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MINISTRY OF INDUSTRY

REPUBLIC OF LEBANON
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# PROVISION OF SERVICES FOR THE ASSESSMENT OF E-WASTE & BATTERIES IN LEBANON

BASELINE ASSESSMENT OF TYPES & QUANTITIES OF E-WASTE & DEVELOPMENT OF SYSTEMS & THEIR FINANCIAL ASSESSMENT

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## Disclaimer

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# List of Acronymes

| | |
|---|---|
| AA | Additional Area |
| ABS | Acrylonitrile butadiene styrene |
| AGM | Absorbent Glass Mat |
| ALI | Association of Lebanese Industrialist |
| ALMEE | Lebanese Association for Energy Saving and Environment |
| BFS | BlackForest Solutions |
| CAGR | Compound Annual Growth Rate |
| CAPEX | Capital Expenditures |
| CCFL | Cold Cathode Fluorescent Lamp |
| CRT | Cathode ray tube |
| DREG | Decentralized Renewable Energy Generation Project |
| EDL | Électricité du Liban |
| EEE | Electrical and Electronic Equipment |
| ELARD | Earth Link and Advanced Resource Development |
| EPR | Extended Producer Responsibility |
| E-products | Electrical and electronic products |
| ESM | Environmentally Sound Management |
| EU | European Union |
| E-Waste | Electrical and electronic wastes |
| FE | Ferrous |
| FPD | Flat panel display |
| FR | Flame Retardants |
| GDP PPP | Gross Domestic Product at Purchasing Power Parity |
| HS | Harmonized System |
| ICT | Information and Communication Technology |
| IRENA | International Renewable Energy Agency |
| ISWMS | International Solid Waste Management System |
| IT | Information Technology |
| ITO | Indium tin oxide |
| L | Line |

| | |
|---|---|
| LCD | Liquid crystal display |
| LCEC | Lebanese Center for Energy Conservation |
| MENA | Middle East and North Africa |
| MoE | Ministry of Environment |
| MoET | Ministry of Economy and Trade |
| MoEW | Ministry of Energy and Water |
| MoI | Ministry of Industry |
| NEA | National Environment Agency |
| NFE | Nonferrous |
| NGO | Non-Governmental Organization |
| OPEX | Operational Expenditures |
| PCB | Printed circuit boards |
| PE | Polyethylene |
| POM | Put on Market |
| PP | Polypropylene |
| PPPs | Public-Private Partnerships |
| PRO | Producer Responsibility Organization |
| PS | Polysterene |
| PU | Polyurethane |
| PV | Photovoltaic panels |
| SWOT | Strengths, Weaknesses, Opportunities, Threats |
| TaDWIR | Towards a Decentralized Waste Management Integrated Response |
| TFS | Trans Frontier Shipment |
| UNDP | United Nations Development Program |
| UNU | United Nations University |
| WEEE | Waste Electrical and Electronic Equipment |

# Executive Summary

Nowadays, electronic waste (e-waste) is the most rapidly growing waste stream. The challenge of e-waste is of even greater concern in developing countries because most of them lack the capacity of handling and recycling the hazardous materials contained in e-waste. This often leads to the disposal of e-waste with municipal waste in dumpsites, consequently polluting the environment and posing health risks to the community.

Data relating to Electronic and Electrical Equipment (EEE) and the flow of e-waste in Lebanon are not well-known. This report presents the findings of a baseline assessment of the types and quantities of e-waste and the development of systems, and their financial assessment conducted by Earth Link and Advanced Resource Development (ELARD) and BlackForest Solutions (BFS). The primary objective was to establish a baseline of the e-waste and batteries generation in Lebanon with an estimation of the types and quantities generated. This included a comprehensive description of the available collection and treatment systems along with the stakeholders engaged in the assessment. The methodology mainly involved data acquisition, data analysis, and data forecasting of the e-waste through literature reviews, consultations with stakeholders, calls, questionnaires, and field observations.

The results of the study have shown that in Lebanon in 2022, the total quantity put on the market (POM) was 46,551 tons for EEE, excluding photovoltaic cells (PV), which reached a value of 82,291 tons, and 117,615 tons of batteries. Compared to previous years, the data reveals a 46% decrease in EEE quantities relative to 2017, which can be attributed to the COVID-19 pandemic and the economic crisis in Lebanon. However, PV and batteries quantities experienced a significant, unprecedented increase, marking the year as exceptionally high. The elevated quantities observed in 2022 are attributed to the fuel crisis, currency fluctuations, the total absence of electricity from public sources, and the high cost of electricity from private sources. The unstable situation in the country over the last 5 years has affected the calculation and estimation of future quantities.

The e-waste generated from EEE in Lebanon (excluding PV) was estimated to be 47,501 tons in 2022 and is projected to reach 74,529 tons by 2040. Battery waste was estimated at 33,444 tons in 2022 and could increase to 145,814 tons by 2040 due to the exponential growth in 2021 and 2022 for solar systems batteries that fall under the accumulator category for 3 HS codes. In terms of PV waste, Lebanon is expected to face a significant challenge in the coming years. The current waste generated is approximately 16 tons, and given the energy transition that occurred in 2022, if no action is taken, it could surge to 13,889 tons by 2040 and an alarming 50,454 tons by 2050.

Lebanon currently lacks a proper e-waste treatment facility, and there is limited active engagement from relevant stakeholders in this sector. These stakeholders often lack an awareness of the environmental situation and the necessary know-how for effective e-waste management. The study also included an analysis of the strengths, weaknesses, opportunities, and threats in the current e-waste management situation in Lebanon, revealing several significant gaps such as the absence of a regulatory framework, insufficient infrastructure, limited knowledge among stakeholders, lack of standardized data, and insufficient collaboration among existing stakeholders and institutions.

Considering this scenario, the implementation of extended producer responsibility schemes comes to cover financial needs to establish collection and treatment costs.

OECD defines Extended Producer Responsibility (EPR) as an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle[1]. Based on this principle, EPR has gained momentum over the past few years and establishment of such financial instruments has spread. Aiming the establishment of such a system in Lebanon, a target was set for the countries´ collection of the six e-waste categories. Although the recently updated Integrated Solid Waste Management Strategy (ISWM) has put forth ambitious waste reduction goals, targeting a WEEE collection rate of 4 kg/capita within five years post-strategy adoption, the current report proposed to reach 22% collection rate of all waste fractions by year 5 of the EPR implementation, representing roughly 1,5kg per citizen/year. Currently, the collection rate lingers at a mere 2,92% of Products Placed on

1 https://www.oecd.org/env/waste/extended-producer-responsibility.htm

the Market (POM), equivalent to 0,202 kg/inh. Considering the prevailing conditions, there's a real concern about enforcing such a high target. In-depth analysis suggests recalibrating the goal to a more achievable goal. A range of 20-25% of POM seems more suited to Lebanon's unique circumstances.

Based on these targets, collection channels have been designed based on worldwide best practices and the local context and collected volumes per channel have been estimated. Two primary sources of e-waste were identified by our consultant team: private households and commercial entities, which are comprised of industries, institutions, and large retail shops. These are represented by waste collection events, designated drop-off points, in-store reception, door-to-door collection services, mobile collection points, and local collection centers. For commercial entities, emphasis has been placed on on-demand collection, and options to drop off waste at either local or mobile collection points have been provided. The model was designed targeting the consolidation of volumes from these collection channels in collection centers. These can be either fixed infrastructure or mobile units, depending on the geographic and demographic characteristics of the zones. The pre-defined zones were Beirut, Keserwan and Mount Lebanon, Baalbek Hermel and Beqaa, Akkar, North and Jbeil, and South and Nabatiyeh. To achieve the aforementioned targets, a total of 12 collection centers have been deemed necessary. Metropolitan areas, given their demographic density and available space, will predominantly feature fixed infrastructure. In contrast, mobile collection units will predominantly service rural regions.

Considering the current deficit in WEEE treatment capacities and the projected volume targets, the model proposed a "proof of concept" facility which integrates manual dismantling with semi-automated procedures. The technology proposed was to ensure safe handling of all e-waste types and complete treatment of all fractions after processing and dismantling. The concept includes six treatment lines for temperature exchange equipment, flat panel display and monitors, cathode ray tube television, small IT and small equipment and lamps. Four additional areas were included for battery sorting, and lithium battery shredding, cable and plastic processing. These were included since such treatment systems are inexistant in Lebanon and market and/or disposal possibilities would benefit from enhanced local value creation.

The total system costs, capital (CAPEX) and operational expenditures (OPEX), were estimated for the conceptual scenario. The required investment, including collection channels, consolidation and a sorting and dismantling center was of 7 million 400 thousand USD. On the operational side, the costs were estimated in 8 million 400 thousand USD per year. With such investments, it shall be possible for the country to collect the calculated 13 thousand tons of WEEE per year, equivalent to over 1 million 400 thousand units of equipment and batteries in this period.

As mentioned above a CAPEX of $7.4 million USD has been designated for local collection centers, a sorting and basic treatment center, and a collection network. The breakdown is as follows:

1. Local Collection Centers: 70% of the budget or $3.5 million USD, is allocated for establishing 12 centers to systematically consolidate the electronic waste and batteries.
2. Sorting and Basic Treatment Center: $3 million USD is divided into two parts - $1.5 million USD for machinery and $1 million USD for infrastructure. This is crucial for precise sorting and environmentally friendly waste management.
3. Collection Network: An investment of approximately $900,000 USD is essential for establishing a unified network dedicated to the collection, including proper packaging, of electronic waste and batteries.

To secure funding for local collection centers, external sources such as NGOs and international organizations may need to be explored.

Regarding the sorting and basic treatment center, a promising strategy may involve seeking funding from the System Administrator (equivalent to the Producer Responsibility Organization). This facility could serve as a valuable proof of concept, allowing the country the time needed to improve its infrastructure.

The operational expenditure (OPEX) associated with the collection, transport, consolidation, sorting, and basic treatment of electronic waste and batteries amounts to $ 8.4 million USD annually. This allocation can be further detailed as follows:

1. Sorting and Basic Treatment Center (4 M USD):

- Net Treatment Costs: Approximately $3 million USD is allocated annually for various aspects of net treatment costs, including equipment and infrastructure maintenance and insurance, labor costs, dismantling products, as well as costs associated with either selling the fractions or responsibly disposing of them.

2. Material Transport (2.3 M USD):

- Local Collection and Transport: A significant portion of the budget, $ 2.3 million USD, is dedicated to comprehensive logistics, including the collection of electronic waste and batteries from their sources and their transportation to local collection centers.
- Consolidation and Transportation: After gathering waste materials at the local collection centers, they are consolidated for efficiency and then transported to the sorting and basic treatment facility. This systematic process ensures timely and efficient waste processing.

3. Collection and consolidation network (2 M USD):

- Collection Network: An estimated budget of $500 thousand is allocated to sustain the operations of the 6 collection channels. The primary expenses include labor costs for personnel required at the mobile collection points and the on-demand collection channel, along with compensation for the informal sector for their waste management activities.
- Local Collection Centers: A budget of $1.5 million was estimated to support the maintenance of the proposed 12 collection centers, primarily covering labor costs.

Lastly, the conclusions highlight the challenges due to the country´s lack of a regulatory framework, proper infrastructure for e-waste management, adequate e-waste management know-how and awareness, available data and reporting mechanisms, and an existing network collaboration of relevant stakeholders and institutions to address the issue. To solve these pending issues, the important role of EPR was highlighted and next steps were defined so that Lebanon can make a step ahead towards e-waste management.

PROVISION OF SERVICES FOR THE ASSESSMENT OF

# E-WASTE & BATTERIES IN LEBANON

# 01

# INTRODUCTION

# 1. INTRODUCTION

Waste management in Lebanon remains highly challenging and the country has faced major waste crises during the last decades. To support waste management systems in Lebanon and to improve their environmental and financial sustainability, the TaDWIR (Towards a Decentralized Waste Management Integrated Response) program in Lebanon is currently being implemented by the United Nations Development Program (UNDP) with funding from the European Union (EU). TaDWIR planned activities cover electronic waste and batteries among other types of waste.

The waste generated from the Electronic and Electrical Equipment (EEE), commonly known as electronic waste (e-waste), poses significant environmental and health risks when not managed properly. Unsafe handling may lead to the generation of hazardous substances, such as lead, mercury and cadmium that can contaminate soil, water, air and may increase the risk of fires. In addition, mixed collection of e-waste and batteries with municipal waste will lead to contamination of the latter and thus reduction of recyclability potentials (Rajesh et al., 2022).

Lebanon struggles with various obstacles in managing efficient e-waste collection, recycling, and disposal systems, such as inadequate infrastructure, limited public awareness, insufficient funding, and the absence of a comprehensive regulatory framework. As a result, most of this waste ends up in the hands of scrap-dealers or is mixed up with regular municipal waste, a large proportion remains stored in households and businesses, and a minor part is handed over to specialized actors.

The economic and fuel crises in Lebanon are impacting waste management and are anticipated to impact the amount of e-waste generated. The currency fluctuations have reduced the resources available for waste collection in general and minimized the ability and willingness to collect e-waste in particular. The combination of high transportation costs and lack of logistics intensifies the challenges surrounding e-waste management. Additionally, the power crisis, coupled with high fuel prices and lifting of subsidies on fuel, are driving a transition to solar energy, which is expected to generate more e-waste in the absence of treatment facilities.

In this context, the "Assessment of E-waste and Batteries in Lebanon" project under the TaDWIR program come to address the e-waste challenges, through the assessment of e-waste and batteries in Lebanon and the development of an adequate management system, the Extended Producer Responsibility (EPR), by:

- Developing comprehensive legislation and regulations specifically addressing e-waste management;
- Establishing a well-coordinated collection system with designated collection points;
- Strengthening public awareness campaigns to promote responsible e-waste disposal;
- Encouraging private sector engagement in e-waste recycling initiatives; and
- Facilitating partnerships and cooperation among stakeholders for effective e-waste management.

The purpose of this report is to draw a baseline of the generation of e-waste and batteries in Lebanon with an estimation on the types and quantities generated over the past decade and for the next 15 years, a comprehensive description of the available collection and treatment/export systems along with all engaged stakeholders; and to develop concepts for collection/reverse logistics, dismantling, recycling and export or trans-frontier shipment (TFS) of e-waste and batteries, and conduct a financial assessment for each system. This report includes an introduction, a definition of e-waste, the adopted methodologies, the estimated quantities of e-waste, solar panels, and batteries in Lebanon, a gap analysis, and a framework for the EPR systems with their financial assessment.

PROVISION OF SERVICES FOR THE ASSESSMENT OF

# E-WASTE & BATTERIES IN LEBANON

# 02

# DEFINITION OF E-WASTE

## 2. DEFINITION OF E-WASTE

Electrical and electronic products (e-products) are defined as any household or business item with circuitry or electrical components with power or battery supply. Nevertheless, all e-products come with a life expectancy, and once they stop functioning or new technology makes them obsolete, they must be discarded and become an electronic waste (e-waste) without the intention of reuse (Parajuly et al., 2019).

In general, e-waste consists of glass, plastic, wood, printed circuit boards, batteries, ferrous (steel, iron) and non-ferrous metals (aluminum, copper and lead), concrete, rubber, ceramics, rare earths and other precious metals (gold, silver), and chemical substances (Rajesh et al., 2022).

Various factors are linked to the global e-waste problem and must not be addressed in isolation. A good understanding of these elements illustrated in Figure 2-1 is necessary to resolve the e-waste problem and to find possible solutions (Parajuly et al., 2019).


*Figure 2-1 Elements of the e-waste problem*

*Source: Parajuly et al., 2019*

PROVISION OF SERVICES FOR THE ASSESSMENT OF

# E-WASTE & BATTERIES IN LEBANON

# 03

# METHODOLOGY

# 3. METHODOLOGY

To develop an adequate management framework of e-waste and batteries through the adoption of an EPR system, the following activities were undertaken in different phases: literature review, data collection, data extraction, data processing (including projections) and analysis, and result reporting.

## 3.1 TASK 2 – BASELINE ASSESSMENT OF TYPES AND QUANTITIES OF E-WASTE

The methodology for task 2 involved mainly:

- Data collection through literature review, consultations with stakeholders, field study questionnaires and observations in the field;
- Data extraction from the Lebanese customs website;
- Data analysis, data forecasting/ projections; and
- E-waste and batteries assessment conducted in accordance with the E-waste statistics guidelines on classification reporting and indicators, developed by the United Nations University (UNU).

### 3.1.1 Data Collection

#### 3.1.1.1 Desk Review

The desk review aimed to gather information from several studies, databases, publications, statistics, and reports conducted in Lebanon, the MENA Region, and European countries to understand the status of electronic and electrical equipment in Lebanon in terms of generation, usage, stock estimation, functionality, and disposal behavior.

Such a strategy involved conducting a systematic search using specific keywords related to e-waste, e-waste generation, formal collection, management systems, etc. of e-waste in Lebanon. Multiple databases and search engines were employed to gather a comprehensive set of literature and materials.

#### 3.1.1.2 Stakeholder Mapping

Part of the desk review was to conduct a comprehensive analysis of stakeholders that are concerned with the e-waste sector to develop an EPR system in Lebanon. The review aims to identify and classify relevant stakeholders, by summarizing their role/function, their relevance and expected perception of the project targets and potential cross-cutting cooperation. By focusing on the value chain of electronics and electrical products, relevant key stakeholders from public and private sector, as well as community-based stakeholders, were identified, and grouped into manufacturers, suppliers, collectors/ recyclers, and Lebanese institutions, which cover different roles in the e-waste and battery value chain.

#### 3.1.1.3 Questionnaires and calls

Consultations were held with key regulatory bodies with responsibility for environmental issues, waste management, and those involved in EEE sector which include the Lebanese customs, the Ministry of Environment, the Ministry of Industry, EEE recyclers, major suppliers, etc. Comprehensive well-structure questionnaires (Annex A – Questionnaires) were developed for the main different groups. These questionnaires included detailed questions related to the stakeholders' functions/roles, their knowledge of e-waste, whether they are adopting any waste management policies at their institutions, and their perceptions regarding the project's targets and potential cooperation.

Interviewing the key stakeholders through calls, emails, or site-visits allowed a better understanding of the challenges currently facing the sector and the support needed in developing the e-waste management system. The calls aimed to gather data from the different groups about the EEE market in Lebanon, the main actors, their knowledge of the country legislations, their know-how on e-waste recycling and EPR system, and their willingness to manage e-waste and collaborate with other institutions. Calls were crucial for identifying the gaps that need to be addressed to effectively implement the EPR principle.

### 3.1.2 Measurement Framework and Calculation Steps

In Lebanon, there is a lack of any official measurement of e-waste quantities. However, some existing datasets, such as import/export statistics that are related to EEE and batteries, were available from the Lebanese Customs Administration, a public administration office responsible for collecting customs duties and all other fees and taxes that are mandated to be collected on goods imported into Lebanon, via their website. To improve comparability between countries, a measurement framework that can integrate the harmonized existing data and can serve as the basis for e-waste statistics and indicators, has been adopted to ensure adherence to standardized practices and consistency in data collection and reporting.

The measurement framework of e-waste adopted in this study is consistent with the second edition of E-Waste Statistics Guidelines on Classification, Reporting, and Indicators authored by Forti V., Baldé C.P., Kuehr R. in 2018. The approach covers production, imports, exports, placing on the market, e-waste generation, e-waste management, and other e-waste related activities (Forti et al., 2018).

#### 3.1.2.1 Put On Market

The term "Put on Market" (POM) refers to the amount of EEE consumed in each time and geographical boundary. In this study, the focus is on EEE products, for which readily available import and export data can be obtained from the Lebanese Custom database. The database provides data spanning from 2017 to 2022 for EEE and from 2013 till 2022 for batteries and PV in this study. Each product in the database is identified by a specific code called a harmonized system (HS) code. To facilitate analysis, the United Nations University (UNU) has assigned UNU keys to these HS codes, which represent different main product types. The UNU-keys encompasses about 900 EEE products, organized into 660 primary product types. Foreign trade statistics for each product are registered using the harmonized commodity description and coding system developed by the World Customs Organization. According to this commodity description, there are about 270 codes that are considered relevant to EEE. Descriptions that refer to parts of EEE were excluded to avoid double counting. UNU has developed a total of 54 UNU keys covering these 270 codes for identified EEE products.

For EEE in Lebanon, calculations were made in this study for 204 HS codes divided into 50 UNU-Key and EU-6 categories for which data on import and export is available on the Lebanese Customs website. The UNU-Keys are a product-based classification in which each UNU-KEY has a homogenous lifespan, average weight, material composition, and hazardousness profile. The UNU keys are then linked to the EU six e-waste categories and are used to measure e-waste statistics. The four (4) products excluded are those not found in the Lebanese Integrated National Tariff, such as household central heating (0001), compact fluorescent lamps (0502), LED lamps (0505), and leisure equipment (0703).

For the photovoltaic cells in Lebanon, calculations were made for 1 HS code (8541.40) linked to a UNU key under the large equipment category. In this study, PV values are excluded from the total EEE POM and waste generated values. Meanwhile, it is calculated and discussed separately under the EEE section.

For batteries in Lebanon, calculations were made for 12 HS codes. Batteries HS codes are not mentioned in the E-waste guideline and were not linked to any UNU keys or categories.

To calculate the POM of EEE products, PV, and batteries, the "apparent consumption method" is employed, which requires data on

domestic production, imports, and exports for a specific year (denoted as "t"). This method is widely used in the EU to compute the POM for a given year.

**POM(t) = Domestic Production (t) + Import (t) – Export (t)**

Based on the E-waste guidelines, for countries other than the 28 EU Member States, data on domestic production is not available and could be considered negligible. However, for Lebanon, it is assumed after the calls conducted with the Lebanese industries, that there is no significant domestic production for electronics and therefore, the following approach for POM calculation can be used (Forti et al., 2018):

**POM(t) = Import (t) – Export (t)**

#### 3.1.2.2 E-waste Generated

To calculate the amount of e-waste generated, the Weibull distribution is a valid and widely used approach for defining the lifetime of a product (Tang, 2004). It is a continuous probability distribution used to analyze life data, model failure times and assess product reliability. This approach considers product obsolescence in a dynamic manner by examining the failure rate of a product in a particular year relative to its total lifespan, compared to the fixed average lifespan of the product.

The dynamic lifespan profile is characterized by the scale (α) and shape (β) parameters in the distribution function where 30 years is considered the maximum lifespan of a product.

$$L^{(p)}(t,n) = \frac{\alpha}{\beta^{\alpha}}(n-t)^{\alpha-1}e^{-[(n-t)/\beta]^{\alpha}}$$

In this study, the scale and shape values for the UNU-keys were adopted from the second edition of E-Waste Statistics Guidelines for Non-EU Countries, with the exception of the PV UNU-Key for which scale and shape were set to zero for non-EU countries; therefore, values considered in Netherlands, Belgium, Italy, and France were adopted and used to estimate the waste generated from PV.

Using these parameter values, the e-waste, battery waste, and PV waste generated have been calculated by multiplying the POM by the average lifetime for each product.

$$E\ waste\ generated\ (n) = \sum_{t=t_0}^{n} POM\ (t) * L^{(p)}(t,n)$$

#### 3.1.2.3 Stock

The stock (S) refers to the equipment in households, businesses, and the public sector. The stock of EEE can be determined using household or business surveys on a national level. If that data is not available, it can be calculated using the sales information and the time the equipment spends in the stock phase, called the "product's residence time that includes the dormant time in sheds and exchange of second-hand equipment" (Forti et al., 2018).

The stock is determined by adding up the amount of EEE POM and subtracting the total amount of e-waste generated. It is the summation of all Put on Market in historical years "POM(t)", minus the summation of the "E-waste generated (n)", Where n is the evolution year.

$$S(n) = \sum_{t=to}^{n} POM(t) - \sum_{t=to}^{n} \text{E waste generated } (n)$$

Stock has not been calculated since the available data does not cover historical years. Adopted numbers for the stock were based on the Lebanese National E-waste Monitor Report from 2022.

#### 3.1.2.4 Projections

The FORECAST function in Excel was used to predict/estimate future POM for EEE, PV and Batteries in Lebanon, until year 2040 and 2050 respectively. The forecast function predicts future values by using linear regression, a data analysis technique that predicts the value of unknown data by using another related and known data value. The formula is typically represented as Y=aX + b, where Y represents the dependent variable, a represents the slope of the regression equation, X denotes the independent variable, and b represents a constant term.

Based on the above, the projections for EEE have been made until 2040 using the forecast function and based on the EEE data figuring in the National E-waste Monitor Report from 2000 till 2021. It should be noted that data from the Lebanese Customs website has been extracted for EEE back to 2017 and is therefore not sufficient to estimate future projections. The same approach has been used to project the e-waste generated based on the National E-waste Monitor data from the year 2010 till 2021.

The projections for batteries and PV POM have been made until 2050 using the forecast function and based on the Lebanese Customs data from year 2013 till 2023 (end of August 2023), while the projections for batteries waste and PV waste have been calculated until 2050 using the Weibull function distribution by multiplying the POM projections by the product average lifetime.

## 3.2 TASK 3 – DEVELOPMENT OF TREATMENT SYSTEMS AND FINANCIAL ASSESSMENT

The main goal of task 3 was to design a strategy for collecting, processing and disposing Waste Electrical and Electronic Equipment (WEEE) and batteries in Lebanon, which was then subjected to a financial evaluation.

More specifically, task 3 aimed to:

- Present a mass balance diagram illustrating the existing flows of WEEE.
- Set a collection rate target for WEEE and batteries within the Lebanese context.
- Establish a foundational framework for collecting WEEE and batteries in alignment with the proposed targets.
- Outline a strategy for consolidating collected volumes throughout the nation.
- Conceptualize a preliminary design for a sorting and dismantling center, encompassing the treatment and disposal of resultant fractions.
- Develop a financial calculation model specifically adapted to Lebanon's context, to obtain operational and capital expenditures.
- Provide a set of conclusions and actionable recommendations. The ultimate vision is to pave the way for a WEEE and batteries management system grounded in the Extended Producer Responsibility Principle.

The methodology involved a series of key steps aimed at achieving these objectives.

Firstly, a mass balance was constructed based on the findings from Task 2, completed by existing data and literature on WEEE in Lebanon. This outlined the journey of electrical and electronic products, from their import to their end-of-life disposal methods. Due to the limited data available on the collection and disposal methods for batteries in Lebanon, constructing a mass balance was not feasible. Nevertheless, insights into its current management were gathered from interviews with EcoServ.

Subsequently, collection targets were established by specifying the percentage of WEEE and batteries that need to be collected within Lebanon. A five-year goal was outlined for both. However, for the financial projections, the volumes anticipated to be collected in the first

two years were utilized in the model. This method offers a short-term view of the system, potentially assisting decision-makers in their strategic deliberations.

To guarantee the achievement of the predetermined collection volumes for WEEE and batteries, multiple collection channels were introduced. These involve waste collection events, drop-off points, in-store reception, door-to-door collection by the informal sector, on-demand collection, and mobile collection points. Descriptions and primary attributes of these channels were delineated, with illustrative images of their practical application showcased in Chapter 1Error! Reference source not found.. After collecting waste through the channels, a network of local collection centers to streamline and consolidate these volumes was proposed.

Following this, a preliminary design concept for a sorting and dismantling center was developed, including a schematic layout depicting the main sections of the facility.

Simultaneously, a financial calculation tool tailored to the project's specific requirements was developed. This tool incorporates data on capital and operational expenditures, revenue streams from selling valuable materials, and other pertinent financial parameters. In collaboration with EcoServ, the current pricing information was obtained for various capital and operational expenditures associated with WEEE and battery management in Lebanon. The cost estimates for specialized equipment necessary for WEEE and battery handling were grounded in BFS expertise. It should be emphasized that the process of estimating costs encompassing collection, consolidation, sorting, dismantling, treatment, disposal, and the broader logistics framework represents an initial approximation. Consequently, when precise pricing becomes necessary, quotations from all service and machinery providers will need to be requested.

Additionally, the pricing information was integrated into the financial calculation tool, where the results obtained were used to assess the financial feasibility and sustainability of the proposed collection and treatment scenario.

Finally, to effectively present the findings, analyses, and recommendations, the information was compiled into a cohesive report to offer insights and an executive summary to guide decision-makers in pursuing sustainable WEEE and battery management practices in Lebanon.

PROVISION OF SERVICES FOR THE ASSESSMENT OF

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# 04

# STAKEHOLDERS OVERVIEW

# 4. STAKEHOLDERS OVERVIEW

The structure, relationships, and characteristics of relevant stakeholders lie at the core of any recycling system. A study conducted by the National Environment Agency (NEA) for establishing an e-waste management system for Singapore found that the active participation of stakeholders is necessary to ensure that the e-waste can be managed effectively and efficiently. The assignment of responsibilities to the key stakeholders in the e-waste value chain, known as the Extended Producer Responsibility (EPR) approach, is a common feature for establishing e-waste management systems under which producers ensure their products are recycled upon reaching their end of life by fulfilling e-waste collection targets and channeling the e-waste collected to formal recyclers (NEA, 2018).

Stakeholders in Lebanon involve government offices, public and private sector establishments, educational institutes, business and corporate houses, community-based organizations, along with scrap dealers, sellers, collectors, and recyclers. Among these, industries, offices, establishments, educational institutes, business and households, etc. are chiefly responsible for the generation of the e-waste that are subsequently placed in improper garbage, or few quantities are sold to scrap dealers or picked up for recycling purposes. Ragpickers and scrap dealers collect parts of e-waste and sell them to whole sellers or dismantlers or recyclers after which small parts are actually recycled, while the big quantities are landfilled, burned or exported. Figure 4-1 shows a selection of the main stakeholders involved in the e-waste sector in Lebanon.

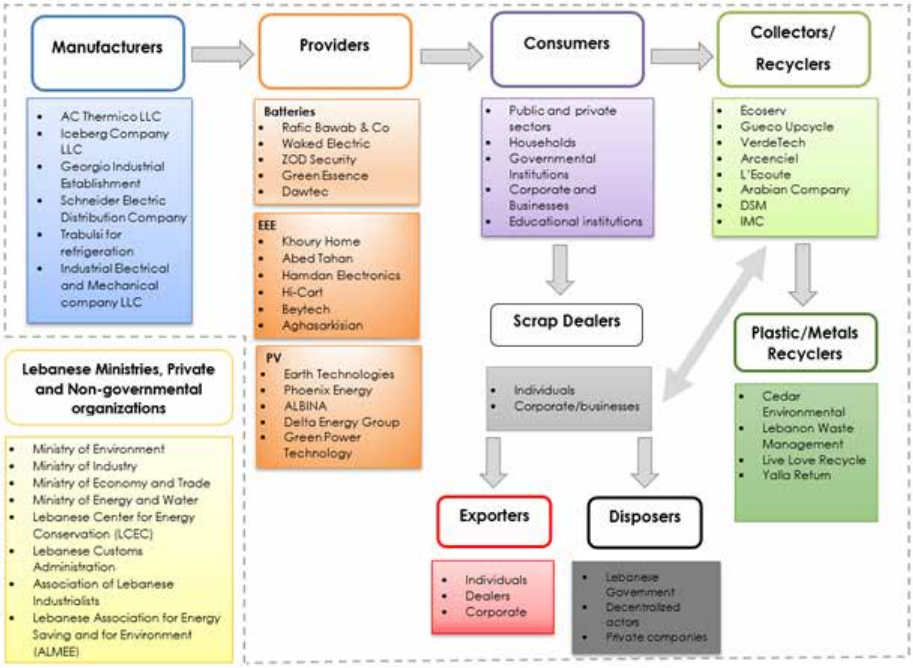



*Figure 4-1 Overview of the stakeholders involved in the e-waste sector in Lebanon*
*Source: ELARD, 2023*

**Manufacturers:**

A list of 100 industries were requested and received from the Ministry of Industry (MoI) to collect data on domestic production in the country. All of the 100 industries were contacted by phone and asked about their specific job role (assembler or producer), their detailed products and their produced/assembled quantities per year. Limited responses were declared, especially when it comes to quantities.

The phone calls revealed that the list provided by the MoI required an update, as only 34% of the industries were engaged in EEE manufacturing. Figure 4-2 summarizes the key findings from the calls conducted with EEE manufacturers as provided by the MoI.

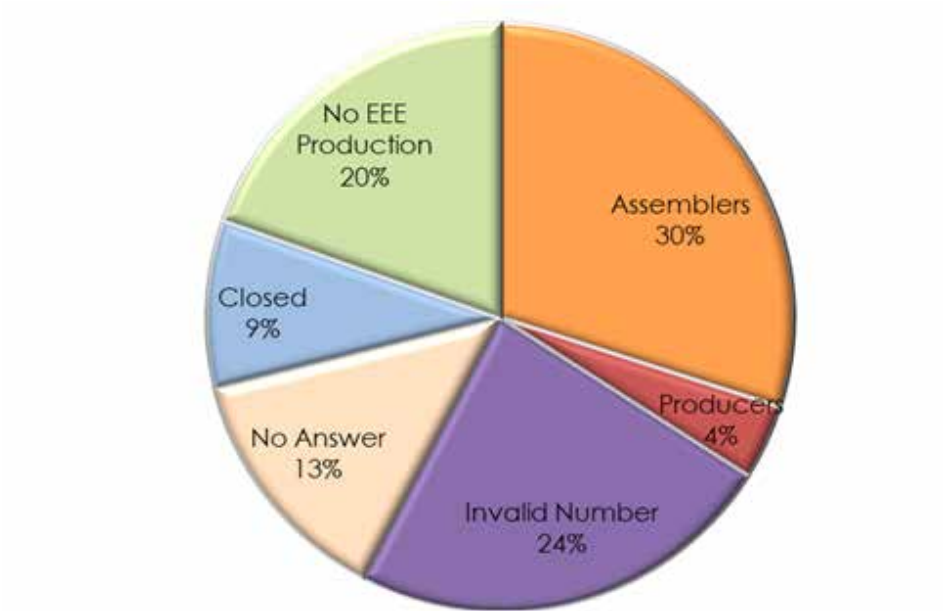



*Figure 4-2 Key findings from the calls conducted with EEE manufacturers as provided by MoI*

Calls reveal that:

- 66% of the companies are no longer in operation. Of these, 9% closed following the latest crisis, 13% did not respond to multiple phone calls, 24% had numbers out of service, and 20% are not engaged in EEE manufacturing.
- 88% of the industries involved in EEE manufacturing are primarily assemblers. This same percentage of assemblers was confirmed through consultations and follow-ups with the Association of Lebanese Industrialists (ALI), validating the Consultants' outcomes. The remaining 12% are producers mainly for temperature exchange equipment and large equipment.
- Assembling activities in Lebanon primarily focus on large equipment, temperature exchange equipment, and small IT.

Annex B – Contacted Stakeholders presents the key findings from the calls conducted with each industry provided by the MoI list.

**Providers:**

According to the Kompass database[1], there are 1,327 companies in Lebanon in the Electrical, Electronics, and Optical sector, with 783 being importers and 1,212 being distributors. Additionally, the country encounters shops and individual sellers with no registration.

Providers were divided into three groups: EEE providers, battery providers (mainly car batteries), and PV providers.

Phone calls have revealed the following:

- Providers of EEE (shops) in Lebanon are not prioritizing environmental concerns and sustainability issues. Most of these suppliers considered discussions about environmental topics a waste of time and they lacked the willingness to collaborate and provide data. It is crucial to prioritize topics like e-waste management and EPR systems along with other environmental and sustainability aspects to raise awareness not only among the key stakeholders in the e-waste sector, but also among the Lebanese population in general. This can be achieved through awareness campaigns, training programs and educational initiatives. EEE suppliers seem primarily focused on topics directly related to their financial interests and economic concerns, often missing the interrelationship of the three pillars of sustainability: the environment, people, and the economy. Annex B – Contacted

1 https://lb.kompass.com/x/distributor/s/electrical-electronics-optical/08/

Stakeholders, Table 4 presents the key responses from the calls conducted with a few EEE shops in Lebanon.

- Providers of batteries (shops) in Lebanon are increasingly focusing on two main types of batteries: lead batteries for automotive use and lithium batteries for solar applications. In the automotive sector, the most commonly imported and supplied battery types include lead acid, SFM, AGM, Gel, traction, and tubular batteries. For solar systems, the primary focus is on lithium batteries due to their reliability, efficiency, and long lifespan, followed by lead-acid batteries. Annex B – Contacted Stakeholders, Table 2 presents the key findings from the calls conducted with a few battery shops in Lebanon.
- PV providers in Lebanon appear to be more interested in environmental concerns. A list of qualified solar PV companies that was published by the Lebanese Center for Energy Conservation (LCEC), as of June 2023, as well as a list of solar PV panels providers received from UNDP were contacted. Around 55% of PV panels providers were responsive to calls and/or emails, while 40% did not respond and only 5% mentioned that they had ceased operations in the sector. Annex B – Contacted Stakeholders, Table 3 presents the key findings from the calls conducted with PV panels providers in Lebanon.
- Among the responsive companies, 64% had been operational before 2019, while the remaining 36% are considered newcomers to the PV market, having started operations in 2021. This increase in new companies is primarily attributed to the rising demand for PV installations in the country, particularly following the severe power crisis in late 2021 and 2022.
- Impressively, 70% of these responsive companies confirm that PV installation is on the rise and all of them are offering warranty systems, with durations ranging from at least 10 years and extending up to 25 years, to support PV installations and to remain competitive in the PV market.
- In terms of PV customers, there is an even split, with half of the customers being households and the other half being businesses.
- When it comes to sourcing products, 58% of the companies are engaged in direct imports, while the remaining 42% procure their products from the local market. The primary type of batteries adopted for solar systems is lithium and the average annual capacity installed by one company is between 2 and 5 MWh. Figure 4-3 summarizes the main types of batteries used for solar systems, and Figure 4-4 shows the percentage of companies based on their annual capacity installed.

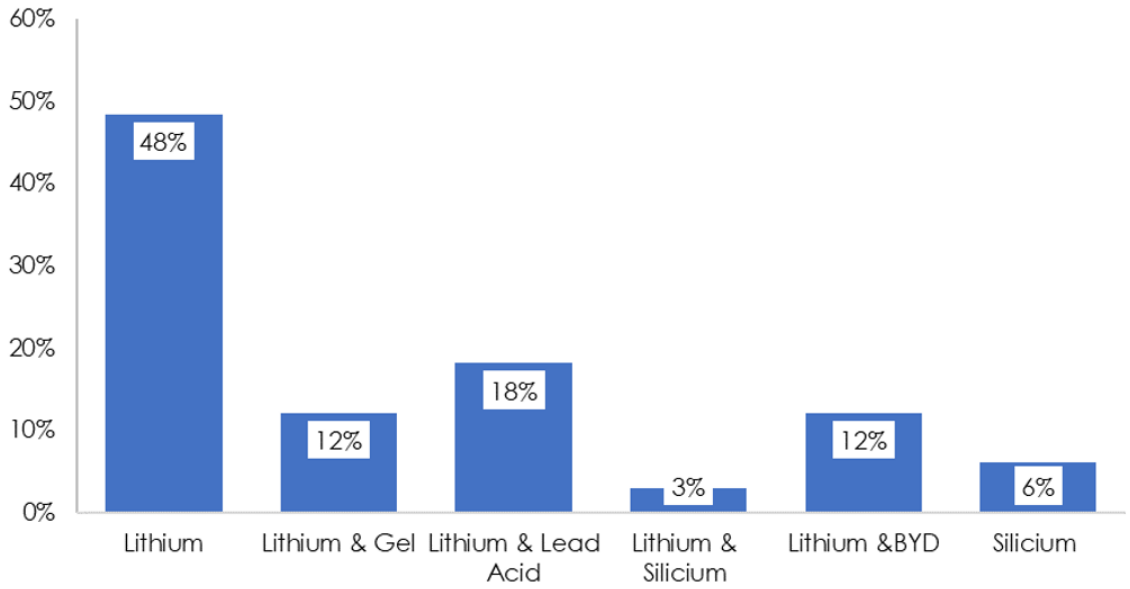



*Figure 4-3 Main types of batteries used for solar systems in Lebanon*

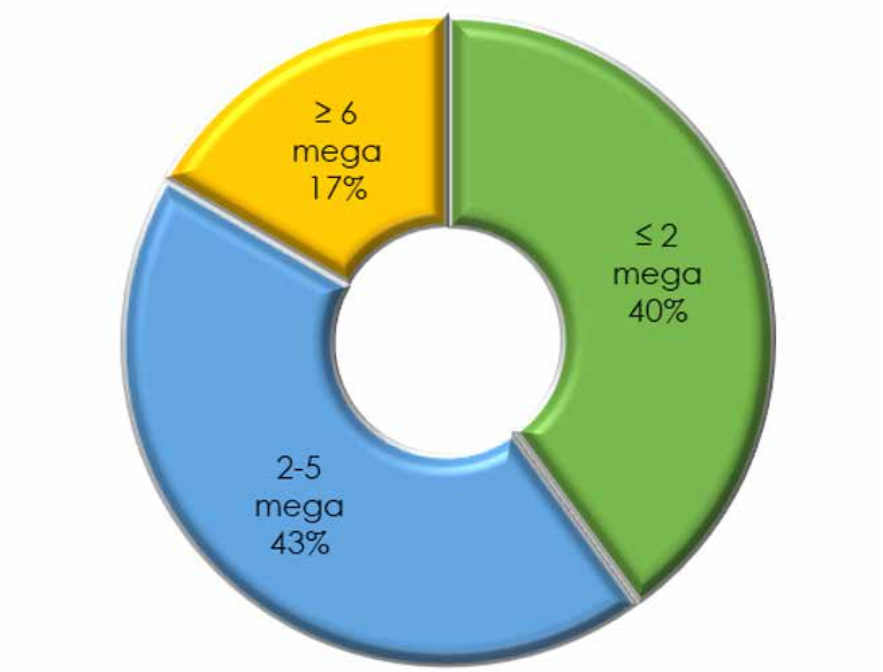



*Figure 4-4 PV Capacity installed yearly per company*

**Consumers:**

In the project context, consumers encompass a wide range of entities, including the public and private sectors, government institutions, educational organizations, and households. Attempts to gather data on the age range of consumers and primary demand for EEE were made during calls with suppliers listed in Annex B. However, the responding suppliers indicated that they do not maintain records on consumers. They emphasized that there is no specific age range or gender that consumes a significant amount of EEE. Instead, demand appears to be driven by individual consumer needs, economic conditions and changes in the market.

**Collectors/Recyclers:**

In Lebanon, there is currently no formal system for collecting or recycling e-waste. Instead, e-waste is primarily collected by informal groups and individuals who either sell the items or extract valuable metal scraps. The identification of e-waste collectors was conducted through desk research and a review of published lists from the Ministry of Environment (MoE). Out of 15 organizations contacted, 10 are still actively involved in e-waste collection, while 5 have stopped operations due to high transportation costs and the challenging economic and logistical conditions.

Among the 10 operational e-waste collectors, Ecoserv stands out as the most active and engaged organization in e-waste dismantling and recycling processes, in addition to their collection activities in several zones covering the whole country. A site visit was conducted to Ecoserv facility. The visit's main findings are summarized in Appendix 16.4. Several attempts were made to visit the VerdeTech facility, but they were not successful since the owner was out of the country, and no other contact reference was provided.

Regarding batteries, two main entities, Aaraybi and IMC, are mainly involved in lead battery treatment. Attempts to visit the two battery facilities were unsuccessful, despite numerous follow-ups being conducted.

Key findings from the calls with active organizations in the collectors/recycler's groups are summarized below:

- All parties work with both businesses and households across all age groups.
- Half of these groups are registered as Non-Governmental Organizations (NGOs) (50%), while the other half operate as private establishments (50%).

- Approximately 80% of them collect all types of e-waste, with the collected items being primarily sent to Ecoserv or VerdeTech for recycling, or sold to repair shops.
- None of these organizations have been required to follow any regulations or standards in their day-to-day operations.
- Around 67% of them expressed interest in participating in training sessions, while 33% did not provide a clear answer.
- Approximately 67% of these organizations lack knowledge about a take-back system, with the remaining 33% have limited knowledge.
- The main challenges faced by most collectors are related to the high logistics costs resulting from the economic crisis and unstable conditions, the lack of awareness and environmental practices, and the absence of an effective waste management system in Lebanon.

It is worth noting that during the call with Arcenciel, it was noticed that the NGO is actively engaged in a Baseline Assessment of the battery value chain project. Several calls and follow-up discussions were held with the project key personnel, aiming to understand the project scope of work and explore potential opportunities for collaboration. It is important to mention that the project was scheduled to conclude around the same time as this project, and as a result, results have not yet been published or made available. The primary objective of the baseline assessment project is to identify the best practices for battery waste management in Lebanon and lay the ground for the development of a national plan for battery waste management. This comprehensive assessment includes a diagnosis of current practices and a legal study.

**Final Disposers:**

The Lebanese Government is primarily responsible for managing final waste disposal through current coastal sanitary landfills. Due to limited government activity, decentralized actors have taken it upon themselves to address waste management locally, leading to a notable increase in waste diversion from landfills (Azzi, 2017).

Amid the ongoing crisis in Lebanon, landfills capacity has been reached, waste is illegally burned at informal dumpsites, and garbage often ends up floating in the Mediterranean Sea.

PROVISION OF SERVICES FOR THE ASSESSMENT OF

# E-WASTE & BATTERIES IN LEBANON

05

# E-WASTE IN LEBANON

# 5. E-WASTE IN LEBANON

E-waste in Lebanon is still a relatively new focus of environmental concern. Obtaining accurate data on e-waste generation, reuse, recycling, and disposal is challenging, primarily because e-waste is often considered part of municipal solid waste, and there is a lack of comprehensive measurement data. However, calculations and estimations of e-waste data in Lebanon have been based on support from Lebanese institutions, regional reports, and scientific literatures.

## 5.1 Classification

The classification of e-waste is required to enable the development of targeted policies, infrastructure and regulations that address the challenges posed by e-waste. To comply with international benchmarking standards, the variety of EEE products is recommended to be grouped appropriately and accordingly it is essential for the application of the measurement framework. The study refers to the UNU-Keys, which contain six categories as outlined by the European Union's Waste Electrical and Electronic Equipment Directive (2012/19/EU) and described in international guidelines on e-waste statistics. To facilitate proper management and disposal of electronic waste, EEE products are classified by similar function, comparable material composition, average weight, and similar end-of-life attributes (Forti et al., 2020). The six categories of e-waste classification are described in Table 5-1.

*Table 5-1 UNU-Keys classification linked to EU-6 WEEE directive*

| EEE category under EU-6 | UNU-KEY | UNU-Key Description |
|---|---|---|
| Temperature exchange equipment | 0108 | Fridges (incl. combi-fridges) |
| | 0109 | Freezers |
| | 0111 | Air Conditioners (household installed and portable) |
| | 0112 | Other Cooling equipment (dehumidifiers, heat pump dryers) |
| | 0113 | Professional Cooling equipment (large air conditioners, cooling displays) |
| | 1002 | Cooled Dispensers (e.g., for vending, cold drinks) |
| Screens and Monitors | 0303 | Laptops (incl. tablets) |
| | 0308 | Cathode Ray Tube Monitors |
| | 0309 | Flat Display Panel Monitors (LCD, LED) |
| | 0407 | Cathode Ray Tube TVs |
| | 0408 | Flat Display Panel TVs (LCD, LED, Plasma) |
| Lamps | 0502 | Compact Fluorescent Lamps |
| | 0503 | Straight Tube Fluorescent Lamps |
| | 0504 | Special Lamps (professional mercury, high- & low-pressure sodium) |
| | 0505 | LED Lamps (incl. retrofit LED Lamps) |
| Large equipment | 0001 | Central heating |
| | 0002 | **Photovoltaic Cells** |
| | 0101 | Professional Heating & Ventilation (excl. cooling equipment) |
| | 0102 | Dishwashers |
| | 0103 | Kitchen equipment (large furnaces, ovens, cooking equipment) |
| | 0104 | Washing Machines (incl. combined dryers) |
| | 0105 | Dryers (wash dryers, centrifuges) |

| | | |
|---|---|---|
| Large equipment | 0106 | Household Heating & Ventilation (hoods, ventilators, space heaters) |
| | 0307 | Professional IT equipment (servers, routers, data storage, copiers) |
| | 0602 | Professional Tools (for welding, soldering, milling) |
| | 0703 | Leisure equipment (sports equipment, electric bikes, juke boxes) |
| | 0802 | Professional Medical equipment (hospital, dentist, diagnostics) |
| | 0902 | Professional Monitoring & Control equipment (laboratory, control panels) |
| | 1001 | Non- cooled Dispensers (for vending, hot drinks, tickets, money) |
| Small equipment | 0114 | Microwaves (incl. combined, excl. grills) |
| | 0201 | Other small household equipment (ventilators, irons, clocks, adapters) |
| | 0202 | Equipment for food preparation (toaster, food processing, frying pans) |
| | 0203 | Small household equipment for hot water preparation (coffee, tea) |
| | 0204 | Vacuum Cleaners (excl. professional) |
| | 0205 | Personal Care equipment (toothbrushes, hair dryers, razor) |
| | 0401 | Small Consumer Electronics (headphones, remote controls) |
| | 0402 | Portable Audio & Video (MP3, e-readers, car navigation) |
| | 0403 | Music Instruments, Radio, Hi-Fi (incl. audio sets) |
| | 0404 | Video (Video recorders, DVD, Blue Ray, set-top boxes) and projectors |
| | 0405 | Speakers |
| | 0406 | Cameras (camcorders, photo & digital still cameras) |
| | 0501 | Small lighting equipment (excl. LED & incandescent) |
| | 0506 | Household Luminaires (incl. household incandescent fittings & household LED luminaires) |
| | 0507 | Professional Luminaires (offices, public space, industry) |
| | 0601 | Household Tools (drills, saws, high pressure cleaners, lawn mowers) |
| | 0701 | Toys (car racing sets, electric trains, music toys, biking computers, drones) |
| | 0801 | Household Medical equipment (thermometers, blood pressure meters) |
| | 0901 | Household Monitoring, Control equipment (alarm, heat, smoke) |
| Small IT | 0301 | Small IT equipment (routers, keyboards, external drives & accessories) |
| | 0302 | Desktop PCs (excl. monitors, accessories) |
| | 0304 | Printers (scanners, multi functionals, faxes) |
| | 0305 | Telecommunication equipment (cordless phones, answering machines) |
| | 0306 | Mobile Phones (incl. smartphones, pagers) |
| | 0702 | Game Consoles |

*Source: Forti V. et al., 2018*

The following two pie charts in Figure 5-1 display the distribution of EEE market products in Lebanon across the six categories, namely lamps, screens and monitors, small IT, temperature exchange, small equipment, and large equipment, according to WEEE EU-6, for the years 2017 (a) and 2022 (b).

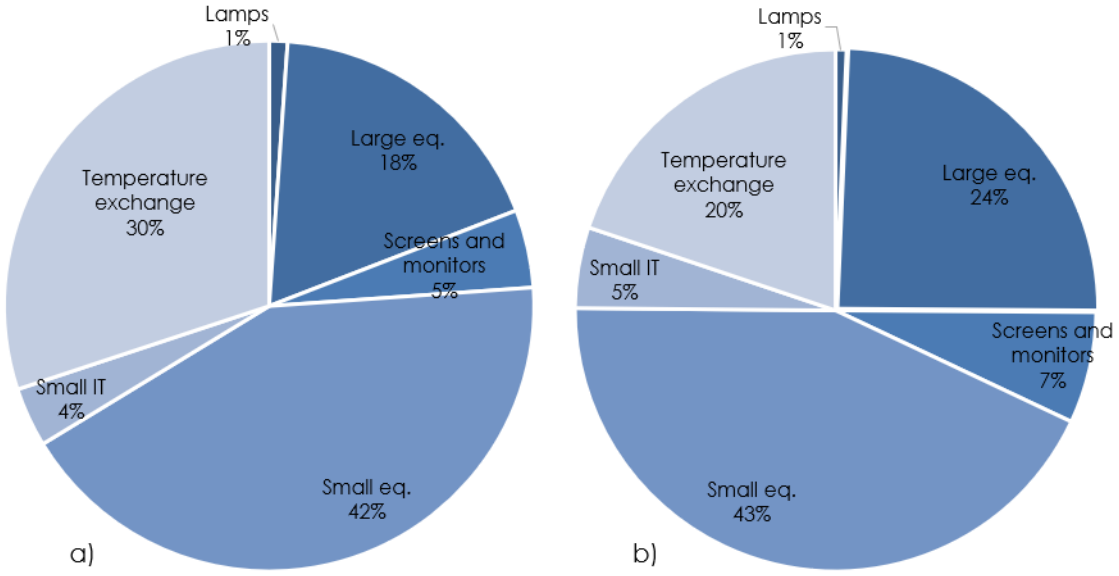



*Figure 5-1 Distribution of EEE POM in Lebanon, based on WEEE EU-6, in 2017 (a) and 2022 (b)*

*Source: Lebanese Customs, 2023*

Small equipment constituted the largest category, making up 42% in 2017 and 43% in 2022. The temperature exchange category witnessed a notable decrease from 30% in 2017 to 20% in 2022 while the large equipment category increased from 18% in 2017 to 24% in 2022. This shift in product distribution can be attributed to various factors. Firstly, advancements in technology may have led to the development of smaller and more compact equipment, resulting in the increased demand for small equipment. Secondly, the decline in the percentage of large equipment could be due to a shift in consumer preferences. Customers might be favoring smaller, more energy-efficient options that occupy less space. The growing emphasis on sustainability and the need for environmentally friendly solutions could also have contributed to the decline in demand for larger equipment. This decline could also be explained by the prevailing crisis since 2019, whereby citizens tend to repair large equipment as long as possible before considering buying new ones, and the renewal of equipment before their end-of-life has become less prevalent. Lastly, the drop in the percentage of products in the temperature exchange category suggests a change in market dynamics. This could indicate a reduced demand for temperature exchange-related products, potentially due to the economic crisis that causes citizens to prioritize their EEE needs, and/or advancements in energy-efficient technologies or alternative solutions that require less temperature control or are less costly.

Overall, these shifts in product distribution between 2017 and 2022 likely reflect evolving consumer needs, technological advancements, Lebanese markets demands, and changing market trends in the electric field, as well as impacts of the crisis after 2019.

## 5.2 QUANTITIES PUT ON THE MARKET

The quantities of EEE imports, exports, and the calculated POM in Lebanon from 2017 till 2022 are illustrated in Figure 5-2.

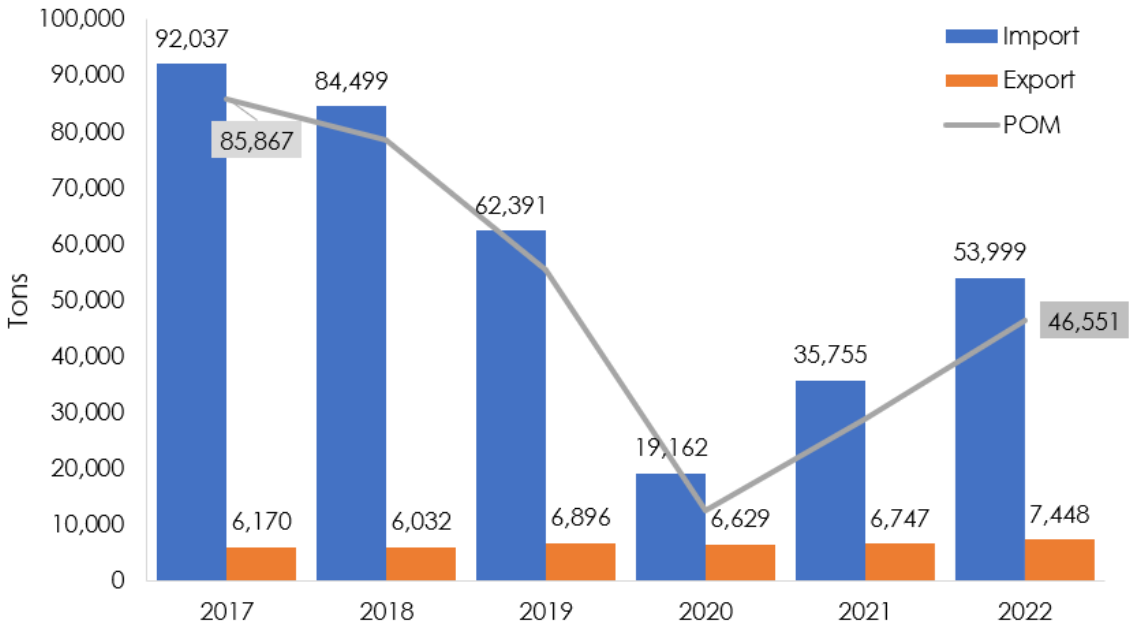
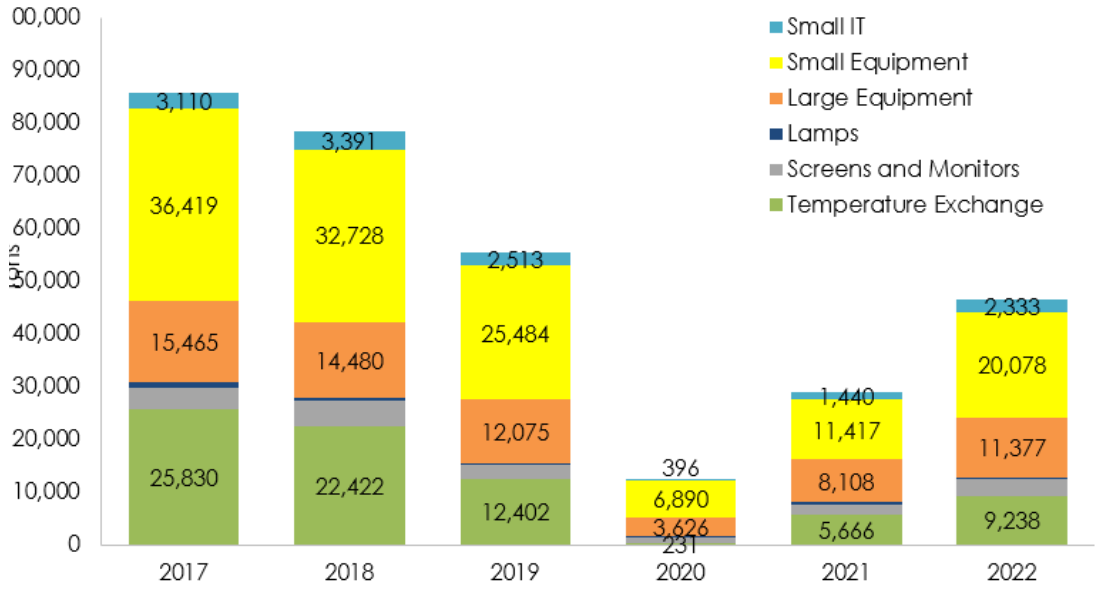



*Figure 5-2 The POM/Import/Export data of EEE products in Lebanon (in tons) from 2017 till 2022*

*Source: Lebanese Customs, 2023*

The data shows that the EEE POM in Lebanon decreased by 46%, from 85,867 tons in 2017 to 46,551 tons in 2022. The lowest POM value was 12,533 tons in 2020 during the COVID-19 pandemic, when precautionary restrictions made shipments between countries difficult. The progressive decrease from 2017 till 2020 can be attributed to the economic crisis in Lebanon, which aggravated in late 2019.

Notably, the graph demonstrates a proportional relationship between POM and imports, as explained by the equation in section 3.1.2.1 where POM in Lebanon represents the difference between imports and exports 3.1.2.1.Figure 5-3 Exports have remained constant at lower values throughout the years covered in Lebanon since the country is not industrially oriented towards EEE. In addition, it is evident that the COVID-19 pandemic and the economic crisis in Lebanon have impacted the flow of electronics. The POM trends for each EEE category as per the EU-6 categories is represented in Figure 5-3 below from 2017 till 2022.



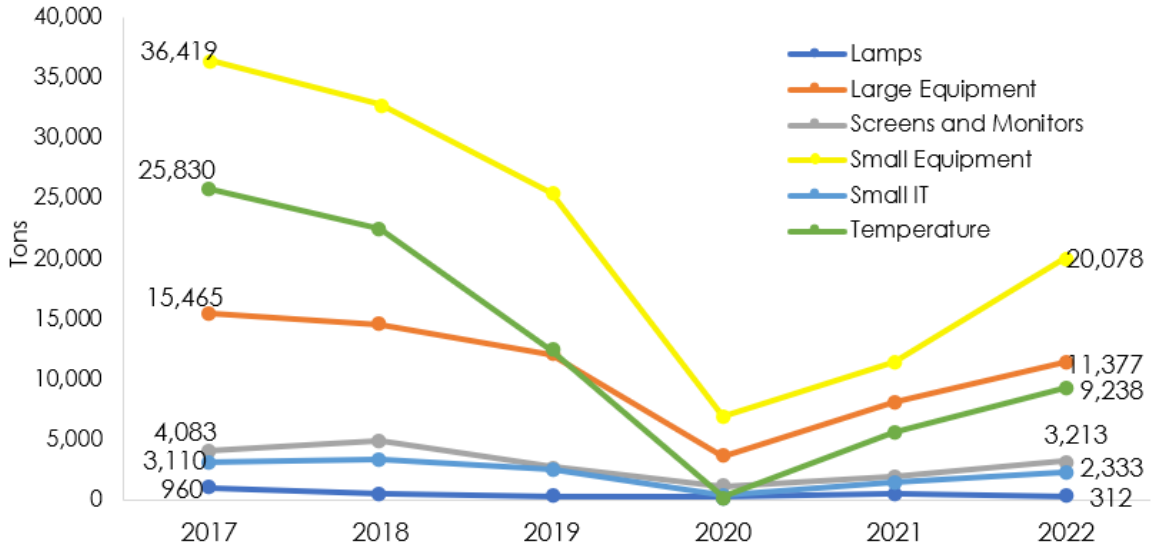



*Figure 5-3 EEE POM values trend per the EU-6 categories*

*Source: Lebanese Customs, 2023*

The graph indicates that the small equipment category has consistently been the largest category over the years, exhibiting the highest POM values. Conversely, lamps represent the lowest category. Small IT devices, screens, and monitors, as well as lamps, have shown relatively stable behavior over the years, with only slight changes in their POM values. Notably, the POM for all six categories reached its lowest point in 2020 among the years analyzed, due to COVID-19 restrictions.

From 2017 to the end of 2019, temperature exchange products had higher POM values than large equipment. However, from 2019 to 2022, large equipment surpassed temperature exchange products in terms of POM. This shift can be attributed to the economic crisis in Lebanon, where consumers are more inclined to purchase only essential equipment and adopt energy-efficient devices; or to changing EEE market demands.

According to a 2022 study by market researchers and consulting providers, Exactitude Consultancy, the global demand for electrical equipment is estimated to grow at a Compound Annual Growth Rate (CAGR) of 11.1% between 2022 and 2030. This growth is driven by several factors, including increasing electricity needs in both developed and developing countries, rising demand for renewable energy sources, and growing use of automation and robotics in various industries. The focus on energy efficiency and the adoption of smart grid technologies are also driving demand for more advanced electrical equipment. In Lebanon, no specific trends in the electrical equipment market have been assessed for projecting future demand. Therefore, global trends were adopted to estimate the POM values (in tons) for the Lebanese EEE products until 2040. Historical data for the country's EEE POM dating back to 2000 was an extrapolation adopted from the Lebanese E-waste Monitor Report (Balde C., et al., 2022). Figure 5-4 summarizes projections until 2040 for the EEE POM values as per EU-6 categories, and Appendix 14.1.1 details the projection values by category and year.

It should be noted that the figures received from the Lebanese customs data (2017-2022) differ from those published in the National E-waste Monitor 2022 for the same years. Therefore, the below figures provide only a general overview about the electric and electronic market trends in Lebanon for 2040.

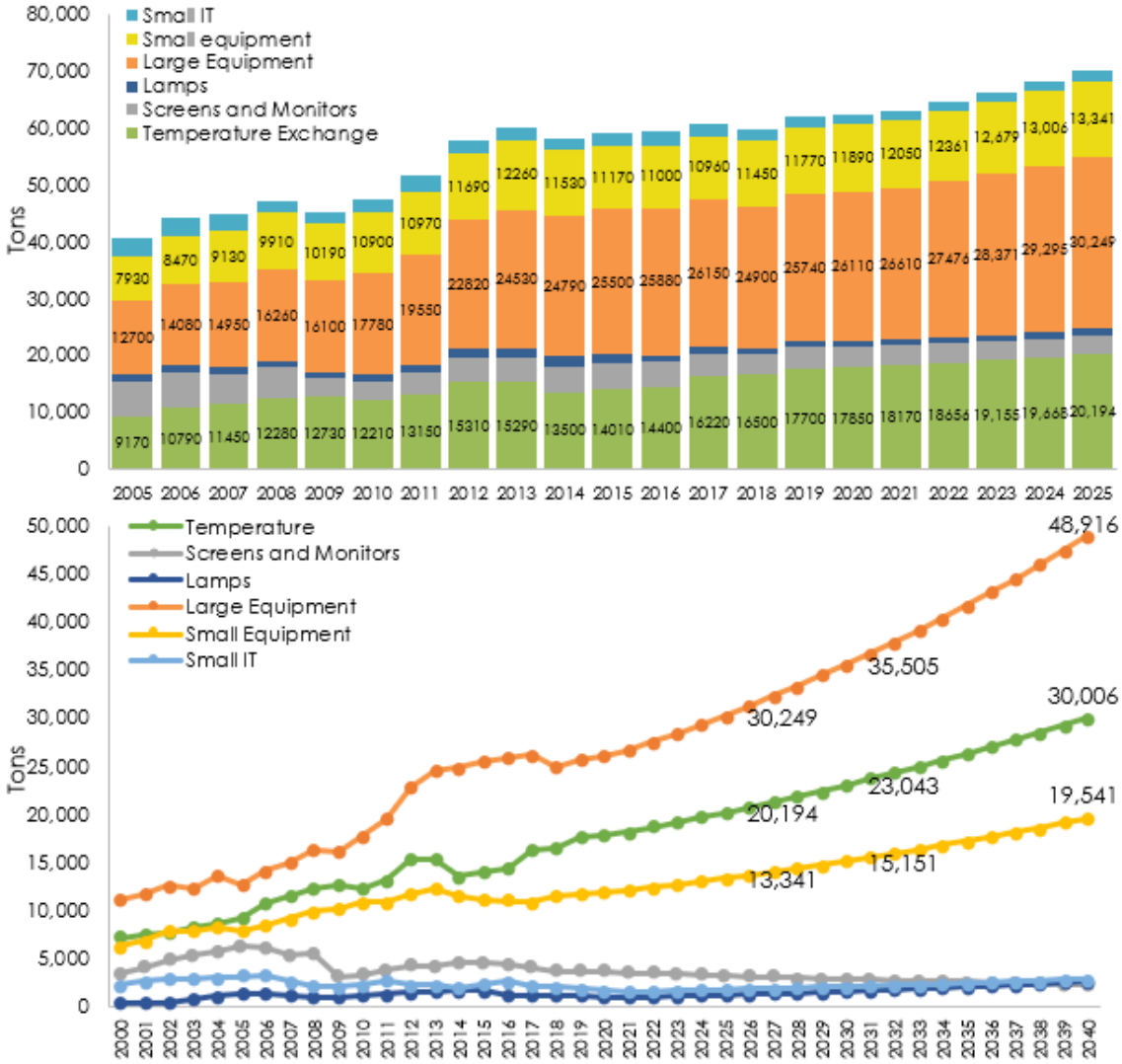



*Figure 5-4 EEE POM projections by year per category in Lebanon until 2040*

*Projections based on the National E-waste Monitor Lebanon 2022 Data, Balde P. et al., 2022*

Projections reveal that the electrical equipment market in Lebanon is expected to continue growing in the coming years, especially for large equipment devices that will reach 48,916tons by 2040, followed by the temperature exchange devices reaching 30,006 tons in 2040. However, the COVID-19 pandemic and the Lebanese economic crisis have impacted EEE growth, slowing down the demand rate.

## 5.3 E-WASTE GENERATED

The global e-waste is projected to grow exhibiting a CAGR of 3.3% during the forecast period through 2030. The accurate size and severity of the future e-waste problem will ultimately depend on production and consumption trends (Exactitude Consultancy, 2022). The e-waste generated in Lebanon is summarized in Figure 5-5 and detailed in Appendix 14.2.1.

The e-waste generated that has been projected based on the e-waste data published in the National E-waste Monitor Report for Lebanon 2022, is estimated to be 47,501 tons in 2022. It is evident that the amount is increasing annually to reach around 74,529 tons in 2040. This trend can be attributed to the fact that every year, a new batch of products reaches the end of their lifespans and becomes waste.

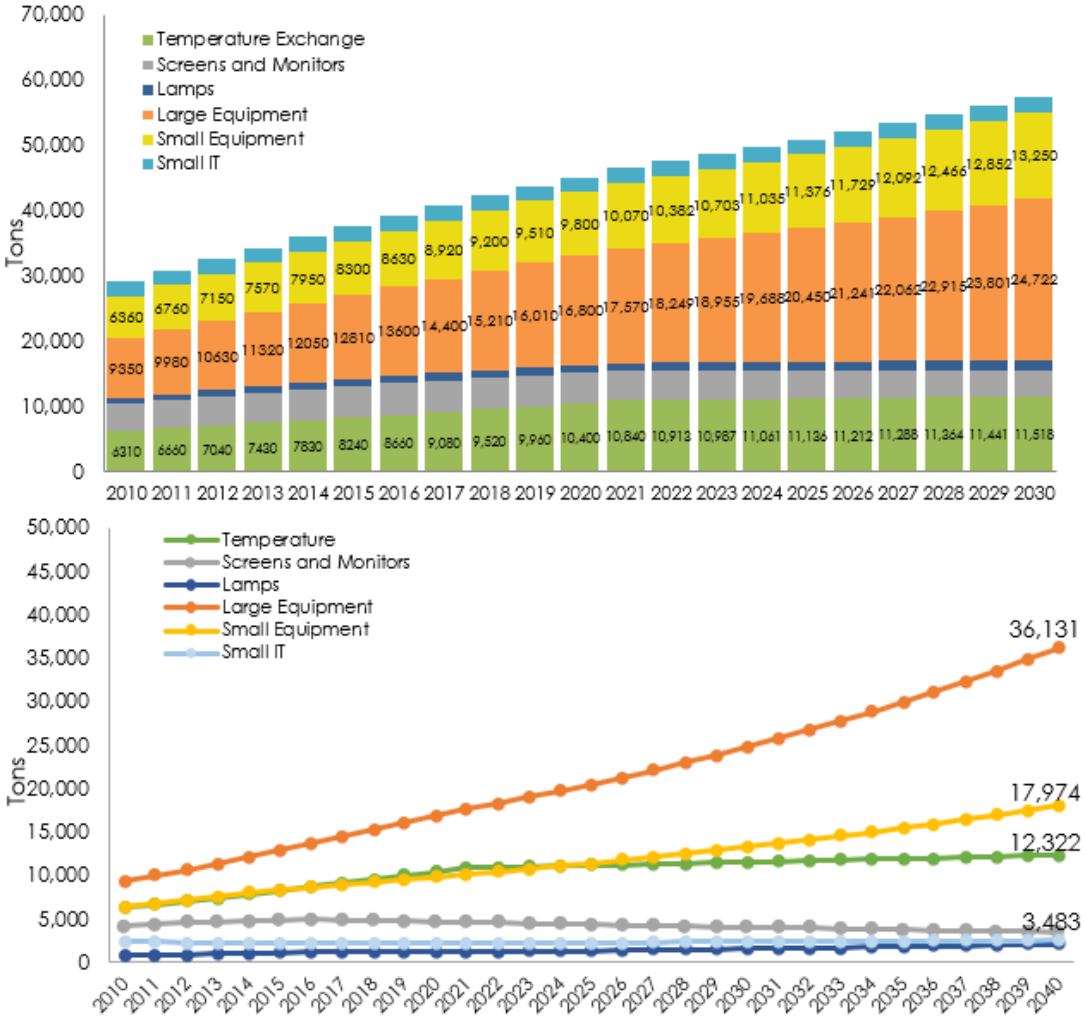



*Figure 5-5 E-waste generated in Lebanon by year per category in Lebanon until 2040*

*Projections based on the National E-waste Monitor Lebanon 2022 Data, Balde P. et al., 2022*

It is crucial to note that Lebanon currently lacks the policies, regulations, and laws to effectively manage e-waste, while e-waste quantities are anticipated to rise steadily over time, potentially even doubling. This underscores the urgent need for robust e-waste management practices and a regulatory framework in Lebanon.

However, it is essential to recognize that these projections of future e-waste quantities carry a degree of uncertainty. They are influenced by socio-economic and technological changes, such as:

- Demand: While the demand for electronic products is likely to increase with population growth and the proliferation of e-products, the average number of devices used may not rise proportionally due to the advent of more efficient technologies.
- Use: Electronic and electrical products are expected to become integral components of vehicles, buildings, and other infrastructural entities.
- Design: As products become more intelligent and intricately designed, e-waste recovery will pose greater challenges. On the bright side, emerging technologies might reduce the overall lifecycle impact of these products
- Sectoral growth: Certain categories, like panels and lighting equipment, will see more frequent use. For instance, rising temperatures and more frequent heatwaves—anticipated future phenomena as a result of climate change—might boost the sales of air conditioning and cooling equipment.

- Material composition: The future may witness the utilization of more recycling-friendly and biodegradable materials in e-products. Factors like innovation and geopolitical shifts could also play pivotal roles in material recovery efforts.

## 5.4 SOLAR PHOTOVOLTAIC IN LEBANON

### 5.4.1 Quantities Put on Market

Lebanon currently relies on gasoline, fuel oil, and gas oil, all of which are 100% imported. Concerns over energy security, coupled with the need for economic stability and growth, have driven energy diversification and a transition to renewable energy (IRENA, 2020).

The Lebanese crisis has led to the collapse of Electricité Du Liban (EDL), which now supplies an average of 2-3 hours of electricity per day. Meanwhile, some areas of the country have experienced complete blackouts (USAID & CSP, 2022). Compared to 2019, the average demand decreased by 52% in 2022 due to the unaffordability of electricity for more than half of the population (Boukhater, 2023) as a result of lifting subsidies on fuel as part of post-crisis reforms. The collapse of EDL, combined with the high cost of electricity from private generators, has boosted solar applications despite the lack of a favorable regulatory and financial environment. Therefore, the total capacity of solar applications is estimated to have reached 690 MW in 2022 (Boukhater, 2023).

Referring to the Lebanese Customs data for import/export activities related to the Photovoltaic cells (PV) in Lebanon, data shows a total of 101,270 tons of solar panels imported between 2013 and 2022 of which 82% were in 2022 alone. Figure 5-6 shows the trend for PV quantities, in tons, of import, export and POM in Lebanon from 2013 till 2022.

It should be noted that in mid-September 2023, the Lebanese Customs updated their website with data for the year 2023 covering import/export activities till the end of August 2023. For PV and Batteries HS Codes, the posted data for 2023 was extracted to evaluate the status of PV and batteries after the exceptional trend observed in 2022 due to the energy transition. PV data for 2023 shows a decrease in quantities imported compared to 2022, but highlights the significant entry of PV systems in Lebanon as compared to the period between 2013 and 2020. Figure 5-6 illustrates PV data till the end of August 2023 (2023*).

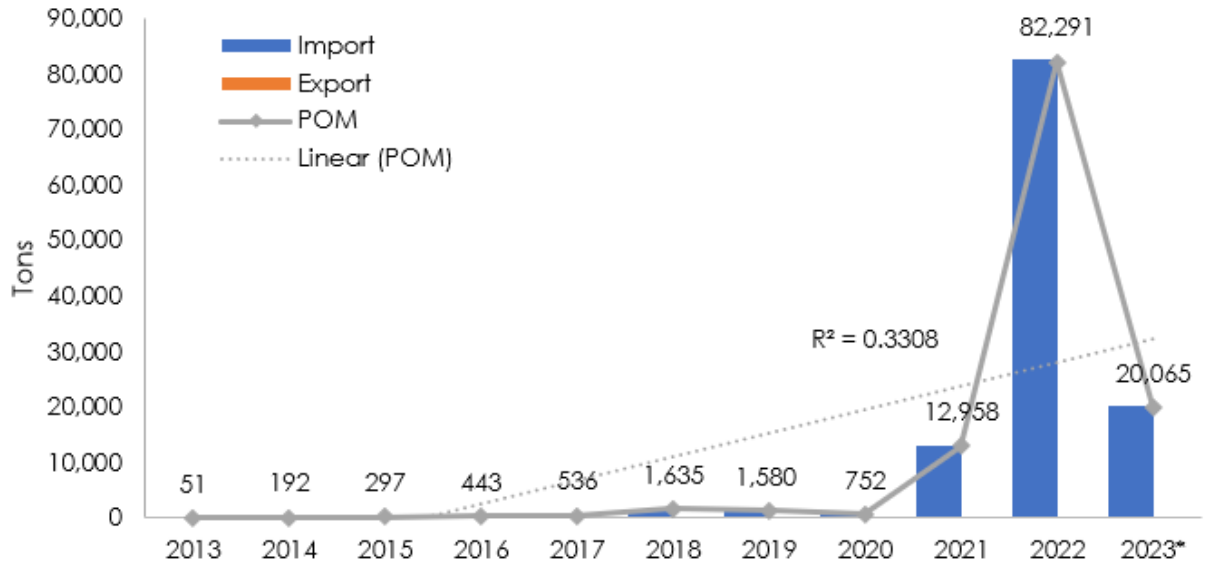



*Figure 5-6 Evolution of PV imports in Lebanon between 2013 and 2023*

*Source: Lebanese Customs, 2023*

The data reveals interesting trends and patterns. Back to 2013, the imports initially increased at a slow pace, starting from 51 tons in 2013 and gradually reaching 1,580 tons by 2019. However, this steady growth was disrupted in 2020 due to the unprecedented COVID-19 crisis, which resulted in a decrease in all imports for that year. The pandemic-related challenges, including halted imports and decreased economic activity, had a direct impact on the PV industry in Lebanon.

Despite the setback in 2020, a remarkable bounce-back with a significant surge in imports occurred in 2022. The PV imports rose steeply from 752 tons in 2020 to 12,958 tons in 2021 and then to an astounding 82,291 tons in 2022. Several factors contributed to this sudden surge. Lebanon has been facing a severe electricity shortage and power outages, highlighting the critical need for alternative energy sources. Additionally, the high subscription cost for private generators, the fuel crisis, and reduced expenses for solar energy projects have prompted a growing interest in PV installations across the country. These conditions created favorable circumstances for a rapid, exceptional, and substantial increase in PV imports in 2022.

The crisis, coupled with high fuel prices and limited availability in the market, prompted Lebanese individuals to seek alternative energy sources other than fossil fuels. Consequently, there was a significant surge in imports between 2021 and 2022, mainly due to investments in solar panels. The main factors driving the demand for solar energy in Lebanon, especially for the upcoming 3 to 4 years, are the following (USAID & CSP, 2022):

- Electricity deficit and blackouts where EDL fails to deliver the amount of electricity required for the country;
- High costs of private generators subscriptions, which were the best solution for EDL gaps before the economic and fuel crisis;
- Fuel crisis resulting in the official end of fuel subsidies. As a result, the cost of subscriptions to private generators has sky-rocketed (generator bills amount to 400 USD per month while the minimum monthly wage in the country dropped to less than 50 USD); and
- Decreased costs for solar energy projects.

The data posted on the Lebanese Customs website for the year 2023 cover the quantities (in tons) of the country's import and export from January 2023 to the end of August 2023. Data shows that the total POM for PV decreased from 82,291 tons in 2022 to 20,065 tons in 2023, which means that what happened in 2022 was so exceptional and critical for the country. The huge quantities of PV observed in 2022, influenced by the fuel crisis, economic situation, exchange rate fluctuation, irregular currency, and unstable market trends, etc. will not rise as significantly as in the upcoming 3 to 4 years. However, PV status will never return to pre-2021/2022 levels.

Another important factor that might have further boosted the exceptional trend in 2022 was the Government's plans to raise the exchange rate adopted to calculate customs duties on imports, commonly referred to as the "Customs Dollar", as a result of the currency's devaluation, and in order to generate additional revenues for the public sector. The exchange rate was effectively raised in December 2022, then again during 2023 to match the black-market rate. This might have encouraged PV system importers and retailers to drastically increase their imports and stocks given the prevailing high demand driven by the situation of the power sector, and the opportunity to pay lower taxes before the application of new customs duties tariffs.

### 5.4.2 PV Waste Generated

With the growing capacity of photovoltaics, waste generated from solar panels when they reach their end of working lives, after around 25-30 years, will also grow, potentially becoming a dead panel dumped in landfills, even though they contain toxic materials like lead that cause environmental pollution. Additionally, they contain valuable materials that could be reused to make new solar cells such as silicon, silver, and copper (Tasnim et al., 2022). PV waste has been added to the WEEE list by the EU (Forti et al., 2018) and many developed countries such as the EU, US and Japan, have been trying to find a scientific solution to deal with the PV waste. Only a few

countries have rules for recycling PV waste and developing countries still do not have any policy for PV waste recycling (Tasnim et al., 2022). In Lebanon, there are no regulations, restrictions, strategies, or plans that are elaborated to manage the quick transition to PV and to address the waste generated from the panels.

In 2022, Lebanese citizens were asking for PV installation as the best technology to alleviate the shortage of traditional energy sources and to avoid the fuel and economic crisis, with no considerations regarding the impact that will occur after the PV panels end-of-life. The calculation for PV waste generated has been based on the Weibull function by multiplying the PV POM by the PV lifetime.

Two projection scenarios were adopted to project the PV POM quantities in Lebanon until 2050, which were then used to calculate the PV waste generated:

- The first POM projection considers data from 2013 till 2023 and accounts for PV quantities in 2022 which makes the projection values very high and non-realistic since upcoming years will not be facing economic and fuel crises in the same severity as of 2022, where the peak-phase transition to the solar system has occurred. PV waste generated using scenario 1 is summarized in Figure 5-7 and represented in Table 14-5.
- The second POM projection considers data from 2013 till August 2023 without accounting for PV quantities in 2022. This projection reveals more realistic and relevant numbers for the upcoming years, especially for the first 5 years, since numbers will not be like those of 2022 but, at the same time, the status will never be as it was before 2021-2022. The Lebanese situation and the crisis phase are causing irregular values and market changes that will remain far from any standard until the end of the crisis. PV waste generated using scenario 2 is summarized in Figure 5-8 and represented in Table 14-6.

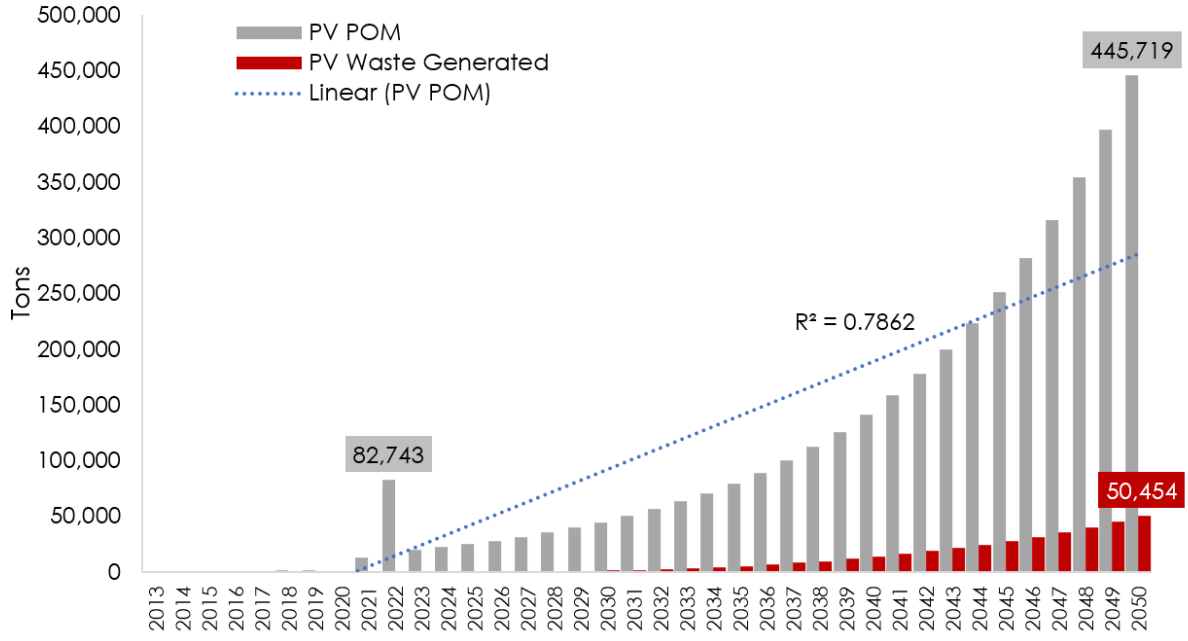



*Figure 5-7 PV POM and Waste generated in Lebanon (in tons) under Scenario 1*

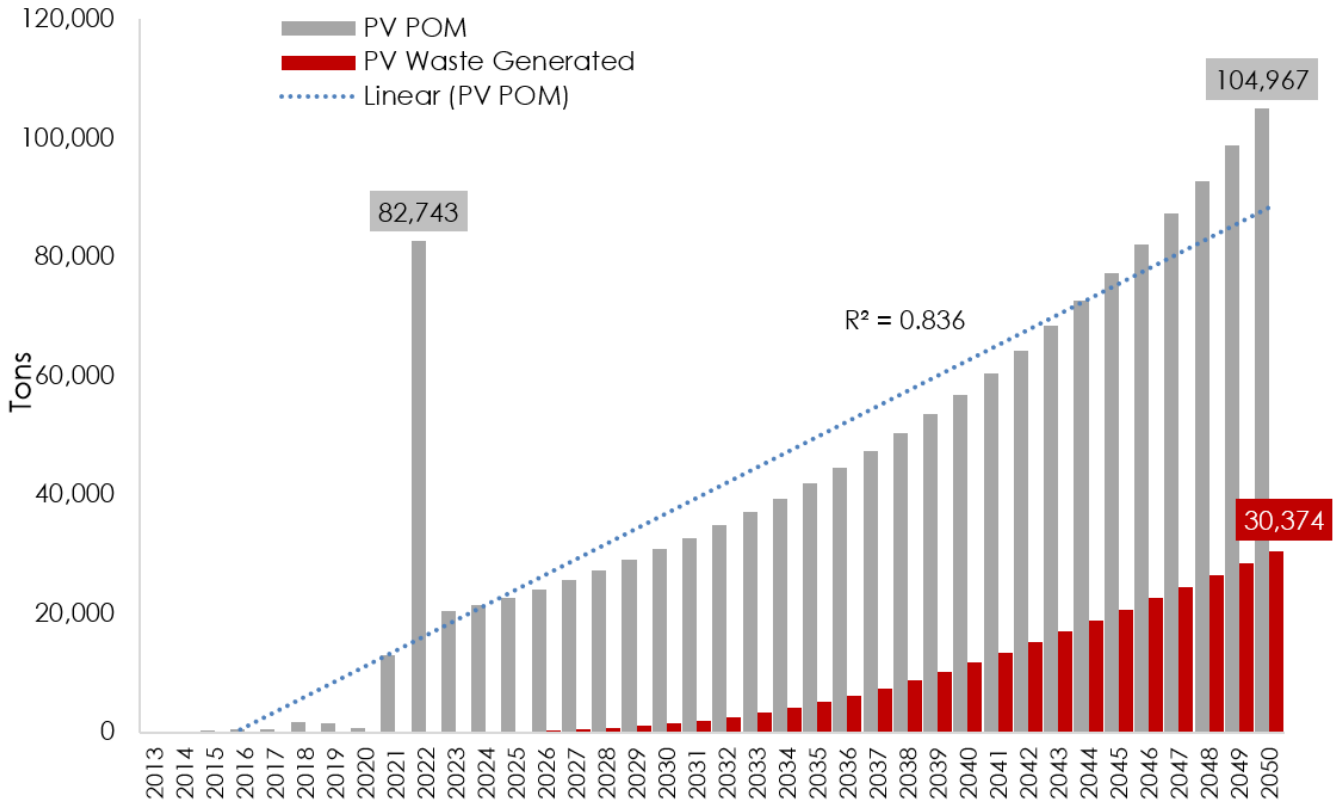



*Figure 5-8 PV POM and Waste generated in Lebanon (in tons) under Scenario 2*

The 2 scenarios highlight an enormous increase in PV POM quantities in the Lebanese market that are estimated to reach 445,719 tons by 2050 under scenario 1 and 104,967 tons under scenario 2 by the same year. Data reveals that waste generated from PV panels will be a real problem to Lebanon starting in the year 2035, when the quantities of panel waste generated will steadily increase and reach between 30,374 tons (scenario 2) and 50,454 tons in 2050 (scenario 1).

The Lebanese market shows an evolution from the absence of know-how in solar systems over a decade ago to an established market today, according to the Lebanese Center for Energy Conservation (LCEC) and UNDP-Decentralized Renewable Energy Generation (DREG) statistics. Therefore, urgent action is needed and strategies for PV recycling should be considered. This is especially true considering that, at their end-of-life, panels need to be disposed of and replaced. If not regulated, imports could become illegal, and if not tackled properly, these panels will pose a significant environmental issue due to their content of hazardous materials.

The following Table 5-2 presents the strengths, weaknesses, opportunities, and threats (SWOT) analysis for Lebanon's end-of-life-PV waste management.

*Table 5-2 SWOT analysis for end-of-life PV waste management in Lebanon*

| STRENGHTS | WEAKNESSES |
|---|---|
| ▪ Presence of programs and projects that aim to upgrade the waste management sector in Lebanon in general, and the e-waste sector in particular<br>▪ Continuous improvement of solar panels efficiency<br>▪ Some stakeholders are aligning their efforts to support the market and ensure its sustainable growth<br>▪ The private sector has played a leading role in the establishment of the PV market | ▪ Lack of specific regulations relating to PV waste<br>▪ Lack of legislation enforcement, which is made worse by the prevailing situation in the country<br>▪ Uncontrolled imports of PV<br>▪ Poor waste management systems and lack of a proper PV plan<br>▪ Insufficient waste infrastructure<br>▪ Lack of revenues to finance the cost of PV waste management systems<br>▪ Presence of low-quality solar products and inverters in the Lebanese market that do not meet the standards set by the Industrial Research Institute[2]<br>▪ Limited expertise in PV waste management<br>▪ Lack of public awareness<br>▪ |
| **OPPORTUNITIES** | **THREATS** |
| ▪ Lebanon is a signatory to several international environmental agreements which may affect the PV systems market and its waste management<br>▪ Polluter Pays Principle promulgated in Law 444/2002<br>▪ Continuous research and innovation in recycling methods<br>▪ The private sector could play a leading role in waste management from solar PV systems<br>▪ | ▪ Generation of harmful chemicals to the environment and the ecosystems from PV panels once they become waste<br>▪ Current situation of Government institutions (recurring strikes and severe understaffing as a result of massive resignations due to drastic devaluation of the currency that has led to a similar reduction of salaries; and the resulting incapability to assume institutions' role in the sector, including legislation enforcement and protection of the environment).<br>▪ Misscommunication between different stakeholders |

## 5.5 INDICATORS

The data collected in Lebanon based on available data sources is compiled using a reporting matrix shown in

Table 5-3. The reporting matrix provides insights that allow for international comparisons, location of data gaps, imputations, application of statistical routines, and construction of indicators (Balde et al., 2022).

2 https://www.pv-magazine.com/2023/06/08/lebanese-households-fight-economic-crisis-with-record-rooftop-pv-additions/

*Table 5-3 Lebanon Reporting Matrix*

| Operation | Quantities (in tons) | 2,017 | 2,018 | 2,019 | 2,020 | 2,021 | 2022 |
|---|---|---|---|---|---|---|---|
| **EEE Put on Market** | **Total** | **85,867** | **78,467** | **55,495** | **12,533** | **29,008** | **46,551** |
| | Lamps | 960 | 544 | 309 | 243 | 484 | 312 |
| | Large equipment | 15,465 | 14,480 | 12,075 | 3,626 | 8,108 | 11,377 |
| | Screens and monitors | 4,083 | 4,902 | 2,712 | 1,147 | 1,893 | 3,213 |
| | Small equipment | 36,419 | 32,728 | 25,484 | 6,890 | 11,417 | 20,078 |
| | Small IT | 3,110 | 3,391 | 2,513 | 396 | 1,440 | 2,333 |
| | Temperature exchange | 25,830 | 22,422 | 12,402 | 231 | 5,666 | 9,238 |
| **EEE Import** | **Total** | **92,037** | **84,499** | **62,391** | **19,162** | **35,755** | **53,999** |
| | Lamps | 978 | 577 | 325 | 249 | 499 | 336 |
| | Large equipment | 16,031 | 14,611 | 12,315 | 3,976 | 8,319 | 11,714 |
| | Screens and monitors | 4,128 | 4,958 | 2,869 | 1,279 | 1,951 | 3,264 |
| | Small equipment | 37,431 | 33,653 | 26,605 | 7,872 | 12,547 | 21,195 |
| | Small IT | 3,584 | 3,816 | 2,897 | 963 | 1,757 | 2,530 |
| | Temperature exchange | 29,885 | 26,884 | 17,380 | 4,823 | 10,682 | 14,960 |
| **EEE Export** | **Total** | **6,170** | **6,032** | **6,896** | **6,629** | **6,747** | **7,448** |
| | Lamps | 18 | 33 | 16 | 6 | 15 | 24 |
| | Large equipment | 566 | 131 | 240 | 350 | 211 | 337 |
| | Screens and monitors | 45 | 56 | 157 | 132 | 58 | 51 |
| | Small equipment | 1,012 | 925 | 1,121 | 982 | 1,130 | 1,117 |
| | Small IT | 474 | 425 | 384 | 567 | 317 | 197 |
| | Temperature exchange | 4,055 | 4,462 | 4,978 | 4,592 | 5,016 | 5,722 |
| **Other Recycling of E-waste by "Ecoserv"** | **Total** | **87** | **195** | **283** | **59** | **81** | **179** |
| | Lamps | - | - | - | - | - | - |
| | Large equipment | - | 12 | 27 | 24 | 20 | 14 |
| | Screens and monitors | 19 | 61 | 89 | 14 | 27 | 57 |
| | Small equipment | 10 | 30 | 43 | 3 | - | 16 |
| | Small IT | 52 | 77 | 111 | 18 | 34 | 87 |
| | Temperature exchange | 6 | 15 | 13 | - | - | 5 |

International indicators are harmonized according to international standards, as per SDG 12 on sustainable consumption and production, and have been defined for EEE POM (indicator 1), e-waste generated (indicator 2), e-waste formally collected (indicator 3) and the e-waste collection rate (indicator 4, which expresses the performance) (Lattoni Giulia et al., 2021). The e-waste management assessment shown in Table 5-4 is adopted from and described in the Regional E-Waste Monitor for the Arab States, 2021. The national e-waste policy and infrastructure are assessed by three development stages A, B, and C that can be roughly interpreted as "advanced", "in transition" and "basic", respectively (Lattoni et al., 2021). Countries with similar GDP or situations similar to the Lebanese e-waste management situation, such as Jordan, Indonesia, Cyprus and Tunisia, are referred to when comparing Lebanon's situation to other countries.

*Table 5-4 Indicators in the e-waste management system and levels for each stage*

| | No. | Description of Indicator | Lebanon | Jordan[3] | Indonesia [4] | Cyprus[5] | Tunisia |
|---|---|---|---|---|---|---|---|
| Legislation | 1.1 | Existence of e-waste specific legislation | B<br>In development<br>(No EPR, no standards/ policies) | B<br>In development<br>(No EPR, Availability of standards/ policies) | C<br>None | A<br>Yes<br>(EPR system available) | C<br>None |
| | 1.2 | Enforced products in national e-waste legislation (mass of all UNU-KEYS as a percentage of all e-waste generated) | C<br>0% | C<br>0% | C<br>0% | A<br>- | - |
| | 1.3 | National e-waste collection target | | C | | | |
| | 1.4 | Standards for e-waste management | | C | | | |
| | 1.5 | Number of multilateral environmental agreements ratified or signed | | A | | | |
| | | | B | - | | | |
| Infrastructure | 2.1 | E-waste collection points | B<br>In main cities only | B<br>In main cities only | C<br>None | - | - |
| | 2.2 | Management facilities for Environmentally Sound Management of e-waste | C<br>Yes, but informal and handle a very small fraction of E-waste | C<br>None | - | A<br>Yes | C<br>None |
| Performance | 3 | E-waste collection rate (%) | - | 2.6%<br>(2019) | - | 2.6%<br>(2016) | - |
| | 3.1 | E-waste collected (in Kt) | 0.09<br>(2020) | 1.3<br>(2019) | - | 2.5<br>(2016) | - |
| | 3.2 | E-waste collected (in kg/ inh) | - | 0.1<br>(2019) | - | 2.9<br>(2016) | - |

3 https://ewastemonitor.info/wp-content/uploads/2021/12/REM_2021_ARAB_web_final_nov_30.pdf
4 https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf
5 https://www.scycle.info/wp-content/uploads/2020/11/In-depth-review_WEEE-Collection-Targets-and-Rates_UNITAR_2020_Final.pdf

| | No. | Description of Indicator | Lebanon | Jordan[3] | Indonesia [4] | Cyprus[5] | Tunisia |
|---|---|---|---|---|---|---|---|
| E-waste quantity | 4 | E-waste generated (in kt) | 47.5 (2022) | 52.7 (2018) | 1,618 (2019) | 15 (2019) | 75.7 (2019) |
| | | E-waste generation intensity (in kg/inh) | 9.8 (2022) | 5.3 (2018) | 6.1 (2019) | 16.8 (2016-2019) | 6.4 (2019) |
| EEE quantity | | EEE POM (in Kt) | 46.5 (2022) | 75.4 (2018) | - | 134 (2016) | 89.7 (2019) |
| | | EEE POM (kg/inh) | 9.6 (2022) | 7.6 (2018) | - | - | 7.6 (2019) |

*Source: Lattoni et al., 2021*

**Jordan**, classified as a lower-middle-income country, is one of the four Arab states with available data on e-waste collection and environmentally sound management (ESM) practices. In 2019, across four Arab States (Jordan, the State of Palestine, Qatar and the United Arab Emirates), Jordan recorded the highest collection rate of 2.6% equivalent to 0.1kg per inhabitant. The country is active in the process of establishing an EPR system for e-waste to be implemented through legislations for waste ESM. The application of legislation goes through the Ministry of Environment while the collection process is under the efforts of municipalities, waste management authorities, private companies, and non-governmental organizations (NGOs). Despite relatively lower e-waste volumes, there remains a lack of official data on e-waste imports and exports in Jordan.

**Cyprus**, classified as a high-income country, has implemented a comprehensive framework that covers e-waste legislation, standards, collection targets, international agreements, and management facilities. Cyprus is facing economic challenges leading to a decrease in EEE POM, while WEEE generation remains at a high level. The economic recession that started in the early 2010s has placed Cyprus with countries having the lowest collection rate in Europe. The WEEE generated volume has been reduced within the country by the presence of informal collectors and street pickers who often export WEEE or treat them as scrap metals.

**Tunisia**, classified as a low-middle income country, has limited statistical information on e-waste imports and exports and data on e-waste collection rates are lacking. Despite this, the quantities of EEE POM and e-waste generated in Tunisia align with the regional average across the Arab Region. The country lacks an EPR system or specific legislation or regulation, and no policies for ESM practices are in place. At the national level, the Ministry of Environment is responsible for e-waste legislation, while the e-waste collection is carried out by a range of entities including local governments, waste management agencies, private enterprises, and NGOs. Tunisia ratified the Basel, Rotterdam, and Stockholm conventions and signed the Minamata Convention.

**Indonesia**, classified as an upper-middle-income country, lacks a national e-waste legislation or specific management laws. The production of electrical appliances stands as a significant industry in Indonesia, contributing substantially to the country's export commodities and the Ministry of Environment is considering the adoption of Extended Producer Responsibility (EPR) principles, holding manufacturers accountable for the end-of-life management of their products. The country's e-waste collection is underdeveloped and primarily relies on informal collectors and scavengers, just as the e-waste processing infrastructure does. While Indonesia has been a party to the Basel Convention since 1993 and ratified the Ban Amendment in 2005, illegal e-waste imports continue through diverse methods.

PROVISION OF SERVICES FOR THE ASSESSMENT OF

# E-WASTE & BATTERIES IN LEBANON

06

# BATTERIES IN LEBANON

# 6. BATTERIES IN LEBANON

## 6.1 CLASSIFICATION

In Lebanon, batteries are classified under two (2) main categories: Primary and Accumulator. Primary cells and batteries, also known as dry cells, are the ones that cannot easily be recharged after one use and are discarded following discharge. However, electric accumulators, also known as rechargeable batteries or secondary batteries, are devices that store electrical energy through a reversible chemical reaction. They are designed to be recharged and reused multiple times (Shabudeen, 2014).

According to the Lebanese Customs, twelve (12) HS codes are associated with batteries in Lebanon and are split between the two categories described as "Primary cells and batteries and Electric accumulators", where each category contains six (6) different types depending on the components used to manufacture each battery. Table 6-1 shows the main characteristics of the available batteries in Lebanon.

*Table 6-1 Battery types and HS Codes in Lebanon*

| Category | Types | Uses | HS Code | Average Lifetime (years) | Adopted scale and shape for the Weibull distribution |
|---|---|---|---|---|---|
| **Primary Cells and Primary Batteries** | Manganese dioxide | Used in devices like flashlights, toys, and remote controls. | 8506.1 | 10[6] | α: 2.40, β: 11.56 |
| | Mercuric oxide | Used in medical devices and hearing aids. Not very common nowadays due to their environmental concerns. | 8506.3 | 3.5[7] | α: 1.43, β: 4.56 |
| | Silver oxide | Used in small electronic devices like watches, calculators, and cameras. | 8506.4 | 2[8] | α: 1.3, β: 2.5 |
| **Primary Cells and Primary Batteries** | Lithium | Used for various applications including cameras, watches, portable electronics such as smartphones and laptops. | 8506.5 | 3.5[9] | α: 1.43, β: 4.56 |
| | Air-zinc | Used in devices like hearing aids and film cameras. | 8506.6 | 2[10] | α: 1.3, β: 2.5 |
| | Others | These encompass various primary cell types. Details on types and specific description for this HS code were not provided by the Lebanese Customs. Therefore, uses can vary according to the types. | 8506.8 | 4.2 | α: 1.14, β: 4.78 |

6 Lithium - Manganese Dioxide Battery (Li-MnO2) Batteries | GlobTek

7 Battery Shelf Life & Shortage - Master Instruments Australian Rechargeable Lithium Battery & Lead Acid Batteries (master-instruments.com.au)

8 Battery Shelf Life & Shortage - Master Instruments Australian Rechargeable Lithium Battery & Lead Acid Batteries (master-instruments.com.au)

9 https://ewastemonitor.info/wp-content/uploads/2021/11/First_Dutch_Waste_Battery_Monitor_online_version.pdf

10 Battery Shelf Life & Shortage - Master Instruments Australian Rechargeable Lithium Battery & Lead Acid Batteries (master-instruments.com.au)

| Category | Types | Uses | HS Code | Average Lifetime (years) | Adopted scale and shape for the Weibull distribution |
|---|---|---|---|---|---|
| **Electric Accumulators, including separators** | Lead-acid, for starting piston engines | Used only for motor vehicles purposes. | 8507.1 | 2[11] | α: 1.3, β: 2.5 |
| | Other lead-acid | Used for backup power supplies, uninterruptible power supplies (UPS), electrical vehicles, and solar (photovoltaic) systems. | 8507.2 | 4[12] | α: 1.43, β: 4.56 |
| | Nickel Cadmium | Used previously in many hybrids' electric vehicles. Nowadays, used in small quantities. | 8507.3 | 2[13] | α: 1.3, β: 2.5 |
| | Nickel-metal hydride | Used in hybrid electric vehicles and electric vehicles applications. | 8507.5 | 4[14] | α: 1.43, β: 4.56 |
| | Lithium ion | Used for electric vehicles and solar power systems. | 8507.6 | 7.5[15] | α: 1.20, β: 8.09 |
| | Others | These encompass various types of batteries, mainly used for vehicles applications and solar systems. Details on this category and specific description for the HS code were not provided by the Lebanese Customs. | 8507.8 | 4 | α: 1.43, β: 4.56 |

## 6.2 QUANTITIES PUT ON THE MARKET

The POM for batteries was calculated the same way as for the EEE, by using the apparent consumption approach, based on import and export data. The quantities of batteries imported, exported, and the calculated POM in Lebanon from 2013 till the end of August 2023 are illustrated in Figure 6-1.

11 Lead Acid battery Downsides & Maintenance (powertechsystems.eu)

12 https://blog.ecoflow.com/us/how-long-does-solar-battery-last/#:~:text=However%2C%20the%20most%20significant%20drawback,between%20three%20and%20five%20years.

13 https://www.batteryuniverse.com/blog/tags/lifespan/

14 https://www.batteryuniverse.com/blog/tags/lifespan/

15 https://www.newark.com/pdfs/techarticles/tektronix/LIBMG.pdf

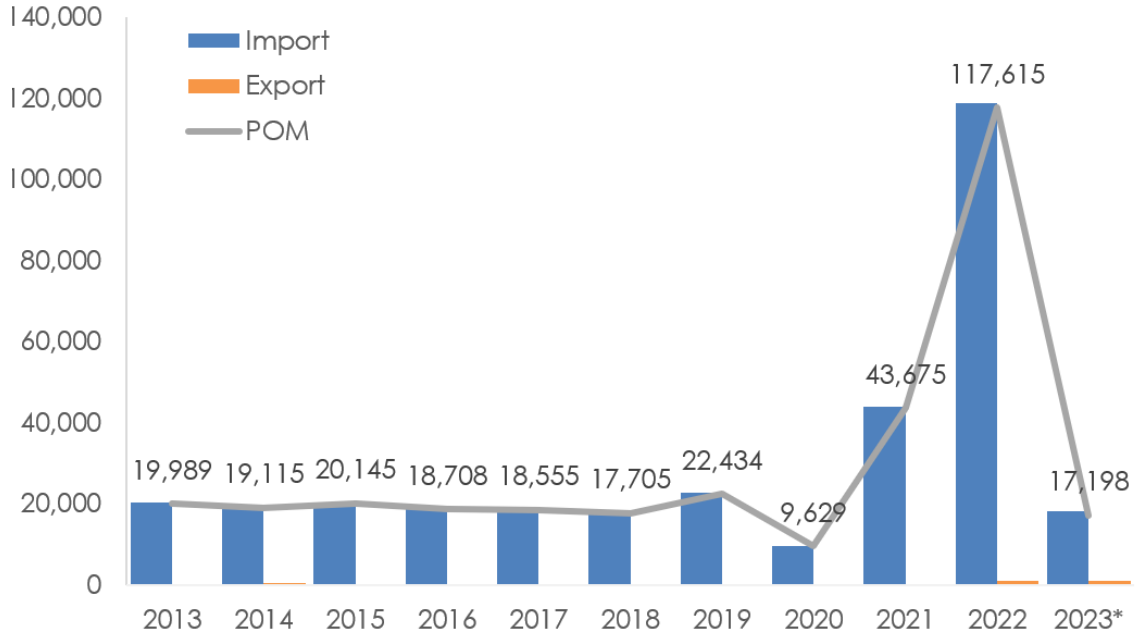



*Figure 6-1 The POM/Import/Export data of batteries in Lebanon (in tons) from 2013 till 2022*

*Source: (Lebanese Customs, 2023a)*

According to Figure 6-1, the POM for batteries is directly affected and proportional to the quantities of batteries imported while the quantities exported remain very low since batteries are considered as hazardous waste and their movement across borders is regulated. The graph shows that **the quantities POM of total batteries in Lebanon has experienced a notable increase from 19,989 in 2013 to 117,615 in 2022 followed by a decrease to 17,198 by August 2023. Data highlights a slight decrease from 22,434 tons in 2019 to 9,629 tons in 2020, which can be primarily attributed to the restrictions imposed by the COVID-19 pandemic**. However, as the COVID situation gradually improved, the Lebanese economic crisis worsened, leading to a shift towards renewable energy, mainly solar energy solutions that require batteries. The high peak detected in 2022 for batteries is directly correlated to the high peak noticed in the PV HS code for the same year (Figure 5-6). According to the Lebanese Customs reference, batteries used for the solar system are being imported to the country under the electric accumulators' category, mainly under the HS codes 8507.2 (Other lead-acid accumulators) and 8507.6 (Lithium-ion) from the HS codes in Lebanon shown in Table 6-1 above, thus explaining the significant increase in batteries numbers for 2022. Figure 6-2 and Figure 6-3 show the variation of POM quantities per batteries main categories and main types, between 2013 and 2022.

It is important to note that solar system batteries may also be imported under the HS code 8507.8 "Other Accumulator" for which no specific details are known by the Customs Authorities on the battery types imported and exported.

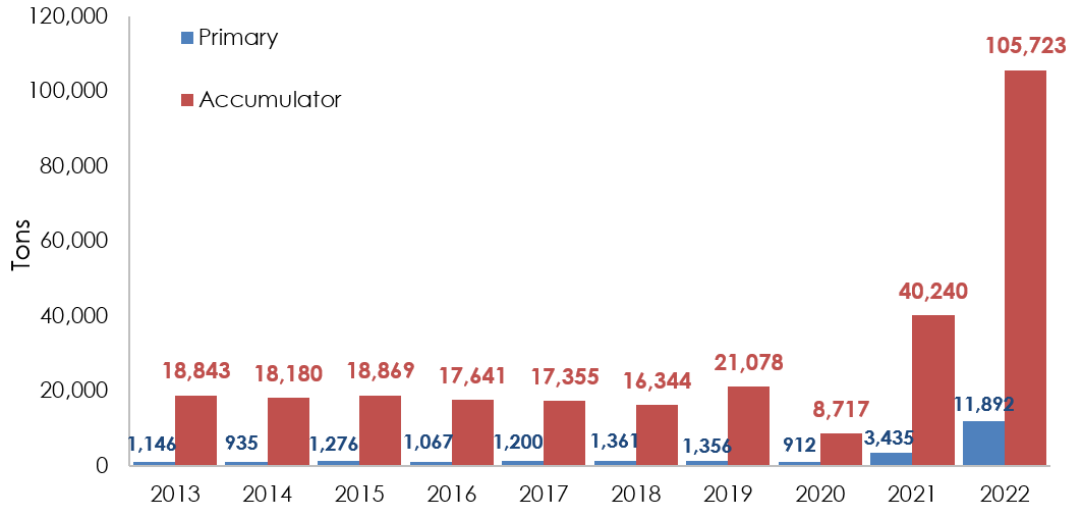



*Figure 6-2 The POM quantities of Batteries (in tons) per category 2013-2022*

*Source: Lebanese Customs, 2023*

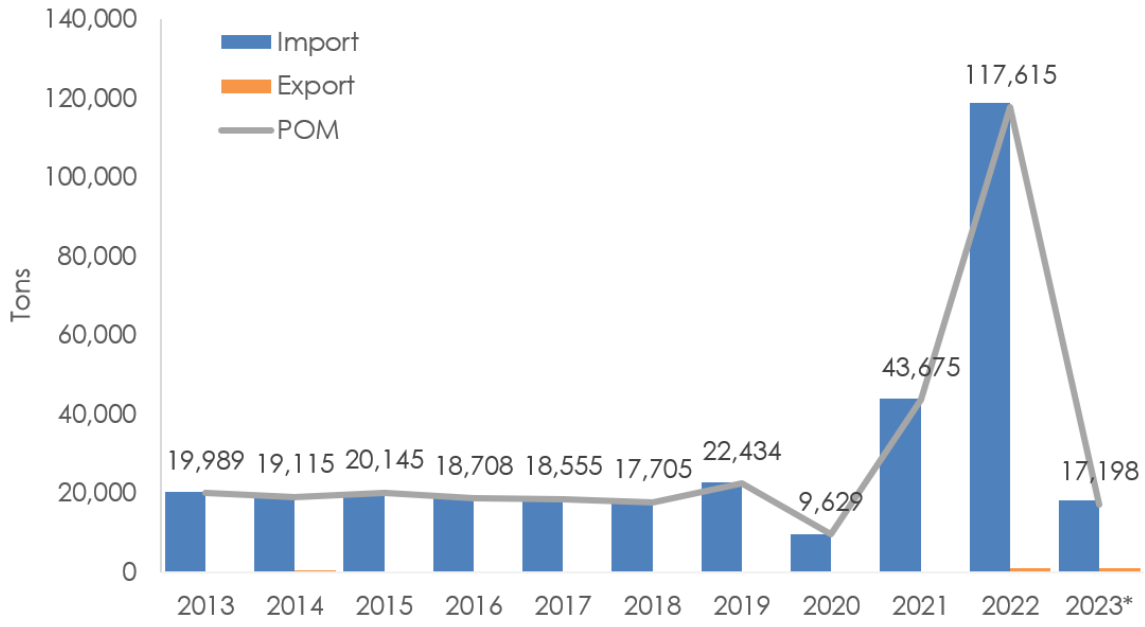



*Figure 6-3 The variation of POM (in tons) for most types of batteries 2013-2022*

*Source: Lebanese Customs, 2023*

Figure 6-2 **shows that the overall import data for batteries, both primary and accumulators, witnessed a general increase during this period, especially for the accumulators, where POM quantities increased by 461% by 2022 compared to 2013 (from 18,843 tons in 2013 to 105,723 tons in 2022)**. This rise can be linked to the energy crisis in Lebanon and the transition towards solar power solutions. With challenges in the power infrastructure and a reliable electricity supply becoming scarce, the demand for batteries as backup power sources skyrocketed across multiple sectors, including households, businesses, and essential infrastructure. The batteries commonly used in solar energy are divided into three (3) main types based on their constituent materials. These are lead acid, lead carbon and lithium batteries (Jawd et al., 2021). Energy-access projects have consistently turned to lead-acid batteries since

they are widely available, robust, and cheap. In recent times, the advancement of Lithium-ion batteries coupled with decreasing Li-ion costs have paved the way for many projects to contemplate using Lithium batteries for superior performance and efficiency (Manhart et al., 2018).

Figure 6-3 **highlights that Lead acid batteries have been the dominant choice in the Lebanese market from 2013 till 2022. On average, the yearly consumption was 11,955 tons for lead-acid batteries meant for starting piston engines. For other Lead-acid batteries, the annual average was 3,570 tons between 2013 and 2020, spiking to 17,053 tons in 2021 and further escalating to 49,602 tons in 2022. This signifies a remarkable increase of 1,026% when juxtaposed with the benchmark year 2013**. Lithium-ion batteries are the second category gaining momentum in the country. The typical quantities of lithium batteries in the market hovered around **11 tons between 2013 and 2020, but jumped to 202 tons in 2021 and then to 3,023 tons in 2022. The "Other Accumulators" category also witnessed a change in POM quantities in 2022**, hitting 36,879 tons. This stands in stark contrast to preceding years, which averaged 3,098 batteries from 2013 to 2021. This "other" category encompasses various types like AGM, GEL, Lead-carbon, and so on, as gleaned from discussions with major battery suppliers in Lebanon.

Data for 2023, as released by the Lebanese Customs, spans up to the close of August 2023. It unveils a sharp drop in the quantities imported into the country compared to 2022, the year the peak transition took place. Many of the imported batteries remained unused and were held in stock.

It is worth highlighting that the Lebanese Parliament deliberated over a proposed increase in exchange rates applicable to taxes, fees, and customs duties, which was implemented towards the year's end. The new taxation system and the new exchange rate on imports (starting with ten times the previous level and increasing up to almost 60 times) have been a main factor pushing importers to import bigger quantities, especially for batteries and PV, as solar systems were hitting the Lebanese market due to the power crisis. Merchants worked to have large stocks for lower fees and began adding goods to be included in the market new rate. In the seven first months of 2022, imports amounted to US$10.5 billion, a figure rivalling pre-crisis benchmarks. This was interpreted as preemptive of the impending rise in the customs dollar rate (Houssari Najia, 2022). The high quantities of imports in 2022, followed by a decrease in numbers by the close of August 2023, can possibly be explained by the same factors as for solar panels.

## 6.3 BATTERY WASTE GENERATED

The generation of waste from batteries has been estimated based on product lifetime distributions and historical data of products Put on Market (POM). The average lifetime for each type of battery was adopted from several desk reviews as shown in Table 6-1 while POM quantities were projected based on import/export data extracted from Lebanese Customs website from 2013 till August 2023. The Weibull distribution function, which the EU employs to chart discard behavior for EEE, was also utilized to gauge the volume of waste emanating from batteries.

Figure 6-4 illustrates that both Batteries POM and Batteries Waste Generated are increasing over the years and are projected to reach 248,110 tons and 145,814 tons by 2040, respectively.

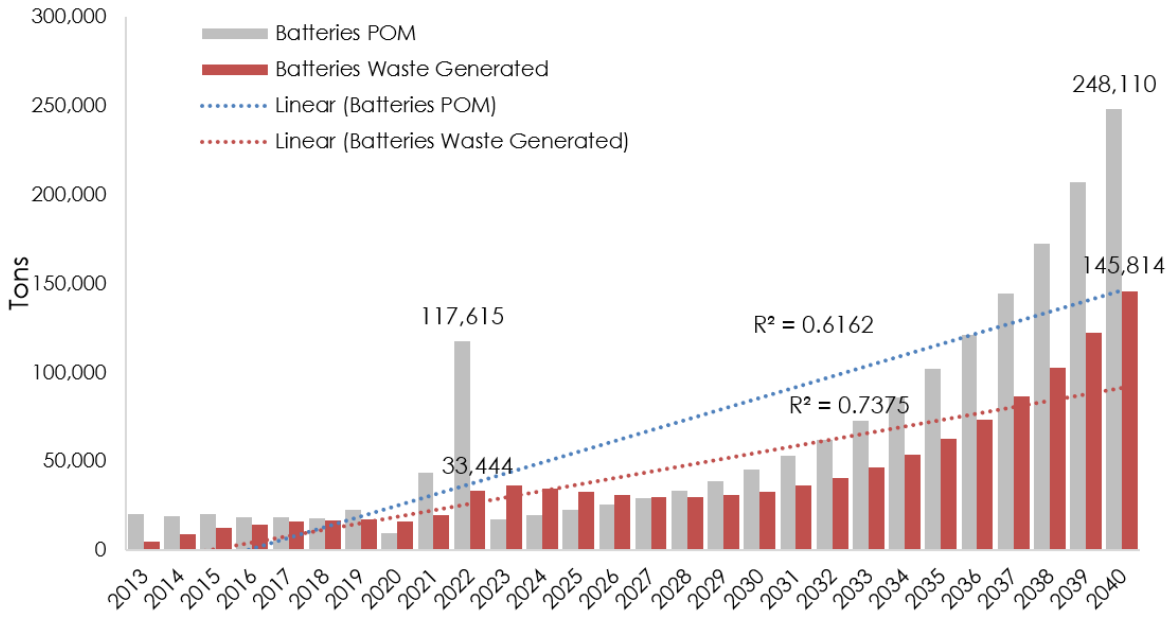



*Figure 6-4 POM and Waste generated from batteries (in tons) in Lebanon*

In Lebanon, the battery manufacturing industry remains underdeveloped, and there is a distinct lack of infrastructure to manage batteries. Given the significant surge in the use of photovoltaic energy systems, it is imperative to establish environmentally sound practices and recycling facilities before a vast number of batteries reach the end of their service. It is worth noting that exporting batteries comes with stringent restrictions. Consequently, comprehensive regulations covering the entire life cycle of batteries should be promptly devised and enforced.

PROVISION OF SERVICES FOR THE ASSESSMENT OF

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# 07

# GAP ASSESSMENT

# 7. GAP ASSESSMENT

Nowadays, electronic waste is the most rapidly growing waste stream. Globally, around 53.6 million metric tons (Mt) of e-waste is produced annually and is projected to increase to 74.7 Mt by 2030 which shows a progressive increase of around 40%. The problem of e-waste is driven by a combination of factors: the rapid technological advancement and rising global demand for electronic devices paired with ineffective waste management and disposal, triggered the e-waste crisis. Globally, a maximum of 17% of the waste stream is soundly managed, whereas the majority ends up in landfills, combined with other waste, incinerated, or is openly segregated in developing countries. Accordingly, valuable resources are wasted, and dangerous chemicals are released, threatening ecosystems and human health (Forti et al., 2020).

Lebanon, like many other nations, faces the environmental, social, and economic impacts of improper e-waste disposal. A comprehensive gap analysis is imperative to evaluate the current state of e-waste management practices in Lebanon, to identify areas of improvement, and to develop strategies for a more sustainable and responsible approach.

A gap assessment for e-waste management practices and current status in Lebanon was carried out through a Strengths, Weakness, Opportunities, and Threats (SOWT) analysis, as illustrated in Table 7-1 to shed light on the existing gaps and deficiencies in the regulatory framework, institutional framework, infrastructure, public awareness, and stakeholder engagement pertaining to e-waste management in Lebanon. By understanding the challenges and opportunities in the current system, a roadmap can be developed to establish a robust EPR system for e-waste management that aligns with best practices and international standards. The main gaps include:

- Lack of regulatory framework;
- Lack of producer knowledge;
- Lack of consumer awareness;
- Absence of standardized data collection and reporting mechanisms;
- Lack of collaboration from existing relevant stakeholders and institutions;
- Limited public awareness and knowledge about proper e-waste handling and recycling;
- Inadequate involvement of key stakeholders such as manufacturers, retailers, and waste management companies.

*Table 7-1 A SWOT analysis for e-waste management practices and status in Lebanon*

| Aspects | Parameters | |
|---|---|---|
| **E-waste management Legislation** | STRENGTHS<br>▪ Presence of some specific laws and regulations that partially address aspects of waste management including hazardous waste which could be applied to E-waste<br>▪ Ban on the import of hazardous materials, including e-waste | WEAKNESSES<br>▪ No specific legislation or regulatory framework for disposal and management of E-waste<br>▪ Unavailability of clear e-waste records and statistics |

| Aspects | Parameters | |
|---|---|---|
| **E-waste management Legislation** | OPPORTUNITIES<br>▪ Ratification of International conventions such as Basel, Rotterdam, Stockholm, Montreal, and Minamata conventions<br>▪ Slight increase in public awareness relating to E-waste and relevant legislation, mainly among educated elites | THREATS<br>▪ Current constitutional gaps, notably absence of a President of the Republic for almost a year, thus inhibiting legislation by the Parliament, and slowing cabinet's work and achievements<br>▪ Failure in implementing effective mechanisms and applying a management strategy |
| **Institutional Framework** | STRENGTHS<br>▪ There have been efforts to draft legislation and policies related to e-waste and batteries waste management, indicating the commitment of institutions to address the problem at a regulatory level<br>▪ Commitment of MoE to solving the E-waste problem in collaboration with concerned stakeholders and through the creation of Public-Private Partnerships (PPPs) | WEAKNESSES<br>▪ Lack of inter-institutional coordination<br>▪ Improper stakeholder assignment and organizational structure<br>▪ Lack of decentralization of responsibilities down to the municipal level<br>▪ Lack of data collection and reporting by the government and other institutions<br>▪ Lack of an integrated legislative framework that defines the role and responsibilities of respective institutions in e-waste management |
| **Institutional Framework** | OPPORTUNITIES<br>▪ Opportunities for collaboration with international organizations, NGOs, and the private sector to leverage expertise, resources, and best practices for better waste management. | THREATS<br>▪ The negative impacts of the crisis on institutions, their human and financial resources since 2019, coupled with limited attendance of employees, which has almost halted institutions' work and achievements and paralyzed the Government. |

| Aspects | Parameters | |
|---|---|---|
| **Implementation Strategy** | STRENGHTS | WEAKNESSES |
| | ▪ Lebanon is seeking support from international organizations and donor agencies to develop and implement effective waste management strategies/systems<br>▪ With the rising concern about environmental issues, there is a potential for public support and engagement in sustainable waste management practices<br>▪ Lebanese Government, civil society and the private sector have been promoting initiatives for e-waste sustainable management and recycling<br>▪ External support for getting expertise and building local capacities | ▪ Low collection rate of household e-waste<br>▪ Insufficient collection points to accommodate generated e-waste<br>▪ Lack of formal e-waste recycling facilities, equipment, and technologies<br>▪ Lack of e-waste management infrastructure, lack of designated proper dumpsites, and lack of space for storing and sorting e-waste<br>▪ Lack of expertise in e-waste management field<br>▪ Lack of an enforced system that challenges sectors to handle their EEE in an environmentally safe manner<br>▪ Lack of household e-waste inventory data<br>▪ Lack of transportation means<br>▪ Lack of incentives for formal e-waste collectors to overcome the cost of transportation and logistics<br>▪ Lack of formal actors in Lebanon that handle e-waste |
| | OPPORTUNITIES | THREATS |
| | ▪ The legal framework under development, covering the circular economy approach, cost recovery for waste management, EPR<br>▪ The Integrated Solid Waste Management Strategy (ISWMS) is currently being updated and will be published soon, tackling E-waste management<br>▪ Technological Advancements: innovative technologies for e-waste recycling and batteries waste treatment can improve efficiency and sustainability | ▪ Lack of awareness among the public, businesses, and institutions in Lebanon about the urgency and importance of implementing effective e-waste management strategies<br>▪ Lack of consumer and producer awareness<br>▪ Continued consumer practices of improper disposal<br>▪ Low willingness to pay for or collaborate in a waste management system<br>▪ Inadequate infrastructure to support implementation due to insufficient funding<br>▪ Adequate infrastructure and management of municipal waste stream not reached yet as a result of multiple factors, worsened by the latest financial and economic crisis |

| Aspects | Parameters | |
|---|---|---|
| **Funding and resource mobilization (Concentrating on EPR)** | STRENGHTS<br>▪ International support<br>▪ Collaboration with local and international businesses, NGOs, and academic institutions increases access to financial resources and expertise | WEAKNESSES<br>▪ Lack of sufficient resources and external funding<br>▪ Funding for e-waste management is not prioritized<br>▪ The absence of a well-established waste management infrastructure for e-waste and batteries may hinder efforts to attract funding and resources |
| | OPPORTUNITIES<br>▪ Current interest and availability of funding for e-waste management<br>▪ Increase in green and sustainable projects and fundings that address e-waste and batteries waste management<br>▪ The ISWMS is currently being updated and will be published soon, tackling funding and resource mobilization, EPR, among other aspects. | THREATS<br>▪ The ongoing economic crisis in Lebanon may affect the allocation of resources and funding for waste management initiatives, including e-waste management |
| **Monitoring & evaluation** | STRENGHTS<br>▪ Existence of a permitted E-waste facility that has developed several collection points | WEAKNESSES<br>▪ Current unavailability and lack of prioritization of monitoring and evaluation systems and efforts by public agencies |
| | OPPORTUNITIES<br>▪ Continuous annual monitoring of E-waste generation is part of the ISWMS currently being updated | THREATS<br>▪ Lack of law enforcement allows the increase of informal practices<br>▪ The impact of the crisis on public institutions and their current status constitutes a challenge to setting up and proper implementation of M&E systems |

PROVISION OF SERVICES FOR THE ASSESSMENT OF

# E-WASTE & BATTERIES IN LEBANON

# 08

# E-WASTE MASS BALANCE

# 8. E-WASTE MASS BALANCE

Like many other countries, Lebanon is struggling with the growing problem of electronic waste. The rapid pace of technology and rising consumerism means devices become outdated faster, resulting in more discarded electronic items. Consequently, a substantial volume of outdated gadgets is discarded, containing components that can potentially be repurposed while also harboring elements detrimental to the environment and human health.

Lebanon's WEEE management is still developing, as the country confronts challenges in infrastructure, regulations, and public awareness. Additionally, limited data availability makes it difficult to understand the full scope of the issue.

Regarding the management of old batteries within Lebanon, the situation is notably complex. A significant portion of these batteries is collected by individuals who operate outside the official waste collection framework, making it difficult to quantify their numbers or trace their final disposition. Although a company, Arcenciel collects various types of batteries, their capacity falls short of addressing the entirety of the problem (EcoServ, 2023)

An alarming practice in Lebanon involves individuals procuring old car batteries from auto shops and extracting lead from them for potential reuse, often without adhering to safety protocols. Finally, certain large organizations, such as the Red Cross, entrust their old batteries to EcoServ for proper disposal (EcoServ, 2023)

In response to these issues, Lebanon is proactively working to establish a WEEE and batteries management system rooted in the principles of Extended Producer Responsibility (EPR). This strategic initiative aims to build capacity, set up better regulations, and create a proper waste management system.

The following text describes the steps towards shaping an effective waste management strategy by introducing the current flows of WEEE. This foundational overview provides valuable insights into the existing status quo within the country.

Due to the limited data available in Lebanon, different sources and references were used to acquire the necessary data for the mass balance. These references have been consolidated into Table 8-1.

*Table 8 -1 Data sources and references for the mass balance of (W)EEE*

| Term | Source |
|---|---|
| EEE POM | Lebanese customs website |
| Stock | National E-waste Monitor for Lebanon |
| E-waste generated | Adapted from Regional E-waste Monitor for the Arab States |
| Voluntary collection | EcoServ |
| Formal collection | Adapted from National E-waste Monitor for Lebanon |
| Informal collection | Adapted from National E-waste Monitor for Lebanon |
| Uncontrolled waste | Adapted from National E-waste Monitor for Lebanon |
| Environmentally sound management | EcoServ |
| Non-environmentally sound management | Estimation based on the acquired data from the Customs Database |
| Environmentally sound management of the stock | Adapted from National E-waste Monitor for Lebanon |

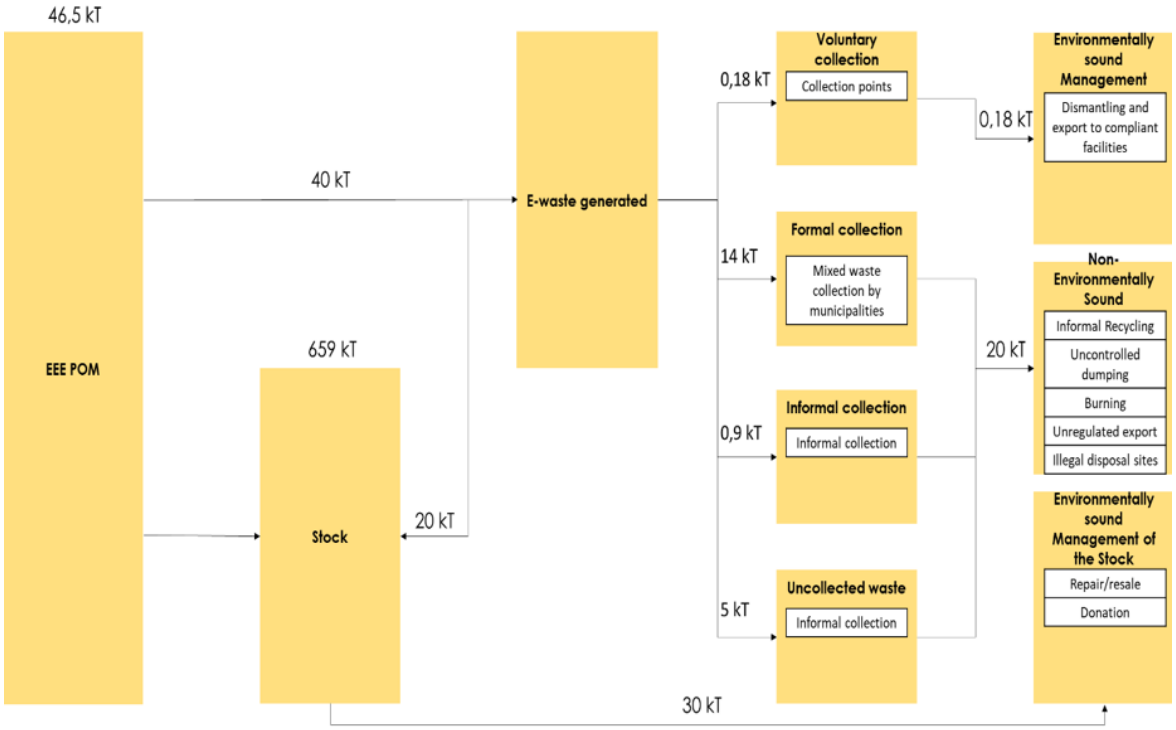


*Figure 8-1 Mass balance of (W)EEE in Lebanon for year 2022*

*Source: BFS, 2023*

Figure 8 -1 Mass balance of (W)EEE in Lebanon for year 2022 illustrates the mass balance of (W)EEE and outlines the various stages in the lifecycle of EEE in Lebanon for 2022

EEE primarily enters the Lebanese market through imports, and there is no reported domestic production of EEE within the country. For this report, the products Placed on the Market (POM) refer to the imported EEE entering Lebanon. Data from the Lebanese customs website (Lebanese Customs, 2023b) indicates that the total quantity of EEE introduced into the Lebanese market in 2022 amounted to 46.5 kilotons (kT).

According to the National E-waste Monitor for Lebanon (Baldé C.P. et al., 2022), a stock of 659 kT electrical and electronic devices have been retained in households or businesses for an extended period. This stock comprises equipment and WEEE that were hibernated within households or businesses. Only about 5% or 30 kT of this stock undergoes environmentally sound management through repair, resale, and donations. Such practices aim to extend the life of electronic products and components.

In alignment with data sourced from the Regional E-waste Monitor for the Arab States (Iattoni et al., 2021)and adjusted to suit this report, it is estimated that a total of 40,000 metric tons (kT) of e-waste is generated in Lebanon. Approximately half of this e-waste is retained within households and institutions, as reported by an internal study conducted by Ecoserv. The remaining 50% is gathered through three primary collection channels:

- Voluntary collection: This channel is a business-initiated effort to collect e-waste independent of legal obligations or formal regulatory systems. All the e-waste collected through such voluntary collection points (specifically by EcoServ) in 2022 amounted to 0.18 kilotons (kT), which was directed towards dismantling or exporting to compliant facilities. Ecoserv is considered the most proactive and committed organization among the operational e-waste collectors. Furthermore, Ecoserv's approach, which

involves collaborating with their "Ambassadors" and collecting WEEE through direct agreements with institutions or via an extensive network of collection points encompassing universities, hospitals, institutes, and shops (comprising over 120 collection bins), is the main reason behind the decision to use Ecoserv's figures in this report exclusively in the voluntary collection channel.

- Formal collection: This channel involves the organized collection of mixed waste, which includes e-waste, by municipal authorities responsible for solid waste management. In alignment with data obtained from the National E-waste Registry for Lebanon and adjusted to suit this report, in 2022, e-waste accounted for 0.9 kT of the collected waste (Baldé C.P. et al., 2022).
- Informal Collection: This channel refers to unregulated collection and processing activities. In this system, e-waste is often collected by scavengers or small-scale traders and may be processed in ways that are not environmentally sound or safe for workers. In Lebanon, the head collector engages individuals, sometimes children, to gather valuable waste materials from e-waste. Specialized trucks equipped with scrapers are deployed to collect this waste and dismantle the waste, retaining the metallic components and discarding the remaining materials into the environment. Households are typically reimbursed a flat fee in exchange for the waste they dispose of. However, this arrangement often lacks environmental oversight. In particular, printed circuit boards (PCBs), a component of electronic waste, are frequently disposed of improperly (EcoServ, 2023). According to the National Waste Monitor for Lebanon, E-waste collected through this informal channel in 2022 amounted to 0.89 kT (Baldé C.P. et al., 2022).

The e-waste collected through formal and informal collection channels, with uncollected amounts (resulting in a total of 20 kT), was not subjected to environmentally sound management practices. This means that this e-waste was handled in ways that pose significant environmental and human health risks. According to EcoServ, these non-environmentally sound practices included uncontrolled dumping, burning, unregulated export, and illegal disposal sites.

Due to the absence of facilities in the country for environmentally sound management practices and processes, some dismantled e-waste is exported to compliant facilities in other countries that adhere to international guidelines for safe and effective recycling or disposal, according to EcoServ. However, it is important to mention that, based on the onsite visit at Ecoserv, there has been no export for the past two years.

Table 8-2 displays the WEEE collection, excluding formal collection, employed in Lebanon, along with the corresponding quantities.

*Table 8-2 WEEE collection methods and quantities in Lebanon in 2022*

| WEEE collection methods | Quantity (tons) |
|---|---|
| Voluntary collection | 179 |
| Informal collection | 800 |

In 2022, 979 tons of WEEE were collected by EcoServ and the informal sector. With an average EEE POM between 2019 and 2022 of 33.575 tons, the WEEE collection rate was estimated at 2.92%. This rate corresponds to an average collection rate of 0.202 kg/inh.

As per the findings of the Regional E-waste Monitor for the Arab States report, the Arab States collectively collected and effectively managed a total of 2.2 kilotons (kT) of e-waste in the year 2019. This translated to an average collection rate of 0.01 kilograms per inhabitant (kg/inh), which represented just 0.1 percent of the total e-waste generated. Jordan exhibited a more robust collection rate of 2.6 percent, while Qatar›s collection rate stood at 0.5 percent.

## 8.1 EEE POM IN OTHER COUNTRIES

A comparative analysis was conducted comparing EEE Put On Market (POM) and WEEE generated from 2017 to 2022 in Lebanon with three other countries—Jordan, Cyprus, and Tunisia. These countries were chosen because of their geographical proximity to Lebanon or their similar economic situations, as reflected by the Gross Domestic Product at Purchasing Power Parity (GDP PPP). Table 8-3 presents the GDP PPP figures and population data for these countries from 2017 to 2022:

*Table 8-3 Economic and population data for Lebanon, Jordan, Cyprus and Tunisia¬¬ (2017-22)*

| Country | GDP PPP (USD/inh) | Population (inh) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| Lebanon | 4.136 | 6,109,252 | 5,950,839 | 5,781,907 | 5,662,923 | 5,592,631 | 5,489,739 |
| Jordan | 4.103 | 10,215,381 | 10,459,865 | 10,698,683 | 10,928,721 | 11,148,278 | 11,285,869 |
| Cyprus | 31.552 | 1,208,523 | 1,218,831 | 1,228,836 | 1,237,537 | 1,244,188 | 1,251,488 |
| Tunisia | 3.804 | 11,811,443 | 11,933,041 | 12,049,314 | 12,161,723 | 12,262,946 | 12,356,117 |

*Source: World Bank, 2022*

In the context of EEE consumption and (WEEE generation, variations and shared challenges can be observed among Lebanon, Cyprus, Jordan, and Tunisia.

Jordan and Tunisia exhibited more modest per capita EEE consumption figures, standing at 7.2 and 7.6 kilograms per inhabitant, respectively. This places them closer to each other and below both Cyprus and Lebanon in terms of EEE consumption.

Lebanon and Jordan have similarities. While Jordan produced slightly more WEEE in total (55 kT), its per capita generation was less at 5.4 kilograms per inhabitant. Lebanon, though generating 50 kT in total, saw a higher per capita generation at 8.2 kilograms.

Tunisia stood out with the most substantial total WEEE generation, accumulating 76 kT, translating to 6.4 kilograms per inhabitant. This sizable figure indicates a pressing need for robust electronic waste management strategies in Tunisia.

In conclusion, the data underscores marked disparities in EEE consumption and WEEE generation across the countries in focus. While Cyprus stands out in terms of EEE consumption, Tunisia grapples with the highest per capita WEEE generation. These variations highlight the necessity of crafting waste management strategies that cater to each country's distinct needs and challenges. At the same time, the commonalities in electronic waste generation across these nations accentuate the regional urgency for comprehensive waste management approaches. This emphasizes addressing both EEE consumption and WEEE generation, fostering a culture of responsible electronic waste management.

Table 8-4 compares these countries based on the EEE Put on Market (POM) and WEEE quantity generation between 2017 and 2022. This information for Jordan, Cyprus and Tunisia was obtained from Global E-waste Monitor Statistics (ITU & UNITAR, 2023).

*Table 8-4 Comparison of Lebanon, Jordan, Cyprus, and Tunisia: EEE POM and WEEE quantity generation (2017-2022)*

| Country | Category | Unit | 2019 |
|---|---|---|---|
| Lebanon | EEE POM | kg/inh | 9.6 |
| | WEEE generated in total | kT | 50 |
| | WEEE generated per inh | kg/inh | 8,2 |
| Jordan | EEE POM | kg/inh | 7.2 |
| | WEEE generated in total | kT | 55 |
| | WEEE generated per inh | kg/inh | 5,4 |
| Cyprus | EEE POM | kg/inh | 18.5 |
| | WEEE generated in total | kT | 15 |
| | WEEE generated per inh | kg/inh | 16,8 |
| Tunisia | EEE POM | kg/inh | 7.6 |
| | WEEE generated in total | kT | 76 |
| | WEEE generated per inh | kg/inh | 6.4 |

Cyprus boasts the highest per capita EEE consumption, with an average of 18.5 kilograms of EEE per inhabitant in 2019. In comparison, Lebanon averaged at 9.6 kilograms per inhabitant, suggesting that Cypriots have a markedly higher rate of EEE consumption.

Jordan and Tunisia exhibited more modest per capita EEE consumption figures, standing at 7.2 and 7.6 kilograms per inhabitant, respectively. This places them closer to each other and below both Cyprus and Lebanon in terms of EEE consumption.

Lebanon and Jordan have similarities. While Jordan produced slightly more WEEE in total (55 kT), its per capita generation was less at 5.4 kilograms per inhabitant. Lebanon, though generating 50 kT in total, saw a higher per capita generation at 8.2 kilograms.

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PROVISION OF SERVICES FOR THE ASSESSMENT OF

E-WASTE & BATTERIES IN LEBANON

# 09

# WASTE MANAGEMENT SYSTEMS FOR E-WASTE AND BATTERIES

# 9. WASTE MANAGEMENT SYSTEMS FOR E-WASTE AND BATTERIES

The collection, consolidation, sorting, and treatment of Waste Electrical and Electronic Equipment (WEEE) and batteries are key components within the framework of a waste management system. These critical stages form the backbone of efforts aimed at responsibly managing electronic waste, safeguarding the environment, and harnessing the potential for resource recovery.

Prior to examining into these essential phases, the establishment collection targets are an absolute prerequisite. These targets serve as the fundamental building blocks upon which a strategy is constructed, providing precise guidance for the systematic and efficient execution of activities related to the collection, consolidation, sorting, and treatment of WEEE and batteries.

In this context, the following chapters delineate the collection targets, detail the design of the collection system, describe how the collected items will be brought together at local centers, and introduce the procedures for sorting and initial processing at the designated facility.

## 9.1 COLLECTION SYSTEM

The recently updated Integrated Solid Waste Management Strategy (ISWM) has put forth ambitious waste reduction goals, targeting a WEEE collection rate of 4 kg/capita within five years post-strategy adoption. Although the objective appears achievable on the surface, a closer examination of the current metrics suggests otherwise. Currently, the collection rate lingers at a mere 2,92% of Products Placed on the Market (POM), equivalent to 0,202 kg/inh. To raise this to 4 kg/inh necessitates collecting approximately 58% of the POM, calculated based on the 2019-2021 POM average.

For context, it took France—armed with an established Extended Producer Responsibility (EPR) system for packaging waste—even before the introduction of an EPR scheme for WEEE—five years to realize a 31% of POM collection rate after the enactment of the WEEE Directive. A full 11 years later, France had reached 48% of POM (Baldé et al., n.d.). On another front, Brazil, through negotiations with its private sector, set a goal to achieve 17% of the POM within a span of five years (Sectoral Agreement for Electronic Waste Management, n.d.)

In light of these global benchmarks, Lebanon's objective to hit 58% of POM appears ambitious. Considering the prevailing conditions, there's a real concern about enforcing such a high target. In-depth analysis suggests recalibrating the goal to a more achievable 1.5 kg/inh or roughly 22% of POM. A range of 20-25% of POM seems more suited to Lebanon's unique circumstances. To foster a sustainable implementation, it's beneficial to adopt interim targets. This entails a moderate increase during the system's initial years, followed by a sharper increment from the third year onward.

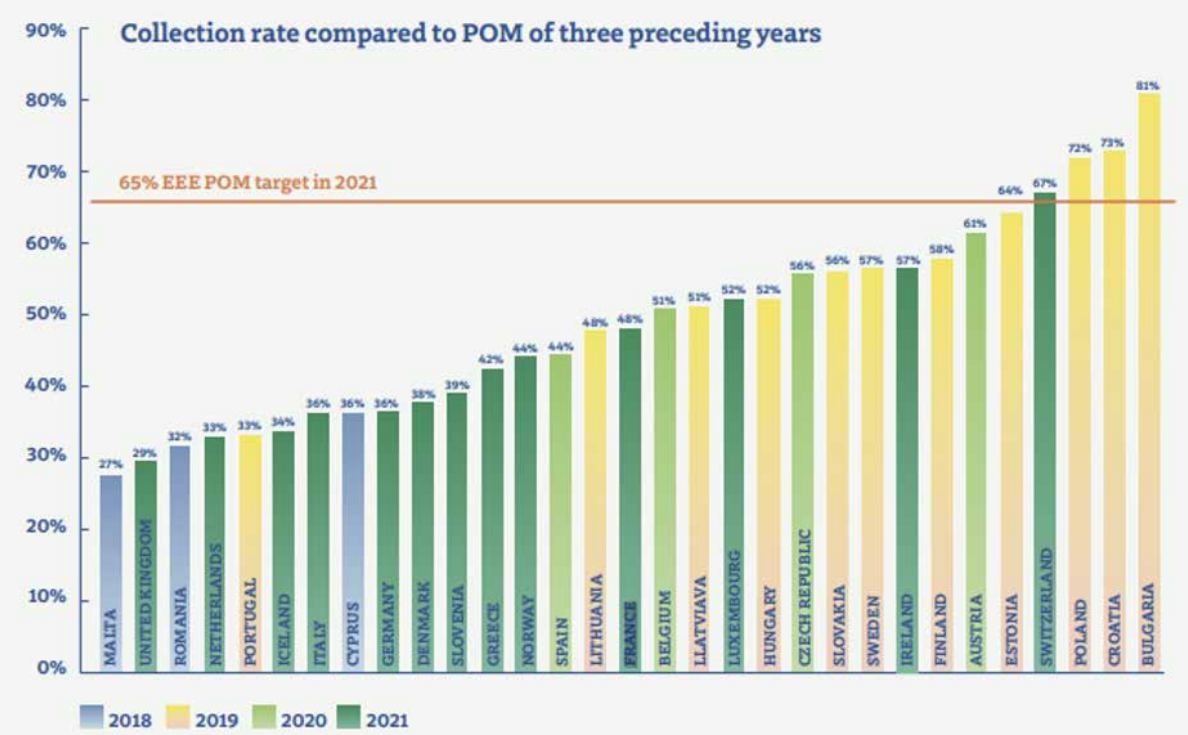


*Figure 9-1 Overview of collection rate compared to EEE POM of three preceding years for Member States of the EU-27, United Kingdom, Switzerland, Iceland, and Norway*

*Source: Baldé et al., 2020*

It's imperative to highlight that such a goal centers on establishing a robust Extended Producer Responsibility System in Lebanon. In relation to this report, all projections are based on figures from the second year of the system's rollout, approximating 10% of POM or a total of 5.000 tons.

*Table 9-1 Proposed WEEE collection rate targets strategy for Lebanon based on the ISWM strategy*

| Year | Collection rate (kg/inhabitant) | Collection rate (% of POM) | 2019 (tons) |
|---|---|---|---|
| Year 1 | 0.4 | 6% | |
| Year 2 | 0.7 | 10% | 5, 000 |
| Year 3 | 0.9 | 13% | |
| Year 4 | 1.2 | 17% | |
| Year 5 | 1.5 | 22% | |

Lebanon boarded on the adoption of photovoltaic (PV) panels in 2013 (LCEC, 2011). The adoption rate was initially modest, but a significant surge occurred in 2021 due to a fuel crisis (Adam, 2023). The power shortages prompted households and industries to increasingly turn to PV systems as an alternative energy source, resulting in a significant increase in the importation of these systems.

Concerning the projected waste from PV panels in Lebanon, there's a noticeable trend indicating an increase in waste generation. However, given that PV panels have a lifespan of at least 15 years, it might be prudent to establish collection targets when the disposal of these panels becomes more pressing, potentially in the next 5 years.

Regarding the conceptual design for managing PV panel waste, the calculations consider allocating a dedicated area within the dismantling center for consolidating collected volumes. These volumes will be stored until they reach sufficient quantities for proper treatment.

It's important to note that recycling technologies for PV panels are currently in the developmental stage in Europe. Therefore, it is advisable to consolidate volumes locally while the technologies continue to mature.

When it comes to batteries, they can be broadly classified into three primary types: portable, automotive, and industrial (European Union, 2006). Historical data obtained through the Lebanese Customs Website (Lebanese Customs, 2023b) shows that portable batteries constitute approximately 5-10% of the total volume of batteries placed on the market (POM).

According to the European new battery regulation, an initial goal was to collect 45% of the POM for portable batteries by 2023 (Landbell Group, 2023). **A similar goal has been discussed and recommended for Lebanon, adopting a collection target of 20% of POM or 0.6 kg/inhabitant within a five-year timeframe following the ISWM strategy implementation.**

Regarding automotive and industrial batteries, the EU currently does not specify specific collection targets; however, their collection is obligatory. Therefore, it is recommended for Lebanon to postpone setting specific collection targets for automotive and industrial batteries until the WEEE Directive provides further guidance.

For the business model, calculations are based on data from the second year following the implementation of the system. The projected collection rates estimated within the model are as follows:

- Collection of 20% of the POM for portable batteries within two years of implementing the system.
- Collection of 15% of the POM for automotive and industrial batteries within two years.

This model aims to harmonize Lebanon's battery collection strategy with international best practices while considering the nation's unique market conditions.

The following table summarizes the proposed battery collection strategy targets.

In Year 2 of the proposed strategy, the goal is to collect 20% of portable batteries, which would amount to approximately 3,000 tons, and 15% of Automotive and industrial batteries, equivalent to roughly 5,000 tons. By Year 5, the collection target increases to 45% for Portable batteries, aiming to collect around 7,200 tons. However, the collection target for Automotive and industrial batteries for Year 5 is yet to be defined, indicating that specific goals for these types of batteries are still under consideration or development.

*Table 9-2 Proposed battery collection strategy targets in the context of Lebanon*

| Year | Batteries type | Collection rate (% of POM) | Quantity (tons) |
|---|---|---|---|
| Year 2 | Portable batteries | 20% | 3,000 |
| | Automotive and industrial | 15% | 5,000 |
| Year 5 | Portable batteries | 45% | 7,200 |
| | Automotive and industrial | To be defined | |

*Source: BFS, 2023*

## 9.2 WEEE AND BATTERIES COLLECTION IN LEBANON

As highlighted in Chapter 2, this report adheres to the EU WEEE Directive's six categories of EEE. This categorization has guided the design of the collection channels and informed the calculations.

Generally, the collection and transport systems for WEEE offer a range of possibilities and options to ensure effective management. Figure 9-2 illustrates the proposed concept of collecting e-waste in Lebanon and the various stages and methods involved.

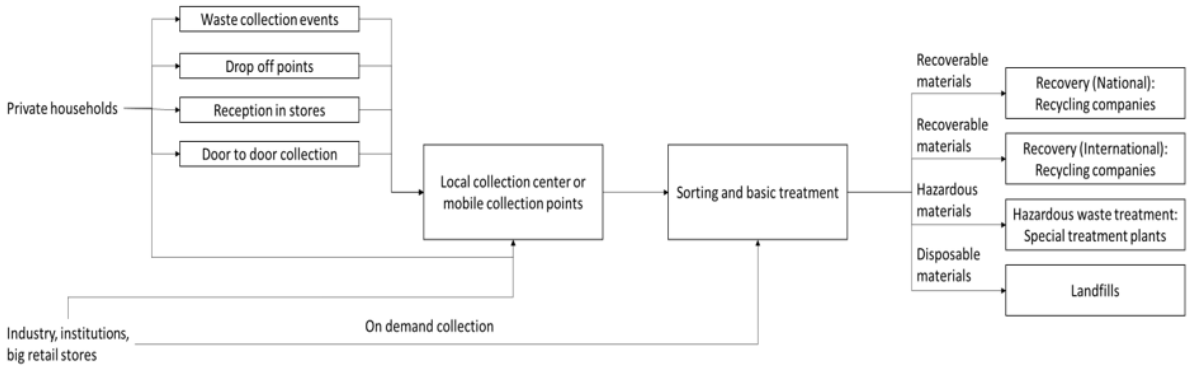


*Figure 9-2 E-waste Collection Channels*

*Source: BFS, 2023*

In an e-waste collection framework tailored to Lebanon's current circumstances, two primary sources of e-waste were identified by our consultant team: private households and commercial entities, which are comprised of industries, institutions, and large retail shops.

To ensure that collection targets are met, multiple collection methods for private households have been proposed in the framework. These are represented by waste collection events, designated drop-off points, in-store reception, door-to-door collection services, mobile collection points, and local collection centers. For commercial entities, emphasis has been placed on on-demand collection, and options to drop off waste at either local or mobile collection points have been provided.

As illustrated in Figure 9-2, **private households** are provided with a variety of possibilities to dispose of their electronic devices when they become e-waste. Waste collection events are designed with a dual purpose: enhancing collection rates and elevating awareness among the populace. Additionally, specific bins, referred to as drop-off points, will be strategically located within commercial establishments. These points offer a convenient and cost-free disposal method for consumers. Within the suggested framework, customers are also given the opportunity to directly return their WEEE to retail stores. Unlike the regular drop-off points, this return mechanism functions "over the counter" or at a designated service desk within the store. The existing "informal" door-to-door collection, predominantly managed by the informal sector, is anticipated to be integrated into the formal collection system. The local collection centers serve as specialized drop-off hubs, accessible to both residents and businesses. Conversely, mobile collection points are envisioned for more rural locations with lower population densities.

For **commercial entities,** the collection process is simplified. They have the option to deposit their waste at local or mobile collection points. Alternatively, they can engage an "on-demand" service for waste pick-up, which then directs the waste either to the collection points or directly to the sorting and basic treatment center, contingent upon the volume and geographical location of the entities.

The overarching objective is for waste from all channels to converge at the local collection points. Preliminary sorting of the WEEE is undertaken at these local collection centers. Subsequently, this waste is transported for sorting and basic treatment. The various collection centers are explained in Table 9-3.

*Table 9-3 E-waste Collection Channels*

| Collection channels | | Definition |
|---|---|---|
| Waste collection events |  | Events are a scheduled, temporary gathering at a specific location where residents can drop off electronic waste. Publicized well in advance, these events provide community members sufficient time to prepare the waste items they wish to dispose of responsibly. Typically lasting for a limited duration like a day or a weekend, the aim of such events is to facilitate bulk collection of targeted waste types in an efficient manner. |
| Drop off points |  | Designated areas within commercial establishments where consumers can safely and responsibly dispose of their electronic waste. These drop-off points are typically marked bins, or separate rooms equipped with proper signage, located in easily accessible areas such as entrances or parking lots. |
| Reception in stores (over the counter) |  | System where consumers can directly hand over their end-of-life or unwanted electronic items to store personnel for proper disposal or recycling. Unlike designated bins, this approach waste handover, usually at a specific counter or service desk within the retail establishment. |
| Mobile collection points |  | Temporary stations set up in various locations, predominantly in rural areas, to facilitate the gathering of end-of-life or unwanted electronic items. Unlike permanent facilities, these mobile points are highly adaptable and can be moved from one location to another according to a predetermined schedule. |
| Door to door collection (informal sector) |  | Unlicensed individuals or small enterprises visit households, businesses, or other entities to directly collect end-of-life or unwanted electronic items. Although this form of collection is not officially sanctioned under Extended Producer Responsibility (EPR) frameworks, it still occurs and is often at odds with the principles of responsible e-waste management. However, EPR programs can seek to integrate these informal collectors into the official system by providing training and certification, thereby improving the overall efficiency and effectiveness of e-waste management. |
| On demand collection |  | A specialized service where businesses can request the pickup and disposal of end-of-life or unwanted electronic items as needed. Unlike regularly scheduled collection services, on-demand collection is initiated by the customer and typically incurs a fee.<br>This service is particularly useful for organizations that generate irregular volumes of e-waste or require disposal services at specific times, such as during an office move, upgrade of IT equipment, or the phasing out of obsolete machinery. |
| Local collection center or consolidation point |  | Centralized locations where consumers and small businesses can drop off end-of-life or unwanted electronic items for proper disposal, recycling, or refurbishment. These facilities are usually operated under a country's Extended Producer Responsibility (EPR) framework or by municipal authorities.<br>Beyond serving as drop-off points, these centers also have a dual role: they consolidate volumes gathered from various collection channels and undertake preliminary sorting. Once sorted, the items are then transported to their subsequent destination, the sorting and basic treatment center. |

*Source: BFS, 2023*

Further details on the collection channels, accompanied by a material flow diagram and illustrative examples from their implementation in other countries, are provided below.

### 9.2.1 Waste Collection Events

As illustrated in Figure 9-3, residents would bring their spent EEE to the event for handover. Following this, the aggregated quantities would be transported to the local collection center. From there, items would undergo transfer for sorting and basic pretreatment, preparing them for either reuse or recycling.

These events are typically organized by the system operator with the aim to facilitate responsible waste management practices among community members. The event may last a short period of time over the weekend and usually takes place at a strategic location to maximize visibility. This may be a community center, a parking lot, or even an accolade to another event.

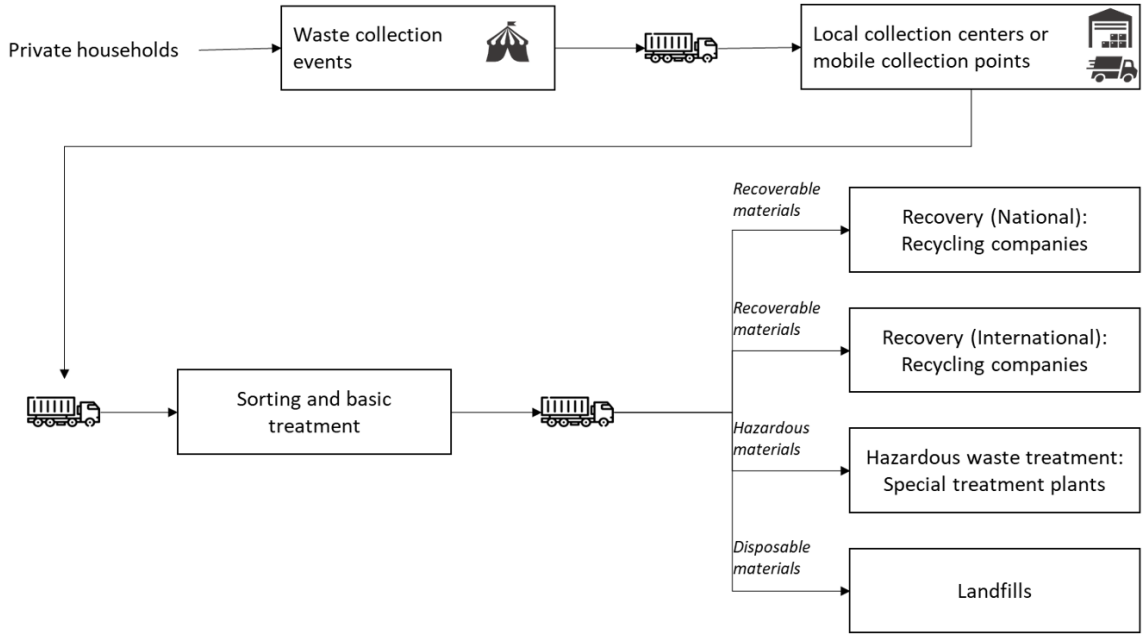


*Figure 9-3 Material flows for WEEE recovered at collection events*

*Source: BFS, 2023*

Suitable waste streams:

- Temperature exchange equipment
- Screens and monitors
- Lamps
- Large equipment
- Small equipment
- Small IT and telecommunication equipment
- All batteries


*Figure 9-4 Examples of WEEE collection at events*

*Sources: Evergreen IT Solutions, 2023; Parajuly K., 2017*

This approach has the double advantage of raising awareness of passers-by and the community at large as well as collecting items and devices. The event may also feature educational components, such as workshops or informational booths, to increase knowledge and understanding about WEEE and its treatment.

### 9.2.2 Drop Off Points

These collection points encourage the recycling or proper disposal of electronic items like old cell phones, laptops, batteries, chargers, and small appliances that should not be thrown in regular trash bins due to their hazardous components but are small enough to carry by individuals and handed over easily. As illustrated Figure 9-5, once enough materials are recovered at drop off points, they can be transported to the nearest collection center or picked by a mobile collection vehicle.

Suitable waste streams:

- Small equipment
- Small IT
- Lamps
- Screens and monitors
- Portable batteries

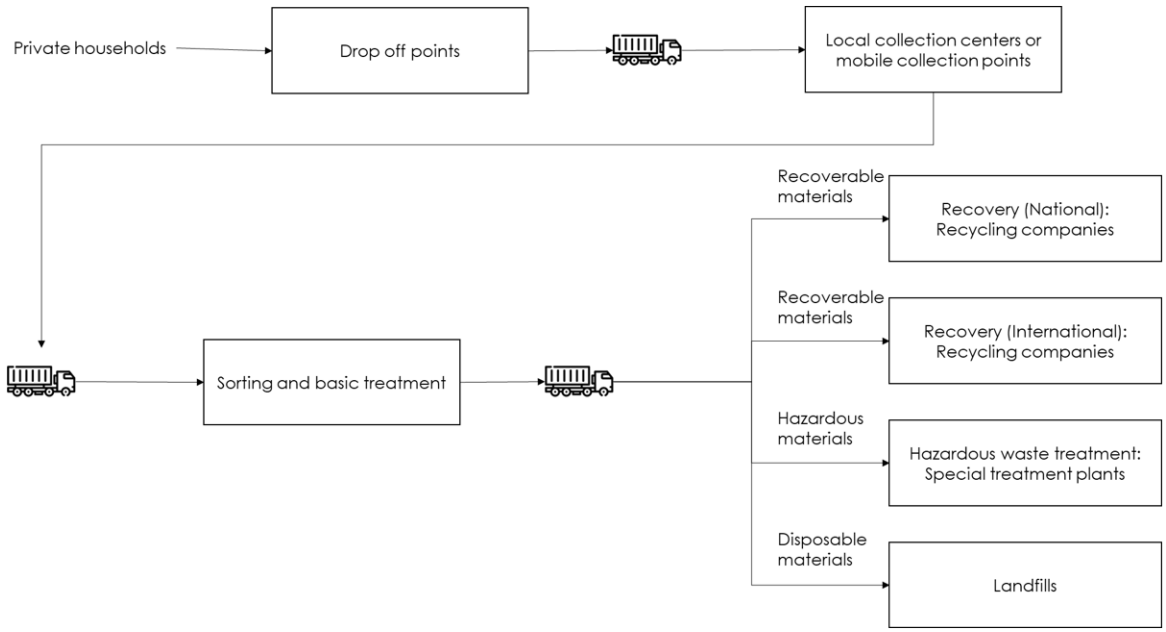


*Figure 9-5 Material flows for WEEE recovered via drop off points*

*Source: BFS, 2023*

These drop-off points are managed either by the commercial establishments themselves or in partnership with waste management companies. The system operator can contract a company that can provide the service, or can lease the bins. Usually, materials can be picked up about once a month or upon request depending on recovered amounts (these points tend to be found in urban settings mostly). Since their location is permanently fixated, they offer a convenient way for the general public to participate in responsible e-waste management, often without incurring any cost for the disposal service:


*Figure 9-6 Examples of WEEE and batteries collection at smaller shops (supermarkets at EEE shops, left) and lager shops (hypermarkets or shopping malls, right)*

*Source: Ashley T., 2021; Glasdon, 2023; Battery Recycling, 2014; Bebat and Recupel*

### 9.2.3 Reception in Stores (Over-the-Counter)

Similarly, to drop-off centers, individuals would carry devices at end-of-life (small or bulky) and hand them over at employees of authorized stores. Once a sufficient amount would be gathered, typically on a monthly basis, the store in question could request the transport to collection centers or by mobile collection vehicles to the sorting and basic treatment facilities. This model is suited for retail shops who sell EEE products exclusively or at for example hypermarkets in urban settings.

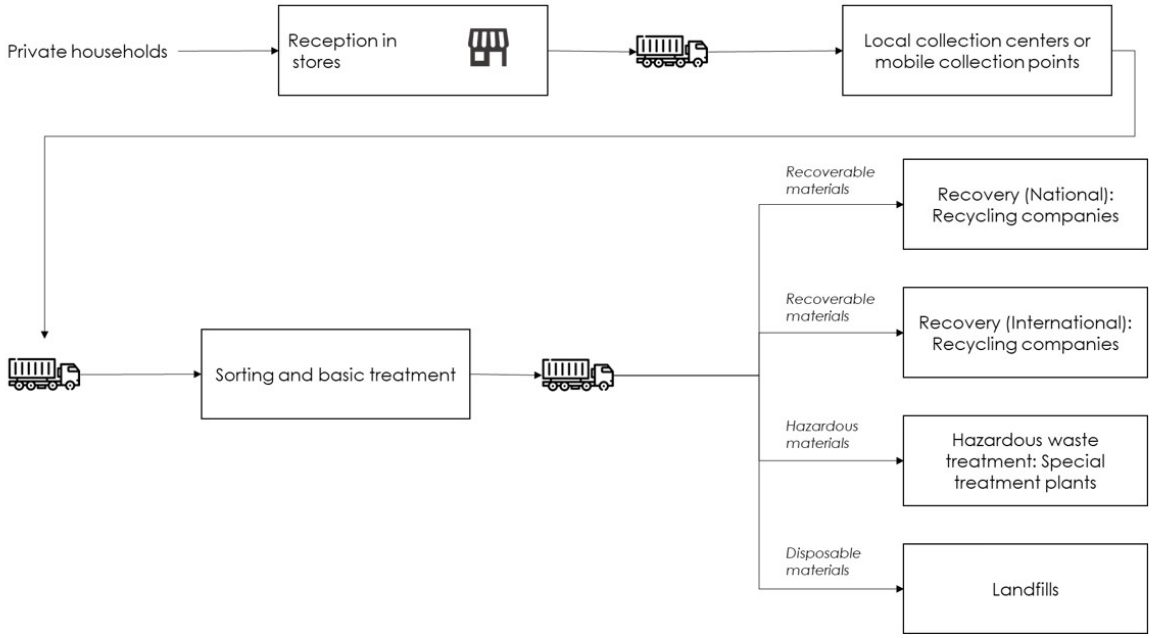


*Figure 9-7 Example of reception of a small device at a store*

*Source: BFS, 2023*

Suitable waste streams:

- Small equipment
- Small IT
- Lamps
- Screens and monitors
- Potable batteries

An example of these operations is presented below:

*Figure 9-8 Example of reception of a small device at a store*
*Source: Stiching Open, 2023*

### 9.2.4 Door-to-Door Collection (Informal Sector)

This form of collections involves the visits to enterprises, businesses, or households directly by individuals operating a transport vehicle. This is a rather expensive form of collection if performed formally and is suitable for both urban and rural settings. However, it is the most common form of collection performed by unlicensed individuals of the informal sector. As shown in Figure 9-9, organizing this form of collection with the proper incentives could be performed in such a way that items reach the local collection center either by handover to a formal vehicle or by direct transport to the collection/treatment center. If performed formally, the route needs to be carefully planned based on amounts expected to be collected and the local collection center or treatment center locations. If performed informally, a limited amount can be transported after collection due to logistics reasons.

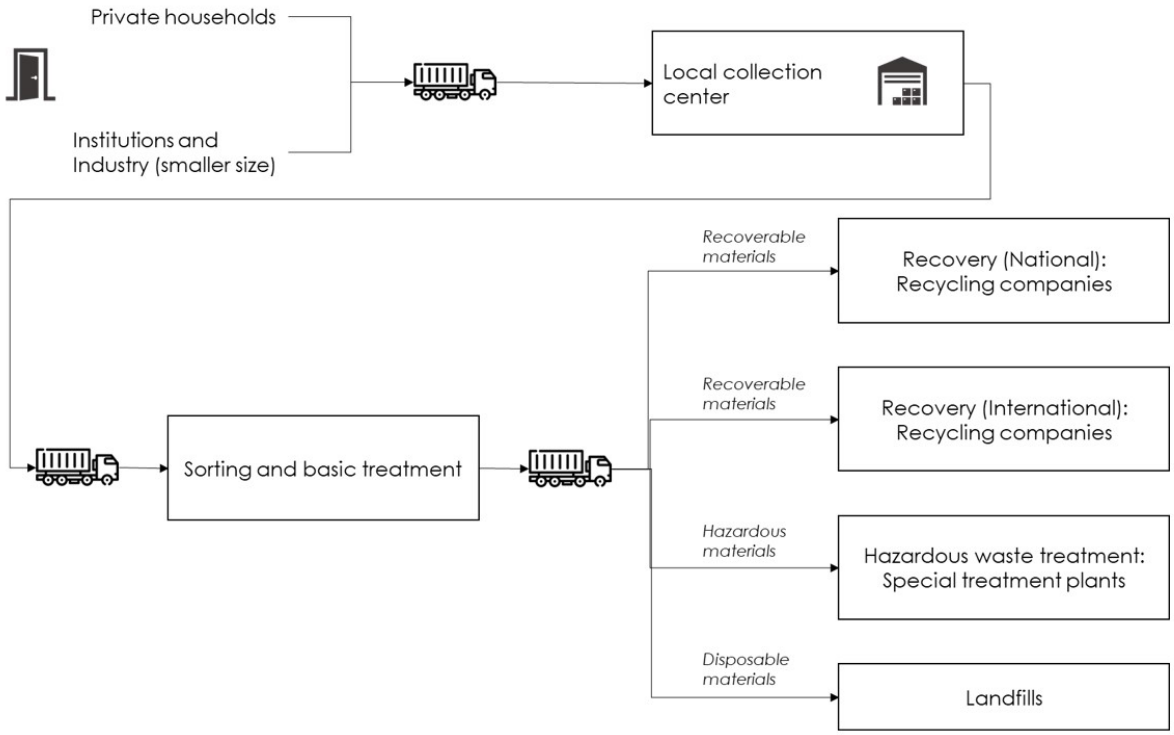


*Figure 9-9 Material flows for WEEE recovered via door-to-door collection*
*Source: BFS, 2023*

Suitable waste streams:

- Small IT equipment
- Small equipment
- Screens and monitors

Initiating the program, there is a vision to collaborate with a select group from the informal sector. The integration process would involve registering them at a designated collection center where all their activities and interactions will be managed.

Additionally, the EPR Administrator should be encouraged to provide real opportunities for informal collectors within the EPR framework. Beyond merely providing a more secure and augmented revenue stream, the Administrator can elevate their contributions by providing training, support, and access to personal protection equipment. This ensures that these workers can collect and sort waste in a manner that is both safe and efficient. Compensation for the informal sector would be based on their waste management efforts, with a pricing model tailored to incentivize their ongoing participation as the project progresses into its subsequent phases.

This form of collection does not necessarily support awareness raising and educational purposes with generators and may pose a challenge from a financial perspective if formalization is attempted.


*Figure 9-10 Examples of the informal sector collection*
*Source: TN City Desk, 2022 ; Clean India Journal, 2022*

### 9.2.5 On Demand Collection

This form of collection is the costliest form of collection for the system since it involves trajectories that involve no or few other devices collection if performed for single individuals. For this reason, the generator usually pays a fee to cover part of the costs of the service. However, if the collection is offered on demand for a large WEEE generator (e.g., a larger office or business), the operations are efficient. This is especially useful for unexpected or irregular WEEE generation and can be economically feasible if adequate critical masses are gathered and stored.

As indicated in the Figure 9- 11 below, the collection and transport of WEEE would transfer the end-of-life devices from the generator to the closest local collection center. This form of collection may be managed by producers, outsourced to the system operator or both, depending on geographical advantages or previously existing take-back systems.

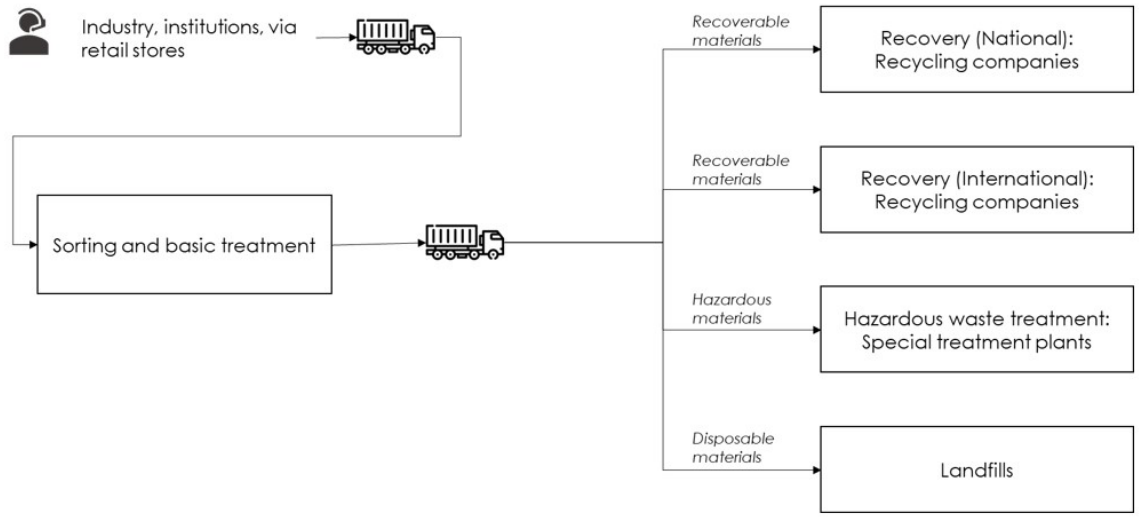


*Figure 9-11 Material flows for WEEE recovered via on demand collection*
*Source: BFS, 2023*

Suitable waste streams:

- Temperature-exchange equipment
- Large equipment, especially
- Automotive and industrial batteries

Some examples of vehicles performing these collection services are presented below:


*Figure 9-12 Examples of vehicles for on-demand collection*
*Source: ewastekuldeep, 2023; UNDP, 2021; BW, 2020*

### 9.2.6 Mobile Collection Points

Producers or manufacturers of electronic and electrical equipment with support from the system operator can launch mobile collection activities. The points, being mobile, are only temporarily stationed at a location and move with a frequency of e.g., one or two weeks to the next location. Such a collection point can be situated at a parking lot, community center, or any other location likely to be easily reachable by residents (on a second degree, it may be useful for passers-by or commuters who might not have devices at hand but return to that location frequently). This is why such a collection service may be suitable for rural areas as well, in all cases at no cost to the user.

Individuals and institutions would hand over the devices to the mobile collection points (typically vehicles or units easily attached to/ displaced by vehicles) who would in turn transport the WEEE either to a local collection center or directly to the sorting and pre-treatment center. The flow is illustrated in Figure 9-13.

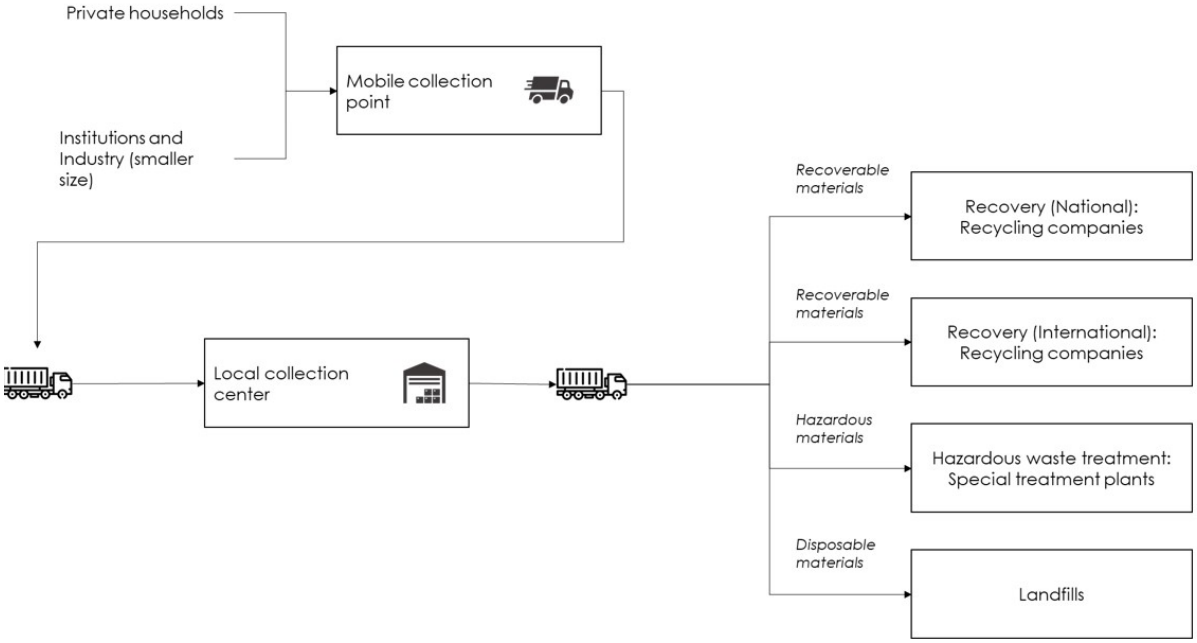


*Figure 9-13 Material flows for WEEE recovered via mobile collection points*
*Source: BFS, 2023*

Suitable waste streams:

- Temperature exchange equipment

- Large equipment
- Lamps
- Portable batteries
- Automotive and Industrial batteries

Such mobile collection points are usually units which are easily attached and moved by a motorized vehicle (as depicted in the left and middle images of Figure 9-14) or a vehicle.


*Figure 9-14 Example of mobile collection points*
*Source: The Hans India, 2020; Lyon Capitale, 2023*

### 9.2.7 Local Collection Center

These centers tend to be the locations consolidating the amounts of materials as a last station before transportation to the treatment and recycling facilities. These collection centers serve private households, businesses, but also mobile collection points on occasion, as illustrated in Figure 9-15. These centers are equipped to handle all categories of electronic or electrical equipment and batteries. These centers ensure that the collected items are sorted and stored in an environmentally responsible manner, facilitating their transportation to larger recycling facilities for further treatment.

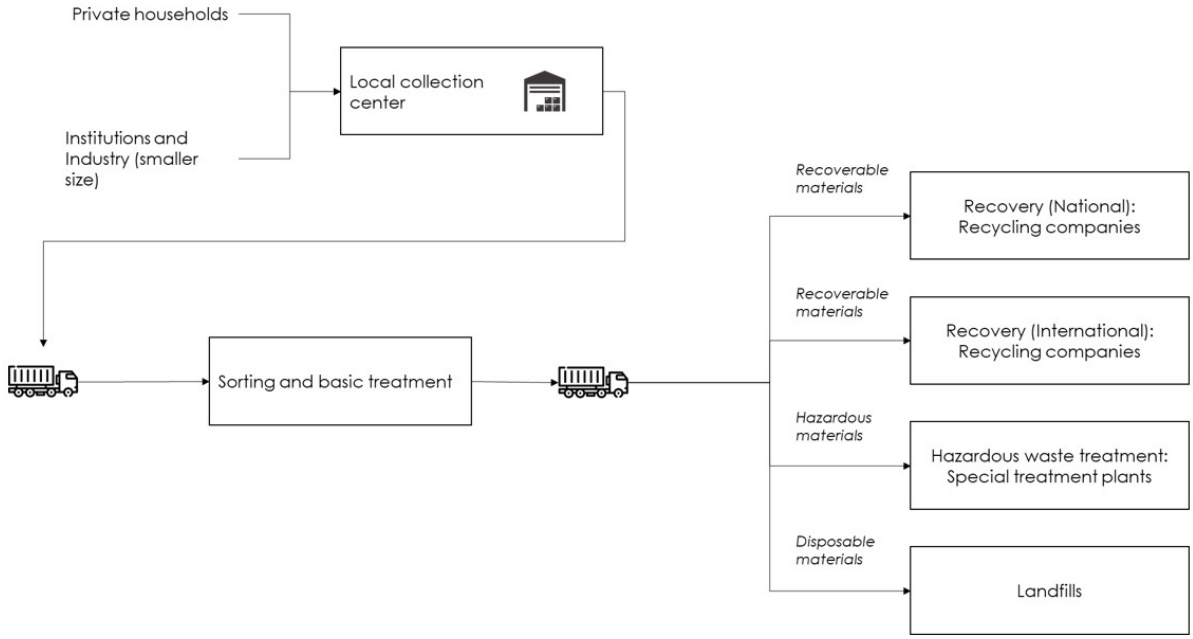


*Figure 9- 15 Material flows for WEEE recovered via the local collection center*
*Source: BFS, 2023*

Collection or consolidation points tend to be set up by the system operator and on occasion by municipalities. The collection of materials from the centers is variable, as too many fluctuations account for the input materials. They tend to be strategically located so that they are well connected and easily reachable by others, while maintaining a reasonable distance to the treatment/dismantling/recycling center.

Suitable waste streams:

- Temperature exchange equipment
- Screens and monitors
- Lamps
- Large equipment
- Small equipment
- Small IT and telecommunication equipment
- All batteries

The collection centers require a smart dimensioning strategy, as they typically accept all (including) bulky WEEE streams. The consultant team recommends that each main city in Lebanon can set up and run such a center. Services would be provided for free for accepting the incoming waste.


*Figure 9-16 Examples of local collection centres*
*Source: Abfall & Wertstoff, 2023*

## 9.3 SORTING AND BASIC TREATMENT

Upon the consolidation of WEEE and batteries at various local collection centers across the country, there's a vision to establish a dedicated sorting and basic treatment facility. This facility, specializing in the processing of Waste Electrical and Electronic Equipment (WEEE) and batteries, aims to safely and environmentally segregate valuable materials from hazardous substances and other components.

The detailed breakdown of the dismantling process for WEEE includes:

- Device Opening: The process begins by removing the external casing or shell, exposing the core components of the electronic equipment.
- Hazardous Element Identification and Extraction: At this stage, components that may pose environmental or health risks are identified and carefully extracted.
- Component Segregation: What remains is systematically categorized, separating materials that hold value or market relevance.

Additionally, as part of the facility's commitment to sustainability, any equipment that retains functionality will be considered for refurbishment and potential re-entry into the market.

Under an Extended Producer Responsibility (EPR) system, the financing for the setup and operation of dismantling centers is typically the responsibility of the producers or manufacturers of the electronic or electrical products. Under EPR, producers are obligated to take financial responsibility for managing the end-of-life products they place on the market.

Producers may finance dismantling centers either directly or indirectly. They may choose to establish and fund their dismantling centers as part of their compliance with EPR regulations, or they may contribute financially to third-party organizations or facilities responsible for managing the dismantling and recycling of their products.

In countries without domestic e-waste producers, establishing a sorting and dismantling facility presents various options. Private sector investors may choose to participate, or international NGOs could offer funding and support, among other potential sources of financing. Alternatively, the EPR operator could finance the first facility as a proof of concept.

PROVISION OF SERVICES FOR THE ASSESSMENT OF

# E-WASTE & BATTERIES IN LEBANON

# 10

# FINANCIAL ASSESSMENT

# 10. FINANCIAL ASSESSMENT

The sustainability and effectiveness of any waste management system, especially for such specialized waste streams, are intrinsically linked to its financial viability. This financial assessment provides a comprehensive examination of the CAPEX and OPEX costs associated with the proposed waste management system for E-waste and batteries.

## 10.1 ASSUMPTIONS

To formulate the business model, certain assumptions regarding the collection flows were made. These assumptions help project a scenario where Lebanon meets the specified collection targets.

### 10.1.1 General assumptions

- Producer Responsibility: Producers and manufacturers (which can be importers) of electronic and battery products are willing to take responsibility for managing their products throughout their entire lifecycle, including collection, recycling, and proper disposal.
- Producer Responsibility Organization (PRO): A centralized operator, responsible for managing all aspects of the EPR program and outsourcing necessary services, is established and effective in coordinating the program efficiently.
- Regulatory Framework: The presence of a supportive regulatory framework. This includes the existence of laws and regulations that mandate EPR for electronic and battery products, specify collection targets, and define the roles and responsibilities of stakeholders.
- Producer Participation: Producers are willing to comply with EPR requirements and are actively engaged in setting up and financing collection and recycling systems.
- Consumer Awareness: Consumers are aware of the importance of recycling electronic waste and batteries and are willing to participate in collection programs.
- Stakeholder Collaboration: Effective collaboration among stakeholders, including producers, government agencies, recycling companies, and environmental organizations, is assumed to ensure the success of the EPR program.
- Compliance and Enforcement: Adequate mechanisms for compliance monitoring and enforcement of EPR regulations are assumed to be in place to ensure that producers fulfill their obligations.

### 10.1.2 Waste Collection Events

For this collection channel, it was assumed that one waste collection event will be organized for every 100,000 inhabitants. This implies that events will cover the entire country twice annually. Consequently, the model anticipates a total of 100 waste collection events each year.

These events are strategically scheduled for weekends to maximize public participation. They are intended to take place in government-owned public spaces or parking areas affiliated with retail channels.

From a logistics standpoint, event organizers will deploy a van to ferry essential equipment for each collection event. Additionally, trucks (of approximately 20 ft in size) will be rented to facilitate waste collection during these events, translating to a need for two to three trucks every weekend.

Post-event, the amassed waste will be transported to the closest local collection center. With these arrangements in place, we project a collection volume of approximately 650 tons annually.

### 10.1.3 Drop Off Points

Drop-off points are envisaged to be located within various commercial spaces such as EEE shops, malls, and markets. Given the variance in their sizes and operational characteristics, two primary waste collection bin sizes have been designated:

- 0,1 m3 bins for supermarkets and medium size electronic shops
- 1,0 m3 bins for hypermarkets, shopping malls and large electronic shops

Collection bins are foreseen to be placed at hypermarkets, supermarkets, large and medium EEE shops and other large establishments (hardware stores, office supply stores, toy stores, etc).

For batteries in particular, two distinct sizes of collection containers have been considered:

- 10 – 12L boxes
- 30L (in average) container tubes

Batteries collection boxes and container tubes could be positioned at supermarkets, medium-sized electronic and electrical equipment (EEE) shops, and various smaller establishments including retail stores, schools, and offices.

As foreseen in the model, all shops are expected to designate space, preferably in their back areas, for the storage of WEEE and batteries. The size of this allocated space will be proportionate to the shop's overall size. Specific sizes and capacities can be seen in Table 10-1.

In this context, shops can be defined as a retail establishment that offers goods or services to consumers for purchase. Specifically, these shops specialize in selling electric and electronic products, ranging in size and variety from small local vendors and specialized electronic distributors to larger-scale retail environments like supermarkets and hypermarkets. Regardless of their size or primary focus, the unifying factor is their direct engagement in the selling of electric and electronic products to end users.

*Table 10-1 Assumptions on container volumes and estimated capacities for drop off points*

| Container type | Container volume | Container capacity (approx.) |
|---|---|---|
| Small collection bin | 0,1 m3 | 10 kg/bin |
| Large collection bin | 1 m3 | 100 kg/bin |
| Battery collection box | 10-12 L | 25 kg/box |
| Battery collection tubes | 30 L | 75 kg/container |

*Source: BFS, 2023*

For the effective operation of these drop-off points, the central management entity will furnish the necessary storage equipment for shops, including pallet cages, pallets, and battery boxes.

*Table 10-2 Number of main retail shops in Lebanon and potential locations where bins will be set up*

| Retail channel | Number of locations In Lebanon | Collection bins (0,1 m3) | Collection bins (1 m3) | Battery collection boxes (10-12 L) | Battery collection tubes (approx. 30 L) |
|---|---|---|---|---|---|
| Supermarkets | 50 | x | - | x | - |
| Medium EEE shops | 400 | x | x | x | - |
| Hypermarkets | 34 | - | x | - | x |
| Shopping malls | 20 | - | x | - | x |
| Large EEE shops | 50 | - | x | - | x |
| Other large establishments (hardware stores, office supply stores, toy stores, etc) | - | - | x | - | - |
| Other small establishments (smaller retail stores, schools, offices, etc) | - | - | - | x | - |
| **Total (units)** | **554** | **194** | **95** | **2,500** | **365** |
| **Total (tons / year)** | | **101** | **1,190** | **1,625** | **712** |

*Source: BFS, 2023*

Table 10-2 outlines the placement strategy for the proposed boxes and containers across shops, retailers, hypermarkets, and other venues. It also indicates the target collection quantities for each bin or box size.

A collection volume of approximately 3,600 tons annually is foreseen.

### 10.1.4 Reception in stores (over-the-counter)

This collection method relies on customers delivering waste directly to shops, specifically "over the counter". The assumption here is that waste reception will mainly be conducted in medium-sized electronic equipment stores. Larger stores likely have dedicated drop-off points.

Participating stores are encouraged to visually promote and simplify the over-the-counter waste reception process for customers. Designated areas, usually located at the back of the stores, are set aside for the aggregation of collected waste.

While shops have the autonomy to decide whether they prefer bin collection or over-the-counter reception, it's projected that at least 243 medium-sized shops will provide over-the-counter waste reception. Although drop-off points and in-store receptions are two distinct collection channels, their similarities allow for joint management.

Consequently, the expected annual collection volume from this method is estimated at 950 tons.

### 10.1.5 Door to door collection (informal sector)

Currently, the informal sector predominantly handles the collection of WEEE from households and institutions, often using their personal vehicles.

To better integrate these informal collectors, the model proposes a pilot initiative that includes:

- Coordination with the informal sector to engage fifteen trucks to collect WEEE.
- Investing in a dedicated app to facilitate planning the waste collection logistics.
- Developing a precise collection plan (by the informal sector), based on inputs either from the app or directly from the system operator.
- Providing essential equipment for safely handling WEEE.

Once WEEE is collected, it is anticipated that the informal sector will deliver the waste to the nearest local collection center or an appointed mobile collection point.

At these collection hubs, waste will be procured from the informal collectors, offering them a financial incentive in return.

A base fee of 200 USD/ton has been suggested for the operations of the informal sector in the preliminary business model computations. However, the final pricing, which might vary based on the product category, is yet to be studied. This pricing structure requires a comprehensive market analysis and validation. Preliminary estimates predict an annual collection of 300 tons of waste using this approach.

While it is true that the informal sector's involvement in e-waste management is relatively low in Lebanon, the intention was to introduce a collection channel that actively incorporates the informal sector into the overall collection system. This channel will also provide a means for household collection. In the initial two years, a selected group from the informal sector will be integrated to pilot the concept. For the collection estimations, it has been factored in that approximately 2% of the generated waste will be collected through this channel.

### 10.1.6 On demand collection

Along this collection channel, due to expected higher volumes by commercial actors, the utilization of 20 ft container trucks (or similar in size) with an elevator platform for the on-demand collection process was assumed. Each truck will be outfitted with essential equipment to gather WEEE and/or battery waste, including pallet cages, pallets, a pallet jack, battery storage boxes, and a weighing station. Every collection team will comprise a driver accompanied by two collection staff members.

Moreover, the app previously introduced for door-to-door collection will be extended to this channel to enhance waste collection logistics. This app will provide specific institutions the ability to request on-demand collection services, catering to:

- Educational Institutions
- Healthcare facilities
- Government offices
- Business and commercial establishments
- Hospitality sector
- Entertainment and recreation

- Transportation sector
- Research and development institutions
- Industrial and manufacturing units
- Data centers and IT firms
- Telecommunication companies
- Public libraries and cultural centers

The model sets a threshold: institutions need to accumulate a minimum of 200 kg of WEEE and/or batteries to request a collection.

This initiative is aimed at encouraging both private and public sectors to recycle their electronic devices. The system operator shall bear the logistics costs charged by the service provider.

### 10.1.7 Local and Mobile collection centers

Local and mobile collection centers play a pivotal role in accepting and storing larger volumes of electronic waste. To optimize coverage, the country has been organized into five distinct zones, informed by geographic and demographic insights as shown in Figure 10-1.


*Figure 10-1 Zones for placement of collection centers*

*Source: BFS, 2023*

Each local collection center is projected to serve approximately 300,000 residents. Given the distribution of the population across the five zones, the calculation is based on the ratio of the number of inhabitants to every 300,000 inhabitants. This breakdown, as illustrated in Table 10-3, helps determine the average number of collection centers required for the region.

*Table 10-3 Country Division by Zones*

| | Country division | Inhabitants* | Ratio Total inh. / 300.000 inh. | Number of local collection centers | Number of mobile collection points |
|---|---|---|---|---|---|
| 1 | Beirut | 341,700 | 1.14 | 1 | 0 |
| 2 | Keserwan-Jbeil, Mount Lebanon | 2,032,600 | 6.7 | 6 | 0 |
| 3 | Baalbek Hermel, Beqaa | 542.700 | 2.24 | 1 | 2 |
| 4 | Akkar, North Lebanon | 961,900 | 3.21 | 2 | 1 |
| 5 | South Lebanon, Nabatiyeh | 963,500 | 3.21 | 2 | 1 |
| | **Total** | **4,842,400** | **16.14** | **12** | **4** |

**Statistics from 2018-2019*

*Source: BFS, 2023*

To achieve the objectives delineated, a total of 16 collection centers have been deemed necessary. Metropolitan areas, given their demographic density and available space, will predominantly feature fixed infrastructure. In contrast, mobile collection units will predominantly service rural regions.

Local collection centers may be setup by the municipalities and supported by the PRO. Of all the local collection centers, half shall be located in the Beirut and Mount Lebanon governorates. Each local collection center will be structured into three main zones: a designated space for 20ft custom-designed waste containers for waste coming from institutions, a warehouse specifically for sorting and storing waste gathered from collection channels, and a distinct section for administrative tasks and security measures.

The mobile collection centers will focus on less densely populated rural areas, ensuring extensive coverage. Mobile collection centers may be managed by waste management companies (outsourced by the system operator). While these centers will primarily serve institutions in rural areas, they will also accept waste from households.

Regular weekend operations in rural areas, like Baalbek and Akkar, will mimic waste collection events. The use of a logistical app is recommended for optimizing visits to municipalities based on institutional demands.

These centers are designed to encourage citizens and institutions to "voluntarily" deposit their WEEE and batteries. For budgetary calculations, it's anticipated that these centers will predominantly receive large equipment and industrial batteries.

Furthermore, it is expected that waste from all channels will be consolidated at local collection centers. However, for efficiency reasons, some may directly reach the sorting and treatment facility.

A potential challenge is that no fees are foreseen to be paid by the collection centers, which might pose a risk in meeting the set targets. The realization of these targets will largely hinge on legislative enforcement that mandates institutions to manage their WEEE responsibly (as per EPR legislation). If initial six-month targets aren't achieved, a financial incentive might be worth considering. The law must obligate institutions to dispose of their waste responsibly.

As these centers come into operation, continuous monitoring and feedback mechanisms must be put in place to gauge their effectiveness and adapt to evolving needs. Community engagement will be key in driving the success of these centers, ensuring that residents are both aware of and trust the facilities. This will necessitate regular public awareness campaigns, open dialogues with the communities, and collaborative problem-solving approaches.

### 10.1.8 Sorting and Basic Treatment Facility

As afore mentioned, a sorting and dismantling facility for WEEE (Waste Electrical and Electronic Equipment) and batteries is designed to manage, and process discarded electronic devices and spent batteries. The facility's primary goal is to safely and ecologically segregate valuable materials, hazardous components, and other constituents.

Initially, one dismantling center for the entire country can be contemplated. Nonetheless, it is anticipated that the dismantling center's capacity could be expanded, incorporating additional equipment, and utilizing more space as the system progresses.

Considering the current deficit in WEEE treatment capacities and the projected volume targets, the proposed facility integrates manual dismantling with semi-automated procedures. This approach is informed by factors such as e-waste type volumes, necessary labor conditions, safe WEEE handling, and both capital and operational costs of technology, all within the context of Lebanon. A general overview of the proposed location, site specifications and capacity are shown in Table 10-4.

*Table 10-4 Main Characteristics of the Sorting and Basic Treatment Center*

| Main characteristics | Details | Map |
|---|---|---|
| Capacity | Designed to handle 13.000 tons of WEEE and batteries. |  |
| Site specifications | Location: Zouk Mosbeh, Mount Lebanon.<br>Area: total area of approximately 2 hectares.<br>Initial space utilization (year 1 and 2): less than 50% of the total area.<br>Expansion plan: Subsequent use of the remaining space with growth in waste volume. | |
| Waste categories in scope | All 6 WEEE categories and batteries. | |
| Automation level | Manual dismantling with semi-automated procedures. | |

*Source: BFS, 2023*

For the business model, a general treatment concept was designed based on the aforementioned assumptions. Within this concept, the facility would have a main reception hall, from where waste types per category shall be forwarded after pre-sorting. For each category, one treatment was estimated as shown in Table 10-5.

*Table 10-5 Dismantling and Treatment Lines at facility*

| Lines (L) | WEEE category | Main procedures |
|---|---|---|
| Line 1 | Temperature exchange equipment | 1. Degassing<br>2. Oil removal<br>3. Manual dismantling<br>4. Insulation removal |
| Line 2 | Flat panel display (FPD) and monitors | 1. Manual dismantling<br>2. CCFL monitor table |
| Line 3 | Cathode ray tube (CRT) television | 1. Manual dismantling<br>2. CRT cutting chamber |
| Line 4 | Large equipment | 1. Manual dismantling |
| Line 5 | Small IT and small equipment | 1. Manual dismantling<br>2. Shredder<br>3. Ferrous (FE) and nonferrous (NFE) separators<br>4. Density separator |
| Line 6 | Lamps and cold cathode fluorescent lamps (CCFL) | 1. Dismantling (when needed)<br>2. Lamp crushing and Hg absorption |
| | Additional areas (AA) | |
| AA1 | Batteries separation into types | 1. Manual sorting |
| AA2 | Cables separation and shredding | 1. Separate cables<br>2. Remove PVC and other plastics<br>3. Shredding and sorting combined unit (FE/NFE/plastic mix) for small IT and cables |
| AA3 | Lithium shredder | Lithium battery wet shredding unit |
| AA4 | Plastic recycling | Shredder, washing unit with water circle, density separator, extrusion line and pelletizer * |

**Consider the presence of flame retardants in WEEE plastics, pellets might have limited product utilization.*

*Source: BFS, 2023*

Figure 10-2, a rough setup of the sorting and basic treatment plant is proposed and taken into account within the business calculations. As proof of concept, considering that this would be the first-of-a-kind facility in Lebanon, the total investment and operational costs were included in the total budget.

Line 1 was planned for the treatment of cooling devices such as refrigerators, freezers, air conditioners, heat pumps and others. The process includes the degassing of such cooling devices, appropriate storage until final treatment, and further manual dismantling, separating mainly plastics, metals, individual components (e.g., compressor), and others (e.g., oil, mercury-containing devices, glass, among others. The main plastics used in refrigerator production include polyurethane (PU) for insulation, polystyrene (PS) for casing and polypropylene (PP), styrene-butadiene-acrylonitrile copolymer (ABS), and polyethylene (PE) for internal parts. From the manual dismantling, these fractions shall be kept sorted in the material storage room for volume consolidation.

Line 2 was estimated for the safe handling of flat panel displays and monitors. For liquid crystal display (LCD) TVs containing CCFL fluorescent tubes, the treatment process focuses on the extraction of hazardous substances and materials, especially mercury, which is removed in a controlled environment (e.g., technology with a vacuum system). Such an approach was suggested since, although screwdrivers may be used to remove the front frame, it would pose potential risks of breaking the backlight unit, resulting in mercury release. These CCFLs proceed to line 6, while the rest of the screen is manually dismantled to recover mainly high-value printed circuit boards (PCB), indium tin oxide (ITO) e.g., coated glass, plastics, metal sheets, and aluminum casings. Output fractions shall be stored for material consolidation.

Line 3 was designed for the specific and safe handling of cathode ray tube (CRT) televisions. Within the proposed treatment scenario, there is a manual dismantling step to remove and separate TV casing, metal wires, and print circuit boards. Following, the CRT cutting table uses a nickel chrome belt heating method that can efficiently separate the glass panel and funnel, collecting internal phosphor to prevent environmental pollution efficiently. This process ensures a high recovery rate of non-contaminated glass, reducing the volumes of hazardous materials (e.g., lead glass) and avoiding operator exposure to toxic released powders. Fractions such as TV casings, depending on the type and color (e.g., ABS black), may be consolidated with the ones from line 2 and be forwarded to the additional area (AA) 4, for plastic recycling.

Line 4 was foreseen for larger equipment such as washing machines, clothes dryers, dish-washing machines, electric stoves, large printing machines, copying equipment, and photovoltaic panels. For this process, only manual dismantling and removal of hazardous fractions were contemplated in the financial estimations.

Line 5 includes all small equipment such as vacuum cleaners, microwaves, ventilation equipment, toasters, electric kettles, electric shavers, scales, calculators, radio sets, video cameras, electrical and electronic toys, small tools, etc. For the conceptual plan, an automated process was planned (due to high volumes and dismantling times per unit). The manual dismantling shall occur for the removal of specific parts (e.g., hazardous fractions or big parts which may harm the shredder). After that, devices enter into a recycling line with a shredder, a ferrous metal separator (e.g., steel, iron), a non-ferrous metal separator (e.g., copper, aluminum), and a density separator for the plastic mix. While the metals shall be conducted in the storage room, the sorted plastic may enter AA4, for further treatment.

Line 6 was designed for lamps (e.g., bulbs) and for CCFLs coming from TVs. If required, a small dismantling step may occur, but the main process is the lamp pre-treatment unit, in which lamps are crushed in a closed chamber, and a vacuum plus filter system absorbs the mercury to be further treated and disposed of.

The additional areas are for further processing of output fractions. Batteries were estimated to be sorted manually. For the case of lithium batteries, due to lack of local treatment possibilities, a lithium shredder technology was proposed. It consists of a wet shredding process, watertight sealed, with low investment requirements and increasing output fraction value through black mass and lithium concentrate. Although relatively new, the technology could suit the country considering the challenges in exporting such types of battery. Cables shall be removed from devices and enter treatment line 5. It was recommended manual cable stripping to facilitate the density separation process, avoid PVC in the plastic mix. The plastic recycling unit was recommended considering the lack of market for such output fraction locally. Two major challenges refer to the presence of flame retardants (FR) in the plastic mixes, and the density separation (considering some FR also change the natural density of plastics). On the other hand, there are available technologies for such processing, and it could be a source of income for the facility.

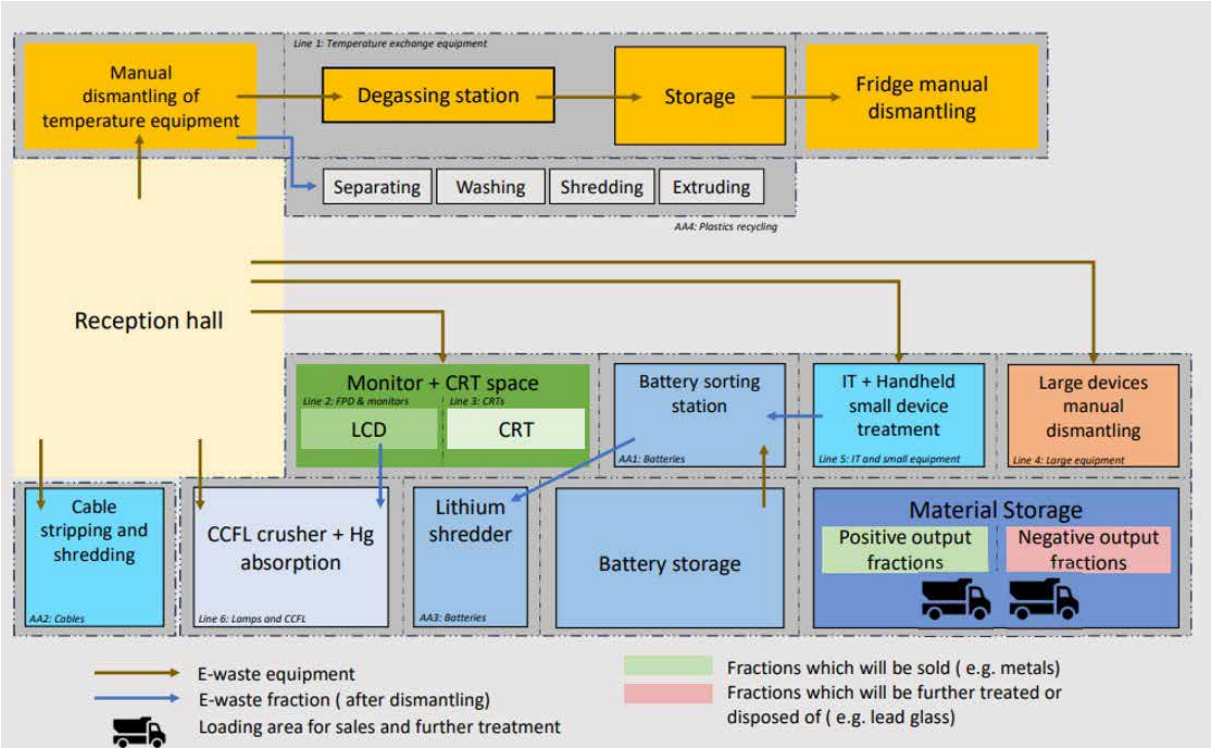


*Figure 10-2 Conceptual plan for the Sorting and Basic Treatment Facility*

*Source: BFS,2023*

It is important to highlight that these assumptions were made to calculate the total investment and operational costs from collection and treatment centers in the country, aiming to reach the set goal. The collection flows, the infrastructure and technology selected must be revised and recalculated by the system operator once the extended producer responsibility scheme is established in the country.

The assumptions and numbers presented are to have a general understanding of the potential costs the system might present when in place.

### 10.1.9 Recycling and final disposal

Upon the dismantling of e-waste, various fractions are produced, as is illustrated in Table 10-6

*Table 10-6 Downstream fractions*

| Group category | Fraction | Positive or negative value |
|---|---|---|
| Ferrous metals | Mixed ferrous metal scrap (iron, steel, and potentially stainless steel) | + |
| | Steel | + |
| | Stainless steel | + |

| | | |
|---|---|---|
| Non-ferrous metals | Copper scrap | + |
| | Magnesium scrap | + |
| | Aluminum scrap | + |
| | Mixed bronze and brass scrap | + |
| | High alloyed nickel | + |
| | Gold | + |
| | Mixed fraction of high copper content | + |
| Non-ferrous metals | Mixed Fe and NF screws | + |
| | Mixed scrap containing different metals, cables/ wires & plastics but without hazardous components | + |
| | Cables & wires without plugs | + |
| | Deflection coil | + |
| PCBs (different grades) | High grade printed circuit boards | + |
| | Middle grade printed circuit boards | + |
| | Low grade printed circuit boards | + |
| Mixed plastics | Mixed plastic types, but without BFRs | + |
| Others, mixed valuable | Processors | + |
| | Strong magnets | + |
| | Laptop screens | + |
| | Hard disc drives | + |
| | CD and DVD drives found in PCs and laptops | + |
| | Power supplies from desktop PCs | + |
| | Large motors from washing machines or vacuum cleaners | + |
| Hazardous waste | Lead-acid batteries | + |
| | Mixed batteries | - |
| | Lithium-ion batteries | Depends on the country |
| | Fluorescent Toner- and Ink-cartridges mixed | - |
| | Fluorescent lamps | - |
| | CRT tubes | - |
| | Leaded glass | - |
| | Phosphor powder | - |
| | Mixed plastics containing Brominated Fire Retardants | - |
| Other, waste | Residual waste | - |
| | Wood pieces | - |
| | LCD layer | - |
| | LCD display | - |
| | Non-leaded glass | - |

*Source: BFS, 2023*

As illustrated in Table 10-6, these fractions are categorized based on their value, falling into either the 'positive' or 'negative' categories. Fractions labelled as 'negative' typically encompass hazardous or mixed waste without significant value, while 'positive' fractions often consist of metals, PCBs, mixed valuable fractions, and plastics.

For the model projections, the assumption has been made that most downstream fractions (excluding other waste) will be exported. This assumption reflects Lebanon's predominant reliance on small-scale recyclers and its expected transition to accommodate larger waste volumes. In some countries, it is common practice to accumulate sufficient volumes of each fraction (a minimum of 20 tons), before publishing international tenders for the sale or disposal of these fractions.

Both categories, 'positive' and 'negative,' can be subject to tenders. This approach opens opportunities for recyclers and hazardous waste management entities to participate and assert their interests in the process.

## 10.2 BUSINESS MODEL RESULTS

To calculate the costs for the proposed system, the team of consultants developed a methodological approach to account for all collection, treatment, and disposal costs, as shown in Figure 10-3.

First, an introductory sheet explains how the model can be used by other actors in the future.

The second step was to define the general parameters such as macroeconomic factors, operational assumptions, costs for infrastructure, staff, machinery, equipment, consumables, and density. This step builds a database used as input information for the following sheets of the model.

The third part collects assumptions, investment, and operational costs for all collection channels. After that, the same applies for the treatment part of the model, including the consolidation and treatment of volumes in the dismantling center.

Step five refers to a material composition database, which links each fraction from the dismantled e-waste to further treatment/disposal and links it to a (positive/negative) price and transport (national / export) based on the concept explained in the assumptions.

Lastly, the output data, costs and revenues are linked with the costs referring to the collection and treatment of the WEEE, reaching final investment and operational costs for the whole system.

*Figure 10-3 Methodology for business model calculations*
*Source: BFS, 2023*

Following the value chain, the main capital (CAPEX) and operational expenditures (OPEX) considered for the collection channels were:

CAPEX:

- Waste packaging equipment
    - Costs covering the purchase of equipment for safe storage and of collected materials
- Waste event equipment
    - Expenses associated with the purchase of bins, signage, and safety barriers, among others
- Vehicle to transport waste event equipment
    - Costs associated with the purchase of trucks for transporting equipment to event locations
- Communication and security equipment:
    - Expenses for the purchase of communication devices to ensure efficient coordination and safety
- Hazardous waste collection license
    - Costs for obtaining the required licenses and permits for handling hazardous materials
- Collection app
    - Costs for developing and implementing a collection app
- Unforeseeable
    - Reserve funds for unforeseen expenses during collection set up

OPEX:

- Transport Costs (to the Collection Location)
    - Costs covering collection vehicle fuel, maintenance, and operational expenses
- Consumables
    - Costs for materials like gloves, safety gear, bags, etc., used during collection and packaging
- Staff Training Sessions
    - Costs for training programs ensure the safe and efficient handling of collected materials
- Office space rental
    - Expenses related to renting administrative offices for coordination and logistics
- Waste packaging equipment maintenance:
    - Costs for regular maintenance and repair of packaging equipment.
- Labor costs
    - Cost for salaries and wages for collection and administrative staff, including both permanent and temporary workers
- Marketing and publicity
    - Costs allocated for promoting collection events and awareness campaigns.
- Vehicle Equipment and Maintenance

- Cost for maintenance and repair of collection vehicles and equipment

- Unforeseeable
  - Contingency fund to address unexpected operational costs during collection activities

Table 10-7 describes the main cost factors (CAPEX and OPEX) for the collection channels.

*Table 10-7 CAPEX and OPEX positions for collection channels*

| Collection channels | Waste Events | Drop-off Points | Reception in Stores | Door-to-door | On-demand | Mobile collection points |
|---|---|---|---|---|---|---|
| CAPEX | Waste packaging equipment<br>Waste event equipment<br>Vehicle to transport waste event equipment | Waste packaging equipment<br>Waste collection bins and containers. | Waste packaging equipment | Waste packaging equipment<br>Communication and security equipment<br>Collection app development | Waste packaging equipment<br>Communication and security equipment<br>Hazardous waste collection license | Waste packaging equipment<br>Waste collection equipment<br>Communication and security equipment |
| OPEX | Transport costs (to the event)<br>Consumable's collection events<br>Staff training sessions<br>Marketing and publicity<br>Vehicle and equipment maintenance<br>Labor cost | Consumables<br>Staff training sessions<br>Office space rental<br>Waste packaging equipment maintenance<br>Waste collection bins and containers maintenance<br>Labor costs | Waste packaging equipment maintenance<br>Labor costs | Consumables<br>Staff training sessions<br>Marketing and publicity<br>Waste packaging equipment maintenance<br>Remuneration to the informal sector<br>Labor costs | Consumables<br>Staff training sessions<br>Office space rental<br>Waste packaging equipment maintenance<br>Labor costs | Transport costs (to the collection location)<br>Consumables<br>Staff training sessions<br>Office space rental<br>Waste packaging equipment maintenance<br>Labor costs |

*Source: BFS, 2023*

For the consolidation and treatment parts of the value chain, similar considerations were made.

**CAPEX**:

- Studies and Permits
  - Costs related to feasibility studies, environmental impact assessments, and obtaining necessary permits and licenses for facility operation

- Infrastructure Setup

    - Costs included for the construction and setup of the facility infrastructure, including buildings and utilities
- Machinery
    - Costs related to the procurement of specialized machinery for sorting, disassembling, and treating some fractions of electronic waste
- Equipment and materials
    - Costs accounted for the purchase of equipment such as conveyor belts, shredders, and sorting, as well as materials like bins and containers
- Vehicle (Forklift)
    - Costs for the purchase of forklifts for the efficient movement of materials within the facility
- Office Setup
    - Costs associated with setting up administrative offices within the facility for coordination and management
- Commissioning and installation
    - Expenses related to the installation and commissioning of machinery and equipment.
- Unforeseeable
    - Reserve funds for unexpected or emergency expenses that may arise during facility set-up

**OPEX:**

- Consumables
    - Costs associated with the procurement of consumables like safety gear, gloves, cleaning supplies, and materials for waste containment
- Software licenses
    - Expenses for software used in facility operations, including inventory, data and customer relations management
- Staff training sessions
    - Costs associated with ongoing training programs to ensure staff is well-equipped for safe and efficient operations
- Land Rental
    - Rental expenses for the land on which the facility is situated
- Marketing and publicity:
    - Budget allocated for promoting the facility's services and raising awareness about responsible e-waste handling
- Infrastructure and equipment maintenance
    - Costs for regular maintenance and repair of facility infrastructure and machinery
- Infrastructure and equipment insurance:
    - Costs for insuring facility infrastructure and equipment against damage or loss

- Labor costs
    - Salaries and wages for facility staff, including operators, maintenance personnel, and administrative staff.
- Export for treatment revenues/costs:
    - Expenses or revenues associated with exporting certain materials for advanced treatment or recycling
- Unforeseeable OPEX
    - Contingency funds to address unexpected operational costs that may arise during facility operations

*Table 10-8 describes the main cost factors (CAPEX and OPEX) for consolidation and treatment.*

| Collection Channels | Local Collection Center | Sorting and Basic Treatment Facility |
|---|---|---|
| CAPEX | Permits<br>Infrastructure setup<br>Commissioning and installation<br>Waste packaging equipment<br>Vehicle (forklift) | Studies and permits<br>Infrastructure setup<br>Machinery<br>Equipment and materials<br>Vehicle (forklift)<br>Office setup<br>Commissioning and installation |
| OPEX | Consumables<br>Staff training sessions<br>Land rental<br>Marketing and publicity<br>Infrastructure and equipment maintenance<br>Infrastructure and equipment insurance<br>Labor costs | Consumables<br>Software licenses<br>Staff training sessions<br>Land rental<br>Marketing and publicity<br>Infrastructure and equipment Maintenance<br>Infrastructure and equipment insurance<br>Labor costs<br>Export for treatment revenues/costs. |

*Source: BFS, 2023*

Based on the previous descriptions and assumptions, the total investment costs to establish a collection and recycling network in Lebanon in 2 years are shown in Table 10-9 and Figure 10-4.

*Table 10-9 Estimated CAPEX costs*

| Part of Value Chain | CAPEX Costs | Cost (USD) | % of cost |
|---|---|---|---|
| Collection | Waste collection events | 73,777 | 1% |
| | Drop off Points | 446,281 | 6% |
| Collection | Reception in stores | 149,654 | 2% |
| | Door to door collection | 35,343 | 0,5% |
| | On demand collection | 148,957 | 2% |
| | Mobile collection points | 34,048 | 0,5% |
| Consolidation | Local collection centers | 3,526,824 | 48% |
| Sorting, treatment and disposal | Sorting and basic treatment center | 3,007,208 | 41% |
| Logistics | Material transport | - | 0,0% |
| | **Total** | **7,422,091** | **100%** |

*Figure 2-1 Elements of the e-waste problem*

*Source: Parajuly et al., 2019*

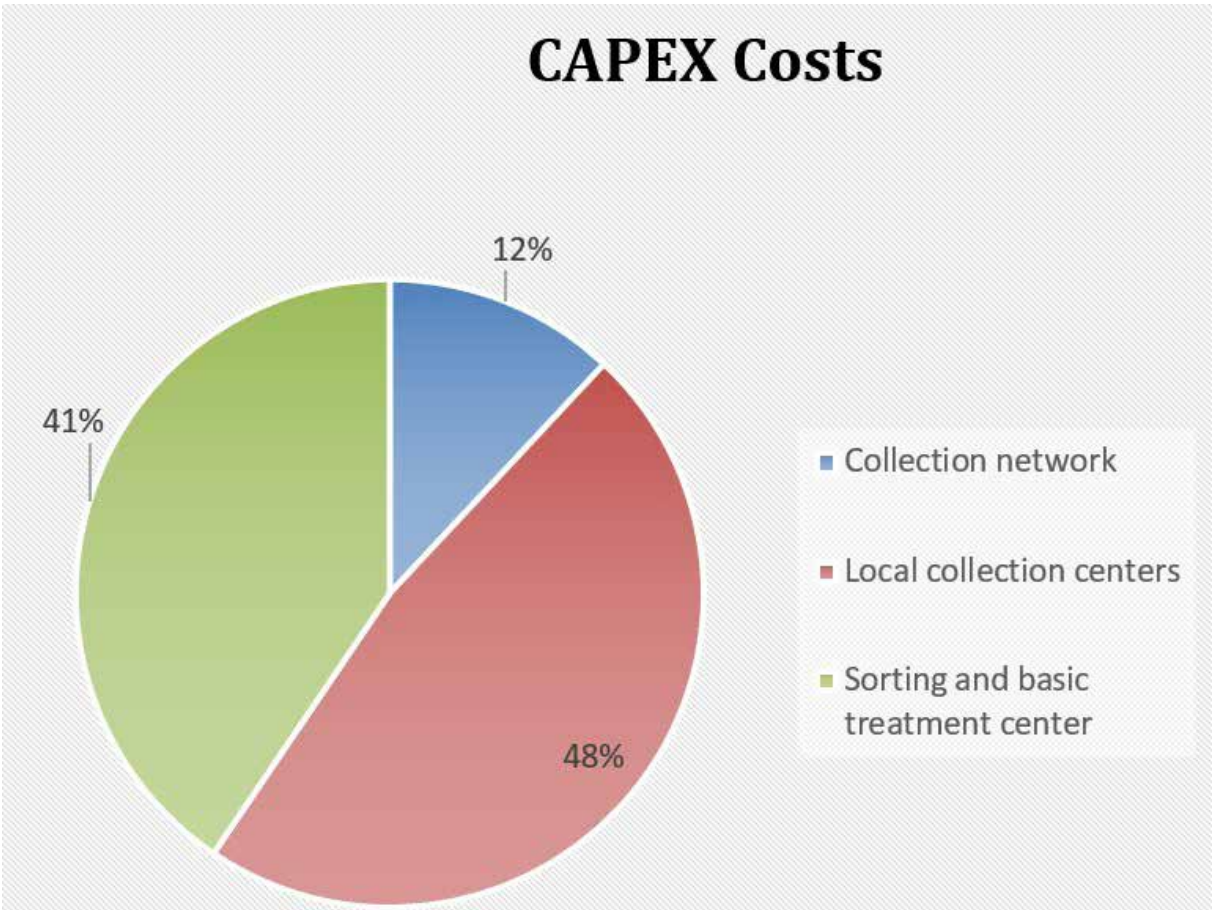


*Figure 10-4 CAPEX costs*

*Source: BFS, 2023*

The operational costs are shown in Table 10-10 and Figure 10-5.

*Table 10-10 Estimated OPEX costs*

| Part of Value Chain | OPEX Costs | Costs (USD/year) | % |
|---|---|---|---|
| Collection | Waste collection events | 32,556 | 0% |
| | Drop off Points | 66,212 | 1% |
| | Reception in stores | 11,744 | 0% |
| | Door to door collection | 117,680 | 1% |
| | On demand collection | 136,295 | 2% |
| | Mobile collection points | 116,451 | 1% |
| Consolidation | Local collection centers | 1,563.,003 | 18% |
| Sorting, treatment and disposal | Sorting and basic treatment cen-ter | 4,114,715 | 49% |
| Logistics | Material transport | 2,295,058 | 27% |
| | **Total** | **8,453,713** | **100%** |

*Source: BFS, 2023*

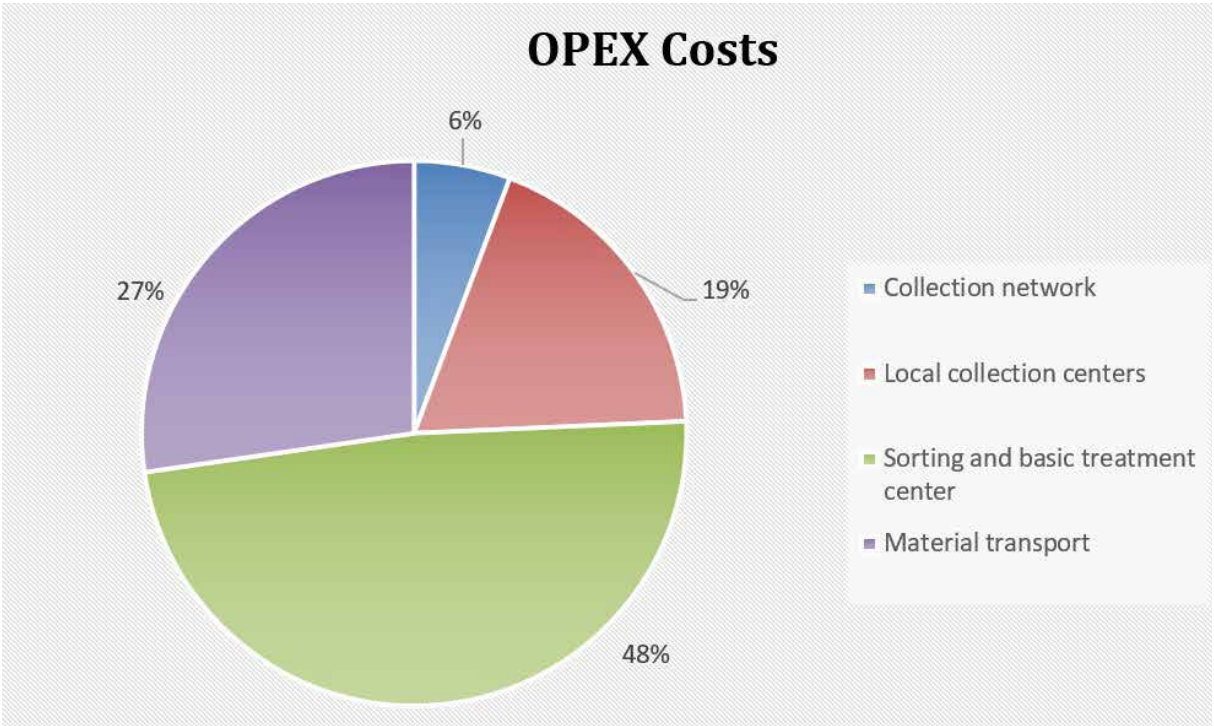


*Figure 10-5 Estimated OPEX costs*

*Source: BFS, 2023*

With such investments, it shall be possible for the country to collect the calculated 13.000 tons of WEEE per year, equivalent to over 1.400.000 equipment, as shown in Table 10-11.

*Table 10-11 Amounts of waste collected per category*

| WEEE Category | Quantities (ton/year) | Average units WEEE per category per year |
|---|---|---|
| Temperature exchange equipment | 1.067 | 28,591 |
| Screens, and monitors | 294 | 28,795 |
| Lamps | 93 | 93,000 |
| Large equipment (excluding photovoltaic panels) | 1,241 | 22,564 |
| Small equipment | 2,068 | 689,333 |
| Small IT and telecommunication equipment | 233 | 156,902 |
| Portable batteries | 2,783 | 139,150 |
| Automotive and Industrial batteries | 5,222 | 261,100 |
| Photovoltaic panels (Inc. Converters) | - | - |
| **Total** | **13,001** | **1,419,435** |

*Source: BFS, 2023*

## 10.3 REVENUES

Understanding the revenues generated from the different categories of electronic waste offers essential insights into the financial feasibility of recycling and recovery efforts. This analysis provides a breakdown of the revenues originating from the WEEE categories.

The revenue estimations in this study are rooted in the methodology outlined in the United Nations University›s «Study on collection rates of waste electrical and electronic equipment.» It is worth noting that further refinement of revenue estimations may be necessary, such as soliciting quotes from WEEE recyclers and waste management companies, to enhance the accuracy of these figures.

*Table 10-12 Revenues estimated per WEEE category*

| WEEE Category | Revenues (total) | Revenues (per ton) |
|---|---|---|
| Temperature exchange equipment | $ 483,941 | $ 454 |
| Screens, and monitors | $ 126,075 | $ 429 |
| Lamps | $ 20,706 | $ 223 |
| Large equipment (excluding photovoltaic panels) | $ 435,215 | $ 351 |
| Small equipment | $ 1,921,355 | $ 929 |
| Small IT and telecommunication equipment | $ 184,152 | $ 790 |
| Portable batteries | $ - | $ - |
| Automotive and Industrial batteries* | $ - | $ - |
| Photovoltaic panels (incl. inverters) ** | $ - | $ - |
| **Total** | **$ 3,171,444** | **$ -** |

**Since no collection targets were specified, it was foreseen that the initial years are dedicated to consolidating volumes. It was anticipated that once a sufficient volume is consolidated the batteries would be made available for sale.*

***At present, recycling technologies for PV panels are still in the developmental phase. Consequently, the plan was to collect and consolidate waste volumes until a suitable recycling solution became available.*

*Source: BFS, 2023*

When analysing both tables (Table 10-11 and Table 10-12), the following observations can be made:

High Volume vs. High Revenue:

- Small equipment: represents 16% of the collected volume but generates the highest revenue (61%), making it a highly profitable category on a per-ton basis (929 USD/ton).

Low Volume vs. High Revenue:

- Small IT and telecommunication equipment: has a relatively low collection volume of 233 tons but produces a high revenue of $184,152 or 790 USD/ton. This indicates significant profitability for this category.
- Temperature exchange equipment: represents 8% of the collected volume of e-waste but generates 15% of the revenues.
- Screens and monitors: represent 2% of the collected volume of e-waste but generate 429 USD/ton, making it a profitable category on a per-ton basis.

Low Volume vs. Low Revenue:

- Lamps: stands out with a lower volume of 93 tons, and it generates one of the lowest revenues, amounting to $20,706 or 223 USD/ton.

In summary, while certain WEEE categories like 'Small equipment' and 'Small IT and telecommunication equipment' show high profitability despite their collection volume, others like 'Portable batteries' and 'Automotive and Industrial batteries' present challenges in revenue generation despite their significant collection volumes. This analysis highlights the varying dynamics of profitability across different WEEE categories, emphasizing the importance of efficient monetization strategies tailored to each category.

PROVISION OF SERVICES FOR THE ASSESSMENT OF

E-WASTE & BATTERIES IN LEBANON

# 11

# LIMITATIONS AND CHALLENGES

# 11. LIMITATIONS AND CHALLENGES

Throughout the study, several challenges were encountered at several stages, which affected the data collection process and the completeness of requested information.

Limitations in data collection include the challenge of obtaining stakeholder collaboration: these either did not respond to calls or did not provide data, or delivered unclear responses, limited data on country level, and outdated information in the existing literature.

- Non-responsive stakeholders: Despite multiple attempts to engage stakeholders through calls, follow up emails and questionnaires, a significant number of stakeholders did not respond or provide incomplete answers. This lack of response hindered the ability to gather comprehensive insights from all relevant stakeholders.
- Stakeholder availability and willingness: Some stakeholders were difficult to reach due to their busy schedules or their limited willingness to disclose data and respond to the questionnaire. This limited the opportunity to include their figures, perspectives, and expertise in the review process.
- Incomplete questionnaires: For stakeholders who did respond, most of them did not answer the entire questionnaire. This incomplete data impacted the thoroughness of the analysis and the ability to draw definitive conclusions.
- Follow-up efforts: To address these limitations and gather as much information as possible, additional efforts were made to contact stakeholders' multiple times. Follow-up calls and emails were made and sent to encourage their participation and provide further clarification on the importance of their input. The follow-up efforts that took place proved to be mostly ineffective as responses to the questionnaires were not received.
- Limited time to ask for and conduct site visits: Efforts were made to conduct site visits to the main relevant stakeholders to gather on-the-ground insights and validate information obtained through other channels. These visits provided valuable contextual information and enhanced the understanding of stakeholder operations. However, some operators in the field (such as Aarayby, Khoury Home, Azzi Electronics, etc.) did not respond to requests for an interview and site visit, others such as IMC, Verdetech respond to calls but not to site visit requests.
- Based on the interviews conducted, there might be illegal imports of EEE, PV panels, and batteries. The quantities of such EEE, PV, and batteries imported illegally is not estimated or calculated and may affect the quantities of EEE and waste generated.

PROVISION OF SERVICES FOR THE ASSESSMENT OF

E-WASTE & BATTERIES IN LEBANON

# 12

# CONCLUSION AND RECOMMENDATIONS

# 12. CONCLUSION AND RECOMMENDATIONS

The baseline assessment of e-waste and battery types and quantities in Lebanon, along with the development of systems and their financial assessment, involved several key steps. These steps included data collection on EEE, PV, batteries, and e-waste generation. Additionally, the study considered future e-waste projections, identified relevant stakeholders, recognized existing disposal pathways, assessed market conditions for recyclable recovery, and developed a system in accordance with the existing treatment context. A mixed-methodology approach was employed, combining literature reviews, phone and in-person interviews, statistical analysis, and consultations. This comprehensive approach was instrumental in achieving the project's objectives and enabled the development of system recommendations for the way forward.

The analysis of trade data revealed that, in terms of EEE, small equipment category represented the highest percentage of quantities put on the market by weight from 2017 to 2022. Notably, PV systems experienced remarkable growth in 2022 compared to previous data back to 2013, signifying a shift towards solar energy adoption driven by the Lebanese economic and fuel crises. This exceptional growth trend also applied to batteries, particularly for lithium and lead-acid batteries, that are used in solar systems.

Contact with the identified stakeholders highlights the need for knowledge sharing concerning e-waste and its proper management. Many stakeholders have limited awareness about the e-waste sector and show minimal interest in collaboration or a willingness to provide information. This lack of engagement has presented challenges in conducting a comprehensive assessment of the e-waste status.

Projections reveal that the quantities of e-waste, PV, and batteries are expected to increase in the coming years. However, it is important to note that the country lacks a regulatory framework, a proper infrastructure for e-waste management, an adequate e-waste management knowledge among producers and consumers, a standardized data collection and reporting mechanisms, and an effective collaboration among existing relevant stakeholders and institutions. These challenges need to be addressed to ensure sustainable and responsible e-waste management in Lebanon.

In order to address such challenges, this first financial assessment was conducted. The major goals were to have a conceptual plan and estimated costs overview of a proper e-waste management in Lebanon. It is important to highlight that, for the model, the input data used reflects a combination of experience, market, and literature-based values. In addition, the suggested technological setup might suffer some modifications if alternative estimations and/or decisions are taken. Once the operator role is filled, a recalculation of the model with real costs is recommended to reach accurate projections.

Such costs could be covered by EPR fees from the private sector, since EPR provides governments with a policy approach for addressing concerning environmental issues caused by post-consumer products such as e-waste and shifting the financial responsibility of this problems to the polluting actors via polluter pays principle. Therefore, the implementation of EPR as future instrument could support the improvement and development of e-waste collection and treatment infrastructure locally.

For that, it is recommended to develop a general EPR concept, based on findings from this baseline and financial analysis. The system must be developed in a way that it suits public and private entities, that is enforced by authorities and complied by producers and importers of e-waste. With the EPR concept and financial estimations, Lebanon shall be ready to move ahead in officially implementing this framework in the country.

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# 13

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# 13. REFERENCES


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# APPENDICES

# 14. APPENDICES

## 14.1 POM PROJECTIONS

### 14.1.1 EEE POM

*Table 14-1 EEE POM projections in Lebanon (in tons)*

| Year | Temperature exchange equipment | Screens and monitors | Lamps | Large equipment (excluding PV) | Small equipment | Small IT and telecom equipment | Total EEE |
|---|---|---|---|---|---|---|---|
| 2000 | 7,150 | 3,380 | 350 | 11,140 | 6,220 | 2,260 | **30,500** |
| 2001 | 7,540 | 4,120 | 380 | 11,640 | 6,880 | 2,600 | **33,160** |
| 2002 | 7,580 | 4,880 | 440 | 12,570 | 7,930 | 2,950 | **36,350** |
| 2003 | 8,240 | 5,280 | 830 | 12,340 | 7,940 | 2,960 | **37,590** |
| 2004 | 8,580 | 5,830 | 1,070 | 13,670 | 8,320 | 3,110 | **40,580** |
| 2005 | 9,170 | 6,250 | 1,360 | 12,700 | 7,930 | 3,150 | **40,560** |
| 2006 | 10,790 | 6,100 | 1,400 | 14,080 | 8,470 | 3,190 | **44,030** |
| 2007 | 11,450 | 5,360 | 1,130 | 14,950 | 9,130 | 2,660 | **44,680** |
| 2008 | 12,280 | 5,510 | 1,040 | 16,260 | 9,910 | 2,170 | **47,170** |
| 2009 | 12,730 | 3,160 | 1,020 | 16,100 | 10,190 | 2,100 | **45,300** |
| 2010 | 12,210 | 3,250 | 1,130 | 17,780 | 10,900 | 2,300 | **47,570** |
| 2011 | 13,150 | 3,790 | 1,290 | 19,550 | 10,970 | 2,730 | **51,480** |
| 2012 | 15,310 | 4,310 | 1,490 | 22,820 | 11,690 | 2,250 | **57,870** |
| 2013 | 15,290 | 4,180 | 1,600 | 24,530 | 12,260 | 2,310 | **60,170** |
| 2014 | 13,500 | 4,550 | 1,700 | 24,790 | 11,530 | 1,980 | **58,050** |
| 2015 | 14,010 | 4,540 | 1,640 | 25,500 | 11,170 | 2,320 | **59,180** |
| 2016 | 14,400 | 4,430 | 1,210 | 25,880 | 11,000 | 2,630 | **59,550** |
| 2017 | 16,220 | 4,030 | 1,140 | 26,150 | 10,960 | 2,190 | **60,690** |
| 2018 | 16,500 | 3,700 | 1,140 | 24,900 | 11,450 | 2,060 | **59,750** |
| 2019 | 17,700 | 3,740 | 1,130 | 25,740 | 11,770 | 1,840 | **61,920** |

| Year | Temperature exchange equipment | Screens and monitors | Lamps | Large equipment (excluding PV) | Small equipment | Small IT and telecom equipment | Total EEE |
|---|---|---|---|---|---|---|---|
| 2020 | 17,850 | 3,710 | 1,050 | 26,110 | 11,890 | 1,670 | **62,280** |
| 2021 | 18,170 | 3,510 | 980 | 26,610 | 12,050 | 1,580 | **62,900** |
| 2022 | 18,656 | 3,435 | 1,033 | 27,476 | 12,361 | 1,631 | **64,593** |
| 2023 | 19,155 | 3,362 | 1,089 | 28,371 | 12,679 | 1,684 | **66,340** |
| 2024 | 19,668 | 3,290 | 1,148 | 29,295 | 13,006 | 1,739 | **68,145** |
| 2025 | 20,194 | 3,220 | 1,210 | 30,249 | 13,341 | 1,795 | **70,009** |
| 2026 | 20,734 | 3,152 | 1,275 | 31,234 | 13,685 | 1,853 | **71,933** |
| 2027 | 21,289 | 3,085 | 1,344 | 32,251 | 14,037 | 1,913 | **73,919** |
| 2028 | 21,858 | 3,019 | 1,417 | 33,301 | 14,399 | 1,975 | **75,970** |
| 2029 | 22,443 | 2,955 | 1,494 | 34,385 | 14,770 | 2,039 | **78,086** |
| 2030 | 23,043 | 2,892 | 1,575 | 35,505 | 15,151 | 2,105 | **80,271** |
| 2031 | 23,660 | 2,830 | 1,660 | 36,661 | 15,541 | 2,173 | **82,526** |
| 2032 | 24,293 | 2,770 | 1,750 | 37,855 | 15,942 | 2,244 | **84,853** |
| 2033 | 24,943 | 2,711 | 1,844 | 39,088 | 16,353 | 2,316 | **87,255** |
| 2034 | 25,610 | 2,653 | 1,944 | 40,360 | 16,774 | 2,391 | **89,733** |
| 2035 | 26,295 | 2,597 | 2,049 | 41,675 | 17,206 | 2,469 | **92,291** |
| 2036 | 26,999 | 2,541 | 2,160 | 43,032 | 17,650 | 2,549 | **94,930** |
| 2037 | 27,721 | 2,487 | 2,277 | 44,433 | 18,105 | 2,631 | **97,654** |
| 2038 | 28,463 | 2,434 | 2,400 | 45,880 | 18,571 | 2,717 | **100,464** |
| 2039 | 29,224 | 2,382 | 2,530 | 47,373 | 19,050 | 2,805 | **103,364** |
| 2040 | 30,006 | 2,332 | 2,667 | 48,916 | 19,541 | 2,896 | **106,357** |

| Year | Primary | | | | | | | Accumulator | | | | | | | All Batteries |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Manganese Dioxide | Mercuric Oxide | Silver Oxide | Lithium | Air-Zinc | Other Primary | Total | Lead | Other Lead | Nickel Cadmium | Nickel Hybrid | Lithium | Other Accumulator | Total | Total |
| 2013 | 634 | 0 | 9 | 7 | 4 | 492 | **1,146** | 13,591 | 4,403 | 4 | 3 | 1 | 841 | **18,843** | **19,989** |
| 2014 | 446 | 0 | 4 | 6 | 48 | 431 | **935** | 13,920 | 2,224 | 9 | 6 | 0 | 2,021 | **18,180** | **19,115** |
| 2015 | 733 | 0 | 1 | 10 | 17 | 515 | **1,276** | 12,285 | 3,346 | 2 | 8 | 3 | 3,225 | **18,869** | **20,145** |
| 2016 | 492 | 0 | 1 | 13 | 3 | 558 | **1,067** | 12,495 | 2,536 | 4 | 12 | 12 | 2,582 | **17,641** | **18,708** |
| 2017 | 453 | 0 | 1 | 32 | 4 | 710 | **1,200** | 11,763 | 3,330 | 33 | 12 | 6 | 2,211 | **17,355** | **18,555** |
| 2018 | 486 | 0 | 1 | 17 | 6 | 851 | **1,361** | 10,455 | 3,587 | 15 | 10 | 10 | 2,267 | **16,344** | **17,705** |
| 2019 | 420 | 0 | 1 | 18 | 2 | 915 | **1,356** | 11,050 | 7,356 | 4 | 9 | 36 | 2,623 | **21,078** | **22,434** |
| 2020 | 156 | 0 | 2 | 9 | 23 | 722 | **912** | 4,990 | 1,776 | 0 | 1 | 22 | 1,928 | **8,717** | **9,629** |
| 2021 | 674 | 0 | 0 | 205 | 2 | 2,554 | **3,435** | 12,803 | 17,053 | 0 | 2 | 202 | 10,180 | **40,240** | **43,675** |
| 2022 | 2,742 | 47 | 0 | 1,164 | 29 | 7,910 | **11,892** | 16,195 | 49,602 | 3 | 21 | 3,023 | 36,879 | **105,723** | **117,615** |
| 2023 | 342 | 1 | 0 | 300 | 19 | 1,737 | **2,399** | 5,005 | 4,783 | 6 | 4 | 2,012 | 3,353 | **15,163** | **17,562** |
| 2024 | 391 | 1 | 0 | 336 | 20 | 1,956 | **2,704** | 5,089 | 5,897 | 6 | 5 | 2,163 | 3,920 | **17,081** | **19,785** |
| 2025 | 447 | 2 | 0 | 375 | 21 | 2,203 | **3,048** | 5,175 | 7,272 | 7 | 6 | 2,326 | 4,582 | **19,367** | **22,414** |
| 2026 | 510 | 2 | 0 | 420 | 22 | 2,481 | **3,435** | 5,262 | 8,966 | 7 | 7 | 2,501 | 5,356 | **22,099** | **25,534** |
| 2027 | 583 | 3 | 0 | 470 | 23 | 2,794 | **3,873** | 5,351 | 11,055 | 7 | 8 | 2,689 | 6,261 | **25,371** | **29,244** |
| 2028 | 667 | 3 | 0 | 526 | 24 | 3,147 | **4,366** | 5,441 | 13,631 | 8 | 9 | 2,891 | 7,319 | **29,299** | **33,666** |
| 2029 | 762 | 4 | 0 | 588 | 26 | 3,544 | **4,923** | 5,533 | 16,807 | 8 | 11 | 3,109 | 8,556 | **34,023** | **38,946** |
| 2030 | 870 | 5 | 0 | 658 | 27 | 3,991 | **5,551** | 5,626 | 20,723 | 9 | 12 | 3,342 | 10,002 | **39,715** | **45,265** |
| 2031 | 995 | 7 | 0 | 736 | 28 | 4,494 | **6,260** | 5,721 | 25,551 | 9 | 15 | 3,594 | 11,692 | **46,582** | **52,842** |
| 2032 | 1,137 | 8 | 0 | 823 | 30 | 5,061 | **7,059** | 5,817 | 31,505 | 10 | 17 | 3,864 | 13,668 | **54,881** | **61,940** |
| 2033 | 1,299 | 11 | 0 | 921 | 31 | 5,700 | **7,961** | 5,915 | 38,845 | 10 | 20 | 4,155 | 15,977 | **64,924** | **72,885** |
| 2034 | 1,484 | 13 | 0 | 1,030 | 33 | 6,419 | **8,980** | 6,015 | 47,896 | 11 | 24 | 4,467 | 18,677 | **77,091** | **86,070** |
| 2035 | 1,696 | 17 | 0 | 1,152 | 34 | 7,229 | **10,129** | 6,117 | 59,056 | 12 | 28 | 4,803 | 21,833 | **91,849** | **101,978** |
| 2036 | 1,938 | 21 | 0 | 1,289 | 36 | 8,141 | **11,426** | 6,220 | 72,817 | 12 | 33 | 5,164 | 25,523 | **109,769** | **121,195** |
| 2037 | 2,215 | 27 | 0 | 1,442 | 38 | 9,169 | **12,891** | 6,325 | 89,783 | 13 | 39 | 5,553 | 29,835 | **131,548** | **144,438** |
| 2038 | 2,531 | 34 | 0 | 1,613 | 40 | 10,326 | **14,544** | 6,431 | 110,703 | 14 | 46 | 5,970 | 34,877 | **158,041** | **172,585** |
| 2039 | 2,893 | 43 | 0 | 1,804 | 42 | 11,629 | **16,411** | 6,540 | 136,497 | 14 | 54 | 6,419 | 40,771 | **190,294** | **206,705** |
| 2040 | 3,306 | 55 | 0 | 2,018 | 44 | 13,096 | **18,519** | 6,650 | 168,301 | 15 | 63 | 6,902 | 47,660 | **229,591** | **248,110** |

*Table 14-2 Batteries POM Projections in Lebanon (in tons)*

## 14.2 WASTE GENERATED PROJECTIONS

### 14.2.1 E-Waste

*Table 14-3 E-waste Projections in Lebanon (in tons)*

| Year | Temperature exchange equipment | Screens and monitors | Lamps | Large equipment (excluding PV) | Small equipment | Small IT and telecom equipment | Total EEE |
|---|---|---|---|---|---|---|---|
| 2010 | 6,310 | 4,100 | 750 | 9,350 | 6,360 | 2,370 | **29,240** |
| 2011 | 6,660 | 4,330 | 800 | 9,980 | 6,760 | 2,330 | **30,860** |
| 2012 | 7,040 | 4,520 | 860 | 10,630 | 7,150 | 2,300 | **32,500** |
| 2013 | 7,430 | 4,680 | 940 | 11,320 | 7,570 | 2,280 | **34,220** |
| 2014 | 7,830 | 4,790 | 1,020 | 12,050 | 7,950 | 2,250 | **35,890** |
| 2015 | 8,240 | 4,860 | 1,090 | 12,810 | 8,300 | 2,240 | **37,540** |
| 2016 | 8,660 | 4,900 | 1,140 | 13,600 | 8,630 | 2,240 | **39,170** |
| 2017 | 9,080 | 4,890 | 1,170 | 14,400 | 8,920 | 2,260 | **40,720** |
| 2018 | 9,520 | 4,850 | 1,180 | 15,210 | 9,200 | 2,260 | **42,220** |
| 2019 | 9,960 | 4,770 | 1,190 | 16,010 | 9,510 | 2,260 | **43,700** |
| 2020 | 10,400 | 4,680 | 1,180 | 16,800 | 9,800 | 2,250 | **45,110** |
| 2021 | 10,840 | 4,580 | 1,170 | 17,570 | 10,070 | 2,220 | **46,450** |
| 2022 | 10,913 | 4,514 | 1,206 | 18,249 | 10,382 | 2,235 | **47,501** |
| 2023 | 10,987 | 4,450 | 1,244 | 18,955 | 10,703 | 2,251 | **48,590** |
| 2024 | 11,061 | 4,386 | 1,282 | 19,688 | 11,035 | 2,266 | **49,719** |
| 2025 | 11,136 | 4,324 | 1,322 | 20,450 | 11,376 | 2,282 | **50,890** |
| 2026 | 11,212 | 4,262 | 1,363 | 21,241 | 11,729 | 2,298 | **52,103** |
| 2027 | 11,288 | 4,201 | 1,405 | 22,062 | 12,092 | 2,314 | **53,361** |
| 2028 | 11,364 | 4,141 | 1,448 | 22,915 | 12,466 | 2,330 | **54,664** |
| 2029 | 11,441 | 4,081 | 1,493 | 23,801 | 12,852 | 2,346 | **56,015** |
| 2030 | 11,518 | 4,023 | 1,539 | 24,722 | 13,250 | 2,362 | **57,415** |
| 2031 | 11,596 | 3,966 | 1,587 | 25,678 | 13,660 | 2,379 | **58,866** |
| 2032 | 11,675 | 3,909 | 1,636 | 26,671 | 14,083 | 2,395 | **60,369** |
| 2033 | 11,754 | 3,853 | 1,687 | 27,703 | 14,519 | 2,412 | **61,927** |
| 2034 | 11,833 | 3,798 | 1,739 | 28,774 | 14,969 | 2,428 | **63,541** |
| 2035 | 11,913 | 3,744 | 1,793 | 29,887 | 15,432 | 2,445 | **65,214** |
| 2036 | 11,994 | 3,690 | 1,848 | 31,043 | 15,910 | 2,462 | **66,947** |
| 2037 | 12,075 | 3,637 | 1,906 | 32,243 | 16,403 | 2,479 | **68,743** |
| 2038 | 12,157 | 3,585 | 1,965 | 33,490 | 16,911 | 2,496 | **70,603** |
| 2039 | 12,239 | 3,534 | 2,025 | 34,785 | 17,434 | 2,514 | **72,531** |
| 2040 | 12,322 | 3,483 | 2,088 | 36,131 | 17,974 | 2,531 | **74,529** |

*Table 14-4 Battery Waste Projections in Lebanon (in tons)*

| Year | Primary | | | | | | | Accumulator | | | | | | | All Batteries |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Manganese Dioxide | Mercuric Oxide | Silver Oxide | Lithium | Air-Zinc | Other Primary | Total | Lead | Other Lead | Nickel Cadmium | Nickel Hybrid | Lithium | Other Accumulator | Total | |
| 2013 | 2 | 0 | 3 | 1 | 1 | 79 | **85** | 3,855 | 512 | 1 | 0 | 0 | 98 | **4,465** | **4,551** |
| 2014 | 9 | 0 | 4 | 2 | 15 | 146 | **174** | 7,571 | 957 | 4 | 1 | 0 | 368 | **8,901** | **9,076** |
| 2015 | 22 | 0 | 3 | 3 | 18 | 216 | **263** | 9,795 | 1,440 | 4 | 2 | 0 | 829 | **12,070** | **12,333** |
| 2016 | 44 | 0 | 2 | 5 | 15 | 284 | **350** | 11,143 | 1,799 | 4 | 4 | 1 | 1,250 | **14,202** | **14,552** |
| 2017 | 72 | 0 | 2 | 9 | 11 | 365 | **460** | 11,704 | 2,148 | 12 | 6 | 2 | 1,561 | **15,433** | **15,893** |
| 2018 | 107 | 0 | 2 | 12 | 9 | 458 | **587** | 11,554 | 2,484 | 15 | 7 | 3 | 1,792 | **15,854** | **16,442** |
| 2019 | 146 | 0 | 1 | 14 | 7 | 549 | **716** | 11,449 | 3,211 | 13 | 8 | 6 | 2,000 | **16,686** | **17,402** |
| 2020 | 186 | 0 | 1 | 14 | 11 | 594 | **807** | 9,657 | 3,393 | 9 | 8 | 8 | 2,093 | **15,166** | **15,973** |
| 2021 | 226 | 0 | 1 | 37 | 9 | 922 | **1,195** | 10,210 | 5,061 | 5 | 7 | 24 | 3,077 | **18,384** | **19,579** |
| 2022 | 271 | 5 | 1 | 178 | 15 | 2,094 | **2,564** | 12,069 | 11,046 | 4 | 8 | 274 | 7,479 | **30,880** | **33,444** |
| 2023 | 329 | 8 | 0 | 260 | 17 | 2,197 | **2,811** | 10,539 | 13,172 | 4 | 8 | 471 | 9,102 | **33,296** | **36,107** |
| 2024 | 388 | 8 | 0 | 306 | 19 | 2,219 | **2,940** | 8,736 | 13,276 | 5 | 8 | 666 | 9,223 | **31,913** | **34,853** |
| 2025 | 445 | 7 | 0 | 337 | 20 | 2,246 | **3,055** | 7,374 | 12,678 | 6 | 7 | 861 | 8,777 | **29,704** | **32,759** |
| 2026 | 497 | 6 | 0 | 362 | 21 | 2,304 | **3,189** | 6,499 | 11,991 | 6 | 7 | 1,058 | 8,189 | **27,751** | **30,940** |
| 2027 | 542 | 5 | 0 | 387 | 22 | 2,401 | **3,357** | 6,003 | 11,567 | 7 | 7 | 1,255 | 7,693 | **26,531** | **29,888** |
| 2028 | 580 | 5 | 0 | 415 | 23 | 2,542 | **3,564** | 5,758 | 11,609 | 7 | 7 | 1,455 | 7,417 | **26,253** | **29,817** |
| 2029 | 611 | 4 | 0 | 448 | 24 | 2,730 | **3,818** | 5,667 | 12,238 | 8 | 8 | 1,657 | 7,421 | **26,998** | **30,816** |
| 2030 | 635 | 4 | 0 | 489 | 25 | 2,968 | **4,122** | 5,665 | 13,530 | 8 | 9 | 1,863 | 7,728 | **28,802** | **32,923** |
| 2031 | 656 | 5 | 0 | 537 | 26 | 3,257 | **4,481** | 5,711 | 15,551 | 9 | 10 | 2,074 | 8,340 | **31,695** | **36,175** |
| 2032 | 674 | 5 | 0 | 594 | 28 | 3,600 | **4,900** | 5,784 | 18,377 | 9 | 11 | 2,291 | 9,259 | **35,732** | **40,632** |
| 2033 | 693 | 6 | 0 | 659 | 29 | 4,001 | **5,388** | 5,870 | 22,113 | 10 | 13 | 2,517 | 10,485 | **41,008** | **46,396** |
| 2034 | 716 | 7 | 0 | 734 | 31 | 4,463 | **5,951** | 5,964 | 26,901 | 10 | 15 | 2,753 | 12,029 | **47,671** | **53,623** |
| 2035 | 747 | 9 | 0 | 818 | 32 | 4,994 | **6,600** | 6,062 | 32,930 | 11 | 18 | 2,999 | 13,912 | **55,932** | **62,532** |
| 2036 | 788 | 11 | 0 | 914 | 34 | 5,599 | **7,346** | 6,163 | 40,450 | 11 | 21 | 3,259 | 16,167 | **66,071** | **73,417** |
| 2037 | 844 | 14 | 0 | 1,021 | 36 | 6,286 | **8,201** | 6,267 | 49,779 | 12 | 24 | 3,533 | 18,838 | **78,452** | **86,653** |
| 2038 | 916 | 18 | 0 | 1,142 | 37 | 7,064 | **9,177** | 6,372 | 61,318 | 13 | 28 | 3,823 | 21,984 | **93,538** | **102,715** |
| 2039 | 1,007 | 23 | 0 | 1,277 | 39 | 7,944 | **10,290** | 6,479 | 75,569 | 13 | 33 | 4,132 | 25,676 | **111,903** | **122,193** |
| 2040 | 1,120 | 29 | 0 | 1,428 | 41 | 8,937 | **11,555** | 6,589 | 93,156 | 14 | 39 | 4,460 | 30,001 | **134,259** | **145,814** |

## 14.3 PV PROJECTIONS

Two projection scenarios were adopted for the PV situation in Lebanon:

- The first POM projection (Table 14-5) considers data from 2013 till 2023 and accounts for PV quantities in 2022 which make the projections values very high and non-realistic since upcoming years will not be facing economic and fuel crises in the same severity as of 2022 where the pick-phase transition to solar system was occurred.
- The second POM projection (Table 14- 6) considers data from 2013 till August 2023 without accounting for PV quantities in 2022. This projection reveals more realistic and relevant numbers for the upcoming years, especially for the first 5 years, since numbers will not be as of 2022 but in the same time, the status will never be as it was before 2021-2022. Lebanese situation and the crisis phase are causing irregular values and market change that will remain far from any standard until the end of the crisis.

*Table 14-5 PV POM and Waste Projections in Lebanon (in tons) _ Scenario 1*

| Year | PV POM | PV Waste Generated |
|---|---|---|
| 2013 | 51 | 0 |
| 2014 | 193 | 0 |
| 2015 | 297 | 0 |
| 2016 | 445 | 0 |
| 2017 | 541 | 0 |
| 2018 | 1,640 | 1 |
| 2019 | 1,593 | 2 |
| 2020 | 784 | 5 |
| 2021 | 12,983 | 8 |
| 2022 | 82,743 | 16 |
| 2023 | 20,412 | 37 |
| 2024 | 22,507 | 82 |
| 2025 | 25,246 | 163 |
| 2026 | 28,318 | 288 |
| 2027 | 31,764 | 471 |
| 2028 | 35,630 | 722 |
| 2029 | 39,966 | 1,054 |
| 2030 | 44,829 | 1,481 |
| 2031 | 50,285 | 2,017 |

| Year | PV POM | PV Waste Generated |
|---|---|---|
| 2032 | 56,404 | 2,675 |
| 2033 | 63,269 | 3,470 |
| 2034 | 70,968 | 4,414 |
| 2035 | 79,605 | 5,521 |
| 2036 | 89,292 | 6,802 |
| 2037 | 100,158 | 8,270 |
| 2038 | 112,347 | 9,934 |
| 2039 | 126,019 | 11,804 |
| 2040 | 141,355 | 13,889 |
| 2041 | 158,558 | 16,201 |
| 2042 | 177,853 | 18,750 |
| 2043 | 199,497 | 21,550 |
| 2044 | 223,775 | 24,619 |
| 2045 | 251,008 | 27,979 |
| 2046 | 281,554 | 31,659 |
| 2047 | 315,818 | 35,697 |
| 2048 | 354,251 | 40,137 |
| 2049 | 397,362 | 45,034 |
| 2050 | 445,719 | 50,454 |

*Table 14-6 PV POM and Waste Projections in Lebanon (in tons) _ Scenario 2*

| Year | PV POM | PV Waste Generated |
|---|---|---|
| 2013 | 51 | 0 |
| 2014 | 193 | 0 |
| 2015 | 297 | 0 |
| 2016 | 445 | 0 |
| 2017 | 541 | 0 |
| 2018 | 1,640 | 1 |
| 2019 | 1,593 | 2 |
| 2020 | 784 | 5 |

| Year | PV POM | PV Waste Generated |
|---|---|---|
| 2021 | 12,983 | 8 |
| 2022 | 82,743 | 16 |
| 2023 | 20,412 | 37 |
| 2024 | 21,333 | 82 |
| 2025 | 22,681 | 163 |
| 2026 | 24,115 | 288 |
| 2027 | 25,639 | 468 |
| 2028 | 27,259 | 714 |
| 2029 | 28,982 | 1,037 |
| 2030 | 30,814 | 1,448 |
| 2031 | 32,761 | 1,956 |
| 2032 | 34,832 | 2,572 |
| 2033 | 37,033 | 3,301 |
| 2034 | 39,374 | 4,152 |
| 2035 | 41,862 | 5,127 |
| 2036 | 44,508 | 6,228 |
| 2037 | 47,321 | 7,453 |
| 2038 | 50,312 | 8,798 |
| 2039 | 53,491 | 10,254 |
| 2040 | 56,872 | 11,813 |
| 2041 | 60,466 | 13,462 |
| 2042 | 64,288 | 15,187 |
| 2043 | 68,351 | 16,973 |
| 2044 | 72,671 | 18,808 |
| 2045 | 77,264 | 20,679 |
| 2046 | 82,147 | 22,576 |
| 2047 | 87,339 | 24,493 |
| 2048 | 92,858 | 26,429 |
| 2049 | 98,727 | 28,387 |
| 2050 | 104,967 | 30,374 |

## 14.4 ECOSERV FACILITY VISIT

A visit to the Ecoserv facility took place on June 13th at 2:00 PM, undertaken by ELARD and BF teams, represented by Zeina Fahed and Aurora Rios, respectively. The primary purpose of the visit was to gain insight into Ecoserv's operations, including a meeting with Dr. Gaby Kassab, the founder, and a site tour during a BaU operational day.

Ecoserv, a non-profit organization, is a key player in e-waste management within the country. In Lebanon, Ecoserv is currently active in the collection of e-waste from bins located in designated drop zones all over the Lebanese territory. This collection occurs on a weekly basis or upon demand and varies according to geographic area. In 2021, the company also introduced a door-to-door service via a mobile app. The NGO is also working on awareness workshops in Schools, Universities as well as municipalities and is developing an upcycling project concept.

Ecoserv primarily collects old, end-of-life, obsolete, and defective electronic products for recycling and environmentally sound disposal, with the exception of lamps. However, it is worth noting that Ecoserv has primarily focused its collection efforts on Information and Communication Technology (ICT) equipment due to challenges such as limited storage space, time-consuming dismantling processes, and transport constraints.

The visit to Ecoserv's facility revealed that the organization engages in purely manual dismantling, which, although time-consuming, enables the recovery of a specific range of materials from e-waste. Ecoserv's manual dismantling process successfully yields materials such as iron, glass, aluminum, plastic, e-plastic, printed circuit boards, wires, and toners. Components that may contain toxic materials are properly stored to be shipped in line with the Basel Convention.

Among these materials, iron, glass, aluminum, and wires are sold in the local market, while plastic is sold to an NGO. Currently, other materials are being stored, with printed circuit boards awaiting export, e-plastic designated for future upcycling programs, and toners awaiting appropriate treatment solutions.

Dr. Gaby Kassab pointed out that e-waste disposal in the country is ineffective for several reasons, such as:

- There is no clear legislation for the disposal of e-waste in Lebanon.
- Some institutions opt to sell their e-waste to scrappers and recyclers who would 'cherry-pick' valuable components. These entities often employ outdated methods such as acid leaching or open-air burning to extract certain elements, inadvertently generating toxic fumes and hazardous pollution in the process. Subsequently, they dispose of the dismantled and highly polluting equipment in nearby ordinary waste bins or, even worse, improper locations.
- Solid waste management companies are not equipped to handle e-waste, as it falls outside their mandate and expertise for disposal.

Ecoserv is dedicated to finding a solution for e-waste in Lebanon and is committed to collaborating and providing their best efforts to achieve the most suitable solution for the country. Photos from the site visit are presented below.

Manual Dismantling Process

Stored equipment



Proper storage of recyclable

Dismantling of an Icos cigarette

# 15. ANNEXES

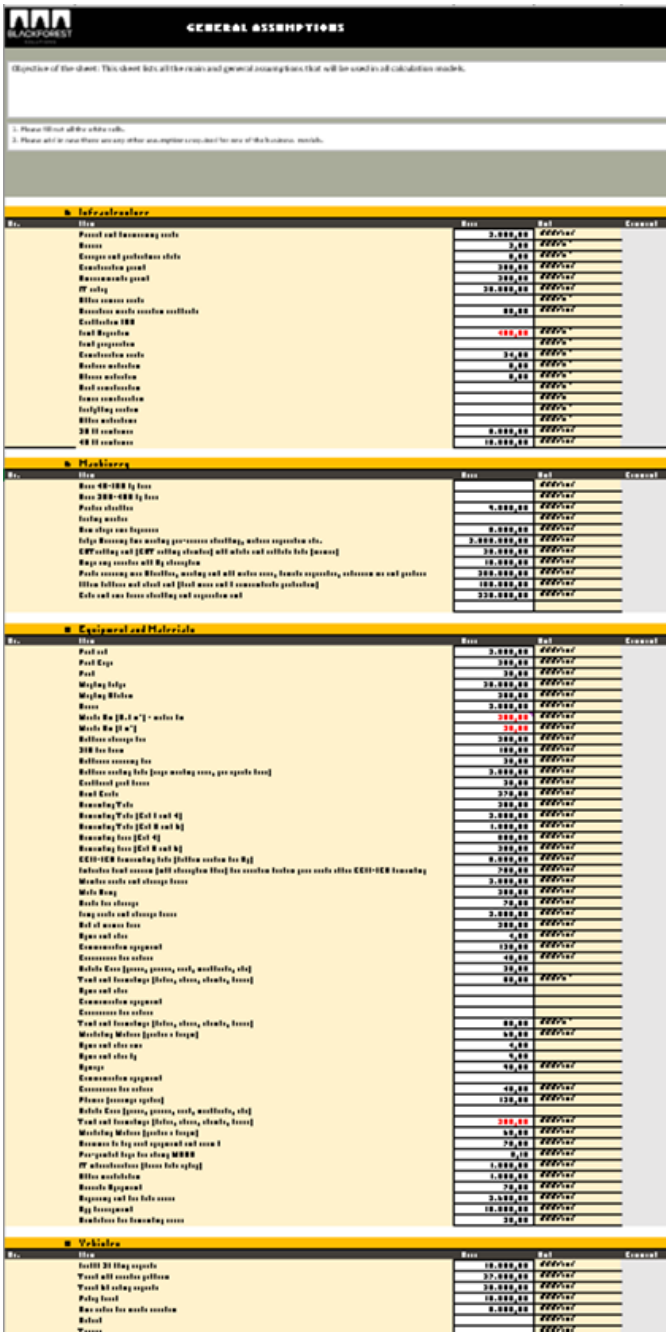
## 15.1 ANNEX A – QUESTIONNAIRES

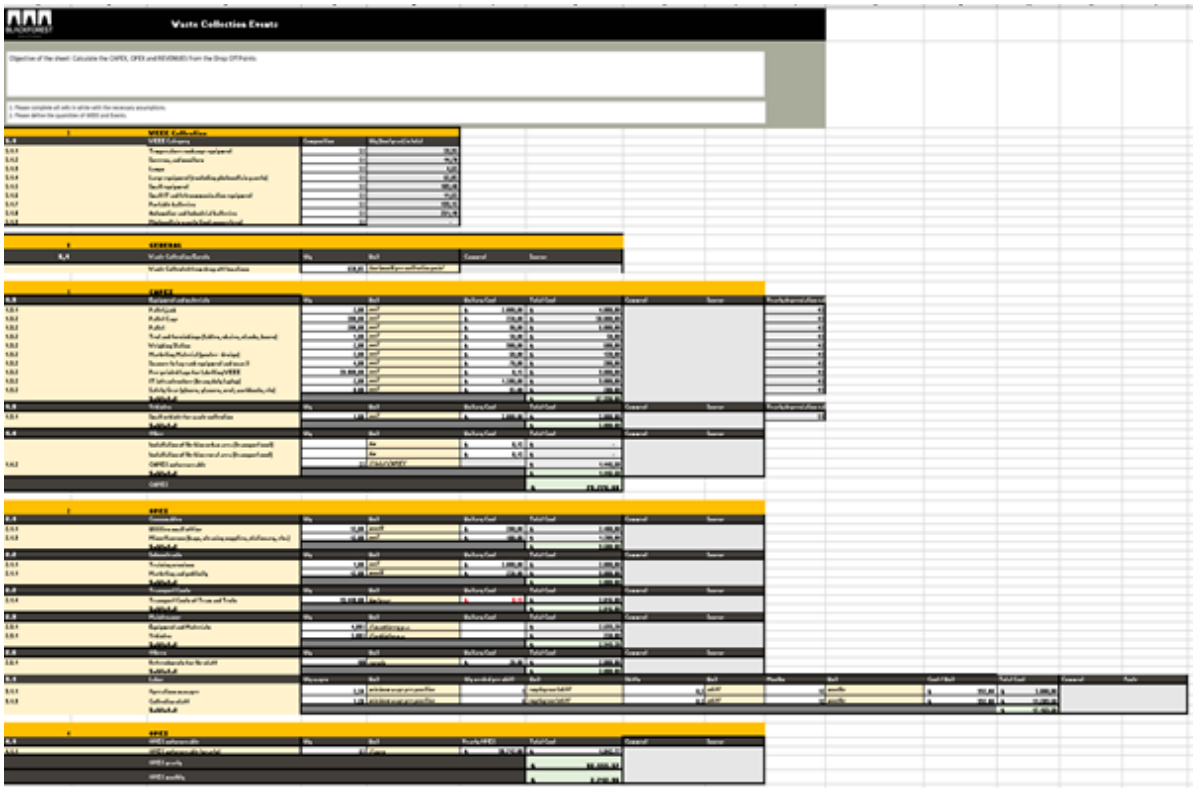
UNDP_E-waste and Batteries_ Stakeholder

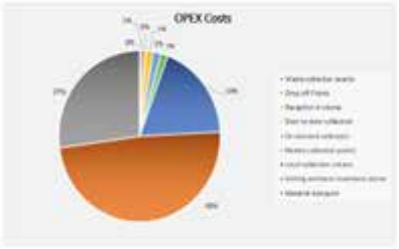
## 15.2 ANNEX B – CONTACTED STAKEHOLDERS

UNDP_E-waste and Batteries_ Stakeholder

## 15.3 ANNEX C – CALCULATION TOOL OVERVIEW




Waste Collection Events


OPEX Costs


CAPEX Costs

UNDP is the leading United Nations organization fighting to end the injustice of poverty, inequality, and climate change. Working with our broad network of experts and partners in 170 countries, we help nations to build integrated, lasting solutions for people and planet.

Learn more at undp.org.lb or follow at @UNDP_Lebanon