ASSESSMENT OF WEEE DISMANTLING BUSINESS OPPORTUNITIES

FORMAL SECTOR

SRI
SUSTAINABLE
RECYCLING
INDUSTRIES

2017

SUSTAINABLE RECYCLING INDUSTRIES

CREDITS

CEDARE Coordination: Hossam Allam (Regional Programme Manager), Ghada Moghny (Programme Coordinator), Lamia Nabil (Communication & PR Officer), Terry Fahmy (Regional Programme Specialist), Rym Hazem (Programme Associate)
WRF Coordination: Mathias Schluep (Programme Director)
Sofies Coordination: David Rochat (CEO, Sofies International), Deepali Sinha Khetriwal (Managing Director, Sofies India), Anahide Bondolfi (Senior Consultant)

AUTHOR

Dr. Fathya Soliman, Senior Expert

GRAPHIC DESIGN

InfoTimes

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CONTACTS

CEDARE - Centre for Environment and Development for the Arab Region & Europe - Sustainable Growth Division - 2 Hegaz St., Roxy, Heliopolis, CEDARE Building P.O. Box: 1057 Heliopolis Bahary, Cairo, Egypt. Tel: +202 24513921/2/3 - Fax: +202 24513918, sgp@cedare.int , www.cedare.int

Sofies - P.O. 2091, rue du Vuache 1, 1211 Geneva 1, Switzerland. Tel: +41 22 338 15 24, geneva@sofiesgroup.com

Sustainable Recycling Industries (SRI) c/o World Resources Forum Association - Lerchenfeldstrasse 5, 9014 St. Gallen, Switzerland, info@sustainable-recycling.org, www.sustainablerecycling.org

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Federal Department of Economic Affairs, State Secretariat for Economic Affairs SECO

Arab Republic of Egypt
Ministry of Communications and Information Technology

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Executive Summary

The current task is carried out within the framework of the Sustainable Recycling Industries (SRI) project being implemented by the Swiss Federal Laboratories for Materials Sciences (EMPA) as mandated by the State Secretariat of Economic Affairs (SECO) of Switzerland. The main objective of this task is to map the licensed & sound recycling companies for end-processing in Egypt for each separate fraction, and delineate, as appropriate, the best possible local beneficiation. For fractions with no solution in Egypt, the task shall map and propose end-processing facilities to be used outside of Egypt – as receivers of material from the new formal SMEs. To meet this objective, a scope of work was implemented including:

- Identifying fractions of IT equipment (desktop, laptops, mobile phones, landline phones, printers, etc...)
- Identifying the licensed & sound recycling companies for end-processing in Egypt for each separate fraction
- Delineating, as appropriate, the best possible local fraction purchaser and the average expected prices
- Identifying the fractions with no recycling solution in Egypt
- Identifying and proposing end-processing facilities to be used outside of Egypt as receivers of material.

The scope of work was implemented through a survey of the formal sector to identify their needs and challenges that they face. On the other hand, a study of the type of fractions produced from the WEEE processing was carried out in order to analyze their end use, value and physical nature. The output of this study identified also the materials produced from processing the fractions. These materials were classified according to their hazardous nature and list of hazardous materials in fractions and their associated hazard and protective requirements were provided in order to protect the workers that handle these materials.

The survey was extended to identify the licensed & sound recycling companies for end processing in Egypt for each material (copper, aluminum, iron, zinc, lead and other alike materials). A list of companies willing to deal with the formal sector was provided; they received samples of the materials under consideration to test the quality of each material through typical end use process (smelting in foundries) to identify their yield; pricing of each material was accordingly valued; it was concluded that the price could increase with the yield of each material and the recycling companies could accommodate the quantities of materials produced from the WEEE activities in Egypt.

The study also revealed that the precious and base metals refining process, even which is carried out by the existing formal sector, produces products of low yield as proved by the end processing of these materials. The outsourcing of refining outside Egypt is a solution for this problem; therefore, the export of the fractions was investigated. It was found that the export of PCBs and Lithium Batteries is a common practice in the formal sector, but some challenges are facing the exporters such as:

- The profitable amount to be exported PCBs and Lithium Batteries (50 ton/month is the minimum quantity that may realize profit)
- The formula between the exporter and the refining facility
- These challenges could hinder the small enterprises, so working in group could overcome these challenges.

A list of end-processing facilities to be used outside of Egypt as receivers of material was provided detailing each company location, address and short description of the activities.

Challenges for the Formal WEEE Recycling Sector

The establishment of formal and efficient WEEE recycling systems faces many challenges such as:

- The legal constraint, as currently no laws specifically addressing waste management for WEEE exist or are being developed in Egypt. In other words, there is currently no way to legally specifying the collection of WEEE as an input to a formal business or industry. As it is complicated to define WEEE as a fraction by rigid law.
- The organizational issue: WEEE recycling requires a great deal of elasticity and flexibility for handling a complex WEEE material input. Furthermore a sound knowledge base is necessary to select the most appropriate processing techniques and operational approaches. EEE technology is growing very fast and components and materials are changing rapidly at short intervals. Thus the handling of WEEE is more easily handled via private small entrepreneurship than via rigid of public systems.
- The dominance of the informal sector, which controls the WEEE in Egypt is jeopardizing the future of the formal sector. Companies are suffering the lack of input flow due to the monopoly of the informal sector.
- In case the PCB are treated in Egypt, large investment is required to establish comprehensive enterprises to process the waste ending by refining the precious and base metals.
- In case the outsourcing of the refining of precious and base metals, a good formula with the external refiner is needed as well as the continuous follow up.

Conclusion and Recommendation

The study revealed the following:

- The current formal sector is of limited capacity that shares a limited market segment; in the contrary of the informal sector that dominates the market and works at neither regulations nor environmental measures that protect the worker and the environment.
- The fractions of IT in Egypt were identified and found to be a source of raw materials needed for the casting industry; in addition, the precious materials should be refined with the state-of-the-art technology in order to minimize the loss during this process. This technology does not exist in Egypt.

- The licensed & sound recycling companies for end-processing in Egypt for each separate fraction were identified, especially the ones that have the capability to recycle the metals produced from the EEE waste recycling. Actual smelting of metal samples was carried out to identify the yield of each type of metal produced from the recycling. It was concluded that the produced copper quality needs to be improved as the yield during smelting proved to be low.
- Each metal was priced according to the smelting test. The price is fundamentally affected by the yield of metal during smelting
- The market price of equipment, fractions and produced metals was surveyed. Special attention was given to the PCBs fraction as their price depends on their content of precious, rare and base metals. It was concluded that this content is decaying as technology advances.
- It was concluded that the fractions that contain precious and base metals should be exported for refining outside Egypt, at least on the short run. A list of companies that can refine the fractions containing those metals (mainly PCBs & Lithium batteries) was provided.

It was recommended that:

The formal sector includes larger number of well-trained Entrepreneurs of small companies; these companies should be supported to:

- Work in controlled work place that protects the worker in the meantime all measures of applicable laws shall be implemented in order not to negatively affect the ambient environment. A program should be planned to support these Entrepreneurs to work within the applicable environmentally sound measures in handling and processing the WEEE
- It is recommended that these small companies work up to the classification and proper dismantling of the fractions and supply their output to larger companies for further processing such as refining since the investment in refining is very high
- In case these companies decided to complete the process and to outsource the fractions refining outside Egypt, this should be done in clusters, i.e. many of them should act in group to gather the required feasible amount, which is 50 ton/month and share the cost of this process in order to realize a profit

EPR strategy should be implemented by making the manufacturer of the product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal.

As a result of the first round survey carried out in 2016 and summarized above, the Sustainable Recycling Industry (SRI) project planned to support the Formal Sector to sustain its operation. The support included a planned to be implemented on all spheres including:

- Identifying the needs assessment of the formal sector
- Planning of a Technical Support Program
- Preparing an implementation schedule
- Follow up with all stake holder to mobilize the sector activities

As a result of SRI effort the formal sector started to move (slowly but surely) towards operating within a legal frame supported by the Ministry of Environment, the Ministry of Information and telecommunication, as well as the Ministry of Finance represented by the Governmental Service Authority.

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List of Abbreviations

BMs	Base Metals
CRT	Cathode Ray Tube
EW	Electronic Waste
ICT	Information Communication Technology
IT	Information Technology
LCD	Liquid Crystal Display
MCs	Metals of Concern
MCIT	Ministry of Communication & Information Technology
NGO	Non-Governmental Organization
PCB	Printed Circuits Board
PGMs	Platinum Group Metals
PMs	Precious Metals
PPE	Personal Protection Equipment
SEs	Scarce Elements
(SECO)	State Secretariat of Economic Affairs of Switzerland
SMEs	Small and Medium Enterprises
SRI	Sustainable Recycling Industries project
SFLMS (EMPA)	Swiss Federal Laboratories for Materials Sciences
WEEE	Waste of Electrical and Electronic Equipment

1

Introduction

Waste of Electronic and Electrical Equipment (WEEE) is a complex combination when dismantled produces a broad spectrum of elements starting from precious metals and ending by hazardous materials; this mixture may cause a serious environmental and health risk to people that handle this WEEE if not properly managed; therefore, It is essential to improve the proper management of WEEE including collection, treatment and recycling of such waste. Unfortunately, the management of WEEE in Egypt is yet to be improved a lot through a proper system for collection, treatment and recovery of materials from the WEEE.

In Egypt, the WEEE is managed by both formal and informal sectors. ***The formal sector is identified as tax-paying business entities and who deals with the EEE-waste as recyclers for environmentally-sound treatment through an environmental permit obtained from the Egyptian Environmental Affairs Agency (EEAA)***. While ***the informal sector consists of self-employed collectors*** who travel door-to-door, using cash with no invoices to purchase a variety of used and waste household items ranging from plastic, paper and metal scraps to household appliances and other electrical and electronic equipment. These informal collectors may also serve as brokers between consumers and medium-level scrap dealers, refurbishers and recyclers. The brokers are controlling the market, especially for the PCBs, allowing for a limited margin for the formal recyclers; that is why the formal sector recyclers are trying to process the PCBs inside Egypt to maximize this margin. The WEEE business is dominated by informal sector; however, there is always a link between the informal and formal sector through a network of waste dealers - the sorted fractions by the informal collectors are delivered to (formal) waste recycling factories and companies inside Egypt. According to the updated review in 2017 carried out within the framework of SRI, the formal sector companies are listed in details as follows:

- International Technology Group ITG: The Company is recycling EW by mechanical process – they are developing the refining process for PCBs. The company uses state-of-the-art WEEE processing line that operates in accordance with the requirements of an environmental permit obtained from EEAA; the line produces many fractions including the ground PCBs materials. The company is currently suffering from the lack of WEEE.

- Egyptian Electronic Recycling Company EERC: The Company is planning to provide a turnkey solution for recycling and refining of PCB; however, so far the company is only dismantling the electronic equipment. According to the company owner, the integrated facility shall be installed and ready for operation (PCBs processing) by the end of 2017.
- RECYCLOBEKIA: The Company main activity is dismantling the electronic waste to obtain the PCBs for export. To date, the company is in the process of preparing the Environmental Impact Assessment Study to obtain the environmental permit to carry out its operation within environmentally sound operations.
- Green Core (previously called – Egyptian Recycling Company ERC): The Company possesses an integrated WEEE processing line that includes: WEEE dismantling, PCBs grinding and metal separation from plastic and fiber, smelting induction furnace, separation basins for metals separation and separation of precious metals. The process efficiency is not identified yet the line is still in probation stage.
- ECO/ Spear Ink Company: The Company offers a complete line of tools and supplies for the refilling process of ink cartridges. To date, the Company is in the process of establishing a new facility for WEEE processing within an environmental sound process. The company manager is also trying to establish Dr. WEEE collection system through an app. Dr. WEEE, that facilitates the collection, dismantling, and sorting of e-waste. He partners with private and public entities.
- Wasteology (Recently merging to the market as environmentally friendly); the Company did not start operation yet.

Most of the currently operating companies receive the WEEE (mostly electronic waste) from collectors, dealers or from producers. They then dismantle, classify and stockpile the waste until further treatment of fractions to produce the elements included such as precious and base metals; part of the dismantled fractions is recycled inside Egypt while others need further refining abroad since this process does not exist in Egypt. This issue needs further investigation, which is part of the current task scope.

The current task is part of the framework agreement of Sustainable Recycling Industries (SRI) project being implemented by the Swiss Federal Laboratories for Materials Sciences (EMPA) as mandated by the State Secretariat of Economic Affairs (SECO) of Switzerland. The aim of the task is to map (the formal sector) and the licensed & sound recycling companies for end-processing in Egypt for each separate fraction, and delineate as appropriate the best possible local beneficiation. For fractions with no solution in Egypt, map and propose end-processing facilities to be used outside of Egypt – as receivers of material from the new formal SMEs. The detailed scope of work entails the following:

- Identifying fractions of IT equipment (Desktop, laptops, mobile phones, landline phones, printers, etc...)
- Identifying the licensed & sound recycling companies for end-processing in Egypt for each separate fraction
- Delineating as appropriate the best possible local fraction purchaser and the average expected prices
- Identifying the fractions with no recycling solution in Egypt
- Identifying and proposing end-processing facilities to be used outside of Egypt as receivers of material

The report incorporates the following sections:

- An introductory section which is mainly the introduction and general background (the current section)
- Methodology and approach adopted to perform the work
- Core section of the study, which includes the survey results (updated in 2017) to identify the WEEE fractions, the licensed & sound recycling companies for end-processing in Egypt for each separate fraction and the best possible local fraction purchaser and the average expected prices
- The fractions with no recycling solution in Egypt shall be identified, the case shall be traced and detailed
- End-processing facilities to be used outside of Egypt as receivers of material shall be also identified

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Scope and Objective

Needs assessment of the E-Waste Sector in Egypt[1] study was carried out as part of the inception phase of the Sustainable Recycling Industries (SRI) project. This study was a contribution in the implementation of the multi stakeholder Green ICT Strategy of the Arab Republic of Egypt[2]. The study focused on the hotspots of the WEEE handling and recovery industry in Egypt. The conclusion of the assessment identified the strength, weakness, opportunities and threats of this business and accordingly, several initiatives were proposed in the form of work packages with the identification of areas where intervention is needed and feasible and indicated the topics needing further research.

As part of work package of the SRI Project, the current study will focus on the formal sector that recovers the WEEE in Egypt. Further details about the end fractions recycling facilities inside and outside Egypt shall be provided and integrated with the WEEE management system. The main objective of this study is to:

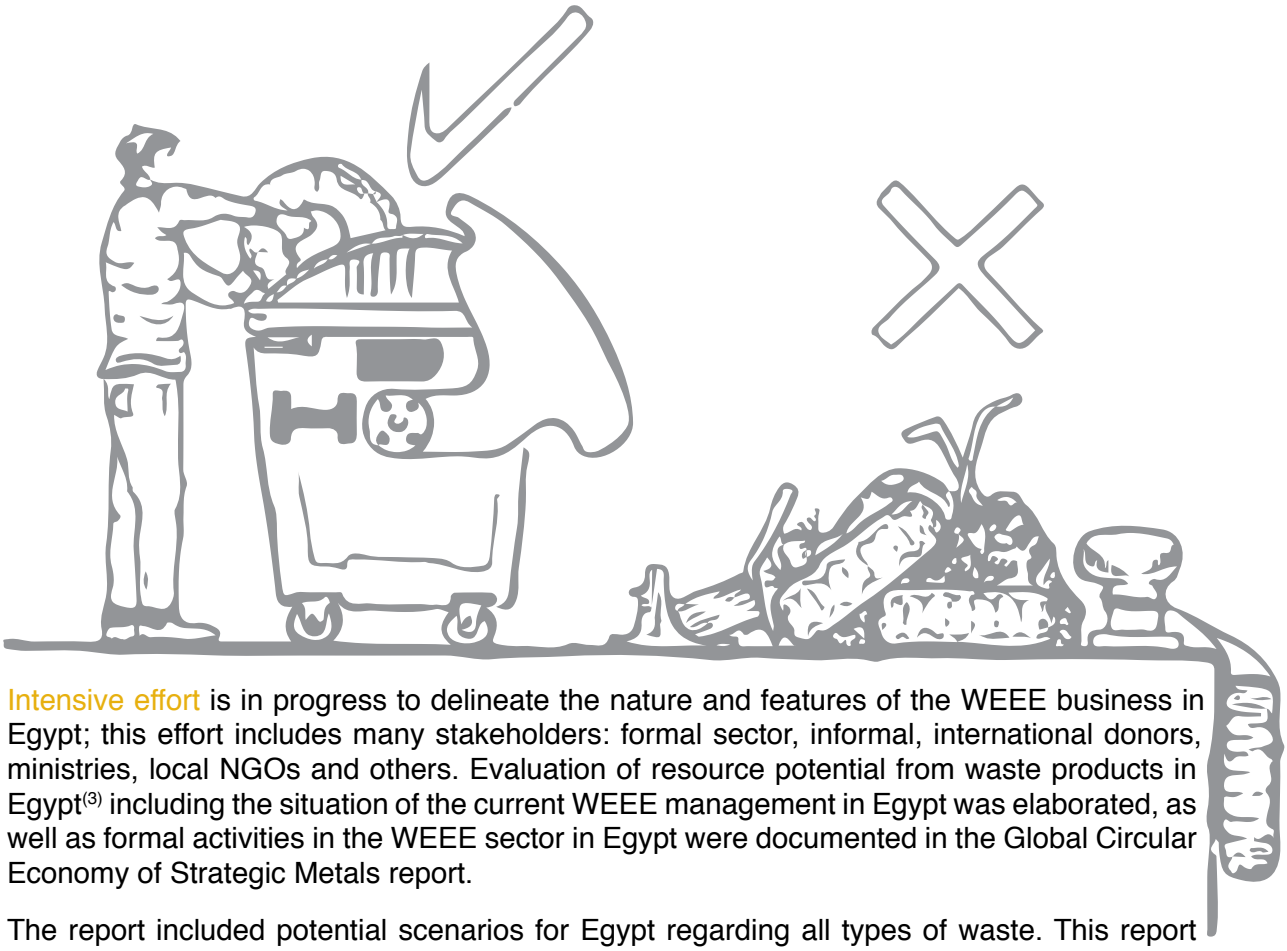
- Support the WEEE formal sector to sustain its work and plan for formal small enterprises that may be established in the future to work in an environmentally sound manner, especially in handling, dismantling and processing the WEEE
- Maintain the resources that feed certain industries such as metals smelters, plastic industry, refurbishing industry and others
- Recommend interventions that may boost the sector
- Identify external sources that might receive fractions for refining, which are not recyclable inside Egypt

1- Needs Assessment of the E-Waste Sector in Egypt – CEDARE – October 2011.

2- Green ICT Strategy. Sep. 5, 2011

3

Previous Work



Intensive effort is in progress to delineate the nature and features of the WEEE business in Egypt; this effort includes many stakeholders: formal sector, informal, international donors, ministries, local NGOs and others. Evaluation of resource potential from waste products in Egypt[3] including the situation of the current WEEE management in Egypt was elaborated, as well as formal activities in the WEEE sector in Egypt were documented in the Global Circular Economy of Strategic Metals report.

The report included potential scenarios for Egypt regarding all types of waste. This report was a milestone that triggered further action to assess the needs of the WEEE business in Egypt. Since the plastic of different types is a major fraction in the WEEE a study marking out the recycling options for WEEE plastic components[4] was conducted. This report covered a broad spectrum of issues concerning the challenge and shows possible solutions based on literature and desktop research as well as numerous interviews with company representatives from the related recycling sector. The report focused on the challenges in the plastic fraction recycling especially the Flame Retarding component (BFR – Brominated Biphenyl Ethers), which is classified as Persistent Organic Pollutant as per Stockholm Convention[5]; accordingly, the Authors proposed how to deal with BFR containing plastics. The GIZ published a Country Report on the Solid Waste Management in EGYPT[6]. The report covered several issues including: Legal and institutional framework, strategies and planning, collection treatment and disposal in Egypt including WEEE, private sector involvement.

Monthly reports are published by the Egyptian Ministry of Communication & Information Technology (MCIT) to review a number of ICT indicators[7] in Egypt; namely Mobile Phones, Fixed Phones, Internet, ICT Sector, ICT Sector's Role in Development, and Post. Assessment of E-Waste Management in Egypt[8] is currently on going to be published by the end of 2016. MCIT has developed a program to enhance Egypt's strategy towards the management of the WEEE[9].

3- Global Circular Economy of Strategic Metals - the Best-of-Two-Worlds Approach (Bo2W) – July, 2014

4- Global Circular Economy of Strategic Metals - Best-of-Two-Worlds Approach (Bo2W) – October, 2014

5- Stockholm Convention: Amendments to Annexes A and C adopted in 2015

6- Country Report on the Solid Waste Management in Egypt – April 2014

7- "ICT Indicators In Brief: Monthly Issue"

8- Eco ConServ - 2016

9- Egyptian Green ICT strategy; Pillars-Partners-Programs 2010 - 2018

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Methodology

In order to achieve the study objective, the following steps were followed:

- Basic information about the formal sector that manages the WEEE was collected from the literature detailed in the previous section
- Field visits were conducted to stakeholders at their facilities in the Greater Cairo area, for direct interviews and data collection
- Site visits to waste recyclers (smelters, industries that use WEEE fractions and others)
- Information on production of Electrical and Electronic Equipment (EEE) was collected through meetings with waste producers such as Orange, Ericson, home appliances production facilities (Toshiba, Universal, Goldi, Electrolux, etc.) During the meeting we discussed the following:
  - What is the type of waste
  - The amount of waste produced per year
  - Where the waste goes
- A questionnaire was used to collect comprehensive information related to the formal sector (Attachment 1)

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WEEE Waste Management in Egypt

The WEEE Waste is managed by:

- **Formal sector**: The sector includes companies and entities that are identified as tax-paying business entities and who deal with the EEE-waste (mainly electronic waste) as legitimate recyclers for environmentally-sound treatment. They are formally registered at the Governmental Authority of Concern through commercial register and tax card, and they acquired an environmental permit to perform the WEEE recycling in an environmentally sound process.

- **Informal sector**: The sector includes all sort of entities that consist of self-employed collectors who travel door-to-door, using cash with no invoices to purchase a variety of used waste; these entities are not registered at any Governmental Authority. It is the dominating sector in the business of EEE Waste management in Egypt – details of this sector are out of this report scope.

The Following Table shows the details of the formal sector for WEEE in Egypt. The sector includes several types of WEEE management entities, which are:

- Waste recyclers that dismantle and process the WEEE components such as computers and all elements containing metals to obtain fractions for further processing
- Merchants that collect all sort of WEEE and fractions for export

The recyclers of this sector are dealing with components of the equipment that produce certain fractions and metals. They do not use bulk components such as CRT, LCD, bulk plastic frames, etc. The next Table includes full information about the sector.

Table 1: Details of the Formal Sector in Egypt

No.	Company	Location	Start Date	Activity
1	International Technology Group (ITG)	6 of October Industrial City	2010	Dismantling, mechanical processing and grinding the PCBs. They have an induction furnace for smelting the fractions (this facility is not currently operating. A chemical refining facility is in the trial stage. The company facility works in environmentally friendly conditions and cares about the workers' health and safety, as all workers are protected with PPEs during work. Dust collection system is installed to collect the emitted dust resulting from the material shredding process
2	Egyptian Electronic Recycling Company (EERC)	6 of October Industrial City	2013	The Company operates in refurbishment and dismantling of E-Waste. The dismantling process starts from certain level and does not include the full equipment. They do not deal with CRTs or LCDs. Through the site visit we observed that the company facility works at an environmentally friendly conditions and cares about the workers' health and safety, as all workers are wearing PPEs and working according to defined instructions posted on special boards inside the workplace. As per the owner, the workers are trained how to follow these instructions.
3	Recyclobekia	Head office at Maadi (the Company has a large storage facility at Maryouteya area)	2011	The Company has no mechanical recycling facility; it collects the dismantled fractions (mainly PCBs). The collected fractions are partially dismantled and sold for further processing and recycling abroad. The company offers data destruction services and provides the E-Waste collection service for free
4	Green Core (previously called Egyptian Recycling Company ERC)	15 May Industrial City	2015	The Company possesses an integrated WEEE processing line that includes: WEEE dismantling, PCBs grinding and metal separation from plastic and fiber, smelting induction furnace, separation basins for metals separation and separation of precious metals. The process efficiency is not identified yet as the line is still in probation stage.

No.	Company	Location	Start Date	Activity
5	ECO/ Spear Ink Company	Alexandria	2012	The Company offers a complete line of tools and supplies for the refilling process of ink cartridges. To date, the Company is in the process of establishing a new facility (ECO) for WEEE processing within an environmental sound process. The company manager is also trying to establish Dr. WEEE collection system through an app. Dr. WEEE, that facilitates the collection, dismantling, and sorting of e-waste. He partners with private and public entities.
6	Wasteology	Pyramids Gardens	2016	The company is currently under construction; according to the owner, he plans to offer end-to-end solution for e-waste management

As shown from the previous Table that the recyclers of the formal sector are not only dealing with full equipment, but they often start dismantling from components that contain metals and PCBs.

The survey revealed that the main sources that generate EEE waste are classified in the following Table:

Table 2: WEEE Sources in Egypt

No.	Company	Location	Activity
1	Oracle	Smart Village	Computers software
2	Orange	Smart Village	Telecommunication operator
3	Vodafone	Smart village	Telecommunication operator
4	Etisalat	Fifth settlement, down town	Telecommunication operator
5	Households	All over Egypt	
6	Governmental Entities	All over Egypt	
7	Banks	All over Egypt	
8	EEE producers	All over Egypt	
9	Others		

The following Figure shows the management sectors & dealers flow as well as the WEEE flow through the sectors of concern:

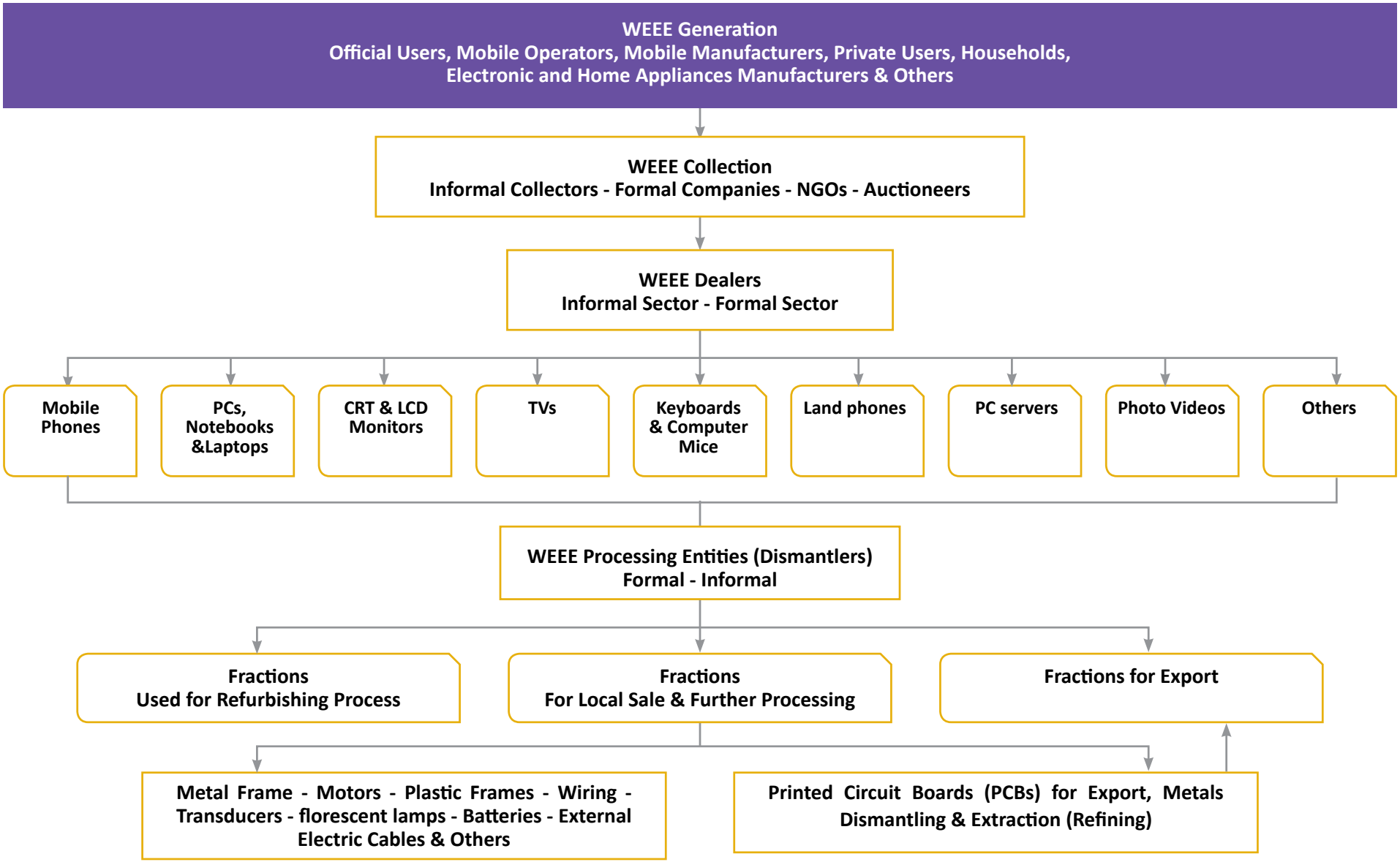


Figure 1: Flow of WEEE

6

Fractions of EEE Waste[10]

10- EERC, RECYKLOBIKIA, ITG

6-1 Type of Fractions

Electrical and electronic equipment incorporates several fractions composed of different materials. These materials range from being precious, rare, basic, to materials of limited value or even hazardous. The bulk materials such as iron, aluminum, plastics and glass account for over 80 weight percentage, while valuable materials are found in smaller quantities but are still of high value; in addition, hazardous elements exist with small quantities, but they cause adverse effect to the handlers. The material composition of different equipment is often similar, but the percentage of different components can vary a lot.

Precious metals such as gold, platinum and silver, and base metals such as copper, aluminum and iron, in addition to the rare metals such as palladium are valuable substances which turn recycling of EEE-waste in general and the Electronic Waste in particular into a profitable business opportunity. On the other hand, the recycling of hazardous substances such as lead, arsenic or brominated flame retardants are critical and pose serious health risks and environment dangers if not properly handled.

WEEE fractions contain various amounts of those valuable substances. Most of the valuable substances are found in printed circuit boards PCBs, which exist in relevant quantities mainly in the categories of office equipment, information and communication equipment as well as entertainment and consumer electronics. Besides, well-known precious metals such as gold, silver, platinum and palladium, also scarce materials like indium and gallium start to play an important role, due to their application in new technologies such as flat screens.

The following matrix presents the fractions of WEEE (Desktop, laptops, mobile phones, landline phones, printers, etc...). More than 80% of the weight consists of silica (glass), plastics, iron and aluminum. Precious and scarce materials account for only a small percentage of the total weight. Nevertheless, the concentration of such metals, such as gold, is higher in desktop computers and mobile phones than found in naturally occurring mineral ore.

Table 3: Fractions of EE Equipment

Equipment \ Fractions	Base & Key Board	Monitor (CRT / LCD)	Metal Frame	Motor	Plastic Frame	Wiring	Transducers	Mother Board	Fluorescent Lamp	Lead Battery	Lithium Batteries	External Electric Cables
TV		•			•	•	•	•				•
Desktop/PC	•		•	•	•	•	•	•	•			•
Monitors		•	•		•	•		•	•			•
Laptop	•	•		•	•	•	•	•	•		•	•
Mobile Phone					•	•		•			•	
Key Board & Computer Mouse	•				•	•		•				
Land Phone					•	•	•	•			•	•
Printer				•	•	•	•	•				•
PC/Servers			•	•	•	•	•	•		•		•
Photo/Video					•	•	•	•			•	•
Copiers	•		•	•	•	•	•	•				•

6-2 Composition of WEEE Fractions

Table 4: Composition of WEEE Fractions

Components / Fraction	Precious Metals: Gold & Silver	Copper	Aluminum	Cables: Copper	Ferrous Metal (Iron)	Cables Plastic	Rare Metals	Lead	Tin	Plastic	Brominated Plastic	Glass	Fire Retardant	Silicon	Mercury	Americium	Barium	Cadmium	Nickel	Cobalt	Arsenic	Lithium	PCB Oil
PCB	•	•	•		•		•	•	•	•			•	•		•							
Metal Frame					•																		
CRT Monitor		•	•		•			•	•	•		•	•	•			•	•	•	•			
LCD Monitor		•	•							•		•	•		•								
Florescent Lamps	•	•	•					•		•	•	•	•		•			•					
Lead Batteries								•		•											•		
Lithium Batteries									•	•												•	
External Electric Cables		•				•																	
Wiring		•	•			•																	
Motors		•			•					•													
Plastic Frame										•	•		•										
Transducers / Capacitors			•							•													•

Heavy Metal Hazardous Material

Valuable Non-hazardous Materials

Generally, metals in EEE-waste can be grouped into precious metals (PMs), platinum group metals (PGMs), base metals (BMs), metals of concern (MCs), and scarce elements (SEs). The following Table shows each material and where it exists in the equipment. The handling of these materials during dismantling and refining processes is rather safe as long as the workers are trained and equipped with the proper Personal Protection Equipment (PPE).

Table 5: Valuable and Non-Hazardous Materials in the Fractions

Material	Usage
Gold	Primarily in all boards as pure metal or plating of connectors
Silver	Primarily in all boards
Copper	Copper wire, printed circuits board tracks, component leads
Aluminum	Nearly all electronic goods using more than a few watts of power electrolytic capacitors
Geranium	Bipolar junction transistors
Iron	Steel chassis, cases and fixings
Lithium	Lithium ion batteries
Silicon	Glass, transistors, ICs, printed circuit boards
Zinc	In galvanized steel parts as coat

Hazardous Materials

Some hazardous materials exist in the WEEE fractions; they are classified as follows:

- Heavy metals: Such as Lead, Mercury, Cadmium, Tin, Antimony and Americium. Despite of value, these metals are hazardous, and should be handled with due care (workers should wear the proper personal protection equipment (PPE).
- Brominated Fire Retardants: These materials exist with plastic inside some fractions. They are classified as Persistent Organic Pollutants (POPs) by Stockholm Convention[11]. Like all POPs, these chemicals possess toxic properties, resist degradation, and bio accumulates They are transported through air, water and migratory species, across international boundaries and deposited far from their place of release, where they accumulate in terrestrial and aquatic ecosystems.
- Liquid hazardous substances used in processing the fractions such as sulfuric acid.

The following Table shows the hazardous materials that exist in each fraction.

11- Revised draft guidance for the inventory of polybrominated diphenyl ethers under the Stockholm Convention, March 2015

Table 6: Hazardous Materials in Fractions

Fraction / Hazardous Material	Mobile Phones	PCB	CRT	Servers Batteries	Ni/Cd Batteries	Solders	Plastic casing	Flat Screens	Thermostats	Sensors	Relays & Switches	Lamps	Smoke detector	Toner Cartridge	Refining Process
Lead			•	•		•									
Mercury	•	•						•	•	•	•	•			
Cadmium					•										
Tin		•				•									
Antimony							•								
Americium													•		
BFR: - Hexabromobiphenyl (HBB) - polybrominated diphenyl ethers (PBDE)							•								
Sulfuric Acid															•
Toner liquid														•	

6-3 WEEE Processing Flow

E-waste recycling consists of four main steps: collection, sorting, dismantling, refining and end processing. Each step is critical for the recovery of metals and recycling economy. End of life electronic components are sorted at the collection facility where useable components are returned to the consumer supply chain. Preprocessing of the waste is one of the most important steps in the recycling chain. After collection, the expired equipment is manually dismantled and individual components are tested and isolated from the waste. During the early stage, housing, wires, drives, and other components are liberated. Mechanical processing is an integrated part of this stage where EEE-waste fractions are shredded into pieces using hammer mills and alike machines. Metal dust is emitted during these processes; accordingly, dust collection equipment should be used to render the process safe. Metals and non-metals are separated during this stage using techniques similar to that used in the mineral dressing such as screening, magnetic, eddy current and density separation techniques. Separation of PMs is performed through a hydrometallurgical process, which results in liquid waste to be treated before discharge. One of the final stages in the recycling chain is the metals smelting and nonmetals like plastics recycling.

Due care should be considered during the waste processing due to the handling of heavy metals and hazardous materials (Table 6 shows the materials of concern). In addition, many byproducts could result from the waste processing; some of them are hazardous. It is a common practice in Egypt that the BFR are dumped in the municipal dumping sites since it should be dumped in the hazardous waste dumping site. The following Figure shows the process flow diagram that describes the whole process. It was noticed during the survey that the formal sector does not receive or deal with the CRT and LCD or light tubes since they are of no use for them. These fractions are left to the informal sector to deal with; however, the informal sector sells the dismantled CRT to special dealers (used glass dealers), which sell the glass to the glass manufacturing companies (formal companies).

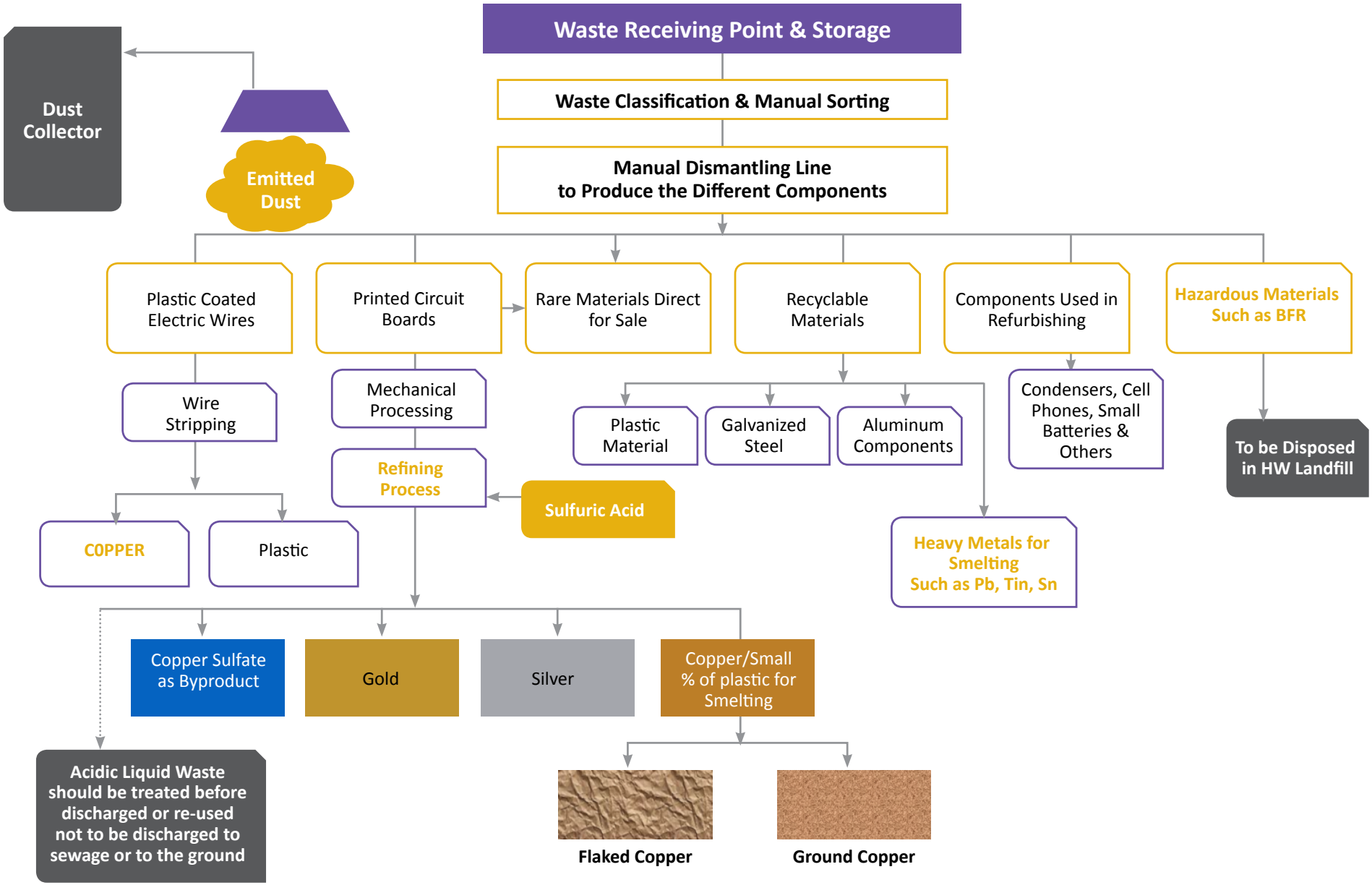


Figure 2: Process Flow Diagram of the Fractions Processing

6-4 Types of Materials Resulting from the E-Waste Processing

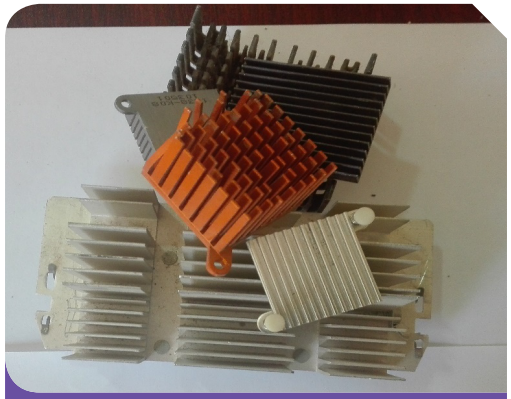
The following pictures show typical materials fractions collected from the visited companies during the site visits:

Ground Copper

Chapped Copper

Copper Cabels

Figure 3: Processed Metals Obtained (different types of copper fractions)



Aluminum

Chapped Copper

Servers & Mobile Station Batteries

Figure 4: Bulk Fractions

Ground Black Plastic

Ground Plastic

Figure 5: Processed Plastic

Copper Sulfate

Liquid Copper Sulfate produced from copper extraction process

Figure 6: Produced Byproduct

The above products were sent to many Licensed & Sound Recycling Companies for End-Processing to test the yield and to obtain a value for each product. In further discussion with these companies, they may accept any product (even in bulk) as long as the plastic content is not large enough to affect the furnaces during the smelting process, so any product should be tested before acceptance.

6-5 Printed Circuit Boards

No quantitative data about of the amount of precious, rare or base metals in the PCBs was available during the mapping of the sector; accordingly, a literature survey was carried out to identify the percentage of precious, rare and base metals included in the PCB since it is the fraction of prime value in the WEEE recycling; it was found that the PCBs exist in WEEE (in the electronic waste in particular) in various amounts. Some devices contain PCBs up to 22% of their mass, while others are limited content 2%; the reported average value is 3%[12],[13]. However, the (PCB) is the element of prime value in the WEEE as it contains a variety of precious, rare and base metals that are of value. The boards are classified to several categories as per the content of PMs such as connectors, BMs such as solders (Cu, Pb and Sn), construction elements such as iron, nonmetals and organic materials. Intensive effort was exerted since 1993 to identify the metals contents in the PCBs. The following Table shows a brief summary of this effort; it shows that the metal content varies from 20% to 40% by weight and averages 30%; the latest research of 2014 shows that the average metal content was 27%. This variation can be explained by the wide range of board types used, and the change in the composition of PCBs over the years. The content of precious metals such as silver and gold in PCBs has fallen in recent years. While gold contents above 1000 ppm were reported in 1993 and 1995, values reported since then are all below 1000 ppm, they could reach as low as 100 ppm. The following Table shows the typical variation of PCBs composition over the years[14].

Accordingly, the expected metal content in the PCBs shall depend on the type and age of the collected equipment and the market price of these fractions shall accordingly vary. Obviously older equipment shall contain more precious metals; this is obvious from the next Table where the numbers in the last columns are projected from data of 2014.

12- NI M., XIAO H., CHI Y., YAN J., BUEKENS A., JIN Y., LU S. Combustion and inorganic bromine emission of waste printed circuit boards in a high temperature furnace. Waste Manage. 32, 568, 2012.

13- SOHAILI J., MUNIYANDI S., MOHAMAD S. A Review on Potential Reuse of Recovered Nonmetallic Printed Circuit Board Waste, Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 2, (6), 946, 2011.

14- Characterization of Printed Circuit Boards for Metal and Energy Recovery after Milling and Mechanical Separation, 2014.

Table 7: Typical Variation of PCBs Composition over the Years

Metal content	a	b	c	d	e	F	g	h	i	j	k	l	m	n
Cu (%)	19	20	22	12.5	26.8	15.6	19.66	28.7	27.6	14.6	12.58	19.19	28	14.2
Al (%)	4.1	2	–	2.04	4.7	–	2.88	1.7	–	–	2.38	7.06	2.6	–
Pb (%)	1.9	2	1.55	2.7	–	1.35	3.93	1.3	–	2.96	2.44	1.01	–	2.50
Zn (%)	0.8	1	–	0.08	1.5	0.16	2.10	–	2.7	–	–	0.73	–	0.18
Ni (%)	0.8	2	0.32	0.7	0.47	0.28	0.38	–	0.3	1.65	0.39	5.35	0.26	0.41
Fe (%)	3.6	8	3.6	0.6	5.3	1.4	11.47	0.6	2.9	4.79	3.24	3.56	0.08	3.08
Sn (%)	1.1	4	2.6	4.0	1.0	3.24	3.68	3.8	–	5.62	1.41	2.03	–	4.79
Sb (%)	–	–	–	–	0.06	–	–	–	–	–	–	–	–	0.05
Cr (%)	–	–	–	–	–	–	0.005	–	–	0.356	–	–	–	–
Na (%)	–	–	–	–	–	–	–	–	–	–	–	–	–	0.48
Ca (%)	–	–	–	–	–	–	1.13	–	1.4	–	–	–	–	1.69
Ag (ppm)	5210	2000	–	300	3300	1240	500	79	–	450	–	100	135	317
Au (ppm)	1120	1000	350	-	80	420	300	68	–	205	–	70	29	142
Cd (ppm)	–	–	–	–	–	–	–	–	–	–	–	–	–	1183
K (ppm)	–	–	–	–	–	–	–	–	–	–	–	–	–	180
In (ppm)	–	–	–	–	–	–	500	–	–	–	–	–	–	–
Mn (ppm)	–	–	–	–	–	–	9700	–	4000	–	–	–	–	81
Se (ppm)	–	–	–	–	–	–	–	–	–	–	–	–	–	21
As (ppm)	–	–	–	–	–	–	–	–	–	–	–	–	–	11
Mg (ppm)	–	–	–	500	–	–	1000	–	–	–	–	–	–	–
Pd (ppm)	–	50	–	–	–	–	–	33	–	220	–	–	–	–
Co (ppm)	–	–	–	–	–	–	300	–	–	–	–	400	–	–
Ti (ppm)	–	–	–	–	–	–	–	–	–	–	–	400	–	–
Total Metals (%)	**31.9**	**39.3**	**30.1**	**22.6**	**40.2**	**22.2**	**46.5**	**36.1**	**35.3**	**30.1**	**22.5**	**39.1**	**31.1**	**27.6**

Key Note of the Table:
(a) Feldman (1993); (b) Menetti *et al.* (1995); (c) Iji *et al.* (1997); (d) Veit *et al.* (2002);
(e) Zhao *et al.* (2004); (f) Kim *et al.* (2004); (g) Wang *et al.* (2005); (h) Creamer *et al.* (2006);
(i) Marco *et al.* (2008); (j) Hino *et al.* (2009); (k) Das *et al.* (2009); (l) Yoo *et al.* (2009);
(m) Oliveira *et al.* (2010).

6-6 Environmental Concerns & Associated Hazard during Fractions Processing & Required Mitigation Measures

In addition to those valuable materials there are part of the various fractions; such materials are: Heavy metals, fire retarding materials and liquid produced from the refining process. These substances should be managed properly in order not to negatively affect either the workers or the environment as per the following Table that presents the adverse effect of the exposure to each material as well as the recommended mitigation measures required during handling. Each material safety data sheet (MSDS) was used to recommend the required mitigation measures.

Table 8: List of Hazardous Materials in Fractions, Associated Hazard and Protective Requirements

Material	Route of Entry to the Body	Associated Hazard and Adverse Health Effect	Mitigation Measures & Protective Requirements[15]
Lead	Inhalation & Ingestion	Affecting: - The Central Nervous System - Cardiovascular System - Reproductive System - Kidneys - Gastrointestinal System - Gingival System	- Provide exhaust or process ventilation to meet the required exposure limit - Use of proper PPE (dust resistant gloves, safety goggles, etc.) - Properly dispose the after use contaminated cloth - Workers should decontaminate their body contaminated organ before leaving the workplace - Half mask and air purifying respirator equipped with efficient filter - First aid should exist in place - Absolutely, no child labor is allowed
Mercury	Inhalation, Ingestion, Skin Contact, Eye Contact, Chronic Exposure & Aggravation of Pre-existing Conditions	- Harmful if absorbed through skin. Affects the kidneys and Central nervous system. May cause allergic skin reaction - Sensory impairment, dermatitis, memory loss, and muscle weakness - Danger! Corrosive. Causes burns to skin, eyes, and respiratory tract. May be fatal if swallowed or inhaled	- In case of accidental release ventilate area of leak or spill. Clean-up personnel require protective clothing and - Respiratory protection from vapor. - In case of Spills: Pick up and place in a suitable container for reclamation or disposal in a method that does not generate misting. Sprinkle area with sulfur or calcium polysulfide to suppress mercury. Do not flush to sewer Handling and Storage: - Keep in a tightly closed container, store in a cool, dry, ventilated area. - Protect against physical damage. Isolate from any source of heat or ignition. - Do not use or store on porous work surfaces (wood, unsealed concrete, etc.). Follow strict hygiene practices. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.
Cadmium	Inhalation, Ingestion, Skin Contact, Eye Contact, Chronic Exposure & Aggravation of Pre-existing Conditions	- May cause gastrointestinal irritation with nausea, vomiting and diarrhea - Ingestion may produce fluid loss, acute renal failure, and cardiopulmonary depression - Liver disease or skin disease may be at increased risk from exposure to this substance	- Use proper personal protective equipment - Vacuum or sweep up material and place into a suitable disposal container - Avoid generating dusty conditions - Remove all sources of ignition - Use a spark-proof tool - Provide ventilation

15- Reference to Material Safety Data Sheet (MSDS)

Material	Route of Entry to the Body	Associated Hazard and Adverse Health Effect	Mitigation Measures & Protective Requirements[15]
Tin	Inhalation, Ingestion, Skin Contact, Eye Contact	- Tin compounds have variable toxicity - Elemental tin and inorganic tin compounds have toxicity and are poorly absorbed when ingested - Some inorganic tin salts are irritating or can liberate toxic fumes on decomposition	<u>Accidental Release Measures</u> - Use proper personal protective equipment - Clean up spills immediately, observe precautions in the Protective Equipment section. - Sweep up or absorb material, then place into a suitable clean, dry, closed container for disposal. Avoid generating dust - Conditions: Provide ventilation.
Antimony	Inhalation, Ingestion,	- Carcinogenic potential	- Use proper personal protective equipment
Barium	Ingestion	- Brain swelling, muscle weakness - Damage to the heart, liver and spleen	- Use proper personal protective equipment
PBDEs, PBBs Polybrominated diphenyl ethers[16]	- Routes of potential human exposure to PBBs and PBDEs are ingestion, inhalation or dermal contact[17] - Under thermal treatment possible formation of dioxins and furans: Inhalation, Ingestion, Skin Contact, Eye Contact, Chronic Exposure & Aggravation of Pre-existing Conditions	- The U.S. Department of Health and Human Services (DHHS) states that PBBs are reasonably anticipated to be human carcinogens based on sufficient evidence of carcinogenicity from experimental animal studies - WHO, the International Agency for research on Cancer (IARC) classified PBBs as "probably carcinogenic[18] to humans" (IARC 2013) - Cause serious eye irritation - Cause skin irritation - May cause allergy or asthma symptoms or breathing difficulties if inhaled - May cause an allergic skin reaction - May cause respiratory irritation - Cause damage to organs through prolonged or repeated exposure: respiratory system	- Do not breathe dust/fume/mist/vapors - Use only outdoors or in a well-ventilated area - In case of inadequate ventilation wear respiratory protection - Wear eye/face protection - Wear protective gloves - Do not eat, drink or smoke when using this product - Wash thoroughly after handling - Contaminated work clothing must not be allowed out of the workplace - It is not recommended for recycling

16- EPA, (US - DHHS) Technical Fact Sheet – Polybrominated Diphenyl Ethers (PBDEs) and Polybrominated Biphenyls (PBBs) - January, 2014

17- U.S. Department of Health and Human Services (DHHS). 2011. "Report on Carcinogens: Twelfth Edition." http://ntp.niehs.nih.gov/ntp/roc/twelfth/roc12.pdf

18- World Health Organization, International Agency for Research on Cancer (IARC). 2013. "Agents Classified by the IARC Monographs, Volumes 1107-." http://monographs.iarc.fr/ENG/Classification/index.php

Material	Route of Entry to the Body	Associated Hazard and Adverse Health Effect	Mitigation Measures & Protective Requirements[15]
Polychlorinated biphenyls (PCB)	Inhalation, Ingestion	- Cancer, effects on the immune system, reproductive system, nervous system, endocrine system	- In case of inadequate ventilation wear respiratory protection - Wear eye/face protection - Wear protective gloves - Do not eat, drink or smoke when using this product - Wash thoroughly after handling - Contaminated work clothing must not be allowed out of the workplace
Chlorofluorocarbon (CFC)	Inhalation, Ingestion	- Deleterious effect on the ozone layer - increased incidence of skin cancer / genetic damage	- Do not breathe dust/fume/mist/vapors - Use only outdoors or in a well-ventilated area - In case of inadequate ventilation wear respiratory protection
Americium (Am) (Americium occurs naturally in uranium minerals, but only in trace amounts	Inhalation	- Radioactive element, it is toxic due to its radioactivity	- Do not breathe dust/fume/mist/vapors - Use only outdoors or in a well-ventilated area - In case of inadequate ventilation wear respiratory protection
Sulphur Acid	Inhalation, Ingestion and dermal contact	- Danger! Extremely corrosive. Causes severe burns and / or eye damage - Mist: Causes respiratory irritation. Harmful if inhaled - Harmful or fatal if swallowed - Reacts violently with water - Concentrated Sulfuric Acid will react with many organic materials and may cause fire due to the heat of the reaction - Not flammable, but reacts with most metals to form explosive/flammable hydrogen gas	Small Spill: - Cover with dry earth, sand or other non-combustible material or absorb with an inert dry material and place in a loosely covered plastic or other appropriate waste disposal container - If necessary: Neutralize the residue with a dilute solution of sodium carbonate, lime, or another suitable neutralizing agent Large Spill: - Stop leak if possible without risk. - Dike with dry earth, sand or other non-combustible inert material. - Prevent entry into sewers or waterways - Consider neutralizing the residue with sodium carbonate, lime, other suitable neutralizing agent - Ensure adequate decontamination of tools and equipment following clean up. - Comply with regulations on reporting releases dispose of waste material at an approved waste treatment/disposal facility, in accordance with applicable regulations - Do not dispose of waste with normal garbage or to sewer systems

7

Licensed & Sound Recycling Companies for End-processing in Egypt for each Separate Fraction

7-1 Details of Companies that Can Process Materials from Different Fractions

The main materials resulting from the fractions of the WEEE produced by the formal sector were detailed in sub-section 6.4. These materials could be locally recycled in companies (mainly foundries) of different types such as ferrous and non-ferrous materials production facilities. A full survey was carried out to identify the licensed & sound recycling companies for end-processing in Egypt for each separate fraction. Samples of the materials (ferrous and non-ferrous) were delivered to many of these facilities for testing and identifying the actual material yield after melting. The following Table presents the details of these facilities as a result of the survey:

Table 9: Licensed & Sound Recycling Companies for End-processing in Egypt for each Separate Fraction

No.	Company Name	Location	Classification	Smelting material	Product	Remarks
1. Public Works Sector to Process the Produced Metals						
1.1	General Metals	Cairo Governorate Helwan	Large Licensed	Copper, copper alloy materials (zinc, tin & lead) & Aluminum	Diversity of products	Company receives the raw materials by large quantities through auctions
1.2	Egypt Copper Works	Alexandria	Large Licensed	Copper	Diversity of products	Company receives the raw materials by large quantities through auctions
1.3	Egypt Cables Company	Qalyoubia Governorate Shoubra El Khemah	Large Licensed	Copper	Electric copper cables of different sizes	Company receives the raw materials by large quantities through auctions
1.4	Military Factory No. 63	Cairo Governorate Helwan	Large Licensed	Ferrous & Non-Ferrous: copper (copper alloy materials - zinc, tin & lead) & aluminum	Diversity of products	Company receives the raw materials by large quantities through auctions
1.5	Delta Steel Mills	Qalyoubia Governorate Shoubra El Khemah	Large Licensed	Ferrous material	Different steel products	Company receives the raw materials by large quantities through auctions
2. Private Sector Formal Companies to Process the Produced Metals						
2.1	Tawakol for Metallurgical Industries	Qalyoubia Governorate: - Shoubra El Khemah Facility (1) - El SAFA Facility (2)	Large Licensed	Ferrous & Non-ferrous materials: copper (copper alloy materials- zinc, tin & lead) & aluminum	Diversity of products	The company purchases the raw material by direct order from approved known sources The company received a sample from different materials (Flaked copper, ground copper, aluminum & steel) produced from the WEEE to identify the yield during the smelting process
2.2	Engineering Industries	Qalyoubia Governorate, Shoubra El Khemah	Medium Licensed	Ferrous & Non-ferrous materials: copper (copper alloy materials- zinc, tin & lead) & aluminum	Diversity of products	The company purchases the raw material by direct order from approved known sources The company received a sample from different materials (Flaked copper, ground copper, aluminum & steel) produced from the WEEE to identify the yield during the smelting process

No.	Company Name	Location	Classification	Smelting material	Product	Remarks
2.3	El Masreya for Copper Manufacturing - Ali Hefzy Factories	Cairo Governorate Helwan	Large licensed	Copper	Several copper products	The company can receive all types of cooper and copper alloys as raw material
2.4	El Amana Company	Qalyoubia Governorate: Qalyoub Facility Giza Governorate: 6 of October Facility	Large licensed	Copper and alloying elements such as zinc, tin and lead	Copper alloys products (Brass & Bronze)	The company can receive all types of copper and copper alloys elements as raw material
2.5	El Masreya for Lead Smelting, Refining and Manufacturing & Batteries Manufacturing	Sharkia Governorate: 10th of Ramadan Industrial City	Medium licensed	Secondary smelting of lead included in used batteries in addition to new batteries manufacturing	Lead ingots, lead alloys, lead pipes & lead oxide and lead batteries of different capacities	The company receives all types of used lead batteries
2.6	Lead Smelting, Refining and Manufacturing Factory	Qalyoubia Governorate, El Safa Industrial Estate, Abou Zaabal	Medium	Secondary smelting of lead included in used batteries	Lead ingots, lead alloys, lead pipes & lead oxide	The company receives all types of used lead batteries
3. Private Sector Small Informal Foundries						
3.1	Cluster of copper & Aluminum foundries in Qalyoubia Governorate	Shoubra El Khemah	Small	Copper alloys (scrap) and aluminum	Diversity of products	The companies receive all types of non-ferrous scrap

No.	Company Name	Location	Classification	Smelting material	Product	Remarks
3.2	Cluster of copper smelters in Cairo Governorate	El Tounsy Area	Small	Copper alloys (scrap)	Diversity of products	The companies receive all types of copper and copper scrap
3.3	Cluster of copper smelters in Cairo Governorate	El Basateen Area	Small	Copper alloys (scrap)	Diversity of products	The companies receive all types of copper and copper scrap
3.4	Several sporadic small smelters in Cairo Governorate	El Gamaleya, Mansheyet Naser, and Darrasah area	Small	Copper alloys (scrap)	Diversity of products	The companies receive all types of copper and copper scrap
3.5	Cluster of copper smelters in Alexandria Governorate	Different locations in Alexandria	Small	Copper alloys (scrap)	Diversity of products	The companies receive all types of copper and copper scrap
3.6	Cluster of copper smelters in Dakahleya Governorate	Meet Ghamr area	Small	Copper alloys and aluminum	Diversity of products	The companies receive all types of non-ferrous materials
4. Private Sector Licensed Companies to Process the Byproducts Resulting from Processing the PCBs						
4.1	Kafr El Zayat Chemical Companies	Kafr El Zayat	Large	Copper Sulphate (Solid Phase)	Several chemical products	

Classification of the Ministry of Industry

- Small Company: Employs Less than 50 employees
- Medium: Employs 50 to 100 employees
- Small: Employs more than 100 employees

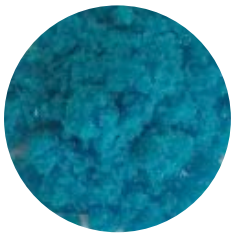
7-2 Products Quality and Market Value

During the site visits we collected samples of copper, aluminum and iron from the recycling companies to be sent to Licensed & Sound Recycling Companies for End-processing in Egypt for each Separate Fraction. This was done to identify the quality of each product in order to evaluate its market price. The samples such as copper, aluminum and iron were melted within the normal process of the recycling facility to identify the yield of each material; the price of each material was accordingly evaluated as Egyptian Pound/ton. This exercise was carried out with medium size formal private sector companies that have smelting facilities (item No. 2.1 to 2.4 in Table 9) that could accommodate large tonnage per year of copper, aluminum and iron. The interesting fact is that these companies can purchase the metals by direct order from the recyclers. The smelting capacity of each facility was checked, and it proved to accommodate large quantities that could reach 1000 ton/year for all companies. The following Table shows the results of this exercise:

Table 10: Yield of Each Material and Corresponding Market Price

No.	Type of Material	Source of Material	Yield during Melting	Market Price EGP/Ton July 2016	Remarks
Non Ferrous Materials					
1	Copper Cables of diameter 0.5 to 1.5 mm	Several sources	> 90%	70,000	This value is dynamic in the increasing side
2	Copper Cables of diameter > 1.5 mm 	Several Sources	> 90% High purity copper if properly stripped	75,000	
3	Tin (solder material in PCBs)	Several sources	High purity produced from the PCBs	300,000 – 350,000	Extracted amount from a PCB is limited to grams
4	Ground Copper: 	ITG	70 to 75%	Value could not be identified	Plastic content in the sample affected the yield, accordingly this fraction is currently very difficult to market unless the end user has the proper pollution control equipment installed over the smelting furnace

No.	Type of Material	Source of Material	Yield during Melting	Market Price EGP/Ton July 2016	Remarks
5	Shipped Copper (Flakes): 	ITG	60 to 65%	Value could not be identified	The plastic content is higher than the previous type in addition to plastic dust content. The same condition as the previous fraction applies
6	Aluminum: 	EERC	80 to 85%	25,000	Heat Sink material of high purity
7	Used Lead Batteries: 	EERC	60 to 70%	Value is identified by the international stock market at the sale date	The yield represents the lead obtained from the lead smelting process
Ferrous Materials					
8	Non Galvanized quality Steel:	Several sources	80 to 85%	6,100 to 6,300	The yield depends on the type of the sheet metal
9	Galvanized Steel: 	EERC	70 to 75%	5,900 to 6,000	
Non Metals					
10	Black Plastic: 	ITG	Up to 80%	Variable prices	

No.	Type of Material	Source of Material	Yield during Melting	Market Price EGP/Ton July 2016	Remarks
11	Solid Copper Sulfate: 	ITG	Depends on the copper extraction Process	Undefined price	
12	Copper Sulfate Solution: 	ITG	Depends on the copper extraction Process	Undefined price	

8

Best Possible Local Fraction Purchaser and the Average Expected Prices

8-1 Flow of the WEEE in the Egyptian Market

The flow of the WEEE in the Egyptian market is as follows:

First Stage: The process starts by the collection system, mainly dominated by the informal sector. The source of electronic equipment is mainly:

- Governmental organizations such as ministries, governmental service offices, public hospitals, universities and others
- Corporate companies such as mobile service providers
- Houses including households
- Small and medium private enterprises
- NGOs

Second Stage: This process is followed by the dismantling of the equipment which is carried out in both formal and informal sectors. The dismantling process by the formal sector is carried out at strictly applied environmental measures to protect the worker and the environment (according to what was observed at ITG & EERC).

Third Stage: Further processing such as refining. This requires the export of the fractions (mainly PCBs) abroad for further refining and extraction of precious, rare and base metals.

8-2 Circulation of WEEE in the Egyptian Market

The WEEE reaches the end users through the following routes:

Governmental and Public Sector Auctions:

These auctions are announced and held regularly to avoid stockpiles. No prerequisite for auction attendance except the commercial register and the tax card of the participating entity. No environmental permit is required. The responsible entity on this type of auction is the "General Authority of Government Services"; it is affiliated to the Ministry of Finance. It is authorized to control and follow-up the various sales programs of the governmental agencies; it conducts various sales operations on behalf of government agencies comprising the auctions of used stockpiles including the used electronic equipment.

No obvious rules that govern these auctions exist; this allows the informal sector to dominate these auctions and deprive the formal sector from obtaining the WEEE.

Corporate Companies Auctions:

The corporate Companies follow the same procedure of the General Authority of Government Services regarding the auction procedure; this still increases the Informal sector monopoly on the WEEE.

NGOs Auctions:

The NGOs receive WEEE as donation from several sources as the corporate companies. They sell this product through auctions to mainly the informal sector.

Industrial Companies:

The industrial companies from all sectors follow the same previously described procedure.

8-3 An Overview on the Economic of the WEEE in Egypt

The following Table shows the best possible local equipment collected from the local market and produced fractions and materials and the average expected prices in the market based on the collected data during the course of the current study[19]. The flow of most important fractions is detailed, and local prices are shown. Furthermore, dealers involved in each step are listed and average market price for each equipment, fractions and components is reported.

19- EERC & RECYCLOBIKIA (as main companies in the formal sectors)

Equipment	Receiver	Exporter	Expected Price (USD/Ton)	Refining Companies outside Egypt
TV	Dismantlers (prices in the previous column are offered by Dismantlers) As for Refurbishers (see Figure 7)	N/A	N/A	N/A
Desktop Pentium 1,2,3				
Desktop Pentium 4,5				
Monitor CRT				
Monitor LCD				
Laptop				
Mobile Phone without battery				
Mobile Phone battery				
Keyboard & mouse				
Land Phone				
Printer				
PC Servers G2/G3/G4/new				
Photo Video				
Copier				

Fractions	Price (EGP/Ton)	End Recycler	Exporter	Expected Price (USD/Ton)	Refining companies outside Egypt
Cables (Copper) starting from 0.5 to 4 mm diameter	10,000-50,000				
Metal Frame (Iron)	1000-2000	Foundries Table (9)	N/A	N/A	N/A
Batteries (Lead Acid)	4000-6000	Foundries Table (9)			
Motor	Upon its size	Refurbishers			
Processors	Dynamic price				
Rams	450,000	Recyclers			
Mobile phone PCBs	370,000	Recyclers			
PCB Pentium 2,3	105,000	Recyclers			
PCB Pentium 4 and higher	53,000	Recyclers			
Plastic Frame	800	Recyclers			
CRT Board	7,000	Recyclers			
LCD, LED Boards - Medium Grade	20,000 : 30,000				
CRT Board - Low Grade	2,500				
Electric Equipment Board - Low Grade	2,500				
CPU	70 - 80 /Unit				
Batteries (Lithium Ion)	4000 - 6000	Exported Directly	Some recyclers		

The Table also shows that the prices of older equipment such as computers (Pentium 1,2 and 3) are of higher values than Pentium 4 and 5 because of their higher contents of precious, rare and base metals. Same applies to mobile phone boards. This goes along with the information reported in the literature and shown in Table 7. An estimate of the refining cost and expected profit margin was discussed with a member of the formal sector that is involved in the export of PCBs for refining abroad (EERC). The cost of refining ranges between 1000 to 1300 Euro/ton including a percentage of the refined material shared by the refining company. Margin profit of this process depends on the deal between the client and the service provider; the percentage of the refined material shared is the key figure for this margin that ranges between 15 to 20%. This margin is mainly affected by the following:

- The refining company capabilities and the used technology
- The refining company credibility and reputation
- Type of fractions processed

8-4 Characteristics of the WEEE Collection System

The informal sector dominates the collection process; many participants are involved in the collection system such as:

- Waste producers
- Collectors
- Auctioneers
- Dealers
- NGOs

The main concern about the collection system is the monopoly of the goods mainly by the dealers that might affect the market price; however, the informal sector is the main supplier of used equipment to the formal sector; this justifies the dependency relation between the two sectors.

8-5 Characteristics of the Dismantling System

The dismantling process is carried out after the waste segregation and testing to separate the re-used equipment. This process is carried out by both the formal and informal sectors. The formal sector is interested in valuable fractions that produce valuable materials. These fractions are mainly PCBs, batteries, processors, iron frames, and copper cables. As for copper cables, the dismantling process is through stripping machines that exist in the informal copper smelters; it is recommended that the formal smelters possess these machines to strip the copper wires directly without passing by informal smelters. It is also recommended that the formal waste dismantlers possess these types of machine to strip the copper wires.

The main challenges of the dismantling process are the environmental measures that should be applied during dismantling of fractions, especially the ones that include hazardous substances. However it is mandatory, this issue is not of the informal sector concern.

Furthermore, except for few formal companies, the dismantling is carried out without any environmental protection to the workers that do not differentiate between the hazardous and non-hazardous fractions. The main concern behind this dismantling is to reach the fractions of value, and no care is taken towards the handling and disposal of the hazardous materials such as, for example, the fire retarding materials, CRTs and capacitors, which are handled without personal protection equipment (PPEs) and eventually ending at the wrong place. It is normal to dump these hazardous materials into the municipal dumping sites or even pile them in the streets and open areas.

This issue is of concern; SRI planned a program to train the formal sector people working in the WEEE handling and processing, especially the starts up (young Entrepreneurs), on how to handle and dismantle the WEEE in an environmental sound procedure and to use the proper PPEs and tools; in addition, the training shall also include how to distinguish between the hazardous and non-hazardous material.

8-6 Characteristics of the Metals Extraction & Refining Process

The refining process is mainly a process performed in both the formal and informal sectors used for precious and base metals extraction from the PCBs. This process is manually done in the informal sector, where hazardous substances such as acids and other dangerous materials are used at no control measures

The main challenge of the refining process efficiency, which is a target (especially for the formal sector) since if influences the quality of the extracted metals. From the survey carried out during the course of the current study, some refined metal samples like copper were collected and tested in many smelting facilities; low yield was recorded as a considerable percentage of plastic material was found to be attached to the copper. Nonetheless, the formal sector (ITG, EERC & RECYCLOBIKIA) is trying hard to improve the refining efficiency.

9

Fractions with no Recycling Solution in Egypt

9-1 Processing of PCBs

Before proceeding in the discussion of this item and as stated before, the formal sector does not process the CRT, LCD, plastic or plastic with flame retardant. It is only interested in components that produce metals such as computer case frames, PCBs and batteries, etc. As for capacitors or transformers if any exist they are sold to refurbishers, but how they use it; this was not clear in the survey.

From the previous discussion, it is obvious that the precious and base metals extraction from the PCBs and rechargeable Lithium batteries is not done in Egypt, so export of these fractions to be professionally processed and refined in specialized companies outside Egypt is a solution. The PCBs are sorted in different qualities, the CPU, the capacitors and the batteries are separated. The classification of the PCBs is shown in the next list.

The dismantled fractions are wrapped and then packed in Self Contained Units (SCUs) of 14 ton capacity ready for export. The PCBs and Batteries are processed in dedicated companies for precious & base metals refining where the metals are extracted then sold in London Metal Stock Exchange to the account of the exporter. The following diagram shows the flow of the PCBs during exporting process.

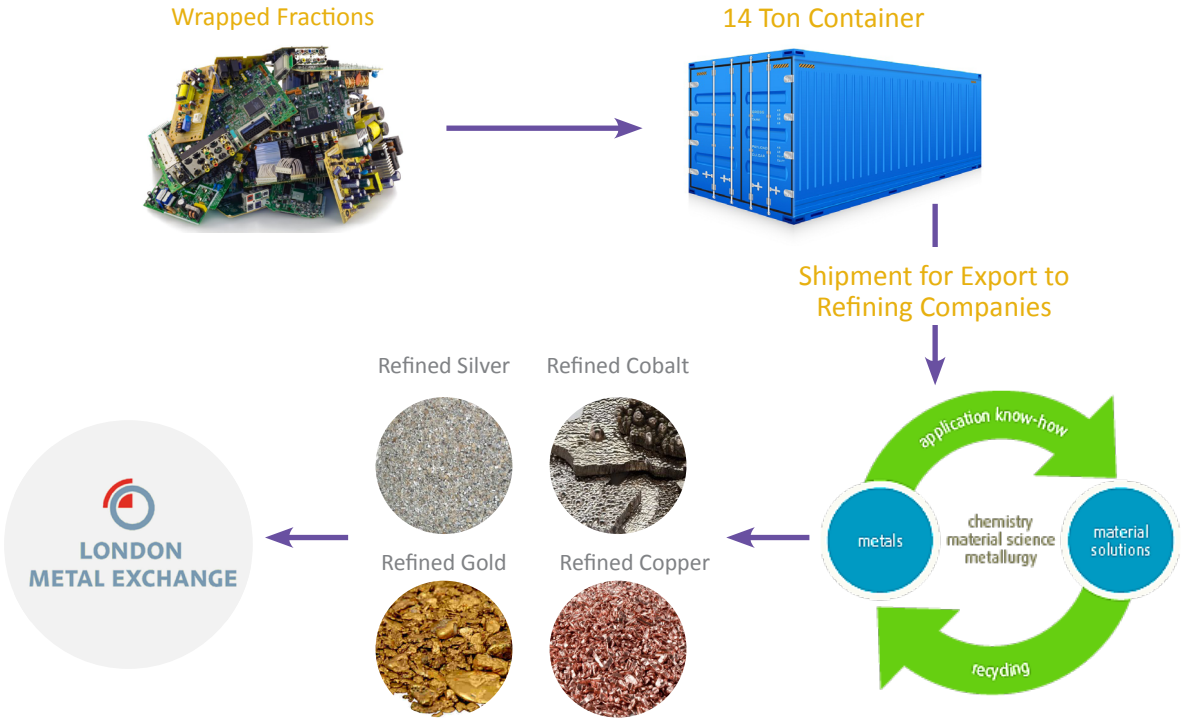


Figure 7: Fractions Export for Metals Refining

9-2 Challenges of Refining the Fractions Outside Egypt[20]

Outsourcing the fractions refining outside Egypt is not a straight forward process, as it needs planning and preparation of deals with the refining companies; following are the main concerns of this process:

- Exporter should reach a good feasible deal (feasible formula) with the refining facility in order to realize profit
- In order that the process is feasible, a large amount of PCBs in particular should be collected and packed in SCUs of 14 ton capacity. This needs a lot of investment
- The feasible quantity for outsource refining is about 50 ton/month (according to RECYCLOBIKIA). In case the exporter could not afford this quantity, more than one exporter could share the deal

20- RECYCLOBIKIA

10

Proposed End-Processing Facilities outside Egypt

The following Table shows a list of refining companies in several parts of the world. Some of these companies already deal with the formal sector in Egypt:

Table 11: List of Fractions Refining Facilities outside Egypt

Fractions Refining Companies				
#	**Company Name**	**Location**	**Website**	**Remarks**
Companies Separating and Refining Precious Metal				
1	Umicore	Belgium	http://www.umicore.com/	It is one of the large materials technology and recycling companies in the world. It is well known all over the world and has business with many of EEE formal sector producers and recyclers in Egypt
2	Aurubis	Germany	https://www.aurubis.com info@aurubis.com	Apart from copper and copper products, Aurubis also produces (refine) precious metals, such as gold and silver
3	Electro Cycling	Germany	http://www.electrocycling.de/en	Large company specialized in WEEE recycling
4	Cimelia Resource Recovery Pte Ltd	Singapore	www.cimeliaglobal.com	Singapore's largest E-Waste management, recycling, and PGM recovery and refining. They use BAIT (Best Available Innovative Technology) technique that comprises: - Precious metals (PGM) recovery and refining - Base metal recovery - CRT recycling - Jewellery Scrap/ Plating Filters Recycling & Refining Plant - Catalytic Converters Recycling & Refining Plant - Rechargeable battery recycling
5	JX Nippon Mining & Metals	Japan	http://www.nmm.jx-group.co.jp/english/	This company is mainly copper refining; the precious and rare metals contained in copper concentrates are recovered. They use a hydro-metallurgical process for recovery of precious and rare metals
6	Emak Refining and Recycling	Turkey	http://www.emakmakina.com/	E-waste fractions refining to recover gold, silver, platinum, palladium & waste liquid treatment

Fractions Refining Companies				
#	Company Name	Location	Website	Remarks
7	ELDAN Recycling	Spain	http://eldan-recycling.com/en	Retrieve e.g. various fractions of ferrous and SS (Stainless Steel), various fractions of non-ferrous metals (Aluminum, Copper, Brass and Printed Circuit Boards (PCB's)), refining material containing Copper, Brass, Zinc, Lead and Precious Metals (PM)
8	Donald McCarthy Trading Pte Ltd	Singapore	www.donaldmcarthy.com	Precious Metal Recovery: Recovery of low concentrations of precious metals (Au, Pt, Pd, Ag) from industrial scrap materials
Intermediaries Companies				
9	Cloud Blue	Worldwide mainly Canada and USA	http://www.cloudblue.com/	- Micro Company that works with audited downstream refiners and smelters to return the commodities to the manufacturing stream when possible
10	Equation Recycling Pte Ltd	Singapore	www.equrecycling.com.sg	- Cathode Ray Tubes (CRT) Recycling - Copper Recovery
12	ALBA Electronics Recycling GMBH	Germany	https://aer.alba.info/unternehmen.html	Recycling of electronic waste

11

Challenges for the Formal WEEE Recycling Sector

The establishment of formal and efficient WEEE recycling systems faces many challenges such as:

- The legal constraint, as currently no laws addressing waste management for WEEE exist or are being developed in Egypt. In other words, there is currently no way to legally specify the collection of WEEE as an input to a formal business or industry. As it is complicated to define WEEE as a fraction by rigid law.
- The organizational issue: WEEE recycling requires a great deal of elasticity and flexibility for handling a complex WEEE material input. Furthermore, a sound knowledge base is necessary to select the most appropriate processing techniques and operational approaches. EEE technology is growing very fast and components and materials are changing rapidly at short intervals. Thus the handling of WEEE is more easily handled via private small entrepreneurship than via rigid of public systems.
- The dominance of the informal sector, which controls the WEEE in Egypt is jeopardizing the future of the formal sector. Companies are suffering the lack of input flow due to the monopoly of the informal sector.
- In case the outsourcing of the refining of precious and base metals, a good formula with the external refiner is needed as well as the continuous follow up.
- There is currently no sound formal option for end processing of some e-waste fractions, and they represent important volumes, so it would not be viable to export them. This concerns mainly the cables (no mechanical stripping facility existing in Egypt, only informal open burning), the plastic (no formal shredding company) and the CRT leaded glass.

12

Conclusion and Recommendation

The current study revealed the following:

- The current formal sector is of limited capacity that shares a limited market segment; in the contrary of the informal sector that dominates the market and works at neither regulations nor environmental measures that protect the worker and the environment.
- The formal sector does not process the WEEE components from scratch; it only processes the components that contain metals. The process starts in the informal sector, which is the main supplier to the formal one. All dismantling and separation is done under no environmental or health and safety requirements and control. This problem should be taken into consideration by training and capacity building of the informal sector. The transformation of informal sector to a formal one is mandatory in order to have a consistent and complying full system.
- It is recommended that wire stripping machines are used for stripping the copper wires either at the formal dismantlers or at the end users of the copper such as smelters.
- The Extended Producer Responsibility (EPR) might be a solution to reach an environmental objective of a decreased total environmental impact of a product especially for the hazardous elements.
- The fractions of IT in Egypt were identified and found to be a source of raw materials needed for the casting industry; in addition, the precious materials should be refined with the state-of-the-art technology in order to minimize the loss during this process. The refining process is yet to be developed in order to maximize the output from the PCBs fractions refining.
- The licensed & sound recycling companies for end-processing in Egypt for each separate fraction were identified, especially the ones that have the capability to recycle the metals produced from the EEE waste recycling. Actual smelting of metal samples was carried out to identify the yield of each type of metal produced from the recycling. It was concluded that the produced copper quality needs to be improved as the yield during smelting proved to be low.
- Each metal was priced according to the smelting test. The price is fundamentally affected by the yield of metal during smelting.
- The market price of equipment, fractions and produced metals was surveyed. Special attention was given to the PCBs fraction as their price depends on their content of precious, rare and base metals. It was concluded that this content is decaying as technology advances.
- It was concluded that the fractions that contain precious and base metals should be exported for refining outside Egypt, at least on the short run. A list of companies that can refine the fractions containing those metals (mainly PCBs & Lithium batteries) was provided.

It is recommended that:

The formal sector includes larger number of well-trained entrepreneurs managing small companies on how to handle, dismantle and process the WEEE the proper way; these companies should be supported to:

- Work in controlled work place that protects the worker in the meantime all measures of applicable laws shall be implemented in order not to negatively affect the ambient environment
- It is recommended that these small companies work up to the classification and proper dismantling of the fractions and supply their output to larger companies for further processing such as refining since the investment in refining is very high
- In case these companies decided to complete the process and to outsource the fractions refining outside Egypt, this should be done in clusters, i.e. many of them should act in group to gather the required feasible amount, which is 50 ton/month and share the cost of this process in order to realize a profit
- EPR strategy should be implemented by making the manufacturer of the product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal
- It is recommended to develop or look for solutions for end processing of CRT leaded glass, for cable stripping and for WEEE plastic valorization.

13

Effort exerted to support the Formal Sector

Following the results of the baseline study focusing on identifying the business opportunities for the Formal Sector, SRI Project planned a series of activities to support the sector based on the identified challenges. The plan included the following:

13-1 Needs Assessment Study of the Formal Sector

Following the Baseline Assessment, specific requirements for sustainable e-waste recycling were developed in the form of audit for all the companies registered as formal. The audit was based on the main requirements from WEEELABEX normative document on Treatment V10.0, adapted for the Egyptian context, and it was carried out based on international standards given by the international experts and in synergy with the Guidance Principles as developed by SRI. The audit was mainly a tool to identify the current status of each company leading to assess the needs of the company to sustain its proper operations.

A series of steps were carried out to fulfill the needs of the formal sector. These steps were supported by SRI management. These steps include:

Addressing the General Authority of Government Services

Series of communications went on in the past few months between the Ministry of Environment and the General Authority of Government Services upon SRI and the Electronic and Medical and Electronic Waste Management Projects (the GEF Project). This effort resulted in the issuance of a formal request from the Ministry of Environment – Waste Management Regulatory Agency (WMRA) to the Authority to confine the auctions of the WEEE to the formal sector (Companies having the Environmental Permits granted after the EIA study) only and exclude the informal auctioneers. The Authority responded positively to the request.

WMRA is following up with the Authority to activate the agreement and assure that their upcoming activities are including.

A Correspondence from the Minister of Environment to the Minister of Communication and Information Technology

The correspondence content explained the formal sector problem regarding the shortage of the WEEE dominated by the informal sector. The Minister of Environment proposed that the formal sector should participate in the Communication Service Operators such as Orange, Vodafone and Etisalat auctions rather than the currently auctioneers from the informal sector. In addition, he recommended the following:

- The two ministries collaborate in organizing events with the participation of the mobile operators service companies, the maintenance agencies, traders etc. to upgrade their knowledge concerning the hazard of the WEEE and the to explain the safe methodology to handle and dispose these materials.
- Disseminate the guidelines prepared by the Ministry of Environment and to introduce the formal sector companies.

The Ministry of Environment is considering the corresponded proposal and a team from WMRA and the GEF Project are currently following up the implementation.

Correspondence between WMRA and Telecommunications Regulatory Authority

Management Regulatory Agency (WMRA) addressed the Telecommunications Regulatory Authority to share the content of the WEEE handling Guidelines; besides, WMRA recommended that the Authority stops Orange's auction of July 11, 2017 and redirect it to the two ministers to include the formal sector. The correspondence referred to the previous letter between the two Ministers to enhance the Authority decision. WMRA is following up with the Authority.

SRI is following up to support the formal sector regarding availing the WEEE in order to put their facilities on operation.

Appendix 1

Available options for end treatment of e-waste fractions after mechanical shredding or manual dismantling

Output fraction	Current common buyer in the formal sector and type of treatment	Issue for the final processing (formal and informal)
Shredded material (after mechanical processing)		
Shredded material containing copper plastic mix (e.g. Printed circuit board PCB shredded)	Copper smelting in Egypt	- Low yield of metal in the test done with shredded PCB - Minimum yield acceptable for refiners: 70% of copper - Environmental risk with chemical processing if not performed properly by the recycler - Many small scale chemical processing in the informal sector, with high environmental and social impact (risk of child labor, health issues…) - Only gold and copper are partially valorized, loss of other precious metals, rare earth…
Shredded material containing aluminum plastic mix	Aluminum smelting in Egypt	- Min for refiners: 60% of aluminum
Not shredded material (after manual dismantling)		
Electronic card not shredded without capacitors	Export to different international smelters or intermediaries selling to international smelters	- Recyclers / dismantlers complain about the low price they receive from international recyclers, the fact that they are paid about 6 to 12 months after shipment, the fact that brokers in Egypt get all the margin as they cannot purchase directly from the collectors, but it has to be done through the dealers - Recyclers/dismantlers claim that the only way to be economically viable is to process the PCB in Egypt or to join with other dismantlers and export bigger amount (about at least 50 t. per shipment)
Electronic card not shredded with capacitors	Export to different international smelters or intermediaries selling to international smelters	- Lower price than without PCB, else same issues - Most of the exported PCB are exported without capacitors

Output fraction	Current common buyer in the formal sector and type of treatment	Issue for the final processing (formal and informal)
Leaded glass from CRT screens	None identified	- Currently, the formal sector does not deal with these fractions - Could be sold to glass recyclers, but they should be aware of the included heavy metals
LCD screens	None identified	- The formal sector does not deal with these fractions
Copper	Copper smelters in Egypt	- The copper smelters require that the copper should be free from plastic since it negatively affects the smelting furnaces and it emits dioxin and furan during smelting - Many small informal smelting companies exist in Egypt; these smelters are longing to receive raw material especially copper to keep their operations running
Aluminum	Aluminum smelters in Egypt	- The bulk aluminum parts such as connectors exhibit a high yield that could reach 90%, so it is preferable to smelt large sizes - Many small informal smelting companies existing in Egypt that need the aluminum to keep their business running
Bronze/Brass	Copper alloy smelters in Egypt	- Same condition as copper
Iron/steel	Steel refineries in Egypt	- Any size could be smelted
Stainless steel	Steel refineries in Egypt	- The iron smelters deal with stainless steel
Plastics without BFR	None identified	- It is not of the formal sector interest - The informal recyclers shred it and sell it for plastic processing companies
Plastics with BFR	None identified	- This should be disposed of in the hazardous waste landfill at cost
Mixed plastic	None identified	- Mixed plastic has no value, it goes to the informal sector, end processing is most probably illegal dumping - The informal sector shred it and sell it to the plastic processing companies
Plugs from cables	None identified	- It is not of the formal sector interest - If they are properly dismantled it can go to the smelters

Output fraction	Current common buyer in the formal sector and type of treatment	Issue for the final processing (formal and informal)
Cables with plugs	None identified	- Cables are currently stripped from plastic cover by burning, which produces a lot of emissions; this problem should be resolved - Plugs should be separated as they contain plastic as much as metal
Cables without plugs	None identified	- The majority (about 95%) doesn't go to formal facilities but is burnt outdoor by the informal sector (furan and dioxin emission)
Power supply	None identified	- Sold to refurbishers
Drives	None identified	- Sold to refurbishers
Mobile phones without batteries	(Dismantled)	- Sold at high prices to dismantlers because of the precious metals high content
Motors / inductors / transformers	None identified	- It is not of the formal sector interest - It is a common practice in Egypt that these elements are refurbished and sold at reasonable prices at a very known market in the middle of Cairo called SABTEYA
Parts with low metal content (mouse, keyboard…)	Refurbishers in Egypt	- Final processing/disposal of parts not reused in the dumping site because of their low value - The parts that can't be reused should be dismantled
Capacitors	Refurbishers in Egypt or hazardous landfill sites(Alexandria)	- If not reused, they should be landfilled in a hazardous waste landfill at cost
Lead batteries	Sold to lead smelters in Egypt	- Smelters should work with license from EEAA
Lithium batteries	Exported for proper processing	- Exported
Fluorescent tubes (e.g. from LCD)	Hazardous landfill site (Alexandria)	

- The smelters do not exert any effort in dismantling or stripping; they also do not like to smelt any metal containing plastic

Appendix 2:

General information	
Name of organization	
Main activity	
Activity related to e-waste	
Structure	NGO ( ) SME ( )
Contact person	**Name:**
	Position:
	Mobile: **Email:**
Number of workers	
website	
Address	
Area covered	
Operating since	
License to operate from MoE	**Yes ( ) No ( )**

Collection (or input for the processing)				
Type of full equipment collected	**Item**	**Quantity**	**Fraction %**	**Purchased price (EGP/piece)**
	PC			
	Laptop			
	Printer			
	Keyboard			
	Mobile phone			
	CRT Monitors			
	Flat Screen Monitor			
	others			
Type of partially dismantled/ clean fraction collected	**Item**	**Quantity**	**Fraction %**	**Purchased price (EGP/piece)**
	PCB			
	Cables			
	Electron gun from CRT			
	Hard drives			
	Transformers			
	Motors			
	others			
Type of fraction ready for end treatment collected	**Item**	**Quantity**	**Fraction %**	**Purchased price (EGP/piece)**
	Ferrous Metal			
	Aluminum			
	Copper			
	Plastics With Bfrs			
	Battery			
	Capacitor			
	CRT (Lead Glass)			
	Others			

Collection (or input for the processing)		
Type of transport and container		
Type of Supplier	SME / NGO / Gov. / private household / informal collectors	
	SME:……,……,……, ……	
	NGO: ……..,……..,……,……	
	Gov: ……..,……..,……, ……	
	Private household: ……..,……..,…… ……	
	Informal collectors: ……..,……..,…… ……..	
	Others: ……..,……..,…… ……	
Total Capacity		Ton/year
Frequency of collection and communication ways	1 per week / on demand / ……	
Other waste collected together	Scrap metal / no other waste / all household waste	
Main Challenge	Very small amount per client / cherry picking / unclear origin	
Main Barriers		

Processing	
Manual Processing	
Mechanical Processing	
Open Burning	
Chemical Processing	
Main Challenge	
Main Barriers	

Output				
Type of waste	**Item**	**Quantity**	**Fraction %**	**Expected Price (EGP/Kg)**
Total Amount		Ton/year		
Next Destination				
	E-Waste Recycler			
	Plastic Recycler			
	Export			
	Scrap Metal Dealer			
	Dumping			
	Others			
Processing at Destination				
Main Challenge				
Main Barriers				
Comments				

2017

SRI Project - Egypt

SRI SUSTAINABLE RECYCLING INDUSTRIES

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Federal Department of Economic Affairs,
State Secretariat for Economic Affairs SECO

Arab Republic of Egypt
Ministry of Communications
and Information Technology

WORLD RESOURCES FORUM

Empa
Materials Science and Technology

sofies
leading sustainability

CEDARE