



Perspective



Advancing Circular Economy for Managing Electric Vehicles Battery Waste in Developing Countries by Harnessing Private Sector Initiatives and SMEs Education

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Abstract: The rapid growth of electric vehicles (EVs) adoption in the Asia-Pacific presents new and critical sustainability challenges, particularly the management of end-of-life battery waste amid insufficient infrastructure and regulatory frameworks. With annual end-of-life battery volumes projected to surge across developing countries, prevalent informal recycling practices risk significant environmental and health hazards. The circular economy approaches, including reuse, remanufacturing, and recycling, offer viable solutions for mitigation but still require improved policies, cross-sectoral collaboration, financial support, and targeted education for Small-and-Medium-Enterprises (SMEs). This paper shows targeted and strategic interventions are necessary to advance responsible EVs battery safe disposal, build resilient infrastructure, and foster sustainable urban mobility and long-term economic sustainability across the developing countries.

Keywords: electric vehicle (EV) battery; circular economy; end-of-life (EoL); emerging economies; Small-and-Medium-Enterprises (SMEs); education

1. Introduction

The rapid adoption of electric vehicles (EV) is reshaping urban mobility transformation and is a critical component of climate change mitigation strategies. In developing countries, particularly across the Asia-Pacific region and other parts of the world, the significant growth has been striking. Between 2020 and 2023, countries such as China, India, Brazil, and South Africa recorded annual EV sales growth rates exceeding 30 percent, with projections suggesting that EV could represent 15–20% of new vehicle sales in these regions by 2030 [1]. This rapid EV uptake, while beneficial for emissions reduction, introduces a substantial new challenge such as the effective management of end-of-life (EoL) EV batteries.

The main challenge is the lack of efficient collection, recycling, and repurposing systems. Unlike the developed countries, which often benefits from established infrastructure and regulatory frameworks for facilitating battery collection and recycling, while many developing Asia-Pacific countries with fragmented waste management systems, limited regulatory oversight, and insufficient formal recycling facilities [2,3]. Recent studies highlight the magnitude of this problem. In India alone, it is estimated that over 128,000 tonnes of lithium-ion battery waste will be generated annually by 2030 [4,5] while Brazil and South Africa may see volumes reaching 35,000 tonnes per year and surpass 10,000 tonnes per year, respectively [4].

Current, low and weak formal collection rates less than 10% in parts of Southeast Asia, drive EV battery waste into informal markets where safety and environmental standards are largely disregarded [6]. In other developing countries, informal recycling in Nigeria exposes thousands of workers to hazardous substances [7] and



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dismantlers in Mongolia often replace faulty cells under dangerous conditions without proper procedures. Furthermore, nearly 45% of 146 surveyed countries, primarily in the Asia-Pacific region, maintain weak regulations for second-hand vehicle imports, often resulting in uncontrolled battery disposal and subsequent air and land pollution [7]. The environmental and human health consequences of improper battery disposal are severe. Hazardous materials such as lithium, cobalt, and nickel can leach into soil and water, causing long-term contamination [8,9].

The primary objective of this research paper is to propose and articulate a multi-stakeholder policy framework, the Circular Economy Roadmap for EV Battery Waste, specifically tailored for the socio-economic contexts of developing countries. Unlike existing models from the developed countries, this study seeks to examine how integrating private sector investment and SME-led educational capacity-building can formalize fragmented waste systems. The research aims how localized interventions, such as second-life applications and SME vocational training, can overcome the lack of centralized infrastructure identified in the Asia-Pacific region.

This context highlights a critical disparity as illustrated in Table 1, there is a significant mismatch between projected waste volumes and domestic recycling capacity in emerging and developing countries. While countries like India, Brazil, and South Africa face massive waste surges, they possess minimal formal recycling infrastructure compared to established hubs like China. This gap necessitates enhanced circular economy strategies to mitigate escalating environmental and economic risks. Therefore, this paper contends that advancing the circular economy for EV battery waste requires harnessing private sector initiatives and strategically educating SMEs to integrate sustainable management practices into the formal economy. the projected annual EV battery waste volumes by 2030 for key countries and regions in Asia and the Pacific, alongside their current share of global recycling capacity. Table 1 highlights significant disparities, with countries like India, Brazil, and South Africa facing large waste generation but possessing minimal recycling infrastructure. This underscores the urgent need for enhanced circular economy strategies in the Asia-Pacific developing countries to mitigate escalating environmental and economic risks. Therefore, this research paper argues that advancing the circular economy for EV battery waste in developing countries necessitates harnessing private sector initiatives and strategically educating Small and Medium-sized Enterprises (SMEs) to formalize and integrate sustainable waste management practices.

Table 1. Country-wise EV battery waste generation and recycling capacity (2024–2030).

| Region/Country | Estimated Annual EV Battery Waste (2030, Tonnes) | Share of Global Recycling Capacity (2024) | Key Policy/Market Drivers | Notable Regulations/Initiatives |
|---------------------|--|---|--|-------------------------------------|
| Brazil | 35,000 | <1% | Growing EV market, government incentives | National recycling targets |
| China | >500,000 | 70% | Strict recycling mandates, industry subsidies | NEV regulations, Interim Measures |
| India | 128,000 | <1% | Rapid EV adoption, emerging recycling regulations | Battery Waste Management Rules 2022 |
| South Africa | 10,000 | <1% | Green mobility programs, limited formal recycling | Green Mobility programs |
| Asia-Pacific (APAC) | >1,200,000 (regional) | 57% (APAC overall) | Battery production hub, expanding recycling infrastructure | Regional mandates, subsidies |

Note: This table adapted from [10,11], highlights the significant “readiness gap” in emerging markets like India and Brazil, where minimal recycling infrastructure (<1% global share) exists despite massive projected waste volumes.

2. Methodology

This research employs a qualitative documentary analysis and scoping review methodology to construct a policy framework for EV battery circularity. The quantitative data presented in Table 1 and Figure 1 were synthesized from a combination of multi-lateral institutional reports and industry market forecasts. The inclusion criteria analysis for this study was limited to peer-reviewed literature and institutional reports, focusing on lithium-ion battery waste management within “Emerging Economies” or “Developing Countries” across the Asia-Pacific region, Latin America, and Africa.

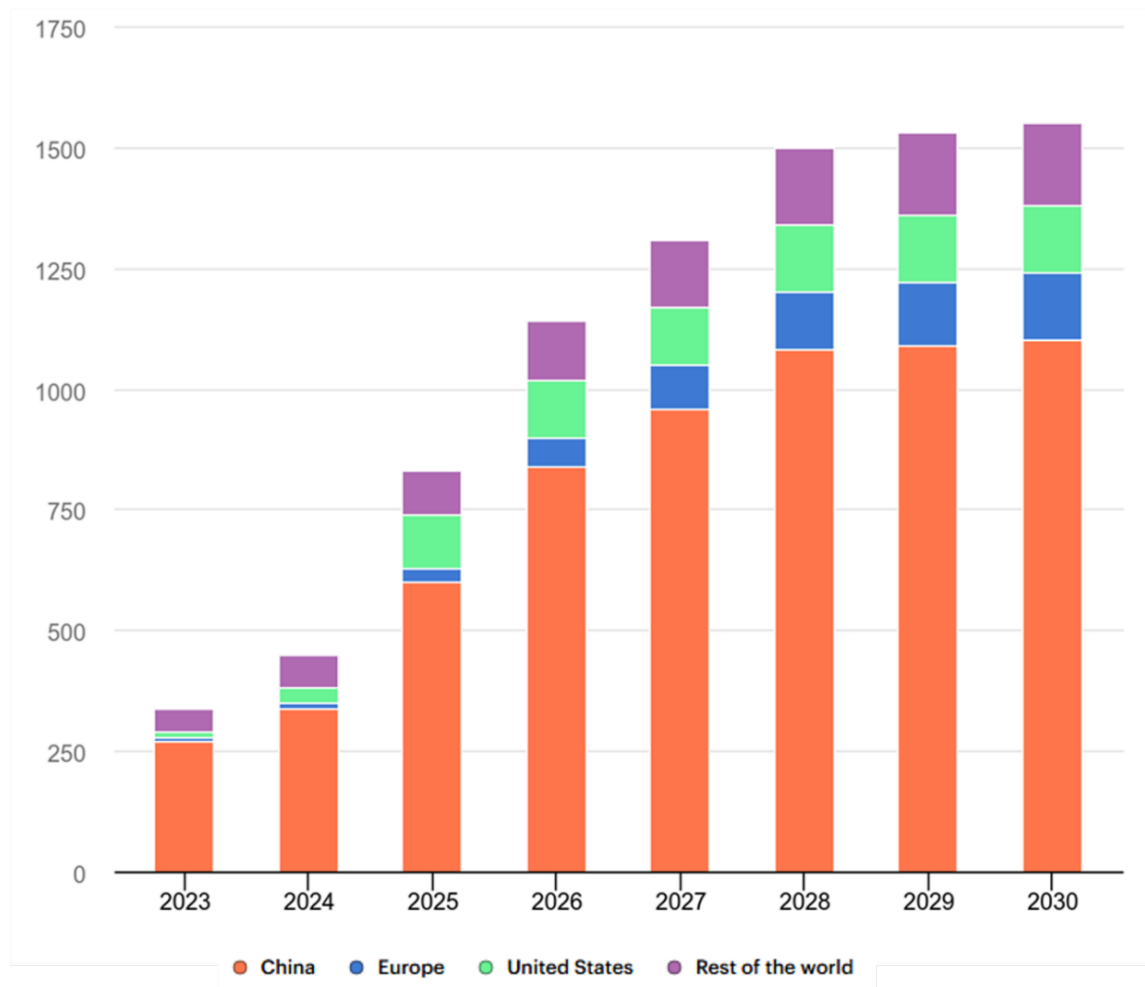


Figure 1. Expected battery recycling capacity by region, 2023–2030. Note: [12] Adapted from IEA (2024), this visualization underscores the dominance of China in the global recycling landscape and the comparatively negligible capacity currently allocated to the “Rest of the World”, highlighting the urgent need for localized infrastructure in the Asia-Pacific and other emerging regions.

3. Transformative Potential of Circular Economy Strategies

Circular economy approaches offer a critical and viable solution for managing the growing challenges of EV battery waste by systematically prioritizing reuse, remanufacturing, and recycling [13]. This model represents a necessary shift away from the linear “take-make-dispose” paradigm toward a closed-loop system where material resources are kept in use for the maximum possible duration [14]. Figure 2 illustrates the technical stages that require to transform a spent battery into a source of critical raw materials, which is a central pillar of the Circular Economy Roadmap. The cycle begins with the systematic retrieval of EoL batteries from the market through EPR take-back systems. Batteries are dismantled ideally supported by “design for disassembly” principles. Subsequently, through advanced metallurgical process, the black mass is refined to extract high-purity lithium, cobalt, nickel and manganese. The recovered minerals are reintegrated into production for new battery cells, effectively closing the resource loop and reducing the environmental footprint of mining.

A central strategy within this framework is the promotion of second-life applications for EV batteries. This involves repurposing batteries, which still hold significant capacity often 70–80%, for less demanding roles, primarily as stationary energy storage. For instance, in South Africa, repurposed batteries can stabilize intermittent renewable energy supply, potentially extend the useful life of the hardware while substantially reduce the global carbon footprint and saving up to 63 million tonnes of CO₂ emissions compared to producing new batteries [15]. Industry analysis suggests the market potential for second-life batteries in stationary storage could exceed 200 gigawatt-hours by 2030, offering a cost advantage of 30 to 70% over new units for applications like grid stabilization and renewable power storage [16].



Figure 2. Industrial cycle of EV battery recycling and material recovery. Note: This figure created by authors, provides the operational guidance and technological solutions that serve as a bridge between policy governance and the industrial solution.

Beyond reuse, the successful recovery of critical materials specifically lithium, cobalt, and nickel are crucial. Achieving high recovery rates requires the deployment of cost-effective and environmentally sound recycling technologies capable of handling diverse battery chemistries [17,18]. Furthermore, this transition requires robust policy drivers, mostly notably Extended Producer Responsibility (EPR) schemes. EPR frameworks hold original producers responsible for the entire life cycle, including the EoL management of their batteries, thereby incentivizing eco-design principles that prioritize longevity, easy disassembly, and recyclability to efficiently retrieve valuable materials [19,20]. The European Union's New Battery Regulation (2023) [21] serves as a benchmark for this regulatory push, formalizing responsibility transfers across market participants.

Digital integration also plays a transformative role, technologies, such as the Internet of Things (IoT), Machine Learning (ML), and blockchain are increasingly used to enhance the transparency and traceability of the EV battery supply chain, ensuring ethical and efficient movement of EoL assets. While large corporations are typically responsible for industrial-scale recycling and eco-design, their participation in developing countries is often hindered by financial risks and investing in advanced, high-volume and regulatory ambiguity [22].

In parallel, SMEs are uniquely positioned to localize CE efforts such as battery refurbishing, repair, and decentralized collection and recycling services. However, these actors frequently lack the technical expertise, financial access, and policy clarity necessary to fully adopt CE principles. Despite their proximity to local markets, many SMEs are currently unable to fully embrace CE principles because they lack the necessary technical skills, financial support, and policy clarity [23]. The economic viability of recycling depends on securing sufficient volumes of waste and having adaptable processes for diverse battery [24]. In developing countries where many EV are imported, the original design often lacks features for easy disassembly, complicating recycling and making it less economically attractive [25]. Consequently, targeted CE education and capacity-building programs are indispensable. These initiatives are essential for empowering SMEs with the specialized technical skills needed for the safe and efficient execution of battery reuse, remanufacturing, and material recovery processes [26]. Successful implementation of these strategies from advanced recycling to local second-life applications requires strong policy support, consistent investment in research and development, and specific capacity-building initiatives focused on innovation within local SME contexts.

4. Harnessing Private Sector Initiatives for Circularity

The effective advancement of a circular economy for EV battery waste in developing countries relies critically on stimulating and supporting private sector initiatives. While the public sector establishes the regulatory environment, it is private businesses ranging from multinational manufacturers to local recycling startups that execute the practical of collection, processing, and material recovery activities. Currently, private sector participation in the Asia-Pacific is often hampered by significant investment risks, market uncertainty, and a lack of clear, long-term policy signals [22].

To overcome these barriers, strategies must prioritize financial incentives, regulatory clarity, and the fostering of strategic partnerships. Large Original Equipment Manufacturers (OEMs) and battery producers are key players, tasked with efficient implementation of EPR systems efficiently. This necessitates the establishment of efficient take-back systems to retrieve EoL batteries from diverse sources, including consumers, vehicle service centers, and scrap dealers [27]. In emerging economies, these systems often need to be tailored to informal distribution and vehicle ownership patterns. Strategies may include leveraging mobile collection points or formal partnerships with existing informal waste collectors to increase geographical reach and facilitate the formalization of the supply chain [28]. Furthermore, the involvement of the private sector is also vital for mobilizing the substantial capital investment required to build advanced recycling infrastructure.

Beyond financial investments, the private sector is a primary driver of innovation in circular design and industrial technology. Manufacturers must commit to “design for disassembly” by engineering batteries that are easier to repair, repurpose, and recycle [29]. This transition involves standardizing battery module designs and implementing clear, informative labeling components. Furthermore, private companies are pioneering the development of second-life applications for stationary energy storage. Partnerships between vehicle manufacturers and energy utility companies are essential for testing, certifying, and safely deploying repurposed EV batteries to support local electricity grids or provide backup power for commercial buildings, thereby reducing the need for new battery production [30].

Furthermore, the integration of digital solutions, such as blockchain technology for the transparent tracking of battery provenance, state-of-health, and material composition, represents a critical private sector investment. These technologies enhance supply chain trustworthiness and ensure compliance with global sustainability standards [31]. However, for this participation to flourish in emerging economies, governments must provide clear policy incentives. These should include tax breaks for investing in recycling infrastructure, preferential procurement for products using recycled content, and regulatory stability to lower the business risk for long-term investments [32]. Ultimately, the private sector has the ability to create commercially viable, environmentally responsible, and scalable collection and processing networks serves as the cornerstone of a functional circularity of EV battery.

5. Strengthening Data Analysis and Country-Level Insights

A deeper analysis of EV battery waste trends across Asia-Pacific economies shows clear and significant differences in both the scale of waste generation and institutional preparedness. Large markets, including China, Japan and India are expected to generate the highest volumes of end-of-life (EoL) batteries, driven by rapid vehicle uptake and expanding domestic manufacturing bases. China led the region, with projection exceeding 500,000 tonnes of annual end-of-life battery waste by 2030, supported by over 70% of global recycling capacity [10,12]. This dominant position is reinforced by strict recycling mandates, established EPR frameworks, and significant digital traceability systems that track batteries throughout their life cycle [33]. Japan, while generating lower waste volumes, has prioritized second-life battery use, particularly for grid stabilization, renewable energy storage, and disaster preparedness, reflecting a strong alignment between energy and waste policies [15].

In contrast, India faces a significant “readiness gap”. While projected to generate over 128,000 tonnes of battery waste annually by 2030, its formal recycling capacity remains limited and unevenly distributed across states. Despite the introduction of the Battery Waste Management Rules (2025) which mandate EPR and recycling targets, enforcement remains uneven, and allowing the informal handling continues to play a significant role in the value chain [2,34]. This gap between projected waste growth and institutional readiness highlights the urgent need for investment, skills development, and clearer operational guidance to manage the impending waste surge.

In Southeast Asian economies such as Indonesia, Thailand, and Vietnam represent emerging markets where waste volumes are still modest but expected to grow rapidly due to the dominance of electric two- and three-wheelers in urban transport [35]. Indonesia is emerging as a key player due to its large nickel reserves and growing ambition to position itself as a regional battery manufacturing hub. However, national policy remains heavily weighted toward upstream production, with downstream EoL collection and recycling strategies still in their

infancy. Without timely regulatory development, battery waste management risks lagging behind industrial expansion. Similarly, Malaysia and the Philippines contend with fragmented waste systems and a lack of EV-specific frameworks to guide reuse or second-life applications, increasing the reliance on unregulated informal streams [36]. Similarly, Thailand has taken initial steps to align EV promotion with circular economy principles through its Bio-Circular-Green (BCG) economy model. The pilot projects on battery reuse and discussions around producer responsibility are underway, yet formal recycling infrastructure for EV batteries remains limited. Vietnam and the Philippines are experiencing rapid growth in electric motorcycles, which will generate large volumes of smaller battery packs [37]. These batteries often enter informal recycling streams, raising concerns about worker safety and environmental pollution. Least developed countries such as Cambodia and Lao PDR face a different set of challenges. Waste management systems in these countries are under-resourced, and hazardous waste treatment capacity is minimal, increasing the likelihood of unsafe storage or informal dismantling of batteries [36]. EV adoption is still limited, but most vehicles and batteries are imported second-hand, often without clear information on battery age or condition. For Pacific Small Island Developing States, geographic isolation and lack of infrastructure make battery logistics and safe disposal prohibitively expensive. Without regional cooperation mechanisms, these batteries risk being stored unsafely or exported without adequate oversight [12].

This comparative analysis highlights that policy priorities must be differentiated based on market maturity and geographic constraints. Large-scale economies must focus on the rapid industrialization of recycling infrastructure and material recovery, while smaller economies need regional collaborative solutions, shared facilities, and strong import controls to prevent the accumulation of unsafe and unmanageable of hazardous waste disposal. Such differentiated approaches are essential to realistic and effective circular economy planning in the Asia-Pacific regional context, especially for developing economies.

6. Policy Options

The following recommendations outline actionable strategies that governments, industry stakeholders, and civil society can undertake to foster a sustainable, inclusive, and resilient circular economy for EV batteries. Figure 2 was derived using a Gap-Intervention Analysis, which bridged the quantitative “capacity gap” identified in Figure 1 and Table 1, where projected waste volumes in emerging economies such as India’s 128,000 tonnes significantly exceed their current global recycling share of less than 1%. This theoretical framework transitions from the quantitative problem (Figure 1) to the qualitative solution (Figure 3) by categorizing interventions into governance, technology, informal integration, and community awareness to address the specific disparities highlighted in the country-level data. Table 2 provides a “Theory of Change” linking the specific geographic and market disparities identified in the country-level analysis to the four pillars of the proposed framework.

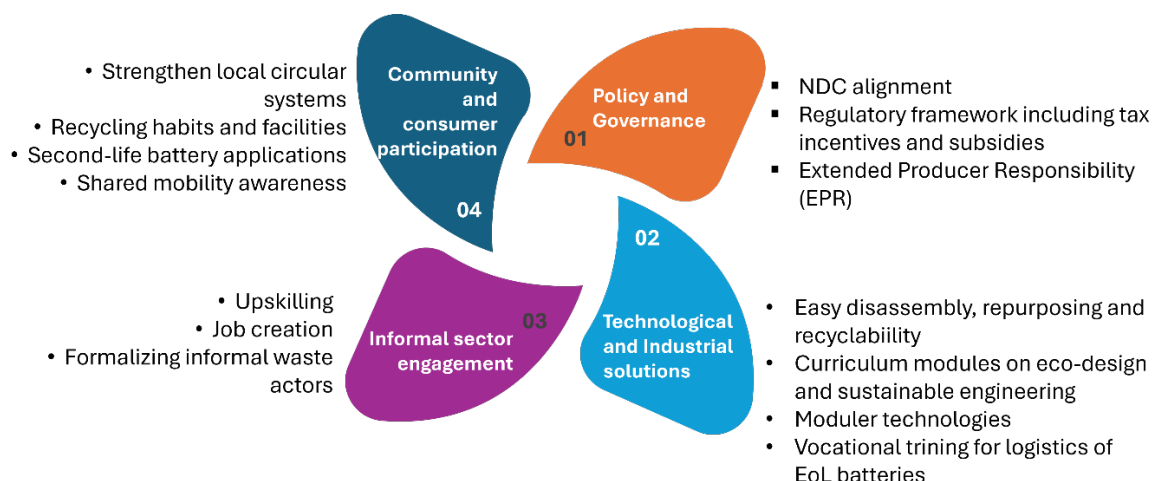


Figure 3. Key interventions of CE roadmap for EV battery waste management. Note: Developed by authors using a Gap-Intervention Analysis, this framework categorizes essential actions into four pillars, Policy and Governance, Technological Solutions, Informal Sector Engagement, and Community and Consumer Participation, to transform the “Quantitative Problem” of waste growth into a “Qualitative Solution” for economic and environmental resilience.

Table 2. Strategic mapping of socio-technical barriers to circular economy interventions.

| Identified Barrier | Impact on Circularity | Proposed Intervention | Targeted Outcomes |
|---|---|--|---|
| Fragmented waste management system | High rates of informal sector, hazardous dismantling | Policy and Governance (include EPR mandates and landfill bans) | Formalization of battery collection and safety protocols |
| Lack of design standards | Complex and costly disassembly for recyclers | Technological Solutions (focus on “Design for disassembly”) | Improved economic viability of material recovery |
| Financial/Technical SME Gaps | Inability of local firms to adopt safe repurposing technology | Informal Engagement (include loans and vocational certification) | Expansion of local second-life battery markets |
| Informal market dominance | Environmental leaching and worker toxicity | Community Participation (include public safety campaigns and authorized repair incentives) | Reduction in uncontrolled disposal and improved public health |

Note: This table created by authors and synthesize the “Country-level insights’ to differentiated policy planning.

6.1. Policy and Governance

The foundational step for governments, is the development and strictly enforcement of regulations for EV battery disposal, with a clear emphasis on EPR and mandatory recycling targets. Many countries in the Asia-Pacific region currently lack robust frameworks, leading in widespread informal and unsafe battery handling, stringent EPR schemes are necessary to mandate that manufacturers and importers manage EoL collection and recycling. This strategy incentivizes investment in eco-design (batteries made for easy recycling) and the construction of requisite recycling infrastructure. Regulations should include clear, enforceable recycling targets based on total battery weight to maintain adaptability to technological changes, reinforced by landfill bans to discourage irresponsible disposal. Furthermore, policies must also support the establishment of certified, safe recycling and repurposing facilities, to replace hazardous informal operations with environmentally sound alternatives.

Recognizing the critical role of local actors, financial support, including grants and low-interest loans, must be provided to enable SMEs to adopt circular economy practices. Many regional SMEs face high initial technology costs and limited credit access [38]. Consequently, governments and international partners should facilitate access to concessional financing and investment guarantees to empower SMEs in developing localized innovative solutions for battery reuse, remanufacturing, and material recovery. This financial support must be integrated with targeted technical training and pilot projects co-funded by vehicle importers or international donors, to serve as demonstration models, showcasing the financial and environmental benefits of circular approaches and de-risking investment for early adopters.

6.2. Technological and Industrial Solutions

Governments, industry associations, educational institutions, and private sector partners should collaborate to develop comprehensive curricula and capacity-building initiatives that address the specific needs of all stakeholders from SMEs and technicians to waste handlers and local communities. These programs should address essential topics such as safe battery handling, advanced recycling and repurposing technologies, regulatory compliance, and circular business models. By providing hands-on, practical training, these initiatives will empower stakeholders to adopt and innovate sustainable practices confidently.

Additionally, continuous learning and knowledge-sharing platforms can further foster a culture of circular economy thinking, accelerating the transition to sustainable battery waste management, stimulating local innovation, and contributing to job creation and economic resilience throughout the Asia-Pacific region. Strategic investment in education is the cornerstone for linking technological and industrial solutions. By prioritizing this alignment, organizations can unlock the full potential of circular economy initiatives and build long-term environmental and economic resilience.

6.3. Informal Sector Engagement

Local SMEs focused on battery recycling, which is often linked in the value chain and informal sector engagement in developing countries, should be integrated into the formal economy through agreements with major vehicle importers. Such partnerships not only fast-track the building of state-of-the-art recycling facilities but also stimulate demand for the recovered materials, which is crucial for building a stable circular economy ecosystem.

By accelerating the deployment of necessary infrastructure requires strategic collaborations between public authorities and private entities, there are various untapped potentials to enhance recycling capacity and create market incentives. Public-Private Partnerships (PPPs) are a key mechanism to mobilize the significant investment needed for advanced recycling technologies, such as hydrometallurgical and direct recycling methods, which offer superior material recovery rates.

Governments can effectively catalyze private sector involvement by introducing strong fiscal incentives, including tax breaks, low-interest loans, subsidies, and carbon credits, to reduce the financial barriers to entry. Strategic collaboration between large EV importers and specialized waste management companies can streamline logistics and ensure efficient operation.

6.4. Community and Consumer Protection

Through this pillar, the public education campaigns are necessary to communicate the environmental and economic benefits of responsible EV battery disposal while emphasizing the dangers of informal handling and the importance of using authorized facilities for battery replacement and recycling. Consumers must be made aware of the fire and safety risks associated with attempting to replace EV batteries themselves and be encouraged to utilize professional services that ensure safe, compliant handling and transfer of used batteries to designated processing centers.

At the same time, targeted training programs for SMEs, technicians, and local recycling enterprises are essential to equip them with the technical knowledge and skills required for safe and efficient battery management [23]. Drawing on successful international frameworks such as the European Union's Battery Regulation and China's battery recycling policies, governments should develop educational initiatives tailored to local socio-economic contexts, ensuring inclusivity and accessibility for all stakeholders, including marginalized communities and informal workers.

7. Conclusions and Future Perspective

The rapid adoption of EV in developing countries across the Asia-Pacific region presents a critical window of opportunity to establish a robust circular economy for managing EoL batteries. This transition is essential to simultaneously mitigate environmental harm and unlocking new economic value. The current situation, characterized by high projected waste volumes in countries like India and Brazil and alongside minimal formal recycling infrastructure, necessitates an urgent and focused shift away from the linear "take-make-dispose" model. This paper argues that advancing a CE in these contexts requires a strategic two-pronged approach, one is harnessing private sector initiatives, and another is significantly educating and empowering SMEs.

The proposed operational roadmap links EPR mandates for large manufacturers with vocational certification programs for SMEs. This interlinked approach aims to transform battery waste into a resource by providing a testable pathway for local governments to formalize the informal sector. Such formalization is critical for securing material supply chains and creating decentralized "green" jobs in the battery repair and recycling industry.

Under this framework, the private sector, particularly large manufacturers and importers, must be mandated through EPR policies to lead investment in advanced, safe recycling technologies and establish efficient national take-back systems. To be effective, these systems must be culturally and logistically adapted to emerging markets, potentially integrating existing informal collection networks. Concurrently, empowering SMEs is essential, as these actors are vital for localized repair, refurbishing, and second-life battery applications. This requires dedicated financial support such as low-interest loans and grants, coupled with targeted technical training on safe handling, advanced recovery techniques, and circular business models. Together, mandatory recycling targets, PPPs for infrastructure, and comprehensive stakeholder education form a cohesive roadmap for transitioning the EV battery value chain into a sustainable, closed-loop system.

Looking ahead, future perspective demands continuous innovation and proactive policy alignment to keep pace with rapid technological change in battery chemistry and design. The next decade will see a substantial increase in both the volume and diversity of EoL batteries, emphasizing the need for flexible, multi-chemistry recycling processes. Research and development investment should focus on direct recycling technologies, which are more energy-efficient and yield purer materials, thereby increasing the economic competitiveness of recycled content. The future policies must also address the full integration of digital technologies, including blockchain and Artificial Intelligence (AI), to ensure transparent, safe, and traceable management of batteries throughout their entire lifespan, from manufacturing to eventual material recovery.

Furthermore, circular economy education initiatives must evolve into institutionalized vocational and professional certifications to guarantee a continuously skilled workforce capable of scaling up repurposing and recycling operations safely. Ultimately, the success of these strategies will be measured not just by the volume of batteries recycled, but by the extent to which they promote a truly inclusive circular economy. Such a system must formalize informal workers, create green jobs, and secure critical material supply chains to ensure the region's long-term environmental and economic resilience. Finally, strategic investment in policy, human capital, and private action are essential drivers for turning the challenge of EV battery waste into a significant economic

opportunity. This interlinked framework and approach for repositioning waste management as a catalyst for long-term sustainability and economic resilience across the developing countries.

Author Contributions

A.K.: conceptualization, methodology, data curation, visualization, supervision, writing—original draft and writing—review & editing; S.R.B.: resources, visualization, writing—original draft and writing—review & editing. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author.

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The authors declare no conflict of interest. Given the role as Editorial Board Member, A.K. had no involvement in the peer review of this paper and had no access to information regarding its peer-review process. Full responsibility for the editorial process of this paper was delegated to another editor of the journal. Views expressed in this paper are those of the authors and should not necessarily be considered as reflecting the views of or carrying the endorsement of the United Nations.

Use of AI and AI-Assisted Technologies

No AI tools were utilized for this paper.

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