Improving the circularity of e-bus batteries

Regulatory framework and end of life management for Li-Ion batteries in Colombia, India and Tanzania

Electric buses, Circular economy, Colombia, India, Tanzania

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH commissioned the development of a measures catalogue for inclusion of circular economy principles into e-bus planning and procurement. In this vein, a series of three workshops were organized in Bogotá, Dar es Salam and New Delhi with the core aim of presenting the developed measures. The article is the result of three study tours organized parallel to the workshops and presents short summaries on the status regarding the e-mobility targets, regulatory frameworks, and current capacities for end-of-life (EoL) management of Lithium-Ion batteries.

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The transport sector is known to be the third highest emitter of greenhouse gases globally and presents a challenge in achieving emissions [1] with further research placing it second on the hierarchy of problematic sectors to control [2]. The message is clear: emissions reduction in the transport sector is difficult to realize. To compound issues further, highly congested cities suffer the public health effects of air pollution. In 2019 alone 4.5 million deaths were recorded as result of ambient air pollution [3]. The situation is more pronounced in transitioning economies such as Colombia, Tanzania, and India where policy makers must balance the need to increase public infrastructure, and reduce road congestion while achieving emissions reduction targets.

To support this, GIZ commissioned the Oeko-Insitut e.V. for the development of a measures catalogue for inclusion of circular economy principles into e-bus planning and procurement. The catalogue is designed to be a practical guide for policy makers and procurement practitioners in transitioning economies to address the needs of policy formulation, procurement tendering, maintenance, and sound EoL management of e-bus components, particularly batteries. In this vein, a series of 3 workshops were organized in Bogotá, Dar es Salam and New Delhi with the core aim of presenting the catalogue to governments, municipalities, and transport agencies. Parallel to the workshops, study tours were conducted in each of the countries (Colombia, Tanzania, India respectively). The following country specific analysis is the result of these study tours. Short summaries present the status quo of the electric vehicle targets and market development, regulatory frameworks, and current capacities for EoL management of Lithium-Ion batteries.

Colombia

E-mobility targets and market development

The Colombian government implemented a National Strategy for Electric Mobility in 2019, aimed at increasing the share of electric mobility in the country. The country is working towards it's targets, but progress has already been made especially in cities like Bogotá, which has achieved its ambitious target of 1,485 e-buses in 2023 and has set a further target for 100 % e-bus purchasing by 2023 [4]. Colombia's market has shown significant progress in the transition to electric mobility, partially due to government incentives such as reduced VAT, zero tariffs, preferential tax rates and exemptions from transit restrictions for electric vehicles. The increasing adoption of electric mobility will lead to a substantial increase in EoL batteries, prompting the government to develop a revised regulatory framework for their management.

Regulatory framework

The EoL management of batteries in Colombia has been regulated since 2010, starting with Resolution 1297 which focused on portable Li-Ion batteries. This resolution established take-back and collection systems based on the principles of Extended Producer Responsibility (EPR). In the following years, a total of 31 collection systems for batteries were approved by the responsible authority in Colombia, and 12,000 collection points for portable batteries were installed in the country [5]. The regulatory framework was later enhanced by Resolution 2246 in 2017, introducing management indicators for better monitoring and evaluation. In 2022, Resolution 851 replaced the previous framework, extending the scope to include industrial and electric vehicle batteries, and explicitly aligning its requirements with EPR principles. According to the new regulatory framework, the collection of Li-Ion batteries from electric vehicles will be mandatory from 2024 onwards. The requested collection rate will start with 0.5 % in 2024, increasing to 23 % in 2033.

Current capacities for EoL management of Li-Ion batteries

Currently, there are three collective schemes: Pilas con el ambiente, Recopila and ARBAM-(Motorola) and 27 individual schemes operating in the country, mostly focused on portable batteries. However, the take-back scheme Recoenergy, currently in

charge of collecting used lead-acid batteries, plans to expand its capacities to include the collection of Li-Ion batteries from vehicles in the coming years. Additionally, there are two active Li-Ion battery recycling plants in Colombia, Altero (*figure 1*), and Innova Ambiental, both with smaller processing volumes due to insufficient collection volumes. Furthermore, two companies focused on reuse or repurposing of Li-Ion batteries were identified. The start-up BatX offers energy storage systems. For the assembly of their systems, the company integrates recycled and reused components of Li-Ion batteries. The second company Recobatt repurposes used Li-Ion batteries from electric vehicles for second life applications.

Challenges and outlook

The increasing number of e-buses will lead to a rise in EoL batteries, and while Colombia has introduced requirements for their collection and management, these will only become mandatory from 2024 with low collection rates initially. This may result in a significant gap between targets and actual waste battery volumes due to the rapid growth of the e-vehicle market, highlighting the need for improved regulatory frameworks and investment conditions for scaling up recycling infrastructure.

Figure 1: Altero: Modular Li-Ion battery recycling facility in Colombia
Source: Oeko-Institut e.V.

India

E-mobility targets and market development

The Indian government has implemented initiatives such as the National Electric Mobility Mission Plan and the Phase-II of the Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME) scheme to promote electric vehicles (EVs) and boost domestic manufacturing capabilities. According to e-Amrit, a portal handled by the National Institute for Transforming India [6], there were 380 EV manufacturers registered in India until 31st July 2021 (this includes passenger cars, two and three wheelers, buses, and others). The country aims for substantial adoption of EVs, targeting 70 % of commercial cars, 30 % of private cars, 40 % of buses, and 80 % of two-wheeler and three-wheeler sales to be electric by 2030. With the increasing adoption of EVs and the significant number of buses in India's public transport system, there is a growing need for battery EoL management. By the year 2030 the annual market for recycling of Li-Ion batteries in India is expected to be around 22 - 23 GWh, which could translate into market opportunities estimated around USD 1,000 million [7].

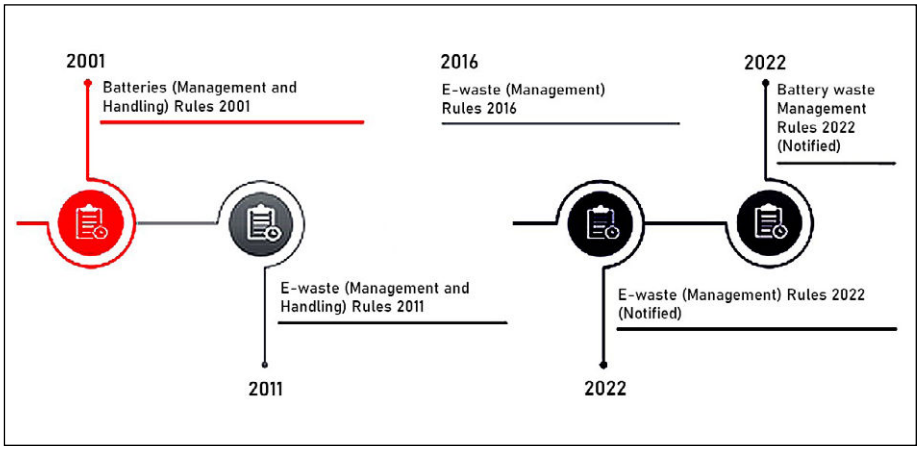

Figure 2: Evolution of battery and e-waste management rules in India Source: Dds+

Regulatory framework

In India, the Ministry of Environment, Forest and Climate Change, along with Central and State Pollution Control Boards, administer the regulations for EoL waste management. Various rules and guidelines have been published to promote circularity and sound EoL management of valuable resources, including plastic, tires, EoL vehicles, e-waste, batteries, lubricants, and oil. The handling and management of used batteries have been regulated since 2001, and the rules were further amended in 2022 to include a wider scope of batteries and introduce EPR obligations. *Figure 2* summarizes the evolution of battery and e-waste management regulation in India.

The Battery Waste Management (BWM) Rules 2022 in India cover all types of batteries, including E-vehicles, portable, automotive, and industrial batteries. Under the current regulation, every producer is obliged to collect and recycle minimum 70 % of the quantity of batteries placed on the market in the three preceding financial years starting from Fiscal Year 2024-2025. Recovery targets for batteries for various applications are shown in *figure 3*.

The rules also include mandatory targets for battery recycling and recovery to pro-

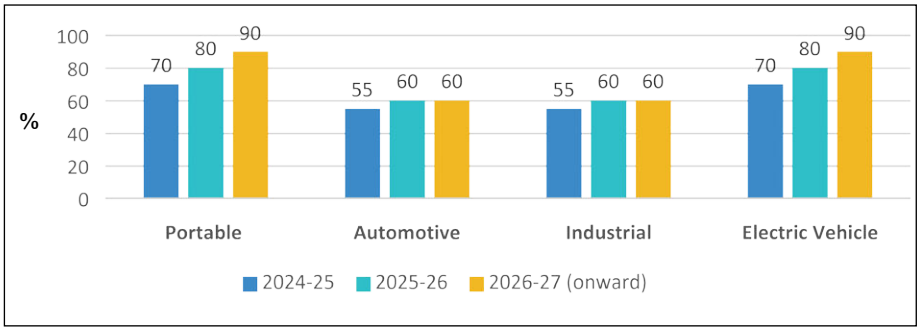

Figure 3: Recovery targets for the batteries from different sectors as per BWM rules 2022

Source: own elaboration

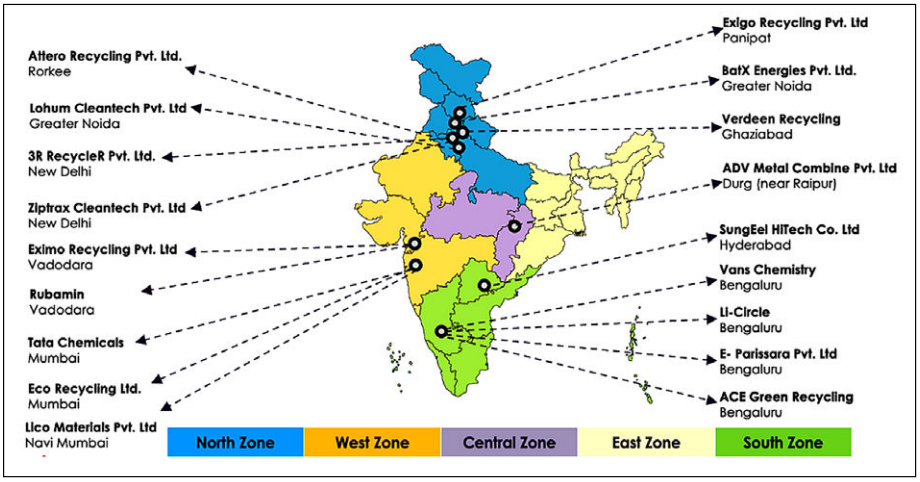

Figure 4: Li-Ion battery recyclers in India

Source: Dss+

mote investment in recycling technologies and create sustainable business opportunities. The reuse of recovered materials is mandated to enhance circularity and reduce dependency on imported battery cells.

Current capacities for EoL management of Li-Ion batteries

The recycling of Li-Ion batteries is a growing industry in India, driven by the increasing adoption of EVs. Start-ups are establishing recycling facilities to extract critical raw materials and repurpose waste batteries. At least 30 recyclers have been identified in India, primarily processing defective and discarded batteries, and some are signing agreements with EV OEMs for future EoL battery collection. *Figure 4* depicts the names and locations of 18 out of 30 identifies Li-Ion battery recyclers in India.

Most recyclers in India currently produce black mass through crushing and shredding batteries, but some are establishing leaching plants to extract valuable metals. Three business models have been identified: remanufacturing battery packs, metal recovery from black mass, and repurposing for second-life applications. This last one is focusing on developing proprietary technology for the testing and refurbishment of lithium cells from used automotive. Furthermore, recyclers are investing in technologies like spectroscopy to improve recovery processes and increase material purity. These developments contribute to creating a comprehensive value chain for sound EoL battery management and support the ecosystem for Li-Ion battery cell manufacturing in India.

Challenges and outlook

The lack of battery manufacturing plants in India is also a drawback, but government schemes such as the Production Linked Incentive (PLI) scheme for Advanced Cell Chemistry (USD 2.49 billion) and the FAME Scheme (USD 1 billion) are aiming to support local industry efforts in ramping up battery manufacturing capacities. However, the collection system for batteries and safe transportation of waste batteries from cities to recycling plants need improvement to ensure sufficient volumes for recycling. Awareness among stakeholders in public transportation is crucial for promoting better performance and prolonging the lifespan of e-bus batteries, thereby reducing the volume of waste batteries requiring end-of-life management. Nevertheless, the implementation of BWM rules and EPR principles is expected to enhance waste battery collection nationwide and reduce dependency on battery cell imports.

Tanzania

E-mobility targets and market development

Tanzania currently has the highest deployment of electric vehicles in East Africa, primarily consisting of two- and three-wheelers. However, the overall market penetration is still low, and electric buses have not been deployed yet due to a lack of clear government policies supporting e-mobility. Subsequently, total investment in e-mobility companies is still very limited and the existing 11 e-mobility local companies have only been able to raise USD 1 million so far [8]. Additionally, the uncertainty regarding future end-of-life battery volumes highlights the dependence on future policy frameworks and supporting measures from the Tanzanian government.

Regulatory framework

Tanzania's regulatory framework currently does not explicitly address the EoL management of electric vehicle batteries. However, the recently reviewed Environmental Policy recognizes the need for integrated waste management systems and mentions the lack of clear policy guidance on e-waste management. The main legislation governing environmental management, the Environment Management Act No.4 of 2004, is expected to address Li-Ion battery management in its new version, considering the promotion of electric vehicles for reducing carbon emissions. However, more attention is currently given to the management of used lead-acid batteries, and the implementation of a draft policy for lead-acid batteries faces challenges related to scope and institutional responsibilities.

Current capacities for EoL management of Li-Ion batteries

Currently, Tanzania has limited capacity for managing used and EoL Li-Ion batteries. Chilambo General Trade Company Ltd. is the only company in Tanzania that accepts these batteries (*Figure 5*), primarily from solar energy applications, but the bulk of the collected batteries are cobalt- and nickel-free LFP chemistry, which poses recycling challenges. Attempts to sell the collected batteries for testing and reuse in second-life applications in Kenya have been unsuccessful, leading to prolonged storage. In 2022, the batteries were eventually exported by a foreign trader, and their final destination is unknown.

Challenges and outlook

Currently, Tanzania lacks comprehensive services for Li-Ion battery maintenance, testing, reuse, repurposing, and recycling, partly due to the relatively new field of electric mobility and limited market size. The development of such capacities depends on the demand from e-mobility providers and manufacturers as well as the willingness to invest in high-quality battery maintenance and end-of-life management. Government policies can also play a role by implementing minimum requirements and establishing roles and responsibilities through EPR systems. ■

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Figure 5: Storage and dismantling area of Chilambo General Trade Company Ltd.

Source: Oeko-Institut e.V.

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