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E-Bus Mission

Improving the circularity of E-Bus batteries

Status of regulatory framework and end of life management capacities

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Background

The transport sector is known to be the third highest emitter of greenhouse gases globally and presents a challenge in achieving emissions (Schwanen 2020) with further research placing it second on the hierarchy of problematic sectors to control (Ayetor et al. 2020). 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 (Richard Fuller et al. 2022). The situation is more pronounced in transitionining economies such as Colombia, Tanzania, and India where policy makers must balance the need to increase public infrastructure, reduce road congestion while achieving emissions reduction targets.

To support this, the Oeko-Institut e.V. was commissioned by The Deutsche Gesellschäft für Internationale Zussamenarbeit (GIZ) GmbH for the development of a measures catalogue for inclusion of circular economy principles into E-Bus planning and procurement.This task is embedded within the Transformative Urban Mobility Initiative (TUMI) and the global project "TUMIVolt –Electric Mobility from renewable energies" on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), focussing on sustainable electric mobility. The overall aim of the project is to support city and national governments in the sustainable implementation of E-Mobility solutions. 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 end-of-life (EoL) management of E-bus components, particulatly 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 these countries (Colombia, Tanzania, India respectively). The following country specific analysis is the result of these study tours and presents short summaries on the status quo regarding 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

In 2019 the Colombian government published a National Strategy for Electric Mobility (Law 1964) aimed at increasing the share of electric mobility in the country. For this purpose, electrification targets for the public heavy-duty sector were established.

One main objective of the strategy was to reach 600,000 electric vehicles by 2023 and build five charging stations in main urban areas by 2022 (Ministerio de Ambiente y Desarrollo Sostenible 2020). Out of these objectives, the target on charging infrastructure has been already achieved. The city of Medellín alone has already installed 30 public and 5 fast charging stations within the urban perimeter. Moreover, two initiatives are focusing on inter-city chargers. The first of them led by Terpel, a national gas station company, has already 12 stations operating across the country. The other one is focused on connecting the three cities in the so called "Coffee Axis" by providing fast-chargers for electric vehicles travelling between them (Celemín Mojica 23 Aug 2022).

While the sales rates for e-vehicles are rapidly growing, by April 2022 only 7,782 electric vehicles were registered with the national vehicle registry (Villegas 2022).

The country´s capital Bogotá is one of the cities in Latin America with most progress with regards to electrification of public transport. The ambitious target of 1,485 e-buses by 2022 was reached in 2023. Furthermore, the city has a minimum purchase requirement of 30% electric vehicles for public transport by 2025, and 100% e-bus purchasing by 2023 (TUMI E-Bus Mission 2022b).

Besides Bogotá, further intermediate Colombian cities such as Barranquilla and Valledupar have also set ambitions targets and achieved fast progress towards higher shares of (public) electric mobility (TUMI E-Bus Mission 2022a; 2022c).

With the third biggest population in Latin America, Colombia's market is showing significant progress in the transition to electric mobility. By 2021 the country had already surpassed the 1% plug-in service sales and 1% pure battery electric vehicle sales (Celemín Mojica 23 Aug 2022). This progress can partially be attributed to the government's incentives to purchases of electric vehicles. These include reduced VAT, zero tariffs and a preferential tax rate. An additional significant incentive for the purchase of electric vehicles, is the exemption from the transit restrictions on certain days which apply to gasoline and diesel vehicles in many cities of the country. Due to the increasing share of electric mobility, the volumes of EoL batteries from electric vehicles are expected to significantly increase in the coming years. The Colombian government adresses the upcoming developments by a revised regulatory framework for EoL batteries, including batteries coming from electric vehicles.

Regulatory Framework

The EoL management of batteries has been regulated in Colombia since 2010. The first legislation addressing this topic was Resolution 1297 of 2010, applicable to portable batteries and aimed at the environmentally sound management of portable Li-ion batteries (Ministerio de Ambiente, Vivienda y Desarrollo Territorial 2010). Other types of Li-ion batteries such as industrial or electric vehicle batteries were excluded from this early regulatory framework. In addition, Resolution 1297 established take-back and collection systems to be operated according to principles equivalent to the environmental policy instrument of Extended Producer Responsibility (EPR) (despite not explicitly mentioned). 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 (Ministerio de Ambiente y Desarrollo Sostenible 2017).

The Colombian regulatory framework was later complemented by Resolution 2246 of 2017, aiming to further enhance environmentally sound EoL battery management (Ministerio de Ambiente y Desarrollo Sostenible 2017). This Resolution mandated a set of management indicators for operating battery collection and management systems aimed at better monitoring and evaluation of these.

In 2022, Resolution 851 of 2022 replaced the previously regulatory framework for EoL management of batteries in Colombia (Ministerio de Ambiente y Desarrollo Sostenible 2022). The scope of this new regulation was extended to include industrial batteries, as well as batteries from electric vehicles. Moreover, it officially introduces EPR as important instrument to enhance battery collection and support environmentally sound EoL management. 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.

Li-Ion Recycling and repurposing infrastructure

As of March 2023, there are two recycling plants for Li-ion batteries operating in two of the main industrial regions in Colombia.

Two further start-ups operating business models for repurposing of used E-vehicle batteries in second life applications were identified.

Current capacities for EoL management of Li-Ion batteries

The first take-back schemes for collection of waste batteries in Colombia were established in 2010 following requirements in Resolution 1297. In the following years, numerous collective and individual take-back schemes were registered thereby increasing collection capacities for waste batteries (including used Li-Ion batteries). As of beginning of 2023, the collection capacities for EoL batteries include three collective take-back schemes: Pilas con el ambiente, Recopila and ARBAM-(Motorola). In addition, 27 individual collection schemes operate throughout the country. Until now, these take-back schemes collect mostly portable (Li-ion) batteries. So far, bigger batteries coming from industrial applications or electric vehicles are not collected on a larger scale. 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.

There are currently two active LIB recycling plants in Colombia: Altero situated next to Medellín (Figure 1), and Innova Ambiental close to Cali. Both are small scale facilities, with current processing volumes of 15 - 30 tonnes of used Li-Ion batteries per month. Although their theoretical treatment capacities are higher with 90 - 300 t /month, there are currently no sufficient collection volumes of Li-Ion batteries to use their full capacities. Both plants conduct mechanical treatment, which results in separated fractions of plastic, metals and black mass. Whereas the plastic and metal fractions are mainly fed into local value chains, the black mass is currently exported to North America or Europe for further processing.

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. Beyond those companies, further stakeholders are currently elaborating the possibilities to built up facilities for EoL management of Li-Ion batteries in the region. Some of them have active regional cooperations or ongoing negotiations for technology transfer with actors in Costa Rica, Chile and Brazil.

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

Challenges and Outlook

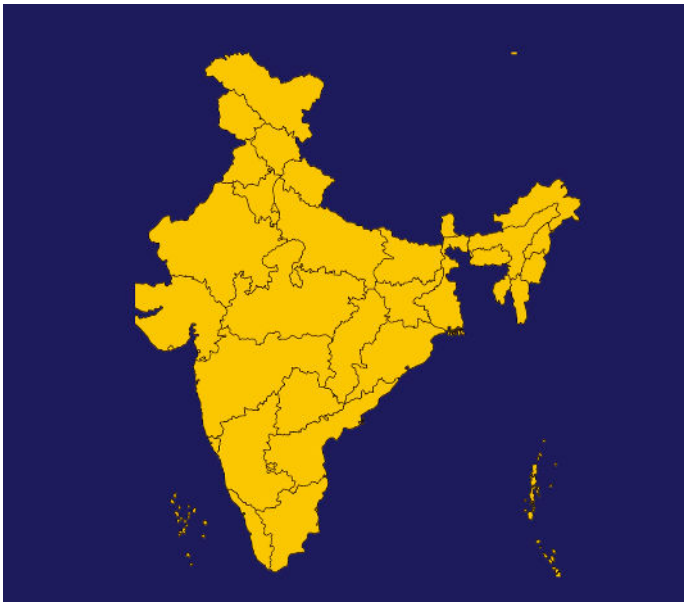
Electric mobility including E-buses have been defined as one important measure to make public transport more sustainable. Numbers of deployed E-buses in Colombia are expected to constantly increase over the next years, which inevitably will also lead to increased volumes of EoL batteries.

Colombia is also one of the first countries in Latin America which introduced specific requirements for collection and management of EoL Li-ion batteries from electric vehicles in its regulatory framework. Nevertheless, the mandatory requirements will be applicable from 2024 onwards, starting with very low collection rates applicable to industrial and e-vehicle batteries currently in the national market. This might lead to a significant gap between collection and management targets and actual volumes of waste batteries resulting from the rapid market growth in the e-vehicles sector. At the same time, maintaining the existing EoL management capacities relies on sufficient collection volumes of used Li-ion batteries. Already today, existing recycling infrastructure does not operate at its full capacity due to low collection rates in the country. Furthermore, current investment conditions for upscaling recycling infrastructure beyond small-scale operations were mentioned as significant challenge by several experts. In this context it will be crucial that the government keeps enhancing and improving the (regulatory) framework for waste battery management in Colombia and integrate learnings over time while adapting to new market developments.

Credit: Öko-Institute

India

E-mobility targets and market development



The government of India have put in place the National Electric Mobility Mission Plan 2020 which seeks to enhance national energy security, mitigate adverse environmental impacts from road transport vehicles and boost domestic manufacturing capabilities for electric vehicles (Ministry of Heavy Industries & Public Enterprises 2012). In addition to this, the government has given notice for Phase-II of the Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME) scheme to stimulate the ecosystem of e-vehicles in the country (NITI Aayog 2021).

According to e-Amrit, a portal handled by the National Institute for Transforming India (NITI Commission), there were 380 e-vehicle manufacturers registered in India unti 31st July 2021 (this includes passenger cars, twoand three wheelers, buses, and others). With the increasing adoption of e-vehicles in the national market, this number is increasing exponentially.[1]

India's 2030 vision of e-mobility aims for 70 per cent of all commercial cars, 30 per cent of private cars, 40 per cent of buses, and 80 per cent of two-wheeler (2W) and three-wheeler (3W) sales to be electric by 2030. Achieving this vision would result in a total of 102 million e-vehicles for the country (Singh et al. 2020).

The road transport sector accounts for 13% of carbon emissions in India. Buses are one of the most significant modes of public transport in India and state transport units own and operate 150,000 buses that carry 70 million passengers daily (Singh 2022). India targets to deploy 50,000 e-buses by 2030 in various cities. With the fast-growing adoption of the e-vehicles in various modes of transportation and growing energy demand in the country, there is an urgent need for management capacities in India for batteries reaching its EoL. According to a 2019 report by JMK Research & Analytics, 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 $1,000 million (JMK Research & Analytics 2019).

[1] https://e-amrit.niti.gov.in/Manufacturers

Regulatory Framework

In India, regulations for EoL waste management are governed by the Ministry of Environment, Forest and Climate Change (MoEFCC) who works together with Central and State Pollution Control Boards. Many regulations have been published towards achieving circularity and sound EoL management of valuable resources such as plastic, tires, EoL vehicles, e-waste, batteries, lubricants, oil and others. Extended producer responsibility (EPR) schemes have also been introduced via multiple rules and regulations. In the following, applicable policies, and regulations relevant to the management of EoL vehicles (ELV) and its batteries are briefly described:

Anticipating substantial increase in number of ELVs in coming years, in 2019 the Indian Central Pollution Control Board (CPCB) published the "Guidelines for the Environmentally Sound Facilities for handling, processing, and recycling of ELVs in India" (Central Pollution Control Board 2019). These guidelines are relevant for e-vehicles which are rapidly being adopted under the FAME scheme. The aim of this document is to ensure proper management of e-vehicles upon reaching their intended lifespan or for the purposes of resource recovery.

The handling and managing of used batteries has been regulated in India since 2001 under the Batteries (Management and Handling) Rules (Ministry of Environment and Forests 2001).

This document established responsibilities for all the key players of the battery lifecycle – the manufacturer, assembler, importer, re-conditioner, consumer, bulk consumers, auctioneers, and the central pollution control board. These rules were amended in 2011 where the definition of a bulk consumer expanded to include to various departments and institutions. The battery rules were further amended in 2022 to include a wider scope of batteries beyond lead acid batteries, as well as batteries from a wider range of applications. The amendments were drafted in consultation with stakeholders and the first draft published in 2020 included various chemistries of lithium-Ion batteries. Further, EPR for batteries was introduced in these draft rules thereby putting responsibility on the producers for the collection, recycling, and environmentally safe and sound management of the battery waste. The Battery Waste Management Rules (BWM) 2022 was updated to also include targets for recycling and recycled content (Ministry of Environment, Forest & Climate Change 2022). The amended rules were notified on 22nd August 2022 and came into force from 1st April 2023. Figure 2 summarises the evolution of battery and e-waste management regulation in India.

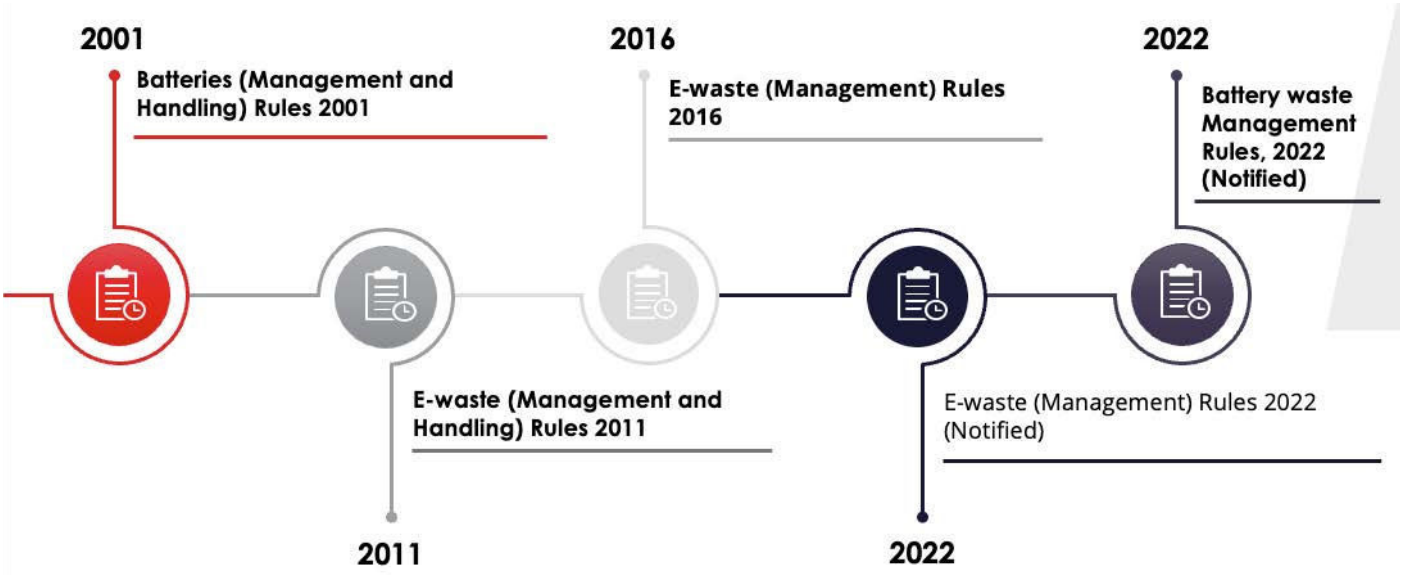


Figure 2: Evolution of battery and e-waste management rules in India. (Source: Dds+)

The 2022 Battery Waste Management Rules cover all types of batteries including e-vehicle batteries, portable batteries, automotive batteries, and industrial batteries. EPR obligations in the battery rules require all waste batteries to be collected and sent for recycling or refurbishment and prohibits disposal in landfills and incineration. To meet the EPR obligations, producers may engage individually or authorise any other entity for collection, recycling, or refurbishment of waste batteries. To help fulfil the obligations of producers, a centralised online portal for exchange of EPR certificates between producers and recyclers or refurbishers in India is available.

The battery waste management (BMW) rules 2022 also include mandatory targets for recycling and recovery. These are aimed at promoting new technologies and investment in recycling and refurbishment industry as well as create new sustainable business opportunities. 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 FY[2] 2024-2025 (i.e., for FY 2024-2025, Minimum 70% of the quantity of Battery placed in the market in 2021-22). Recovery targets for batteries for various applications are shown in the figure below.

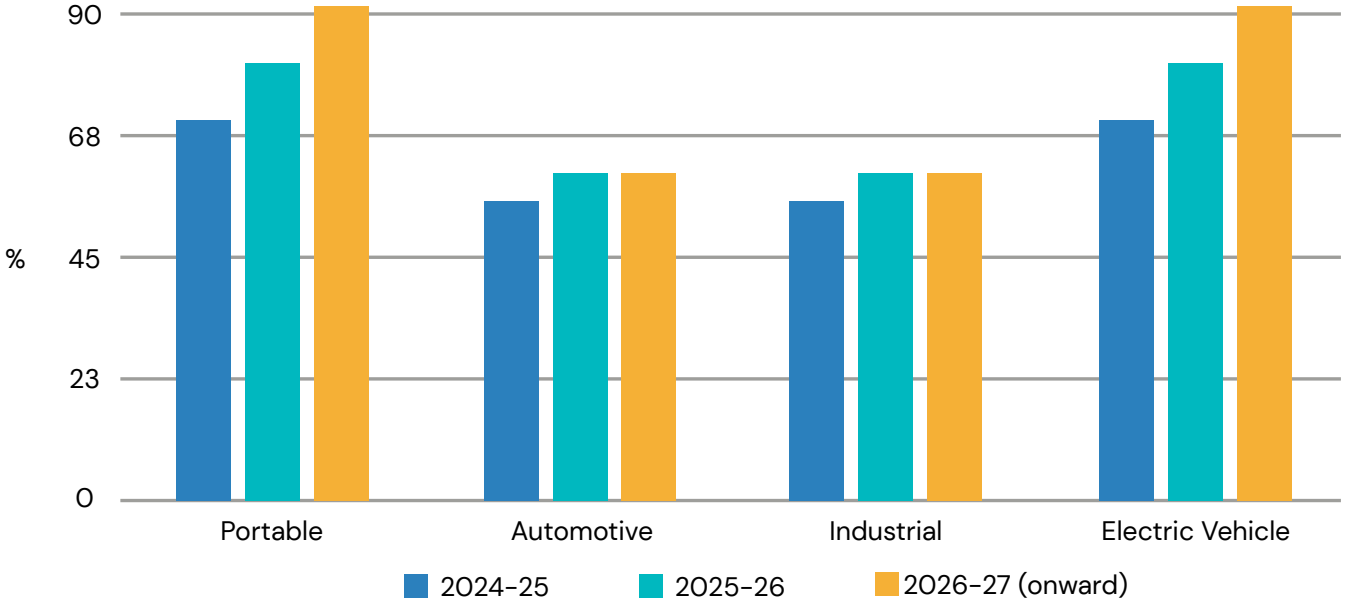


Figure 3: Recovery targets for the batteries from different sectors as per BWM rules 2022 (Source: own elaboration)

[2] FY: Fiscal year

[3] *In contrast, Lead acid battery recycling is a highly developed industry in India. There are 672 used lead acid battery recyclers in India registered by Central Pollution Control Board with authorized total capacity coming to 3530842 MTA.*
See: https://cpcb.nic.in/uploads/hwmd/List_Used_LA_Batteries_Registered_Recyclers.pdf

Current capacities for EoL management of Li-Ion batteries

Recycling of Li-Ion batteries is an emerging industry in India. Given the focus on increasing the number of e-vehicles on the roads in the form of 2, 3, 4 wheelers and E-buses, various start-ups are setting up Li-Ion battery recycling facilities for reuse, repurposing, and extraction of critical raw materials from waste batteries and bringing them back into manufacturing. Although collection and recycling targets are set under the Battery Waste Management Rules 2022, there is a need for clear regulations for safe collection and transportation of EoL batteries.

Today, most of the EoL batteries in India are collected from the informal sector as well as through aggregators located in the cities. In this context, many recyclers are establishing their battery collection networks in each city in a decentralised manner. The Central Pollution Control Board has recently opened the portal for registration of Li-Ion battery recyclers in India. An official list of recyclers along with their authorised capacities is not yet available on the portal.

However, based on the market research and consultation with industry experts, at least 30 recyclers have been identified in India. Currently all recyclers operate by mostly processing defective batteries as well as discarded batteries resulting from testing processes by manufacturers and original equipment manufacturers (OEMs). Meanwhile, recyclers are also signing agreements and MoUs with OEMs for e-vehicles in the country thereby laying the grounds for the future collection and take-back of expected volumes of EoL batteries. Figure 4 depicts the names and location of 18 out of 30 identified Li-Ion battery recyclers in India.

In terms of technology, currently, most of the recyclers in India are producing black mass from the Li-Ion batteries by crushing and shredding the batteries. A few recyclers are now establishing leaching plants thereby extracting cobalt, nickel, manganese, and lithium using multiple hydro-chemical processes.

Overall, three types of business models in the EoL management of Li-Ion batteries have been identified. The first business model focusses on the remanufacture of new battery packs from lithium-ion cells. The second business model business model is the recovery of metals such as cobalt, nickel and manganese derived from the black mass obtained from recycling of lithium- ion batteries. The third business model is the reuse and repurposing for second life applications.[4] This last one is focusing on developing proprietary technology for the testing and refurbishment of lithium cells from used automotive batteries and combine them into battery packs that are sold for less energy intensive applications. Further, recyclers are also investing in technologies such as spectroscopy for identifying the chemistries and composition of batteries. With this technology, [5] recyclers expect to improve their recovery processes and further increase the purity of extracted materials.

Overall, India is already on the path of setting up the entire value chain for sound EoL management of the waste batteries. At the same time these developments contribute to creating an ecosystem for manufacturing Li-Ion battery cells in the country.

Li-Ion Recycling and repurposing infrastructure

Based on the market research, 30 Li-Ion battery recyclers, mainly start-ups, have been identified in India who are already into battery waste processing or about to set-up a treatment facility.

[4] *Data received from the Lohum representative.*

[5] *Data received from Batx representative.*

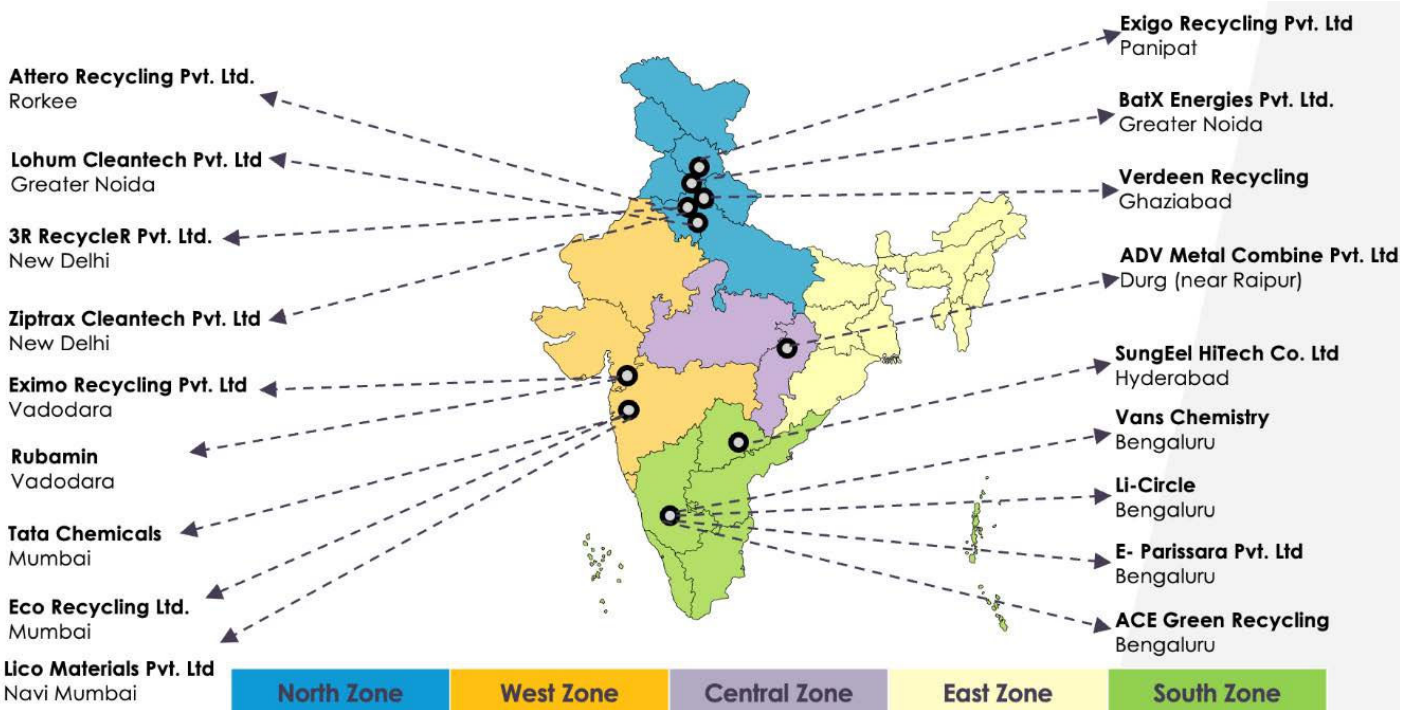


Figure 4: Li-Ion battery recyclers in India. (Source: Dss+)

Figure 5. Study tour at Batx on 27th April 2023.
(Source: Oeko-Institut e.V)

Challenges and Outlook

At CoP-26, India committed itself to a net-zero target by 2070 and set ambitious goals to achieve by 2030. If the country wants to deploy 50,000 E-buses by 2030, one the biggest challenges is the financing of this ambitious target. To achieve this, innovative and sustainable business models towards, both acquisition and operation of E-buses should be promoted. The main reason is that E-buses have high upfront capital costs, and the path to profitability through revenues is still not clear (Desai 2022).

A further challenge is the fact that now there are no battery manufacturing plants in India. This is being addressed both by the government´s Production Linked Incentive (PLI) scheme for Advanced Cell Chemistry (US$ 2.49 billion) and the FAME Scheme (US$ 1 billion). These programs aim to finance local industry effort to ramp up battery manufacturing capacities (India Ministry of Heavy Industries 2022). Even so, the manufacturing of Li-ion batteries in India will require feedstock of raw materials which are expected from battery recyclers.

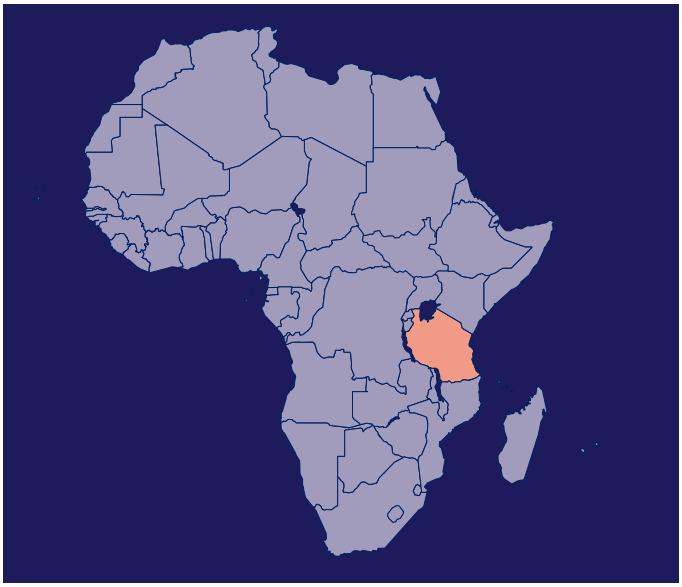
Another current challenge is the collection system for batteries and safe transportation of waste batteries from cities and towns to provide sufficient volumes for the recycling plants. As of now, most of the waste batteries come from the consumer electronics industry and only little battery volumes received for recycling result from e-vehicles.

The importance of safe collection, and recycling of E-bus batteries towards improving the circularity is yet to be understood by stakeholders on the ground, especially those in public transportation. Therefore, awareness among relevant stakeholders such as drivers, bus operating managers, city officials is needed. This is key for ensuring better performance, and prolonged lifespan of E-bus batteries which will ultimately translate into reduced volumes of waste batteries in need for EoL management.

The decision of ownership or lease of electric vehicles used in public transportation, maintenance and replacement time frame, monitoring battery health etc. at city level is also one of the challenges identified in the workshop discussion held on 26th April 2023 in New Delhi. It is unclear which approach will be preferred as the country rolls out its e-mobility policies. What is clear, is that with the implementation of the Battery Waste Management (BWM) rules in 2022, and inclusion of EPR principles will contribute to boost collection of waste batteries across the country. This is necessary in establishing a supply chain for recycling Li-Ion batteries from ELV on a national level and reducing dependency on the import of battery cells from other countries.

Tanzania

E-mobility targets and market development



With an estimated number of 5,000 electric vehicles, Tanzania is East-Africa's country with highest e-vehicle deployment. Major driving factors are moderate electricity tariffs of 220 TZS per kWh (US$ 0.10) as well as fluctuation and widely unsubsidised prices for conventional fuels (Courtright et al. 2023). Even so, the total market penetration is still low and most electric vehicles are two- or three-wheelers. Despite the existence of a developed public transport system in the country's biggest city Dar es Salaam, electric buses have not yet been deployed in Tanzania. e-vehicle deployment is hampered by a lack of a government policy clearly supporting e-mobility, as well as limited coordination between government bodies.. 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 US$ 1 million so far (Courtright et al. 2023). The development of the e-mobility sector in Tanzania will therefore strongly depend on the future framework conditions and whether the Tanzanian government will introduce clear and effective supporting policies such as reduced import taxes for e-vehicles and their components. This also means that future EoL battery volumes from electric vehicles are hard to predict. While volumes will stay low to moderate for the next years, this might change once the e-mobility sector gains market share.

[1] https://e-amrit.niti.gov.in/Manufacturers

Regulatory Framework

Currently, the EoL management of electrical vehicle batteries is not explicitly addressed by Tanzania´s regulatory framework. Nevertheless, in the following those policies, acts and regulations relevant for the management of waste batteries in general will shortly be described.

The recently reviewed Environmental Policy (Vice President's office 2021) addresses hazardous waste management as one of several focus areas relevant for environmental protection in Tanzania. Although it does not contain any concrete actions or measures for batteries, it highlights the need to promote integrated waste management systems. It stresses the increasing amounts of e-waste and the necessity to tackle the problem of unsound management. In this context, it mentions the absence of clear policy guidance on e-waste management, the lack of designated facilities for e-waste disposal[6] and the lack of a formal and centralized system for sharing e-waste information as current challenges for sound EoL management. Although the policy does not directly refer to any e-mobility targets, the promotion of green technologies is included in its objectives. It is expected that e-vehicles will be among those green technologies that will address current pollution challenges.

The main legislation to implement the Environmental Policy is the Environment Management Act No.4 of 2004 (Minister of State Vice President's office 2004) . Although in its current form the Act does not comprise specific requirements for Li-ion battery management, it is expected that the new version currently being developed will address the matter. As electric vehicles are an emerging issue and are currently being promoted for reduction of carbon emissions to combat climate change, national waste management experts expect respective additions in the next version.

There are several environmental regulations under Environmental Management Act 2004 that address hazardous wastes management, including lead-acid and lithium-ion batteries. Most relevant for Li-ion batteries are the 2021 environmental management regulations enacted in government notice (GN) No. 388 on e-waste (Minister of State Vice President's Office 2021) and GN No. 389 on hazardous waste (Minister of State Vice President's office 2021).

These regulations describe the legal framework and responsibilities of each stakeholder for control and management of different hazardous wastes. In addition, they include the precautionary principle, polluter pays principle and extended producer responsibility (EPR) as guidelines for the management of hazardous waste in Tanzania.

Although Li-ion batteries are already addressed by Tanzania's regulatory framework, currently more attention is given to the management of used lead-acid batteries. The export of used automobile batteries, lead scrap, crude and refined lead, and all forms of scrap metals is prohibited by the Tanzania Revenue Authority (TRA) under Section 70 of the East African Community Customs Management Act, 2004 (East African Community Secretariat 2019). Furthermore, a few years back a draft policy for the management of lead-acid batteries was developed. The policy recommendation was developed by Pure Earth in collaboration with UNEP in one of their projects in Tanzania.

According to local waste management experts, the implementation of the draft into practice is facing two main challenges until today: One is the focus on lead-acid batteries which is seen as an obstacle for taking a broader scope for environmental protection that includes further relevant issues. The second challenge is the lack of clarity in institutional responsibilities. Currently, the Division of Environment of the Vice President´s Office (VPO-Doe) plays an important role in providing regulations and legislation on the environmentally sound management of hazardous wastes. The National Environment Management Council (NEMC) is the overall coordinator of implementing policies, laws and regulations. So far it is not defined which ministry or national authority would take the lead and oversee implementation of the regulation addressing Li-ion batteries.

In sum, Tanzania´s regulatory framework does not yet provide specific regulations for the management of used batteries from electric vehicles. Nevertheless, important elements of the framework are currently under review and the institutional set-up is planned to be adapted. The outcomes will be decisive for the question, how the management of e-vehicle batteries will be handled in Tanzania in the future.

[6] *One achievement noted so far is the registration of 16 companies to deal with e-waste in Tanzania by mid 2023.*

[7] *Although the East African Community Customs Management Act refers to automobile batteries, it becomes clear from the context and the strong focus on lead containing components that electric vehicles batteries are not in scope.*

Current capacities for EoL management of LIB

There is currently only one company in Tanzania that accepts used and EoL Li-ion batteries. The company Chilambo General Trade Company Ltd. is located around 10 km West of Dar es Salaam and is specialised on the treatment of hazardous waste, including electrical and electronic waste and chemical waste. In the past years, this company had accumulated 80 tonnes of used Li-ion batteries, mostly resulting from solar energy applications. The company's aim is to develop a solution for the environmentally sound management of these types of waste in Tanzania. However, it must be considered that the bulk of collected batteries correspond to the LFP[8] chemistry which are cobalt- and nickel-free. At the moment, recycling solutions for these type of batteries are associated with substantial net-costs (Akamewane et al. 2022).

Attempts to sell the collected volumes to existing companies in Kenya working on testing and reuse for second-life applications have failed. Therefore, Chilambo had to resort to prolonged storage of the Li-ion batteries. In 2022, a foreign trader offered a free pick-up and export of the collected batteries, which was accepted by the Chilambo management. The final whereabouts of the batteries are unknown, although it is assumed that the reuse of cells is the only means to generate economic profits from this type of Li-ion batteries.

Subsequently, Tanzania has currently no developed capacities for managing used and EoL Li-ion batteries. Therefore, at the moment sound EoL management requires shipments of batteries to environmentally sound operators in other regions such as Asia, Europe or South-Africa. While local companies like Chilambo General Trade Company Ltd. may assist in interim storage, packaging and shipment (including Basel Convention notification procedures), there are yet no local experiences for handling larger batteries resulting from electric vehicle. Moreover, despite the existence of 11 active companies in the e-mobility sector, no approaches around battery reuse and repurposing are yet developed in Tanzania.

Figure 8. Storage and dismantling area of Chilambo General Trade Company Ltd. (Source: Oeko-Institut e.V.)

[8] *LFP: lithium iron phosphate*

Challenges and Outlook

Fully fledged services around Li-ion battery maintenance, testing, reuse, repurposing and recycling are currently not available in Tanzania. This is partly due to the relatively new field of electric mobility and the still limited size of this market in the country. A crucial aspect for developing the Li-ion battery servicing and EoL management capacities will be whether relevant players such as e-mobility providers and manufacturers will request such services. A futher aspect is the willingness to pay for high quality in both, battery maintenance for prolonged lifespan and EoL management.he import of battery cells from other countries.

Government policies may further influence the development of sound EoL management solutions by introducing and enforcing minimum requirements for managing used and EoL batteries which include a clear allocation of roles and responsibilities. The latter aspect may consider a system of Extended Producer Responsibility (EPR) where producers and importers are held responsible for collection and environmentally sound management of equivalent amounts of batteries as they have brought onto the national market.

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