Advancing Circularity in E-Mobility sector

GIZ Approach

Rohan Shailesh Modi | 25.04.2024

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

Activities by different projects

1. **Global Project: Transformative Urban Mobility Initiative**
2. **Global Project: Go Circular**
3. **Develop PPP : Costa Rica**
4. **GIZ Kenya Project**

LOOP Poster


Sustainable Lithium-Ion Batteries
for e-mobility
1
raw material extraction
Work towards a mining sector that respects social and ecological factors and our climate.
RECOMMENDATIONS
2
transport
Use sustainable transport modes to transport all battery materials along the life cycle.
RECOMMENDATIONS
3
raw material processing
Ensure fair and transparent processes throughout the entire supply chain.
RECOMMENDATIONS
4
battery design & production
Design for durability and circularity
RECOMMENDATIONS
5
battery use in e-mobility
Charge Li-Ion Batteries of EVs with renewable electricity for all transport modes to bring down emissions.
RECOMMENDATIONS
6
further use / second life
Extend the lifetime of batteries
RECOMMENDATIONS
7
recycling
Set-up take-back systems for recycling financed through extended producer responsibility.
RECOMMENDATIONS
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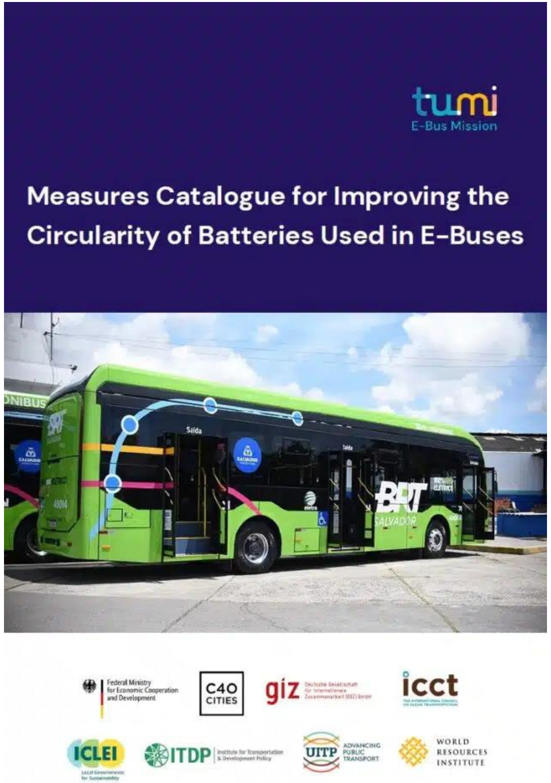
Advancing the Circularity of E-Bus Batteries

Launched in 2023, the catalogue addresses the topic at different project levels like policy formulation, tendering, E-bus maintenance, and safe disposal of non-reusable/recyclable components of e-buses.

i. Precisely explains each of the 11 measures
ii. Shares best practices &
iii. Stipulates specific tender clause for each measure



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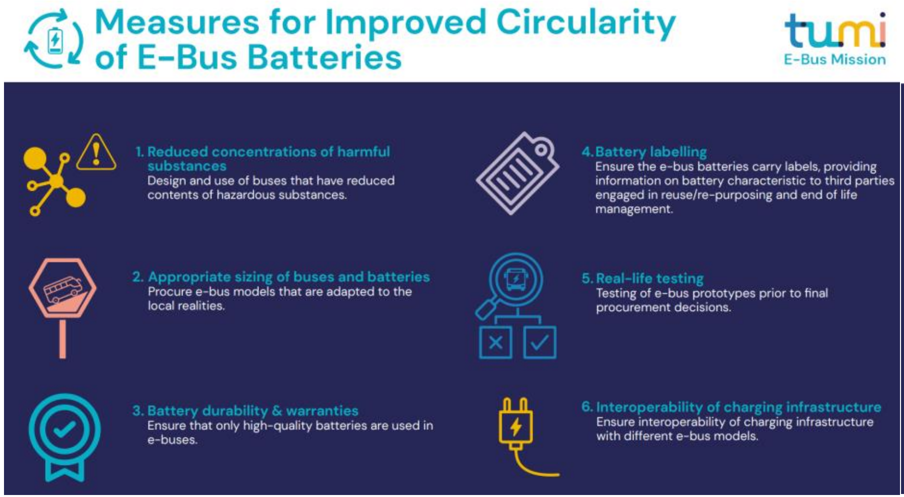
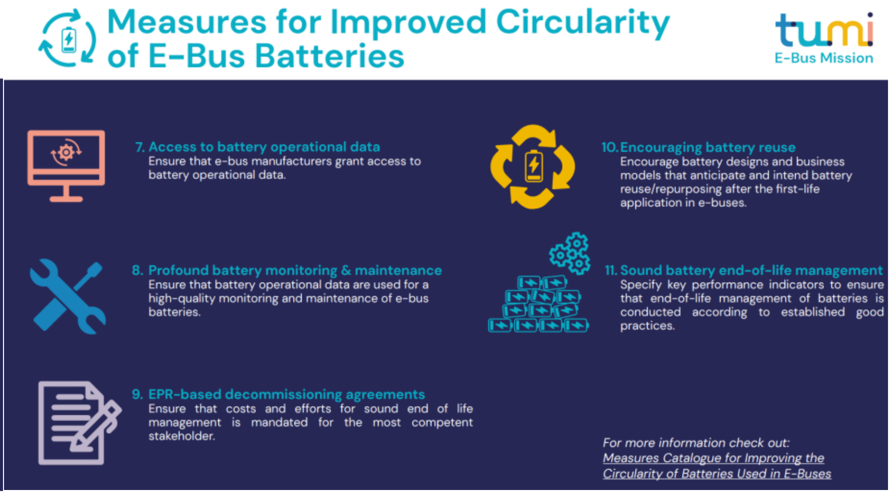
Circular Economy for E-Bus Procurements

Crisp Measures Catalogue *(11 measures) – Launched April 2023*





Access Measures Catalogue in 5 languages here

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Measure 1: Reduced Concentrations of Harmful Substances

What?	Design and use of buses that have reduced contents of hazardous substances
Why?	Hazardous substances can have detrimental effects on human health and the environment, particularly during the end-of-life phase. Furthermore, such substances are often obstacles for high-quality recycling.
Policy relevance	High: Substance regulations and bans are most effective when imposed and enforced through national legal framework

Proposes a text for e-bus procurement that is widely based on the established passenger vehicle regulations in the European Union

Box 1: Draft criteria for procuring e-buses with reduced concentrations of harmful substances

The air conditioning of buses shall use a refrigerant with a global warming potential not higher than 150 CO_2 equivalents.
In addition, electric buses shall not contain lead, mercury, cadmium, or hexavalent chromium. Exemptions are possible for:

- Lead as an alloying element in the following applications:
  - Steel for machinery purposes and batch hot dip galvanised steel components containing up to 0.35% lead by weight
  - Aluminium alloys with a lead content up to 0.4% lead by weight
  - Copper alloys containing up to 4% lead by weight
- Lead and lead compounds in the following components:
  - Lead in lead-acid batteries
  - Lead in high melting temperature type solders (i.e. lead-based alloys containing 85% by weight or more lead)
  - Electrical and electronic components which contain lead in a glass or ceramic, in a glass or ceramic matrix compound, in a glass-ceramic material, or in a glass-ceramic matrix compound
  - Lead in PZT-based dielectric ceramic materials of capacitors being part of integrated circuits or discrete semiconductors
- Hexavalent chromium in the following applications:
  - Hexavalent chromium as an anti-corrosion agent of the carbon steel cooling system in absorption refrigerators up to 0,75% by weight in the cooling solution:
    - designed to operate fully or partly with electrical heater, having an average utilised electrical power input ≥ 75 W at constant running conditions;
    - designed to fully operate with non-electrical heater.

In case further exemptions for the use of lead, mercury, cadmium or hexavalent chromium are needed, they should be specified in the offer, including a technical justification for each requested exemption. An exemption may only be granted in case it is convincingly explained that substitution would either have negative impacts on product safety or would create more environmental harm.

Measure 2: Appropriate Sizing of buses & batteries

What?	Procure e-bus models that are adapted to the local realities
Why?	Ensure that e-bus model(s) are suitable for local requirements so that long-term usability is given
Policy relevance	Low: Appropriate sizing of e-buses and batteries depends on the local conditions and demands and cannot be determined on a central policy level.

Due to the high-cost implications of batteries, battery oversizing is to be avoided. Nevertheless, under sizing is also a risk, as undersized battery capacity may significantly impact the bus's functionality.

Measure proposes aspects to be considered at procurement stage and also shares a good practice from city of Leipzig, Germany.

Box 2: Good practice example – quality requirements for e-buses in the city of Leipzig

The City of Leipzig (Germany) works on a gradual transition of its bus fleet to battery electric buses. Buses are procured, owned and operated by the Leipziger Verkehrsbetriebe, which is a municipality-owned transport agency. In its tendering strategy, the Leipziger Verkehrbetriebe require that suppliers must guarantee that the buses and their batteries achieve minimum performance requirements for ten years of constant operation. Instead of solely using indirect performance indicators (e.g., at least 80% of remaining battery capacity after a defined number of years), tender and contract specifications require that e-buses can – after ten years of constant operation under the given conditions in Leipzig – still cover a distance of 80 km with one battery charge. The 80 km are derived from typical operating conditions in Leipzig, which uses a combination of depot- and on-route charging. Further operating conditions in Leipzig are also specified in the tender documents, including information on terrain and prevailing temperature ranges. In case one or more supplied e-buses fail to meet this requirement, the supplier is contractually required to provide remedy such as a replacement of the battery.

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Measure 3: Battery durability & Warranty

What?	Ensure that only high-quality batteries are used in e-buses
Why?	High-quality batteries have longer lifetimes, need less frequent replacements and are therefore more resource and cost efficient
Policy relevance	High: Minimum durability requirements can be integrated in national legislation on batteries and/or vehicles

To prevent the use of sub-standard batteries, the measure proposes battery minimum durability requirements for tendering documents.

Box 3: Draft criteria for procuring e-buses with durable batteries

The supplier shall ensure that the e-bus batteries' State of Certified Energy (SOCE) is in-line with the following minimum performance requirements or better:

Vehicle age/km	State of Certified Energy
From start of life to 6 years or 400,000 km, whichever comes first	80 %
Vehicles more than 6 years or 400,000 km, and up to whichever comes first of 10 years or 500,000 km	70 %

The supplier shall submit evidence of compliance through independent test protocols in line with verification methods and procedures set out in the United Nations Global Technical Regulation on In-vehicle Battery Durability for Electrified Vehicles.

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Measure 4: Battery Labelling

What?	Ensure that e-bus batteries carry labels and QR-codes providing information on battery characteristics to third parties engaged ion reuse/repurposing and end-of-life management.
Why?	Easy access to information on battery characteristics can support sound decision-making in end-of-life management.
Policy relevance	High: Battery labelling is most effective when applied uniformly across all e-vehicle types. This is best achieved through industry standards combined with mandatory roles to apply such standards

Systems like battery passport could be very helpful but until such a system is developed /adapted in local context. The measure proposes a draft tender text which could be used to oblige EV manufacturer to share information in an easily accessible manner.

Box 4: Draft criteria for the labelling of e-bus batteries

The producer shall equip all battery packs with a well visible and accessible label / digital identifier (e.g., QR code) linked to a data website given information on at least the following battery characteristics:

- the battery chemistry (cathode and anode type)
- the manufacturer
- the date of manufacture
- the minimum, maximum and mean voltage
- the rated capacity

The website shall retain the information for at least 15 years from the date of manufacture and shall be made publicly accessible without any charge and registration procedure.

The labelling and information provided shall further be aligned with common industry formats for this purpose, including the size, design and placement of the labels, and the format of digital data provision. Information on further battery characteristics shall be additionally provided through the system in line with established practices and legal requirements.

Measure 5: Real-life Testing

What?	Testing of e-bus prototypes prior to final procurement decisions
Why?	Ensure that e-bus model(s) are suitable for local requirements so that long-term usability is given.
Policy relevance	Low: Real-life testing is meant to test vehicle suitability for a specific local context. Central policy approaches have limited effects here.

Aspects like passenger numbers & additional baggage during operation of E-buses in certain cities can be overlooked in the procurement process, while finalizing E-bus specs. In that context, transit agencies and operators can aim at testing new e-bus models prior to purchase orders.

Box 5: Good practice example – testing of bus prototypes in India

In India, five large cities (Delhi, Calcutta, Surat, Bengaluru, and Hyderabad) joined forces in their efforts to procure electric buses. In this 'Grand Challenge', a total number of 5450 electric buses were procured through one tender process. While this large volume enabled a significant discount of unit prices, it also allowed to introduce further tendering requirements. Amongst others, the tendering process considered an interim stage in which the three best-rated supplier candidates were asked to provide prototypes for real-life testing. The results of this testing were used in the final selection of the supplier (Modi 2022).

A comparable large-scale follow-up tender for electric bus operation has been published in 2022 (6465 e-buses) and another one is planned for 2023 (~5000 e-buses) (Convergence 2022). Such demand bundling opens significant possibilities to request circular economy requirements including those described in all other recommended measures.

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Measure 6: Interoperability of Charging Infrastructure

What?	Ensure interoperability of charging infrastructure with different e-bus models
Why?	Interoperable charging systems can be used for a wide variety of e-bus models and therefore have usually a long lifetime, which supports resource conservation and long-term cost reduction.
Policy relevance	High: Policymakers can regulate the interoperability of charging interfaces and protocols on a central (national) level.

For a complete interoperable system the measure proposes to look into four main parts:

- **Charging types & methods (AC&DC or inductive**
- **Output power**
- **Charging interfaces (plugs/connectors)**
- **Communication protocol between charger & EV**

Box 6: Good practice example – Interoperability of charging infrastructure in Israel

Starting in 2030, Israel has stipulated that all new buses for public transport must be fully electric. Diesel-powered buses currently account for less than 1% of total vehicles in the country, hence this goal is highly achievable. The Israeli Ministry of Environmental Protection together with the Ministry of Transport and Road Safety have coordinated their efforts to achieve this goal through a mix of regulations and standards. One important pilar of their strategy was to achieve interoperability of charging infrastructure for public and private vehicles. The government has developed mandatory standards based on EU DC charging requirements CCS-type 2 and Open Charge Point Protocol (OCPP) for communication between charging points and electric vehicles. The use of already existing and accepted standards and regulations helps with enforcement for import and registration of vehicles. To support the adoption of e-buses further, the Ministry of Transport operates depot charging stations for municipal fleets and private e-bus fleets at a fee. Business models based on depot charging are also present for both public e-bus fleets and private citizens irrespective of the brand of vehicle. Whiles this approach is successful to achieve interoperability, a shortcoming of the national policy is the 100% shift to e-busses without ensuring sufficient availability of charging stations. This situation has led to new e-buses being unused and currently warehoused which amounts to losses in profitability to the state and private fleet operators.

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Measure 7: Access to battery operational data

What?	Ensure that e-bus manufacturers grant access to battery operational data
Why?	Battery operational data is key to enable a thorough monitoring of battery state-of-health and for various measures around maintenance and extension of battery lifetimes.
Policy relevance	High: Policymakers can introduce mandatory rules for battery manufacturers and electric vehicle providers to grant access to battery operational data.

The measure identifies 7 key questions which should be kept in mind while asking for data from OEMS.

And proposes a draft procurement text for tenders on access to battery diagnostic data.

Box 7: Draft procurement text on access to battery diagnostic data

The suppliers shall enable continued monitoring of battery diagnostic data as specified in the table below and give the client full access to this data. This also includes the client's right to extend this data access to any third party nominated by the customer.

Signal	Unit	Value resolution	Time resolution
Battery current over time	A	0.1 A	≤ 1 sec
Battery voltage over time	V	0.1 V	≤ 1 sec
Cell temperature (avg/min/max) over time	°C	0.1°C	≤ 10 sec
Cell voltage (avg/min/max) over time	V	0.001 V	≤ 1 sec
Battery state of charge (SoC) over time	%	0.1 %	≤ 10 sec
Accumulated charge throughput	As	0.1 As	≤ 60 sec

The signals indicated in the table shall be continuously sampled during operation and charging and provided in a digital format compatible with publicly available software. All signals must be time-synchronous. All signals shall be made available through a standard output interface such as CAN or FMS.

The following additional battery information must be made available to the client upon purchase:

- Name of battery pack supplier
- Nominal battery pack energy (in kWh)
- Battery cell chemistry
- Battery model or serial number
- Battery topology and wiring:
  - Nominal cell capacity (in Ah)
  - Nominal cell voltage (in V)
  - Number of modules per battery pack
  - Number of cells per module

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Measure 8: Profound battery monitoring & maintenance

What?	Ensure that battery operational data are used for a high-quality monitoring and maintenance of e-bus batteries
Why?	High-quality monitoring and maintenance can significantly extend the battery lifetimes
Policy relevance	Low: Battery monitoring and maintenance measures fall into the sphere of e-bus fleet operators and cannot be regulated on a central level.

The measure proposes that it is important to opt for an organizational structure that sets incentives for a high-quality service & that encourages operators to enable long battery lifetimes. This may be achieved by:

E-bus as a service: Operators do not own the e-buses and batteries but have a contractual arrangement with a provider who also takes care of the batteries. In such settings, it is usually also in the interest of the provider that e-buses and batteries are thoroughly monitored and maintained.

Special monitoring and servicing agreements: Operators may choose to contract a third party specialised in battery diagnostics and maintenance. The contractual arrangements should be tailored in a way that the service provider has tangible own benefits from a good service, including prolonging battery lifetimes[13]. It is noteworthy that most of the monitoring and servicing can be done remotely through access to battery operational data. Therefore, access to such data is an important prerequisite

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Measure 9: EPR-based decommissioning agreements

What?	Ensuring that costs and efforts for sound end-of-life management do not fall onto municipalities, transit agencies or bus operators. Extended Producer Responsibility shall ensure that efforts and costs for sound end-of-life management are to be covered by producers.
Why?	Sound end-of-life management of batteries may be associated with additional costs. In addition, the realisation of sound end-of-life solutions for batteries requires specific know-how that is not within the core competencies of e-bus operators.
Policy relevance	High: Extended Producer Responsibility is best introduced through nationwide mandatory systems that require producers and importers to take suitable action to take back and soundly manage wastes arising from their products.

For countries with no existing EPR frameworks the measure proposes that most reliable way to secure that EOL management is obligating the private sector as a procurement strategy that combines a) procurement of buses, b) maintenance and c) sound management of end-of-life equipment.

Box 9: Draft procurement text on EPR-based battery decommissioning

The supplier shall take over full responsibility for the end-of-life management of the batteries after their first use in e-buses.

The responsibility will accrue once the e-bus owner and the supplier or a third party in charge for battery maintenance, jointly conclude that a battery does not fulfil its intended function anymore and cannot be restored through conventional maintenance measures anymore (decommissioning decision).

Once one or more e-bus batteries cannot fulfil their intended functions anymore, they shall be extracted from the vehicles and managed in a safe and responsible manner in-line with the requirements specified in section [link to respective section, e.g. as specified in Box 11].

The supplier's responsibilities encompass all logistical, administrative, and financial aspects related to these tasks and shall be conducted in a timely manner and within [X] weeks after having been informed about the decommissioning decision. The supplier's responsibilities may be fulfilled through a third party assigned by the supplier, presupposing this entity can prove capability to conduct all related tasks with due care and in-line with given provisions.

The supplier shall give evidence that they have sufficient capacities to fulfil this requirement in [name of city and country] and guarantee availability for at least [12] years starting from the date of commissioning of the e-buses and batteries. This evidence may refer to adequate provisions made with a Producer Responsibility Organisation for vehicle-batteries that is registered as such in [name of country].

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Measure 10: Encouraging battery reuse

What?	Encourage battery designs and business models that anticipate and intend battery reuse/repurposing after the first-life application in e-buses
Why?	Many aged batteries that are not suitable for powering e-buses any more can still be used in other applications. Such reuse or repurposing significantly extends the battery lifetimes.
Policy relevance	Medium: Policymakers can encourage reuse/repurposing strategies. This may be achieved through EPR policies (see measure 9) that entail mandatory targets for battery reuse and repurposing.

Acknowledging the various uncertainties of future battery second-life markets, as well as the lack of clear design-for-reuse standards, the measure proposes a draft tender text to be used to encourage design-for-reuse by closely linking it with other measures like no. 9 & 11.

Box 10: Draft procurement text to encourage battery reuse

Suppliers are encouraged to design e-bus batteries in such a way that they can be reused/repurposed after their first life as e-bus batteries, and to integrate reuse/repurposing into their business model. Design strategies might involve (but might not be limited to) battery packs that can be transferred to other power storage applications without physical modification, and the use of battery management systems allowing interoperability with one or more common stationary applications. Related business models might involve (but might not be limited to) to efforts to take back used batteries with the intention of deploying them in second-life applications such as stationary power storage.
The supplier shall indicate whether he follows one or more such approaches and provide background explanations and underlying concepts, including links to relevant documents and websites. In addition, the supplier shall give background whether these initiatives

- Are applicable to the e-buses and batteries offered under this tender
- Are implemented or planned for the setting of [name of city and or country]

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Measure 11: Sound battery EOL

What?	Specifying key performance indicators to ensure that end-of-life management of batteries is conducted according to established good practices
Why?	To ensure that user and end-of-life batteries are managed according to ambitious circular economy requirements
Policy relevance	High: Sound management of e-vehicle batteries should ideally be regulated on a national level in a way that sub-standard processes and disposal pathways are banned and effectively sanctioned

The measure proposes draft performance indicators to ensure that the EOL batteries are managed according to ambitious circular economy requirements.

Box 11: Draft performance indicators for contracts on sound end-of-life management of vehicle batteries

The batteries shall be picked-up, transported and processed according to international good practices in all related fields, including fire safety, road safety and occupational health and safety.

All batteries shall undergo a state of health assessment with a view to determine their reuse/repurposing potentials. Batteries, battery modules and battery cells found suitable for reuse/repurposing shall be used accordingly.

Batteries, battery modules and battery cells found unsuitable for reuse/repurposing shall be recycled. Recycling is to be conducted in line with international good practices and with the aim to effectively prevent emissions of hazardous substances, recover embedded raw materials and reduce waste volumes for disposal.

The applied recycling processes shall at least achieve a recycling efficiency of 50% (at least 50% of the mass of the battery is recycled) and enable the recovery of copper, cobalt and nickel.

All conducted steps shall be conducted in full compliance with applicable national and international laws and regulations.

The operator taking over the batteries shall submit evidence for compliance with the requirements above. As a minimum, the operator shall provide the following documentation to the client:

- All licenses and permits as required by national law (to be provided prior to taking over the batteries).
- A certificate over sound management of all received batteries. The certificate should give clear information on the whereabouts of each battery or parts and fractions thereof, applied management processes and links to downstream operators who took over all or part of the generated materials (to be provided within 3 months from taking over the batteries).

Footnotes:

- The recycling efficiency of 50% is a value that is well achievable with current good practices. In Europe, more ambitious mandatory minimum values are planned (65% by end of 2025, 70% by end of 2030) and also combine this with material specific minimum recovery levels (e.g. 50% for lithium and 90% for cobalt, nickel and copper by end of 2027) (Council of the European Union 2023).
- The recovery of copper, cobalt and nickel is well established in current Li-ion battery recycling processes. In the future, lithium may be added to this list. Nevertheless, lithium recovery is not yet a standard practice.

Study Tour

Transport Agencies exploring first hand battery - ecosystem

African partners at the Chilambo General Trade Company, Tanzania

Indian transport Agencies at BatX Energies Laboratory, India

Access More Information <u>here</u>

Global Programme Go Circular

Supporting the global transition to a circular economy

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

PREVENT – ECON Pilot Nigeria

Management of End-of-life Li-ion Batteries through E-waste Compensation in Nigeria

Feasibility study on options for developing environmentally sound recycling solutions in Nigeria

Authors:

Andreas Manhart, Johannes Betz, Tobias Schleicher, Inga Hilbert (Öko-Institut e.V.)

Reinhardt Smit, Hannah Jung (Closing the Loop)

Dr. Leslie Adogame (SRADev Nigeria)

with support of Israel Olagunju and Adrian Clews (Hinckley Recycling Ltd.) and Oluwatobi Adegun (Verde Impacto Nigeria)

Study completed in:
Freiburg, Lagos, Amsterdam
March 2022

Supported by:

german cooperation
DEUTSCHE ZUSAMMENARBEIT

PREVENT
Waste Alliance

Report on EOL Li-Ion Management for Nigeria:

- Feasibility study on options for environmentally sound management of Li-Ion Batteries in Nigeria
- Management options are being described for collection, handling & storage, Reuse & repurposing and
- Further treatment options (e.g. shipment, thermal or mechanical pre-processing)
- Economic analysis and recommendations
- ECON has been scaled by Vodafone in Partnership with Closing the Loop (GIZ mentioned in the FAQ)

Find more information on the Pilot over here:

- Link to the Management EOL Li-Ion report
- Link to the webinar

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Forthcoming: Circular Battery Academy

unitar
United Nations Institute for Training and Research

Sustainable Cycles (SCYCLE) Programme

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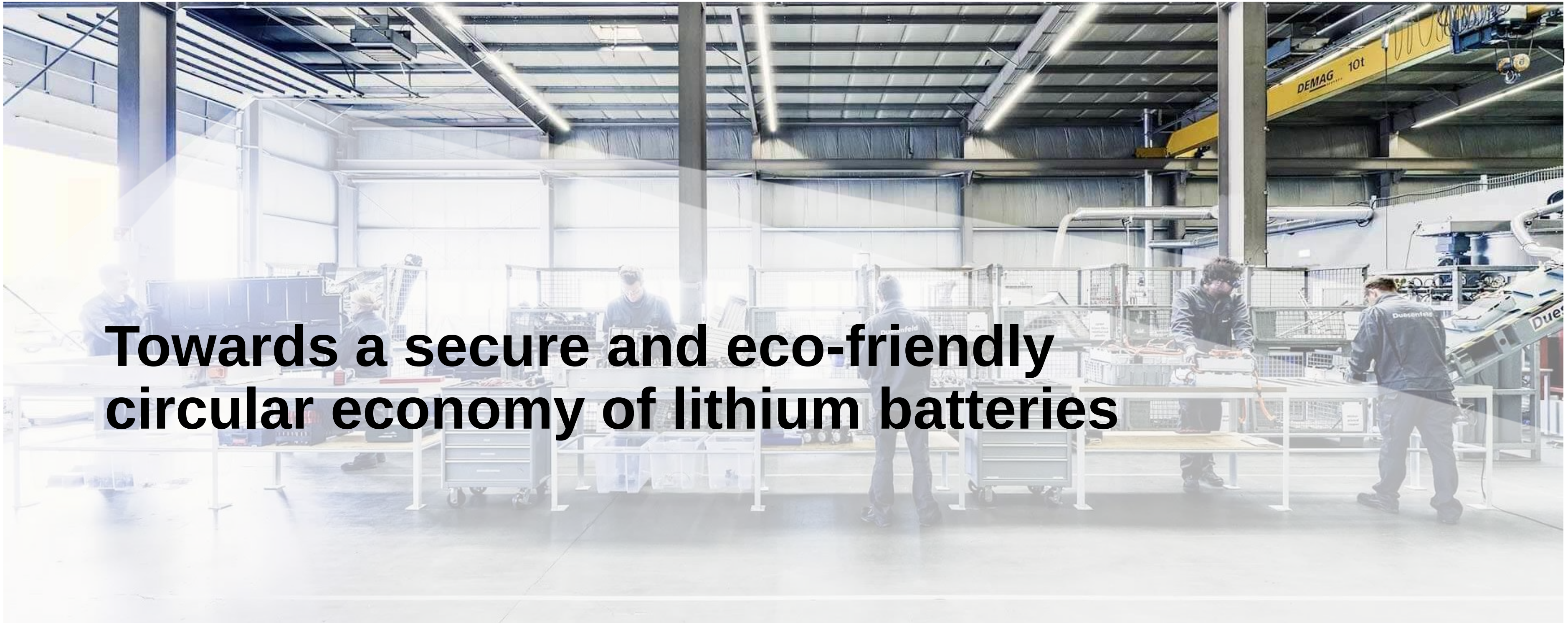
Home > News > E-waste Business Boot Camp (BBC) Berlin, September 2018

Circular Battery Academy:

- Tender forthcoming (April 2024):
- 3 theoretical online classes around Li-Ion Battery Circularity, followed by 6 in-depth online classes on Li-Ion battery refurbishment
- Followed-up with on one-week in-house training for SME and Start-Ups already involved in the sector (e.g. mobility start-ups of Refurbishment Start-ups)
- Based on the Ewaste-Academies for Managers, Business Bootcamp for E-waste and the TUMI online courses for E-Mobility



Towards a secure and eco-friendly circular economy of lithium batteries

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develoPPP
Where business meets development.

FORTECH Circular

Objective

The technical and framework conditions for a secure and eco-friendly recycling process of lithium batteries in Costa Rica are improved

- **WP1: CB & technology transfer on battery recycling**

- **WP2: pilot collection system of lithium batteries for recycling or 2nd use**

160 tons of batteries were collected until the end of the project by Fortech with the support of other partners (30% from electric vehicles and 70% small equipment)

- **WP3: development of a regulatory framework**

Standard procedures regarding the import, collection, 2nd-life and handling of used Li-ion batteries were developed jointly with the ministries

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Capacity Development EV Batteries
PEM Motion, GIZ & FORTECH

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FORTECH
PEM MOTION

FORTECH

BATTERY HANDLING MANUAL

Capacity Building for many stakeholders

2nd life applications

- 4 tricycles powered by 2nd-life batteries were manufactured for a group of low-income women recyclers
- 5 golf carts that ran on lead batteries were converted to electric with 2nd life batteries


PROMOTION OF
ELECTRO-MOBILITY IN
KENYA
Testing Applicability of Used EV Batteries for Second Life
Applications in Kenya – GIZ 84454799

Objectives

Evaluate Technology & Stakeholders: Analyze current EV battery technologies in Kenya, assess existing battery management infrastructure, and identify key players across the battery life cycle.

Explore Second-Life Applications:

Test the feasibility of repurposing used EV batteries in promising applications, considering economic benefits and technical suitability. This culminates in the production of a functional working prototype repurposed EV battery for energy storage.

Develop a Battery Management Plan (BMP):

Outline a roadmap for implementing second-life applications in Kenya, including stakeholder roles, policy considerations, and best practices.

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