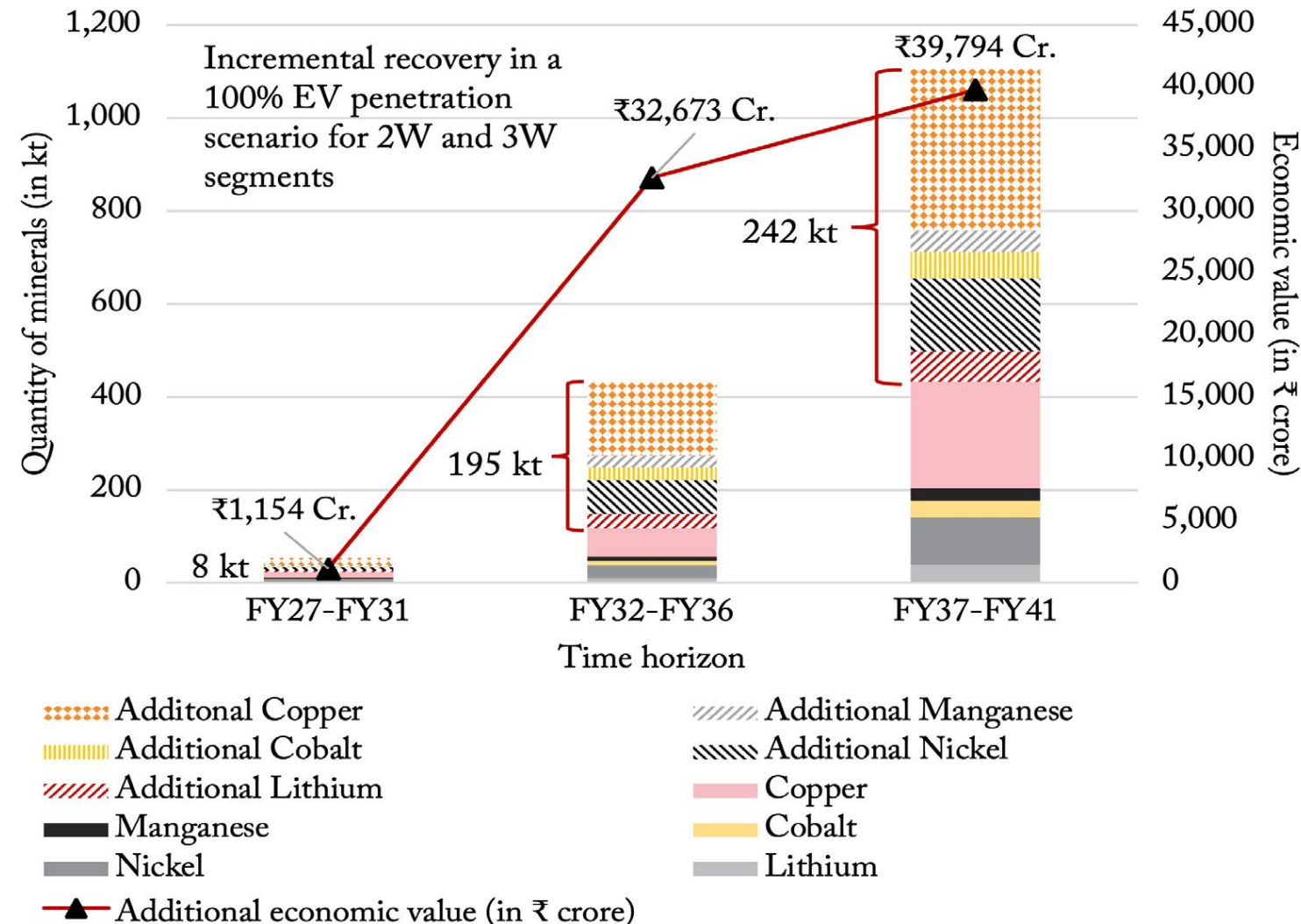
- Unlike in the case of quantity of recovered minerals, **economic value** of EV battery recycling is a **key factor** in the critical minerals play.
- **Lithium** contributes the **largest share** of **recoverable value**.



Economic attractiveness of recycling is shaped not only by quantity of recovered minerals but also by their relative market values.

Recycling Market In An Accelerated EV Adoption Scenario

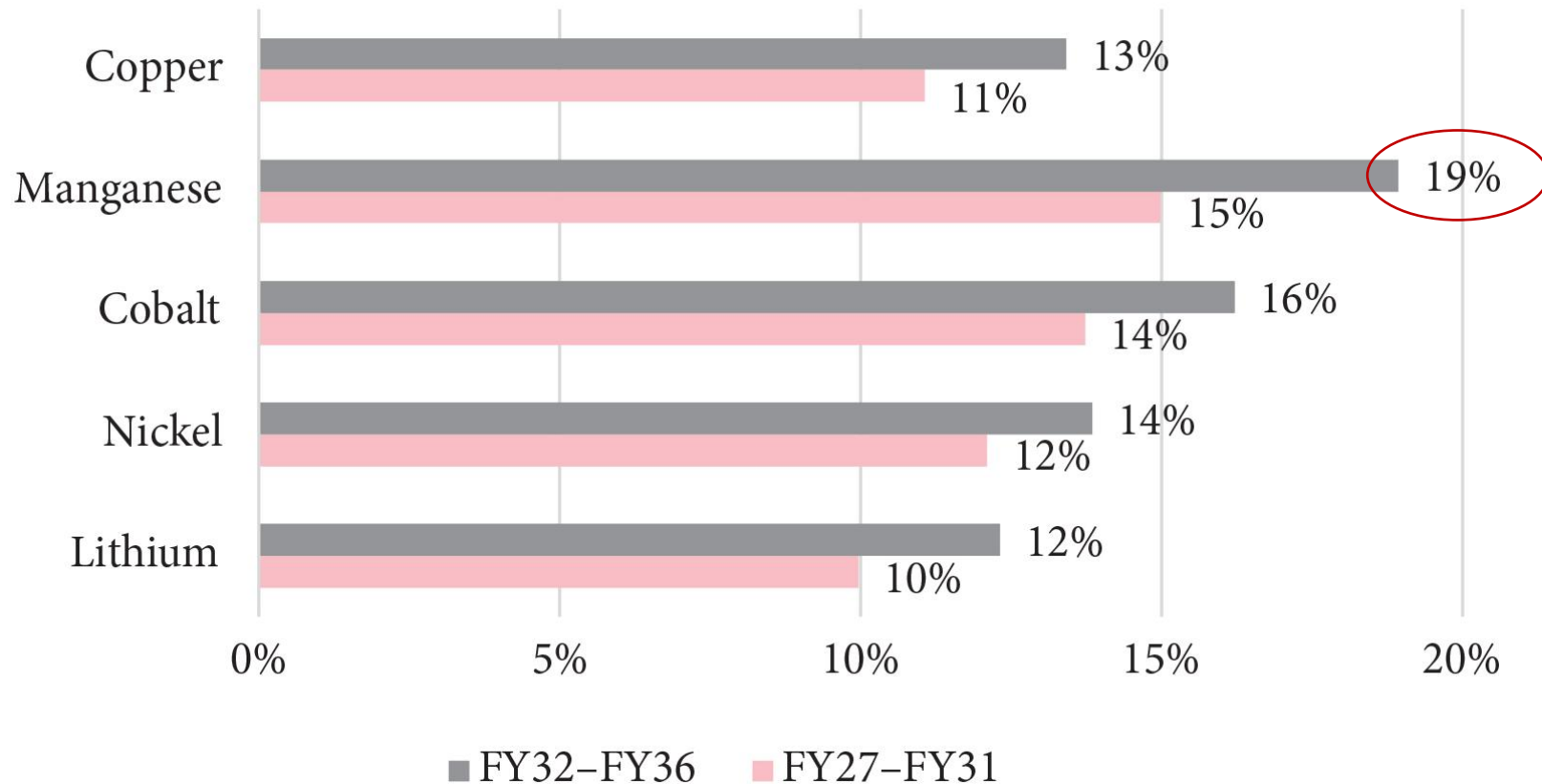
A Scenario of 100% Electric Share in 2W and 3W Sales



- Anticipation of **oil price hike** boosts **EV sales**, especially in segments like **2W** and **3W** that are already seeing momentum in the shift.
- A possible **accelerated growth scenario** can be **100% electric** share in these segments within the assessment period.
- This will lead to a **greater number** of **LiBs** entering circulation and eventually **retiring**.
- Recoverable **minerals increase** by 8 kt during immediate 5 years and as much as **242 kt** towards FY41.
- Translating to **₹74,000 crore** (US\$8,661 million) in **additional economic value** over the assessment period.

Sufficiency To Meet Demand For EV Battery Manufacturing

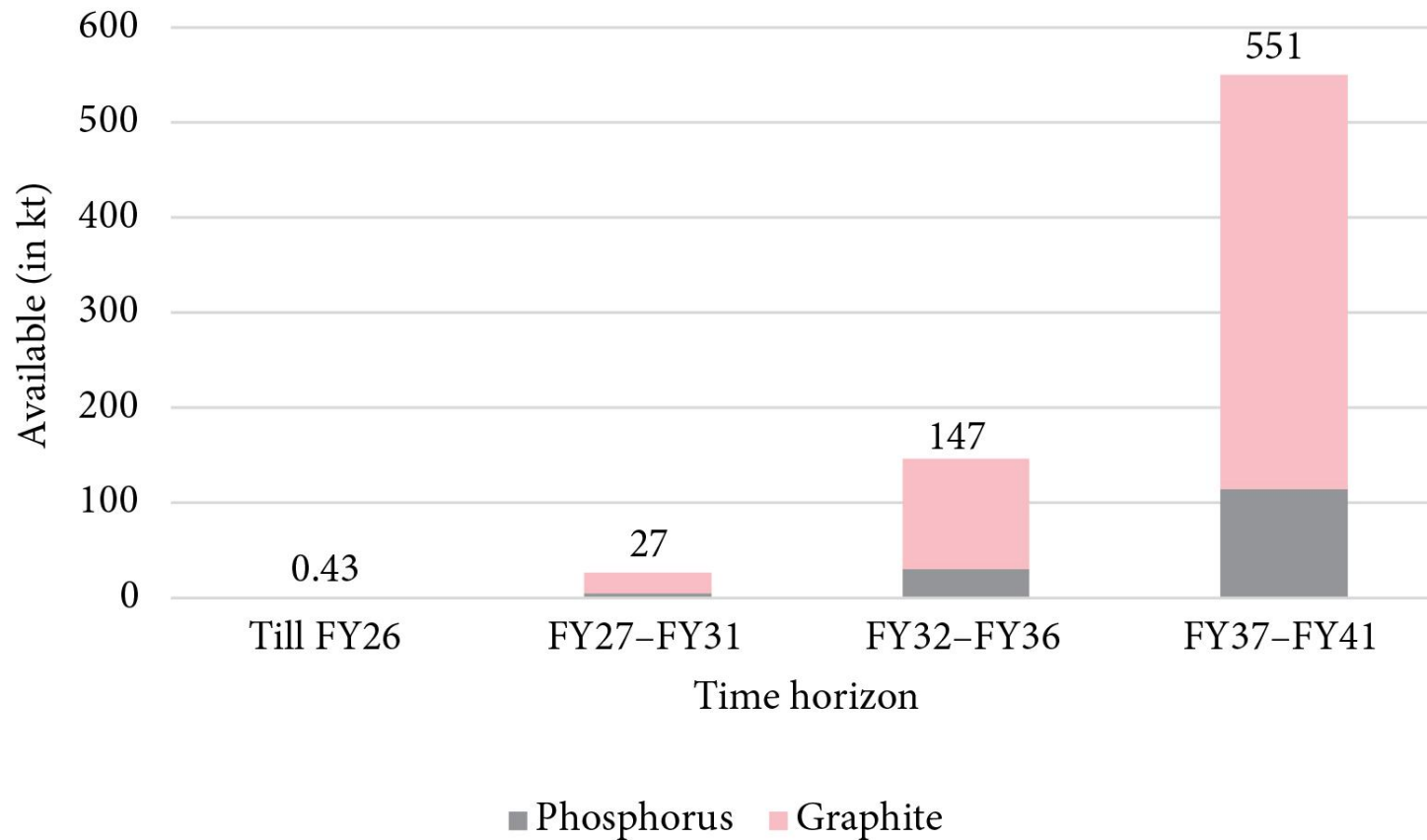
Share of Recycled Minerals in Mineral Requirements for EV Battery Manufacturing



Recycling and reusing can meaningfully supplement primary mineral requirements for EV battery manufacturing.

Some Battery Minerals Falling Out Of Favour

Mineral Streams in EV Batteries that Remain Unrecovered

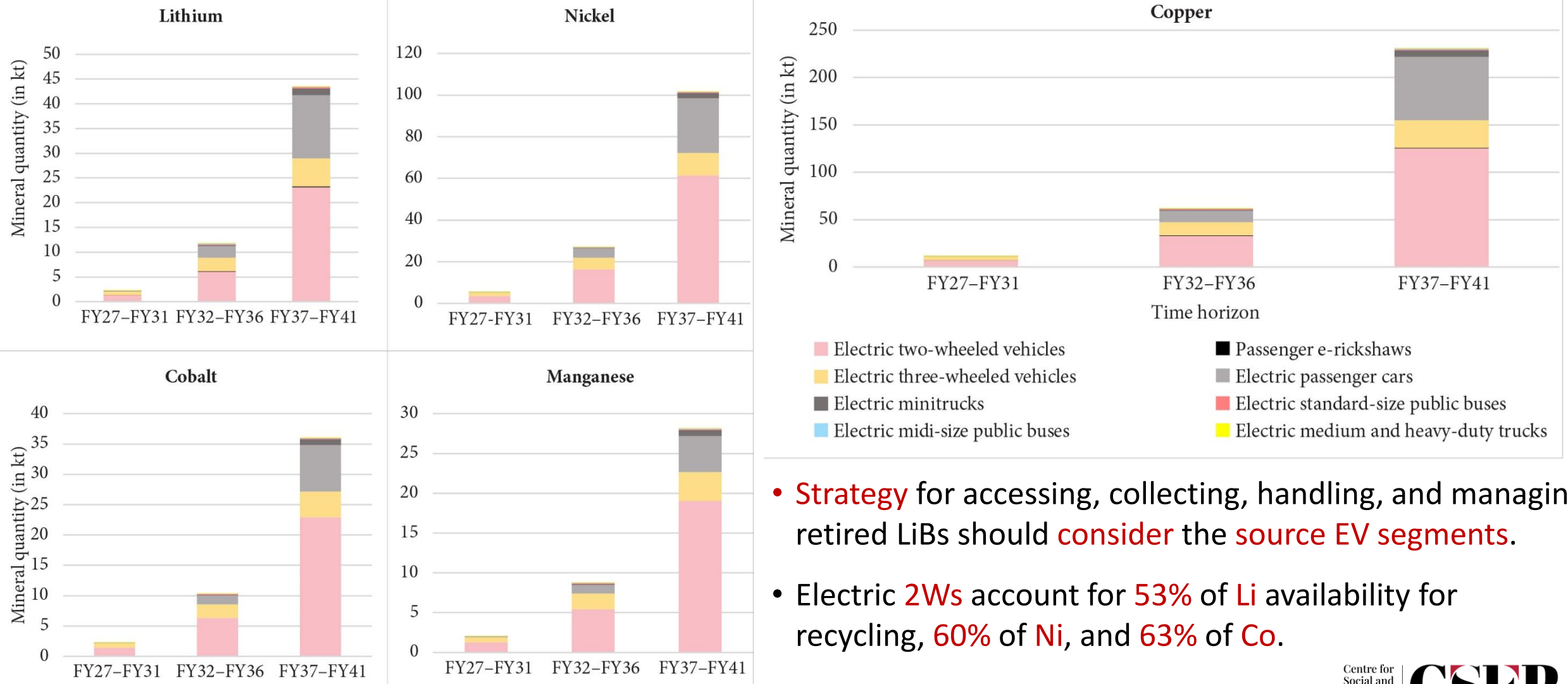


- Recyclers **prioritise** minerals with **stronger recovery economics**.
- Certain minerals, such as **phosphorus** and **graphite**, are largely **left untapped** despite their non-trivial share in EV batteries.

Note: Graphite has multiple industry use-cases. Preference for recycled mineral depends on the grade and the cost vis-à-vis virgin.

Which EV Segments Are Important?

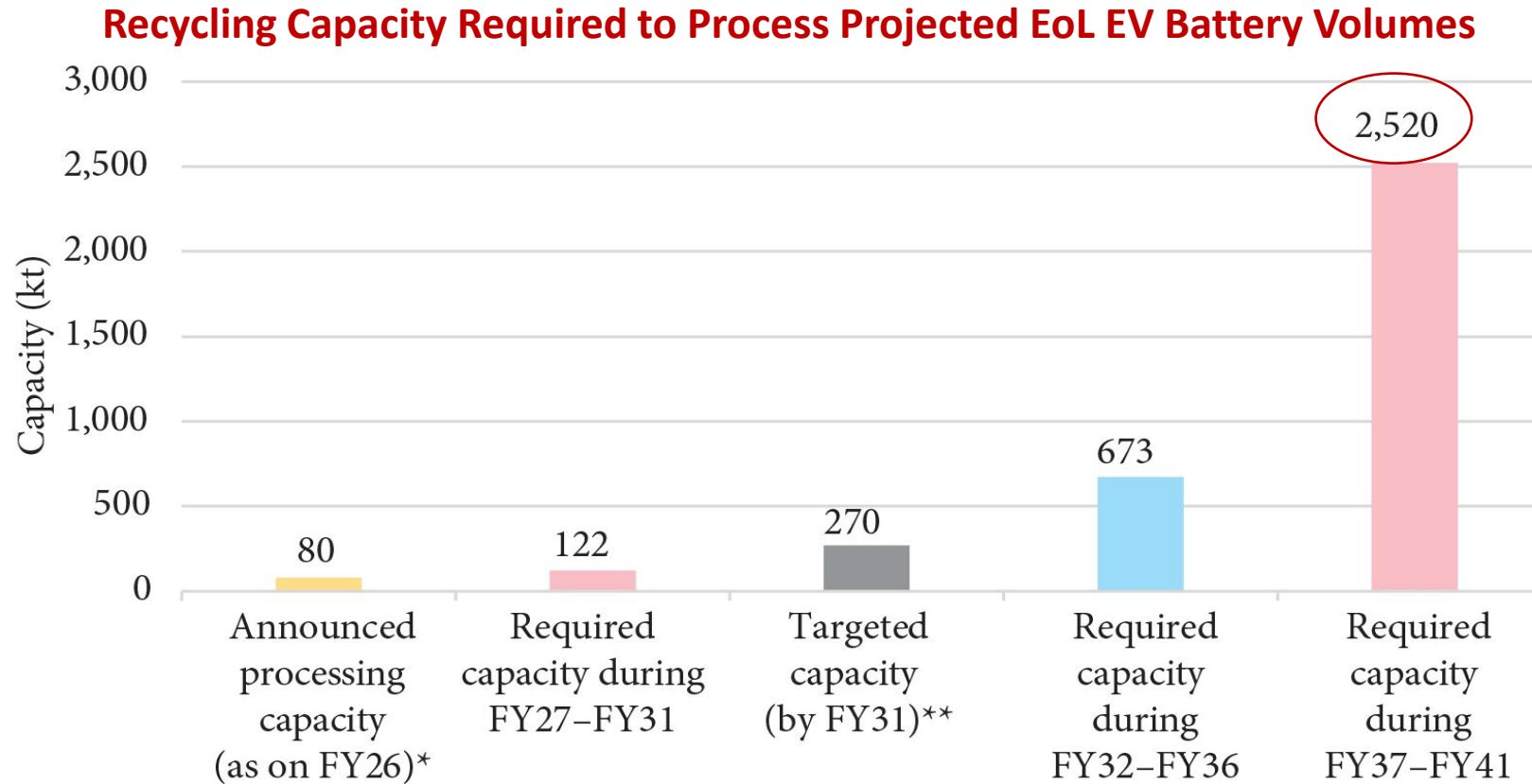
Contribution of EV Segments to Availability of Battery Minerals for Recycling



- **Strategy** for accessing, collecting, handling, and managing retired LiBs should **consider** the **source EV segments**.
- Electric **2Ws** account for **53%** of **Li** availability for recycling, **60%** of **Ni**, and **63%** of **Co**.

What Will It Take to Unlock the Opportunity?

Current Capacity Plans Suffice Only Initial Recycling Demand



Note:

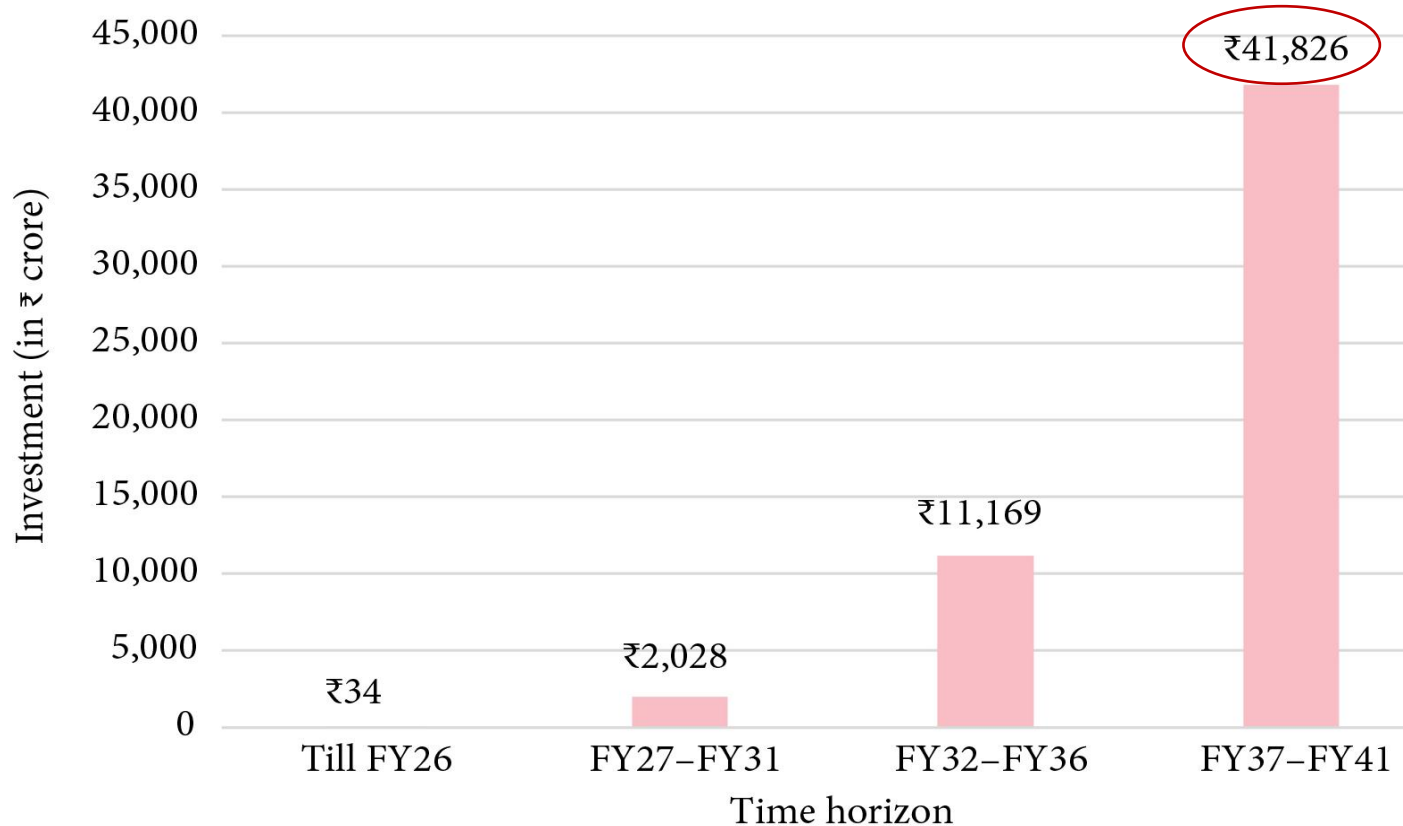
*NITI Aayog's report: Advancing Circular Economy of Waste Electronic and Electrical Equipment (E-waste) and Lithium-Ion Batteries in India

** Ministry of Mines' Scheme Guidelines for Critical Mineral Recycling Incentive Scheme (2025). Following evaluation of proposals, 58 entities have been chosen as eligible to participate, with a pledged capacity of about 850 kt. These cover feedstocks from e-wastes and other scraps too.

- **Announced** and **targeted** capacities **meet** only **early demand**, with much **larger scale-up** needed in **later years**.
- Starting **commercial operations** at required scale **“just in time”** is **unlikely** to be **feasible** in practice.

Scaling Up Capacity Will Require Significant CapEx

CapEx* Required to Scale EV Battery Recycling Infrastructure



*At current value, based on hydrometallurgical route of recycling

- India's LiB recycling **ecosystem** will need to **move beyond pilot-scale** or early commercial capacity to absorb future EoL battery flows.
- **Delay** in capacity planning **risks a mismatch** between availability of spent EV batteries and the infrastructure to process them.
- **Some recyclers** are not investing in setting up full recycling processing line to recover minerals and instead are producing and **exporting black mass**, mostly to China.
- Continuing this practice will be akin to **letting precious resources leave** the country's shores.

Call To Action To Support India's EV Battery Circularity

- 1 Mandate** sourcing of **recycled** critical and strategic **minerals** as part of the effort to create **national critical minerals** stockpile. → **Ministry of Mines**
- 2 Revisit** existing **BWMR** provisions to align timelines for battery **collection targets** with **actual battery life** and set **mineral-specific** recovery targets. → **MoEFCC**
- 3 Develop** and **notify standards** for battery characterisation, repurposing, and recycled mineral quality. → **BIS, MeitY, and Ministry of Mines**
- 4 Offer** **buy-back** or take-back programmes for spent EV batteries. → **EV owners, manufacturers, automobile dealers, service providers, and battery recyclers**
- 5 Introduce** standards to support **ease of battery circularity** at the design and manufacturing stage. → **BIS, MeitY, and MoRTH**
- 6 Develop** testing infrastructure for battery characterisation to support repurposing and recycling. → **MHI**
- 7 Harmonise** regulations for safe collection, storage, and transportation of used EV batteries. → **Petroleum and Explosives Safety Organisation** and **state governments**
- 8 Monitor** black mass movement and **limit exports** to ensure domestic mineral recovery. → **Ministry of Commerce and Industry**
- 9 Build** recycling **capacity, collection, and transportation** networks before retirement volumes grow dramatically. → **Battery recyclers**
- 10 Encourage** long-term agreements for predictability of waste-battery volumes and prices. → **EV manufacturers and battery recyclers**

Acronyms: MoEFCC (Ministry of Environment, Forest and Climate Change); BIS (Bureau of Indian Standards); MeitY (Ministry of Electronics and Information Technology); MoRTH (Ministry of Road Transport and Highways); MHI (Ministry of Heavy Industries)

Caveats To Consider

- Battery circularity **opportunity** is highly **dependent** on **how EV uptake** in the country takes shape in future. EV sales trends across segments are a key input in deriving the volume of LiBs in circulation.
- There are **multiple stages** of the **battery circular economy** primarily centred around battery repurposing and recycling. Considering the current maturity of battery repurposing market, it is challenging to account accurately for these impacts.
- **Estimates** of **recovered minerals** are **conditional** on a range of **factors**, from salient LiB chemistry mix in the EV market to the extraction processes employed by the industry to the EV battery profiles (capacity, energy density, longevity, etc.). How these elements will evolve over time is hard to anticipate.
- **Economic value** of battery recycling is **contingent** on **market prices** of recovered **minerals**. These market prices depend on commodity market, which, like any trading platform, is dynamic and difficult to forecast.

The research considers transparent assumptions and an assessment framework amenable to periodic updates.

For More Insights And Details, Refer To The Working Paper



Link to download: <https://csep.org/working-paper/battery-circularity-in-india-a-billion-dollar-long-term-opportunity-the-case-of-ev-batteries/>

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sdas@csep.org

+91 9711009767

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