ELECTRIC VEHICLE BATTERY RECYCLING AND EXTENDED PRODUCER RESPONSIBILITY (EPR)

REFORM THE TERMS OF ACTION

POLICY BRIEF

ELECTRIC VEHICLE BATTERY RECYCLING AND EXTENDED PRODUCER RESPONSIBILITY (EPR)

REFORM THE TERMS OF ACTION

POLICY BRIEF

Authors: Anumita Roychowdhury and Moushumi Mohanty

Lead research: Moushumi Mohanty

Cover and design: Ajit Bajaj

Layout: Kirpal Singh

Production: Rakesh Shrivastava and Gundhar Das

Citation: Anumita Roychowdhury and Moushumi Mohanty 2026, *Electric Vehicle Battery Recycling and Extended Producer Responsibility (EPR): Reform the Terms of Action*, Centre for Science and Environment, New Delhi

Published by
Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
Phones: 91-11-40616000
Fax: 91-11-29955879
E-mail: cse@cseindia.org
Website: www.cseindia.org

Contents

1. The spotlight

The Battery Waste Management Rules, 2022, (BWMR 2022)[1] and its subsequent amendments by the Ministry of Environment and Forests and Climate Change (MoEFCC) are important steps forward for the prevention of environmental contamination with hazardous waste and also for ensuring strategic recovery of valuable material from spent batteries—metals and minerals. This enables a closed-loop system of a circular economy that reduces the demand for new virgin material extraction for new batteries.

In addition to governing the collection, transport, safe disposal, and recycling of end-of-life batteries, the principle of "Extended Producer Responsibility" (EPR) plays a central role in the lifecycle management of the batteries. Simply put, this makes the producers, including manufacturers, importers, assemblers, and brand owners, responsible for the collection, recycling, safe disposal, and sustainable material recovery and use of the recovered material from end-of-life batteries in new batteries. The EPR is also an opportunity to drive product innovation for the recyclability and durability of the batteries. This has enormous potential to build a new economic enterprise and jobs. Fundamentally, the EPR strategy enables centralized responsibility for the safe handling and disposal of end-of-life (EOL) batteries, material recovery, reuse, and recycling to improve overall resource efficiency in the sector.

EV batteries typically reach end-of-life in a vehicle when the 'state of health' of the batteries drops to 70-80 per cent of the original capacity. After that, the battery needs to be repurposed and put to secondary use, such as secondary battery storage, as the battery still retains significant energy. Only after exhausting that capacity are the batteries discharged, dismantled, and recycled. Therefore, under the EPR framework, producers are required to assess the residual capacity for second use and are responsible for managing this lifecycle application by partnering with the recyclers and the refurbishers. They need to carry out appropriate testing, certification, and safe transportation.

The apex pollution monitoring body, the Central Pollution Control Board (CPCB), is responsible for overseeing compliance through online monitoring. All producers and recyclers are registered on a central portal. Since the notification of the BWMR 2022, the rules have been amended sequentially in 2023, 2024, and 2025 to further strengthen the EPR provisions (see Box: Evolution of the Extended Producer

EVOLUTION OF EXTENDED PRODUCER RESPONSIBILITY RULES IN INDIA

2022 notification

Battery Waste Management Rules (BWMR 2022) integrates and sets targets for Extended Producer Responsibility. EPR is applicable to different types of batteries, based on the average life of the battery.

The EPR target includes the collection targets mentioned, recycling and/or refurbishment target as per the collection target of the respective year. This will require the recycling of battery materials such as lead, nickel, lithium, cobalt, plastics, rubber, glass, etc.

The Extended Producer Responsibility target for the producer is specific to the kind of battery (viz. Lead Acid, Li-ion, Nickel Cadmium, Zinc-based Battery, etc.) within each type of battery.

The producer will meet their EPR obligation through the EPR certificate made available by the recycler or refurbisher. In case of the non-availability of EPR certificates with recyclers or refurbishers, the producer shall have the responsibility of collection as well.

2023 amendment

Every Producer has the obligation of EPR for the battery they introduce in the market and they put to self-use. They need to meet the recycling or refurbishing obligations as per the schedule.

Every Producer shall have the obligation for environmentally sound management of pre-consumer waste battery generated during the manufacturing or assembling or import of a battery or battery pack and every Producer will file the annual returns in respect of pre-consumer waste battery generated in the preceding financial year.

Every Producer shall meet the collection and recycling and refurbishment targets for the battery or battery pack made available in the market, including for self-use.

Every Producer shall obtain registration from the Central Pollution Control Board through an online centralized portal. The Central Pollution Control Board shall issue a certificate of registration upon registration of the Producer.

The Producer will discharge its EPR obligation in respect of batteries already made available in the market till the closure of operations, in accordance with the provisions of these rules.

The total weight of waste battery processed by an entity involved in the refurbishment of waste batteries, on a quarterly basis, shall be made available on the portal developed by the Central Pollution Control Board for the generation of EPR certificates.

No EPR certificate shall be generated for the recycling or refurbishment of waste Battery imported under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

The Central Pollution Control Board shall fix the highest and lowest price for the EPR certificate every six months or as required, keeping in view the cost for collection and environmentally sound management of waste battery and the environmental compensation regime in force.

2024 amendments

In the Battery Waste Management Rules, 2022, the Central Pollution Control Board shall fix the highest and the lowest price for Extended Producer Responsibility certificates which shall be equal to 100 per cent and 30 per cent, respectively, of the Environmental Compensation that can be levied on the obligated entities for non-fulfilment of EPR obligations.

The exchange price of the EPR certificate between registered entities through the portal shall be between the highest and the lowest prices referred.

There may be a carry forward of up to 20 per cent of the average quantity of battery placed in the market per year during the seven-year cycle to the next compliance cycle. Up to 60 per cent of the remaining quantity of battery placed in the market during the applicable compliance cycle may be carried forward to the next compliance cycle.

2025 amendment

Producers are to provide the EPR information in writing to the Central Pollution Control Board—print a bar code or Quick Response code containing the EPR registration number on the battery or battery pack; or equipment having a battery or battery pack; or packaging of the battery or battery pack; or packaging of the equipment having a battery or battery pack; or bulk packaging of batteries or battery packs, not for retail sale.

The Extended Producer Registration number must be printed on the product information brochure. The Central Pollution Control Board should publish a consolidated list of such producers, who have provided the information to it on the centralised online portal and update their details every quarter.

Marking of the chemical symbol 'Cd' or 'Pb' is not applicable where the metal concentration of Cadmium in the battery is less than or equal to 0.002 per cent (20 parts per million) or Lead in the battery is less than or equal to 0.004 per cent (40 parts per million) by weight.

Responsibility rule in India). Currently, close to 4000 producers, recyclers, and refurbishers are registered with the CPCB, which oversees registration, credit issuance, and compliance monitoring through a digital portal.

The rules have outlined clear targets for manufacturers that require a 90 per cent recovery rate of battery materials by 2026-27, increasing from 70 per cent in 2024-25. Producers must also incorporate a minimum percentage of recycled materials in the new cells, starting at 5 per cent in 2027-28 and reaching 20 per cent by 2030-31. Both manufacturers and importers of lithium-ion batteries will have to comply with these targets.

As per the rules, registered producers need to submit a comprehensive EPR plan outlining strategies for battery collection, handling, storage, transportation, and recycling to meet the collection/recycling targets. They need formal agreements or Memorandums of Understanding (MOUs) with authorized and registered recyclers or refurbishers and proof of authorization for collection centers, transporters, and recyclers to ensure the responsible collection and recycling of used batteries. The rules require digital tracking of the battery lifecycle to ensure traceability and facilitate compliance. The manufacturers will have to file annual compliance reports. This will be managed and overseen by the CPCB through a central portal. The CPCB oversees the EPR registration for producers, collection, and reporting. Waste batteries will have to be sent for recycling or refurbishing, not landfilling or incineration.

To govern the entire process, the rules further mandate environmental compensation for non-compliance with the EPR targets. This requires a regular monitoring and auditing system by the CPCB. Manufacturers need to publish recovery information whilst ensuring proper recycling and safe disposal of waste batteries. This will also require a product coding system and establish a full lifecycle tracking system. In fact, Niti Ayog has announced plans to initiate a "battery passport" system to give EV owners detailed digital information about the batteries in use. This will include information on the source, composition, performance, lifecycle, and supply chain with an embedded QR code. This is a critical step forward for recycling as well.

Clearly, the implementation of the EPR will require strong preparedness to address a range of operational issues in the ecosystem including regulatory standards, enforcement mechanisms, EPR pricing, infrastructure and systems for collection, transport and recycling, financial incentives and support systems, a technology roadmap, and battery innovation. This requires massive augmentation of the infrastructure for the collection, transport, and recycling of EOL batteries, and accurate data on product lifecycle and traceability of the batteries.

The operational framework for the implementation of the EPR requires urgent attention at this early stage of growth of the EV industry as well as the recycling industry. In the first week of September 2025, the Cabinet approved a Rs 1500 Crore incentive programme to promote critical mineral recycling. This is part of the National Critical Mineral Mission (NCMM), to build domestic capacity and supply chain sustainability by the recycling of secondary sources. This requires urgent interventions to strengthen the eco-system for the EV battery recycling industry.

While this strengthening of the regulatory system is an important step forward, its effectiveness lies in the proper development of different aspects of the eco-system for the effective operation of the EPR policy. Compliance with EPR regulations requires effective battery collection, recycling infrastructure, standardized and recycling conducive battery design, well-developed logistics for collection and transportation of used batteries, effective EPR pricing, consumer awareness, battery tracking platforms, and committed budgetary allocation for battery waste management. The litmus test of this system is the ultimate recovery and refining of metals and minerals for further utilization in new batteries.

A critical factor in this system is the pricing of EPR that creates a financial incentive for responsible battery collection and recycling and ensures that the producers are paying for the end-of-life management of their products. This requires a fair price mechanism that includes a floor price and fair compensation for the recyclers to enable adequate investments in technologies for infrastructures and in the advanced refinement of the extracted material.[44] At the same time, this must ensure environmental safety. A lack of fair pricing can encourage fraudulent practices and the dumping of waste, poor recovery, and loss of material. This can defeat the objective of EPR.

The review of EPR implementation indicates that EPR prices are often not structured to cover the true and full costs of battery end-of-life management, leading to insufficient funding for safe and effective collection and recycling. This is compounded by a focus on cost minimization rather than waste prevention and eco-design, which discourages innovation, resulting in producers paying too little. This weakens the economic viability of proper recycling. Low EPR prices can distort the market, making it cheaper to illegally dump batteries than to manage them properly, creating significant environmental and health risks. Cost minimization limits fees, and the fees producers pay under EPR might be too low, similar to other e-waste streams. This leads to a "documentation-only" compliance approach where actual processing is minimal. Current EPR fee structures do not sufficiently take into account the real end-of-life costs and fail to encourage producers to design batteries for waste prevention and easier end-of-life management. The EPR fee to product cost ratio is too low to have a significant impact on producers' product design decisions. The current cost coverage is based on the concept of "necessary costs" which seeks to limit the level of the fee to what is necessary and minimize waste management costs. As the external costs associated with (managing) the products' end-of-life are not internalized, there is little space to use revenues for eco-design and waste prevention measures.

To enable a more efficient eco-system for life cycle management and recycling, battery producers need to set aside a mandatory budget for battery collection and recycling. Otherwise, this can lead to low, market-determined spot prices, which are often set by informal recyclers and fail to incentivize infrastructure development for safe handling.

It is important to underscore that while recycling regulations and EPR are expected to ensure the safe dismantling of batteries for material recovery, they also have to catalyze and promote the development of an advanced refining industry that is capable of extracting and separating out the minerals and metals from the black mass powder—a mixture of cathode and anode materials from spent lithium-ion batteries—for further value addition. This means that after a battery is deep-discharged and mechanically shredded, the metal-rich fraction extracted is refined further to remove the recoverable materials like lithium, cobalt, nickel, manganese, etc., for processing and for use in new batteries. It is more important to develop this refining and processing industry to maximize material gains and prevent export.

Currently, there are several recyclers—largely dominated by start-ups—that are capable of extracting black mass from spent batteries, but the capacity for refinement and processing to produce battery-grade material from the black mass to support local battery manufacturing is inadequate. There are concerns that a lot of the black mass is being exported out of the country, leading to a serious loss of valuable resources. This needs to be addressed urgently.

An even bigger concern is the inadequate feedstock to sustain the recycling industry. A combination of a small EV market, low generation of used and spent batteries, and the practice of exporting black mass out of the country has seriously constrained the domestic supply chain of battery feedstock for the recycling industry. It is anticipated that if not addressed, this can make the continuity of several start-ups uncertain and unsustainable. The representatives of the recycling industry express deep worries and hold that only a nominal capital expenditure (capex) subsidy for plants and machinery to the recycling industry cannot guarantee sustained growth. The governance framework has to ensure the appropriate development of the refining industry to effectively recover the resources.

India's EPR framework under the Battery Waste Management Rules (BWMR), 2022, has established a forward-looking foundation for battery recycling and circular economy development. By placing responsibility on producers to ensure the collection, recycling, and safe disposal of batteries, the regulation aligns environmental objectives with resource security. Yet, persistent challenges in pricing, erosion of black mass, weak compliance, reverse logistics, and safety standards highlight the risk of the system being undermined by weak enforcement and malpractice. Unless these gaps are addressed, India's recycling ecosystem may remain underdeveloped, leading to the loss of mineral resources, increased costly mineral imports, and compromise the country's clean energy transition.

In view of the fact that the implementation of EPR is central to building an effective circular economy and is also one of the key drivers of product innovation and material efficiency, the Centre for Science and Environment has assessed different aspects of its implementation. It has engaged with the recycling industry as well as the start-up producers of EVs to examine the preparedness, barriers, and the way forward on EPR. This policy brief highlights some of those insights from the ground.

The way forward: Summary highlights

This review brings out that without a realistic floor price, stringent certification protocols, clear black mass regulations, robust collection networks, and stronger safety standards, the framework risks being undermined by malpractices and lost economic opportunities. By raising the EPR floor price, banning black mass exports, developing the domestic refining sector, formalizing the informal sector, engaging municipalities, and establishing national safety standards, supporting R&D infrastructure and skilling, among others, India can move toward a recycling system that is environmentally sound, economically viable, and strategically secure. Taken together, these measures can transform the EPR framework into a robust, transparent, and enforceable system. By rationalizing floor prices, banning black mass exports, formalizing the informal sector, addressing low-value chemistries, and strengthening safety and accountability, India can build a recycling ecosystem that is both economically viable and environmentally sound.

- **Rationalize and enforce EPR floor price:** Set a realistic minimum price for EPR credits that reflects true recycling costs. Tighten penalty structures to deter free-riding and fraudulent certification.

- **Close the black mass loophole:** Classify black mass as hazardous waste unless processed on-site. Enforce CPCB Standard Operating Procedures (SOPs) across states and impose an explicit ban on black mass exports.

- **Strengthen Reverse Logistics and Formalize Informal Sector:** Develop ward-level collection centres and dismantling hubs in partnership with municipalities. Integrate informal collectors into licensed supply chains with training, incentives, and safety protocols.[87]

- **Ensure viability of low-value chemistries:** Introduce producer co-financing or viability gap funding for the recycling of LFP and similar chemistries. Support R&D in advanced recycling technologies tailored to India's battery mix.

- **Enhance safety, skilling, and accountability:** Issue national guidelines for the safe storage, transport, and dismantling of batteries. Launch formal skilling programs and enforce Environmental, Health, and Safety (EHS) standards across the recycling chain. Mandate third-party audits to ensure producer liability and material traceability.

- **Mandate a battery passport framework:** Develop a digital record system for all batteries, capturing chemistry, State of Health (SoH)/State of Charge (SoC), usage history, and recycled content. Integrate with GST and EPR portals, leveraging India's digital infrastructure capabilities.

- **Recognize refurbishing in EPR compliance:** Explicitly include verified second-life applications as eligible outcomes under BWMR 2022. Establish third-party validation protocols for documenting reuse and repurposing.

- **Establish national standards and certification:** Create Bureau of Indian Standards (BIS)/National Accreditation Board for Testing and Calibration Laboratories (NABL)-backed testing and certification protocols for refurbished batteries. Standardize safety, performance, and quality benchmarks to build market trust.

- **Enable secure data sharing:** Require Original Equipment Manufacturers (OEMs) to share anonymized Battery Management System (BMS) data in standardized formats. Develop protocols for collaboration between OEMs, refurbishers, and recyclers while protecting confidentiality.

- **Provide financial incentives for circularity:** Introduce green credits, viability gap funding, and storage-linked subsidies for refurbishing. Mandate public procurement of refurbished batteries for decentralized energy storage projects.

- **Performance-linked fiscal incentives:** Fiscal incentives for recycling need to be performance-linked, and the key performance indicators have to ensure the quantification of black mass generated annually with an effective tracking mechanism, inventory of the amount of refined material recovery in the country, stoppage of clandestine export of the black mass, uptake of refined material by the EV producers, among others.

- **Stop diversion of feedstock:** National and state governments should mandate or incentivize formal partnerships between recyclers, OEMs, dismantlers, and waste collectors to ensure end-of-life batteries enter safe recycling channels rather than informal or overseas markets that weaken domestic supply chains.

- **Prevent overcapacity:** Rapid expansion of facilities without adequate feedstock can lead to underutilization and financial instability, as seen globally. Policymakers should carefully design incentives to prevent overcapacity. Support schemes should prioritize sustainable operations, proven technologies, and integration into the broader value chain rather than subsidizing speculative start-ups.

- **Support upstream solutions:** Policies should promote reuse and repurposing as formal bridge strategies, not just environmental add-ons. Encouraging second-life applications can extend value chains, generate near-term revenue, and help secure future recycling inputs.

- **Provide support to R&D to improve recovery rates:** Excessive dependence on metal prices exposes recyclers to unpredictable margins and potential insolvency. The government should promote cost-efficient recycling by offering support for R&D in advanced recycling technologies (hydro-metallurgical methods, direct recycling) focusing on improving recovery rates, reducing costs, and minimizing environmental impacts, helping recyclers withstand market volatility.

- **Need vertical integration and scale:** Vertical integration and scale cannot be replicated through capacity-building alone. It would be prudent to consider targeted industrial policy: building vertically integrated value chains, supporting domestic cathode and anode manufacturing, and aligning recycling with EV and energy storage growth strategies.

- **Standardization and certification to build market confidence:** India urgently needs a national standard for repurposed batteries to ensure uniform benchmarks for quality, safety, and performance. In the absence of such standards, each repurposer is forced to validate products independently, leading to inefficiencies, higher costs, and slower market scalability. Establishing certification mechanisms—potentially modeled on BIS protocols or through NABL-accredited laboratories—would streamline acceptance and create confidence among end-users. Integrating repurposed batteries into national storage tenders and clean energy procurement frameworks would further reinforce market legitimacy and accelerate adoption.

- **Need third-party audits for compliance and liability:** The compliance landscape is riddled with confusion and loopholes. For instance, if only battery cells are imported and assembled domestically, liability often shifts to the entity branding the battery, leading to exploitation of regulatory grey areas. In cases involving multiple brand owners, smaller partners are frequently left with the burden of compliance, while larger OEMs offload their responsibility. Policy must address this by mandating third-party audits, physical verification of recycling facilities, and linking credits to actual material recovery rather than paper-based claims. Liability should also be clarified to ensure that brand owners or importers of record remain accountable, preventing large OEMs from shifting responsibility onto smaller intermediaries. Without these measures, the battery sector risks replicating the failures seen in plastics and consumer electronics recycling. In the consumer electronics industry, for instance, producers often choose not to fulfill their obligations despite the relatively low cost of compliance (e.g., Rs 12[2] for a Rs 3,999 power bank). This is typically driven by a preference to divert spending toward marketing rather than environmental responsibility. The lack of credible enforcement further diminishes the incentive to comply, allowing widespread evasion of EPR requirements.

- **Strategic Directions for Recyclers:** Global experience suggests that recyclers cannot rely solely on downstream material recovery. Building upstream partnerships with OEMs, waste collectors, and dismantlers is critical to securing consistent feedstock. Reuse and repurposing should be treated as core strategies, not merely as environmental commitments, since they provide interim value and help lock in future supply. The e-waste sector provides a useful precedent. Once a fragmented and speculative industry, it evolved into the IT Asset Disposition (ITAD) market as electronics matured, consolidating around services such as logistics, compliance, and safe handling. Similarly, battery recyclers should capitalize on their strengths in safe collection, hazardous material management, and regulatory compliance. The ability to guarantee safety and reliability may be just as valuable as material recovery yields.

- **Build Infrastructure and Skills**: Develop decentralized refurbishing and recycling hubs, integrated with dismantling and collection centres. Launch national skilling programmes on diagnostics, repurposing, and safety protocols.

- **Foster collaborative governance**: Create structured platforms for OEMs, recyclers, refurbishers, and policymakers to co-develop protocols. Support large-scale pilots for second-life batteries in grid and off-grid applications. For OEMs, dismantlers, and compliance schemes, early collaboration with recyclers is equally important. They must recognize the strategic importance of end-of-life planning and invest in partnerships with recyclers and repurposers to prevent future monopolies, reduce commodity market risks, and secure supply chains. Upstream collaborations and diversification into multiple battery streams are essential for securing long-term viability. Beyond EVs, governments can create enabling frameworks for recycling across underexplored battery segments—stationary storage, industrial batteries, and other sub-sectors—to broaden recycler revenue streams and reduce sectoral risk concentration.

The industry now has tested infrastructure, operational learning, and a growing talent base—foundations that did not exist five years ago. The future will depend on a strategy. Companies that align their decisions with market realities—understanding not only their own position but also the incentives of suppliers and customers—will be best positioned to survive.

2. Towards implementation of extended producer responsibility

While EPR is a progressive step toward sustainability and a circular economy, several weaknesses have surfaced, indicated by pricing disputes, malpractices in the unorganized sector, fraudulent certification, gaps in reverse logistics, and the contentious debate on black mass classification. This has exposed vulnerabilities in the framework. Unless addressed through timely regulatory and institutional reforms, these gaps risk undermining both India's environmental goals and its strategic resource security.

These gaps also have to be located within the nature and structure of the recycling industry. It is necessary to distinguish between recycling and shredding of batteries. Shredding operations use hazardous waste end-of-life Lithium-ion batteries as input and hazardous and other wastes as output. It is just a preparatory activity for recycling. It requires less than 10 per cent of the investment needed for actual recycling/refining and does not recover any critical metals.

India's battery shredding capacity is expanding rapidly, with estimates around ~100,000 metric tons per year across vendors, but EV adoption and cell manufacturing progress have remained slow, leading to limited scrap availability. This is in direct contrast to the situation globally highlighted in a Bloomberg article. Input feeds to recycling plants mostly (70 per cent) comprise manufacturing scrap while the rest is from spent batteries. Recycling capacity lies underused as a result and is expected do so till the late 2020s. As battery manufacturing in India is at a nascent stage, recycling plants receive minimal manufacturing scrap, while a large percentage of spent batteries is exported abroad as black mass. India risks overbuilding if it continues at the current pace, potentially resulting in underutilized plants and financial stress for shredding companies.

Hydromet-based recycling, also called 'refining', is a high-capital expenditure (Capex) and high-technology business which is suffering due to illegal exports of black mass by existing shredding companies across the country. The above factors make recycling non-profitable and unattractive for investment today.

Diversifying into repurposing and refurbishing may appear logical, but in India's 2025 context, it is not a business for industrial scale (pilot scale only) due to the limited availability of suitable batteries. Repurposing right now is more like repair or putting to another use, which is not really recycling. Also, looking at the falling cell prices, the retail market is not attractive other than in unorganized small markets. Unorganized small repurposing activity could be profitable but is unsafe and tax non-compliant.

EV cell manufacturing in India is still at a nascent stage, with no operational gigafactories, leaving the country highly dependent on consumer electronics and EV scrap. Currently, e-rickshaws have lead-acid batteries, though a gradual shift to lithium-ion is underway. Commercial two- and three-wheelers are also increasingly adopting lithium-ion. In the early years, most of these batteries were based on NMC chemistries. The quality of these early 2W/3W batteries is poor and unsuitable for repurposing. The limited supply and the economic and safety challenges of repurposing NMC batteries make repurposing unviable at this stage. While Lithium Iron Phosphate (LFP) cells only began entering the Indian market around 2023-24, they are better suited for second-life applications. There are a few start-ups in this area, but they are more like pilot plants and struggling for funds due to difficulty in scaling up. There is hardly any automation, and it is labour-intensive, leading to scalability issues.

EPR pricing mechanism—Challenges

Under the Battery Waste Management Rules, 2022, the CPCB has issued guidelines for (i) the imposition of an environmental compensation charge (ECC) for non-compliance and (ii) defined the thresholds of the EPR pricing that is linked to the ECC.

The Rule 13 (3) of BWMR states that the CPCB will prepare and recommend guidelines for the imposition of the ECC from the producers, and entities involved in the refurbishment and recycling of waste batteries, in case of non-compliance of rules. Furthermore, Section 10 (17) states that the CPCB shall fix the highest and the lowest EPR which shall be equal to 30 per cent to 100 per cent respectively of the ECC leviable on the obligation for non-fulfilment of the EPR as determined by the CPCB. This means that recyclers will only be able to trade the metal EPR credits in the range of 30-100 per cent of the ECC cost.

Simply put, EPR pricing includes the cost that the producers need to pay for battery recycling, with a floor price setting a minimum payment to ensure fair compensation for recyclers and prevent unsafe and wasteful disposal. The floor price sets the minimum cost that producers must pay for the recycling or disposal of their batteries, ensuring that recyclers who invest in advanced technology are fairly compensated. If the floor price is set too low, it creates incentives for cost-cutting and opens the door for fake recyclers—companies that claim to recycle batteries but in reality dump hazardous waste while issuing fraudulent certificates of compliance. This can lead to the massive and permanent loss of critical minerals.

The guidelines take note of the fact that the infrastructure for the Lithium-ion and other batteries is nascent. Therefore, the EPR floor price addresses the high cost of processing by supporting significant investments in research and development and health and safety measures. Additionally, it will ensure 100 per cent battery coverage, making collection and logistics economically viable and protecting recyclers from the risk of fluctuating commodity prices.

The guidelines have further laid down the boundary conditions for EPR credit cost. This asks for the setting of EPR costs of various metals at a lower market value of these metals to ensure that metals are recovered from the recycling of the waste batteries “rather than purchasing metals from the market and selling them and generating EPR credit”. India has thus adopted a differentiated pricing principle for key metals and minerals per kilogram in the battery chemistry. This enables metal-wise credits.

The guidelines have further stated the method of estimating EPR pricing (see Box: *Environmental compensation charge and EPR costs of metals*). This essentially means that the lowest and the highest EPR pricing will be set at 30 per cent to 100 per cent of the Environmental Compensation Charge respectively. This can vary from Rs 2400 for Lithium to Rs 36 for Aluminium and Iron. The key principle is the linking of incentives and disincentives. In case of non-compliance, the producers will pay ECC while the incentive or the EPR pricing is connected with the cost of the ECC.

The economics of recycling is further complicated by the significant price variations across different battery chemistries. Different lithium-ion battery chemistries pose distinct challenges for recyclers. While LCO (Lithium Cobalt Oxide) and NMC (Nickel Manganese Cobalt) offer higher recoverable value, LFP (Lithium Iron Phosphate) batteries—widely used in EVs and stationary storage—yield far less and are uneconomical to recycle under current conditions. For instance, as per market information:

- **LCO (Lithium Cobalt Oxide):** Rs 200-270/kg, currently the highest volume feedstock entering the recycling sector.

ENVIRONMENTAL COMPENSATION CHARGE AND EPR COSTS OF METALS

As per the CPCB guidelines, the environmental compensation charge (ECC) is calculated per tonne of waste. This includes:

i) Cost of handling, collection, transportation of waste battery = Rs 70,000 per tonne.

The processing cost to recover key batteries has been estimated as follows:

Metal	Average processing cost (of metal)
Lithium	2,330
Cobalt	485
Nickel	485
Manganese	485
Copper	200
Aluminium	50
Iron	50

Assuming that the batteries contain an equal quantity of all seven metals, the cost of collection and transport of each metal (per kg of metal) will be Rs 70. The cost of recovery of each metal is calculated by adding the cost of handling, collection, and transport, for each metal and the processing cost of each metal, and this will serve as the ECC cost of each metal. From this, the EPR prices are derived at 30-100 per cent of the ECC cost.

Metal	Total ECC cost (Rs/kg of metal) = Average cost of collection, storage, transportation and processing	EPR cost (30-100% of the ECC) (Rs)
Lithium	2,400	720-2,400
Cobalt	555	166-555
Nickel	555	166-555
Manganese	555	166-555
Copper	270	81-270
Aluminium	120	36-120
Iron	120	36-120

Note: The ECC cost of cadmium and zinc can be the same as lithium due to limited availability.

- **NMC (Nickel Manganese Cobalt):** Rs 100-180/kg, with volumes growing due to the two-wheeler EV market.
- **LFP (Lithium Iron Phosphate):** Rs 32-50/kg, significantly lower value, making it economically unviable without OEM support.

Concern over EPR pricing

The recycling industry has expressed deep concerns over the inadequate and low floor price as this cannot recover the high recycling costs, making advanced and formal recycling expensive and financially unviable. This, they fear, will lead to more informality with a higher environmental footprint and loss of material and weak auditing of the system. Without proper EPR pricing and enforcement mechanism, producers can resort to fraudulent documentation and may evade responsibility by paying a minimal fee. An effective floor price is needed to increase investments in more advanced recycling and refining techniques, support formal recycling, address the high cost of processing, and reduce price volatility. Effective enforcement of EPR floor pricing for EV battery recycling requires setting a price that reflects actual costs, implementing strong, digitized tracking and auditing, imposing significant penalties for non-compliance, and integrating the informal recycling sector into the formal system through training and support. Multi-stakeholder collaboration and periodic price reviews are also crucial for ensuring economic viability, preventing fraud, and fostering a sustainable circular economy for batteries.

The Indian EV Battery Recycling industry's response to the CPCB's 2024 EPR price guidelines includes concerns over the economic viability of the low-end price and the need for greater flexibility. They are concerned about the sustainability of a lower mandated price for certain battery types. This industry also wants market-driven pricing. They feel a low price risks undermining sustainability and could lead to toxic waste in landfills. It is likely that a low price could create a market where companies might try to avoid their EPR responsibilities by not adhering to the rules. The industry representatives feel that collection cannot be sustained purely from the profit generated by recycling activities. To make the system viable, a minimum floor price must be enforced.

The industry highlights several principles for recycling and EPR pricing. If, without a proper recycling ecosystem and EPR pricing, the toxic waste gets dumped, the cost of cleaning up can be enormous. This has to be a referral while deciding the EPR costs that the producers need to pay. The EPR pricing cannot depend solely on what producers consider to be affordable. It requires much stronger rationalization. The current estimation of EPR pricing is grossly understated. It is calculated on the basis of the cost of bringing the battery to the recycler. The industry representatives feel that the environmental compensation cannot be based on a simple freight cost, for instance. There are guestimates that the current rule of 30 to 100 per cent of the ECC cost virtually works out to be a mere 0.3 per cent of the battery cost. It is alleged that the EV producers can pass on this cost to consumers easily. The industry representatives volunteer to estimate that if the metal price fixed by the government for lithium, for cobalt, for nickel, for manganese, and graphite, are multiplied by their respective amounts of weight in a battery, and multiplied by the amount to be paid, it may work out to be 0.16 per cent of the total cost of the battery. They claim that the EPR price fixed by the MoEFCC is not adequately linked with environment compensation and is grossly understated. In contrast, the minimum EPR charge or the environmental fee in Europe for a battery seller is supposed to be 4 per cent of the battery price. This can pay for the recycling. If not addressed, this may be limiting and restrict the expansion of the recycling industry in India.

The weakness of the current system is that there is no official system of tracking the amount of black mass generated, traded, and material recovered for further utilization. This inventory is not officially recorded and tracked.

The EV manufacturing stakeholders, on the other hand, hold different views on the current pricing mechanism. The Indian Battery Manufacturers Association (IBMA) has reacted against the CPCB guidelines that propose a minimum EPR credit pricing at 30 per cent of the ECC. IBMA recommends market-driven pricing for EPR credits to balance economic feasibility and consumer affordability and that this mechanism be also extended to all certified recyclers and not only to integrated facilities with proper traceability to waste battery input. And safeguards could be adopted to address the potential double-accounting of EPR credits. They hold that manufacturers have already invested in reverse logistics for proper collection, handling, and transportation of used batteries to authorized recyclers. According to the IBMA, including recycling costs in the EC while requiring manufacturers to purchase EPR credits at high prices could lead to duplicate reimbursements to recyclers. IBMA suggests that EPR credits be made available at no cost to manufacturers already incurring expenses at all stages of waste management.

Oversupply of EPR certificates vs. limited Recycling undercut pricing: India's battery recycling sector faces a critical imbalance between the supply of EPR certificates and actual recycling activity. While the quantity of waste being genuinely recycled remains limited, a large number of EPR certificates are being issued. The pricing dynamics are clearly influenced by supply and demand. An oversupply of certificates chasing a small volume of real waste has caused EPR prices to collapse. Similar trends were previously observed in plastics and e-waste, where prices fell to as low as Rs 0.50-Rs 2 per kg. In the lithium and cobalt segment, cobalt prices have already dropped from Rs 500 to Rs 350 per kg and are trending further downward.

When recyclers can make profits, competition drives EPR prices down, sometimes close to zero. Conversely, if recyclers face losses, they may demand significantly higher compensation for accepting waste, creating tension between producers and recyclers. For instance, lithium battery recycling can range from Rs 500-Rs 2000 depending on the market and the recyclers' cost structures. This volatility highlights the need for a more transparent and monitored system to ensure that EPR pricing accurately reflects actual recycling and incentivizes legitimate recyclers, while preventing market distortions caused by false claims.

The international battery recycling market today is marked by significant overcapacity, particularly in pre-processing. Facilities in several regions are running at less than half capacity and struggling to secure enough feedstock to remain viable. Limited feedstock and falling metal prices force recyclers to compete by offering higher prices, eroding already thin margins and exposing them to high commodity market volatility. Since 2022, only a few quarters have seen positive price trends for battery metals, leaving many operators with costs exceeding revenues. This dynamic is driving a sharp slide as private equity-, venture capital-, and government-backed start-ups compete to outlast one another. But unlike digital platforms, the recycling industry cannot generate demand artificially—feedstock is limited to the number of batteries that physically reach end of life. The result is a fragile ecosystem where rising feedstock costs and squeezed margins threaten the survival of smaller players. China offers a sharp contrast to this fragility. Its strong domestic EV market provides a steady stream of end-of-life batteries and creates demand for recovered materials. Vertical integration with materials production allows recyclers to remain viable, while scale and capital investments fuel new product development and expansion. This positions China at the centre of the global battery value chain, reinforcing its bid for long-term dominance. The global logic is straightforward: local handling and collection may be dispersed, but once batteries are shredded into black mass, the market becomes international—dominated by established players with deep capital reserves, advanced technology, and the ability to withstand commodity market fluctuations.

Misrepresentation and unjust enrichment and price collapse: A significant driver of the price collapse is misrepresentation by some recyclers. Certain entities claim EPR credits without actually processing materials, often exporting black mass abroad or falsely declaring it as refined output. This practice allows recyclers to profit without investing in real recycling, while genuine recyclers and producers are disadvantaged. Weak oversight by State Pollution Control Boards (SPCBs), the Central Pollution Control Board (CPCB), and Customs exacerbates the problem. Ambiguities in Harmonized System (HS) codes for black mass further facilitate misdeclaration and unauthorized exports.

Regulatory gaps and enforcement challenges: The regulatory framework for battery recycling is fragmented. SPCBs oversee recyclers at the state level, CPCB monitors SPCBs, Customs manages cross-border movement, and the Ministry of Environment, Forest and Climate Change (MoEFCC) sets policy. In practice, each agency often redirects responsibility to another, leaving enforcement gaps. For example, R2 recyclers authorized only for shredding and preparatory work are still able to export black mass abroad, often misrepresenting it in Goods and Services Tax (GST) invoices. This fragmentation undermines both EPR compliance and domestic resource security.

Clarifying true recycling and EPR eligibility: The objective of battery recycling is to secure critical metals—lithium, cobalt, and nickel—for domestic use. However, current EPR allocations sometimes reward preparatory activities, such as separating copper or aluminum foils, which are then sold to secondary recyclers. While these secondary recyclers convert the material into usable ingots, only they should ideally receive EPR credits. True recycling, in policy terms, should be limited to entities capable of extracting metals at industrial purity levels suitable for batteries or other industrial applications. Preparatory activities, including collection, transport, storage, and shredding, should not automatically qualify for EPR credits.

Supply–demand dynamics and price volatility: EPR pricing is highly sensitive to market dynamics. When recyclers can profit, competition drives prices down, sometimes close to zero. Conversely, if recyclers face losses, they may demand higher compensation for accepting waste, creating tension with producers. For instance, lithium battery recycling can range from Rs 500-2,000, depending on the market and recyclers' cost structures. The current oversupply of EPR certificates, coupled with non-compliance, continues to depress prices, discouraging investment and reducing the effectiveness of EPR as a circular economy tool.

The Urgent Need for Centralized Oversight: To ensure EPR achieves its intended outcomes, stronger regulatory enforcement is required. This includes strict auditing of EPR claims, clear HS codes for black mass, and a centralized mechanism to prevent illegal exports. Coordinated action by MoEFCC, CPCB, SPCBs, Customs, and Director General of Foreign Trade (DGFT) is essential to close loopholes, ensure only legitimate recyclers receive credits, and secure critical metals within India.

Bypassing the system

There are reports that several producers bypass the requirement and instead procure fake recycling certificates at artificially low prices from unscrupulous recyclers. Industry observers point to parallels from the plastics recycling sector, where fraudulent certification has damaged the credibility of the system. In categories like consumer electronics, where 50-60[3] per cent of supply comes from the unorganized sector, OEMs rely on fake billing and informal cash deals to meet compliance. This perpetuates a cycle where real collection does not occur, genuine recyclers are undercut, producers end up financing the export of critical raw materials, and the recycling ecosystem remains weak. Breaking this loop requires strict enforcement of floor price compliance, investment in collection centres, and active public outreach. Without these, fake recyclers will continue to thrive, producers will escape accountability, and genuine recycling will remain underutilized. Unless the EPR floor price for batteries is rationalized, experts warn that the battery recycling sector risks facing the same fate. The stakes are particularly high: improper recycling could cost India more than $1 billion[4] in foreign exchange losses by 2030, as the country continues to depend heavily on imports of cobalt, lithium, and other strategic minerals.

3. Black mass—the black hole

Closely linked to the EPR debate is the management and classification of black mass. This is the output of the primary shredders of batteries who extract the black mass—the black powdery material from the batteries that contain high-value lithium, cobalt, nickel, manganese and copper mixed with non-metallic components like carbon, polyvinylidene fluoride binder, residual electrolyte, waste foils, shredded plastics, and heavy metals. This is an intermediate product of the recycling process. Currently, the recycling industry is dominated by the shredders who mechanically shred waste batteries to a mix of hazardous substances in a black mass. Ambiguity in the rules has created a massive loophole in the black mass trade and EPRs.

It is evident from industry conversation that many entities incorrectly label and misclassify black mass as a product instead of hazardous waste to bypass regulations and earn EPR credits. Although classified under HS code 8549 as hazardous waste requiring export licenses, black mass is often misrepresented as a "product" to bypass restrictions and shipped overseas. This loophole enables exports, leading to a drain of resources and fraudulent EPR crediting. Incorrect HS codes avoid strict permissions required by the MoEFCC, DGFT for hazardous waste, and customs vigil. These practices create a loophole and trade continues, despite a ban on black mass exports.

One of the reasons for black mass export is the lack of advanced domestic refining infrastructure to process black mass and extract valuable metals in India. This requires further treatment and processing to extract the valuable metals and minerals. In the absence of adequate treatment and refining capacity in the country, it is alleged that a lot of the black mass containing the valuable resources is exported out of the country, leading to a direct draining of resources. There is a limited market for high-purity recycled battery materials within India, as most domestic battery manufacturing currently relies on imported cells. The expensive and time-consuming processes of testing, sampling and refining black mass discourage investment in domestic processing units.

Recognizing this risk of material outflows, recyclers such as Attero Recycling[5] have formally requested a ban on the export of black mass. Their petition argues that given India's lack of mining capacity, the country must conserve these materials for domestic use. Their argument is aligned with international practice, as several countries have already imposed strict restrictions or bans on such exports to safeguard their resource security. The representatives of the industry have also appealed to the Government of India for stopping the export of lithium-ion battery black mass to prevent the drain and save investments. This will require the Director General of Foreign Trade to restrict the black mass Harmonized System Nomenclature (HSN) code and clarify that the HSN Code specific to lithium-ion battery waste and scrap is “restricted” for exports to ensure compliance at the customs level.

The recycling industry has cited rules to state that the legal framework under the Hazardous and Other Wastes (Management and Transboundary Movement) (HOWM) Rules, 2015, Rule, requires prior written permission of the MoEFCC before the import or export of Hazardous waste. Such export and import of hazardous or other wastes from and into India, respectively, will be deemed illegal if it is done without permission of the Central Government and does not conform to the shipping details provided in the movement documents. Also, if such trade leads to the deliberate disposal of hazardous or other waste in contravention of the Basel Convention and of general principles of international or domestic law, it will be deemed illegal.

It has been alleged by the recycling industry that despite the CPCB’s classification of black mass as hazardous waste and the HOWM Rules, many recyclers are exporting black mass by misdeclaration and deliberately using nomenclatures and HSN Codes which are incorrect. It is evident that as per the standard operating procedure (SOP) issued by the CPCB in January 2025, a checklist of Minimal Requisite Facilities for utilization of hazardous waste under Rule of the HOWM Rules, 2016, covers “utilization of Black Mass (generated by Lithium-ion battery dismantlers/recyclers or e-waste dismantlers/recyclers) for the recovery of Carbon/ Graphite material and metal compounds (sulphates, cabonates, phosphates of Co, Mn, Ni, Li, Cu, Fe, Al and Na) by adopting hydrometallurgy”.

The danger in this process is that shredding units are exporting black mass as a “product”, to take EPR credits on metals contained in black mass. These are not being sold to local refiners. By bypassing the rules, a lot of EPR credits are being generated illegally. Some sell the black mass to trading companies or subsidiary companies for taking the EPR benefit. Therefore, State Pollution Control Boards need to revise the approvals of shredding companies to incorporate only the word “Black Mass” as their output and not include other nomenclature.

This issue was deliberated upon during the meeting of the Technical Review Committee[6] (TRC) in December 2024, where members discussed whether black mass should be classified strictly as waste or as an intermediate product. The committee also recommended that the CPCB assess domestic recycling capacity, review stakeholder practices, and provide clarity on black mass classification in SPCB consents. The matter remains under deliberation, but the strategic importance of black mass makes decisive regulatory action urgent.

As per the minutes of the TRC meeting on January 2, 2025, the committee noted that "a product or by-product should usually have a fixed composition and follow some standards". The composition of black mass generated would depend on the chemistry of the batteries being recycled, so it would have no fixed composition, but vary from batch to batch. Though black mass is traded as such, it has no use unless further processed for the recovery of metals. Hence, the trade is more in the nature of a trade in wastes. It is also true that black mass would contain heavy metals with concentration beyond the limits mentioned in the rules. After hearing the views of the CPCB and the applicant, the committee was of the opinion that Black mass should be considered as Hazardous waste, unless processed in the same premises for the recovery of critical minerals. Any import/export of Black Mass needs to be dealt with under HOWM Rules, 2016. However, since Black Mass is not mentioned standalone in HOWM Rules, 2016, its import/export shall be dealt with under Rule 12 (8) of HOWM Rules, 2015. Accordingly, any import/export of black mass should be allowed only to the actual user and after permission from the MoEF&CC as per the HOWM Rules, 2016, as amended from time to time.

Protecting black mass for domestic use is strategically vital. India lacks significant mining capacity, and black mass offers one of the few domestic sources of critical minerals needed for EVs, solar panels, and electronics. Policy must therefore explicitly ban or enforce stringent restrictions on the export of black mass, bringing all transactions under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. Uniform enforcement across State Pollution Control Boards is also necessary, as inconsistent classifications currently allow some operators to treat black mass as a product despite lacking processing capacity. CPCB's SOP already provides a practical classification framework: black mass may be treated as an intermediate only if processed within the same premises where it is generated; otherwise, it must be treated as hazardous waste.

The document further observes that SPCBs are not applying a uniform approach in their treatment of black mass. In some cases, it is rightly classified as hazardous waste. But in others, consents to operate describe it under alternative labels such as "metal oxide powder" or "copper with graphite powder"—even where facilities lack the hydrometallurgical capacity to process it. This inconsistency has effectively allowed some companies to treat black mass as a product rather than as waste. Aligning all SPCB authorizations with this standard will prevent misclassification, close export loopholes, and preserve resources for India's recycling ecosystem.

In its deliberations, the TRC stressed that black mass cannot be treated as a conventional product or by-product. Its composition varies depending on the battery chemistry, with no fixed standards. Black mass also has no intrinsic use until further processed for the recovery of metals, and in many cases, it contains heavy metals at concentrations beyond permissible limits under the HOWM Rules. On this basis, the committee concluded that black mass should be classified as hazardous waste, unless it is processed within the same premises for the recovery of critical mineral. The committee also recommended that all import and export of black mass must fall under the HOWM Rules, 2016, specifically Rule 12(8). This means such transactions should be permitted only to actual users and must receive prior approval from the MoEF&CC. Finally, since the CPCB has already finalized an SOP, all consents to operate and authorizations issued by SPCBs and PCCs should align with CPCB's guidance, thereby preventing the misclassification of black mass as a product.

With India's recycling sector expanding rapidly, the scale of the problem is set to grow unless regulatory gaps are urgently addressed. According to the CPCB, there are currently 16 operational units processing lithium-ion batteries. Among these, 12 EPR-registered facilities also process black mass into metal compounds, with a combined input capacity of 75,500 metric tonnes per year. This indicates both the rising domestic capacity for black mass processing and the urgency of closing loopholes that allow misclassification and unauthorized exports.

In September 2025, the Central Board of Indirect Taxes and Customs (CIBC) of the Ministry of Finance issued a letter on the prevention of the illegal export of Li-ion battery black mass—a crucial resource that is classified as hazardous waste. It took cognizance of the Technical Review Committee of the MoEFCC, which clarified that black mass falls under the scope of the HOWM Rules, 2016. Since black mass is not explicitly listed in the schedules of these rules, its import and export are governed by Rule 12(8). This provision mandates that any such transboundary movement must have prior written permission from the MoEFCC and be restricted to actual users, ensuring traceability and environmental compliance. Further, the letter mentions instances of misdeclaration where several exporters have reportedly falsified product descriptions and HSN codes to disguise black mass exports. While the material should correctly fall under Chapter 8 sub-chapter 8549, Electrical and electronic waste and scrap, attempts have been made to classify it under unrelated tariff headings such as CTH 28419000, 81052030, 75012000, or 75040000. Such practices not only bypass regulatory controls but also pose risks of the uncontrolled shipment of hazardous material. In response, authorities have been urged to intensify vigilance to detect and prevent illegal consignments. Customs officials have been specifically instructed to scrutinize declarations more carefully, enforce compliance under the Customs Act, 1962, and initiate necessary action against violators. Strengthening oversight is seen as critical to safeguard both environmental interests and India's access to valuable secondary raw materials needed for battery manufacturing and clean energy transitions. It is not very clear how effective the enforcement has been. The recycling industry alleges considerable export of black mass from different ports of India.

Overall, restricting illegal exports would increase the black mass availability for hydrometallurgical recycling units. Stricter regulatory enforcement and monitoring are essential to ensure black mass remains within India, reducing import dependence for critical metals and enabling a truly circular economy for battery materials. It will also ensure that EPR money goes to the compliant recyclers, reducing incentives for unethical players and ensuring that government incentives are not counter-productive.

4. Challenges of the informal sector

Much of the material entering the recycling market passes through the unorganized sector. While some actors are legitimate, many engage in malpractices such as issuing fake bills, conducting cash transactions, and evading GST. This not only causes revenue loss for the government but also distorts competition. Recyclers who adhere to formal governance standards, maintain transparency, and pay full taxes are squeezed out of material supply chains. This undermines capacity utilization in compliant recycling plants and drives down the credibility of the entire industry.

The policy solution lies in the gradual formalization of the sector. Integrating informal players into licensed supply chains through training, safety protocols, and incentives would preserve their collection efficiency while curbing malpractice. At the same time, strict audits and GST enforcement must ensure that only legitimate transactions are counted toward EPR compliance. This dual approach would safeguard government revenue, level the playing field for formal recyclers, and close the credibility gap.

A realistic EPR floor price that reflects the true costs of recycling needs to be enforced. Because penalties for non-compliance are tied to the EPR floor price, weak pricing also leads to inadequate fines, undermining deterrence. Alongside stricter monitoring, penalties should be recalibrated. The BWMR provides for penalties ranging between 30[7] per cent and 100 per cent of processing costs for non-compliance; this wide pricing band leaves room for manipulation. The Extended Producer Responsibility (EPR) credit cost is set at these percentages of the Environmental Compensation (EC). For non-compliance with EPR targets, penalties are applied as environmental compensation, with the rate determined by the battery's metal content and the specific violation. A streamlined framework with a narrower and more transparent price range is therefore essential to discourage fraudulent practices and ensure that recycling remains both environmentally sound and economically viable. Investment in collection centres and mandatory public awareness campaigns by producers would further strengthen compliance and create a more reliable supply of used batteries for recycling. If the manufacturers do not set aside a mandatory budget, they may only pay a spot price to the informal recyclers. This will undermine the economic viability of recycling and advanced refining. The EPR floor price is expected to cover the cost of safe dismantling, labour and skills, and technologies for advanced recycling.

This dependence on the informal sector in battery collection and dismantling creates serious risks of chemical exposure, fire, and environmental damage. The safe storage and transportation of high-voltage lithium-ion batteries remain unresolved challenges globally, and India faces similar vulnerabilities. In the absence of clear policy guidelines, recyclers and logistics operators are left uncertain about best practices, increasing the likelihood of fires, leakages, and accidents during transit.

The lack of adherence to EHS standards is a critical concern. More so because many informal recycling facilities operate with unskilled labour, minimal training, and poor safety protocols. This has resulted in documented cases of fires, accidents, and even fatalities. The absence of formal skilling programs compounds the risks, exposing workers to severe hazards. While some recyclers invest heavily in EHS compliance and undergo stringent audits, they are forced to compete with operators running unsafe facilities at a fraction of the cost. This undermines industry credibility and deters long-term investment.

To address this, national guidelines on the storage, transport, and dismantling of lithium-ion batteries must be urgently issued. These should set minimum standards for protective gear, training, and facility design. Compliance costs could be shared between producers and recyclers to reduce the burden on smaller operators. A parallel focus on formal skilling programs would not only raise safety standards but also create a trained workforce to support the expansion of India's recycling capacity. At the same time, workers face hazards from exposure to carcinogenic substances such as cobalt and nickel, often without adequate protective equipment. While awareness of fire-related risks has improved in recent years, the long-term health impacts of chemical exposure remain poorly addressed in regulation and practice.

5. EPR and refurbishing of batteries

The EPR framework currently requires OEMs to demonstrate recycling outcomes, but it does not adequately account for repurposing as a legitimate compliance pathway. Those who repurpose batteries often remain excluded from the formal reporting system, as the EPR portal is designed primarily around recycling targets rather than holistic lifecycle management. To address this, EPR guidelines must explicitly recognize verified repurposing activities as valid compliance outcomes. This should be supported by clear documentation protocols and independent third-party validations to ensure traceability without discouraging second-life use.

Batteries have a longer usable life beyond their first use. Despite variance in degradation among cells, a majority of cells within a battery pack— sometimes 60-70 per cent— still retain usable energy capacity after vehicle end-of-life. Prematurely recycling these cells is both an environmental and economic disservice. Instead, prioritizing reuse and repurposing before recycling can maximize national resource utilization.

The economic advantage of repurposed batteries needs to be integrated with product plans. Refurbished battery packs are often priced 30 per cent lower than new ones, while still offering warranties of up to five years and more than 2000 charge cycles. Their competitiveness lies in cost per cycle, making them particularly suitable for applications where long-duration energy storage is more important than high power output. In India, this includes households, small businesses, and rural microgrids, where affordability and durability are critical.

Practical deployments already demonstrate the potential. In Jharkhand,[8] second-life batteries along solar panels are powering more than 12 off-grid villages. In Bangalore,[9] refurbished packs are used at EV charging hubs in combination with solar energy, reducing dependence on the grid and lowering costs. These use cases highlight the scalability of repurposed batteries across both rural and urban contexts.

Scaling refurbishing, however, has its own set of challenges. Refurbishers require access to relevant data from the Battery Management System (BMS). Without accurate information on State of Health (SoH), State of Charge (SoC), cycle history, and temperature variations, refurbishers are forced to rely on time-consuming and costly physical testing to assess the viability of each cell. Making this data available in standardized, non-proprietary formats would enable quicker diagnostics, reduce testing costs, and significantly scale up the refurbishing process. Such transparency would also improve safety, as potential risks like cell imbalance or early signs of degradation could be identified before batteries are deployed in second-life applications.

Repurposing lacks standardization. There is no unified testing agency or protocol to certify second-life batteries. The repurposing entity must underwrite and validate each battery's risk profile independently. This exercise depends on data from the testing of the cells, and testing protocols can take four to five hours per pack, limiting throughput and raising costs. Data-driven diagnostics and digital tools could reduce this to under an hour. This is essential for scalability. The lack of certification agencies, skilling programmes and decentralized refurbishing hubs further slows progress, leaving the sector largely unstandardized and fragmented. Establishing decentralized service hubs and predictive software tools will be critical to operational efficiency. Data, therefore, is key to safe and efficient refurbishing.

The need for data and traceability is closely linked with the inevitability of cell degradation. The unpredictable aging of lithium-ion cells necessitates robust data monitoring. Cell degradation depends heavily on usage history and environmental conditions. The absence of this kind of data makes predictive modelling challenging. In practice, the weakest cell in a pack limits the pack's usability. Continuous monitoring, such as checking voltage, current, and temperature every few seconds, allows the early identification of degradation and can prevent failures before they occur. Accurate assessments of SoC[10] and SoH[11] are therefore essential before batteries can be repurposed. In practice, refurbishers often disassemble packs to estimate health because BMS data is rarely shared. A digital framework that makes this data accessible in standardized formats would reduce costs, improve safety, and enable greater confidence in second-life batteries.

Traceability is equally important for manufacturing. From 2027,[12] the CPCB will require that new batteries include a minimum share of recycled content. Without robust digital tracking, verifying compliance will be nearly impossible. Current trade classification systems, such as HS codes and GST-based mechanisms, cannot distinguish virgin from recycled materials. Differentiated codes and a digital traceability framework are therefore critical to ensure both transparency and compliance.

Identifying and segregating the healthy cells to design a refurbished battery requires a strategy. Typically, refurbishers rely on advanced inventory tools and algorithms to match cells with similar performance characteristics, ensuring compatibility in repurposed battery packs. The approach is often compared to building a football team—where players with comparable strengths are grouped together to achieve optimal performance. By applying such data-driven strategies, refurbishers can process mixed inventories from multiple OEMs and assemble reliable second-life products, even when the original cells vary in chemistry or usage history.

6. Reverse logistics and collection gaps

Unlike forward logistics, reverse logistics requires the safe collection, dismantling, storage, and transport of end-of-life batteries. India's current networks are fragmented, under-funded, and inefficient, forcing many batteries into the informal sector. For EPR success, a functional reverse logistics system is essential, yet India's collection networks remain fragmented and underfunded. Over 90[13] per cent of small batteries and e-waste are collected through informal channels, which lack the capacity and safety protocols to handle high-voltage EV batteries.

For EPR implementation of EV batteries in India, a multi-layered reverse logistics system is needed, including convenient collection points (e.g., take-back programs, partnerships with local bodies) for consumers, efficient transportation networks that ensure safety, centralized sorting and diagnostics centres for battery assessment, and a network of authorized refurbishers and recyclers for proper disposal. Key components include digital tracking platforms for waste management, capacity building for handlers, safe storage protocols, adherence to environmental and safety standards, and detailed record-keeping for compliance.

Reverse logistics requires authorized collection centres for battery drop-off and collection. This requires collaboration between recyclers, vehicle manufacturers, local bodies, and e-waste recyclers for take-back programs and collection points. Consumers need easy ways to return used batteries to reduce improper disposal. Developing robust logistics for the safe and compliant transportation of batteries, which are hazardous materials, is necessary. Centres need to be set up to inspect, sort, and test batteries to determine if they can be refurbished, repurposed, or sent for recycling and processing.

The focus has to be on authorized recyclers/refurbishers with certified entities that follow strict environmental and safety protocols for processing the batteries. The system has to ensure the proper retrieval of valuable materials from the batteries through these authorized facilities.

Infrastructure and technology: Digital platforms are needed for tracking battery waste management activities, from collection to final disposition. Record-Keeping is essential for precise records of all activities for audits and to prove compliance with EPR regulations. This requires the training of waste management staff and awareness campaigns to educate consumers and stakeholders on responsible battery disposal. Compliance and governance involve the centralized registration of producers with the CPCB to obtain an EPR authorization. This requires state-level involvement to also register recyclers and ensure compliance within their states.

A national registry needs to be created to track SoH, recycled content, and EPR compliance across the value chain. Parallel investments in skilling programmes will be necessary to professionalize refurbishing, uphold environmental and safety standards, and create employment. Finally, collaboration among OEMs, recyclers, refurbishers, and policymakers should be institutionalized through structured platforms, supported by R&D on predictive diagnostics and tropical battery design.

Batteries designed for disassembly and repurposing from the outset will reduce lifecycle costs and promote renewable energy adoption. Integrating repurposed batteries into residential solar systems can democratize energy access and enable peer-to-peer trading models, turning households into micro energy producers. Policy support for storage-linked solar incentives can further accelerate this transition

However, repurposing comes with technical and design considerations. Repurposed battery packs are typically 20-30 per cent larger than their new counterparts due to the need for reengineering and additional monitoring systems. While this may present challenges in space-constrained environments like apartments, installations in landed homes or rooftops are generally feasible. With careful pack design and robust monitoring, repurposed batteries can match new batteries in safety, provided thermal and usage parameters are managed proactively.

Municipalities are largely absent from the collection ecosystem, leaving household batteries such as AAA virtually uncollected. Setting up ward-level collection centres, supported by either private operators or public–private partnerships, could provide a more reliable collection network. These centres could provide structured drop-off points for consumers, reduce dependence on informal channels, and improve recovery rates. At the same time, dedicated and safe dismantling hubs integrated with informal networks but equipped with protective gear, standards, and training, will be necessary to formalize the sector while preserving its efficiency. This will not only allow informal collectors to transition into safer, formalized roles; it could become a viable model that recognizes the real cost of collection, supports awareness campaigns, and provides mechanisms for job creation in waste management.

7. Need battery passport to support recycling industry

The battery passport offers a structural solution to the lifecycle management and recycling of batteries. A battery passport is a digital record tied to each battery, containing comprehensive information on its origin, chemistry, usage history, recycling potential, and sustainability credentials. This enables the traceability of the State of Charge (SoC), which indicates the remaining available charge in a battery. Accurate SoC estimation helps prevent overcharge or deep discharge, both of which can accelerate degradation. This also tracks State of Health (SoH), which reflects the long-term aging and capacity loss of a battery compared to its original rated performance. SoH is critical in determining whether a battery can be safely reused, refurbished, or must be recycled.

SoC and SoH cannot be measured directly; they are inferred from parameters like voltage, current, temperature, impedance, and charge/discharge rates. Including SoC and SoH data in a digital battery passport would allow refurbishers, recyclers, and regulators to assess the residual value and safety of end-of-life batteries without destructive testing. This is essential for enabling reliable second-life applications and ensuring compliance with circular economy mandates.

The European Union[14] has already mandated battery passports by 2027, and the Global Battery Alliance[15] has piloted interoperable prototypes to support global adoption. The Indian government has also announced plans to develop a digital Battery Passport for EVs. This initiative aligns with the BWMR 2022. The battery passport requires a digital identity. Each battery will have a unique ID and QR code containing detailed information, similar to an Aadhaar identity. Lifecycle data and information will include origin, performance, durability statistics, chemical composition, intended use, and end-of-life information. The passport helps prevent unsafe practices, such as using battery cells of different vintages, which can lead to performance imbalances and fire risks. By elevating product safety and quality, the system aims to strengthen India's electric vehicle export capabilities. The passport provides the full traceability needed for promoting battery reuse, repurposing, and recycling.

A key challenge is the lack of clear mechanisms for OEMs to collaborate with repurposers. Many OEMs remain reluctant to engage, concerned that performance failures in repurposed batteries could damage their brand reputation, even though these products are no longer under their direct responsibility. To overcome this, a structured framework is required that enables repurposers to operate independently while still sharing essential performance data with OEMs. Establishing a standardized data-sharing protocol between OEMs and repurposers can help. This can be integrated into the proposed battery passport framework, ensuring secure access to essential BMS and performance data, enabling independent operations for repurposers while allowing OEMs to track outcomes, reduce reputational risk, and feed lessons back into product innovation and lifecycle management. Going forward, battery traceability systems must evolve beyond being a compliance tool to become enablers of safe and value-driven second-life applications. For this, data collected through BMS and asset registries should be made accessible not only to OEMs and regulators but also to repurposers, in anonymized and standardized formats.

Battery passport mechanisms must incorporate second-life data, enabling downstream users to view the full lifecycle of a battery. Without such transparency, the repurposing market will remain fragmented, and many batteries will prematurely move to recycling due to lack of accessible information.

A key challenge is ensuring seamless data sharing and interoperability among different actors in the battery supply chain. Verifying the accuracy and reliability of collected passport data will be crucial for user and market confidence. The success of this initiative relies on strong collaboration between the government, ministries, and industry stakeholders to develop the necessary regulatory framework and infrastructure. The Battery Passport is a critical enabler for India’s upcoming battery swapping policy, providing owners with essential battery details through a simple scan of the QR code.

India is uniquely positioned to embed a battery passport into its ecosystem from the outset as it scales up domestic manufacturing under the Production Linked Incentive (PLI) scheme for Advanced Chemistry Cells. A localized version of the passport could help build a national database on battery performance under tropical conditions, enable accurate predictions of residual life, support compliance with recycling-content mandates, and enhance global competitiveness through transparent supply chains.

Developing such a system will require meticulous planning and coordination. It would be necessary to define minimum datasets—capturing key parameters such as SoH, usage cycles, and battery chemistry—while establishing access protocols that protect OEM confidentiality yet meet the operational needs of refurbishers and recyclers. Seamless integration with existing digital systems like the GST network and the EPR portal will also be vital. India's proven capability in creating large-scale digital public infrastructure, exemplified by Aadhaar and United Payments Interface (UPI), offers a solid foundation for deploying a national battery passport system.

To fully realize the benefits of refurbishing and strengthen traceability across the battery value chain, a few priority actions are essential. National standards for refurbishing, repurposing, and testing must be urgently formulated, supported by certification mechanisms under BIS or NABL frameworks. Battery passports should be made mandatory for both new and second-life batteries, embedded within the Battery Waste Management Rules (BWMR) 2022. Moreover, refurbishers should be granted access to anonymized BMS data to ensure operational safety while maintaining OEM data confidentiality.

8. Financial incentives for circularity

At the same time, circularity should be incentivized through mechanisms such as green credits, storage-linked subsidies, and public procurement mandates for refurbished batteries. The repurposing sector cannot scale if it continues to operate with thin margins and limited access to capital. Current financial structures favour recycling, which is underpinned by immediate scrap value. To make repurposing viable, dedicated mechanisms such as green credits, viability gap funding, or storage-linked incentives under clean energy policies should be introduced. In addition, public procurement mandates that prioritize repurposed batteries for decentralized energy storage can help create assured demand, build investor confidence, and signal institutional trust in second-life solutions.

Since OEMs do not contribute to collection costs, recyclers must bear these expenses. The policy must introduce viability gap funding or shared producer responsibility for low-value chemistries. Price variations for battery recycling stem from variations in the types and ratios of critical materials, such as cobalt, nickel, and lithium, across different chemistries, which affect recovery costs and the market value of salvaged materials. LFP batteries, for example, offer long life but yield lower priced recoverable metals compared to cathode chemistries like NMC.

Support for R&D in advanced recovery processes, coupled with targeted subsidies combined with a framework for a rationalized EPR price, could enable the recycling viability of LFP batteries. By making producers accountable for these costs, the framework would align economic incentives with environmental responsibility. At current price points, especially for LFP, sustainable collection is nearly impossible without systemic interventions. If this issue remains unresolved, India could face a future crisis of unprocessed LFP waste, undermining the very goals of EPR.

GLOBAL EV BATTERY RECYCLING POLICIES AND END PRODUCER RESPONSIBILITY

United States of America

The United States has built its EV battery recycling framework on the Resource Conservation and Recovery Act (RCRA), which classifies most end-of-life lithium-ion batteries as hazardous waste due to their ignitability and reactivity. To ease collection and transportation, the Universal Waste Rule provides a streamlined pathway, though full RCRA requirements apply once batteries reach permitted facilities. In May 2023, the U.S. Environmental Protection Agency (EPA) clarified requirements through a comprehensive guidance memo,[16] specifying storage, safety, and permitting obligations, particularly around "black mass."

Several strategic initiatives are underway. EPA has amended its waste management rules to include a new universal waste category[17] for lithium batteries to strengthen safety and promote recycling. The EPA is also leading the development of a national Extended Producer Responsibility (EPR) framework under the Infrastructure Investment and Jobs Act.[18] This framework will cover all chemistries and formats, defining producer obligations, collection models, reporting requirements, and cost structures. Complementing this effort are federally mandated best practices for collection and voluntary labeling guidelines, due by 2026, which aim to improve collection rates, enhance consumer awareness, and reduce safety risks. In parallel, the EPA has introduced a streamlined chemical review process to support innovation in new battery technologies.

California has taken a leadership role, pioneering comprehensive state-level regulations. The Responsible Battery Recycling Act of 2022[19] mandates producer-funded stewardship programs for all covered batteries, operational by 2027, while Senate Bill 615[20] requires a core exchange program for EV traction batteries by 2025. Implementation is led by CalRecycle, which is empowered to set consumer fees and enforce compliance. California's integration of zero-emission vehicle (ZEV) mandates with robust end-of-life management requirements creates a holistic model that other states and the federal government could adopt.

Despite this progress, significant gaps remain in US policy. Unlike the EU and China, the U.S. framework lacks mandatory recycling targets, clear performance standards, and strong enforcement mechanisms. Stakeholders including environmental groups, researchers, and industry coalitions have called for stricter material recovery mandates, federal producer responsibility laws, and stronger emissions controls for recycling facilities. Without these, the US risks falling behind global leaders in resource security and circular economy development.

Strengthening the US approach will require setting binding recovery targets, ensuring producers bear responsibility for end-of-life management, and creating sustainable financing mechanisms. California's model shows how regulatory innovation can align EV adoption goals with recycling requirements. If adopted nationally, such measures could transform the US into a leader in sustainable battery management, securing critical mineral supply chains while protecting communities and the environment.

China

China has emerged as the global leader in electric vehicle (EV) battery recycling, accounting for nearly 70 per cent of global recycling capacity. This dominance stems from its massive EV market, strategic focus on resource security, and proactive policy interventions to manage the surge in end-of-life batteries expected over the next decade. By 2028, over four million tonnes[21] of used EV batteries are projected to be scrapped annually, underscoring both the scale of the challenge and the economic opportunity.

China's policy framework combines Extended Producer Responsibility (EPR), a government "whitelist" of approved recyclers, traceability requirements, and material recovery targets. Under EPR, EV manufacturers must establish collection networks and partner with certified recyclers. Only whitelisted companies that meet strict recovery, safety, and environmental standards qualify for subsidies. Alongside, a national traceability platform ensures monitoring of batteries from production to recycling. Recovery targets are ambitious: at least 90[22] per cent for lithium and 98[23] per cent for nickel, cobalt, manganese, copper, aluminum, and rare earths. Regulations also mandate that recycling enterprises reinvest a share of revenues in R&D and prioritize cascade utilization, ensuring second-life applications in energy storage.

A series of regulations over the past decade have steadily tightened requirements. Interim measures in 2018 established EPR principles, while the 2024 "Specifications for the Comprehensive Utilisation of Waste EV Batteries"[24] introduced stricter recovery benchmarks and R&D obligations. The GB38031-2025[25] safety standard further integrates operational safety with end-of-life recycling, requiring batteries to withstand severe thermal and mechanical stress without fire or explosion. These evolving measures reflect an iterative approach—moving from broad guidelines to detailed, enforceable standards.

On the ground, hydrometallurgical processes dominate China's recycling sector, given their high recovery rates, while direct recycling methods are emerging as a lower-emission alternative. Despite rapid capacity expansion—expected to reach 11 million tons annually by 2030[26] —implementation challenges persist. Informal workshops continue to dominate collection, processing most end-of-life batteries outside regulatory oversight. This leakage stems from higher prices and convenience offered by informal operators, exposing gaps in enforcement, financing, and consumer awareness.

China's approach demonstrates both strengths and vulnerabilities. Its large-scale investments, stringent recovery targets, and traceability systems set global benchmarks. At the same time, weak enforcement, limited consumer incentives, and the persistence of an informal sector constrain effectiveness. The lack of standardized methodologies for battery health assessment, recycling reporting, and carbon accounting further hampers system optimization. To ensure long-term sustainability, experts highlight the need for dedicated financing mechanisms, standardized assessment tools, and stronger enforcement against illegal operators.

Overall, China's experience shows how early policy intervention, integration of recycling into the EV ecosystem, and ambitious recovery standards can build scale rapidly. Yet, without closing implementation gaps and incentivizing consumer participation, much of the recycling flow risks leaking into informal channels.

The Chinese model offers important lessons for India: combining regulatory mandates with industrial policy, while simultaneously addressing the realities of market incentives and enforcement.

European Union

The European Union has established a comprehensive and forward-looking framework for EV battery recycling under the new Batteries Regulation (2023/1542),[27] which will fully replace the 2006 Batteries Directive by 2025. The regulation adopts a full life-cycle approach, covering sourcing, manufacturing, use, and end-of-life management, and aligns with the EU's broader circular economy and clean energy objectives. Its primary goals are to minimize environmental and social impacts, reduce dependence on imported raw materials, and enhance strategic autonomy by securing domestic supply of critical battery materials such as lithium, cobalt, and nickel. The European Battery Alliance,[28] launched in 2017, supports the development of a sustainable, competitive, and innovative battery value chain across

Europe. Implementation of the new regulation is phased, starting February 2024, giving stakeholders time to adapt to new obligations.

Key provisions of the regulation include mandatory collection of all EV, industrial, and SLI batteries, prohibitions on landfilling or energy recovery, and treatment in facilities adhering to minimum standards and best available techniques. Recycling efficiency and material recovery targets are stringent: lithium recovery from waste batteries of 50[29] per cent by the end of 2027 and 80 per cent by the end of 2031; Copper, Cobalt, Lead, Nickel 90 per cent by the end of 2027 and 95 per cent by the end of 2031. Minimum recycled content requirements are also mandated for new batteries, rising incrementally through 2036.

The regulation introduces the Battery Passport Initiative,[30] requiring all EV batteries sold in the EU from 2027 to have a digital passport detailing material composition and recycling pathways. Labeling with QR codes ensures access to lifecycle information and hazardous substance data. Extended Producer Responsibility (EPR) is reinforced, making producers responsible for collection, treatment, and recycling costs, while due diligence obligations address environmental and social risks in raw material sourcing. Carbon footprint declarations will become mandatory from February 2025, with potential future thresholds.

Challenges to implementation include scaling recycling infrastructure to meet growing volumes, technological barriers to high-efficiency material recovery, and increasing complexity in battery chemistries and designs. Achieving ambitious recycling and recycled-content targets may be constrained by the long lifespan of EV batteries, and logistical challenges exist in operationalizing the battery passport and facilitating second-life applications. To address the issue of unavailability of black mass for recycling and to ensure material security, the European Commission is now officially classifying black mass, which is shredded battery waste essential for electric vehicle recycling, as hazardous waste. This decision introduces New Hazardous Waste Codes[31] for these intermediate battery fractions.

The reclassification is based on up-to-date information regarding the composition of black mass, aligning with the Classification, Labelling and Packaging (CLP) Regulation[32] that implements the Globally Harmonised System (GHS) in the EU. According to the Commission, this move will enable better control over black mass shipments, especially by banning its export to non-OECD countries, in compliance with the Basel Convention and the Waste Shipments Regulation. Ultimately, this supports the Battery Regulation's objective to foster a circular economy, increase security of supply for raw materials and energy.[33]

Furthermore, consistent enforcement across all 27 member states, competition from global recyclers, and potential regulatory barriers for non-EU companies are additional concerns.

Collectively, the EU's regulatory framework represents a robust model for battery lifecycle management, integrating collection, recycling, reuse, producer responsibility, and innovation incentives, while highlighting the need for ongoing monitoring and policy support to achieve a sustainable and circular EV battery economy.

Norway

Norway has established a proactive and comprehensive framework for EV battery recycling, grounded in the Pollution Control Act (1981)[34] and the Waste Regulation (Regulation No. 930)[35]. These laws aim to prevent pollution, ensure environmentally sound waste management, and regulate hazardous materials, including end-of-life lithium-ion batteries. Batteries are classified as hazardous for transport, requiring specialized packaging, certified transport vehicles, and clear labeling, reflecting their risk of thermal runaway. Norway's legislation closely aligns with EU directives while incorporating national adaptations to manage the growing EV battery market.

With one of the world's highest EV penetration rates, Norway faces an early influx of retired batteries. To address this, it has developed a Battery Strategy emphasizing sustainability, industrialization, and attracting private investment. Key actors include Batteriretur,[36] with a nationwide battery collection network, Hydrovolt,[37] Europe's largest dedicated EV battery recycling plant, and FREYR,[38] integrating recycling into its gigafactory operations. Norway's policy emphasizes the creation of a circular battery economy, spanning raw material sourcing, production, use, collection, and recycling.

Challenges include ensuring recycling infrastructure keeps pace with increasing battery volumes, addressing technological complexity due to diverse chemistries and evolving battery designs, and managing the absence of historical usage data for early EV batteries, which complicates reuse or second-life applications. Standardization of battery pack designs, clearer regulations for second-life use, and improved material recovery rates are additional priorities. Norway's abundant renewable energy provides a competitive advantage for energy-intensive recycling, supporting long-term sustainability.

While Norway's approach has the advantages of early market leadership, robust regulatory alignment with the EU, industrial partnerships, and a commitment to circularity, the EV battery recycling journey has not been as smooth as expected. Electric vehicle (EV) batteries are demonstrating longer lifespans than initially anticipated, resulting in a slower-than-expected supply of end-of-life batteries for recycling. Hydrovolt, a Norwegian recycling firm and subsidiary of Norsk Hydro ASA, inaugurated a semi-automated facility in 2022 designed to discharge and dismantle up to 12,000 metric tons of batteries annually—equivalent to approximately 25,000 EVs. However, the company expects to process only about one-third[39] of this planned capacity in the current year.

Despite these delays, Norway is positioning itself as a pioneer in managing the full lifecycle of EV batteries while preparing for the rapid growth of end-of-life battery volumes in the coming years.

Japan

Japan's battery recycling strategy is guided by existing waste management regulations and a strong culture of environmental responsibility. The country emphasizes the creation of a circular economy for batteries through collaboration between manufacturers, recyclers, and research institutions. Government investment supports the development of cost-competitive and technologically advanced lithium-ion battery recycling methods, targeting 70 per cent lithium recovery and 95 per cent recovery of nickel and cobalt.

Japan relies primarily on voluntary collection and recycling schemes, with Producer Responsibility Organizations (PROs) like the Japan Battery Recycling Center (JBRC) playing a central role in collecting non-industrial batteries. The government encourages innovation and environmental compliance through investments and plans to mandate carbon emission disclosures for battery production, tying environmental performance to eligibility for subsidies.

Key challenges include high recycling costs, limited domestic feedstock due to EV exports, and growing demand for batteries outpacing recyclable volumes. To address these, Japan actively engages in international collaboration, including data-sharing initiatives with the EU to optimize recycling and reduce reliance on rare metal imports. The approach reflects a combination of voluntary producer responsibility, government-led technology investment, and global cooperation.

THE BATTERY RECYCLING CHALLENGES IN THE GLOBAL SOUTH

Africa's EV battery recycling sector is in an early developmental stage, with most countries lacking comprehensive regulatory frameworks. Nevertheless, there is increasing recognition of the economic and environmental potential of recycling, including the recovery of lithium, cobalt, and nickel to support new battery production and a circular economy.

Several countries have initiated pilot programmes[41] for battery collection and recycling. Public-private partnerships and international collaborations are critical for resource mobilization, knowledge transfer, and infrastructure development. Countries like Kenya, South Africa, and Nigeria are taking early steps, with Nigeria enacting legislation on battery lifecycle management.

Africa faces substantial hurdles, including insufficient infrastructure, limited public awareness, high recycling costs, and weak regulatory oversight, which can lead to improper disposal. A major concern is waste colonialism, where high-income countries might export spent EV batteries to Africa, creating environmental and ethical risks. Despite these challenges, the region has an opportunity to develop job-creating, locally adapted recycling solutions while building regulatory capacity and promoting sustainable industrial growth.

9. The way forward

This review brings out that without a realistic floor price, stringent certification protocols, clear black mass regulations, robust collection networks, and stronger safety standards, the framework risks being undermined by malpractices and lost economic opportunities. By raising the EPR floor price, banning black mass exports, formalizing the informal sector, engaging municipalities, and establishing national safety standards, India can move toward a recycling system that is environmentally sound, economically viable, and strategically secure.

These reforms are not just technical necessities—they are essential for safeguarding India's clean energy transition and resource independence.

- **Rationalize and enforce EPR floor price:** Set a realistic minimum price for EPR credits that reflects true recycling costs. Tighten penalty structures to deter free-riding and fraudulent certification.

- **Close the black mass loophole:** Classify black mass as hazardous waste unless processed on-site. Enforce CPCB SOPs across states and impose an explicit ban on black mass exports.

- **Strengthen Reverse Logistics and Formalize Informal Sector:** Develop ward-level collection centres and dismantling hubs in partnership with municipalities. Integrate informal collectors into licensed supply chains with training, incentives, and safety protocols.

- **Ensure viability of low-value chemistries:** Introduce producer co-financing or viability gap funding for the recycling of LFP and similar chemistries. Support R&D in advanced recycling technologies tailored to India's battery mix.

- **Enhance safety, skilling, and accountability:** Issue national guidelines for the safe storage, transport, and dismantling of batteries. Launch formal skilling programs and enforce EHS standards across the recycling chain. Mandate third-party audits to ensure producer liability and material traceability.

- **Mandate a battery passport framework:** Develop a digital record system for all batteries, capturing chemistry, SoH/SoC, usage history, and recycled content. Integrate with GST and EPR portals, leveraging India's digital infrastructure capabilities.

- **Recognize refurbishing in EPR compliance:** Explicitly include verified second-life applications as eligible outcomes under BWMR 2022. Establish third-party validation protocols for documenting reuse and repurposing.

- **Establish national standards and certification:** Create BIS/NABL-backed testing and certification protocols for refurbished batteries. Standardize safety, performance, and quality benchmarks to build market trust.

- **Enable secure data sharing:** Require OEMs to share anonymized BMS data in standardized formats. Develop protocols for collaboration between OEMs, refurbishers, and recyclers while protecting confidentiality.

- **Provide financial incentives for circularity:** Introduce green credits, viability gap funding, and storage-linked subsidies for refurbishing. Mandate public procurement of refurbished batteries for decentralized energy storage projects.

- **Fiscal incentives for recycling needs to be performance-linked** and the key performance indicators have to ensure the quantification of black mass generated annually with an effective tracking mechanism, inventory of the amount of refined material recovery in the country, stoppage of clandestine export of the black mass, uptake of refined material by the EV producers, among others.

- **Stop diversion of feedstock:** National and state governments should mandate or incentivize formal partnerships between recyclers, OEMs, dismantlers, and waste collectors to ensure end-of-life batteries enter safe recycling channels rather than informal or overseas markets that weaken the domestic supply chains.

- **Support upstream solutions:** Policies should promote reuse and repurposing as formal bridge strategies, not just environmental add-ons. Encouraging second-life applications can extend value chains, generate near-term revenue, and help secure future recycling inputs.

- **Provide support to R&D to improve recovery rates:** The government should promote cost-efficient recycling by offering support for R&D in advanced recycling technologies (hydro-metallurgical methods, direct recycling) focusing on improving recovery rates, reducing costs, and minimizing environmental impacts, helping recyclers withstand market volatility.

- **Need vertical integration and scale:** It would be prudent to consider targeted industrial policy: building vertically integrated value chains, supporting domestic cathode and anode manufacturing, and aligning recycling with EV and energy storage growth strategies.

- **Need third-party audits for compliance and liability:** Policy must address this by mandating third-party audits, physical verification of recycling facilities, and linking credits to actual material recovery rather than paper-based claims. Liability should also be clarified to ensure that brand owners or importers of record remain accountable, preventing large OEMs from shifting responsibility onto smaller intermediaries.

References

1 Battery waste management rules 2022, MoEFCC, https://cpcb.nic.in/uploads/hwmd/Battery-WasteManagementRules-2025.pdf

2 Discussion with stakeholders

3 Central Pollution Control Board, 2024, Guidelines for imposition of the environmental compensation charge under the Battery Waste Management Rules, 2022, https://eprbattery.cpcb.gov.in/upload/adminDoc/Notice_EC%20Guidelines.pdf

4 Anand, Saurav; October 3, 2024. Battery waste rules under scrutiny: Calls for higher EPR floor price grow louder; accessed at https://energy.economictimes.indiatimes.com/news/power/battery-waste-rules-under-scrutiny-calls-for-higher-epr-floor-price-grow-louder/113890412

5 MOEFCC, December 20, 2024. Decision of Ministry of Environment, Forest and Climate Change with respect to discussion on issues pertaining to clarifications sought on Hazardous and Other Wastes (Management & Transboundary Movement) Rules, 2016, as approved by the Competent Authority on the basis of recommendation of the 90th Meeting of the Technical Review Committee (TRC) held on 20 th December, 2024; accessed at https://moef.gov.in/uploads/pdf-uploads/pdf_67bc078f1776e7.68070678.pdf

6 Ibid.

7 CPCB; September 10, 2024. Guidelines for imposition of Environment Compensation (EC) under Battery Waste Management Rules, 2022; accessed at https://eprbattery.cpcb.gov.in/upload/adminDoc/Notice_EC%20Guidelines.pdf

8 Kislaya, Kelly; November 20, 2018. From Bulbs to Grinders: How the Power of the Sun Transformed 12 Jharkhand Villages; accessed at https://thebetterindia.com/164393/jharkhand-solar-power-transformation-news/

9 Parikh, Sagar; June 10, 2025. Bengaluru opens solar-powered EV charging station; accessed at https://www.electrive.com/2025/06/10/india-bengaluru-opens-solar-powered-ev-charging-station/

10 Roy Chowdhury, Mohanty, Garg; January 31, 2025. Policy Brief: Making Safe and Durable Electric Vehicles; accessed at https://www.cseindia.org/policy-brief-making-safe-and-durable-electric-vehicles-12597#:~:text=The%20BMS%20plays%20a%20critical,%2C%20weather%2C%20geography%20and%20durability.

11 Ibid.

12 CPCB; August 2022. Battery Waste Management Rules; accessed at https://cpcb.nic.in/uploads/hwmd/BR_SOP.pdf

13 Goldar, Amrita, Nair, Kartik et al., June 2024. Unravelling India's E-Waste Supply Chain: A Comprehensive Analysis and Mapping of the Key Actors Involved; accessed at https://icrier.org/pdf/UnravellingIndia-E-Waste.pdf

14 DIN; January 15, 2025. Path Cleared for the Battery Passport; accessed at https://www.din.de/en/din-and-our-partners/press/press-releases/path-cleared-for-the-battery-passport-1197480#:~:text=Whether%20in%20electric%20vehicles%2C%20e,Battery%20carbon%20footprint

15 GBA; 2024 Battery Passport Pilots. accessed at https://www.globalbattery.org/battery-passport-mvp-pilots/

16 Sidley; August 16, 2023. U.S. EPA Memo Offers Direction on Lithium Battery Recycling—Essential to the Future Supply Chain for Battery Electric Vehicles; accessed at https://environmentalenergybrief.sidley.com/2023/08/16/u-s-epa-memo-offers-direction-on-lithium-battery-recycling-essential-to-the-future-supply-chain-for-electric-vehicle-batteries/

17 EPA; September 18, 2025. Code of Federal Regulations; accessed at https://www.ecfr.gov/current/title-40/chapter-I/subchapter-I/part-273?toc=1

18 USEPA, July 2025. Extended Battery Producer Responsibility (EPR) Framework; accessed at https://www.epa.gov/electronics-batteries-management/extended-battery-producer-responsibility-framework-battery

19 AB-2440 Responsible Battery Recycling Act of 2022;accessed at https://leginfo.legislature.ca.gov/faces/billHistoryClient.xhtml?bill_id=202120220AB2440

20 Gaia; October 2, 2024. GAIA and Environmental Justice Organizations Applaud Governor's Decision to Veto SB 615; accessed at https://www.no-burn.org/governor-newsom-vetoes-sb-615-supporting-stronger-ev-battery-recycling-standards/

21 Zuo Mandy, May 6,2025. China's dying EV batteries, solar cells are powering a circular economy in new-energy era; accessed at https://www.scmp.com/economy/global-economy/article/3309074/chinas-dying-ev-batteries-solar-cells-are-powering-circular-economy-new-energy-era

22 Rho Motion, August 20, 2024. China releases proposed standards for battery recycling; accessed at https://rhomotion.com/news/china-releases-proposed-standards-for-battery-recycling-industry-update/#:~:text=Recovery%20rates%20The%20new%20proposal%20outlines%20stricter,cobalt%2C%20and%20manganese%20remain%20unchanged%20at%2098%25

23 Ibid.

24 IEA, October 23, 2024. Specifications for the Comprehensive Utilisation of Waste EV Batteries 2024; accessed at https://www.iea.org/policies/24987-specifications-for-the-comprehensive-utilisation-of-waste-ev-batteries-2024

25 National Standard for the People's Republic of China, GB 38031-2025; March 28, 2025. https://www.chinesestandard.net/PDF.aspx/GB38031-2025

26 OFweek, June 23, 2025. China's Battery Recycling Industry: Poised for Exponential Growth Amid Regulatory Push; accessed at https://en.ofweek.com/ofweek-news/detail/chinas-battery-recycling-industry-poised-for-exponential-growth-amid-regulatory-push.html#:~:text=According%20to%20reporting%20by%20People's,will%20reach%204.246%20million%20tons

27 EUR-LeX, European Union; July 12, 2023. REGULATION (EU) 2023/1542 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL; accessed at https://eur-lex.europa.eu/eli/reg/2023/1542/oj/eng

28 Department of Economic and Social Affairs, United Nations; Creating an EU Framework for the development of a sustainable battery value chain in support of cleaner mobility and more efficient energy storage; accessed at https://sdgs.un.org/partnerships/creating-eu-framework-development-sustainable-battery-value-chain-support-cleaner#:~:text=In%20October%202017%2C%20Vice%20President,and%20kick%2Dstart%20these%20projects

29 IEA; October 22, 2024. EU Sustainable Batteries Regulation; accessed at https://www.iea.org/policies/16763-eu-sustainable-batteries-regulation

30 Rizos, Vasileios; Urban, Patricia; March 5, 2024. Implementing the EU Digital battery Passport; accessed at https://circulareconomy.europa.eu/platform/sites/default/files/2024-03/1qp5rxiZ-CEPS-InDepthAnalysis-2024-05_Implementing-the-EU-digital-battery-passport.pdf

31 European Commission 2025; Amending Decision 2000/532/EC As Regards An Update Of The List Of Waste In Relation To Battery Related Waste, accessed at https://environment.ec.europa.eu/document/download/48cdc11b-facb-429a-80ad-4b37bce77ced_en?filename=Newsitem_LoW_Batteries_validated%20DG.docx; viewed on September 09, 2025

32 The European Parliament and the Council of the European Union; December 16, 2008. Classification, packaging and labelling of chemical substances and mixtures; accessed at https://eur-lex.europa.eu/legal-content/ENG/LSU/?uri=CELEX%3A32008R1272#:~:text=WHAT%20IS%20THE%20AIM%20OF,the%20transport%20of%20dangerous%20goods

33 European Commission, Directorate-General for Environment 2025, New battery-related waste codes will boost circular management of batteries and their critical raw materials, Press Release on 5 March 2025, https://environment.ec.europa.eu/news/battery-related-waste-codes-update-set-boost-circular-economy-2025-03-05_en#:~:text=Today's%20Decision%20clarifies%20that%20black,to%20scientific%20and%20technical%20progress., viewed on September 09, 2025

34 Government of Norway; March 13, 1981. Pollution Control Act; accessed at https://www.regjeringen.no/en/dokumenter/pollution-control-act/id171893/

35 Regulation on recycling and treatment of waste (waste regulations); accessed at https://bwcimplementation.org/sites/default/files/resource/NO_Regulation%20No.%20930%20of%202004_EN.pdf

36 Nordic Council of Ministers 2024; Production & Recycling of EV Batteries; accessed at https://pub.norden.org/temanord2024-502/6-0-collection-and-transport.html

37 Murray, Cameron; March 17, 2022. Northvolt's battery recycling plant Hydrovolt commences operations in Norway; https://www.energy-storage.news/northvolts-battery-recycling-plant-hydrovolt-commences-operations-in-norway/#:~:text=The%20facility%20has%20the%20capacity,energy%20storage%20systems%20(ESS)

38 Business Norway; July 18, 2022; Its world record in electric cars is creating a battery recycling revolution in Norway; accessed at https://businessnorway.com/articles/closing-the-recycling-gap-norways-circular-battery-economy

39 Lundgren, Kari; March 19, 2025. Longer-Lasting EV Batteries Slow Ramp Up at Recycler Hydrovolt; accessed at https://www.bloomberg.com/news/articles/2025-03-19/longer-lasting-ev-batteries-slow-ramp-up-at-recycler-hydrovolt

40 Argus Media; December 14, 2022. Viewpoint: Battery recycling key to net zero in Japan; accessed at https://www.argusmedia.com/en/news-and-insights/latest-market-news/2400483-viewpoint-battery-recycling-key-to-net-zero-in-japan

41 Rho Motion; September 24, 2024. Africa's battery recycling landscape, an emerging market; accessed at https://rhomotion.com/news/africas-battery-recycling-landscape-an-emerging-market-industry-update/#:~:text=Meanwhile%2C%20South%20Africa's%20Cwenga%20Lib,help%20you%2C%20get%20in%20touch.

As India's electric mobility sector grows, the Battery Waste Management Rules (2022) face a critical hurdle: undervalued EPR certificates. Currently, certificate prices are too low to cover the actual costs of environmentally sound recycling. This creates a risk of "paper compliance", where credits are traded without genuine material recovery.

Furthermore, the domestic circular economy is being undermined by the export of black mass, which drains valuable feedstock from the country. Without a regulated floor price for EPR certificates and stricter oversight, recyclers cannot afford the advanced technology needed for high-yield recovery, threatening both India's resource security and its environmental goals.

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phone: 91-11-40616000 Fax: 91-11-29955879
E-mail: cse@cseindia.org Website: www.cseindia.org