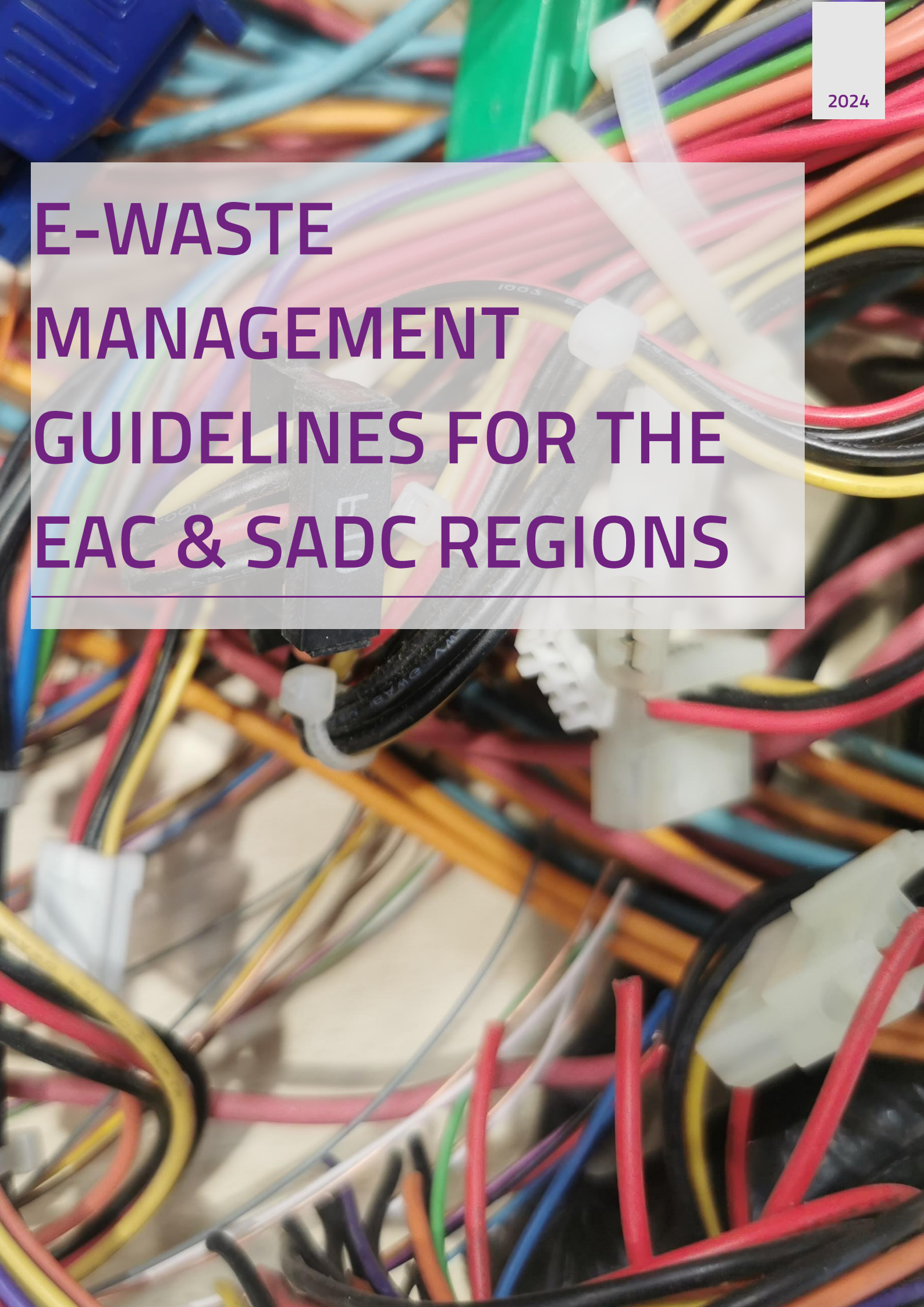

2024

E-WASTE MANAGEMENT GUIDELINES FOR THE EAC & SADC REGIONS

E-WASTE MANAGEMENT GUIDELINES FOR THE EAC & SADC REGIONS

Commissioned by
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Division of Decarbonization and Sustainable Energy
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DISCLAIMERS

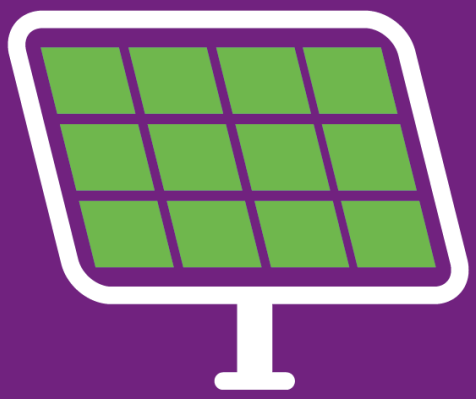
EXECUTIVE SUMMARY

This report provides comprehensive guidelines to improve e-waste management for lighting, cooling, and photovoltaic equipment in the SADC and EAC regions as part of the Energy Efficient Lighting and Appliances in Southern and Eastern Africa (EELA), project funded by the Swedish Government through the Swedish International Development Cooperation Agency (SIDA) and implemented by UNIDO, with the Southern Africa Development Community Centre for Renewable Energy and Energy Efficiency (SACREEE) and the East African Centre of Excellence for Renewable Energy and Energy Efficiency (EACREEE) serving as the execution centers. It begins with a detailed situation analysis, presenting generation data, current regulations, and regional initiatives. The analysis highlights the technical challenges and opportunities in refurbishing, dismantling, and recycling these waste streams, emphasizing the need for policies that consider logistics and the entire value chain to promote a circular economy.

A regional strategy, akin to the EACO model, is proposed for EAC and SADC regions, aimed at harmonizing efforts and establishing a robust EPR framework. This framework would offer legal and administrative support, business opportunities, and knowledge transfer, facilitating national policy development. Steps for launching an EPR framework are outlined to help countries identify gaps and plan next steps, regardless of their current implementation stage.

The Guidelines stress the importance of infrastructure and capital investments to maximize material and energy recovery from end-of-life equipment. Feasibility studies, supported by comprehensive data, are essential for understanding the collection, transport, and export value chain of WEEE businesses, and understanding the suitable ratio for local recycling versus WEEE component exports. While exporting certain components to advanced recovery facilities is currently necessary, the long-term vision is to establish advanced recycling hubs in Africa, promoting legal and efficient WEEE trade within compliant African recyclers. Additional benefits to circularity are job creation and an ever-increasing business environment for SMEs and entrepreneurs in the field.

The financial aspects, including the need for funding and capital investment estimation, are addressed, highlighting the role of EPR in balancing financial responsibility between the private and public sectors. Government involvement remains crucial, but only for key roles and functions. The report concludes by outlining the necessary capacities and awareness for sustainable WEEE management, detailing the roles of various stakeholders and the knowledge required to fulfil them. Early public awareness and understanding of the e-waste market dynamics are crucial for effective policy design, enforcement, and implementation.



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List of Abbreviations

Africa Telecommunications Union
ATU
Basel, Rotterdam, and Stockholm
BRS
Best Sustainable Recycling
BSR
Chlorofluorocarbons
CFCs
Civil Society Organizations
CSOs
Common Market for Eastern and Southern Africa
COMESA
Compact fluorescent lamps CFL
East African Centre of Excellence for Renewable Energy and Efficiency
EACREEE
East African Communications Organisation
EACO
East African Community
EAC
East African Standards Committee
EASC
EELA Project Coordination Unit PCU
Electric and Electronic Equipment
EEE
End-of-Life Appliances ELA
Energy Efficient Lighting and Appliances in Southern and East-ern Africa
EELA
Environmental Impact Assessment
EIA
ethylene-vinyl-acetate
EVA
extended producer responsibility
EPR
Focus Group Discussions FGDs
Geographical Information Systems (GIS)
Harmonized System codes
HS codes
Hydrochlorofluorocarbons
HCFCs
International Renewable Energy Agency
IRENA
International Telecommunication Union
ITU
Minimum Energy Performance Standards
MEPS
Persistent Organic Pollutants
POPs
polyurethane
PUR
Product Registration System PRS
public-private partnerships PPPs
Put on the Market
POM
SADC Centre for Renewable Energy and Energy Efficiency
SACREEE
Southern African Development Community
SADC
Southern African Development Community Cooperation in Standardization SADCSTAN
standard operating procedures SOPs
Swedish International Development Cooperation Agency SIDA
The Common Market for Eastern and Southern Africa

COMESA	3
United Nations	
UN	x
United Nations Industrial Development Organization	
UNIDO	x
UNU United Nations University.UNU	9
Used Electric and Electronic Equipment	
UEEE	1
Waste Electric and Electronic Equipment	
WEEE	x
Waste Management of Southern Africa IWMSA	15

List of Definitions

Dismantling	(Careful) manual separation of equipment parts and components. Tools such as electric or pneumatic screwdrivers can be deployed to accelerate the speed of dismantling.[1]
Distributor	Any natural or legal person in the supply chain, other than the manufacturer or the importer, that makes a device available on the market, up until the point of putting into service.[2]
EPR	A policy principle to promote total life cycle environmental improvements of product systems by extending the responsibility of the manufacturers of the product to various parts of the entire life cycle of the product, and especially to the take-back, recycling and final disposal of the product.[3]
Generator	Any person or entity whose act or process produces hazardous waste or whose act first causes a hazardous waste to become subject to regulation.[4]
Hazardous	A hazardous waste is a waste with properties that make it dangerous or capable of having a harmful effect on human health or the environment. Different jurisdictions determine what the dangers are; some examples are flammable, toxic, mutagenic properties.[5]
Importer	'Importer' means any natural or legal person established within a country (or region with common jurisdiction, such as the European Union) that places a device from a third country on the European Union market.[6]
Informal sector	Informal sector (enterprise-based definition) refers to the production and employment that takes place in unincorporated, small or unregistered enterprises.[7]
Manufacturer	A manufacturer is a person or company that produces finished goods from raw materials by using various tools, equipment, and processes, and then sells the goods to consumers, wholesalers, distributors, retailers, or to other manufacturers to produce more complex goods.[8]
Non-valuable fraction	Non-valuable fractions of e-waste refer to fractions for which there is no market demand or represent unwanted costs. Examples are most thermoplastics with flame retardants.[9]
Official business activities	Economic activities carried out by economic operators registered as legal entities with an operating license which obliges them to pay taxes; these operators are subject to regulation and governmental oversight.[10]
Photovoltaic equipment	Refers only to solar panels in this document, excluding motors, batteries, inverters, and all other fixtures or equipment connecting the panels to the grid or consumers.
PRO	A Producer Responsibility Organization (PRO) is a company or organization set up by manufacturers to help meet their regulatory obligations for reclaiming and recycling waste from products. These organizations are common in electronics-related areas, where used parts are often hazardous and need special disposal techniques.[11]
Preparation for reuse	Preparation for re-use comprises any operation performed to bring used electrical and electronic equipment or its components into a condition to meet the requirements of a next potential owner. In general, this activity may contain the steps of: disassembly; cleaning (including data erasure); inspection; component exchange; component retrieval; component reprocessing; reassembly, including recombination of parts; and testing.[15]

[1] *End-of-life management for ICT equipment. ITU, 2012. Retrieved from https://www.itu.int/dms_pub/itu-t/oth/4B/04/T4B0400000B0013PDFE.pdf. Page: 16*
[2] *MDCG 2021-27 Rev.1 Questions and Answers on Articles 13 & 14 of Regulation (EU) 2017/745 and Regulation (EU) 2017/746. https://health.ec.europa.eu/document/download/82d9adbc-dbf0-40d4-93ed-ade673c8232a_en?filename=mdcg_2021-27_en.pdf. Page 3.*
[3] *[b-EC-WEEE] ITU-T L.1021, 2018. Retrieved from https://api.globalewaste.org/publications/file/177/L-1021-Extended-producer-responsibility-Guidelines-for-sustainable-e-waste-management.pdf. Page 1*
[4] *Introduction to Generators (40 CFR Part 262). United States Environmental Protection Agency, 2005. https://www.epa.gov/sites/default/files/2014-12/documents/gen05.pdf. Page 3*
[5] *U.S. Environmental Protection Agency. (n.d.). Learn the basics of hazardous waste. Retrieved from https://www.epa.gov/hw/learn-basics-hazardous-waste.*
[6] *European Commission, 2020. Factsheet for authorised representatives, importers, and distributors of medical devices and in vitro diagnostic medical devices. Retrieved from https://ec.europa.eu/health/md_newregulations/overview_en.*
[7] *ICLS, 1993 apud Institute for Economic Justice Job Summit Policy Brief Series – Stream 3, Policy Brief 1: Informal Economy/Sector – August 2018. https://iej.org.za/wp-content/uploads/2020/07/Stream-3-Policy-Brief-1-Informal-Economy-Sector.pdf. Page 2.*
[8] *Corporate Finance Institute. (n.d.). Manufacturer. Corporate Finance Institute. Retrieved from https://corporatefinanceinstitute.com/resources/valuation/manufacturer/#:~:text=What%20is%20a%20Manufacturer%3F,production%20of%20more%20complex%20goods.*
[9] *ERAN. (n.d.). Glossary. Retrieved May 15, 2024, from https://eranpc.co.za/resources/glossary/.*
[10] *Adapted from ISO IWA 19:2017, 2017. Retrieved from https://www.iso.org/obp/ui#iso:std:iso:iwa:19:ed-1:v1:en:ref:39.*
[11] *Second Life, 2022. The Role of Producer Responsibility Organization (PRO). Retrieved from https://www.secondlife.earth/learning-center/role-producer-responsibility-organization.*

Processing	Processing of WEEE involves collecting, manually sorting, and disassembling waste electrical and electronic equipment, followed by mechanical processing to break down materials, and then separating and recovering valuable metals, plastics, and other components, while safely disposing of hazardous substances.[12]
Producer	Producers are defined as any organization manufacturing, assembling and / or importing EEE. This group is composed of the hardware brands and their associations (IT association, consumer electronics, electronic components, etc...), but also of "unidentified" producers, when the equipment is non-branded.[13]
Recycling	Waste materials are reprocessed into products, materials or substances whether for the original or other purposes[14]
Refurbishing	Refurbishment comprises any action necessary to restore a unit up to a defined condition in function and form that may be inferior to a new unit. The output product meets the original functionality specifications. To refurbish a product requires disassembling the unit only to the extent that is required to ensure the testing and reprocessing of all components does not meet these specifications. The unit's composition and design is not changed significantly.[15]
Remanufacture	Remanufacturing comprises any action necessary to build up as-new products using components taken from previously used electrical and electronic equipment as well as new components, if applicable. The output product meets the original OEM functionality and reliability specifications.[15]
Repair	Repair comprises any action necessary to correct any faults in a unit preventing its specified operation. The output product is in functioning condition. To repair a unit requires only process steps necessary to restore the specified operation. The unit's composition and design are not changed significantly.[15]
Retailer	An individual or company or business entity that sells goods to consumers through various distribution channels, including physical stores and e-commerce platforms. Retailers also play a role in e-waste management by providing collection points for consumers to return their old or unwanted EEE. These collection points can be found at retail stores, service centres or designated drop-off locations. Retailers are responsible for properly handling e-waste and transferring it to approved recycling facilities.[16]
Reuse	Re-use of electrical and electronic equipment or its components is to continue the use of it (for the same purpose for which it was conceived) beyond the point at which its specifications fail to meet the requirements of the current owner and the owner has ceased use of the product.[15]
Service provider	Operator engaging in one or more of the following activities: transporting, dismantling, aggregating, interim storage prior to export, or recycling facility for cooling, lighting, and photovoltaic equipment.
Unofficial business activities	Economic activities carried out by economic operators not registered as legal entities (i.e. without an operating license) with income greater than the legal minimum wage as well as above the subsistence-level minimum; these operators deliberately evade compliance with local or national regulations.[17]
Valuable fractions	Valuable fractions of E-waste refer to fractions with market demand, for which the market is willing to pay. It may be necessary, however, to prepare the materials before sale, for instance by size reduction.[18]
WEEE	A complex mixture of materials and components that, because of their hazardous content and if not properly managed, can cause major environmental and health problems.[3]
Waste prevention	Practical actions that reduce the waste quantity and/or the hazard potential and/or the hazardous content of products and materials prior to becoming wastes. Prevention may include strict avoidance, source reduction, and direct reuse.[3]

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[12] HSE. (n.d.). Waste Electrical and Electronic Equipment recycling (WEEE). Retrieved from HSE website: https://www.hse.gov.uk/waste/waste-electrical.htm.

[13] Schluep, M., Müller, E., & Rochat, D., 2012. e-Waste Assessment Methodology: Training & Reference Manual. e-Waste Africa project of the Secretariat of the Basel Convention. Retrieved from https://www.unep.org/resources/report/e-waste-assessment-methodology-training-reference-manual. Page 17

[14] EACO East African Communications Organization Working Group 07 on E-Waste Management and Green ICTs. Regional E-Waste Management Strategy 2022-2027.

[15] Solving the E-Waste Problem (StEP) White Paper: One Global Understanding of Re-Use — Common Definitions. United Nations University/StEP Initiative, 2009. Solving the E-Waste Problem (StEP) White Paper: One Global Understanding of Re-Use — Common Definitions. United Nations University/StEP Initiative, 2009. https://www.step-initiative.org/files/_documents/whitepapers/StEP_TF3_WPCommonDefinitions.pdf. Page: 8

[16] Mondaq, 2022. India - Waste Management - A New Dimension to E-Waste Management in India: E-Waste Management Rules 2022 & The Global E-waste Monitor 2024 by ITU. https://www.mondaq.com/india/waste-management/1307756/a-new-dimension-to-e-waste-management-in-india-e-waste-management-rules-2022-. https://www.itu.int/hub/publication/d-gen-e_waste-01-2024.

[17] Adapted from ISO IWA 19:2017, 2017. Retrieved from https://www.iso.org/obp/ui#iso:std:iso:iwa:19:ed-1:v1:en:ref:39.

[18] ERAN. (n.d.). Glossary. Retrieved May 15, 2024, from https://eranpc.co.za/resources/glossary/.

HOW TO READ THESE GUIDELINES

The United Nations Industrial Development Organization (UNIDO) is the specialized agency of the United Nations (UN) that promotes industrial development for poverty reduction, inclusive globalization, and environmental sustainability. UNIDO is implementing a project entitled "Energy Efficient Lighting and Appliances in Southern and Eastern Africa" (EELA) to create market and institutional conditions to transform the market environment to stimulate increased diffusion of efficient lighting products and appliances across all sectors in the East African Community (EAC) and Southern African Development Community (SADC) (hereinafter "the Regions"). The project is implemented by UNIDO in cooperation with the East African Centre of Excellence for Renewable Energy and Efficiency (EACREEE) and the SADC Centre for Renewable Energy and Energy Efficiency (SACREEE).

The purpose of these Guidelines is to support government institutions in the development of policies, standards, and promotion of practices for sustainable e-waste management in the EAC and SADC regions, namely for lighting and cooling equipment, and solar panels. The document suggests supplementary measures and points that support the recommendations, particularly the development of extended producer responsibility (EPR) policies and harmonizing data and performance standards. The technical recommendations extend to the whole supply chain but emphasize refurbishment and treatment of those categories including Waste Electric and Electronic Equipment (WEEE) preventing harm to individuals and the environment.

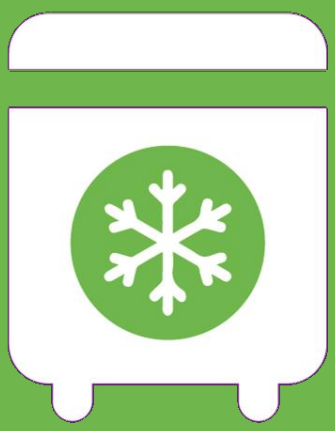
The Guidelines begin with the results of a situational analysis including Electric and Electronic Equipment (EEE) and WEEE statistics, an infrastructure assessment, a policy overview on WEEE and EPR, and positive regional initiatives in Section II. A brief explanation on the components and properties of the 3 WEEE streams in question is presented in Section 0, along with explanations in their intrinsic value and hazards. Sections 1 to 5 then expand on recommendations on strategic 1), legislative (2), infrastructural (3), financial (0), and social (0) levels.

For understanding these Guidelines, it is necessary to remember that materials in many electronics do not have any value, and those which do, often require high-end technologies for their extraction. Therefore, governments should consider the best approaches to ensure the best possible combination of local manual dismantling and pre-processing techniques in combination with foreign buyers for valuable components.

The plurality and heterogeneity of the members of the EAC and SADC Regions are acknowledged. Therefore, the Guidelines propose standardized approaches regardless of the stage of development and implementation of policies in member states, for each country to tailor measures and cascade provisions to fit its context.

As a final note, these recommendations are to the best of the authors' ability harmonized with publications by the East African Communications Organisation (EACO), International Telecommunication Union (ITU), Africa Telecommunications Union (ATU), and International Renewable Energy Agency (IRENA).

INTRODUCTION



I. SITUATIONAL ANALYSIS & LEGISLATIVE CONTEXT

Data and statistics

To understand data and statistics, defining WEEE categories is necessary. Although different WEEE legal classifications exist, these are often based on the European Union's system (see Annex 4)[19]. Essentially, lamps and any device with a plug or batteries can be classified as e-waste. This document will focus on i) lighting equipment, ii) cooling equipment, and iii) solar panels in its propositions and solutions.

In order to understand the magnitude of WEEE generation in a country, there are some strategies that can be followed to make estimates, for example analyzing EEE imports data from customs. Countries should ideally have a registry of EEE imports using Harmonized System codes (HS codes) (see Annex 5). Manufactured or imported equipment "Put on the Market" (POM) for statistics purposes, combined with devices' average lifetimes and average weights, can provide an estimate of WEEE generation trends. By the date of this report, virtually all cooling, lighting, and photovoltaic equipment was imported to the EAC and SADC regions. Except for five countries (Eswatini, Rwanda, South Africa, Uganda, and Zimbabwe) manufacturing refrigerators and freezers[20], no Original Equipment Manufacturers (OEM) for solar panels, lighting equipment, and air conditioners were identified by the date of the study.

Obtaining statistics for used Electric and Electronic Equipment (UEEE) is challenging, since local refurbishment and repair efforts are not documented and reported. Because EEE becomes waste at varying points in time depending on usage, POM, UEEE and estimations of their stock in households and businesses are helpful to predict WEEE generation rates. Table 1 presents comparative examples of WEEE generation rates and formal collection in the Region.

According to the Global E-waste Monitor from International Telecommunication Union (ITU), the generation rate of WEEE increased from 300,000 to 430,000 tons per year in the EAC and from 500,000 to 580,000 tons per year in the SADC between 2019 and 2022[21]. Moreover, in many countries, e-waste is the fastest growing waste component.

Table 1: WEEE generation per country, for 2022[22].

	Unit	Madagas-car	Kenya	Rwanda	South Africa	Tanzania	Uganda	Zambia	Africa	World
Population	1000	29,260	53,490	13,618	59,646	64,530	46,584	19,740	1,408,201	7,951,000
Yearly WEEE generation	1000 t/y	19	88	10	527	61	41	23	3,551	61,908
Per capita generation	kg/ y cap	0.6	1.6	0.7	8,8	0.9	0.9	1.1	2.5	7.8
Formal collection	1000 t/y	0	0	2	23	0	0	0	25	13,800
EoL Lamps	1000 t/y	4	12	2	64	8	8	3	n/a	7,800
EoL cooling equipment	1000 t/y	3	24	2	137	12	8	6	n/a	13,300

[19] *For statistical purposes, however, some studies additionally adhere to the United Nations University's 54 categories and HS codes (see Annex 4 and Annex 5 for more details).*
[20] *United for Efficiency (UNEP-U4E) 2021. Overview of the Market on Refrigerating Appliances and Room Air Conditioners in East and Southern Africa.*
[21] *Cornelis P. Baldé et al., 2024. International Telecommunication Union (ITU) and United Nations Institute for Training and Research (UNITAR). Global E-waste Monitor Geneva/Bonn. ewastemonitor.info/wp-content/uploads/2024/03/GEM_2024_18-03_web_page_per_page_web.pdf.*
[22] *Global E Waste Monitor 2024 and Global E-waste Statistics Partnership (GESP), 2024; Hussein Mohamed Omar, 2022. "Solid waste management related legislation: Analysis of its adequacy for implementation of extended producer responsibility schemes in Tanzania," International Journal of Environmental Analytical Chemistry.*

	Unit	Madagas-car	Kenya	Rwanda	South Africa	Tanzania	Uganda	Zambia	Africa	World
EOL solar panels	1000 t/y	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	600

Formal Infrastructure for WEEE

The total refurbishment and treatment capacity (tons per year) for cooling, lighting, and photovoltaic equipment in the EAC and SADC is unknown. While pre-sorting and dismantling are mostly performed by informal or semi-formal actors and generally not documented nor reported for WEEE, few countries have formal infrastructure for advanced recovery and treatment (namely South Africa, Namibia, Rwanda)[23]. In South Africa, one of the most regulated WEEE markets in the continent, the majority of the companies are aggregating equipment rather than recycling it[24].

Despite refurbishers' efforts to repurpose or repair EEE, design for repair is not a premise for many international OEMs, and sufficient spare parts are likely to be either unavailable in some EAC and SADC countries or too expensive to promote such practices effectively. A system that ensures manufacturers encourage consumers to purchase functional spare parts would be useful but is not widely available for most WEEE streams, including cooling and photovoltaic equipment. Outdated equipment and variations in models are an additional challenge.

At the same time, informal and semi-formal actors operate at variable degrees of safety while attempting to recover valuable components inside cooling and photovoltaic devices. While most informal e-waste workers are knowledgeable in identifying valuable components within cooling equipment and are skilled in retrieving them, no incentives (and limited technical possibilities) exist for handling hazardous components in them (see 0). Since lamps typically cannot be refurbished, they are discarded and, in the best case, landfilled[25]. General data and statistics on refurbishers for WEEE or a public registry are generally not available in the regions.

For solar panels, distributors may offer support and troubleshoot or exchange damaged panels within the warranty period, which is usually 6 to 12 months after commissioning a unit. For solar parks, case-by-case conditions apply and are usually established contractually prior to shipment. Normally, initial performance tests are conducted for newly shipped panels, and defective or damaged units are sent back. Generally, all defective or end-of-life (EoL) solar panels are either shipped back to the producer for reprocessing or landfilled locally. Of all its valuable materials, only aluminium can be recovered manually or with basic tools and resold in local markets.

The time taken to obtain a license to operate a WEEE management facility and the associated costs of Environmental Impact Assessment (EIA) studies and other investigations are a constraint experienced by firms across all stages of the value chain[26]. Additionally, a challenge faced by formal facilities to treat on an advanced level (beyond manual dismantling), especially for cooling equipment, is obtaining the recognition by the Basel, Rotterdam, and Stockholm (BRS) Secretariats. This means that a facility located in an EAC or SADC country, able to manage a certain category of WEEE, will not be allowed to import materials from neighboring countries until it can be recognized by BRS, thereby foregoing gate fees and material flows to European or other facilities[27].

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[23] United Nations Institute for Training and Research (UNITAR), International Telecommunication Union (ITU), & International Solid Waste Association (ISWA), 2024. Global E-waste Monitor 2024. United Nations. Retrieved from: https://ewastemonitor.info/the-global-e-waste-monitor-2024/.

[24] Lydall, M., Nyanjowa, W., & James, Y., 2017. Mapping South Africa's WEEE dismantling, pre-processing and processing technology landscape. Waste research development and innovation roadmap research report.

[25] Only South Africa has banned the landfilling of WEEE.

[26] EACREEE, 2019. Overview of the On-Grid and Off-Grid Lighting Markets in East and Southern Africa. Retrieved from: https://www.eacreee.org/sites/default/files/eela/reports/att/EELA_SADC_and_EAC_Lighting_Market_Assessment_Report_v.2.0.pdf.

[27] Stakeholder consultation with EPR policy expert and R2 project manager in Kenya, Ms. Sarah Njahu. 15.04.2024

Also relevant for infrastructure are collection vehicles, especially for bulky cooling and photovoltaic devices, and "drop-off points" or collection points for lamps. Collection capacities, such as the number of licensed transporters and tonnages per year, are unknown. Care should be taken when transporting solar panels to repair or export back to maximize resource recovery. For safety, refrigerators should always be transported upright to prevent damage to the compressor and refrigerant system.

International Law & Regional Initiatives

The Basel, Bamako, and Stockholm Conventions are the main instruments regulating the use and trade of cooling, lighting, and photovoltaic equipment and their components (see Annex 2 for details). While some EAC and SADC members have ratified the Conventions, definitions, classifications, and, in particular, differences between EEE for re-use and WEEE among countries lead to ambiguities. Harmonization is needed to successfully prevent illegal WEEE trade, for example establishing what constitutes conclusive proof of offences, non-negligible quantities, offensive behaviour, and functionality tests[28]. Nonetheless, compliant WEEE intra-African trade takes place between South Africa, Nigeria, and Tunisia, Congo, Zimbabwe, and Mozambique[29].

The East African Communications Organisation (EACO) aims to harmonize policies, strategies, and regulations on e-waste management in the region. Under a regional e-waste Strategy[30], Tanzania, Rwanda, Uganda, Burundi, Kenya, and South Sudan discuss coordination structures and a common framework that can be "cascaded" into national levels. Although the EACO is primarily focused on telecommunications equipment, the strategy encompasses all WEEE.

The Common Market for Eastern and Southern Africa (COMESA), on the other hand, is a free trade area with 21 Member States[31] and promotes increased cooperation and integration in i) infrastructure, industry, and private sector development, ii) trade and custom services, and iii) gender and social affairs. COMESA has participated in the development of harmonised Minimum Energy Performance Standards (MEPS)[32] for its members and could contribute to similar initiatives.

The East African Standards Committee (EASC) works for the standardization and conformity assessment at regional and national level. The Committee also maintains the catalogue and authoritative texts declared "East African Standards". Similarly, the Southern African Development Community Cooperation in Standardization (SADCSTAN) works for the standardization and conformity assessment in the SADC region. The EASC and the SADCSTAN may be the stakeholders able to promote standards and certifications schemes such as the e-Stewards Standard, EPEAT, or EN 50625[33].

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[28] *INTERPOL, 2015. Countering WEEE Illegal Trade Market Analysis - Recommendations roadmap Summary Report.*
[29] *International Telecommunication Union and the World Economic Forum, 2021. Policy practices for e-waste management. Geneva: International Telecommunication Union. api.globalewaste.org/publications/file/278/Policy-practices-for-e-waste-management.pdf*
[30] *The Regional E-Waste Management Steering Committee Under EACO Working Group 07 "Regional E-Waste Management Strategy, 2022 – 2027". https://www.eaco.int/admin/docs/publications/EACO%20Regional%20E-waste%20Management%20Strategy%202022-2027.pdf.*
[31] *Burundi, Comoros, Democratic Republic of Congo, Eswatini, Kenya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Somalia, Sudan, Uganda, Zambia and Zimbabwe*
[32] *The United Nations Environment Programme (UNEP), together with the EACREEE and SACREEE, are collaborating under the United for Efficiency (U4E) initiative to harmonize Minimum Energy Performance Standards (MEPS) for cooling products like air conditioners and refrigerators within the EAC and SADC. This involves regional market assessments, development of harmonized MEPS and labels, and technical support for implementation, with the goal of ensuring a minimum performance of imported equipment and standard metrics for assessing its efficiency.*
[33] *Standards applied in mature WEEE regulated markets for service providers and recyclers.*

Existing national policies

Across the EAC and SADC regions, there is a wide spectrum of regulatory developments regarding e-waste, with each country at a different stage of policy drafting, ratifying, and implementation. Rwanda and South Africa are the only countries to have implemented both e-waste and EPR legislation. Kenya, Madagascar, Tanzania, Uganda, and Zambia are either revising or developing e-waste and/or EPR regulations and drafts. Figure 1 illustrates the status of WEEE/EPR legal developments in the region and Annex 3 lists them.

Angola, Botswana, Comoros, Congo, Eswatini Kingdom, Lesotho, Malawi, Mauritius, Mozambique, Seychelles, Somalia, South Sudan, and Zimbabwe have not developed formal policy framework for e-waste management and EPR, highlighting the varied stages of regulation and implementation across the region.

As for EEE, there are special regulations for lighting and cooling equipment in some of the EAC and SADC countries. For the first, Kenya, Madagascar, Namibia, Seychelles, South Africa, Uganda, Zambia, and Zimbabwe have adopted MEPS on a certain degree and have drafted energy-efficiency policies, demanded labelling efforts and compulsory specifications, as well as banned some technologies (South Africa banned incandescent lighting in 2014)[34].

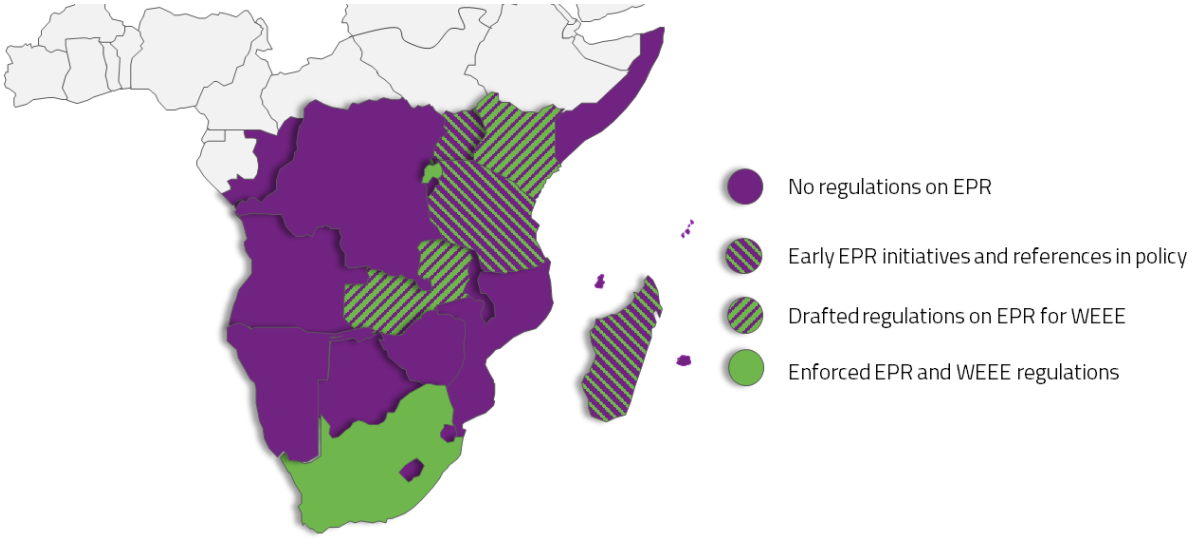

Figure 1: EAC and SADC regulation status on WEEE and EPR. Source: BFS 2024.

Needs assessment

To ensure more effective management of WEEE in the EAC and SADC regions, several needs have been identified. Below are the key needs categorized into four sections: Legal, Infrastructural, Financial, and Capacities and Awareness.

Legal

1. **Clear WEEE and EPR (or similar framework) regulations enactment:** Implementing clear regulations for WEEE and EPR frameworks is crucial for establishing accountability among manufacturers, importers, and distributors. These regulations ensure that all parties involved are responsible for the entire lifecycle of electrical and electronic products, from production to end-of-life disposal. Such frameworks help in reducing environmental impact

[34] *EACREEE, 2019. Overview of the On-Grid and Off-Grid Lighting Markets in East and Southern Africa. https://www.eacreee.org/sites/default/files/eela/reports/att/EELA_SADC_and_EAC_Lighting_Market_Assessment_Report_v.2.0.pdf Last access April 2024*

and promoting sustainable practices by mandating proper recycling and disposal mechanisms.

2. **Regional harmonized WEEE classifications & equivalences between them:** Harmonizing WEEE classifications across regions ensures consistency and efficiency in handling e-waste. By establishing equivalent categories and standards, it becomes easier to manage and track e-waste, facilitating better data collection and reporting. This harmonization supports international trade compliance and helps in comparing and analysing WEEE management practices across different countries, promoting regional cooperation and improved regulatory compliance.
3. **Improved monitoring & quality control of imported goods with minimum performance standards:** Enhancing the monitoring and quality control of imported goods is essential to prevent the influx of low-quality, short-lifespan products that quickly become e-waste. Setting minimum performance standards ensures that only durable and efficient products enter the market, thereby reducing the overall volume of e-waste generated. This approach also protects consumers and promotes the importation of environmentally friendly and sustainable products.
4. **Realistic but binding collection targets:** Establishing realistic yet binding collection targets for e-waste ensures that sufficient amounts of WEEE are collected and properly processed. These targets motivate stakeholders to actively participate in e-waste management programs and ensure that the collected e-waste is channelled through formal recycling processes. Binding targets also provide a measurable benchmark for assessing the effectiveness of e-waste management strategies and policies.
5. **WEEE trade compliant with Basel & Bamako conventions:** Ensuring that the trade of WEEE complies with international conventions like Basel and Bamako is critical for preventing illegal dumping and promoting environmentally sound management of hazardous wastes. These conventions provide guidelines for the transboundary movement of hazardous wastes, ensuring that they are managed and disposed of safely. Compliance with these conventions helps in safeguarding human health and the environment from the harmful effects of improper e-waste disposal.
6. **Comparable requirements for licensed recyclers & transporters:** Establishing comparable requirements for licensed recyclers and transporters ensures a level playing field and promotes fair competition within the e-waste management sector. These requirements include standards for operational practices, safety protocols, and environmental compliance. By standardizing these criteria, it becomes easier to regulate and monitor the activities of recyclers and transporters, ensuring waste is handled responsibly.

Infrastructural

7. **Data on technological and infrastructural capacities & gaps:** Collecting comprehensive data on the existing technological and infrastructural capacities is essential for identifying gaps and planning necessary investments. This data helps in understanding the current state of e-waste management facilities, their capabilities, and the areas that require improvement. Accurate data collection supports informed decision-making and the development of targeted strategies to enhance e-waste management infrastructure.
8. **Feasibility studies of needed investment in advanced recycling capacities (reducing exports to Europe & promoting circularity in EAC and SADC):** Conducting feasibility studies to assess the investment needs for advanced recycling capacities is crucial for promoting

circular economy principles within the EAC and SADC regions. By reducing the dependency on exporting e-waste to Europe and developing local recycling facilities, these regions can create sustainable waste management systems. Feasibility studies provide insights into the economic viability and technical requirements for establishing these facilities, ensuring efficient resource utilization and waste minimization.

9. **Landfill bans for WEEE are not enforceable without adequate alternatives:** Implementing landfill bans for WEEE is ineffective without providing adequate alternatives for proper e-waste disposal and recycling. Ensuring that there are sufficient facilities and systems in place for collecting, processing, and recycling e-waste is essential before enforcing such bans. This approach prevents illegal dumping and encourages responsible disposal practices, protecting the environment and human health.
10. **Sufficient interim storage solutions for transboundary cooperation:** Establishing sufficient interim storage solutions for e-waste is necessary to facilitate transboundary cooperation and efficient waste management. Interim storage facilities provide a safe and temporary holding space for e-waste before it is transported to recycling or disposal facilities. These solutions support regional collaboration in managing e-waste and ensure that it is handled and stored safely, reducing the risk of environmental contamination.
11. **Safe & efficient refurbishment capacities and spare parts availability:** Developing safe and efficient refurbishment capacities, along with ensuring the availability of spare parts, is crucial for extending the lifespan of electrical and electronic products. Refurbishment reduces the volume of e-waste generated and promotes the reuse of products. Ensuring the availability of spare parts supports these refurbishment activities and encourages consumers to repair and maintain their devices rather than disposing of them.

Financial

12. **EPR or similar framework to ensure sufficient budgets for WEEE handling:** Implementing an EPR or similar framework ensures that sufficient financial resources are allocated for the proper handling and management of WEEE. By distributing financial responsibility among producers, importers, and distributors, these frameworks generate funds needed for collection, recycling, and disposal activities. This financial mechanism supports the development and maintenance of sustainable e-waste management systems.
13. **Legal enforcement and guarantees to promote investment and Public-Private-Partnerships:** Providing legal enforcement and guarantees is essential for attracting investment and promoting public-private partnerships (PPPs) in e-waste management. Legal frameworks that ensure compliance and protect investments encourage private sector participation and collaboration with public entities.
14. **Financial incentives for managing WEEE fractions without market value:** Offering financial incentives for managing WEEE fractions that lack market value encourages the proper handling and recycling of all types of e-waste. These incentives compensate for the costs associated with processing and disposing of non-valuable fractions, ensuring that they are managed responsibly. Financial support for such activities promotes comprehensive e-waste management and reduces the risk of illegal dumping.
15. **Investment needed to improve treatment capacities and thus reduce exports:** Investing in improving local treatment capacities for e-waste is essential for reducing the dependency on exporting waste to other regions. Developing advanced recycling and treatment facilities locally promotes a circular economy and ensures that valuable materials are recovered and

reused. Investment in these capacities supports sustainable e-waste management practices and minimizes the environmental impact of e-waste exports.

16. **Fair competition for licensed companies (limiting informal/semi-formal sectors):** Ensuring fair competition for licensed companies by limiting the activities of informal and semi-formal sectors is crucial for maintaining high standards in e-waste management. Regulating and formalizing these sectors ensure that e-waste is handled by licensed and compliant entities, promoting environmental and safety standards. Fair competition encourages innovation and investment in the e-waste management sector.
17. **Formalization of informal organizations to follow standards & report data:** Formalizing informal organizations involved in e-waste management ensures that they follow established standards and report data accurately. This process integrates these organizations into the formal sector, providing them with access to resources and support for improving their practices. Formalization promotes transparency, accountability, and compliance with environmental regulations, enhancing the overall effectiveness of e-waste management systems.

Capacities and Awareness

18. **Raising public awareness to improve formal WEEE collection:** Raising public awareness about the importance of proper e-waste disposal and the available collection mechanisms is essential for improving formal WEEE collection rates. Educational campaigns and outreach programs inform the public about the environmental and health impacts of e-waste, encouraging responsible disposal practices. Increased awareness leads to higher participation in formal collection programs and reduces the incidence of improper e-waste disposal.
19. **Capacity building to promote regulation and standard adherence among retailers, importers, authorities, formal recyclers, transporters, and informal actors:** Building the capacities of all stakeholders involved in the e-waste management chain ensures adherence to regulations and standards. Training programs and workshops provide retailers, importers, authorities, recyclers, transporters, and informal actors with the necessary knowledge and skills to manage e-waste responsibly. Capacity building promotes compliance, improves operational efficiency, and enhances the overall effectiveness of e-waste management systems.
20. **Harmonization in WEEE classification and reporting across countries' customs, statistics, and trade authorities in the region (supporting legal trade):** Harmonizing WEEE classification and reporting across countries' customs, statistics, and trade authorities supports legal trade and efficient e-waste management. Standardized classifications and reporting mechanisms facilitate accurate data collection, monitoring, and analysis. This harmonization ensures consistency in e-waste management practices and promotes regional cooperation and compliance with international trade regulations.

A summary of needs in the regions for an improved handling of WEEE is presented below. The Guidelines in 0 have been developed considering these gaps.

Summary of the needs assessment in the Regions for better WEEE management

Legal

1. Clear WEEE and EPR (or similar framework) **regulations enactment**
2. Regional **harmonized WEEE classifications** & equivalences between them
3. Improved monitoring & quality **control of imported goods** with minimum performance standards
4. Realistic but **binding collection targets**
5. **WEEE trade compliant with Basel & Bamako conventions**
6. **Comparable requirements for licensed recyclers & transporters**

Infrastructural

7. **Data on technological and infrastructural capacities & gaps**
8. **Feasibility studies of needed investment in advanced recycling capacities (reducing exports to Europe & promoting circularity in EAC and SADC)**
9. **Landfill bans for WEEE are not enforceable without adequate alternatives**
10. Sufficient **interim storage** solutions for transboundary cooperation
11. **Safe & efficient refurbishment capacities and spare parts availability**

Financial

12. EPR or similar framework to ensure **sufficient budgets** for WEEE handling
13. Legal enforcement and guarantees to **promote investment** and Public-Private-Partnerships
14. Financial incentives for managing **WEEE fractions without market value**
15. Investment needed to improve treatment capacities and thus **reduce exports**
16. **Fair competition for licensed companies** (limiting informal/semi-formal sectors)

Capacities and awareness

18. Raising **public awareness** to improve formal WEEE collection
19. **Capacity building to promote regulation and standard adherence among retailers, importers, authorities, formal recyclers, transporters, and informal actors**
20. Harmonization in WEEE **classification and reporting** across countries' customs, statistics, and trade authorities in the region (supporting legal trade)

II. TECHNICAL CONSIDERATIONS FOR LIGHTING, COOLING, AND PHOTOVOLTAIC EQUIPMENT

Lighting equipment

Different product types are described and illustrated in Table 2 and Figure 2. United Nations University (UNU) Key Description is a system used to categorize types of electronic and electrical equipment for waste management and recycling. Lamps are mainly made from glass, but may also contain mercury, lead, barium, arsenic, nickel, copper, phosphorous, and combinations thereof, posing pollution and health risks at their end of life (EOL). When in contact with water and acids stemming e.g. from organic wastes, heavy metals can leach into soil and groundwater. The lipophilic properties of these metals result in their accumulation in animal tissue and the food chain. Mercury exposure can lead to neurological and developmental issues, while lead toxicity can cause neurological damage and developmental harm[35]. Exposure to arsenic can lead to various health issues, including skin, lung, bladder, and liver cancer, while inhalation of their and other metal fumes can lead to additional respiratory issues[36].

Table 2: HS codes and UNU key for lighting equipment[37] [38].

UNU Key	UNU Key Description	HS Code	HS Description
0501	Lamps (pocket, Christmas, excl. LED & incandescent)	851310-210	Portable, electric, designed to function by their own source of energy (excluding no. 8512) / Lighting or visual signaling equipment; electrical, of a kind used on bicycles, excluding articles of heading no. 8539
0502	Compact Fluorescent Lamps (incl. retrofit & non-retrofit)	853931-90	Discharge lamps, fluorescent, hot cathode (excl. with double ended cap)
0503	Straight Tube Fluorescent Lamps	853941-49	Arc-lamps/ Ultra-violet or infra-red
0504	Special Lamps (professional mercury, high- & low-pressure sodium)	853931-32-39	Fluorescent lamps, hot cathode/Mercury or sodium vapour/ Discharge lamps, other than ultra-violet lamps
0505	LED Lamps (incl. retrofit LED lamps & household LED luminaires)	NA	NA
0506	Household Luminaires (incl. household incandescent fittings)	940510/20/30	Chandeliers, other electric ceiling or wall lights/Lamps, electric; floor-standing or for table, desk or bedside/Lighting sets of a kind used for Christmas trees.
0507	Professional Luminaires (offices, public space, industry)	940540	Lamps and light fittings

[35] *Kornaros, M., & Mahmoud, Y. A.-G., 2023. Toxicity of heavy metals and recent advances in their removal: A review. Toxics, 11(7), 580. Retrieved from: https://doi.org/10.3390/toxics11070580.*

[36] *Balali-Mood, M., Naseri, K., Tahergorabi, Z., Khazdair, M. R., & Sadeghi, M., 2021. Toxic mechanisms of five heavy metals: Mercury, lead, chromium, cadmium, and arsenic. Frontiers in Pharmacology, 12, 643972. Retrieved from: https://doi.org/10.3389/fphar.2021.643972*

[37] *United Nations University (UNU), Statistics Netherlands (CBS), BIO Intelligence Service by Deloitte (BIO), & Regional Environmental Center (REC). 2014. Study on collection rates of waste electrical and electronic equipment (WEEE): Possible measures to be initiated by the Commission as required by Article 7(4), 7(5), 7(6) and 7(7) of Directive 2012/19/EU on waste electrical and electronic equipment (WEEE). Retrieved from: https://ec.europa.eu/environment/pdf/waste/weee/Final_Report_Art7_publication.pdf.*

[38] *Forti, V., Baldé, C.P., & Kuehr, R. (2018). E-waste Statistics: Guidelines on Classifications, Reporting and Indicators (2nd ed.). United Nations University, ViE – SCYCLE, Bonn, Germany. ISBN: 978-92-808-9066-2 (Print), 978-92-808-9067-9 (Digital).Retrieved from: https://collections.unu.edu/eserv/UNU:6477/RZ_EWaste_Guidelines_LoRes.pdf.*

Figure 2: Examples of lighting equipment[39].

Advanced processing for compact fluorescent lamps (CFL) and crushed lamps usually involves either manual horizontal feeding (fluorescent tubes) or crushing and conveyor transport of materials to a drum sieve. Automatic separation captures glass and fluorescent powder, directing them through a vacuum system for ventilation and dust extraction. Other fractions are sorted within the sieve and subsequently shredded, allowing an electrostatic separator to differentiate valuable non-glass materials into conductive (steel, copper), non-conductive (aluminum, plastic), and mixed categories. A filtration system further separates fluorescent powder from the air, with a final stage removing free mercury gas through an active carbon filter. The recovered fluorescent/mercury powder and contaminated materials (glass, filters) are collected in barrels for further treatment in a distiller and eventual disposal or advanced recovery.

Cooling equipment

Cooling equipment refers to the equipment listed in Table 3. These devices contain several hazardous components, including metals (such as steel, copper, and aluminum), plastics, insulating foam (polyurethane, PUR foam[40]), electronic components (potentially containing lead, cadmium, and mercury), refrigerants (including CFCs, HCFCs, and HFCs with global warming potentials), compressor oils, and mercury. Improper handling and disposal of these components leads to air and water pollution, soil contamination, ozone depletion, climate change aggravation, neurological and developmental issues, carcinogenic effects, and respiratory problems.

New refrigerators and freezers POM do not contain banned and phased-out refrigerant gases or PUR foam, but the equipment in stock in African households will still reach recyclers and refurbishers in years to come.

Table 3: HS codes and UNU key for lighting equipment.

UNU Key	UNU Key Description	HS Code	HS Description
0108	Refrigerators	841821	Refrigerators; for household use, compression-type, electric or other
0108	Refrigerator-freezer	841810	Refrigerators and freezers; combined refrigerator-freezers, fitted with separate external doors, electric or other
0111	Air conditioners	841510-81-82	Air conditioning machines; comprising a motor-driven fan and elements for changing the temperature and humidity, window or wall types, self-contained/ Air conditioning machines; incorporating a refrigerating unit and a valve for reversal of the cooling or heat cycle
0109	Freezer	841830-40	Freezers: of the chest type, not exceeding 800l capacity/ Freezers: of the upright type, not exceeding 900l capacity.

[39] *The University of Chicago, Environmental Health and Safety. https://safety.uchicago.edu/environmental-health/hazardous-waste-and-handling/batteries-lamps-and-ballasts-disposal/ Last access 05/2024*

[40] *PUR foam is a low-dense and very voluminous material, costly to store and transport for that reason. Polyurethane foam contains various chemicals, including isocyanates, flame retardants, and blowing agents, which can release toxic gases when burned. These gases can cause respiratory irritation, dizziness, nausea, headaches, additional to creating smog and acceleration of global warming.*

0108	Refrigerators, compression type	841821	Refrigerators; for household use, compression-type, electric or other
0108	Refrigerators, non-compression type	841829	Refrigerators; household, electric or not, other than compression or absorption-type
0109	Freezers (upright) <800 L	841830	Freezers: of the chest type, not exceeding 800l capacity.
0109	Freezers (upright) <900 L	841840	Freezers: of the upright type, not exceeding 900l capacity.

PUR foam can be treated through mechanical recycling (such as regrinding and adhesive pressing), chemical processing (including hydrolysis and glycolysis), thermochemical processing (like pyrolysis and gasification), and energy recovery by incineration[41]. As for (H)CFCs, they are usually recovered and purified for reuse. The recovery unit is operated to create a vacuum, drawing the HCFCs from the equipment into recovery cylinders, where they undergo filtration and purification to remove moisture, oil, and other contaminants. The purified gases are then transferred to dedicated storage cylinders for transport to reclamation facilities, where they are further processed to remove impurities and meet testing performance standards. This may involve distillation, fractionation, or other purification methods. The reuse of recycled refrigerant is usually restricted to the system from which it was recovered.

Solar panels

Over 90 percent of the current solar cell market has been based on silicon[42]. Cadmium tellurium (CdTe) solar cells are the second most common[43] and Gallium arsenide (GaAs) solar panels exist to a minor extent. They are reported to be efficient and durable, thus desirable in challenging conditions[44]. Some thin-film solar panels additionally contain copper and/or selenium[45].

Solar panels contain a combination of potentially harmful substances such as lead, cadmium, and selenium and rare materials like silver, tellurium, and indium. Materials with high embedded energy values, such as silicon and glass, are also present. One of the main technical challenges to recycling solar panels is delaminating and removing encapsulant material ethylene-vinyl-acetate (EVA). Treatment machine providers for solar panels usually achieve separation and size reduction of ferrous metals, non-ferrous metals, plastic, glass, and EVA.

The recycling process begins by removing the aluminum frame. However, manual removal often results in glass breakage, hindering further component separation. Proper dismantling of the aluminum frame allows for the mechanical separation of glass from silicon wafer and back foils. If not separated properly, broken glass panels containing traces of silver and other materials are typically sent to local cement industries[46]. The major components of c-Si panels, including glass, aluminum, and copper, can be recovered at yields greater than 85% by panel via mechanical separation. However, without additional thermal, chemical and metallurgical steps, impurity levels

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[41] *Zevenhoven, R. (2004). Treatment and disposal of polyurethane wastes: Options for recovery and recycling. Helsinki University of Technology, Department of Mechanical Engineering, Energy Engineering and Environmental Protection Publications. (Report TKK-ENY-19). Retrieved from: http://users.abo.fi/rzevenho/tkk-eny-19.pdf.*

[42] *GreenMatch. (n.d.). Silicon photovoltaic cells. Retrieved June 5, 2024, from https://www.greenmatch.co.uk/solar-energy/solar-panels/photovoltaic-cells/silicon.*

[43] *U.S. Department of Energy. (n.d.). Cadmium telluride. Retrieved June 5, 2024, from https://www.energy.gov/eere/solar/cadmium-telluride#:~:text=CdTe%20solar%20cells%20are%20the,to%20conventional%20silicon%2Dbased%20technologies.*

[44] *Pineda, M., Nerín, C., & Aznar, M., 2021. Plastic pollution research in Mediterranean Islands: A bibliometric study. International Journal of Environmental Research and Public Health, 18(12), 6107. https://doi.org/10.3390/ijerph18126107.*

[45] *El-Deeb, F. M., 2019. Modern processing and insights on selenium solar cells: The world's first photovoltaic device. Journal of Solar Energy Research, 5(1), 12-24. Retrieved from https://www.researchgate.net/publication/331405519_Modern_Processing_and_Insights_on_Selenium_Solar_Cells_The_World's_First_Photovoltaic_Device.*

[46] *GOGLA The Voice of the Off-Grid Solar Energy Industry 2022. E-waste Toolkit Module 1 Briefing Note Technical introduction to recycling of off-grid solar products. 6 7*

are too high to reach high market values[47]. In other words, valuable components in solar panels can be recovered, but only if they are exported considering the current WEEE management situation in EAC and SADC regions.

There are not enough volumes of solar panel waste yet to justify investments in panel recycling plants[48]. They are currently shipped to OEMs or recycling plants or landfilled.

Table 4: HS codes and UNU key for solar panels.

UNU Key	UNU Key Description	HS Code	HS Description
0002	Photovoltaic Panels (incl. inverters)	854140 / 85414012	Photosensitive semi-conductor devices, including photovoltaic cells whether assembled in modules or made up into panels / Solar cells, assembled in modules or made up into panels

Overview of recyclable components in WEEE & advanced mechanical processing options

Because WEEE categories and individual equipment models vary greatly, it is important to consider the intrinsic value of WEEE components in combination with their hazardousness. Usually, the presence of hazardous materials implies that investments are required in advanced processing equipment and staff training and/or disposal fees and transport at a hazardous waste landfill. The presence of valuable materials does not automatically mean that it is physically possible to reclaim them manually or in sufficient quantities to make a profit margin by recyclers. Figure 3 and

Table 5 below illustrates these trade-offs for cooling, lighting, and solar equipment. It is thus evident that additional financing sources, such as EPR schemes, are necessary to incentivize and ensure the adequate treatment of WEEE.

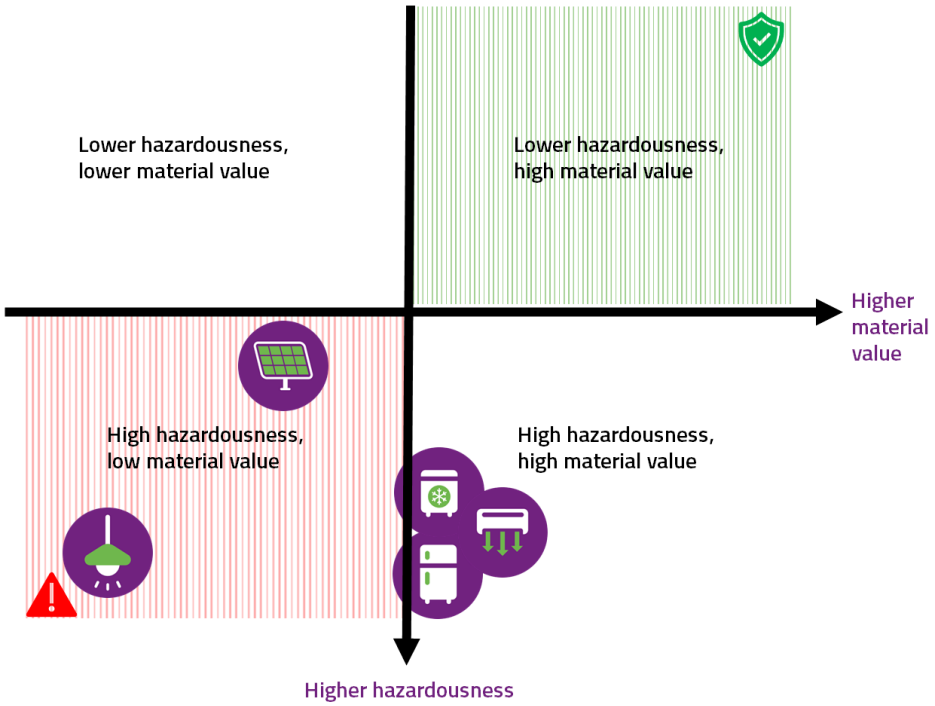

Figure 3: Hazardousness and market value of WEEE and their components tradeoffs.

[47] *Pennington et al., 2016 and Sander et al., 2007 cited in International Renewable Energy Agency (IRENA), & International Energy Agency Photovoltaic Power Systems (IEA-PVPS), 2016. https://www.irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels.*

[48] *International Renewable Energy Agency (IRENA), & International Energy Agency Photovoltaic Power Systems (IEA-PVPS), 2016. End-of-Life Management: Solar Photovoltaic Panels. International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems. https://www.irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels.*

Table 5: Valuable and hazardous materials found in WEEE according to manual & advanced mechanical processing.

		Solar panels (excluding batteries)		Cooling equipment (refrigerators)		Lighting equipment (fluorescent lamps)	
Manual dismantling	**Priority hazardous components & their treatment**	Ethyl Vinyl Acetate (EVA)	OEM recycling	PUR foam	Thermal treatment/ landfill	Mercury	Stabilization
		Heavy metals	Landfill/ advanced recovery	(H)CFCs	Recovery, chemical treatment	Heavy metals	Landfill/ advanced recovery
	Recoverable materials for local markets	Aluminum		Metals Glass		None	
	Materials for disposal	Plastics Mixed cables		PUR foam		All	
	Materials for export	Panel screens		Refrigerants Low-grade boards			
Mechanical processing	**Recoverable materials for local markets**	Aluminum Glass Metals		Glass Ferrous metals		Purified glass Purified metals	
	Materials for disposal	Mixed materials, EVA		Refrigerants PUR foam		Stabilized mercury Mixed components	
	Materials for export	Copper		Low-grade boards Copper		None	

GUIDELINES FOR WASTE COOLING, LIGHTING, & PHOTOVOLTAIC EQUIPMENT IN THE EAC & SADC REGIONS

1. REGIONAL STRATEGY

Key challenges need to be overcome to develop sound e-waste management systems in EAC and SADC regions. These include 1) ensuring funds to kick-start and maintain systems, 2) optimizing collection logistics, 3) enforcing compliance legislation via transparent penalty systems while allowing fair market competition[49]. Policymakers can effectively implement policies by understanding national framework conditions, involving diverse stakeholders in decision-making, and developing a comprehensive strategy.

The EACO's Working Group 7 (e-waste and green ICTs) developed a Strategy for harmonizing and promoting policy developments in 6 East African countries[50]. The expansion of the EACO's scope to remaining EAC countries is desirable, as this could facilitate coordination with other institutions such as the EASC and EACREEE.

In parallel, it is recommended to leverage existing organizations in the SADC region such as SADCSTAN and SADCTRLC, as well as the Institute for Waste Management of Southern Africa (IWMSA), to ensure maximum regional harmonization and synergies achieved by economies of scale and knowledge sharing[51]. According to the EACO's strategy, there would be regional and national steering committees for the SADC. They would be responsible for driving and tracking approaches. Creating working groups that can advise the regional committees for 1) Policy, 2) Finance, and 3) Standards, monitoring, and capacity building.

An important gap in the current EACO strategy (and its potential SADC equivalent) is the absence of a recommended WEEE classification scheme. A common nomenclature would achieve three main objectives: first, that countries without a legal categorization in place may adopt it; second, that trade can be better monitored regardless of domestic national laws; and third, that data analysis and planning can be performed in an efficient way once different categories find their equivalents in the regional standard.

The idea would be to harmonize the EACOs and equivalent SADC regional strategy standards, tools, and objectives as much as possible and cascade them down to national policy. It must be noted that a baseline assessment of the quantity, types, and composition of these WEEE categories in each country is required for decision-making and strategy development at national and regional levels.

2. HARMONIZED E-WASTE POLICY IN THE REGION

EPR is a legal framework that emphasizes the accountability of manufacturers for their products, extending beyond the production phase to encompass their entire lifecycle, including recycling and disposal. By distributing management responsibilities among producers, municipalities, and citizens, EPR ensures the availability of sufficient data and funds to manage WEEE.

Typically, Producer Responsibility Organizations (PROs) are the administrative organizations implementing EPR. EEE producers typically contribute to the funding of this organization in proportion to their market share for the products and their composition. PROs manage relationships among stakeholders and oversee producers' compliance with EPR requirements and targets, being able to proportionally charge EEE producers in relation to their market share. Data, contracts, and funds are transferred by the PRO as illustrated in Figure 4. It is possible to implement

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[49] *Africa Clean Energy Technical Assistance Facility & Sofies, 2019. E-Waste Policy Handbook: Catalysing Africa's Solar Markets.*
[50] *The Regional E-Waste Management Steering Committee Under EACO Working Group 07 "Regional E-Waste Management Strategy 2022 – 2027". Retrieved from: https://www.eaco.int/admin/docs/publications/EACO%20Regional%20E-waste%20Management%20Strategy%202022-2027.pdf.*
[51] *SADC official website, 2024. "Standards & Quality Infrastructure" https://www.sadc.int/pillars/standards-quality-infrastructure.*

EPR without PROs, but a compliance scheme is necessary. Electronics' manufacturers meet these obligations in countries with legal frameworks of Extended Producer Responsibility frameworks – there is no reason why they should not have the same obligations in Africa.

To encourage consumers to hand over their equipment to collection centers, PROs should be responsible for providing incentives such as discounts on new purchases, vouchers, or other financial benefits. These incentives not only increase participation rates but also ensure that e-waste is directed through proper channels for recycling and disposal.

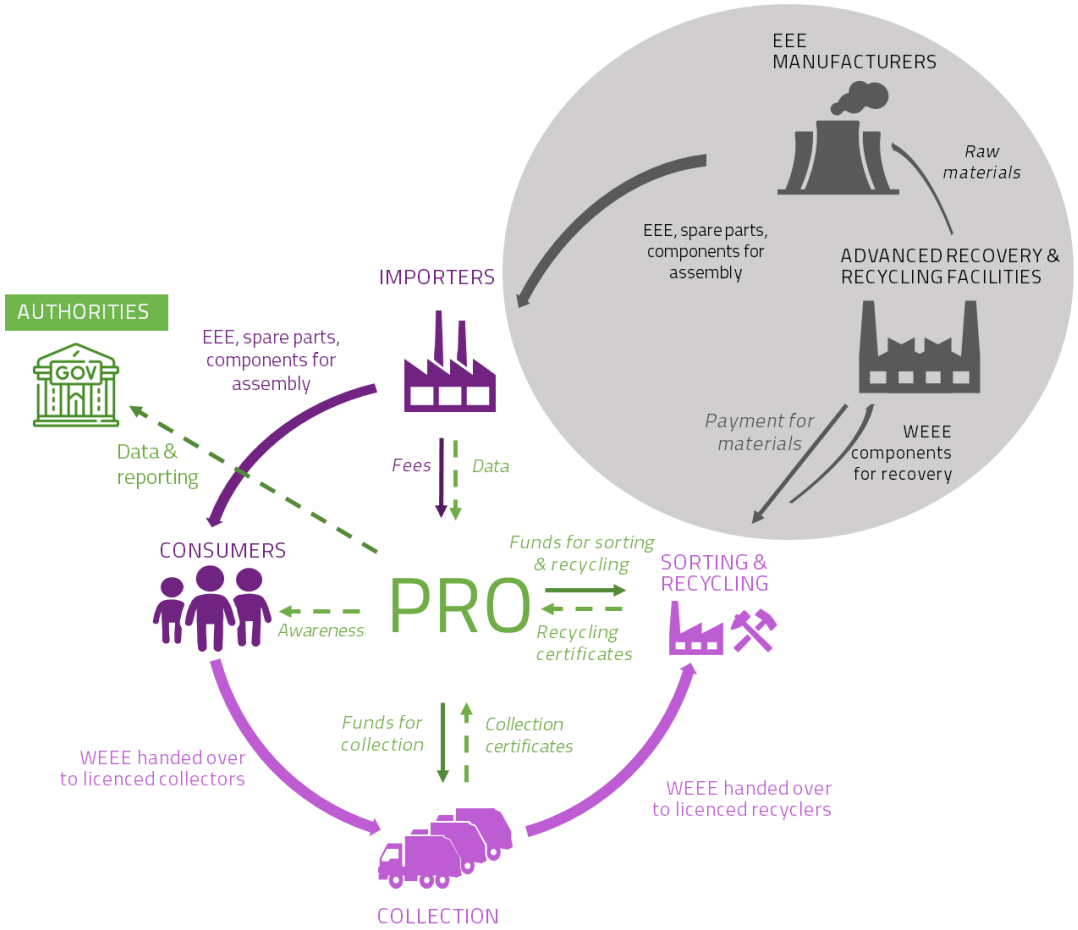

Figure 4: Producer Responsibility Organization model for EPR implementation (the grey circle encompasses actors and activities outside the EAC and SADC).

2.1. Regional WEEE & EPR policy focus areas

Definitions and harmonization

WEEE policy is often combined with EPR policy, as is the case in Uganda and Rwanda, and the EACO's strategy also takes a combined step. Regardless of whether combined or separate WEEE and EPR policies are developed nationally, the main goal is having similar or equivalent definitions and providing a framework to borrow key aspects of the structure of legislation. Especially for data gathering, trade, and feasibility studies, a common EEE and WEEE language should be used. National legislation on EPR would cascade down from a regional strategy tailored into national policy. Countries with limited capacities to develop policy starting anew, can build on elements and structures provided by other countries in the region[52].

[52] *For example, Kenya has e-waste guidelines outline the basic requirements for each value chain facility, while Ugandan policy indicates potential roles and responsibilities of stakeholders. These policies and guidelines can act as a steppingstone to the region.*

Legal definitions of WEEE already vary in the Regions with differences between the only two countries having implemented EPR[53]. While lighting equipment is a separate category in both cases, solar panels and cooling equipment data are not readily comparable at present, thus limiting the comparison and analysis of data and statistics. Downstream, for the purpose of monitoring exports, the Basel Convention will include, from 2025 onward, a new entry A1181 covering hazardous e-wastes, its components and wastes from the processing of e-waste (e. g. some fractions from shredding)[54].

Each country's laws and regulations must contain targets for yearly collection based on the regional WEEE categories. In the case of solar panels, which have not been in the market to reach their end-of-life, and which should have longer lifetimes than 20 years, targets should be adapted accordingly.

Licensing facilities and service providers

National legislation on used electronics and refurbishment must indicate minimum requirements for companies to obtain licenses to handle WEEE. This means a set of licensing criteria for transporters, refurbishers, and recyclers should be developed to ensure a minimum standard for service provision in the field. At the same time, all licensed WEEE service providers should appear in an official public registry to streamline and standardize the services offered and their pricing at a national and regional level. This would enable the trade of critical WEEE as well for safe handling and disposal, as countries would have comparable requirements and enforcement mechanisms.

The licensing requirements could address not only operational aspects, but also administrative ones. Operational aspects address, for example, the presence of a firefighting system, proof that only competent and trained individuals operate heavy machinery (such as a shredder) or handle sensitive substances (such as lamp crushing equipment). But beyond safety and environmental performance, administrative requirements could include i) reporting data at a determined frequency and in a specified format, ii) compliance with labor rights, and iii) proof of collaboration with only licensed parties. The idea is that, to be compliant, licensed organizations may only contract the services of other compliant organizations. For example, a licensed transporter is only allowed to transfer WEEE to a licensed recycler, and if this cannot be demonstrated to the authorities, a fine can be charged. To support these interactions, a registry of licensed refurbishers should exist online and be updated regularly (as soon as licenses are conceded or retrieved).

All facilities and service providers should be able to prove that all e-waste is handled responsibly. In other words, proving that the tons of WEEE entering the facility/vehicle are equal to the sum of tons being handed over to the next actor (see Figure 4 for the supply chain of EEE/WEEE and their components). All facilities must show proof of contracted licensed transporter services to a landfill and proof of payment for the disposal of by-products at hazardous waste landfills (see 3.6 for more details). Finally, fees to obtain licenses should be comparable between regional service providers and promote healthy competition while keeping the highest possible performance standards.

While solar panel and lamp repair and refurbishment is not possible, for cooling appliances it is. The assurance of know-how and training of repair shops for cooling devices is essential because of the presence of CFCs in them. At the same time, the availability of spare parts and replacements for various models is needed. This is a challenging aim since models and technologies change rapidly.

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[53] Rwanda's policy in the Official Gazette no.31 of 30/07/2018 Annex 1 establishes 13 categories based on function, While South Africa establishes 4 categories based on size and 2 additional categories for lamps and batteries (Gazette 43880 "National Environmental Management: Waste Act (59/2008): Extended producer responsibility scheme for the electrical & electronic equipment sector").

[54] Secretariat of the Basel Convention. Basel Convention E-waste Amendments.

Still, it can be a requirement for importers to ensure distributors and retailers will provide information about refurbishment options and spare parts.

Trade: Standards of performance and import control

While already governed by the Bamako and Basel Conventions, illegal trade is hard to prosecute and monitor. This is partly because of the differences between EEE for re-use and WEEE among countries and insufficient functionality testing. Therefore, minimum performance standards (similar to the MEPS or potentially included in them) should exist for traded solar panels and cooling appliances. The trade of used lighting equipment should be banned between countries. As a reference, the labels developed for EEE in Europe could guide the selection and preference of well-performing products over others[55].

Only high-quality solar panels and cooling equipment should be allowed to be imported as new items or items performing at high quality according to a predefined standard. At the same time, manufacturers should provide data on their types (Silicon, Cadmium Telluride, or other) and components, agree to be part of a registry and agree to participate in take-back schemes and facilitate information to recyclers about components and hazards. Only new equipment with a warranty or used equipment meeting performance standards should be imported as products. The MEPS already exist for lighting and cooling equipment; thus, building upon them and integrating end-of-life management may be a practical possibility.

The Bamako and Basel Conventions seek to minimize and control transboundary movements of hazardous wastes within the African continent. Three key factors would facilitate compliant WEEE trade in EAC and SADC countries with advanced recycling infrastructure: i) the compatibility of safety and performance standards of treatment plants between countries, ii) compatible categories and declarations in HS and WEEE codes, and iii) the recognition of licensed African recyclers by the BRS convention Secretariats.

The creation of favorable conditions for the transboundary shipment of key components of these devices to licensed facilities under the BRS framework is important[56]In the short term, it may not be possible to establish processing capacities for the most hazardous fractions requiring incineration or recover materials for ELA. The waste volumes, especially for solar technology, are currently insufficient to justify investment.

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[55] The EU Directive 2024/825 "empowering consumers for the green transition through better protection against unfair practices and through better information" demands member states to integrate the directive into their legislation by 2026, giving time for adaptation to the new standards to consumers and producers. The Directive removes vague terminology and imprecise claims from product descriptions which could mislead the public. Practically, it clarifies the liability of traders regarding unnecessary software updates, early obsolescence, the unjustified obligation to buy spare parts from OEMs only.
The Directive also facilitates information to consumers through a harmonized label on all products, promoting transparency.
[56] Africa Clean Energy Technical Assistance Facility & Sofies 2019. E-Waste Policy Handbook: Catalysing Africa's Solar Markets. Retrieved from: https://www.ace-taf.org/wp-content/uploads/2019/11/ACE-E-Waste-Quick-Win-Report20191029-SCREEN.pdf.

2.2. National EPR schemes & steps for a successful implementation

This action plan outlines essential steps for establishing an EPR scheme and consists of two phases: Phase 1 focuses on setting up the EPR framework and legislation, while Phase 2 transitions to the practical implementation of EPR operations and waste management.

Phase 1: Establishing the EPR Framework and Legislation

The initial phase leads to the required elements to design and publish a national EPR framework.

1. **Step 1: Producer & WEEE definition**

The environmental authorities must define who qualifies as a producer under the EPR scheme. This includes local manufacturers or assemblers, importers, brand owners.[57], and online vendors of lighting, cooling, and photovoltaic equipment. The definition should consider regional recommendations and terms.

HS and WEEE definitions should be clear for relevant authorities and service providers to ensure data gathering and comparability regionally.

2. **Step 2: EPR Registry**

It is necessary to understand the volume and quality of products entering the national market as well as monitor obligated companies and their activities. A registry, as an electronic database or digital platform, should be designed to collect, store, and manage essential information related to EPR compliance. The EPR registry is a traceability tool for recording and tracking data concerning producers, brand owners, importers, and other upstream stakeholders. Key components and functions of a registry typically include:

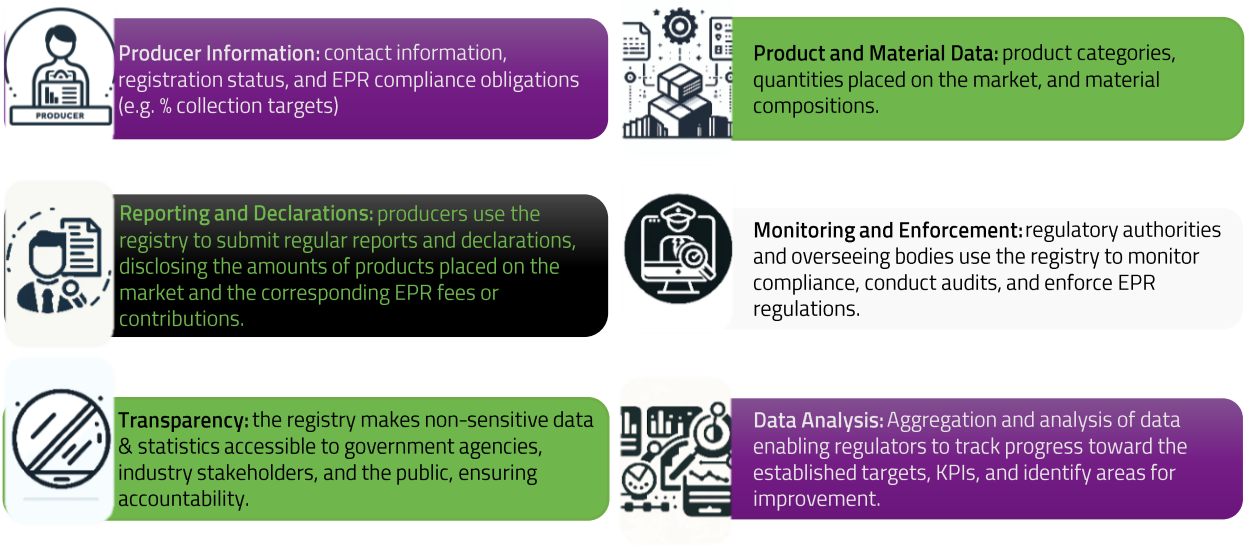

Figure 5: Key components and functions of an EPR registry.

The registry can also encompass waste operators, capturing details of their operations. These waste management companies can be categorized based on the services they provide, e.g. i)

[57] *For example, Coca-Cola-branded fridges are sometimes provided to retailers for free by the brand*

Equipment refurbishers, ii) WEEE collection (specifying WEEE category codes), iii) WEEE storage and/or sorting, and iv) WEEE processing and treatment.

3. Step 3: EPR governance structure and PRO model definition

The governance structure outlines the roles and responsibilities of all stakeholders, including producers, government entities and enforcement authorities, and the PRO. The PRO governance structure is how a PRO is structured, managed, and regulated (see Figure 6). In other words, this specifies whether it will be a for-profit or not, whether there will be a monopoly or competitive PROs, their decision-making processes, accountability mechanisms, and the PRO(s)' relationship with government authorities and other stakeholders. This structure ensures that the PROs operate efficiently and transparently. It is not mandatory to found PRO(s); otherwise, national governments must entrust EPR compliance to one of the Ministries or their Institutions.

In considering the implementation of National EPR schemes, it is worth exploring the potential integration with the existing Product Registration System (PRS). This integration could streamline processes, centralize data management, and enhance monitoring and enforcement capabilities. However, it is crucial to ensure that the system remains flexible and capable of handling the specific requirements of EPR without becoming overly complex. Further feasibility studies and stakeholder consultations are recommended to evaluate this integration comprehensively.

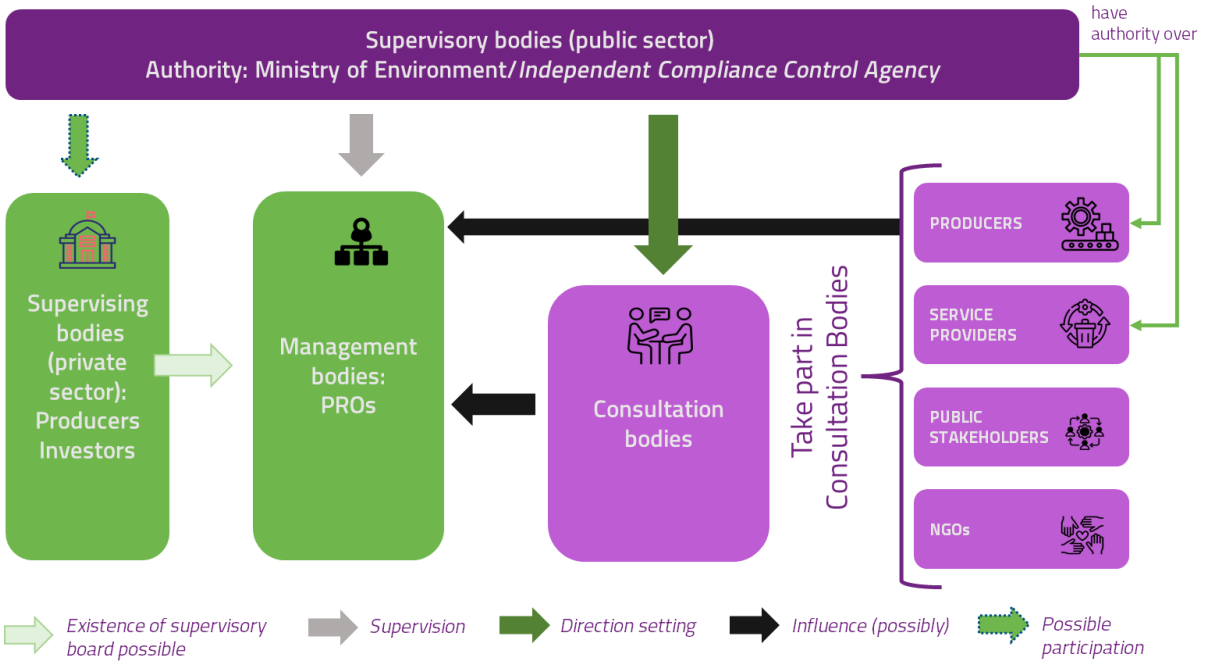

Figure 6: PRO Governance Structure

4. Step 4: Downstream infrastructure availability & and licensing

The identification, audit, and license provision to WEEE operators is necessary to ensure enough compliant service providers carry out the environmentally-sound practices described in policy. This applies to companies refurbishing, transporting, dismantling, aggregating WEEE or providing recycling and interim storage services before export (for cooling, lighting, and photovoltaic equipment). At the same time, it must be ensured that a hazardous waste landfill is available, and charges harmonized fees for disposal of certain WEEE by-products that cannot be locally recycled or exported (for more details see 3.6). (Regional harmonization and compatibility of requirements for licensing, trade, and penalties is necessary.)

5. Step 5: EPR targets establishment

Targets are typically derived from EEE placed on the market and serve as guiding benchmarks for producers and regulatory authorities. The targets should be established for collection and recycling, and they can be set according to distinct cooling, lighting, and photovoltaic EEE categories[58]. Recommendations for setting targets include:

- Understanding the current baseline of separate WEEE collection percentage and transfer to licensed facilities (sufficient data availability and reporting are an indicator of readiness)
- Acknowledgement that data accuracy may be limited until the registry becomes fully operational
- Gradual and progressive target increase over time, ambitious to push stakeholders, but realistic to be able to impose fines

6. **Step 6: Penalty systems definition**

The environmental authorities and the compliance control agency must establish the penalty framework for the EPR scheme. Non-compliance for producers subject to penalties should include:

i) failing to register as producer
ii) providing inaccurate information
iii) failing to meet obligations and transfer the EPR fee to the PRO

Although environmental authorities oversee licensing and audits of service providers (aggregators, recyclers, transporters, inter alia), PROs typically require recycling certificates and proof of disposal or export of components. Therefore, an auditing system should be coordinated to ensure only licensed and compliant parties are involved. This is another reason why EAC and SADC licensing requirements and standards alignment is important, facilitating compliant inter-African WEEE component trade and penalizing illegal practices.

7. **Step 7: National EPR policy enactment**

The environmental authorities develop and release the EPR legal framework only once steps 1-5 are implemented. Producers would ideally have been part of the policy draft process. At minimum, they would need to be informed about upcoming changes in legislation and be granted a grace period (for instance 2 years) to adapt and comply with the regulations. Additionally, national legislation should be in harmony with (not contradicting, rather surpassing the mandates of):

i) The Basel and Bamako Conventions
ii) Regional (EACO or SADC equivalent) provisions and plans
iii) National hazardous wastes regulations
iv) National landfill regulations

Finally, which activities are financed under the e-waste legislation must be defined.

[58] *An interesting example in the South African EPR legislation includes targets for lighting equipment. These are targets for take-back, recovery, and recyclability over a span of 5 years and specific to the type of lighting equipment in question, see Annex 7 for details.*

Phase 2: Commencing Operations

This phase involves steps for launching EPR operations and monitoring their progress.

8. **Step 8: Operational Setup and Awareness Raising**

The Producer Responsibility Organisations (PRO) defines the collection network, pricing, fees, infrastructure needs, and documentation platforms. From this point forward, awareness-raising campaigns must be launched to educate consumers about the EPR scheme and the environmental impact of WEEE.

9. **Step 9: Waste service providers auditing**

Waste operators must undergo regular audits conducted by the compliance control agency and the PRO. Facilities involved in collection and recycling must be compliant to keep their licenses and presence in the official list of authorized organizations.

10. **Step 10: EPR Registry roll-out**

The environmental authorities establish a rollout date for producers to complete their registration and report their placed-on-market (POM) quantities. The managing entity supervises the process, identifies issues, and report them accordingly. The registry must be kept up to date.

11. **Step 11: Initiation of EPR operations under EPR**

Formal operations begin once producers and waste service providers are part of the registry. The PRO manages waste collection and treatment networks, reporting quantities to the registry. Voluntary operations may continue during the interim period before full enforcement. KPIs are set.

12. **Step 12: Reporting, monitoring, and enforcement**

The compliance control agency supervises all aspects of the EPR scheme, verifying registrations, validating registry data, and confirming licenses. It enforces penalties for non-compliance.

13. **Iterative Step 13: EPR system review**

To ensure adaptability and continuous improvement, the environmental authorities coordinate regular reviews of the EPR system. This process will involve revising targets, KPIs, assessing operations, making necessary adjustments, and holding stakeholder meetings for feedback and collaborative solutions. Cooperation and exchanges with other countries and regional bodies (EACO and SADC equivalent, SACREEE, EACREEE, COMESA, inter alia) takes place to share information and knowledge.

An illustrative scheme on the main step to establish an EPR system are shown in Figure 7.

An EPR-meter

Countries in the EAC and SADC Regions are at different planning, drafting, and implementing stages for EPR policy (see Annex 3: Overview of countries in their region with WEEE/EPR policies or drafts for more details). These steps distributed along two phases are meant as orientation to identify potential next steps and gaps (if any) in current national policy developments. This way, countries could use the concept of this EPR-meter to assess their progress in implementation easily and address any pending steps.

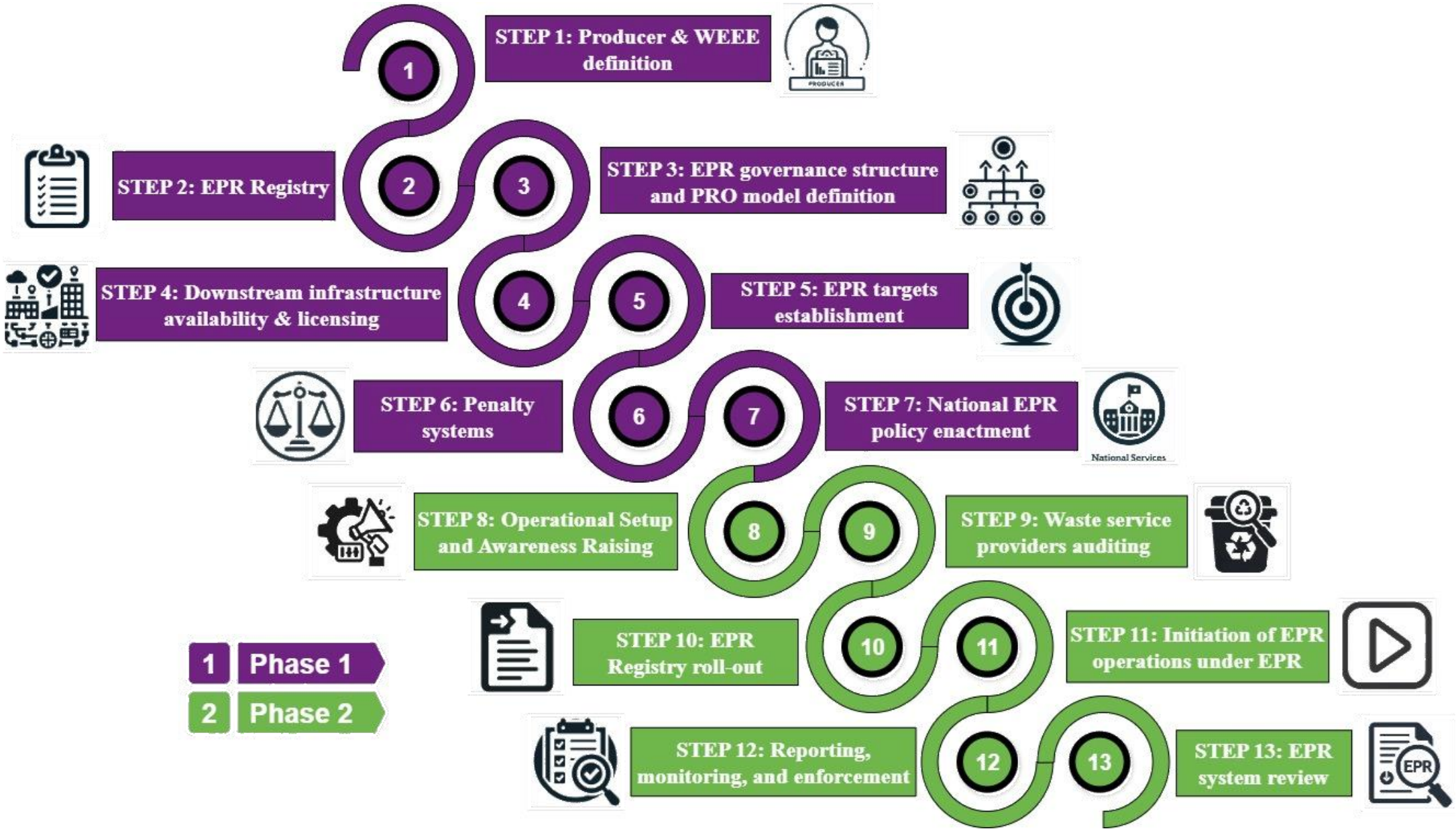

Figure 7: EPR-meter steps and phases

3. INFRASTRUCTURE

The value chain of these e-waste devices is multifold. All actors need digital and physical infrastructure to fulfil their roles in the e-waste value chain efficiently and to enable cooperation between national and regional stakeholders. The figure below illustrates the movement of EEE, WEEE, and their components among actors. It is often observed movements of second hand EEE, and even WEEE from e.g. European countries sold to the African market. This is a key issue considering that most of the countries in the continent lack infrastructure to properly deal with the waste generated/imported.

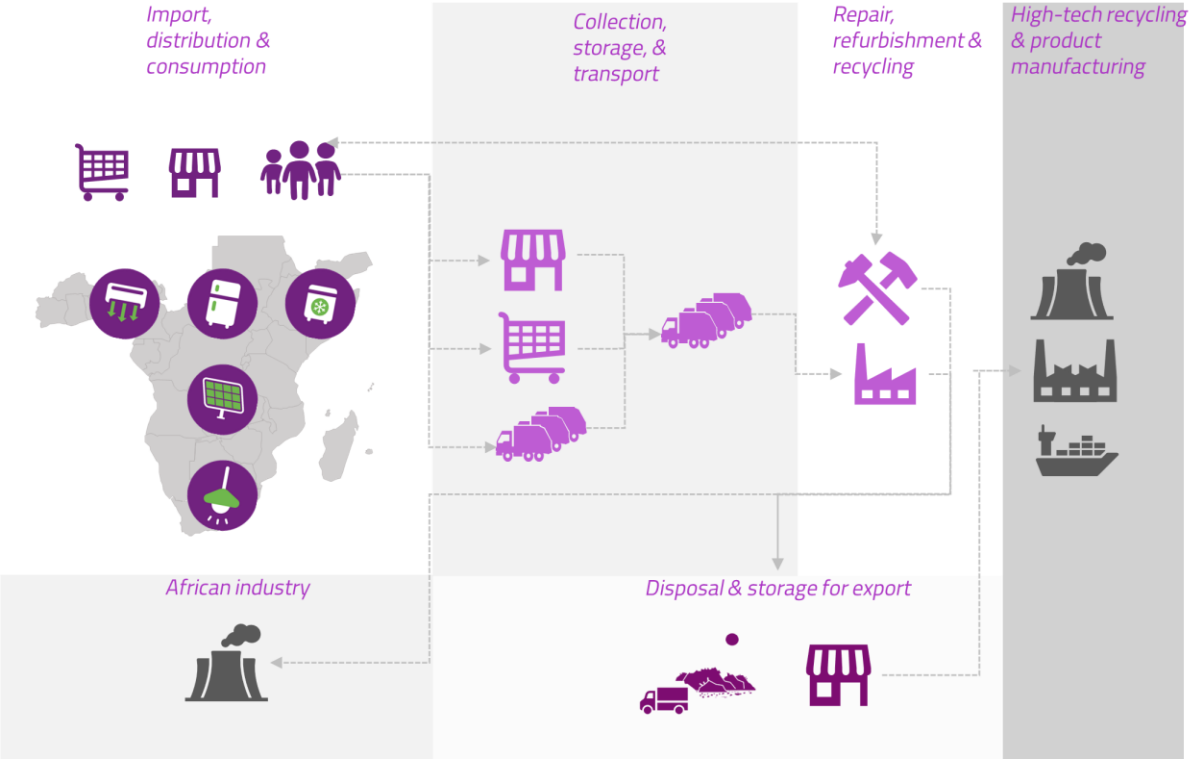

Figure 8: The WEEE value chain.

3.1. Data and feasibility

It is necessary to have enough updated data to assess the feasibility of upscaling or upgrading a WEEE recycling facility. First, it is important to know how many waste tons per year of lighting, cooling appliances, and solar panels are generated. At the same time, projecting future generation trends for the next fifteen years at least is recommended, so dimensioning efforts contemplate the upcoming needed capacities. In addition, it is necessary to understand existing infrastructure's capabilities and geographical distribution since transportation costs shall be minimized. The difference between the tons per year can be currently treated and the ones that will need treatment will reveal where and whether investment is needed (in case of retrofitting as opposed to greenfield developments).

Estimating which types of EEE are currently in the market as stock and in which quantities are challenging. Estimates of waste generated from EEE in a country can be derived by considering the quantities and quality (secondhand electronics) of products introduced to the market, POM, the typical weight of each component, and the typical lifespan of the various components of that equipment. This approach, known as the "sales-lifespan" model, aligns with the common

methodology adopted by the European Commission[59]. Many factors and probabilities are at play to estimate when EEE will become WEEE[60], but mostly so regarding when they will be disposed of (as WEEE is typically kept at homes or storage areas in commercial or industrial setups when the equipment is bulky, and no exchange alternatives exist, e.g., exchanging an old refrigerator for a new one). Based on these principles, stocks, and estimations for lighting equipment should be much easier to estimate than for cooling and photovoltaic equipment.

All these results enable estimations to determine how many tons per year in principle require collection, transport, and processing at present and in the future. At a national level, this will help national PROs, local governments, and private companies make decisions and plan, as well as establish EPR fees for various device types. Regionally, it will help plan investment in more sophisticated technologies and larger-scale recycling operations. The advantages of having a common classification for WEEE and equivalences for recycling facilities are easily recognizable.

*Database **de**velopment*

A database is an essential infrastructure for compiling, analyzing, and publishing data and information. It could gather statistics, lists of service providers, news, and calls for applications inter alia. National databases could be developed to fit local needs, while, at the same time, key data and information could be integrated into the regional platform described in 0 page 40. The regional strategy could look deeper into linking useful features and functionalities among databases and maps.

A national database, as a minimum, should include data on types and quantities of e-waste generated (according to harmonized nomenclature), collected, transported, and processed, as well as the locations of collection points, treatment facilities, and disposal sites. An interactive map and other features could result in a more user-friendly interface. Data should be collected from municipalities, recycling facilities, and manufacturers to ensure comprehensiveness. The database developers should incorporate validation and error checking features to ensure quality and reliability. Up to date data sharing capabilities should be implemented to improve coordination and response times in e-waste management[61].

Mapping tools are crucial for visualizing data from the database, helping identify hotspots for e-waste generation and "sinks" as facilities for their management. Geographical Information Systems (GIS) or equivalent tools can process input data to map e-waste hotspots, collection points, and treatment facilities, aiding in efficient route planning and resource allocation. Spatial analysis tools study e-waste distribution, optimizing the placement of collection points and treatment facilities in high-need areas, enhancing overall efficiency[61].

3.2. Implementing standards for service providers

Specific operational, environmental, and administrative standards should exist for each actor in the e-waste management chain, from collectors to recyclers, to adhere to, thus ensuring high performance, safety levels, and fair competition.

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[59] *Africa Clean Energy Technical Assistance Facility & Sofies 2019. E-Waste Policy Handbook: Catalysing Africa's Solar Markets. Retrieved from: https://www.ace-taf.org/wp-content/uploads/2019/11/ACE-E-Waste-Quick-Win-Report20191029-SCREEN.pdf.*

[60] *For example, in certain instances, the life cycle of the complete system (e.g., solar home systems or street lighting) can surpass that of the batteries, causing multiple replacement cycles to occur during the system's lifetime. Based on Africa Clean Energy Technical Assistance Facility & Sofies 2019. E-Waste Policy Handbook: Catalysing Africa's Solar Markets.*

[61] *UNEP., 2020. Guidelines for the Development of a National Waste Management Strategy: Moving from Challenges to Opportunities. United Nations Environment Programme. Retrieved from https://www.unep.org/ietc/resources/toolkits-manuals-and-guides/guidelines-national-waste-management-strategies-moving.*

This involves establishing guidelines for safe handling, defining standards for each actor and facility, and setting up audit and penalty mechanisms to ensure compliance. Comparable standards should be enforced throughout the region, otherwise trade, free-riding, and illegal actions may arise.

All facilities in the region, as will be specified in more detail in 3.5, should follow a baseline standard on a) planning and administration requirements, b) operational requirements, c) physical requirements and facility setup, and d) HSE requirements. For example, measures must be implemented to minimize emissions and prevent contamination, such as proper ventilation systems and containment of hazardous by-products[62]Administratively, detailed records of all e-waste handled, processed, and disposed of should be mandatory, with regular reports to authorities providing data on volumes, types of e-waste processed, and disposal methods used in the required standardized format.

Equivalent requirements should exist for multiple aspects, including:

- Licensing requirements
- Profile and training of personnel
- Safety and protocol establishment
- Drafting and following standard operating procedures (SOPs)
- Documentation and reporting of data
- Ensuring that only licensed third parties deliver and offtake WEEE and its components
- Results of audits
- Fees and penalties

To implement standards for service providers in the e-waste sector in the EAC and SADC regions, it is essential to define clear and objective guidelines that ensure effective price regulation and minimum performance standards, as well as an efficient strategy for collecting solar panels, lamps, and cooling devices.

Firstly, price regulation should ensure that all service providers operate with fair and transparent tariffs aligned with the actual costs of collecting, transporting, and recycling e-waste. Additionally, minimum performance standards should be established, including specific requirements for the safe and environmentally responsible handling of these materials. This includes ensuring that devices are not damaged during transport and that refrigerators are kept upright to prevent leaks of hazardous substances[63].

Regarding the collection strategy, it is crucial to create a comprehensive network of collection points for solar panels, lamps, and cooling devices. This network can include exchange points at retailers, dedicated collection sites, and case-by-case agreements to ensure that all consumers have easy access to proper disposal options. Collaboration with retailers and service centers can also facilitate collection and ensure that devices are processed safely and efficiently[63].

[62] *ATU., 2020. E-Waste Guidelines for Africa Telecommunications Union Member States. Retrieved from https://atuuat.africa/atu-d-reports/.*
[63] *UNEP., 2020. Guidelines for the Development of a National Waste Management Strategy: Moving from Challenges to Opportunities. United Nations Environment Programme. Retrieved from: https://www.unep.org/ietc/resources/toolkits-manuals-and-guides/guidelines-national-waste-management-strategies-moving.*

3.3. Collection, transport, and aggregation

Take-back and collection approaches

PROs, on behalf of producers, can establish and manage nation-wide WEEE take-back systems. Similar requirements and standards should exist in the region. PROs or third parties can conduct audits to evaluate the efficiency, accuracy, and veracity of reported data, compliance with standards, and other performance metrics. The government, however, would be responsible for giving out warnings and fines if standards are not met. Because individuals or institutions, the general public, are in the custody of WEEE, various collection options that cater to their needs and circumstances must exist. A good logistics system design considers the interface with the consumer and reacts in an agile way to changes and disruptions, reducing costs and preserving WEEE integrity. Therefore, an approach integrating multiple collection strategies (Figure 9) ensures that e-waste collection is accessible and convenient for everyone[64].

In the EAC and SADC regions, the informal sector plays a crucial role in WEEE collection. Integrating informal workers into the formal system can significantly enhance efficiency and compliance. PROs should be responsible for organizing training programs for informal collectors. These training programs would cover safe handling and recycling practices, ensuring that informal workers are knowledgeable about environmental standards and safety protocols. Additionally, PROs, in collaboration with local governments, can offer financial incentives, protection equipment, and access to formal markets to encourage the formalization of informal collectors. This integration would not only improve data accuracy and safety but also ensure that informal collectors contribute effectively to the formal e-waste management system.

[64] *Step Initiative, 2015. E-waste Prevention, Take-back System Design and Policy Approaches. Retrieved from https://www.step-initiative.org/files/_documents/green_papers/Step%20Green%20Paper%20Prevention%20&%20Take-back%20System.pdf.*

Take-back schemes	Consumers return their used electronic devices when purchasing new ones (applicable for cooling, lighting, and phtovoltaic equipment). Consumers could have the option to take their used appliances to any participating shop that collects waste, not necessarily the same shop where the item was purchased, especially if rebates are involved.
Exchange programs	Programs where consumers can exchange old equipment for new or refurbished items (applicable for solar panels and cooling equipment). Allowing informal collectors to participate by collecting old equipment and bringing it to designated centers for exchange might be effective. Offering incentives for their participation could encourage more involvement.
Deposit in equipment	Consumers pay a deposit when purchasing large electronic devices, refunded upon returning the device for recycling (applicable for solar panels and cooling equipment). Informal collectors could act as intermediaries, collecting devices and returning them to designated centers on behalf of consumers. Providing financial incentives for their services would support this process.
Drop-off points	Convenient drop-off points in public places such as shopping centers and municipal offices makes it easier for consumers to dispose of small e-waste (applicable for lamps). Establishing partnerships with informal collectors to manage and operate drop-off points could be advantageous. Training them to handle e-waste safely and efficiently would be important.
Collection events	Organizing regular e-waste collection events in communities encourages residents to bring in their old electronic devices for recycling (applicable for cooling, lighting, and phtovoltaic equipment). Including informal collectors in organizing and executing these events might enhance their success. Providing training and necessary equipment, along with offering incentives for their involvement, could be beneficial.
Mobile collection vehicles	Setting up mobile collection units that visit different neighbourhoods can make e-waste disposal more accessible, especially in areas without fixed drop-off points (applicable for cooling, lighting, and photovoltaic equipment). Employing informal collectors to operate and assist with mobile collection units might be effective. Equipping them with tools and training for safe collection, and providing incentives for their participation, would support this strategy.

Figure 9: WEEE collection strategies

Transportation and interim storage

Because the intrinsic value in WEEE may not always be sufficient to cover transportation costs to recycling facilities and from recycling facilities to landfills or export, additional funding mechanisms, subsidies, or logistical optimizations might be necessary to support the transportation process. To address this, operators should optimize logistics by consolidating/aggregating quantities, planning efficient routes, and partnering with credit nearby recycling facilities[65]. Additionally, adopting more sustainable transportation methods like maritime shipping and rail, as opposed to road freight, can significantly enhance overall efficiency and reduce costs[66].

Localized aggregation points which exist in urban and peri-urban areas can enhance logistics and processing efficiency[67]. Additionally, integrating IT systems for tracking and managing e-waste is also recommended to improve transparency and regulatory compliance[Error! Bookmark not defined.]. T ransportation vehicles and storage facilities must be equipped to preserve the physical and

[65] *Another reason why listing and mapping officially licensed facilities on a public platform is advantageous*
[66] *International Energy Agency (IEA): Transport Energy Efficiency, IEA Energy Efficiency Series, 2010. Available from http://www.iea.org/papers/2010/transport_energy_efficiency.pdf.*
[67] *Forti, V., Baldé, C. P., Kuehr, R., & Bel, G. (2020). The Global E-waste Monitor, 2020. United Nations University (UNU), International Telecommunication Union (ITU), and International Solid Waste Association (ISWA). Available from: https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf.*

chemical integrity of equipment (i.e., by preventing potential collisions and exposure to sunlight and humidity/rain[68]) as much as possible. This helps prevent pollution and ensure workers' safety, but it also increases and preserves the material or component value of the devices. Therefore, the types of vehicles and containers used for transport must be suitable. As for storage, implementing safeguards like impermeable flooring and protective coverings for storage areas that are resistant to weather conditions[69] is another efficient countermeasure.

On another note, records of transactions (collection, delivery) of equipment must be kept for their aggregation and reporting. Operators should be required to measure the weight of e-waste and components, whether incoming or outgoing to other operators as part of their licensing process. Specific protocols should define criteria for the handling and storage of certain e-waste categories that include hazardous substances prone to environmental release or complicating further processing[70]. For example, this applies especially to compact fluorescent lamps (CFLs) that contain mercury and require careful handling or to discarded cooling units to prevent the refrigerant release or the compressor's oil release[71].

The necessity of interim storage arises due to logistical and regulatory challenges in transporting e-waste. E-waste often must be temporarily stored to accumulate enough, justifying transportation costs and ensuring compliance with the Basel Convention. Interim storage facilities should be in accessible urban or peri-urban areas to optimize logistics. These facilities must be equipped with impermeable flooring and protective coverings to prevent environmental contamination and maintain the integrity of the e-waste by preventing exposure to sunlight, humidity, and physical damage. Proper record-keeping of all transactions and weight measurements of e-waste is essential for regulatory compliance and efficient management. Interim storage allows for proper handling and containment before exporting to the nearest accredited regional hub in Africa or, if unavailable, to Europe, ensuring that environmental and safety standards are met[72].

3.4. Refurbishment

In managing EoL solar panels and cooling equipment, ensuring the availability and quality of spare parts coupled with know-how and following safety measures may contribute significantly to a more circular economy in the EAC and SADC regions. This is because identifying the reasons/components malfunctioning may permit their replacement and replacing the equipment in the market. Because of logistics issues, repair and refurbishment shops would ideally be able to visit the locations where the faulty equipment is or provide instructions to users so they can diagnose issues and rule out common problems.

For this to work, OEMs and importers should prioritize establishing official repair shops, including in-house services for larger equipment and fostering partnerships with smaller businesses to facilitate accessibility to spare parts. Establishing a centralized database and mapping licensed service providers for cooling and photovoltaic systems can streamline maintenance efforts and

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[68] *Contact with rain or water is undesirable as it is one of the main means of heavy metal leaching, short circuits, and pollution.*
[69] *Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on Waste Electrical and Electronic Equipment (WEEE Directive). https://eur-lex.europa.eu/resource.html?uri=cellar:ac89e64f-a4a5-4c13-8d96-1fd1d6bcaa49.0004.02/DOC_1&format=PDF.*
[70] *Solving the E-Waste Problem (StEP) Green Paper: Recommendations on Standards for Collection, Storage, Transport and Treatment of E-waste—Principles, Requirements and Conformity Assessment. United Nations University/StEP Initiative, 2012. https://www.step-initiative.org/files/_documents/green_papers/StEP_GP_End%20of%20Life_final.pdf.*
[71] *Oil contamination results in additional cleaning efforts to recycle other components, increasing operational costs and labor. This contamination also lowers the quality of recycled materials, reducing their market value. It can additionally accelerate machinery wear or complicate separation processes due to oil interference, affecting sorting technology efficiency.*
[72] *Basel Convention, 2011. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. Retrieved from https://www.basel.int/TheConvention/Overview/tabid/1271/Default.aspx.*

ensure the availability of qualified technicians. Additionally, sufficient information on the equipment's components is important because if the devices are dismantled, some parts may be reused to refurbish other equipment and the remaining parts processed and prepared for sale. Sales require complete and specific knowledge of the component's composition – otherwise, the material's price is lower, or off-takers may refuse to purchase them.

Civil organizations, recyclers, and associations should advocate for including the "Right to Repair" in national policy.[73]. Labels or requirements in implemented standards such as the MEPS can complement these efforts. As a result, manufacturers and brands supporting the Right to Repair would more easily penetrate/dominate the market over time.

Finally, importers and distributors need to be aware of refurbishment possibilities. This way, they can guide consumers and link them to nearby refurbishment and repair centers or offer these themselves. Synergies can easily develop between importers/distributors, who are in contact with suppliers, and repair shops, which need access to spare parts and knowledge.

3.5. National WEEE processing centers & advanced recycling hubs for the region

Regional infrastructure

To address the pressing need for effective e-waste management in the region, establishing one or a few modern regional hubs could create synergies and economies of scale. These hubs would have state-of-the-art facilities capable of effectively treating various e-waste components. Advanced processing technologies, such as incineration for oils, contaminated plastics, foams, and other hazardous components, would be employed to ensure environmentally sound disposal practices. Advanced treatment technologies for PUR foams, such as high-temperature incineration in rotary kilns with flue-gas cleaning systems, are essential to minimize environmental impact. Recovery and purification systems can capture and recycle these gases efficiently for refrigerants. Recovery units create a vacuum to draw refrigerants, which are filtered, purified, and transferred to storage cylinders for further processing. This ensures compliance with environmental regulations and reduces the need for hazardous waste disposal[74].

Capacitors containing hazardous substances like polychlorinated biphenyls (PCBs) require specialized handling due to environmental and health risks. Handling at a regional level is beneficial for the EAC and SADC regions, as regional hubs can leverage economies of scale, offering cost-effective and advanced technologies like high-temperature incineration. Regional collaboration allows countries with limited resources to manage hazardous e-waste effectively by sharing infrastructure and expertise[75].

In addition to advanced treatment capabilities, these regions would feature temporary storage options for materials destined for export to neighboring countries, promoting cross-border trade while adhering to regulatory standards. To complement these efforts, advanced processing techniques would manage all components locally whenever possible, reducing reliance on Chinese

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[73] The Right to Repair movement in Europe aims to empower consumers by advocating for legislation that ensures consumers have access to information, spare parts, and repair services for the products they purchase. seeks to reduce electronic waste by promoting repairability and extending the lifespan of products. It also aims to challenge planned obsolescence practices employed by manufacturers.

[74] UNEP, 2020. Guidelines for the Development of a National Waste Management Strategy: Moving from Challenges to Opportunities. United Nations Environment Programme. Retrieved from: https://www.unep.org/ietc/resources/toolkits-manuals-and-guides/guidelines-national-waste-management-strategies-moving.

[75] International Telecommunication Union, 2021. E-waste Policies and Regulatory Frameworks. Retrieved from: https://www.itu.int/en/ITU-D/Climate-Change/Pages/ewaste/Ewaste_Policies_and_Regulatory_Frameworks.aspx.

and European facilities (and needed transportation). Fostering trade between BRS-credited treatment facilities is advantageous for materials recovery and supporting the Regions' economy while keeping valuable resources within Africa. This recognition helps prevent illegal dumping and promotes environmentally sound waste management.

Furthermore, integrating local certification or similar accreditation programs with regional validity into the operational framework of these regional hubs ensures adherence to international standards, promotes transparency in trade, and enhances the credibility of the e-waste management industry in the Regions.

Facilitating trade between countries for functional equipment and certified BSR (Best Sustainable Recycling) treatment facilities is essential to ensure compliance with international standards and promote sustainable e-waste management practices. One critical aspect is obtaining Basel recognition, which ensures that the transboundary movements of hazardous wastes, including e-waste, comply with stringent international regulations. This recognition helps prevent illegal dumping and promotes environmentally sound waste management.

National infrastructure

Each country should develop infrastructure to handle lamps, metals, cables, plastics, and motors involved in treating WEEE. National centers must align dismantling activities with end-receivers' capabilities and maintain documentation of materials. Facilities must align dismantling activities with end-receivers' capabilities and maintain comprehensive documentation of incoming and outgoing materials. Developing and regularly updating SOPs is important, and adherence should be evaluated via routine internal inspections and audits by external third parties.

Conducting repairability assessments for solar panels and cooling equipment is essential to determine whether these items can be repaired and reused. This involves evaluating the condition of the panels and cooling units, diagnosing common faults, and establishing repair protocols. Facilities should be equipped with diagnostic tools such as digital multimeters to measure voltage, thermographic cameras to detect hot spots, insulation testers to check electrical integrity, solar panel efficiency analyzers, gas leak detectors, and oscilloscopes to analyze electrical waveforms to assess the functionality of these components and ensure that repairs meet safety and performance standards.

It is important to ensure facilities align dismantling activities with end-receivers' capabilities and maintain comprehensive documentation of incoming and outgoing materials.

Facility infrastructure and equipment play important roles, necessitating precise weighing equipment, dedicated areas for specialized activities, and proper storage and segregation of dismantled components. Adequate signage, fire protection measures, and a reliable power supply are essential for facility setup.

Machinery and equipment for Recycling Plants

Setting up a recycling plant involves creating a workshop with the necessary infrastructure to dismantle and prepare components for recycling, disposal, or export. Equipment should include:

- Precision scales for measuring the weight of incoming and outgoing materials and controlling material flow & efficiencies
- Dismantling tables equipped with manual and pneumatic tools for dismantling electronic devices and sufficient lighting should be provided
- Adjustable chairs to ensure worker comfort and ergonomics
- Equipment for the extraction of refrigerants

- Sealed containers for the safe storage of refrigerants
- Conveyor belts for feeding shredders
- Shredders
- Lamp crushers with vacuum dust removal and gas filtration
- Vehicles for placing heavy materials and loads on pallets or transporting them
- Cable strippers or shredders to reduce the size and separate metal from plastics
- Adequate containers for mercury-containing dusts to export for treatment, among others.

Boxes, mesh containers, pallets, and other similar equipment are necessary.

Annex 8: Tools and facility for the recycling plant lists other examples of equipment materials and work prepared for the setting of the recycling plant based on the amount of ten working tables.[76]

Safety and trained personnel

Workers may encounter health risks in WEEE treatment facilities, including the risk of exposure to toxic dusts and fumes, physical injury, hearing loss, and fire accidents. Employers must, therefore, provide information about these risks and ensure via appointed employees, SOPs, and protocols, a safe and healthy workplace.[77]. These programs should cover identifying and safely handling hazardous materials commonly found in solar panels and cooling equipment. Workers should be trained in using PPE, with regular mandatory training sessions and certifications to keep staff updated on the latest safety procedures and emergency response protocols.

CFCs and cooling appliances	Safely extracting and storing CFCs from cooling appliances using specialized equipment like refrigerant recovery machines, vacuum pumps, and leak detectors to prevent atmospheric release
Shredders	Operating shredders should highlight injury risks from moving parts and the importance of using protective barriers and emergency stop mechanisms. Workers must use machine guards and lockout/tagout systems, with regular maintenance and safety checks to ensure safe operation.
Lamps with mercury	Training on containment and recycling equipment to prevent mercury release, including using mercury vacuum systems, lamp crushers with filtration systems, and proper storage containers. Workers should wear PPE such as gloves, safety glasses, and respirators to avoid mercury exposure during operations. By-products and dusts as well as spent filters must be adequately contained and landfilled.

Figure 10: Training and Safety Measures for WEEE Handling

Regular audits by independent regulatory bodies are essential to ensure compliance with operational, safety, environmental, and administrative standards. These audits must identify issues and recommend corrective actions by the service provider. Depending on the regional

[76] *Wang, F., 2008. Economic conditions for developing large scale WEEE recycling infrastructure based on manual dismantling in China: the learning experience from the setup of a pilot plant. Leiden University and Delft University of Technology, Leiden/Delft, The Netherlands. Retrieved from: https://www.researchgate.net/publication/236838716_Economic_conditions_for_developing_large_scale_WEEE_recycling_infrastructure_based_on_manual_dismantling_in_China.*

[77] *California Department of Public Health.. Hazard evaluation system and information service: Electronic waste. Retrieved from: https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/OHB/HESIS/CDPH%20Document%20Library/eWaste.pdf.*

standard, clearly defined penalties for non-compliance, such as fines, license suspension, or facility closure, to encourage strict adherence to standards[78].

3.6. Disposal & export

Landfills

Hazardous waste landfills are a necessary component of waste management infrastructure, providing a final disposal solution for certain hazardous materials that cannot be further recycled with available technology and exported. These landfills must be equipped with two layers of impermeable liners (typically HDPE liners of a certain thickness) and be filled according to a capping strategy (preventing rainfall contact or dust displacement by wind). Landfills should also be equipped with leachate and gas capture systems, leak detection systems, and periodic maintenance and testing. Landfills must adhere to stringent emissions regulations, meaning that the collected liquid leachate and gases must be processed to stabilize them and prevent air and soil pollution. Site selection criteria should prioritize areas that minimize environmental impact and ensure the long-term integrity of the landfill.

Delivering certain WEEE components to landfills is banned in South Africa and could be a strategy for other countries. However, this is only valid when alternative treatment (export, advanced recycling recovery, incineration) is available. Otherwise, it might have a counter effect promoting illegal dumping. In all cases, landfilling some components or by-products of treatment is inevitable. It is technically impossible to avoid it. Therefore, countries imposing bans should articulate clearly and carefully which components and under which circumstances the bans are valid.

Acceptance criteria for landfills should be in place. These should involve allowing only WEEE components that are not reactive, such as chemically unstable, self-igniting, or flammable, inter alia. Landfills in each country should only accept wastes generated in their respective country, otherwise valid public opposition (not-in-my-backyard effects) may arise. In every circumstance, penalties for illegal dumping must be severe to encourage disposal and delivery to specialized landfills. Finally, a mandatory "gate fee" should be paid for each ton disposed of at the landfill. Typically, different fees are applicable depending on the hazardous waste in question.

Export

Exporting hazardous waste under international agreements such as the Basel and Bamako Conventions facilitates responsible waste management practices. Inter-African trade and establishing regional hubs can support waste transportation to facilities equipped for advanced recovery processes. For instance, Original Equipment Manufacturers in China may specialize in recycling solar panels, while European facilities are well-suited for recovering mercury-containing materials. These strategic partnerships enable the diversion of hazardous waste from landfills and promote the short-term sustainable recovery of valuable resources.

Identifying generation trends and geographical hotspots can further inform decision-makers and enable them to initiate targeted interventions. In the long run, a network of African WEEE treatment facilities with advanced recovery technologies recognized by the BRS Conventions should exist. This would encourage cooperation and support from adjacent and neighboring countries on the one hand and ensure valuable and rare materials are kept in Africa, benefiting local industries on the other.

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[78] *STEP, 2020. Recommendations on Standards for Collection, Storage, Transport, and Treatment of E-waste: Principles, Requirements, and Conformity Assessment. Retrieved from: https://collections.unu.edu/eserv/UNU:6134/step_gp_end_of_life_final.pdf.*

A summary of the proposed interaction between small-scale, advanced, and high-investment infrastructure for WEEE management in the region is presented below, for three hypothetical neighboring countries where only one of them has an advanced recycling hub:

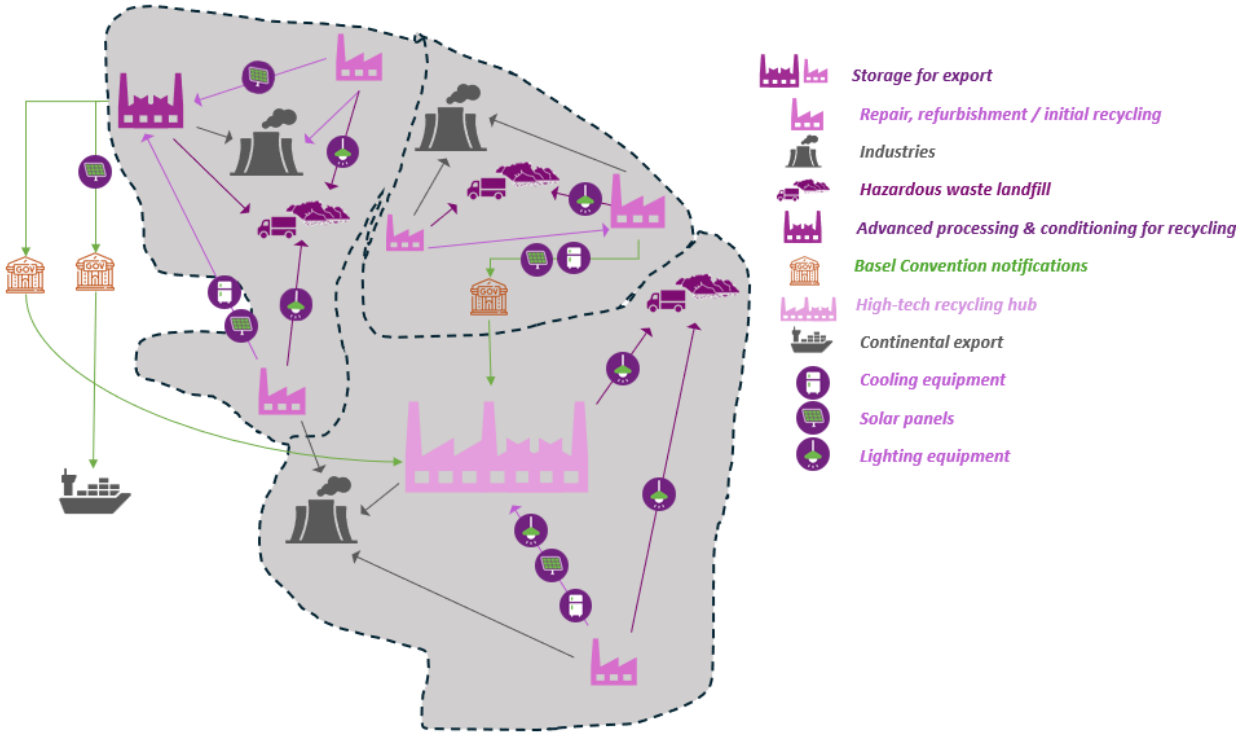

Figure 11: Infrastructure for dismantling, recycling, and disposal, based on 3 hypothetical countries. It is not made on a scale or according to any hotspots and geographical considerations; it is for illustration purposes only.

4. FINANCE

Funding sources

Efficient and safe WEEE management requires both public and private financing sources. Public participation is important to guarantee commitment and engagement from donors and international developing agencies. National governments are, therefore, expected to allocate a percentage of their budget for policy development, monitoring and implementation, participation in regional conventions, and support infrastructure development and service provision. Development agencies will likely have the main role in funding and facilitating these initiatives. Funding approaches similar to those of the EACO can be undertaken.

At national and local levels, incentives should be extended to the informal sector to encourage participation, but only under certain conditions. For instance, sellers of e-waste and their components must be registered to ensure proper tracking and compliance. Cooling equipment must be aggregated without removing or retrieving parts and transported safely. If handled at all, solar panels must be transported to prevent cracks on the panel and include all parts, including aluminum frames.

Governments can further support investors through concessions, tax breaks, and expedited administrative processes. Since the regional bodies (working groups in the EACO and SADC equivalent) would develop performance standards, requirements, and auditing tools, a significant burden would be lightened for local governments. This means that guidelines and factsheets would be available to support liability insurance options, leaner EIA study requirements, and other ends.

EPR reach and limitations

EPR programs can significantly finance recycling efforts by shifting the financial burden onto manufacturers and importers. A major advantage of EPR schemes is that they can be self-financed quickly upon launch and implementation. This is because the PRO normally does not need to make substantial upfront investments and face cash flow issues, it merely channels and manages funds, ideally using own software for transactions and compliance. For instance, in the case of lamps, manufacturers and importers would be responsible for establishing collection points at retail outlets or partnering with existing recycling facilities. The PRO would simply channel the funds to transporters, hazardous waste landfills (short-term), and advanced recycling hubs (for advanced processing and recovery processes).

However, the setup of the PRO itself, for example, developing the registry, staff recruitment, website development, office setup, and legal official registration, are all elements that need financing *before* the launch of EPR. In other words, although EPR is self-financing, it requires a seed capital to establish its infrastructure and operational framework.

Although EPR relieves governments from burdens, efforts and resources need to be provided by administrations. Developing EPR policy, building capacities in ministries, auditing service providers, and other activities require the public sector's investments, especially in human resources. Other enabling aspects for smooth e-waste management include indirect infrastructure and services. This includes aspects such as industrial areas with access to sufficient electricity and water in constant supply for recyclers, paved roads, a robust taxation system, double-lined sanitary landfills with capturing systems, inter alia.

Investment requirements

E-waste management businesses must consider that resources are required for:

- Obtaining sufficient quantities of WEEE, keeping the equipment's physical integrity
- Transporting the devices to treatment/refurbishment locations
- Disposing of hazardous materials (either locally, at a hazardous waste landfill, or exported under the Basel Convention framework)
- Contracting the services of licensed service providers only

However, not all aspects of e-waste management are necessarily covered by EPR. It is necessary to define which activities belong to the EPR scheme and which not (see Phase 1 in Section 0).

Manual dismantling, while helpful at the initial stages of cooling and photovoltaic equipment, is insufficient to reach efficient material recovery yields and is unable to handle hazardous materials within these electronic devices. Thus, advanced machinery is necessary for effective and safe recycling practices. Therefore, once enough data is available and feasibility assessments have been made (see 3), securing essential capital expenditure (CAPEX) investments for advanced machinery in shredding and separation technologies are needed.

PPPs could be formed to plan and develop regional hubs, with private investors providing funding and expertise while governments offer support through land grants or tax incentives. PPPs could facilitate the establishment of specialized recycling facilities equipped to handle refrigerants and hazardous materials found in cooling equipment. Similarly, for solar panels, solutions for EVA and technology to quickly identify the types of panels (silicium versus cadmium, etc.). could be developed by such partnerships.

5. CAPACITY BUILDING & AWARENESS RAISING

Stakeholder categorization and information needs

Raising awareness and building capacities among stakeholders involved in managing cooling, lighting, and photovoltaic equipment is imperative to ensure effective participation in the WEEE chain. Through targeted sensitization and training initiatives, stakeholders can gain the knowledge and skills to fulfill their roles effectively. However, it is important to recognize that capacity building and awareness raising are not one-time efforts but ongoing processes that require continuous investment of time and resources to ensure long-term effectiveness.

Throughout the EAC and SADC Regions, capacity building and awareness-raising initiatives must be tailored to each stakeholder's specific contexts and requirements. This involves providing them with various tools and information they need to make informed decisions and develop their own programs. Nevertheless, there is no need for each country's stakeholder group to repeat efforts and work, which is why a regional strategy and platform would promote efficient knowledge sharing. Fostering collaboration and communication across stakeholder groups in the region (e.g., all lamp recyclers in the EAC or all customs authorities in the SADC) could, therefore, be advantageous. Effective engagement methods include convening focus groups discussions with key stakeholders, such as recyclers and government officials, to gather insights on e-waste management.

Focus Group Discussions (FGDs) are a qualitative research method used to gather insights from participants through guided discussions. The outcomes of FGDs are reached by selecting participants who represent the stakeholder groups involved in the study, creating guiding questions to steer the conversation, and facilitating the discussions in a structured manner. The data collected during these sessions, including audiovisual recordings and notes, are then analyzed to identify themes, gaps, and areas for improvement. The final step involves compiling the findings into a comprehensive report that offers recommendations based on the insights gained from the discussions.

In addition, the organization of expert panels and workshops for specific topics such as e-waste polity, financing instruments, training on safe handling and recycling techniques would foster knowledge exchange and increase within the region.

Besides that, community engagement programs, typically facilitated by local governments and including civil society actors play a major role in awareness raising towards citizens and can be very effective for e-waste management. By employing these methods, stakeholders can collaborate effectively, share knowledge, and develop coordinated approaches to e-waste management across the region.

Table 6 summarizes different stakeholders and their roles and/or needs in capacity-building and awareness-raising efforts for different stakeholders, in groups of:

a. Ministries and authorities
b. Producers (importers, assemblers)
c. Distributors (retailers)
d. Repair shops and refurbishers
e. E-waste managers (transporters, collectors, aggregators, dismantlers, recyclers)
f. Disposal sites
g. Informal actors
h. General public
i. Academia & Civil Society Organizations (CSOs)

Table 6: Stakeholder capacities required for role fulfilment.

	Stakeholder	Capacities built for:
a	Ministry of Environment	· Enactment & enforcement of legislation related to WEEE and EPR · Licensing entities involved in WEEE management · Data collection for monitoring · Auditing WEEE service providers & suggesting corrective measures/fines · Keeping an updated public registry of service providers (collection, transport, refurbishment, recycling, disposal) · Definition of eligibility criteria for fund utilization based on WEEE processing volumes · Collaboration with entities developing/retrofitting WEEE infrastructure (from a technical and legal perspective) · Communication with disposal sites operators to regulate fees · Sanction illegal dumping and illegal WEEE mishandling
	Ministry of Trade & Industry	· Development of standards for product imports & exports · Monitoring compliance with standards · Auditing incoming EEE for compliance
	Bureau of Statistics	· Aggregate data from ministries, customs, and service providers · Analyze data and publish reports regularly on WEEE-related parameters, if available, matching the regional strategy · Collaborate with PRO(s) to manage data and statistics
	Bureau of Standards	· Develop MEPS or equivalent for cooling, lighting, and photovoltaic equipment · Define norms and standards along the WEEE chain
	Ministry of Communication & Information	· Oversight of technical aspects of awareness programs · Support for monitoring & evaluation activities · Leadership in implementing awareness initiatives
	Ministry of Finance & Economic Development	· Establishment of advanced recycling fees (in coordination with PRO(s)) · Collection & management of fees (in coordination with PRO(s)) · Definition of eligibility criteria for fund utilization based on WEEE processing volumes · Collaboration with entities developing/retrofitting WEEE infrastructure (from a financial perspective)
	Revenue Authority or Customs	· Control of quality of imported goods according to MEPS or similar · Maintenance of statistical records for imported & exported cooling, lighting, & photovoltaic equipment · Penalizing cases of non-compliance and breaches
	Local governments	· Implementation of localized awareness campaigns · Ensuring availability & compatibility of data with national registries
	Basel Convention focal points	· Regulate EAC & SADC members' efforts to trade cooling, lighting, & photovoltaic equipment or components · Responding quickly to requests & granting PICs where applicable · Identifying breaches that may be sanctionable
b	Importers	· Compliance with most recent regulations, including data gathering and reporting · Labelling products with constituents · Knowledge of product performance standards · Facilitating take-back programs · Keep customers' records to facilitate collection · Indicating an envisaged lifespan & arranging or bearing responsibility for take-back · Arranging for defective collection · Notifying breaches by manufacturers (false declarations) · Random performance testing · Signaling refurbishment options, ensuring spare part availability & distribution · Rejecting damaged or substandard shipments · Providing incentives for high-performing equipment and enforcement support · EPR fee payment to PRO or equivalent
	Assemblers	· Labelling products with constituents · Informing consumers about refurbishment & take-back · Describing hazards in products

		· Evaluating the possibility of purchasing recovered materials from WEEE recyclers/refurbishers
c	Retailers, distributors & shops	· Maintaining customer records for collection · Reporting sales information · Indicating an envisaged lifespan & arranging or bearing responsibility for take-back · Arranging for defective items collection · Notifying breaches by manufacturers (false declarations) · Testing of equipment performance · Signaling refurbishment options, ensuring spare part availability & distribution · Being connected to refurbishers in the vicinity
d	Refurbishers	· Handing over unusable materials to licensed recyclers & collection centers · Providing incentives to consumers to donate · Conceiving efficient and cost-effective logistics systems · Acquiring know-how & keeping up with technologies & devices for good performance
e	Collection service providers	· Obtaining a license & being enrolled in the scheme · Storing WEEE & pre-sorting for record-keeping · Arranging deals with licensed transporters to reach recyclers · Reporting data according to national guidelines · Setting up & maintaining take-back points · Ensuring physical integrity of equipment · Specifying items handled by schemes · Encouraging collection & return of materials to formal centers · Participating in awareness campaigns development
	Transporters	· Ensuring adequate packaging to preserve the physical integrity of equipment · Ensuring safe & fair conditions for workers · Refusing burned or cannibalized equipment · Keeping records of movements & transactions · Reporting data according to national guidelines · Obtaining the required transportation license · Participating in awareness campaigns development
	Recyclers	· Adhering to licensing requirements · Gathering & reporting data · Ensuring safe & fair conditions for workers · Handling hazardous wastes responsibly · Reinvesting revenue in the facility · Storing equipment awaiting disposal or export · Establishing pricing for cooling, lighting, & photovoltaic equipment or components for international and national buyers · Refusing equipment with signs of burning · Collaborating with informal groups only under permitted conditions (see 16) · Participating in awareness campaigns development
f	Disposal sites	· Developing standards for acceptance criteria allowed in the landfill for cooling, lighting, & photovoltaic equipment or their components · Keeping a registry of quantities · Setting transparent & standard fees
g	Informal sector & collectors	· Aggregating WEEE & handing over without signs of burning or component removal
h	Consumers	· Separating cooling, lighting, & photovoltaic equipment from other wastes · Disposing of equipment or their components at approved centers · Refurbishing, selling, donating WEEE
	Schools	· Integrating WEEE topics into the school curriculum · Educating students about proper disposal of WEEE · Conducting awareness campaigns
i	Universities & academia	· Researching cooling, lighting, & photovoltaic equipment management · Integrating WEEE topics into academic curricula · Developing innovative cooling, lighting, & photovoltaic equipment recycling & disposal solutions · Conducting awareness campaigns

	· Participating in pilots and initiatives wherever possible
CSOs	· Advocating for policy changes to promote sustainable WEEE management · Providing technical, legal, financial expertise · Providing services for WEEE recycling initiatives

Fulfilling the potential stakeholder roles depicted above requires a variety of initiatives and interventions. Several outreach programs would need to be financed by international development organizations and carried out on their behalf by appointed national CSOs, regional and national working groups, local expert consultants, a few international consultants, and other parties.

Platforms for Integration, training, & collaboration

A regional platform is a useful vehicle to support the EACO's and future SADC equivalent strategy. Regional platforms could promote exchange and partnerships between associations working in WEEE, academia, manufacturers, EPR organizations, and other interest groups. The tools and information developed for capacity building, policy drafting, performance standards, licensing criteria, and auditors training, inter alia, could be easily shared. This could play a significant role in improving WEEE management and trade for recycling in the region. The platform in question could have multiple features; some examples are described below:

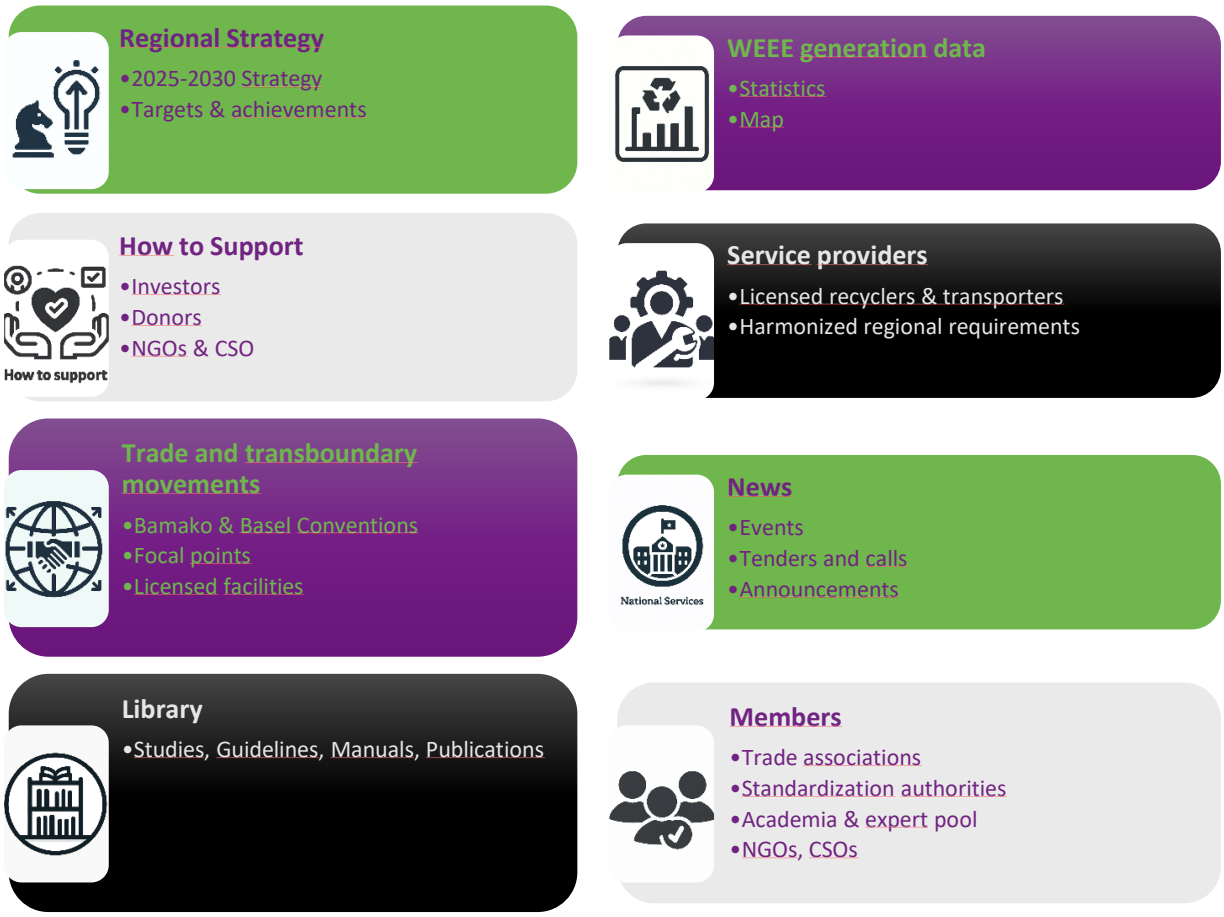

Figure 12: Features of a regional platform for WEEE management and trade.

By investing in these efforts over time, stakeholders can develop the expertise and awareness necessary to address emerging issues, adapt to changing regulations, and contribute effectively to the sustainable management of cooling, lighting, and photovoltaic equipment.

CONCLUSIONS

In their introduction, these Guidelines describe the results of a situation analysis of waste lighting, cooling, and photovoltaic equipment in the SADC and EAC Regions. The analysis includes presented generation data and statistics, along with a listing and mapping of enforced and drafted WEEE and EPR regulations, positive regional initiatives, and existing formal infrastructure. To complement this information, technical details about the 3 WEEE streams highlighting challenges and value in their refurbishment, dismantling, and recycling were presented in a separate section. This seeks only to illustrate why policy must consider logistics and the business model of the completely value chain.

The Guidelines propose developing a regional strategy similar to that of the EACO for additional EAC members and the foundation of an equivalent institution in the SADC. This would promote harmonization and provide a strong EPR legal and administrative framework for countries to cascade into national policies and tools, information, instruments, business opportunities, and know-how transfer. The steps for developing and launching an EPR framework are presented, hoping that countries, no matter their implementation stage, may identify existing gaps and next steps accordingly.

While infrastructure and capital investments are necessary to ensure that end-of-life lamps, cooling equipment, and solar panels can be handled to the maximum possibilities that allow material and energy recovery, data needs to be available to allow for feasibility studies that reflect the whole collection, transport, and export value chain of WEEE businesses. Although, for some stream components, export to foreign facilities with advanced recovery technology is currently the only outlet for their safe handling, the vision in the future is to develop advanced WEEE recycling hubs in Africa, ensuring true circularity in the industry, and creating jobs and an adequate business environment for SMEs and entrepreneurs.

The needs for finance, sources of finance, and requirements to estimate capital investment needs are also addressed. Although EPR is a powerful tool for redistributing financial responsibility in a transparent and more balanced way between private and public sectors, there are still resources and roles to play by the governments of member countries.

Finally, the capacities and awareness required to make any WEEE initiative successful in the long run are outlined in the last chapter. The potential roles of each actor and enabling knowledge and capacities required to fulfill those roles are described. The earlier public awareness is raised, and the earlier producers, recyclers, and governments understand the forces in the e-waste service market, the easier it will be for policy to be designed, enforced, and implemented.

ANNEXES

Annex 1: Processors and recyclers in the Regions

Table 7: Major formal recyclers in SADC and EAC (non-exhaustive)[79].

Country	Recycler	Operations and focus
Burundi	Glice	All WEEE
Kenya	WEEE Center Kenya	All WEEE
Kenya	Enviroserve	WEEE pre-dismantling and pre-processing in SADC and EAC countries. The HQ is an ITAD and ISO certified facility.
Kenya	E-Waste initiative Kenya	All WEEE
Kenya	Synomet	All WEEE
Namibia	Scrap Salvage	Metal waste recycling through container supply and collection
Namibia	NamiGreen	Printer and printer cartridges, phone, computer, as well as a server, mainframe, and telecommunication equipment
Namibia	Rent-a-Drum	Hazardous waste management and export. 10% of exports are to South Africa.
Namibia	E-waste Experts Namibia	Office and household electronics, solar power accessories, generators, electrical cables, car batteries, and communications equipment
Rwanda	Carlcare Company	Refurbishment
Rwanda	Wastezon 2.0	Refurbishment and trade
Rwanda	Enviroserve	WEEE pre-dismantling and pre-processing in SADC and EAC countries. The HQ is an ITAD and ISO certified facility.
SADC	Sims Recycling	WEEE
South Africa	Gauteng	IT and other categories
South Africa	DESCO ELECTRONIC RECYCLERS	Cooling equipment and other WEEE
South Africa	E-Waste Africa	Lamps recycling
South Africa	ReClite	Lamps recycling
South Africa	SA Precious Metals Ltd	PCB materials
South Africa	Syndawonye	All WEEE
South Africa	Enviroserve	WEEE pre-dismantling and pre-processing in SADC and EAC countries. The HQ is an ITAD and ISO certified facility.
South Sudan	WEEE Center South Sudan	All WEEE
Tanzania	Chilambo General Trade Company	All WEEE
Tanzania	WEEE Centre Tanzania	All WEEE
Uganda	WEEE Centre Uganda	All WEEE
Zimbabwe	Enviroserve	WEEE pre-dismantling and pre-processing in SADC and EAC countries. The HQ is an ITAD and ISO certified facility.

[79] *Lydall, M., Nyanjowa, W., & James, Y. 2017. Mapping South Africa's WEEE dismantling, pre-processing and processing technology landscape. Waste research development and innovation roadmap research report. Last access April 2024.*
ITU 2024. National E-waste Monitor Namibia. D-GEN-E_WASTE.05-2024-02-PDF-E.pdf (itu.int)

Annex 2: International policies and conventions applicable to WEEE and its components

International conventions developed by the UN and its bodies are relevant for EEE production and trade containing hazardous materials, particularly within African borders, as well as UEEE and WEEE transboundary movements.

As per these instruments of international law, these non-binding agreements have various degrees of implementation by EAC and SADC members. In other words, some of them have been signed, signed but not ratified, or not signed.

- **Basel Convention (1989)** – regulates **transboundary hazardous waste movements** preventing illegal WEEE transport.
- **Montreal Protocol (1989)** – promotes eliminating substances **like Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs)** found in cooling devices.
- **Rotterdam Convention (1998)** – promotes shared responsibility in hazardous chemical trade, encouraging safe handling and informed international trade practices of WEEE.
- **Stockholm Convention (2001)** – targets the elimination of Persistent Organic Pollutants (POPs), including those present in e-Waste.
- **Bamako Convention (1991)** – promotes the prevention of the **final destination of hazardous waste** produced elsewhere to be dumped in African countries.
- **Maputo Protocol (2005) -** guarantees the right of **women** to live in a healthy and sustainable environment by regulating **proper standards** for the storage, transportation, and disposal of toxic waste.

Annex 3: Overview of countries in their region with WEEE/EPR policies or drafts

Table 8: Countries in the SADC and EAC region with EPR and/or WEEE legislation enforced (status 05 2024)[80].

Country	EPR	WEEE	Name of instrument	Year	Authority	Webiste
Kenya		x	Guidelines for E-Waste Management in Kenya	2010	NEMA	Hyperlink
	x		Public notice to all producers	2023	NEMA	Hyperlink
Madagascar	[81]	x	Decree No 2015-930 Regarding Classification and Ecologically Rational Management of Waste Electronic and Electric Equipment	2016	MOEF	[82]
Rwanda	x	x	Regulation N°002 Of 26/4/2018 Governing E-Waste Management in Rwanda	2018	Rwanda Utilities Regulatory Authority	Hyperlink
Tanzania	[81]		Sustainable Waste Management Policy 2021 and SWM Act 2022	2021,2022	NEMA	Hyperlink
	x				NEMA	[82]
		x	The Environmental Management (Control and Management Of WEEE) Regulations, 2021	2021	NEMC	Hyperlink
South Africa	x	x	National Environmental Management: Waste Act, 2008; Amendments to The Regulations and Notices Regarding EPR, 2020	2020	Dept. of Forestry, Fisheries, & Environment	Hyperlink
Uganda	[83]	x	Electronic Waste (E-Waste) Management Policy for Uganda	2018	Ministry of Information and Communications Technology	Hyperlink
Zambia	[81]	x	The Environmental Management (Extended Producer Responsibility) Regulations, Statutory Instrument No. 65 of 2018 (EPR Regulations)	2018	ZEMA	u

[80] Angola, Botswana, Comoros, Congo, Eswatini Kingdom, Lesotho, Malawi, Mauritius, Mozambique, Seychelles, Somalia, South Sudan, and Zimbabwe have not enacted WEEE or EPR legislation.
[81] *Basis for EPR established, but not an EPR regulation.*
[82] *The document was not found on the Ministry's website.*
[83] Advanced Recycling Fees (ARF) on electronic equipment.

Annex 4: WEEE categories by the EU legislation

E-waste is defined by the Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on Waste Electrical and Electronic Equipment (WEEE). It refers to devices that the owner discards, including all components, sub-assemblies and consumables which are part of the product at the time of discarding).

Table 9: Legal categorization of WEEE in Europe[84].

Category		Examples
1	Temperature exchange equipment	Refrigerators, freezers, equipment which automatically delivers cold products, air conditioning equipment, dehumidifying equipment, heat pumps, radiators containing oil and other temperature exchange equipment using fluids other than water for the temperature exchange.
2	Screens & monitors	Screens, televisions, LCD photo frames, monitors, laptops, notebooks.
3	Lamps	Straight fluorescent lamps, compact fluorescent lamps, fluorescent lamps, high intensity discharge lamps — including pressure sodium lamps and metal halide lamps, low pressure sodium lamps, LED.
4	Large equipment (any external dimension more than 50 cm)	Washing machines, clothes dryers, dish washers, cookers, electric stoves, electric hot plates, luminaires, equipment reproducing sound or images, musical equipment, appliances for knitting and weaving, large computer-mainframes, printing machines, copying equipment, coin slot machines, medical devices, monitoring and control instruments, automatic machines, photovoltaic panels.
5	Small equipment (no external dimension more than 50 cm)	Vacuum cleaners, carpet sweepers, appliances for sewing, luminaires, microwaves, ventilation equipment, irons, toasters, electric knives, electric kettles, clocks and watches, electric shavers, scales, appliances for hair and body care, calculators, radio sets, video recorders, musical instruments, equipment reproducing sound or images, toys, sports equipment, computers for biking, diving, running, rowing, etc., smoke detectors, heating regulators, thermostats, tools, medical devices, small monitoring and control instruments, small equipment with integrated photovoltaic panels.
6	Small IT and telecommunication equipment	Mobile phones, GPS, pocket calculators, routers, personal computers, printers, telephones.

[84] *Compilation from the regulation as presented in "The Global E-waste Monitor 2020".*

Annex 5: UNU & HS WEEE categorization

The UNU-KEYS are 54 categories developed to classify WEEE based on lifetimes, composition, and weight. They may be used to convert the 6 and 10 EEE categories of the EU WEEE Directives and to collect data on EEE put on the market (POM) via HS coding. Since e-waste generation statistics and trends are often based on this POM data and the average life expectancy of a product, UNU classifications are typically followed for statistical analyses when matched with HS codes.

Table 10: HS codes for products and corresponding UNU WEEE classification codes (examples) (n.e.s. in this table means not elsewhere specified). [85]

UNU-KEY	UNU Key Description	HS	HS Description
0101	Professional Heating & Ventilation (excl. cooling equipment)	845110	Dry-cleaning machines
0101	Professional Heating & Ventilation (excl. cooling equipment)	845130	Ironing machines and presses including fusing presses
0102	Dishwashers	842211	Dish washing machines (domestic)
0103	Kitchen (large furnaces, ovens, cooking equipment)	851660	Electric cooking, grilling & roasting equipment nes
0104	Washing Machines (incl. combined dryers)	845011	Automatic washing machines, of a dry capacity < 10 kg
0104	Washing Machines (incl. combined dryers)	845012	Washing machines nes, capacity <10 kg, built-in drier
0104	Washing Machines (incl. combined dryers)	845019	Household/laundry-type washing machines <10 kg, nes
0104	Washing Machines (incl. combined dryers)	845020	Household or laundry-type washing machines, cap >10kg
0105	Dryers (wash dryers, centrifuges)	842112	Clothes-dryers, centrifugal
0105	Dryers (wash dryers, centrifuges)	845121	Drying machines, capacity <10 kg, except washer-drier
0105	Dryers (wash dryers, centrifuges)	845129	Drying machines, nes
0106	Household Heating & Ventilation (f.i. hoods, ventilators, space heaters)	841460	Ventilating hoods having a maximum width < 120 cm
0106	Household Heating & Ventilation (f.i. hoods, ventilators, space heaters)	851621	Electric storage heating radiators
0106	Household Heating & Ventilation (f.i. hoods, ventilators, space heaters)	851629	Electric space heating nes and soil heating apparatus
0108	Fridges (incl. combi-fridges)	841821	Refrigerators, household compression type
0108	Fridges (incl. combi-fridges)	841822	Refrigerators, household absorption type, electric
0108	Fridges (incl. combi-fridges)	841829	Refrigerators, household type, including non-electric
0109	Freezers	841830	Freezers of the chest type, < 800 litre capacity
0109	Freezers	841840	Freezers of the upright type, < 900 litre capacity
0111	Air Conditioners (household installed and portable)	841510	Air conditioners window/wall types, self-contained
0111	Air Conditioners (household installed and portable)	841581	Air conditioners nes with reverse cycle refrigeration

[85] *Source: Forti, V., Baldé, C.P., & Kuehr, R. (2018). E-waste Statistics: Guidelines on Classifications, Reporting and Indicators (2nd ed.). United Nations University, ViE – SCYCLE, Bonn, Germany. ISBN: 978-92-808-9066-2 (Print), 978-92-808-9067-9 (Digital).Retrieved from: https://collections.unu.edu/eserv/UNU:6477/RZ_EWaste_Guidelines_LoRes.pdf.*

Annex 6: Technical factsheet for the categories

Each e-waste type has its specific features that must be considered by the time of final disposal, within EPR, and within business models of recyclers. There are many factors to evaluate when comparing specific attributes for recycling e-waste residues and how those features might affect WEEE recycling processes.

Table 11: Comparative attributes of different WEEE categories.

	Solar panels	Refrigerators	Fluorescent lamps
Waste sources (examples)	Rural and urban settings, centralized and decentralized infrastructure	Restaurants, hospitals, laboratories, offices, residences, malls, airport, industry	Restaurants, hospitals, laboratories, offices, residences, malls, airport, industry, and public streets
Distribution	Ubiquitous	Ubiquitous	Ubiquitous
Hazardous components (extract)	**Lead**, **tin**, copper wires, and **cadmium or tellurium** coating	**HFCs** and **HCFCs**[86], **Polyurethane foams**	**Mercury**
Valuable components (extract)	Aluminum Panel components if sold at local markets	Metals	-
Average lifetime	25 years	15 years[87]	7,000 to 15,000 hours
Average weight	High > 35 kg/module	High >35 up to 130 kg	Low < 1 kg
Qualitative market value as waste[88]	Medium	Medium	Low
Health & environmental impact	Medium	High	High

[86] *Hydrochlorocarbons, hydrochlorofluorocarbons with a much higher global warming potential than CO_2. Many are banned and regulated by the Montreal Protocol (1989).*
[87] *Guidehouse Germany GmbH 2023. Cooling Sector Prospects Study Lebanon.*
[88] *Considering both hazardous (expensive to manage) and valuable components (with a high market value and plenty potential buyers), considering international buyers*

The table below highlights main technical and logistical obstacles faced when recycling e-waste, finding common points among the three e-waste types.

Table 12: Overview of specific challenges to recycling.

	Solar panels	Refrigerators	Fluorescent lamps
Technical obstacles to recycling	Only frames can be fixed locally; it is generally difficult for the user to detect and repair defects in the panel. Actual recycling into other panels is only possible at the factories themselves in China, the USA, or Europe.	Polyurethane foam releases toxic fumes when heated or compressed and requires incineration under controlled flue gas emissions. Refrigerants and capacitors are hazardous and require special extraction equipment, training for processing, and special personal protective equipment.	Technology for crushing under high extraction and security measures for mercury recovery is expensive. Coils and other components have minor value.
Logistical obstacles for repair/ recycling	Damages during transport Heavy to move (usually at least 2 people required)	Generally difficult to transport without a vehicle.	Little to no value is present in most lamps, so paying transportation costs is not compensated by any material sale.
Valuable components	Aluminum frame, copper, steel	Metals, glass	None

The regional legislation on WEEE, EPR, imports on used EEE and official data availability are presented in I. Some of the EAC and SADC countries have special regulations for lighting and cooling equipment. For lighting equipment, Kenya, Madagascar, Namibia, Seychelles, South Africa, Uganda, Zambia, and Zimbabwe have adopted MEPS to a certain degree, have drafted energy-efficiency policies, demanded labeling efforts and compulsory specifications, as well as banned some technologies (South Africa banned incandescent lighting in 2014)[89].

[89] *EACREEE, 2019. Overview of the On-Grid and Off-Grid Lighting Markets in East and Southern Africa. https://www.eacreee.org/sites/default/files/eela/reports/att/EELA_SADC_and_EAC_Lighting_Market_Assessment_Report_v.2.0.pdf Last access April 2024*

Annex 7: Collection and recycling targets under EPR, the case of South Africa

In 2020, South Africa implemented its EPR framework along with compliance requirements, ensuring that all stakeholders are aligned with the collection and recycling targets. The targets are for take-back, recovery, and recyclability over a span of 5 years and specific to the type of lighting equipment in question.

Table 13: Collection Goals for WEEE under South Africa's EPR Regulations[90]

Product	Targets (%)														
	Mandatory take back					Recovery					Recyclability				
	Y1	Y2	Y3	Y4	Y5	Y1	Y2	Y3	Y4	Y5	Y1	Y2	Y3	Y4	Y5
(I) Gas Discharge Lamps	12	16	19	23	31	90	95	96	97	98	93	93	93	93	93
Low pressure discharge lighting - Fluorescent	15	20	25	30	40	90	95	96	97	98	95	95	95	95	95
HID	15	20	25	30	40	90	95	96	97	98	95	95	95	95	95
Lighting for special purposes	5	8	8	10	12	90	95	96	97	98	90	90	90	90	90
(II) Retrofit LED	15	20	25	25	25	78	83	83	83	88	60	70	75	75	75
LED linear tubes	15	20	25	25	25	75	80	80	80	85	60	70	75	75	75
LED Bulbous shape	15	20	25	25	25	80	85	85	85	90	60	70	75	75	75
(III) New LED sources	5	10	15	20	20	80	85	90	90	90	70	75	85	85	85
LED lighting and luminaires	5	10	15	20	20	80	85	90	0	90	70	75	85	85	85
(IV) Other Light Emitting Devices	10	15	20	25	30	73	73	73	73	73	62	62	65	67	67
Vehicle/Automotive Lighting	10	15	20	25	30	80	80	80	80	80	50	50	60	65	65
Lighting from other electronic equipment	10	15	20	25	30	90	90	90	90	90	85	85	85	85	85
Others	10	15	20	25	30	50	50	50	50	50	50	50	50	50	50
(V) Luminaires and Lighting Equipment	5	10	15	20	30	90	92	94	96	96	95	95	95	95	95
Fixtures/Modules/Associated electrical components	5	10	15	20	30	90	92	94	96	96	95	95	95	95	95
(VI) Laser, Pixel and UGVC lighting	2	2	2	2	2	70	70	70	70	70	70	70	70	70	70
Laser, Pixel and UGVC lighting	2	2	2	2	2	70	70	70	70	70	70	70	70	70	70
(VII) Off grid Solar powered lighting	5	10	15	17	19	77	78	80	80	80	80	82	85	87	87
Off grid solar lighting	5	10	15	20	20	80	85	90	90	90	70	75	85	85	85
Lighting solar panels	5	10	15	15	18	70	70	70	70	70	90	90	90	90	90
Solar lighting energy storage	5	10	15	15	18	80	80	80	80	80	80	80	80	85	85
(VIII) Incandescent and Halogen light bulbs	50	60	65	70	70	95	95	95	95	95	95	95	95	95	95

[90] *Waste Act of 2008 (act no.59 of 2008) by the Department of Environment, Forestry, and Fisheries. Annexure 1 "Amendments to the Regulations and Notices Regarding Extended Producer Responsibility, 2020".*

Halogen lamps	50	60	65	70	70	95	95	95	95	95	95	95	95	95	95
Incandescent filament lamps	50	60	65	70	70	95	95	95	95	95	95	95	95	95	95
Colletion	**The collection of waste lighting lamps as a percentage against the import of new lighting lamps;**														
	n.b in a growing economy 100% is not possible as this would mean 0% growth of the market														
Recovery	**The ability to separate the various fractions from the product and liberate for further recycling**														
Recyclability	**The ability to change recovered fractions into new raw material or new products**														

Annex 8: Tools and facility for the recycling plant

Table 14: Examples of equipment needed per e.g. 10 dismantling working tables .

Item	Quantity	Description
Collection Containers	Varies	Suitable containers for safe collection of different types of e-waste and hazardous components.
Transport Equipment	Varies	Trucks and vehicles adapted for safe transport of e-waste.
Manual Dismantling Tools	Multiple sets	Screwdrivers, pliers, hammers, etc.
Pneumatic Tools	10 sets	Pneumatic tools for dismantling.
Personal Protective Equipment (PPE)	Multiple sets	Gloves, safety glasses, masks, appropriate clothing.
Storage Facilities	Varies	Secure and regulated areas for temporary storage of e-waste before recycling or disposal.
Dismantling Tables	10 tables	Robust tables equipped with tools for dismantling.
Adjustable Chairs	10 chairs	Ergonomic chairs adjustable for height.
Lighting Systems	10 lights	Fluorescent lights for adequate visibility.
Sealed Containers	5 containers	For safe storage of toxic components like Liquid Crystal Displays and mercury lamps.
Precision Scales	2 scales	Scales for measuring the weight of recycled materials.
Disassembly Tools for Solar Systems	Multiple sets	Specialized tools for safely disassembling solar panels and components.
Safety Equipment for Solar Systems	Multiple sets	Insulated gloves, face shields, and other PPE.
Testing and Diagnostic Tools	Multiple sets	Equipment to assess the condition and functionality of components (mainly cooling and photovoltaic equipment)
Component Storage Solutions	Varies	Bins and shelves for organizing separated components.
Recycling and Disposal Equipment	Varies	Machines for shredding, sorting, and processing materials.


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