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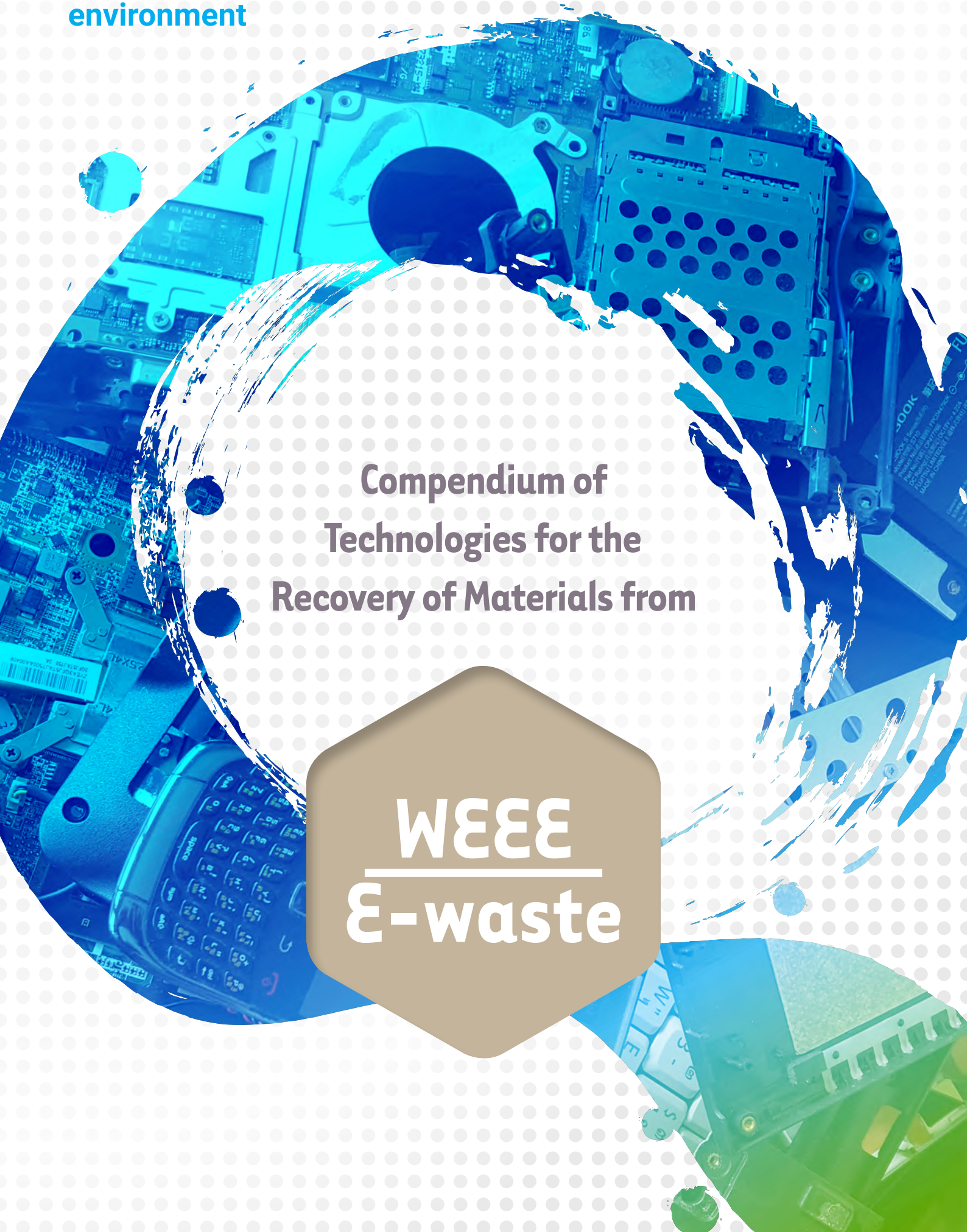

Compendium of Technologies for the Recovery of Materials from

WEEE
E-waste

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Acknowledgement

Author **Amit Jain** (Consultant) \ Project Team – AIT RRC.AP **Guilberto Borongan** (Programme Specialist and Coordinator) | **Prakriti Kashyap** (Senior Programme Officer) | **Nang Sian Thawn** (Programme Officer) \ Supervision – UN Environment IETC **Shunichi Honda** (Programme Officer) | **Mushtaq Memon** (Programme Officer) \ Peer Reviewers and Contributors from ASEAN Member States and Experts **Mohammad Shah Rezza Nassaruddin** | **Rithirak Long** | **Vanhxay Phiomanyvone** | **Nur Akmal** | **Ni Ni Thin** | **Anuphan Ittharatana** | **Pornpimon Chareonsong** | **Vuttichai Kaewkrajang** | **Pattanan Tarin** | **Chalalai Rungruang** | **Nguyen Anh Tuan** | **Sunee Thapinta** | **Ridwan Tamin** | **Darren Koh** | **Masnellyarti Hilman** | **Yulisa Djaja** | **Supawan Tantayanon** | **Saroj Srisai** | **Rocky Pairunanasean** | **D. Wardhana Hasanuddin Suraadiningrat** | **Mushtaq Memon** | **Prakriti Kashyap** | **Shunichi Honda** | **Guilberto Borongan** \ Cover design Lowil Fred Espada (Professional Independent Graphic Design) \ Cover photo Guilberto Borongan

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Abbreviation

Ag	silver
APME	Association of Plastic Manufacturers in Europe
AT	Austria
Au	gold
B2B	Business to Business
B2C	Business to Consumer
BATRRT	Best Available Treatment, Recovery and Recycling Techniques
BE	Belgium
BG	Bulgaria
BIOS	Basic Input / Output System
BOQ	Bill of Quantities
CCFL	Cold Cathode Fluorescent Lamps
CD	Compact Disc
CEEW	Consumer Electrical and Electronics Waste
CFCs	Chlorofluorocarbon
CFCs	chloro-fluorocarbons
CFLs	Compact Fluorescent Lamps
CHWTSDF	Common Hazardous Waste Treatment, Storage and Disposal Facility
Co	cobalt
CPU	Central Processing Unit
CRT	Cathode Ray Tube
Cu	copper
CY	Cyprus
CZ	Czech Republic
DCF	Designated Collection Facilities
DE	Germany
DK	Denmark
DNA	Deoxyribonucleic acid
DTIE	Division of Technology, Industry and Economics
EC	European Community
EE	Estonia
EEA	European Environment Agency
EEC	European Economic Community
EEE	Electrical and Electronic Equipment
EHS	Environmental, Health and Safety
EIA	Environment Impact Assessment
EoL	End-of-Life
EPR	Extended Producer Responsibility
ES	Spain
EST	Environmentally Sound Technologies
EU	European Union
FI	Finland
FR	France
GPS	Global Positioning System
GR	Greece
HCFCs	hydrochloro-fluorocarbons
HR	Croatia (Hrvatska)
HU	Hungary
ICSC	International Chemical Safety Cards
ICT	Information and Communication Technology
ICWMT	International Conference on Waste Management and Technology
IE	Ireland
IETC	International Environmental Technology Centre
ILO	International Labour Organization
In	indium

IT	Information Technology
IT	Italy
ITEW	Information Technology Electronics Waste
kg	kilogram
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LIBs	Lithium Ion Batteries
LT	Lithuania
LU	Luxembourg
LV	Latvia
mg	milligram
MNC	Multi National Company
MRM	Manufacturers Recycling Management
Mt	metric tonnes
NL	Netherlands
ODS	Ozone Depleting Substances
PBBs	polybrominated bi-phenyls
PBDEs	polybrominated diphenyl ethers
PC	Personal Computer
PCB	Printed Circuit Board
Pd	palladium
PL	Poland
PM	precious metals
PT	Portugal
PUR	polyurethane
PVC	Poly Vinyl Chloride
RAM	Random Access Memory
REE	Rare Earth Elements
RO	Romania
RPM	round per minute
Sb	antimony
SE	Sweden
SI	Solvenia
SK	Slovak Republic
Sn	tin
STEP	Solving the E-waste Problem
TFL	Tubular Fluorescent Lamps
TV	Television
UK	United Kingdom
UK	United Kingdom
UNEP	United Nations Environmental Programme
UNU-IAS	United Nations University Institute for the Advanced Study of Sustainability
USD	United States Dollar
USEPA	United States Environmental Protection Agency
WDA	Waste Diversion Act
WEEE	Waste Electrical Electronic Equipment
WIPO	World Intelectual Property Organization
WHO	World Health Organization

EXECUTIVE SUMMARY

Rapid growth in waste generation is a major by product of increasing consumption. As per the World Bank estimates, by 2025, 4.3 billion urban residents will generate 2.2 billion tonnes per year of municipal solid waste[1]. Over the years, the nature and composition of waste has undergone significant changes due to changed consumption and consumer behavior. As a result, diverse waste streams are emerging, creating problems for national and local government for their sustainable management. Since waste management has a strong bearing on environment, and public health, the adverse impacts of improper waste management are very serious and well documented. It has been reported that poorly managed waste has significant impact on the health, local and global environment and economy. The United Nations Environmental Programme (UNEP), through International Environmental Technology Centre (IETC), Division of Technology, Industry, and Economics (DTIE) is implementing "Waste Management Programme" based on the principle of 3R (reduce, reuse and recycle). IETC aims to promote identification and implementation of environmentally sound technologies (ESTs) for collection, storage, treatment, disposal, recovery and recycling of different waste streams. In this context, UNEP DTIE-IETC has prepared a compendium of environmentally sound technologies (EST) for WEEE/e-waste management.

This compendium describes information on commercially available or near commercially available technologies and associated techniques for resource recovery from WEEE/e-waste and subsequent treatment of residual wastes. The key fields of information in the compendium are: type of technology – detailed process description, type of waste handled, products (if any), emissions, job potential and capacities available; Operational/technical details including parameters for specifications for procurement, operation and maintenance requirements, and specific aspects for developing countries; Environmental and social considerations; Investment and operating costs; Institutional and regulatory requirements; Pros and Cons with respect to developing countries; Examples of real life applications; Photographs and sketches and Suppliers. Criteria have been developed to facilitate the assessment of various technology options to shortlist the most relevant and suitable technologies. Furthermore, guidelines of the technologies have been developed based on the available techniques and technologies for WEEE/e-waste management including collection, storage and primary and secondary dismantling for resource recovery and proper disposal of WEEE/e-waste. A framework for effective E waste management system worked out by E waste management organizations, is illustrated, and the E waste management practices in Argentina, Australia, Brazil, Canada, Europe Union, Hong Kong, Japan, South Africa, United States of America, Thailand and India are discussed.

The compendium is spread over 6 chapters. Chapter 1 gives an introduction, overview of E waste, objectives, scope and format. A basic understanding of the issue of waste management has been provided in the initial chapters.

Chapter 2 describes the Classification of WEEE/e-waste and WEEE/e-waste Streams consisting of mechanism of WEEE/e-waste trade, conceptual understanding of WEEE/e-waste material flow WEEE/e-waste streams, average life of electronics goods, WEEE/e-waste composition, recyclability and hazardousness, source of WEEE/e-waste generation in developing countries, environmental and health impact of WEEE/e-waste, major stakeholders and guidance notes. These notes will assist the target audience about the WEEE/e-waste stream identification, their classification and composition, likely waste streams and planning for identifying scale of WEEE/e-waste management in a particular geography.

Chapter 3, Perspective of WEEE/e-waste Management, describes the National and social policies/laws/regulations/institutional roles in developed countries (policies/laws/regulation, institutional mechanism) and national and social policies/laws/regulations/economic/institutional roles in developing countries, brief methodology for assessment of quantity of WEEE/e-waste generated in a country, WEEE/e-waste management (collection, transportation, storage, primary and secondary dismantling/recycling and disposal and guidance notes. Guidance notes also provide a broad road map to assist the target audience in assessing and developing enabling policy/laws/regulations and institutional framework for WEEE/e-waste management. Guidance notes provide insights to assess whether WEEE/e-waste is addressed in the existing environmental/related legislation of the country, identify the gaps and the regulations where WEEE/e-waste can be addressed and whether there is a need to address it in a new law.

Chapter 4 Compendium of technologies for the recovery of materials/energy from WEEE/e-waste, describes technologies for collection, technologies for transportation, technologies/techniques for storage, technology for primary and secondary dismantling/recycling, technology for disposal, environmental soundness and applicability of technologies to particular WEEE/e-waste stream and guidance notes. The chapter gives insight on the usage of results obtained as part of WEEE/e-waste inventory assessment for planning and implementation of WEEE/e-waste management, i.e. scale and level of technology. Guidance notes provides assistance to target audience to assist in identification of the problem, its extent and capacity required to manage it.

Chapter 5, WEEE/e-waste Technology Selection, describes economic, technical environmental and social implications of technologies, development of criteria for selection of technology and guidance notes. Guidance notes provide a broad framework to assist in the design and development of technical specifications for the E-waste management system. This will assist technical personnel/WEEE/e-waste implementation agencies/other stakeholders to identify technical options for WEEE/e-waste collection, transportation, treatment and disposal systems.

Chapter 6, Case Studies, describes various case studies: Developing Countries, lessons learned and best practices and conclusions.

The financial viability of all the stages of the E-waste management chain is vital for its implementation. Financing mechanism of collection, transportation, treatment and disposal of E-waste may include market-based instruments (economic instruments), including recycling fee and environmental tax based on the amount and type of waste. To assist policy makers in understanding financial mechanism for E-waste management, examples from developed and developing countries have been discussed.

Different countries are at different stages of implementation of the E-waste management system. Therefore, the countries and target audience need to first assess the level of their current system. Guidance notes at the end of each chapter will assist them to carry out this assessment. If a particular country has already achieved a level based on the outputs of a respective chapter, then they can proceed as per the guidance given in next chapter. This will also assist them to fix their objectives and decide on the extent of intervention required to achieve these objectives. Finally, they can prepare a work plan and allocate resources to complete the required activities.

CHAPTER 1: INTRODUCTION

1.0 Introduction

Rapid growth in waste generation is a major by product of increasing consumption. As per the World Bank estimates, by 2025, 4.3 billion urban residents will generate 2.2 billion tonnes per year of municipal solid waste[2]. Over the years, the nature and composition of waste has undergone significant changes due to changed consumption and consumer behavior. As a result, diverse waste streams are emerging, creating problems for national and local government for their sustainable management. Since waste management has a strong bearing on the environment, and public health, the adverse impacts of improper waste management are very serious and well documented. It has been reported that poorly managed waste has a significant impact on the health, local and global environment and economy. Improper management of waste also results in higher downstream costs of management. Furthermore, it results in a loss of resources, which could be saved and/or recovered through its proper management based on the waste hierarchy, circular economy and 3R (reduce, reuse and recycle) approach. One such emerging waste stream is electronic waste (e-waste).

The United Nations Environmental Programme (UNEP), through International Environmental Technology Centre (IETC), Division of Technology, Industry, and Economics (DTIE) is implementing the "Waste Management Programme", which is based on the principle of 3R (reduce, reuse and recycle). IETC aims to promote identification and implementation of environmentally sound technologies (ESTs) for collection, storage, treatment, disposal, recovery and recycling of different waste streams. In this context, UNEP DTIE-IETC has prepared a compendium of environmentally sound technologies (EST) for WEEE/e-waste management. The key audience of this compendium will be technology selection decision makers. This work will compliment the work being done globally and regionally, on the subject by UNEP and other related agencies. The following sections describe the overview of WEEE/e-waste, objectives, scope and format of the compendium.

1.1 Overview of WEEE/e-waste

As per UNU-IAS estimates[3], the total amount of WEEE/e-waste generated in the world in 2014 was 41.8 million metric tonnes (Mt). It has been forecasted to increase to 50 Mt by 2018. This WEEE/e-waste is comprised of 1.0 Mt of lamps, 6.3 Mt of screens, 3.0 Mt of small IT (such as mobile phones, pocket calculators, personal computers, printers, etc.), 12.8 Mt of small equipment (such as vacuum cleaners, microwaves, toasters, electric shavers, video cameras, etc.), 11.8 Mt of large equipment (such as washing machines, clothes dryers, dishwashers, electric stoves, photovoltaic panels, etc.) and 7.0 Mt of cooling and freezing equipment (temperature exchange equipment). The growing amount of WEEE/e-waste is not only an environmental issue, but also a source of precious metals and rare earth elements. Therefore, the intrinsic material value of global WEEE/e-waste has been estimated to be 48 billion euros in 2014, based on global trade prices. The material value is dominated by gold, copper and plastics contents. Furthermore, environmental burden based on the annual supply of toxins from WEEE/e-waste comprised of 2.2 Mt of lead glass, 0.3 Mt of batteries

[2] *A Global Review of Solid Waste Management; The World Bank*
[3] *The Global e-waste Monitor 2014; United Nations University*

and 4 kilo tonnes (kt) of ozone-depleting substances (CFCs). About 15.5% of the total WEEE/e-waste generated is getting scientifically recycled. Since the last two decades, many national governments in Europe and other developed countries have made continuous efforts for WEEE/e-waste management. However, the majority of the countries in the world are without WEEE/e-waste management systems.

Over the past two decades, policymakers, producers and recyclers in various countries have created specialized "take back and treatment systems" to collect WEEE/e-waste from final owners and process it in professional treatment facilities. Unfortunately, despite these efforts, the collection and state-of-the-art treatment of WEEE/e-waste is limited, and most nations are still without WEEE/e-waste management systems. More than 80% of documented WEEE/e-waste is not being collected and treated in an environmentally sound manner.

1.2 Objectives

The main objectives of this compendium include:

- To facilitate the technology decision makers in making more informed decisions;
- Develop criteria to facilitate the assessment of various technology options to shortlist most relevant and suitable technologies and prepare compendium of commercially available or near commercially available technologies and associated techniques for resource recovery from used WEEE/e-waste.

1.3 Scope

The scope of this compendium covers information on commercially available or near commercially available technologies and associated techniques for resource recovery from WEEE/e-waste and subsequent treatment of residual wastes. The key fields of information in the compendium are: type of technology – detailed process description, type of waste handled, products (if any), emissions, job potential and capacities available; Operational/technical details including parameters for specifications for procurement, operation and maintenance requirements, and specific aspects for developing countries; Environmental and social considerations; Investment and operating costs; Institutional and regulatory requirements; Pros and Cons with respect to developing countries; Examples of real life applications; Photographs and sketches and Suppliers. Criteria have been developed to facilitate the assessment of various technology options to shortlist most relevant and suitable technologies. Furthermore, guidelines of the technologies have been developed based on the available techniques and technologies for WEEE/e-waste management, including collection, storage and primary and secondary dismantling for resource recovery and proper disposal of WEEE/e-waste.

The preparation of this compendium has involved a collection of data from secondary sources, including publications from scientific journals, reports and web sites. A case study based approach has been adopted to provide the practitioner examples of live situations so that it can be adopted in a country/geographical region or city. The compendium should be usable in all the countries, where WEEE/e-waste projects have been initiated.

1.4 Format of the Report

This **Compendium** has been compiled in six chapters. **Chapter 1** gives introduction, overview of WEEE/e-waste, objectives, scope and format of the report. **Chapter 2 gives Classification of WEEE/e-waste and WEEE/e-waste Streams** consisting of mechanism of WEEE/e-waste trade, conceptual understanding of WEEE/e-waste material flow WEEE/e-waste streams, average life of electronics goods, WEEE/e-waste composition, recyclability and hazardousness, source of WEEE/e-waste generation in developing countries, environmental and health impact of WEEE/e-waste, major stakeholders and guidance notes. These notes will assist the target audience about the WEEE/e-waste stream identification, their classification and composition, likely waste streams and planning for identifying scale of WEEE/e-waste management in a particular geography.

Chapter 3 Perspective of WEEE/e-waste Management describes National and social policies/laws/regulations/institutional roles in developed countries (policies/laws/ regulation, institutional mechanism) and national and social policies/laws/regulations/ economic/institutional roles in developing countries, brief methodology for assessment of quantity of WEEE/e-waste generated in a country, WEEE/e-waste management (collection, transportation, storage, primary and secondary dismantling/recycling and disposal and guidance notes. Guidance notes also provide a broad road map to assist target audience in assessing and developing enabling policy/laws/regulations and institutional framework for WEEE/e-waste management. Guidance notes provide insights to assess whether WEEE/e-waste is addressed in the existing environmental/related legislation of the country, identify the gaps and the regulations where WEEE/e-waste can be addressed and whether there is a need to address it in a new law.

Chapter 4 Compendium of technologies for the recovery of materials/energy from WEEE/e-waste describes technologies for collection, technologies for transportation, technologies/techniques for storage, technology for primary and secondary dismantling/recycling, technology for disposal, environmental soundness and applicability of technologies to particular WEEE/e-waste stream and guidance notes. The chapter gives insight on the usage of results obtained as part of WEEE/e-waste inventory assessment for planning and implementation of WEEE/e-waste management i.e. scale and level of technology. Guidance notes provide assistance to target audience to assist in identification of the problem, its extent and capacity required to manage it.

Chapter 5 WEEE/e-waste Technology Selection describes economic, technical environmental and social implications of technologies, development of criteria for selection of technology and guidance notes. Guidance notes provide a broad framework to assist in design and development of technical specifications for tire waste management system. This will assist the technical personnel/WEEE/e-waste implementation agencies/other stakeholders to identify technical options for WEEE/e-waste collection, transportation, treatment and disposal systems.

Chapter 6 Case Studies describes Case Studies: Developing Countries, lessons learned and best practices and conclusions.

CHAPTER 2: CLASSIFICATION OF WEEE/E-WASTE and WEEE/E-WASTE STREAMS

2.0 Introduction

Global e-waste industry assessment indicates that e-waste management market was valued at US$ 17 billion in 2015 and is expected to reach US$ 50 billion in 2022.[4,5] The supply to this market is triggered by the decreasing average life of electrical and electronic equipment, which facilitates their "trading" for secondary material recovery. An assessment of WEEE/e-waste market structure requires an understanding of WEEE/e-waste as a "tradable secondary resource commodity" and its "mechanism of trading". As per 2014 estimates, 41.8 million tonnes of WEEE/e-waste offers recovery of 27 million tonnes of material worth US$ 54 billion. A "Mechanism of Trading" can be described in terms of life cycle of electrical and electronic equipment, starting from manufacturing/production/import, consumption, WEEE/e-waste generation, market regulations and facilities of material recovery and disposal. The impact of WEEE/e-waste market can be described in terms of composition and recyclability and associated trade and related environmental, occupational health and safety issues. The following sections describe WEEE/e-waste and its classification; mechanism of WEEE/e-waste trade and conceptual understanding of WEEE/e-waste material flow; WEEE/e-waste composition, recyclability and hazardousness; environmental health and socio-economic impact of WEEE/e-waste; to facilitate an understanding of WEEE/WEEE/e-waste market followed by guidance notes to assess WEEE/e-waste market in a country/geographical region/city.

2.1 WEEE/e-waste Definition and Classification

Based on a Step Initiative, WEEE/e-waste is a term used to cover all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of re-use. It is also referred to as WEEE (Waste Electrical and Electronic Equipment), electronic waste or E-scrap in different regions. WEEE/e-waste includes a wide range of products, almost any household or business item with circuitry or electrical components with power or battery supply. WEEE/e-waste can be classified into the following categories.

- **Temperature exchange equipment:** Also more commonly referred to as, cooling and freezing equipment. Typical equipment is refrigerators, freezers, air conditioners, and heat pumps.

[4] *https://www.alliedmarketresearch.com/e-waste-management-market*
[5] *https://globenewswire.com/news-release/2016/07/20/857387*

- **Screens, monitors:** Typical equipment comprises televisions, monitors, laptops, notebooks, and tablets.
- **Lamps:** Typical equipment comprises straight fluorescent lamps, compact fluorescent lamps, fluorescent lamps, high intensity discharge lamps, and LED lamps.
- **Large equipment:** Typical equipment comprises washing machines, clothes dryers, dish washing machines, electric stoves, large printing machines, copying equipment and photovoltaic panels.
- **Small equipment:** Typical equipment comprises vacuum cleaners, microwaves, ventilation equipment, toasters, electric kettles, electric shavers, scales, calculators, radio sets, video cameras, electrical and electronic toys, small electrical and electronic tools, small medical devices, small monitoring and control instruments.
- **Small IT and telecommunication equipment:** Typical equipment comprises mobile phones, GPS, pocket calculators, routers, personal computers, printers, and telephones.

These categories have been defined as per ease of WEEE/e-waste streams requiring specific collection, treatment and disposal mechanism. Furthermore, definition and classification differs from country to country. Examples of definition and classification are given below.

2.1.1 European Union

Definition as per EU directive with status of its transposition and variation in major EU countries is described in Appendix 1 followed by WEEE/e-waste's reference in Basel Convention. WEEE Directive (EU, 2002a) describes WEEE/e-waste as "Electrical or electronic equipment, which is waste including all components, subassemblies and consumables, which are part of the product at the time of discarding." Directive 75/442/EEC, Article 1(a) defines "waste" as "any substance or object, which the holder disposes of or is required to dispose of pursuant to the provisions of national law in force". 'Electrical and electronic equipment', or 'EEE', means equipment which is dependent on electrical currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such current and fields falling under the categories is set out in Annex IA to Directive 2002/96/EC (WEEE) and designed for use with a voltage rating not exceeding 1000 volts for alternating current and 1500 volts for direct currents.

Annex IA
Categories of electrical and electronic equipment covered by this Directive.

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)
7. Toys, leisure and sports equipment
8. Medical devices (with the exception of all implanted and infected products)
9. Monitoring and control instruments
10. Automatic dispensers

Annex IB

List of products, which fall under the categories of Annex IA are given below:

1. Large household appliances: Large cooling appliances; refrigerators; freezers; other large appliances used for refrigeration, conservation and storage of food; washing machines; clothes dryers; dish washing machines; cooking; electric hot plates; microwaves; other large appliances used for cooking and other processing of food; electric heating appliances; electric radiators; and other fanning, exhaust ventilation and conditioning equipment.
2. Small household appliances: vacuum cleaners; carpet sweepers; other appliances for cleaning; appliances used for sewing, knitting, weaving and other processing for textiles; iron and other appliances for ironing, mangling and other care of clothing; toasters; fryers; grinders, coffee machines and equipment for opening or sealing containers or packages; electric knives; appliances for hair-cutting, hair drying, tooth brushing, shaving, massage and other body care appliances; and clocks, watches and equipment for the purpose of measuring indicating or registering time scales.
3. IT and telecommunications equipment: centralized data processing; mainframes; minicomputers; printer units; personal computing; personal computers (CPU, mouse, screen and keyboard included); laptop computer (CPU, mouse, screen and keyboard included); notebook computers; notepad computers; printers; copying equipment; electrical and electronic typewriters; pocket and desk calculators; and other products and equipment for the collection, storage, processing, presentation or communication of information by electronic means; user terminals and systems; facsimile; telex; telephones; pay telephones; cordless telephones; cellular telephones; answering systems; and other products or equipment of transmitting sound, images or other information by telecommunications.
4. Consumer equipment: radio sets; television sets; video cameras; video recorders; hi-fi recorders; audio amplifiers; musical instruments; and other products or equipment for the purpose of recording or reproducing sound or image, including signals or other technologies for the distribution of sound and image than by telecommunications.
5. Lighting equipment: luminaries for fluorescent lamps with the exception of luminaries in households; straight fluorescent lamps; compact fluorescent lamps; high intensity discharge lamps, including pressure sodium lamps and metal lamps; low pressure sodium lamps; and other lighting or equipment for the purpose of spreading or controlling; light with the exception of filament bulbs.
6. Electrical and electronic tools (with the exception large-scale stationary industrial tools): drills; saws; sewing machines; equipment for turning, milling, sanding, grinding, sawing, cutting, shearing, drilling, making, holes, punching, folding, bending or similar processing of wood, metal and other materials; tools for riveting, nailing or screwing or removing rivets, nails, screws; or similar uses; tools for welding, soldering or similar use; equipment for spraying, spreading, dispersing or other treatment of liquid or gaseous substances by other means; and tools for mowing or other gardening activities.
7. Toys, leisure and sports equipment: electric trains or car racing sets; hand-held video game consoles; video games; computers for biking, diving, running, rowing, etc.; sports equipment with electric or electronic components; and coin slot machines.
8. Medical devices (with the exception of all implanted and infected products): radiotherapy equipment; cardiology; dialysis; pulmonary ventilators; nuclear medicine; laboratory equipment for *in-vitro* diagnosis; analysers; freezers; fertilization

tests; and other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability.

9. Monitoring and control instruments: smoke detector; heating regulators; thermostats; measuring, weighing or adjusting appliances for household or as laboratory equipment; and other monitoring and control instruments used in industrial installations (e.g. in control panels).
10. Automatic dispensers: automatic dispensers for hot drinks; automatic dispensers for hot or cold bottles or cans; automatic dispensers for solid products; automatic dispensers for money; and all appliances which deliver automatically all kind of products.

2.1.2 Canada

Canada's WEEE/e-waste regulations are enforced at the provincial level. The WEEE/e-waste definitions or statements as per these regulations are given below.

Alberta

Electronics Designation Regulation A.R.94/2004 published on 12 May 2004 and has come into force from 1 October 2004 as Appendix to Environmental Protection and Enhancement Act defines "Electronics" as all electrical and electronic equipment or devices, whether intended for consumers, industrial or commercial use, and includes, without limitation,

- Television
- Computers, laptops and notebooks, including CPUs, keyboards, mouse, cables and other components in the computer
- Computer monitors
- Computer printers, including printers that have scanning or fax capabilities, or both
- Scanners
- Audio and video playback and recording systems
- Telephones and fax machines
- Cell phones or other wireless devices and
- Electronic game equipment, but does not include electronics contained within and affixed to a motor vehicle

PCBs are at a concentration level of 50 mg/kg or more.

Electronics has been defined as designated material for the purpose of Part 9, Division 1 of the Act and the "Designated Material Recycling and Management Regulation". The term used instead of WEEE/e-waste is "Disposal of Electronics" under this regulation.

British Columbia

Schedule 3,"Electronic Product Category" was included in "British Columbia Recycling Regulation" dated 7 October 2004 as amended on 16 February 2006. The electronic product category consists of "Computers" that are designed for desktop use by an individual, for desktop use as a server or to be portable, except hand held devices, "Desktop Printers" and "Televisions". The electronic product category does not include computers and televisions that are part of or attached to vehicles, marine vessels or commercial or industrial equipment.

Computers include a computer monitor and computer peripheral. Computer peripheral means a keyboard, mouse or cable that attaches or is attached to a computer. Desktop printer means a printer that will print on paper not exceeding 8.5 inches in width but does not include a label printer. "British Columbia Stewardship Plan for End-of-Life Electronics", a plan formulated in response to the above regulation defines WEEE/e-waste as "End of Life" electronics where electronics means the electronic product category mentioned above.

Nova Scotia

"Solid Waste-Resource Management Regulations" made under Section 102 of the Environment Act as amended on February 22,2007 mentions "Electronic Products Stewardship Programme" in Part II. "Electronic Product" means an electrical device or electronic equipment that is a designated material. "Designated Material" has been defined as materials listed in Column 1 of Schedule "B" and includes the following electronic items.

- Televisions
- Desktop, laptop and notebook computers, including CPU's, keyboards, mice, cables and other components in the computer
- Computer monitors
- Computer printers, including printers that have scanning or fax capabilities or both
- Computer scanners
- Audio and video playback and recording systems
- Telephones and fax machines
- Cell phones and other wireless devices

"Electronic Product Stewardship Programme" means a programme that establishes a process for collection, transportation, reuse and recycling of electronic products and, if no further options exist, the disposal of any residual electronic product components and incorporates the principles of a pollution prevention hierarchy by replacing disposal with reuse and recycling of electronic products.

Ontario

The Waste Electronic and Electrical Equipment (WEEE) regulation under the *Waste Diversion Act, 2002* (WDA) was filed on 14 December, 2004 and amended in 2009. The regulation designates seven categories of electronic and electrical equipment as waste, and targets more than 200 items that could be designated, including computers, telephones, broadcast equipment, televisions and CD players, children's toys, power tools, lawn mowers and navigational and medical instruments. Products targeted under Ontario WEEE legislation are given in table 2.1.

Table 2.1: Products Designated under Ontario Legislation

Schedule	Priority Categories	Items
Schedule 1	Household Appliances	49 Items
Schedule 2	IT Equipment	28 Items
Schedule 3	Telecommunications equipment	24 Items
Schedule 4	Audio-Visual Equipment	24 Items
Schedule 5	Toys, Leisure Equipment and Sports Equipment	11 Items
Schedule 6	Electrical and Electronic tools	32 Items

Schedule	Priority Categories	Items
Schedule 7	Navigational Measuring, Medical Monitoring or Control Equipments	36 Items

Source: European Commission DG Environment, Bio Intelligence Service (2004). *Synthesis report [ENV.G.1/FRA/ 2004/0081, Study No.16], Gather, process, and summarise information for the review of the waste electric and electronic equipment directive (2002/96/EC).*

Saskatchewan

"The Waste Electronic Equipment Regulations" effective on February 1, 2006 and amended in 2009, under The Environmental Management and Protection Act, 2002, defines WEEE/e-waste as "waste electronic equipment", which means electronic equipment that the consumer no longer wants. "Electronic Equipment" means any electronic equipment listed in Column 1 of Table 1 of these regulations. This table includes the following electronic equipment:

- Personal desktop computer, including the central processing unit and all other parts contained in the computer
- Personal notebook computer, including the central processing unit and all other parts contained in the computer
- Computer monitor, including cathode ray tube, liquid crystal display and plasma
- Computer mouse, including cables
- Computer printer including dot matrix; ink jet; laser; thermal and computer printer with scanning or facsimile capabilities or both
- Television (cathode ray tube, liquid crystal display, plasma and rear projection)

2.1.3 India

As per Draft WEEE/e-waste (Management) Rules, 2015 dated March, 2016, WEEE/e-waste is defined as "electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment and repair processes". "Electrical and electronic equipment means equipment which are dependent on electric current or electro-magnetic field in order to become functional". A total of 21 categories of electrical and electronic equipment including their components, consumables, parts and spares covered under Schedule 1 of this Rule.

Schedule – I

Sr. No.	Categories of Electrical and Electronic Equipment	Electrical and Electronic Equipment Code
i.	**Information Technology and Telecommunication Equipment**	
	Centralized Data Processing: Mainframes, Minicomputers	ITEW1
	Personal Computing: Personal Computers (Central Processing Unit with Input and Output Devices)	ITEW2
	Personal Computing: Laptop Computers (Central Processing Unit with Input and Output Devices)	ITEW3
	Personal Computing: Notebook Computers	ITEW4
	Personal Computing: Notepad Computers	ITEW5
	Printers including cartridges	ITEW6
	Copying Equipment	ITEW7
	Electrical and Electronic Typewriters	ITEW8

Sr. No.	Categories of Electrical and Electronic Equipment	Electrical and Electronic Equipment Code
	User Terminals and Systems	ITEW9
	Facsimile	ITEW10
	Telex	ITEW11
	Telephones	ITEW12
	Pay Telephones	ITEW13
	Cordless Telephones	ITEW14
	Cellular Telephones	ITEW15
	Answering Systems	ITEW16
ii.	**Consumer Electrical and Electronics**	
	Television Sets including sets based on (Liquid Crystal Display and Light Emitting Diode Technology)	CEEW1
	Refrigerator	CEEW2
	Washing Machine	CEEW3
	Air-conditioners excluding centralized air conditioning plants	CEEW4
	Fluorescent and other Mercury containing Lamps	CEEW5

Source:http://www.moef.nic.in/sites/default/files/EWM%20Rules%202016%20english%2023.03. 2016.pdf, (Accessed on 14 July, 2016)

2.1.4 Japan

There is no specific definition of WEEE/e-waste as defined in the regulatory system. WEEE/e-waste is covered under laws to promote recycling within Japan. The two major laws covering the broad range of WEEE/e-waste items are "The Law for Recycling of Specified Kinds of Home Appliances (Home Appliances Recycling Law)" enacted in 1998 and "The Law for Promotion of the Effective Utilization of Resources" enacted in 2000.

In "The Law for Recycling of Specified Kinds of Home Appliances (Home Appliances Recycling Law)", WEEE/e-waste is referred as "Used Consumer Electric Goods Discarded by Consumers". This law covers TVs, Refrigerators, Washing Machines and Air Conditioners. In "The Law for Promotion of the Effective Utilization of Resources", WEEE/e-waste is covered under "Used goods and by-products" which have been generated and their large part is discarded. This law covers personal computers (home and office) and other electronic items. According to this law, "Used goods" means any articles that are collected, used or unused, or is disposed of (except radioactive materials or those contaminated thereby). "By-product" means any articles obtained secondarily in the process of manufacturing, processing, repair or sale of the product; in the process of supply of energy; or in the process of construction pertaining to architecture and civil engineering (hereinafter referred to as "construction work") except radioactive materials or those contaminated thereby.

2.1.5 Malaysia

WEEE/e-waste has been included as scheduled wastes in the "Environmental Quality (Scheduled Wastes) Regulations 2005. These wastes have been categorized as "wastes from electrical and electronic assemblies containing components such as accumulators, mercury switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or contaminated with cadmium, mercury, lead, nickel, chromium, copper, lithium, silver, manganese or polychlorinated biphenyl". As per guidelines for the classification of "Used

Electrical and Electronic Equipment in Malaysia", there are 27 items considered as WEEE/e-waste under used category.

Used electrical and electronic equipment or components is defined as WEEE/e-waste if it has any of the following criteria: (a) a defect that materially affects its functionality. For example it does not power up; or have a functioning motherboard; or perform Basic Input/Output System (BIOS) or internal set-up routines or self-checks fail; or communicate with the host; or print/scan/copy a test page or the page is not identifiable or readable or is blurred or lined; or read, write or record/burn. (b) Physical damage that impairs its functionality or safety, as defined in the specification. (c) a faulty hard disk drive and a faulty Random Access Memory (RAM) and a faulty Video Card; or (d) batteries made with lead, mercury or cadmium or lithium or nickel that are unable to be charged or to hold power; or (e) insufficient packaging to protect it from damage during transportation, loading and unloading operations; or (f) the appearance of the equipment or components are generally worn or damaged, thus reducing the marketability of the equipment; or (g) the electrical and electronic equipment or components are destined for recycling or recovery or disposal; or (h) the electrical and electronic equipment or components are discarded, or are intended or are required to be discarded; or (i) there is no regular market for the used electrical and electronic equipment or components; or (j) the used equipment or components are old and out dated, and destined for salvaging purpose; or (k) end-of-life electrical and electronic equipment; or (l) for the importing purposes, the age of the electrical and electronic equipment or components is not more than three years from the date of manufactured; or (m) products/goods produced by partially WEEE/e-waste recovery facilities.

2.1.6 Republic of Korea

Article 2 of Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles adopted on 2 April 2007, defines "Waste Electrical and Electronic Equipment" as electrical and electronic equipment, which is classified as "waste" in accordance with Article 2, Section 1 of the Waste Management Act. "Electric and Electronic Equipment" means equipment or device (including components and parts thereto) operated by electric currents and electromagnetic fields.

2.1.7 USA

According to USEPA, electronic products that are "near" or at the "end of their useful life" are referred to as "WEEE/e-waste" or "e-scrap." Recyclers prefer the term "e-scrap" since "waste" refers only to what is left after the product has been reused, recovered or recycled. However, "WEEE/e-waste" is the most commonly used term.

2.2 Mechanism of WEEE/e-waste Trade and Conceptual Understanding of WEEE/e-waste Material Flow

As per UNEP/IETC's WEEE/e-waste volume 1, mechanism of WEEE/e-waste trade can be explained in terms of three elements. These are

1. Material Flow
2. Life Cycle
3. Geographical Boundary

"Material Flow" along the "Life Cycle" of electrical and electronic equipment including the phase of obsolescence within a "Geographical Boundary" forms the basis of WEEE/e-waste generation in cities/countries. Conceptual life cycle of electrical and electronic equipment (EEE) showing the material flow is shown in **Figure 2.1**.

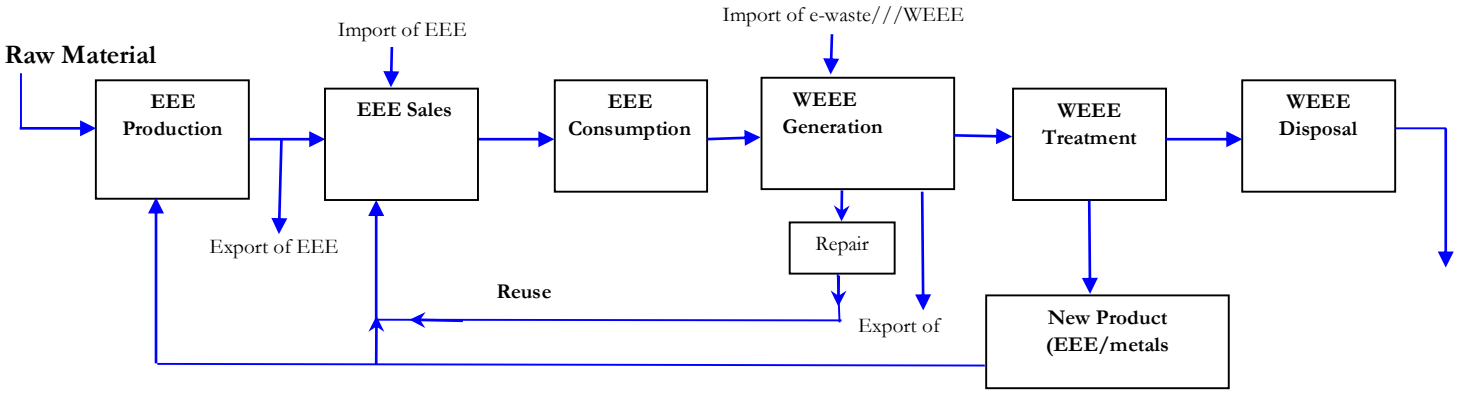


Figure 2.1: Conceptual Life Cycle of Electrical and Electronic Equipment

Source: Jain Amit (2016).

The establishment of material flow within a geographical boundary assists in identifying, networks/chain connecting different phases of life cycle of electrical and electronic equipment and associated stakeholders. Once the chain gets established, "material flow balance" ex. Input/output balances in each phase forms the basis of quantification of WEEE/e-waste in the life cycle analysis of electrical and electronic equipment. **The WEEE/e-waste material flow model developed by the "European Topic Centre on Waste" has been described below and shown in Figure 2.2, to develop a conceptual understanding of WEEE/material flow.**

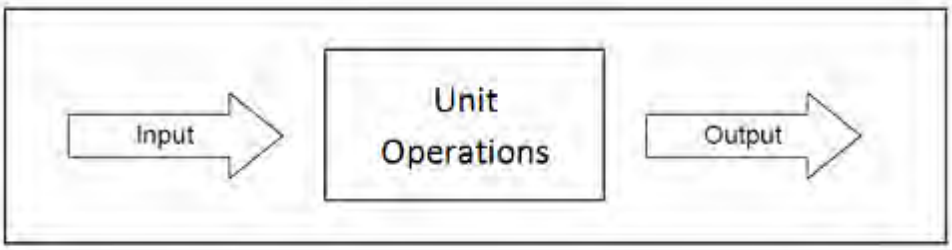


Figure 2.2: Conceptual WEEE/e-waste Material Flow Model

Source: Waste from electrical and electronic equipment (WEEE) – quantities, dangerous substances and treatment methods, EEA Copenhagen, 2003

The material flow model, when applied to "life cycle" of electrical and electronic equipment leads to the evolution of the 'Four-Phase-Model', where each phase describes respective unit operations and different stakeholders.

Phase I:
Unit Operations/Processes/Activities: Production and sales of electrical and electronic equipment including import, export, and input of equipment for re-use from repair of WEEE/e-waste.

Stakeholders: Manufacturers, importers, exporters, and retailers (brand new/second hand).

Phase II:

Unit Operations/Processes/Activities: Consumption of electrical and electronic equipment, use of electrical and electronic equipment in households, offices and industry.

Stakeholders: Consumers like households, commercial places like offices and industry

Phase III:
Unit Operations/Processes/Activities: Collection of end-of-life electrical and electronic equipment, including transfer to treatment/disposal sites, import/export.

Stakeholders: Consumers, importers, exporters, collectors, traders, dismantlers, waste treatment operators

Phase IV:
Unit Operations/Processes/Activities: Treatment/disposal alternatives for WEEE/e-waste ex. repair, decontaminating, dismantling, shredding, landfill and incineration.

The four phase model has been shown in **Figure 2.3** while the input/output material balances explaining the mathematical relationship has been described in **Table 2.2**. The dotted vertical line in the **Figure 2.1** indicates the stage of "obsolescence" in between the second and third phase of life cycle.

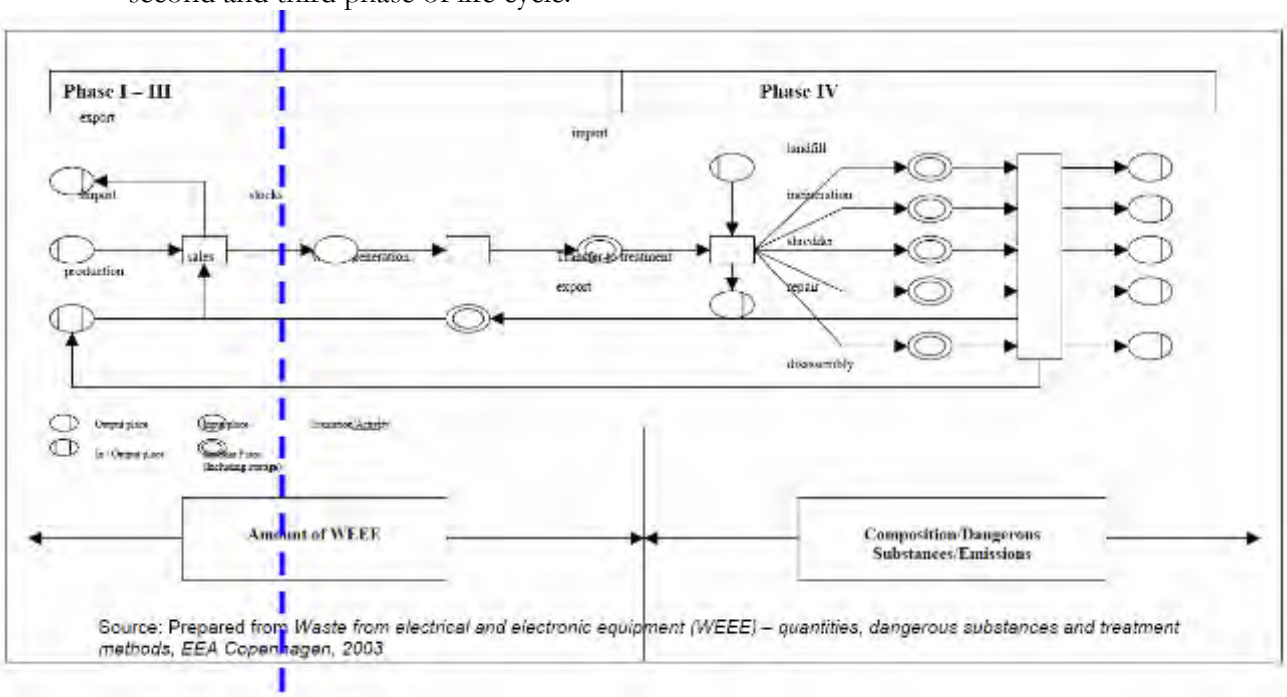


Figure 2.3: The 'Four-Phase-Model'

Source: UNEP Manual, E-waste Volume I: Inventory Assessment Manual, http://www.unep.or.jp/ietc/Publications/spc/EWasteManual_Vol1.pdf, (Accessed on 14 July, 2016)

Table 2.2: Phase wise Life Cycle of Electrical and Electronic Equipment

Phase I – Production/Sales	
Mass or number of equipment sold to consumers within a specified time period (t) is the basic parameter to design this system. It is assumed that no losses occur and no conversion of material takes place in this phase. Therefore Input = Output.	Input/Output for Sales: Input (t) =Production (t) + Import (t) + re-use of collected WEEE (t) – Treatment/Disposal of non—saleable EEE (t) Output (t) = Consumption (t) + Export (t)
Phase II – Consumption	

The design of the model in phase II requires mass/number of pieces of equipment bought and used by the consumers. After a certain time span (average life time t) the end-of-life goods are passed on for collection. It is assumed that in the consumption period no losses occur and no conversion of material takes place. The model will not consider the servicing of the equipment, the replacement of parts etc. Therefore Input = Output.	Input/Output for Consumption: Input (t) = Output Sales (t) – export (t) Output (t) = WEEE generated (t)
Phase III – Collection	
The design of the model in phase III requires mass or number of goods collected after the consumption period. It is assumed that in the collection period no losses occur and no conversion of material takes place. In addition the import of WEEE/e-waste has to be considered. The transport itself and its need for energy are not considered. Therefore Input = Output.	Input/Output for Collection: Input (t) =WEEE generated after consumption (t) + import of end-of-life EEE (t) Output (t) = end-of-life goods transferred to disposal/treatment/reuse [possibilities 1 ….n (t)] + export (t)
Phase IV – Treatment/Disposal	
The design of the model in phase IV requires mass or number of WEEE/e-waste collected and transferred to the different treatment/disposal activities. During this phase, a conversion or transition of WEEE/e-waste takes place, thus creating new materials (fractions, components, dangerous substances). In phase IV the model has to be designed for each specific type of treatment/disposal, taking into account the material input and the conversion of the material. Output depends on conversion/transition of the material and will lead to specific transfer factors.	Note: Treatment/disposal comprises one, two or even successive steps with different technologies used. The formula for this phase can be developed depending on the level of treatment and disposal.

Source: Waste from electrical and electronic equipment (WEEE) – quantities, dangerous substances and treatment methods, EEA Copenhagen, 2003

It may be noted that all the mathematical formulations in this model are functions of time. Therefore, these formulations require following data for a particular geographical region/city/country with respect to time.

1. Production and import data for electrical and electronic equipment
2. Sales and export data for electrical and electronic equipment
3. Local WEEE/e-waste generation data
4. Imported WEEE/e-waste data
5. WEEE/e-waste data transferred for disposal/treatment/reuse

The key time dependent functions related to WEEE/e-waste in this model are "Local WEEE/e-waste Generation" and "Imported WEEE/e-waste". The time factor in "Local WEEE/e-waste Generation" function is defined in terms of "Average Life Time/Obsolescence Rate" of WEEE/e-waste and is an indicator of "Consumer Behavior". "Imported WEEE/e-waste" is a function of time of implementation of regulations controlling import and export of WEEE/e-waste in a geographical region/city/country.

In developed countries, where WEEE/e-waste management system is in operation, the entire trade value chain occurs in organized/formal sector. In developing countries, a part of the trade occurs in unorganized/informal sector. In majority of developing countries, the informal sector engagement starts from the point of collection and continues till the last stage in some capacity. However, other steps/unit operations like WEEE/e-waste processing, production/end products may be present or absent in a country. It has been reported[6] that WEEE/e-waste is locally collected by local recyclers, scavengers, etc. without any legal framework (only recyclable. **Figure 2.1**, **Figure 2.2** and **Figure 2.3** can be used as a conceptual approach to establish material flow chain in a geographical region, identify unit operations inputs and outputs to assess the resource loss and environmental impacts on account of WEEE/e-waste management. This chain can be further modified or customized with inter or intra linkages depending on the WEEE/e-waste processing or end production in a particular country.

2.3 Average Life of Electronic Goods

As per UNU-IAS[7], the time the equipment spends at households, offices and the public sector after it is sold is called the product's lifetime or residence time. After a certain residence time, the product is disposed off. This is known as "WEEE/e-waste generated". Conceptual mapping of WEEE/e-waste generated is shown in **Figure 2.1**.

Average life cycle/obsolescence rate or the product's life time is the time span after which the electrical and electronic item comes to its "end of life". It can be defined in terms of 'active life", 'passive life" and "storage".

Average life cycle/Obsolescence rate = Active Life + Passive Life + Storage

The number of years, a machine can be effectively used is called its active life. After active life, it can be refurbished or reused for certain time period. This time period constitutes passive life. Storage includes storage time before disposal and storage at repair shops before dismantling. **All the three parameters vary in different geographical regions. Therefore, average life cycle/obsolescence rate is a function of time and varies in each geographical region and leads to different WEEE/e-waste inventory**.

2.4 Major Stakeholders

Some of the major stakeholders, identified along the flow include importers, producers/manufacturers, retailers (businesses/government/others), consumers (individual households, businesses, government and others), traders, retailers, scrap dealers, dissemblers/dismantlers, smelters and recyclers. At each step in the flow, business transaction defines the movement of the electronic item in the flow. Generally, in developing country, the last three stakeholders in WEEE/e-waste trade value chain consisting of WEEE/e-waste processing, production/end products and a part of WEEE/e-waste generation fall in the informal sector. The remaining stakeholders fall in the formal sector. The description of each of these stakeholders in developing country context is given below.

[6] Basel Convention Regional Centre in China (2005). *Report on the Survey of the import and Environmentally Sound Management of Electronic Wastes in the Asia-Pacific Region, Asia-Pacific Regional Centre for Hazardous Waste Management Training and Technology Transfer*

[7] Balde, C.P., Wang, F., Kuehr, Huishman, J. (2015). The Global E-waste Monitor, quantity flows and resources

Manufacturers and Retailers

WEEE/e-waste manufacturers and retailers comprise defective IC chips, motherboards, CRTs other peripheral items produced during the production process. It also includes defective PCs under guarantee procured from consumers as replacement items or items, which fail quality tests.

Importers

Importers of WEEE/e-waste like monitors, printers, keyboards, CPUs, typewriters, projectors, mobile phones, PVC wires, etc. are imported. These items could belong to all ranges, models and sizes, and are functional as well as junk materials.

Individual Households

Generally, households exchange WEEE/e-waste with retailers while purchasing a new item, or pass it on to relatives or friends.

Business/Government Sector

The business sector (government departments, public or private sector, MNC offices, etc. pass the obsolete electrical and electronic equipment to dismantlers/recyclers, who pick up these items based on auction or other standard business practices. It may also include incinerators, secured landfill operators both in private and public sectors.

Traders/Scrap dealers/Dissemblers/Dismantlers

The majority of stakeholders in this category fall under unorganised/informal sector. Immediately after securing WEEE/e-waste from various sources, scrap dealers decide which item ought to be dismantled and which to be retained for resale. The unsold WEEE/e-waste item/components find their way to the storehouses for dismantling.

Recyclers/Smelters

These stakeholders are not concentrated in a single place, but spread over different areas, each handling a different item for recycling. In developing countries, the general practices observed is open burning, smelting and acid bath in unorganised/informal sector to recover different metals.

2.5 WEEE/e-waste Composition, Recyclability and Hazardousness

WEEE/e-waste may consist of 60 different elements, which are valuable as well as hazardous and non-hazardous in nature. Since electrical and electronic equipment are major consumers of precious metals, they create a huge global demand. A mobile phone can contain over 40 elements from the periodic table including base metals like copper (Cu) and tin (Sn), special metals such as cobalt (Co), indium (In) and antimony (Sb), and precious metals including silver (Ag), gold (Au) and palladium (Pd). Metals represent on average 23% of the weight of a phone, the majority being copper, while the remainder is plastic and ceramic material. One tonne of phone handsets (without battery) would contain 3.5 kg Ag, 340 g Au, 140 g Pd as well as 130 kg Cu. The Li-ion battery of a phone contains about 3.5 g Co[8].

[8] *Sustainable Innovation and Technology Transfer Industrial Sector Studies; Recycling – From e-waste To Resources; UNEP///STEP Solving the e-wastee-waste Problem*

Table 2.3: Important metals used for electric and electronic equipment (based on demand in 2006)

Metal	Primary production (t/y)	Byproduct from	Demand for EEE (t/y)	Demand/production (%)	Price** (USD/kg)	Value in EEE** (10^6 USD)	Main applications
Ag	20 000	(Pb, Zn)	6 000	30	430	2.6	Contacts, switches, solders
Au	2 500	(Cu)	300	12	22 280	6.7	Bonding wire, contacts, integrated circuits
Pd	230	PGM	33	14	11 413	0.4	Multilayer capacitors, connectors
Pt	210	PGM	13	6	41 957	0.5	Hard disk, thermocouple, fuel cell
Ru	32	PGM	27	84	18 647	0.5	Hard disk, plasma displays
Cu	15 000 000		4 500 000	30	7	32.1	Cable, wire, connector
Sn	275 000		90 000	33	15	1.3	Solders
Sb	130 000		65 000	50	6	0.4	Flame retardant, CRT glass
Co	58 000	(Ni, Cu)	11 000	19	62	0.7	Rechargeable batteries
Bi	5 600	Pb, W, Zn	900	16	31	0.03	Solders, capacitor, heat sink
Se	1 400	Cu	240	17	72	0.02	Electro-optic, copier, solar cell
In	480	Zn, Pb	380	79	682	0.3	LCD glass, solder, semiconductor
Total			4 670 000			45.4	

*** Using the average price in 2007*

Source: Schluep Mathias, Hagelueken Christian, Ruediger Kuehr, Magalini Federico, Maurer Claudia, Meskers Christina, Mueller Esther, Wang Feng (2009). *Sustainable Innovation and Technology Transfer Industrial Sector Studies; Recycling – From E-Waste To Resources; UNEP / STEP Solving the E-waste Problem.*

Table 2.3 indicates the demand from EEE items as % of primary production. Further, it also indicates valuation and their usage in EEE components. Broadly, WEEE/e-waste consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete and ceramics, rubber and other items. Iron and steel constitutes about 50% of the WEEE/e-waste followed by plastics (21%), non - ferrous metals (13%) and other constituents. The presence of elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium and flame retardants in WEEE/e-waste and their components beyond threshold quantities render them hazardous in nature. These items of economic value can be recovered depending on the recycling/recovery technologies.

All WEEE/e-waste is potentially hazardous waste due to unscientific handling, treatment, incineration and dumping. The International Labour Organization (ILO) list of WEEE/e-waste components containing hazardous substances is presented in **Table 2.4**. The list highlights that these components should be treated scientifically and should not end up in a landfill or an incinerator mixed with other types of waste.

Table 2.4: Hazardous Chemicals Contained in Some WEEE/e-waste

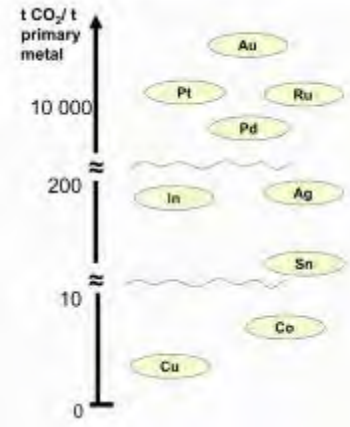
Chemical	Source in Electronic Products	Health Concerns
Antimony	CRTs, Printed Circuit Boards, etc.	Very hazardous in event of ingestion, hazardous in event of skin of eye contact, and inhalation. Causes damage to the blood, kidneys, lungs, nervous system, liver and mucous membranes (Material Safety Data Sheet, 2005)
Arsenic	Used to make transistors	Soluble inorganic arsenic in acutely toxic and intake of inorganic arsenic over a long period can lead to chronic arsenic poisoning. Effects, which can take years to develop, include skin lesions, peripheral neuropathy, gastro-intestinal symptoms, diabetes, renal system effects, cardiovascular disease and cancer (WHO, 2010b).
Barium	Front Panel of CRTs	Short-term exposure causes muscle weakness and damage to heart, liver and spleen. It also produces brain swelling after short exposure (Osuagwu and Ikerionwu, 2010).
Beryllium	Motherboards of computers	Carcinogenic (causing lung cnacer), and inhalation of fumes and dust can cause chronic beryllium disease or beryllicosis and skin diseases such as warts (Osuagwu and Ikerionwu, 2010).
Cadmium	Chip resistors and semiconductors	Has toxic, irreversible effects on human health and accumulates in kidney and liver (Op. cit.). Has toxic effects on the kidney, the skeletal system and the respiratory system, and is classified as a human carcinogen (WHO, 2010c).
Chloro-Fluorocarbons (CFCs)	In older fridges and coolers	Found to destroy the ozone layer and is a potent greenhouse gas. Direct exposure can cause unconsciousness, shortness of breath and irregular heartbeat. Can also cause confusion, drowsiness, coughing, sore throat, difficulty in breathing and eye redness and pain. Direct skin contact with some types of CFCs can cause frostbite or dry skin (US. National Library of Medicine. n.d.).
Cobalt	Rechargeable batteries and coatings for hard disk drives	Hazardous in case of inhalation and ingestion, and is an irritant of the skin. Has carcinogenic effects and is toxic to lungs. Repeated or prolonged exposure can produce target organs damage (Material Safety Data Sheet, 2005).
Copper	Used as conductor	Very hazardous in case of ingestion, in contact with the eyes and when inhaled. An irritant of the skin and toxic to lungs and mucous membranes. Repeated or prolonged exposure can produce target organs damage (Material Safety Data Sheet, 2005).
Dioxins	Created when electronics are burnt in open air	Highly toxic and can cause chloracne, reproductive and developmental problems, damage the immune system, interfere with hormones and cause cancer (WHO, 2010d).
Gallium	Integrated circuits, optical electronics, etc.	Hazardous in case of skin (may produce burns) and eye contact, ingestion and inhalation. Severe over exposure can result in death. Toxic to lungs and mucous membranes. Repeated or prolonged exposure can produce target organs damage (Material Safety Data Sheet, 2005).
Hexavalent Chromium	Used as corrosion protection of untreated and galavanized steel plates and a decorator or hardner for steel housings (Osuagwu and Ikerionwu, 2010)	Damages kidneys, the liver and DNA. Asthamatic bronchitis has been linked to this substance (Osuagwu and Ikerionwu, 2010). Causes irritation of the respiratory system (asthma) and skin, liver and kidney damage, increased or reduced blood leukocytes, cosinophilia, eye injury, and is a known carcinogen (lung cancer).
Indium	LCD Screens	Can be absorbed into the body by inhalation or ingestion. Is irritating to the eyes and respiratory tract and may have long term effects on the kidneys. Environmental

Chemical	Source in Electronic Products	Health Concerns
		effects have not been investigated and information on its effects on human health is lacking therefore utmost care must be taken (ICSC database, n.d.).

Source: Solving the E-Waste Problem (Step) Green Paper; e-waste Prevention, Take-back System Design and Policy Approaches

2.6 Environmental Health and Socio-economic Impact of WEEE/e-waste

Environmental, health and socio-economic impact of WEEE/e-waste has been described both in terms of primary and secondary production of metals. The environmental impact/footprint of the primary metal production has been assessed as significant, since they are mined from ores in which their concentration is low. Some of the impacts include large amount of land required for mining, generation of wastewater and emissions of sulfur-dioxide (SO_2), CO_2 and energy consumption. **Figure 2.4** indicates CO_2 emissions from primary production of metals. Recovery of metals from secondary sources like WEEE/e-waste require small amount of land and generate a fraction of gaseous emissions and waste water.



Important EEE metals	demand for EEE t/a (2006)	data for primary production [t CO_2/t metal]	CO_2 emissions [Mt]
Copper	4 500 000	3.4	15.30
Cobalt	11 000	7.6	0.08
Tin	90 000	16.1	1.45
Indium	380	142	0.05
Silver	6 000	144	0.86
Gold	300	16 991	5.10
Palladium	32	9 380	0.30
Platinum	13	13 954	0.18
Ruthenium	6	13 954	0.08
CO_2 total [t]			23.4

Figure 2.4: CO_2 emissions of primary metal production calculated using the EcoInvent 2.0 database

Source: Sustainable Innovation and Technology Transfer Industrial Sector Studies; Recycling – From E-Waste To Resources; UNEP/STEP Solving the e-waste Problem

However, a number of studies have reported negative impacts of unorganized/informal WEEE/e-waste recycling on surrounding environment and health of inhabitants. Some of the evidence in developing countries is given in **Figure 2.5**.

The recovery techniques used by informal sector to recover recyclable materials often cause contamination. For instance, open-air burning of cables from various products to recover the copper wire from PVC coating in Asia, Africa and Latin America. It has serious impacts on the health of the informal workers because of hydrochloric acid produced, which causes acute respiratory problems. Further environmental damage can be caused by disposal of the non-valuable material. Due to poor socio-economic conditions, unorganized/informal WEEE/e-waste recyclers recover valuable parts and simply dump the non-valuable parts. An example of comparison formal sector recycling in Switzerland and informal sector recycling in India is summarized in **Table 2.5**[9].

[9] McCann Duncann (2015). *Solving the e-waste Problem (Step) Green Paper; e-waste Prevention, Take-back System Design and Policy Approaches*

Table 2.5: Comparison between Switzerland and India with regards to e-waste Generation and Recycling

Criterion	Switzerland		India	
	Level	**Implication**	**Level**	**Implication**
WEEE/e-waste per capita	High	Negative	Low	Positive
Employment Potential	Low	Negative	High	Positive
Occupational Hazard	Low	Positive	High	Negative
Emissions of Toxics	Low	Positive	High	NEgative

Source: Sinha-Khetrival, D., 2005

Figure 2.5: Evidences of air, water and soil pollution and Occupational, Health and Safety Hazards
Source: Jain Amit (2016).

Table 2.5 shows that 'employment potential" is very high in a developing country but at the cost of high "emissions of toxics" to the environment and "occupational hazards".

2.7 Guidance Notes

Objective: The major objective of guidance notes on WEEE/e-waste market is to assist in WEEE/e-waste market assessment, which includes identification, their classification and composition, likely waste stream and planning for WEEE/e-waste inventory assessment. It will also assist in planning for inventory assessment and selection of type of technology. This planning will include delineating the area, establishment of waste trade value chain and identification of stakeholders in geographical area.

Guidance Procedure: Guidance procedure includes completion of following eight steps. The schematic representation of these steps is given in **Figure 2.6**.

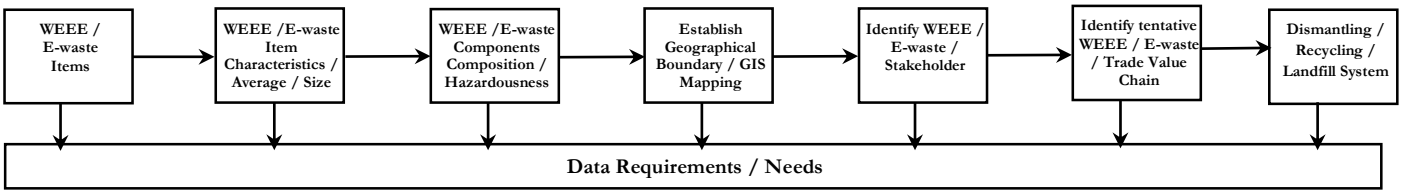


Figure 2.6: Guidance procedure for defining WEEE/e-waste market assessment
Source: UNEP Manual, E-waste Volume I: Inventory Assessment Manual, http://www.unep.or.jp/ietc/Publications/spc/EWasteManual_Vol1.pdf, (Accessed on 14 July, 2016)

Step 1: Determine WEEE/e-waste item of interest as per **section 2.1**. This will assist in studying the item of interest, ex. PCs, TVs, cellular telephones, and refrigerators, etc. Determine the brands, local, national and international, which are available in the market for each item and the year of their introduction in the market. Determine brands which existed earlier. This can be determined through the review of secondary data from industry association or by interacting with local dealers. If the product is manufactured under a brand name, the broad feature of technology used to manufacture item is generally disclosed. This will also assist in identifying its dealer's network, existing facilities for item's manufacture and repair and its membership with local industry association.

Step 2: Determine average weight and size of local, national and international WEEE/e-waste item from each brand ex. capacity of refrigerator (litres)/washing machine, size of monitor/TV/cellular phone. The variation in size of each item should be documented under each brand. Average weight and size along with percentage composition should be estimated.

Step 3: Determine broad components of WEEE/e-waste items as per classification. Determine composition of WEEE/e-waste item from available source like industry association/manufacturer. Determine technology of WEEE/e-waste item e.g. ODS based refrigerator/486/586/Pentium series of PCs and laptops/CRT/front loading/top loading washing machines etc. Determine approximate quantity of recoverable elements from each item based on outputs of step 2 and determine possible hazardous substance in WEEE/e-waste item **(refer to section 2.6 as a guide)**.

Step 4: Establish geographical boundary/system boundary of study area (city/region). Procure maps of the area and prepare base map of the area with physical features marked on it. This mapping will give an insight into the possible sources of WEEE/e-waste and assist in carrying out the primary survey for inventory assessment.

Step 5: Identify different stakeholders like importers, manufacturer, businesses, government, and retailers, consumers who could be WEEE/e-waste generators and mark them as layer two on the base map. Physically verify by carrying out preliminary reconnaissance survey of the identified locations of the stakeholders. Mark the tentative locations by taking latitudes and longitudes of the identified locations through GPS instrument. Identify the stakeholders, which are in the formal/organized sector and which are in the informal sector.

Step 6: Prepare a tentative WEEE/e-waste trade value chain as per conceptual life cycle shown in figure 2.1 and figure 2.2, four phase model given in figure 2.4. These figures should be customized as per preliminary survey, which will be confirmed and established during the field survey.

Step 7: Identify WEEE/e-waste dismantling sites, recycling sites and landfill/dump sites. Physically verify these sites by preliminary reconnaissance survey and marking the tentative locations by recording their latitudes and longitudes through GPS instrument.

Step 8: Identify data needs from these stakeholders based on identified stakeholders in step 5 and trade value chain identified in step 6.

CHAPTER 3: PERSPECTIVE OF WEEE/E-WASTE MANAGEMENT

3.0 Introduction

Perspective of WEEE/e-waste management has been described in terms of existing regulatory and institutional structure as well as assessment of the quantities and extent of WEEE/e-waste to be managed. In this context, description of current practices of WEEE/e-waste management which provides an understanding of policy/laws/regulations and institutional framework related to WEEE/e-waste management in developed and developing countries is presented. The assessment of the WEEE/e-waste quantities are indicative of the recycling industries potential to recover secondary resources, as well as setting environmental targets for detoxification. This information provides baseline information for establishing the necessary infrastructure to collect, finance and treat WEEE/e-waste. The WEEE/e-waste inventory data are useful for policymakers and recycling industry to plan the location, capacity and technologies for recycling infrastructures. This will not only eventually lead to improvement of resource efficiency but also reduce the environmental and health impacts of WEEE/e-waste. Finally, guidance notes provide a broad road map to assist in developing enabling policy/laws/regulations and institutional framework for WEEE/e-waste management as well as inventory assessment.

3.1 National Policy/Laws/Regulations/Institutional Mechanism in Developed Countries

Countries in Europe particularly EU and Japan in Asia have been the frontrunners in formulating and implementing policy/laws/regulations for WEEE/e-waste. The following sections describe policy/laws/regulations in developed countries for WEEE/e-waste management.

3.1.1 Policy/Laws/Regulation

The fundamental principle for development of WEEE/e-waste policies/laws/regulations is based on the conceptual life cycle of electrical and electronic equipment (EEE) as described in **Figure 2.1** chapter 2. The major feature in any policy/law/regulation is the definition of WEEE/e-waste and the sections/blocks in the life cycle which need to be regulated. If a section/block of the life cycle falls outside the geographical boundary of a country, then the WEEE/E- waste is governed by international conventions such as the Basel convention on trans boundary movement of hazardous waste. If all sections/blocks of the life cycle fall within the geographical boundary of a country then a national law/regulation drive the WEEE/e-waste management.

"Extended Producer Responsibility" with "Product Take Back" and "Polluter Pays Principle" policy forms the basis of policy framework in developed countries. WEEE directives provide a regulatory basis for collection, recovery and reuse/recycling targets in EU. It also provides basis for formulation of legal, physical and financial responsibility for member countries. The transportation and development of legislation and compliance

structure as per EU directives is an on-going process in all EU countries. The member states have to guarantee minimum collection, recovery and reuse/recycling targets as specified in the directive. The fundamental principle of WEEE directive is "Extended Producer Responsibility", where producers are responsible for WEEE/e-waste take back. Those European countries, which are not part of EU either follow policies and regulations similar to EU directive or more stringent standards based on WEEE/e-waste management. Countries like Japan have regulations focused on "Reuse, Recycling and Recovery". Other countries like Canada, USA and Australia are developing their systems based on the similar principles of "Stewardship" or "Extended Producer Responsibility".

3.1.2 Other Countries

Australia

" National Waste Policy: Less Waste, More resources" proposes formulation of legislation based on "Product Stewardship". Australia has a national regulation for the disposal of end-of-life computers and television units. In Australia, waste management is primarily the responsibility of state governments and, through them, local governments. "The Product Stewardship Act 2011" was enacted in 2011, which provides a legislative framework for national product stewardship schemes.

Canada

Canada's WEEE/e-waste regulations are in the process of being enforced at the provincial level. Alberta, British Columbia, Nova Scotia, Ontario and Saskatchewan have WEEE/e-waste regulations in place.

Japan

WEEE/e-waste is covered under laws to promote recycling within Japan. The two major laws covering broad range of WEEE/e-waste items are "The Law for Recycling of Specified Kinds of Home Appliances (Home Appliances Recycling Law)" enacted in 1998 and "The Law for Promotion of the Effective Utilization of Resources" enacted in 2000. In "The Law for Recycling of Specified Kinds of Home Appliances (Home Appliances Recycling Law)", WEEE/e-waste is referred as "Used Consumer Electric Goods Discarded by Consumers". This law covers TVs, refrigerators, washing machines and air conditioners. In "The Law for Promotion of the Effective Utilization of Resources", WEEE/e-waste is covered under "Used goods and by-products" which have been generated and their large part is discarded. Recently the law on "Small Appliances" has also been enforced.

New Zealand

There is no legislation, which defines WEEE/e-waste in New Zealand. However, Imports and Exports (Restrictions) Order (No 2) 2004 defines WEEE/e-waste. It states that "Electronic Waste" covers electronic items, which are to be disposed of by recycling or final disposal. Such equipment includes:

- Computer equipment including monitors and printers;
- Mobile and land line telephones;
- Fax machines;
- Photocopying equipment;
- Television sets;

- Video recorders;
- Printed circuit boards; and
- Equipment containing cadmium, mercury or lead batteries.

Republic of Korea

Republic of Korea regulations based on the "Extended Producer Responsibility". Article 2 of Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles adopted on 2 April 2007, define "Waste Electrical and Electronic Equipment" as electrical and electronic equipment, which is classified as "waste" in accordance with Article 2, Section 1 of the Waste Management Act. "Electric and Electronic Equipment" means equipment or device (including components and parts thereto) operated by electric currents and electromagnetic fields.

USA

USA does not have national regulation. However, states have regulations on WEEE/e-waste.

Table 3.1 describes the EPR based schemes in different countries, their starting date and their nature.

Table 3.1: Characteristics of EPR Schemes for WEEE/e-waste

Member State	Start date of EPR scheme(s)	Collective or individual	If collective, number of EPR schemes
Austria (AT)	2005	Collective	4
Belgium (BE)	2001 and 2002	Collective	1
Bulgaria (BG)	2006	Collective	2
Cyprus (CY)	2006	Collective	1
Czech Republic (CZ)	2005	Collective	3
Germany (DE)	2005		2
Denmark (DK)	N/A	Collective	1
Estonia (EE)	2005	Collective	3
Spain (ES)	2002, 2005	Collective	7
Finland (FI)	2000, 2004 and 2005	Collective	6
France (FR)	2005	Both	4
Greece (GR)	2001 and 2009	Collective	2
Hungary (HU)	N/A	Collective	2
Croatia (Hrvatska) HR	N/A	Collective	3
Ireland (IE)	2005	Both	2
Italy (IT)	2004, 2005, 2006, 2007, 2008	Collective	16
Lithuania (LT)	2006	Collective	1
Luxembourg (LU)	2004	Collective	1
Latvia (LV)	2006	Collective and some individual	5
Netherlands (NL)	N/A	Collective	9
Poland (PL)	2005	Collective	2
Portugal (PT)	2006	Collective	2
Romania (RO)	2007	Collective	2
Sweden (SE)	2001, 2007	Collective	2
Solvenia (SI)	2005	Collective	2
Slovak Republic (SK)	N/A	Collective	3

United Kingdom (UK)	N/A	Collective	29

Source: Monier Véronique, Hestin Mathieu, Cavé Jérémie, Laureysens Ilse, Emma Watkins, Reisinger Hubert, Porsch Lucas (2014). European Commission – DG Environment. *Development of Guidance on Extended Producer Responsibility (EPR), Final Report.*

3.2 National and Social Policies/Laws/Regulations/Economic/Institutional Roles in Developing Countries

Policies/laws/regulations and institutional mechanisms in developed and developing countries, where some level of WEEE/e-waste awareness exists, have been described in **Table 3.2**. The table also gives a list of countries that have national WEEE/e-waste regulations and an official take back system.

Africa: Only Cameroon and Nigeria have enforced national WEEE/e-waste related legislation, while Ghana, Ethiopia and Kenya still have legislation pending approval.

America: In Central America, only Costa Rica has implemented national legislation to take back and recycle WEEE/e-waste. In South America, Peru, Bolivia and Ecuador already have national WEEE/e-waste legislation, while Brazil and Chile have national laws pending approval.

Asia: China, India, Viet Nam and Turkey have national WEEE/e-waste related laws. The Philippines and Jordan have regulations pending approval.

Majority of developing countries have either planned or developed their regulations under extended producer responsibility. These countries can learn from the constraints/steps encountered/followed in implementing the EU directive, while designing their regulations under EPR regime. **Table 3.2** below, describes the list of National Regulations and Official Take Back Systems on WEEE/e-waste.

Table 3.2: National Regulation and Official Take Back System on WEEE/e-waste

Continent	Name	National Regulation in force till 2013	Official Take Back System
Africa	Burundi		
Africa	Comoros		
Africa	Djibouti		
Africa	Eritrea		
Africa	Ethiopia		
Africa	Kenya		
Africa	Madagascar		
Africa	Malawi		
Africa	Mauritius		
Africa	Mozambique		
Africa	Rwanda		
Africa	Seychelles		
Africa	Uganda		
Africa	United Repub- lic of Tanzania		
Africa	Zambia		
Africa	Zimbabwe		
Africa	Angola		
Africa	Cameroon		
Africa	Central African Republic		
Africa	Chad		

Continent	Name	National Regulation in force till 2013	Official Take Back System
Africa	Congo		
Africa	Democratic Republic of the Congo		
Africa	Equatorial Guinea		
Africa	Gabon		
Africa	Sao Tome and Principe		
Africa	Algeria		
Africa	Egypt		
Africa	Libya		
Africa	Morocco		
Africa	Sudan		
Africa	Tunisia		
Africa	Botswana		
Africa	Lesotho		
Africa	Namibia		
Africa	South Africa		
Africa	Swaziland		
Africa	Benin		
Africa	Burkina Faso		
Africa	Cape Verde		
Africa	Côte d'Ivoire		
Africa	Gambia		
Africa	Ghana		
Africa	Guinea		
Africa	Guinea-Bissau		
Africa	Liberia		
Africa	Mali		
Africa	Mauritania		
Africa	Niger		
Africa	Nigeria		
Africa	Senegal		
Africa	Sierra Leone		
Africa	Togo		
Americas	Antigua and Barbuda		
Americas	Bahamas		
Americas	Barbados		
Americas	Dominica		
Americas	Dominican Republic		
Americas	Grenada		
Americas	Haiti		
Americas	Jamaica		
Americas	Saint Kitts and Nevis		
Americas	Saint Lucia		
Americas	Saint Vincent and the Grenadines		
Americas	Trinidad and Tobago		
Americas	Belize		
Americas	Costa Rica		
Americas	El Salvador		
Americas	Guatemala		
Americas	Honduras		
Americas	Mexico		
Americas	Nicaragua		
Americas	Panama		
Americas	Canada		
Americas	United States of America		

Continent	Name	National Regulation in force till 2013	Official Take Back System
Americas	Argentina		
Americas	Bolivia		
Americas	Brazil		
Americas	Chile		
Americas	Colombia		
Americas	Ecuador		
Americas	Guyana		
Americas	Paraguay		
Americas	Peru		
Americas	Suriname		
Americas	Uruguay		
Americas	Venezuela (Bolivarian Republic of)		
Asia	Kazakhstan		
Asia	Kyrgyzstan		
Asia	Tajikistan		
Asia	Turkmenistan		
Asia	Uzbekistan		
Asia	China		
Asia	China, Hong Kong Special Administrative Region		
Asia	Japan		
Asia	Mongolia		
Asia	Republic of Korea		
Asia	Taiwan		
Asia	Brunei Darussalam		
Asia	Cambodia		
Asia	Indonesia		
Asia	Lao People's Democratic Republic		
Asia	Malaysia		
Asia	Myanmar		
Asia	Philippines		
Asia	Singapore		
Asia	Thailand		
Asia	Timor-Leste		
Asia	Viet Nam		
Asia	Afghanistan		
Asia	Bangladesh		
Asia	Bhutan		
Asia	India		
Asia	Iran (Islamic Republic of)		
Asia	Maldives		
Asia	Nepal		
Asia	Pakistan		
Asia	Sri Lanka		
Asia	Armenia		
Asia	Azerbaijan		
Asia	Bahrain		
Asia	Georgia		
Asia	Iraq		
Asia	Israel		
Asia	Jordan		
Asia	Kuwait		
Asia	Lebanon		
Asia	Oman		
Asia	Qatar		
Asia	Saudi Arabia		

Continent	Name	National Regulation in force till 2013	Official Take Back System
Asia	Syrian Arab Republic		
Asia	Turkey		
Asia	United Arab Emirates		
Asia	Yemen		
Europe	Belarus		
Europe	Bulgaria		
Europe	Czech Republic		
Europe	Hungary		
Europe	Poland		
Europe	Republic of Moldova		
Europe	Romania		
Europe	Russian Federation		
Europe	Slovakia		
Europe	Ukraine		
Europe	Denmark		
Europe	Estonia		
Europe	Finland		
Europe	Iceland		
Europe	Ireland		
Europe	Latvia		
Europe	Lithuania		
Europe	Norway		
Europe	Sweden		
Europe	United Kingdom of Great Britain and Northern Ireland		
Europe	Albania		
Europe	Bosnia and Herzegovina		
Europe	Croatia		
Europe	Greece		
Europe	Italy		
Europe	Malta		
Europe	Montenegro		
Europe	Portugal		
Europe	Serbia		
Europe	Slovenia		
Europe	Spain		
Europe	The former Yugoslav Republic of Macedonia		
Europe	Austria		
Europe	Belgium		
Europe	France		
Europe	Germany		
Europe	Luxembourg		
Europe	Netherlands		
Europe	Switzerland		
Oceania	Australia		
Oceania	New Zealand		
Oceania	Fiji		
Oceania	Papua New Guinea		
Oceania	Solomon Islands		
Oceania	Vanuatu		
Oceania	Kiribati		
Oceania	Marshall Islands		
Oceania	Micronesia (Federated States of)		
Oceania	Samoa		

Continent	Name	National Regulation in force till 2013	Official Take Back System
Oceania	Tongata		
Oceania	Tuvalu		

Legend Yes No

Source: Compiled from UNU-IAS; The Global e-waste Monitor 2014

3.3 Institutional Mechanism under Extended Producer Responsibility

Institutional mechanism under "Extended producer responsibility" or "Product Take Back" for WEEE/e-waste management system has been described in terms of collection systems, national registry and logistics. Each of these three elements has been further described in terms of different stakeholders and their respective roles/responsibilities. Some of the major elements of "take back" mechanisms which emerge from the regulatory framework under extended producer's responsibility are given below.

1. Definition of WEEE/e-waste
2. Items covered under WEEE/e-waste
3. Cut off date for implementation.
4. WEEE/e-waste inventory
5. Definition of Producer/Importers/Exporters, distributors, collection points, dismantlers, recyclers, disports etc., as identified in the WEEE/e-waste material flow chain.
6. Physical responsibility of collection of WEEE/e-waste from private household and the point/stakeholder from where this responsibility starts, e.g. collection points.
7. Allocation of responsibility for collection, treatment, recovery, recycling and disposal of WEEE/e-waste from private household deposited at collection points.
8. Allocation of financial responsibility mechanism for collection of WEEE/e-waste from private households.
9. Type of financial mechanism, e.g. individual financial responsibility or collective financial responsibility for "historical" or "new" WEEE/E-Waste from private households.
10. Form of financial guarantee for managing WEEE/e-waste from private households.
11. Status of distance sellers and their registration e.g. sellers on the Internet.
12. Allocation of responsibility.
13. Labeling of EEE for producer identification.
14. Producer registration and reporting, e.g. reporting periods, criteria for B2B and B2C, definition of "put on the market", reporting formats.

Clarity on the above elements will assist in development of WEEE/e-waste management system architecture. As an example, a copy of regulations from EU and India are given in **Appendix 3.1.**

3.3.1 Collection Systems

Regulation in each country provides the basis of WEEE/e-waste collection system. There are two generic categories of collection systems at national level i.e. "collective system (monopoly)" and competition based "clearing house system" for managing WEEE/e-waste. The objective of both systems is to provide WEEE/e-waste management services at reduced costs to the consumers i.e. household or business and ensure compliance at the national level.

Collective System
The collective system is a system which is responsible for collection, recycling and financing of all or major parts of WEEE/e-waste within national boundaries. This is the general approach in the countries with an established WEEE/e-waste system. Their legal status differs from country to country, but they are generally nongovernmental, not-for-profit companies which are set up and owned by one or more trade associations. They are named as "Producer Responsibility Organizations". They are organized into product categories in order to focus on achieving maximum efficiency in their recycling operations and to identify markets for recycled material and product reuse.

Clearing House System
The clearing house system is a system in which multiple partners (producers, recyclers, and waste organizations) can provide services on a competitive basis. The government ensures that there is a register of producers and it defines the allocation mechanisms, and reporting and monitoring systems. The responsibilities of a central national coordination body are to determine the collection obligation of each producer (via the national register) and to assign this obligation to the compliance scheme action on behalf of the producer. This body will also establish an allocation mechanism that enables compliance systems to collect WEEE/e-waste in an equitable manner from collection points throughout the territory.

3.3.2 National Registry

Any registered body/agency, which maintains the register of producers/recyclers/waste organizations, inventory of WEEE/e-waste has been defined as national registry. This body/agency can also determine collection obligation of each producer and ensures equitable compliance. This body/agency could be any government entity or a non-profit organization recognized/supported by the government for discharging the above mentioned functions.

3.3.3 Logistics

There are three primary channels of WEEE/e-waste collection. All the three channels address "Business to Consumer" (B2C) and "Business to Business" (B2B) WEEE/Ewaste collection. These channels are municipal sites, in store retailer take-back and producer take-back. Generally, municipal collection sites are usually free for households to use to an unlimited extent, while take-back through retailers is usually free but can be dependent upon the purchase of a new product (both B2C and B2B). The direct producer take-back system may apply to larger commercial equipment and operates on a new for old basis (B2B). The entire mechanism works on a fee basis, either directly or indirectly.

Major factors that impact the institutional mechanism are given below.

1. Total inventory of WEEE/e-waste to determine the economies of scale for institutional operations.
2. Distance and geography of the country/area/region/city, with smaller distances reducing costs for transport and logistics.
3. Population size and density, where a higher population enables the generation of economic efficiencies and economies of scale.
4. Cost of labour, as collection, sorting and treatment are highly labour intensive.
5. Length of time in operation.

6. Consumer behaviour with respect to recycling.
7. The level of WEEE/e-waste recycling awareness in relation to specific product groups.

3.3.4 Lessons from overseas product stewardship schemes

Literature cites that no single product stewardship approach could simply be copied or introduced in any country for a given product. Some of the lessons from the North American and European schemes are given below:

- Programme objectives must be clearly defined;
- Collaborative approaches may be helpful in progressing programs;
- Any market intervention should be transparent, justified, fair, and support competition;
- Effective stakeholder engagement in the programme design will ensure smooth implementation. Existing or planned waste and recycling systems should be taken into account;
- A robust process for establishing fee structures is essential to ensuring perception of fees as fair, reasonable and based on actual programme costs. The fee establishment is in a developing process and must be revisited.
- Most manufacturers are active in global markets and tend to achieve consistent standards that have generally been established in Europe.

The lessons from the Asian schemes are given below:

- Effective design of financial incentives is vital to the success of a scheme.
- A coordinated mechanism which creates incentives and obligations for various players along the supply chain can promote resource efficiency.
- Convenience strongly influences consumer behavior, especially "Collection and Transportation".
- Impacts on competition should be considered—there is a need to balance growth of the recycling industry against opportunity for the formation of monopolies. Furthermore, competition of informal versus formal sector recycling.
- Participation of manufacturers in the physical management of their end-of-life products is a significant factor in the success of EPR schemes.
- Accounting for non-participants is important, e.g. Consumers in Japan pay more for disposing of goods manufactured by non-participants.
- End-of-life consumer goods should not be viewed as worthless 'waste' but as cost-effective sources of materials.

3.4 Brief Methodology for Assessment of Quantity of WEEE/e-waste Generated in a Country

A number of methodologies have been used globally for assessment of WEEE/e-waste. Some of these methodologies have been described below based on inputs from UNEP/IETC, WEEE/e-waste Volume 1, Inventory Assessment Manual and UNU-IAS, The Global WEEE/e-waste Monitor 2014, Quantitative Flows and Resources.

3.4.1 The Time Step Method

The calculation of WEEE is made on the basis of private and industrial stock and sales data. The WEEE/e-waste potential during collection phase at time *t* is calculated from the difference in stock levels of private and industrial equipment during consumption phase in the period between two points in time *t*, plus sales in that period minus the annual waste produced in that time period up to time *t-1*.

Mathematically, the time step method is given below.

WEEE generation (t) =
$[\text{Stock}(t_1) - \text{Stock}(t)]_{private} + [\text{Stock}(t_1) - \text{Stock}(t)]_{industry} + \bullet_{n=t1+1 \text{ to } t-1} \text{Sales}(n) - \bullet_{n=t1+1 \text{ to } t} \text{WEEE}(n)$

with $t_1 < t$

$\text{Stock}_{private}$ = Number of households *saturation level of households/100
= Population/average size of household *saturation level of households/100
$\text{Stock}_{industry}$ = number of work places *saturation level in the industry/100
= number of employees/number of users per appliance

Requirements

1. Information about domestic sales can be obtained from production, import and export statistics.
2. Appliance stock levels can be ascertained from predetermined saturation levels in the household.
3. Industrial stock levels are difficult to obtain and require assumptions.

Constraints

1. Household saturation levels are based on predetermined stock levels.
2. Industrial stock levels are assumed in the calculations.
3. Assumption that all the WEEE/e-waste generated is collected and transferred to treatment and disposal facilities.

Advantages

1. Calculations can be carried out very easily.
2. THE method gives good results in a saturated market.

3.4.2 The Market Supply Method

The calculation of WEEE/e-waste is made from sales data, together with typical lifespan. The waste potential during collection phase at time *t* is calculated from sales figures and information about consumption patterns. Disposal is seen as the opposite of the acquisition of appliances, but with a certain time delay in the subsequent process.

Mathematically, the market supply method is given below:
WEEE generation (t) = sales $(t - d_N)$ + reuse $(t - d_S)$

Where,
d_N - Average lifetime of new items
d_S - Average lifetime of second-hand items

Requirements

1. Information about domestic sales required for this calculation can be obtained from production and export statistics.
2. Average life of new and second hand items. The average life of new goods (Active Life) and second-hand appliances (Passive life) is different.

Constraints

1. The average life, to a large extent, is subjective because in most of the developed countries electrical and electronic equipment is often replaced and disposed of before it reaches its technical end-of-life.
2. WEEE/e-waste are often stored for years.
3. Assumed that all appliances produced in the same year will be in line for disposal after exactly the average life.
4. Assumption that the average variance in life of items of EEE does not change very much, whereas, in reality, lifetimes may become shorter in the future. Therefore, this method is not especially useful in the calculation of WEEE for a dynamic market where technology and life are changing rapidly.

Advantages

1. Necessary data need not be very wide-ranging.
2. Calculations can be carried out very easily using a simple formula
3. Sales data is derived from official statistics from market research institutes or trade organisations and are of good quality and available for a large number of products.

3.4.3 The Carnegie Mellon Method

This method is a variation of "market supply method", where the calculation of WEEE is made from sales data, assumptions about typical lifetimes, recycling and storage. The model considers consumer behaviour when disposing of end-of-life electrical and electronic equipment. This method defines the pathways of electrical and electronic equipment from purchase to end-of-life. At the point of obsolescence, there are four options available to the owner as described below.

- Reuse: Possibly gifted/donated to another user without extensive modification.
- Storage: Not used.
- Recycled: Defined as the product being taken apart and individual materials or
- Sub-assemblies being sold for scrap.
- Landfilled.

Constraints

1. Assumptions are made regarding the pathways or "material flow" during reuse, storage, recycling and landfilling. These assumptions are both product and country specific and therefore demand a good knowledge of consumer behaviour and the disposal position.

2. This model also requires a full coverage of sales data as early as possible in the WEEE/e-waste trade value chain.

Advantages

1. The model allows for an electrical and electronic equipment to be purchased, reused, stored and finally recycled or landfilled representing "material flow" more precisely.

2. This method is ideal for more extensive examination of individual products. Because of the larger amount of input data, the calculation of WEEE is clearly more extensively structured.

3.4.4 Approximate Formula

Two methods have been defined for calculating WEEE/e-waste generation.

3.4.5 Approximation 1

The calculation of WEEE is estimated on the basis of stock and average lifetime data. This method has also been referred to as the 'Consumption and Use' method. This method was used to calculate WEEE/e-waste in the Netherlands. Mathematically, the method is represented by the following equation.

WEEE generation (t) = [Stock $_{private}$ (t) + Stock $_{industry}$ (t)]/average lifetime

Stock $_{private}$ = Number of households *saturation level of the households/100
= Population/average size of household *saturation level of the households/100
Stock $_{industry}$ = number of work places *saturation level in the industry/100
= number of employees/number of users per appliance *saturation level in the industry/100

The required input data for application of this method is stock data and assumptions about average lifetime of appliance.

Constraints

1. A product's constant mean lifespan is assumed in this method.
2. This method is suitable for estimating WEEE in widely saturated markets with no major deviations from the mean lifespan, which is a subjective variable.

Advantages

This method is particularly useful when reliable stock data for an appliance is available

3.4.6 Approximation 2

Sales statistics is used to calculate WEEE/e-waste generation in a particular year, assuming a saturated market. This method is based on the assumption, that with the sale of a new appliance, an old appliance has to be disposed of.

Mathematically, it can be represented as given below.

WEEE generation (t) = sales (t)

Constraints

1. This method is only suitable in a fully saturated market where the purchase of a product leads to the same quantity of waste from the old product. Therefore, this method has limited application in dynamic and developing markets because in these markets a larger part of the sales serves to increase stock and does not initially contribute to waste.
2. This method is unsuitable if the temporary storage or second use of old appliances plays a significant role in consumer behaviour.

Advantages

1. This method is suitable for carrying out an initial assessment.
2. Very limited range of input data required for application of this method.
3. No historical data is required, only sales figures for a particular period of time are required.

3.4.7 Apparent Consumption Approach based on Calculation of Sales and WEEE/E-Waste Generated

As per this approach, the following steps have been used for calculation of WEEE/e-waste generated.

Step 1: Calculation of sales data
Sales = Import – Export. or
Sales = Domestic Production + Import – Export

Step 2: Statistical correction of the sales data. If data sets obtained from secondary sources showed discrepancy, **then time series method using the country data can be used for getting harmonized data sets**.
Determining the WEEE/e-waste generated by country by applying the "Sales – Lifespan Distribution" method with empirical lifespan data.

For example lifespan data is obtained from the 28 EU Member States using the Weibull distribution. The lifetime assumes, mathematically, the form of the Weibull function, with parameters of scale and shape. **The scale parameter, which is associated to the average life of EEE, was fitted to real data in EU in order to get the closest real life characteristics.** The average age of household EEE stocks and the average age of discarded WEEE/e-waste enabled the construction of lifetime profiles for each product. This included the dormant time of electronic equipment on storage[10]. Average age of household EEE stocks and the average age of discarded WEEE/e-waste and dormant time on storage gets correlated to the active life, passive life and storage time described in section 2.4 of chapter 2.

[10] *The Global e-waste Monitor 2014: United Nations University*

3.5 Data Requirements and Data Sources

Data requirements for the application of above mentioned methods are given in **Table 3.3**. The extent of data required depends on the extent of geographical boundary, which could be national, regional or city boundary.

Table 3.3: Data Requirements for WEEE/e-waste Inventory Assessment

Methodology/Data Requirement	Saturation Level		Number of Household	Calculated Sales			Stock Data		Average Lifetime	Storage data	Reuse	Recycle	Landfill
	Household	Industry		Export Data	Import Data	Manufacturing/Production	Private	Industry					
Time Step Method	√	√	√	√	√	√	√	√					
Market Supply Method				√	√	√			√				
Carnegie Mellon Method				√	√	√			√	√	√	√	√
Approximation 1	√	√	√				√	√	√				
Approximation 2				√	√	√							

Data source is an important aspect of WEEE/e-waste inventory assessment. These sources can be divided into secondary data and primary data. The major factors, which should be considered while selecting sources of secondary data, are given below.

- Availability of data
- Reliability of data
- Quantum and range of data
- Completeness of data
- Relevance of data in terms of chosen method of calculation

Reliability, availability, amount and completeness of data are very important factors and differ with products, country, region and city. These factors decide the selection of the method for determining WEEE/e-waste inventory. The major sources of data are given below.

1. National/local Government Agency
2. Industry/Trade/Recyclers/Waste Disposal Operator's Association
3. Market Research Agencies.

An example of data source for each item used in mathematical formulation of all the five methodologies is given in **Table 3.4**.

Table 3.4: Tentative Sources of Data

Data Source/Item	National/Local Government Agencies	Industry/Trade/Recyclers/Waste Disposal Operator's Association (Reports/Published Data)	Market Research Agencies (Reports/Published Data)
Saturation Level Household	√ (ex. census data)	√	
Saturation Level Industry		√	√
Number of Household	√ (ex. census data)		
Export Data	√ (Foreign trade/Customs)	√	
Import Data	√ (Foreign trade/Customs)	√	
Manufacturing/Production		√	√
Stock Data Private		√	√
Stock Data Industry		√	√
Average Life Time		√	√
Storage Data			√
Reuse		√	√
Recycle	√	√	
Landfilled	√	√	

Decision criteria for selection of data with respect to availability, reliability, amount and range of data and completeness of data are given below.

Availability of data

1. Number of sources of data, which can provide data for study area. Generally, more than one source of data is preferred for each item of interest.
2. In what format, data is available i.e. yearly, half yearly, cumulative or distributed
3. Whether the data is published/unpublished, confidential/public.
4. Mode of procurement of data.

Reliability of data

1. Data of at least two sources should match.
2. If there is any variation in sources of data, check the method of calculating and compiling the data from each source. If there is a difference in the calculation and compilation of data, then check the factor responsible for the difference.
3. Check the trends from the data obtained from different sources and correlations with other data.

Amount and Range of data

1. Check the availability of historical data for each WEEE/e-waste item
2. Historical data should be available for more than anticipated average life time of the WEEE/e-waste item

Completeness of data

1. Historical data should be complete without any gap
2. If a gap exists then source, which provides data with minimum gap should be selected so that the gaps could be supplemented
3. Incomplete data can be supplemented by trend analysis or by national/regional/city level assumptions.

The primary data sources are used to confirm the findings of secondary data and to further supplement it. The sources of primary data are major stakeholders of WEEE/e-waste trade value chain, e.g. manufacturers and retailers, importers, exporters, individual households, business/government sector, traders/scrap dealers/dissemblers/dismantlers, recyclers, which are geographically distributed.

3.6 Constraints/Limitations for Developing WEEE/e-waste Inventory in Developing Countries

Chapter 2 describes the conceptual WEEE/e-waste trade value chain. The chain shows that the material flows from an organised/formal sector starting from export/import/production/manufacture till consumption phase, where the major part enters into unorganised/informal sector and a small part enters into formal sector. The major constraints are related to availability, reliability, amount and range and completeness of the data, which makes the application of available methodologies for WEEE/e-waste assessment as described above a very difficult proposition. The description of constraints with respect to each of the items used in mathematical formulations of WEEE/e-waste assessment methodologies is given below.

Sales Data (Export/Import and Manufacturing/Production Data)

1. Since export and import regulations differ in each developing country, export and import data/statistics related to electrical and electronic equipment is not readily available. This

makes the task of calculation of electrical and electronic equipment sales very difficult, even when domestic manufacture/production data is easily available.

2. Absence of domestic laws in these countries leads to uncontrolled import and generation of WEEE/e-waste.

3. Overall sales data of electrical and electronic equipment may be available from different sources identified above but shows variation.

4. Historical sales data may be available only to a limited extent

Saturation Level/Penetration Rate

Saturation level of household or penetration rate of electrical and electronic equipment is easily available but rarely available for industries/commercial establishment. Historical saturation levels/penetration rates may be available to a limited extent.

Stock Data

It is difficult to calculate stock data for private sector and industries at a particular time or phase, due to the extremely dynamic nature of market. This can be easily calculated if electrical and electronic market is a saturated market, where saturation levels are more or less constant.

Storage Data

Storage data is not available as storage can be in the formal/organised sector or in informal/unorganised sector.

Reuse/Recycled/Landfilling

1. In developing countries due to limited disposable income and cheaper options for repair, electrical and electronic equipments are reused thus prolonging the obsolescence rate of electrical and electrical equipment.

2. A majority percentage of WEEE/e-waste items are dismantled and recycled to recover usable parts and materials of economic value in informal/unorganised sector as described in Chapter 3. Therefore, the data related to recycling is not tracked and easily available.

3. In most of the developing countries, landfill sites are open dump sites either operated by an urban local body or they come up on their own. On these sites, WEEE/e-waste residues are dumped, without any assessment of quantity and quality.

Analysis of above constraints shows that the data for electrical and electronic equipment in a developing country available from secondary sources is limited, scattered and reliable to a limited extent. Therefore, WEEE/e-waste inventory assessment in a developing country requires collection of available secondary data followed by its strengthening by national/regional/local assumptions and trend analysis as described in apparent consumption approach.

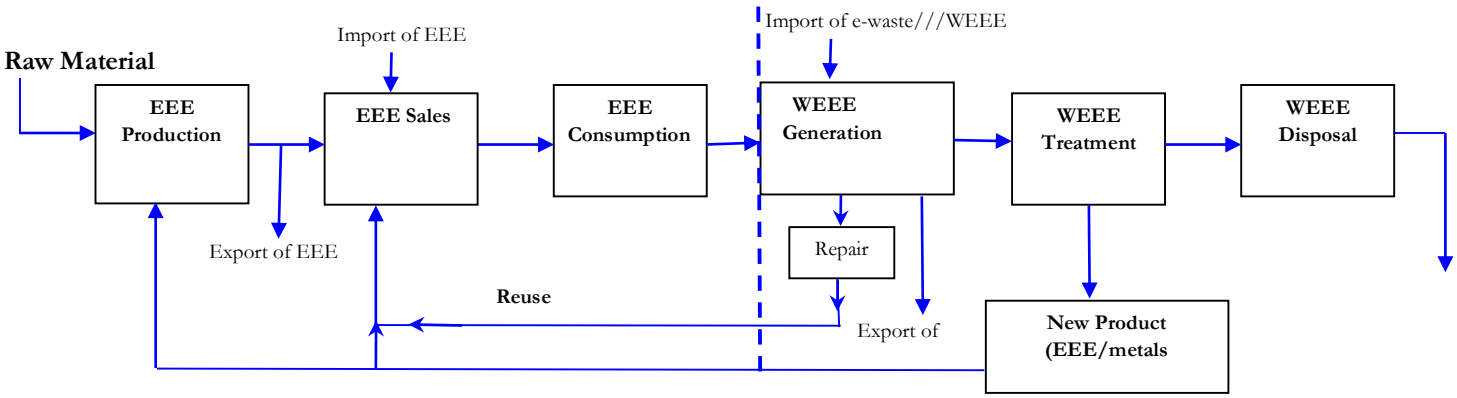


Figure 3.1: Conceptual WEEE/e-waste trade value chain for Inventory Assessment

Application of any WEEE/e-waste inventory assessment methodology in a developing country context requires its customization and strengthening in order to arrive at reasonable WEEE/e-waste inventory estimates. The following sections describe the conceptual approach and methodology to customize "market supply method", tools and techniques to carry out the assessment.

3.7 Conceptual Approach and Methodology

Since "market supply method" requires the minimum data i.e. sales data and average life cycle or obsolescence rate of WEEE/e-waste item, it becomes the preferred choice for WEEE/e-waste inventory assessment in developing countries. The major constraints experienced during WEEE/e-waste inventory assessments using this methodology are given below.

1. Figures related to sales obtained from different stakeholders differ due to two external factors i.e. imports and reuse.
2. Figures related to obsolescence rate/average life of an electrical and electronic item provided by secondary sources of data differ due to storage and reuse of WEEE/e-waste.

The above constraints are overcome by demarcating the WEEE/e-waste trade value chain into two parts at the point of start up of dismantling process. WEEE/e-waste from domestic sources, irrespective of delays due to storage and reuse and imported WEEE/e-waste irrespective of its point of entry will pass through dismantling process. Therefore, the point of entry before dismantling step in WEEE/e-waste trade value chain has been taken to demarcate the chain for application of two different approaches as shown in **Figure 3.1**.

Approach and methodology upstream of demarcation

1. At first WEEE/e-waste inventory is assessed using sales data based on saturation level/penetration rate and obsolescence rate/average life data given by market research agencies.
2. Obsolescence rate/average lifecycle is further checked by using data on depreciation and book value/economic value of the EEE from insurance agencies. Therefore, a range of obsolescence rate/average life cycle of an electrical and electronic item can be fixed with an "upper limit" and "lower limit".
3. Scenario analysis of WEEE/e-waste inventory is carried out using secondary data and obsolescence rate using "upper limit" and "lower limit".

Approach and methodology downstream of demarcation

In this approach, an extensive primary survey is carried out starting from the stage of collection, transportation, dismantling, recycling and disposal as mentioned below.

1. Confirm obsolescence rate from data of primary survey using "tracer technique". Tracer has been defined as a component, which forms an integral part of WEEE/e-waste item, whose movement takes the investigation team through the WEEE/e-waste trade value chain starting from dismantling, recycling till

disposal e.g. CRT in TV/PC/Monitor, compressor in refrigerator and LCD in a cellular phone, as shown in figure 5.2.

2. Identify a tracer from each product and follow it from the start of dismantling process till its final disposal as shown in figure 5.2.

3. Describe and document each process used in dismantling of WEEE/e-waste.

4. Identify the places where each step in this process takes place.

5. Carry out photo documentation and geographical setting of each step. Also find out from primary data, the number of dismantlers involved at the last stage of dismantling.

6. Estimate the quantity of material dismantled at each step using the last step of WEEE/e-waste dismantling and multiplying it with number of stakeholders. Back calculate to check the best fit scenario of WEEE/e-waste inventory obtained from "upper limit" and "lower limit" scenarios.

Estimate the quantity of electronic waste for a particular year based on market projections and obsolescence rate/average life span.

3.8 Guidance Notes

Objective: The major objective of guidance notes is to assist policy makers/other stakeholders to draft new regulations, where WEEE/e-waste "take back" mechanism can be addressed. Six steps identified in guidance notes for WEEE/e-waste definition are given in UNEP's/IETC WEEE/e-waste manual 1. Inventory Assessment Manual is being integrated to new steps to provide a broad road map to assist in the development of enabling policy/laws/regulations and institutional framework for WEEE/e-waste management. Guidance notes from the same manual have been used for EEE/e-waste inventory assessment. **It may be noted that UNEP/IETC WEEE/e-waste Volume 1 and Volume II Manual on inventory assessment and take back systems should also be referred for guidance.**

Guidance Procedure: Guidance procedure includes completion of following fourteen steps as given below

- *Step 1:* Identify the environmental legislation, where Municipal Solid Waste/Hazardous Waste or items related to trans-boundary movement of hazardous waste/Basel Convention are addressed.
- *Step 2:* Identify the sections and subsections where any item related to electrical and electronic equipment are mentioned.
- *Step 3:* Look for following words in the legislation/regulation and their definition and interpretation:

    - Electrical and Electronic Equipment
    - Electrical Assemblies/Components/Products
    - Discarded/Disposal
    - Used Goods/Scrap/Waste
    - Recycle/Reuse
    - Treatment

- *Step 4:* Prepare WEEE/e-waste definition reference matrix with respect to three drivers like definition of "electrical and electronic equipment", description of its "loss of utility" and "way of disposal".

WEEE/e-waste reference in regulations with respect to identified drivers

Regulation/Drivers	Drivers		
	Definition of Electrical and Electronic Equipment (Yes/No)	**Definition of loss of utility (Yes/No)**	**Definition of way of disposal (Yes/No)**
"Hazardous" waste			
"Non-Hazardous" waste			
Regulation related to Basel Convention			
Any other regulation			

In case of "Yes", specify the reference, its coverage and application in domestic and trans-boundary trade.

- *Step 5:* In the case WEEE/e-waste is mentioned either directly or indirectly in any regulation, specify roles and responsibility of following stakeholders

- Generator/Producer
- Exporter/Importer
- Collector/Transporter
- Waste Treatment Operator
- Regulatory Agencies (Local/National)

- *Step 6:* Identify the gaps from the matrix and recommend the tentative content, extent and coverage of WEEE/e-waste.
- *Step 7:* Identification of EEE items in WEEE/e-waste inventory, which are manufactured, imported or exported. This step will assist in defining producer.

	Item					
	PC	**TV**	**Cellphone**	**Refrigerator**		
Manufactured (Y/N)						
Imported (Y/N)						
Exported (Y/N)						

Note: Y/N: Yes or No

- *Step 8:* Define producers, importers, exporters, distributors/retailers, collection points, dismantlers, recycler and disposal based on step 1 to 7.
- *Step 9:* Carry out due diligence on WEEE/e-waste policy/laws/regulations eg. EPR/WEEE directive/other country policy and regulatory framework. Identify the gaps with respect to existing environmental regulations (outputs of step 1 to 3) and recommend tentative content, extent and coverage of WEEE/e-waste policy/laws/regulatory framework.
- *Step 10:* Allocate responsibility for collection, treatment, recovery, recycling and disposal of WEEE/e-waste from private household from other sources e.g. commercial.
- *Step 11:* Financial mechanism and allocate financial responsibility e.g. individual/collective financial responsibility for "new/historical" WEEE-e-waste, using the following template.

- *Step 12:* Map the proposed WEEE/e-waste regulations including responsibilities as per the format given below. For reference, please refer to **UNEP's IETC e-waste Volume III, e-waste take back system.**

Responsibilities	Collection		Takeback/setting up of		Registration Authorization	Filing of annual return	Annual Inventory handled	Transportation to					Financing
			Collection centre										
	Manufacturing/Refurbishing	End of life	Individual	Collectively				Distributor	Producer	Collection Centre	Refurbisher/ Dismantlers/ Recyclers	TSDF Facility	
Producer													
Distributor													
Refurbisher													
Collection Centre													
Consumer													
Bulk consumer													
Dismantler													
Recycler/Reprocessor													
Note: √ means "Yes"													

- *Step 13:* Carryout gap analysis with respect to outputs of step 12.

- *Step 14:* Organize a workshop of major stakeholders like line ministries/government agencies (IT/Electronics/Consumer Durables/Electrical/Industries/Environment/Forests/Finance/Economy and Commerce), industry associations, retailer's associations, municipalities, formal and informal recyclers, transporters, operators for incinerators/hazardous waste management facilities and NGOs to arrive at an acceptable WEEE/e-waste policy/laws/regulations and institutional mechanism.

Guidance on Inventory Assessment

Objective: The objective of guidance notes is to assist the WEEE/e-waste investigation team to apply the customized approach and methodology using the above tools and techniques to assess existing and future WEEE/e-waste inventory.

Guidance Procedure: Guidance procedure for carrying out WEEE/e-waste inventory assessment includes completion of the following activities. **References should be made to case studies presented in UNEP/IETC WEEE/e-waste Volume I, Inventory Assessment Manual**.

Activity 1	:	Establishment of the study area and its geographical limit
Activity 2	:	Identification of WEEE/e-waste and establishment of WEEE/E-waste trade value chain (Identify the WEEE/e-waste streams, Identify the WEEE/e-waste processes, Identify a tracer item and Follow the tracer item through the process in the WEEE/e-waste stream)
Activity 3	:	Estimate WEEE/e-waste quantities and obsolescence rate/ average lifespan through secondary data
Activity 4	:	Verification of obsolescence rate/average lifespan through primary data
Activity 5	:	Identify the products, by products and waste products
Activity 6	:	Establish WEEE/e-waste trade economics
Activity 7	:	Identify and assess the impacts

CHAPTER 4: COMPENDIUM OF TECHNOLOGIES FOR THE RECOVERY OF MATERIALS FROM WEEE/E-WASTE

4.1 Introduction

WEEE/e-waste can be re-used, recycled and harnessed as a source of secondary materials for primary production of their items. As described in chapter 2, WEEE/e-waste consists of items of economic value like base metals, special metals and precious metals, presenting opportunities for secondary materials recovery as well as other items. Usage ranges from reuse of components, recovery of metals for further usage in primary production of electronics and renewable energy equipment. These processes, their applications and the technology required to support them are described in the following sections. At first technologies for collection and transportation and storage have been described. This is followed by a description of technology for dismantling, recycling and extraction of metals. Guidance notes assist the target audience to carry out stepwise due diligence in order to decide the technology required for WEEE/e-waste management.

4.2 Planning and Technologies for Collection Infrastructure

At first, general considerations for planning of collection, transport and storage have been described. These provide basis for determining technical specification for collection infrastructure.

4.2.1 General Considerations for Planning of Collection, Transport and Storage Infrastructure

1. Collection, storage and transport of WEEE/e-waste should be executed in a way that prevents damage to the environment and human health.
2. It ensures that methods are employed to maximize recycling.
3. To enable reuse and effective treatment, operators are required to collect, store, handle and transport WEEE/e-waste in a manner that:
   - Prevents damage to WEEE/e-waste during these operations in order to avoid pollution due to their breakage, leakage or corrosion.
   - Does not hinder the removal and specific treatment of hazardous materials and components in subsequent downstream operations e.g. during detoxification and segregation.
   - Supports the sound reuse and recycling of WEEE/e-waste.
   - Supports the proper disposal or incineration of materials that cannot be treated otherwise.
4. **Hazardous Materials Handling:** At every process step during collection, transport and storage of WEEE/e-waste, there is a potential risk to the environment and human health due to the hazardous materials contained within them. For example, LCD flat panel displays with mercury containing CCFL (cold cathode fluorescent lamps) backlights; Compact fluorescent lamps (CFLs, or "energy saving lamps") containing mercury; Capacitors containing polychlorinated biphenyls; Older cooling and freezing equipment

containing hydrochloro-fluorocarbons (HCFCs) and chloro-fluorocarbons (CFCs) as cooling agents; Lead and cadmium in electronic and electrical components, as well as the brominated flame retardants polybrominated diphenyl ethers (PBDEs) and polybrominated bi-phenyls (PBBs) with a high dioxin and furan potential; Batteries.

- Clearly define hazardous materials and components to be removed from WEEE/e-waste.
- Specify clear provisions regarding the separate treatment of removed hazardous materials and components.
- Specifically outline how this is to be done by the initial handler upon collection of equipment.
- Stipulate specific requirements for the transport and storage of types of WEEE/e-waste containing hazardous materials that are easily released in-to the environment or where the subsequent treatment might be made more difficult by damage to the WEEE/e-waste.

Collection

- WEEE/e-waste should be collected separately from other types of waste in order to provide adequate treatment, thus preventing pollution and loss of resources.
- WEEE/e-waste collection facilities may co-locate with collection facilities for other types of materials, as long as the WEEE/e-waste is not mixed with other waste.
- Adequate space should be available to safely and securely handle and store collected WEEE/e-waste.
- Collection sites should be **located** within a reasonable proximity to consumers, and their services should be well **communicated or advertised** to maximize collection.
- To encourage adequate coverage of an area, **a target distribution** of collection sites should be fixed. Examples of different types of targets (i) the number of containers available (ii) a set number of drop-off locations per area determined by population density (iii) enough containers or facilities should exist so that consumers only have to travel a minimum distance to reach them.
- Products should be **separated** and **stored** by type, to ensure each type of EEE is handled in the most responsible manner without damage or loss.
- To ensure that all of these requirements are met, adequate infrastructure should be in place to support responsible handling and systems or processes to monitor and super-vise handling of WEEE/e-waste at each step.
- Staff should be trained to handle incoming WEEE/e-waste and the equipment and tools required to properly treat the materials at this stage.

4.2.2 Conceptual Approach for Establishing Collection Infrastructure

Collection infrastructure requires **establishment of WEEE/e-waste collection points** and **storage area** in a city/geographical region. As per WEEE EU directive conceptual approach for establishing collection points and storage areas is given below.

1. Appropriate measures should be adopted to minimize the disposal of WEEE/E- waste as unsorted municipal waste and to achieve a high level of separate collection of WEEE/e-waste.
2. Availability and accessibility of the necessary collection facilities should be ensured taking into account, in particular, the population density.
3. The collection and transport of separately collected WEEE/e-waste shall be carried

out in a way, which optimizes reuse and recycling of those components or whole appliances capable of being reused or recycled.

4. Private households should not dispose off WEEE/e-waste as unsorted municipal waste and to collect such WEEE/e-waste separately.
5. Sites for storage (including temporary storage) of WEEE/e-waste prior to their treatment should have impermeable surface for appropriate areas with the provision of spillage collection facilities and where appropriate, decanters and cleanser-degreasers.
6. Sites for storage (including temporary storage) of WEEE/e-waste prior to their treatment should have weatherproof covering for appropriate areas.

4.2.3 Guiding Principles for Design and Formulation of Technical Specifications of WEEE/e-waste Collection Points/Storage Area/Storage Facility

The mode of collection will vary, depending on distances, rural or urban patterns, and the size of collected WEEE/e-waste. The basic elements, which determine the operational efficiency of collection system, are given below.

- accessible and efficient collection facilities
- minimal movements of products
- minimal manual handling
- removal of hazardous substances
- separate reusable appliances
- adequate and consistent information to the users.

Since WEEE/e-waste is hazardous in nature, it is collected, sorted and transported under controlled conditions. In EU, WEEE/e-waste in general is being sorted/separated into five groups depending on different material composition and treatment categories. These groups are given below.

Group 1: Refrigeration equipment - Due to ODS usage, this has to be separated from other WEEE/e-waste.

Group 2: Other large household appliances - because of their shredding with end-of-life vehicles, need to be separated from other waste.

Group 3: Equipment containing CRTs - the CRTs need to remain intact because of health and safety reasons.

Group 4: Lighting (linear and compact fluorescent tubes) - these need to be deposited in a special container (due to Mercury) to ensure they do not contaminate other waste and that they can be recycled.

Group 5: All other WEEE - These equipments can be collected in the same container because there are no recycling or health and safety reasons.

Guiding principles for designing and formulation of technical specifications of collection points/storage area have been developed based on "Code of Practice for Collection of WEEE from Designated Collection Facilities (DCF)", dti, Government of UK, February 2007 and "Guidance on Best Available Treatment, Recovery and Recycling Techniques (BATRRT) and Treatment of Waste Electrical and Electronic Equipment (WEEE)", Department of Environment, Government of UK and other sources.

Designated Collection Facilities (DCF), a DCF should have the following features:

1. Enable household WEEE/e-waste to be collected by the following five streams:

   A – Large household appliances (category 1) other than cooling appliances
   B – Cooling appliances in category 1
   C – Display Equipment containing Cathode Ray Tubes (CRT)
   D – Gas discharge lamps
   E – All other WEEE/e-waste

2. DFC should be able to accommodate required containers, of a size and type appropriate to the site, for display equipment containing CRT, gas discharge lamps and all other WEEE, and hard standing or containers for large households and cooling appliances. Where this is not possible because of the size, policy requirements, layout or accessibility of the site, fewer streams may be collected, provided that these streams, which are collected should be segregated from each other on site. Other sites should be available to receive the other streams from the public and these sites should be located at a reasonable distance in the Local Authority Area and accessible to all on an equal basis.

3. If streams are mixed, then display of equipment and gas discharge lamps should remain separate from other streams and each other, and cooling appliances can be readily identified for uplifting separately.

4. If intended to take household WEEE/e-waste directly from members of the public then it should be able to accommodate a minimum volume capacity of $3m^3$ for gas discharge lamps and 1 m^3 for other WEEE/e-waste.

5. Unacceptable levels of contamination

   a. The presence in a container provided to take WEEE/e-waste of 15% or more by weight of material other than that for which the container is designated, whether or not WEEE/e-waste.

   b. Any of the following prohibited items regardless of weight:

      i. Food waste
      ii. Hazardous waste of a type other than that for which the container is designated
      iii. Liquid wastes other than water

   c. The presence in, on or with any items of WEEE/e-waste not containerized, such that they are either not evident when the item is collected or cannot readily be separated from the item mentioned in (a) and (b).

6. Impermeable surfaces

The impermeability of the surface will depend on how it is constructed and its usage. A surface will not be considered impermeable, if for example,

- It has slabs or paving not properly joined or sealed
- It is composed solely of hard standing made up of crushed or broken bricks or other types of aggregate even if the WEEE/e-waste is also stored in containers
- Spillages or surface water will not be contained within the system.

The impermeable surface should be associated with a sealed drainage system and may be needed even where weatherproof covering is used. This means a drainage system with impermeable components which does not leak and which will ensure that:

- No liquid will run off the pavement other than via the system.
- All liquids entering the system are collected in a sealed sump except where they may lawfully be discharged.

7. Spillage collection facilities

Spillage collection facilities include the impermeable pavement and sealed drainage system as the primary means of containment. However, spill kits to deal with spillages of oils, fuel and acids should be provided and used as appropriate.

8. Weatherproof covering: The purpose of the weatherproof covering for storage is to minimize the contamination of clean surface and rain waters, to facilitate the reuse of those whole appliances and components intended for reuse and to assist in the containment of hazardous materials and fluids.

The areas that are likely to require weatherproof covering will therefore include those storing hazardous or fluid containing WEEE/e-waste or whole appliances or components intended for reuse.

The type of weatherproof covering required will depend on the types and quantities of waste and the storage activities undertaken. Weatherproof covering may in some circumstances simply involve a lid or cover over a container but in others it may involve the construction of a roofed building. An example of impermeable surfaces and weatherproof covering is given in **Figure 4.1**.

Figure 4.1: Examples of WEEE/e-waste collection system (impermeable surface and Weather proof covering) at a collection facility

4.2.4 Technical Specification for fixing Area of Collection Point/Storage Facility

Area of collection point and storage facility is an important feature for fixing up layout of

storage area. For instance in Austria, only retailers with sales area greater than 150 m^2 are obliged to take back WEEE/e-waste, while in Canada, feasibility study for WEEE/e-waste collection system has been carried out considering 1000 ft^2 of collection facility. Different steps to fix up area of collection point/storage facility are given below:

1. Calculate the WEEE/e-waste capture rate for the geographical area served
2. Calculate volume of each of the separated WEEE/e-waste items based on tonnage captured eg. In Canada, the assumptions taken for different WEEE/e-waste items are given below.

    - Cellphone – 0.613 m^3/tonne
    - Telephone – 2.08 m^3/tonne
    - Stereos – 6.502 m^3/tonne
    - Computers – 3.851 m^3/tonne
    - Monitors – 4.952 m^3/tonne
    - Peripherals – 4.049 m^3/tonne
    - TV – 6.146 m^3/tonne

3. Based on the captured, WEEE/e-waste items calculate the bin/container/cage/Gaylord container size and their numbers. Examples of containers are shown in **Figure 4.1**. The types of bins/cages used for WEEE/e-waste collection are shown in **Figure 4.2**.

Figure 4.2: WEEE/e-waste collection bins/cages

Source: UNEP Manual, E-waste Volume II: E-waste Management Manual, http://www.unep.or.jp/ietc/publications/spc/ewastemanual_vol2.pdf, (Accessed on 14 July, 2016)

4. Fix up the area based on container size and numbers. Depending on building laws of the country, fix up covered area, open area and total area.

4.2.5 Technical Specification for Fixing Number of Collection Point/Storage Facility

Different steps to determine number of collection points/storage facilities are given below:

1. Calculate the population served
2. Calculate each of the WEEE/e-waste capture rate per inhabitant per year
3. Calculate the number of collection points required to achieve the target rate
4. Fix up the final number of collection points after studying the study area/land use/geography after deciding the location.

The number of WEEE/e-waste collection points will vary from country to country. An example of local collection facilities per population in some European countries are given in **Table 4.1**.

Table 4.1: Local authority collection facilities per population in 2003

Country	Population (million)	Local authority collection facilities	Ratio (facilities/person)
The Netherlands	16.0	600	1/27 000
Sweden	8.8	600	1/15 000
Norway	4.5	400	1/11 000

Source: EPA Ireland 2003, Waste electrical and electronic equipment (WEEE) collection trials in Ireland. Authors: Wilkinson, S. and Duffy, N. Environmental Protection Agency,Wexford, Ireland

In Canada[11],the feasibility of WEEE/e-waste collection has been carried out by using the following assumptions.

Urban Areas: One collection point per city of 50,000 population and one additional collection point for cities with a metro population of 200,000 or more.

Rural Areas: One collection point per 10,000 people or 50 km radius.

Location of Collection Point/Storage Facility and transportation

Location of WEEE/e-waste collection point is an important factor in WEEE/e-waste collection and transportation system. Different criteria have been used in different countries to identify these locations. The various steps to fix location of collection point/storage facility are given below:

1. Study the consumer behaviour for the best used option for collection points, i.e. retailer take back collection centre, municipal collection centre or other, through a pilot survey. The tentative locations during pilot survey can be fixed based on land use categories and mapping of WEEE/e-waste trade value chain described in chapter 2.
   The literature source[12] cites that in Switzerland, transport distances of 35 to 50 km between WEEE/e-waste collection points (according to type of collection point), which is weighted according to actual collection amount of various types of WEEE/e-waste.
2. Calculate the WEEE/e-waste haulage capacity.
3. Calculate the number of trucks/trailers of different capacities required to transport the WEEE/e-waste.
4. Optimize the route and frequency of collection based on accessibility of the collection site.

4.2.6 General Specifications for Transportation

Domestic Transportation

1. All WEEE/e-waste should be packaged so that damage is minimized during transport.

- When loading equipment on and off trucks or containers, operators should be properly trained to handle the materials in question and use the equipment provided for such activities. In particular, sufficient packaging, labelling and appropriate stacking of collected equipment is necessary.

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[11] *PHA Consulting Associates, (31st March 2006). Electronics Waste Recovery Study, Prepared for Resource Recovery Fund Board, Nova Scotia, Annex J, Table No J1.Annex J,*

[12] *Hishier R. et al (2005). Does WEEE recycling make sense from an environmental perspective? The environmental impacts of the Swiss take-back and recycling systems for waste electrical and electronic equipment (WEEE), Environmental Impact Assessment Review 25 92005) 525-539.*

- Transport vehicles and containers must be properly equipped to minimize damage to WEEE/e-waste equipment. This prevents exposure of hazardous components during transport and minimizes further damage to potentially reusable WEEE/e-waste.
- Special precautions should be taken when handling and transporting hazardous materials. Examples of such equipment are: LCD flat panels, compact fluorescent lamps and waste refrigerators containing HCFC, CFC and/or HFC.

Transboundary Shipments

- End-of-Life (EoL) operators e.g. recyclers, dismantlers must hold all legally required documents and permits for any transboundary shipment of WEEE/e-waste as well as the components, fractions or materials. These documents and permits must be available from the exporting and the importing country, as well as from countries in transit.
- End-of-Life (EoL) operators shall document the type and amounts of incoming and outgoing WEEE/e-waste, reused equipment, components, fractions and materials from facilities directly under their control and maintain evidence of due diligence, tracking and documentation down the complete EoL chain to the final disposal of the incoming devices and materials.
- WEEE/e-waste, components, fractions and materials are transported, stored, handled and treated under conditions that provide a level of environmental, health and safety (EHS) protection as well as efficiency of the recovery process (range and yields of the materials recovered), similar to the country in which the WEEE/e-waste arose.
- Any waste residues resulting from the above operations in the country of import are transported, stored, treated, incinerated or disposed of in a manner that maintains a level of EHS protection similar to the country in which the WEEE/e-waste originated.
- All applicable requirements and targets for transport, storage, treatment and other applicable provisions in the EoL standard are achieved, and there is documentation giving clear evidence of this. This needs to be certified by a third-party.

4.3 Costs of Collection and Transportation

The collection system is designed based on the collection targets, e.g. the amount and types of WEEE/e-waste collected and the distance travelled to bring it to the recycling centres. Because distance to the centres is a factor, a geographical boundary or catchment area for the system must be established. An assessment of the catchment area under "business as usual" (i.e. without any economic instruments) can be carried out by comparing the cost of collection and transport against the value of recoverable items from the targeted WEEE/e-waste.

Cost of collection and transport = Cost of collection centre + Cost of transport

The **cost of collection and transport** is the sum of the costs of establishing and operating the collection centre and of transporting the WEEE/e-waste. The **cost of collection centre** is calculated based on the costs of exogenous variables (capital costs and other cost factors), facility operations and packaging. The **cost of transport** can be calculated based on the tonnes per kilometer (or per mile) rate provided by transporters. An example of assessing the **cost of collection** of WEEE/e-waste in the USA for cathode ray tube (CRT) TVs, CRT monitors and laptops is given below.

4.3.1 Cost of collection centre[13]

Cost of collection centre has been described in terms of exogenous variables facility operation and packaging of WEEE/e-waste.

1. Exogenous variables

Average employee wage	$16	/hour	(LABORSTA 2008)
Benefits	82	%	(Cascadia 2003)
Working days	260	days/year	
Number of shifts	1	shifts/day	
Paid time	7	hours/shift	
Financial rate of return	15	%	
Equipment life	10	years	
Building life	20	years	
Price of electricity	$0.12	/kWh	(EIA 2006)
Price of building space	$1,000	$/m^2$	
Investment maintenance cost	5	%	
Overhead cost	25	%	

Source: Jain Amit (2012). UNEP Manual, E-waste Volume III: WEEE / E-waste "Take-back system", http://www.unep.or.jp/IETC/SPC/news-jul11/UNEP_Ewaste_Manual3_TakeBackSystem.pdf, (Accessed on 14 July, 2016)

2. Facility operations

Capacity (actual amount processed)	100,000	kg
Equipment cost	$2,000	/station
Space requirement	100	m^2/station
Processing rate	300	kg/hr/station
Workers	1	workers/station
Power consumption	1	kW/station
Is equipment dedicated?	0	[1=yes, 0=no]
Forklift cost	$20,000	
Forklifts required per station	0.25	forklifts/station
Forklift power (electric)	2	kW/forklift
Is forklift dedicated?	0	[1=yes, 0=no]

3. Packaging

Gaylord cost	$10	/Gaylord	Take it Back
Gaylord capacity	200	kg	Network (2003)
Pallet cost	$8	/pallet	
Cardboard layer cost	$3	/each	
Pallet CRT capacity	27	/pallet	(FEC 2006)
Cardboard layers per CRT pallet	2	/pallet	
Pallet CPU capacity	45	/pallet	(FEC 2006)
Cardboard layers per CPU pallet	2	/pallet	
Shrink wrap cost	$0.03	/m	
Shrink wrap amount per pallet	17.48	m/pallet	

It has been observed that the greater the number of collection centres in a particular catchment, the greater will be the WEEE/e-waste collection efficiency. A cost-benefit analysis can be carried out by comparing the cost of collection and transport against the value of recoverable items from

[13] *Fredholm, Susan, September 2008. Evaluating Electronic Waste Recycling Systems: The Influence of Physical Architecture on System Performance.*

the targeted WEEE/e-waste. **Table 4.2** gives an example of the cost of collection and transport versus the purchase price of from the targeted WEEE/e-waste in India in 2011.

Table 4.2: Tentative recovery vs. total cost of procurement

No. of computers	Wt in kgs	Cost of transport(USD)			Purchase Price of computer itself/kg @ Rs.20 – 25	Total cost USD) (cost of transport + Purchase Price of computer itself)			Total cost (USD)
		50 km	100 km	200 km		50 km	100 km	200 km	
2	54	6	12	26	18-23	25-29	31-36	45-49	47
10	270	6	12	26	90-113	97-119	103-126	117-139	233
50	1,350	10	20	20	450-563	460-573	470-583	490-603	1166
100	2,700	12.5	25	25	900-1125	913-1138	925-1150	950-1175	2331
Cost of transport, assuming a full load									
Small pickup truck @ Rs. 8				Mini truck @ Rs. 12		Canter truck @ Rs. 15			

Source: Amit Jain (2016). *UNEP Manual, E-waste Volume III: WEEE / E-waste "Take-back system",* http://www.unep.or.jp/IETC/SPC/news-jul11/UNEP_Ewaste_Manual3_TakeBackSystem.pdf, (Accessed on 14 July, 2016)

The above costs are compared to the outputs to be sold from the recycled computers based on prices from metals and commodity market. This will help to benchmark the distance and tonnage of WEEE/e-waste to be transported.

Table 4.2 indicates that under a "business as usual" scenario where there are no economic instruments applied, it is viable to have a catchment area with a radius of between 700 km and 1000 km. This assessment further indicates the price sensitivity for procuring WEEE/e-waste with respect to distance to be transported as well as quantity to be collected. Therefore, a pan country WEEE/e-waste collection and transport system can be conceptualized based on the number of collection stations.

4.4 Technologies for Primary and Secondary Dismantling/Recycling

General considerations for specification for recycling, treatment and disposal:

4.4.1 Recycling

Recycling operations endeavor to maintain or restore as much material as possible that is recovered from WEEE/e-waste to its original quality, in terms of purity and physical and chemical properties. Recycling operations are typically executed in two steps:

1) **Pre-processing**, which prepares the WEEE/e-waste for material recovery.
2) **End-processing**, which consists of material recovery prior to the incineration or landfilling of any remaining material. Organizations involved in material recovery steps may not exclusively handle WEEE/e-waste, and this may include organizations such as metal refineries and plastic recyclers.

4.4.2 Downstream Treatment of Hazardous Materials

Separate treatment of removed hazardous materials and components should be able to achieve the following requirements and targets:

- During or after removal, hazardous materials and components should be treated according to the hierarchy of treatment targets. For example, recycling hazardous materials containing mercury should be prioritized.

- The separate treatment of hazardous materials and components may also occur within a process that is, without initial removal so long as the organization responsible for such treatment identifies the flow and fate of the hazardous materials and components. Hazardous materials and components that cannot be recycled and must be disposed of should be rendered inert in such a process, if possible.
- Incineration and final disposal should only be allowed in facilities equipped to handle such materials and components in a manner that avoids emissions into the environment and which have energy recovery capabilities.

Additionally, requirements should be placed on the downstream operators handling hazardous materials to clearly demonstrate that they actually remove hazardous materials and components from the waste stream, and that they treat these materials effectively in order to prevent pollution in their daily operations.

For Treatment Areas

1. Impermeable surfaces for appropriate areas with appropriate spillage collection facilities and, where appropriate, decanters and degreasers.
2. Appropriate storage for dissembled spare parts.
3. Appropriate containers for storage of batteries, capacitors containing PCBs or PCTS, and other hazardous waste such as radioactive waste.
4. Equipment for the treatment of water, including rainwater.
5. (Suitable) balances for measuring the weight of treated waste.

4.4.3 WEEE/e-waste Treatment Process

The major approach to treat WEEE/e-waste is to first reduce the concentration of these hazardous chemicals and elements through decontamination/dismantling, recycling and recovery of items of economic value e.g. shredding, segregation and smelting and finally dispose WEEE/e-waste fractions through either incineration or landfilling or a combination of both. The WEEE/e-waste treatment options include the following unit operations.

- **Decontamination/Dismantling:** Decontamination/Dismantling is done manually. It includes the following steps.

  (i) Removal of parts containing hazardous/dangerous substances (CFCs, Hg switches, PCB).
  (ii) Removal of easily accessible parts containing valuable substances (cable containing copper, steel, iron, precious metal containing parts, e.g. contacts).
  (iii) Segregation of hazardous/dangerous substance and removal of easily accessible parts.

- **Segregation of ferrous metal, non-ferrous metal and plastic:** This separation is generally carried out after shredding, followed by mechanical and magnetic separation process.
- **Recycling/recovery of valuable materials:** WEEE/e-waste fractions after segregation consisting of ferrous and non-ferrous metals are further treated. Ferrous metals are smelted in electrical arc furnaces, non-ferrous metals and precious metals

are **smelted** in smelting plants.

- **Treatment/disposal of dangerous materials and waste:** Shredder light fraction is disposed of in landfill sites or sometimes incinerated, CFCs are treated thermally, Poly Chlorinated Biphenyl (PCB) is incinerated or disposed of in underground storages, Mercury (Hg) is often recycled or disposed of in underground landfill sites.

Figure 4.3 depicts the simplified flow diagram. This scheme can be classified into:

1. First level treatment
2. Second level treatment
3. Third level treatment

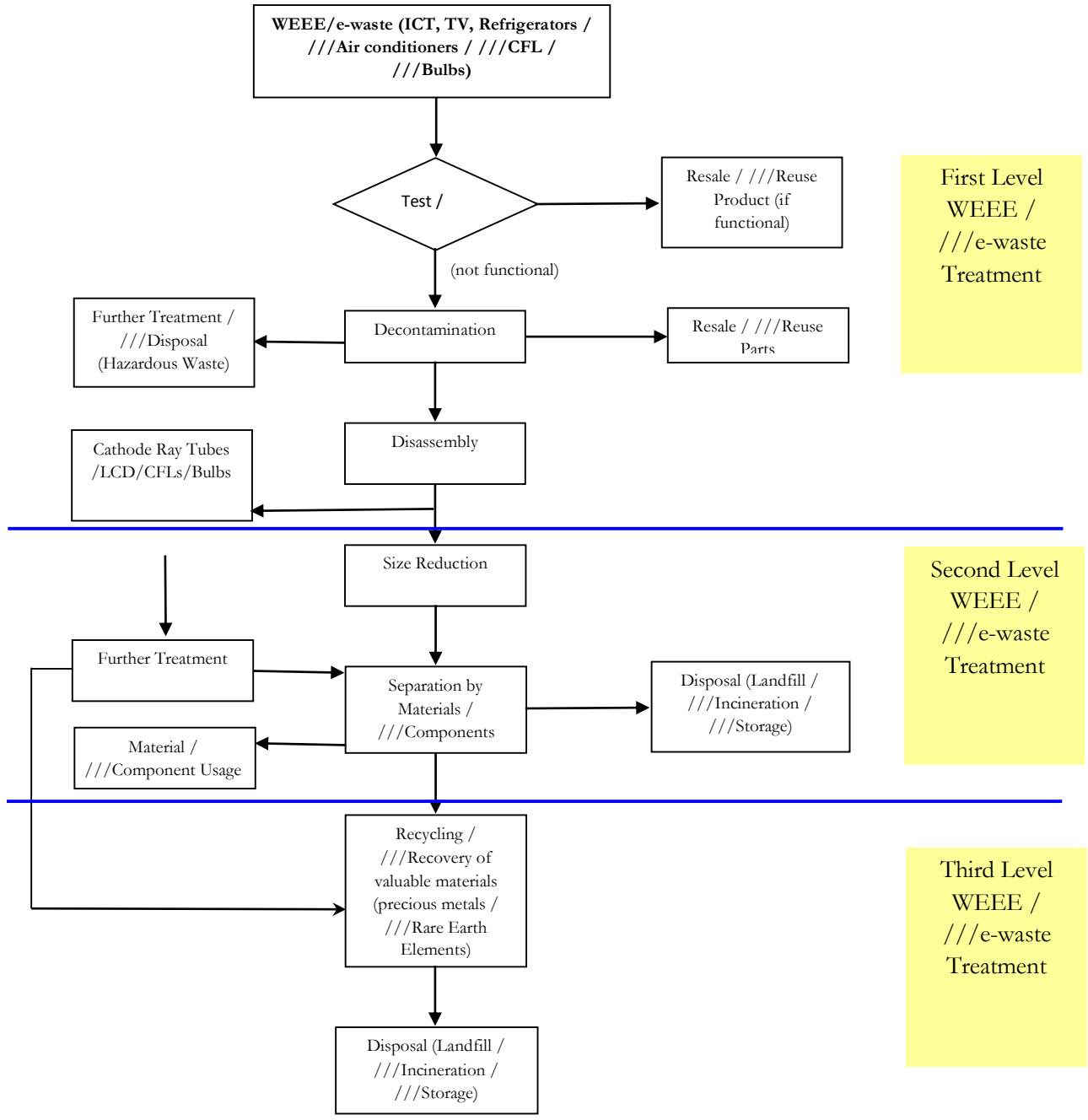


Figure 4.3: Simplified Flow Diagram for the Recycling of WEEE/e-waste

Source: Jain Amit (2016)

All the three levels of WEEE/e-waste treatment systems are based on material flow. The material flows from first level to third level treatment. Each level treatment consists of unit operations, where WEEE/e-waste is treated and output of first level treatment serves as input to second level treatment. After the third level treatment, the residues are disposed of either in hazardous waste landfill or incinerated. The efficiency of operations at first and second level determines the quantity of residues going to hazardous waste landfill site or incineration. Most of the WEEE/e-waste treatment facilities in other countries consist of first and second level treatment at one place, while third level treatment is geographically located at other place. The description of treatment at each level is given in terms of input, unit operations and output in the following sections.

The guiding principles for designing the layout for first and second level treatment facilities will be as per Annex III of EU directive, technical requirements for facilities, which is described below.

4.4.3.1 First Level WEEE/e-waste Treatment

First level WEEE/e-waste treatment process and specifications are described below.

Input: WEEE/e-waste items like TV, refrigerator and Personal Computers (PC)

Unit Operations: The following three-unit operations occur at the first level of treatment

1. Removal of all liquids and gases
2. Dismantling (manual)
3. Segregation

All the three unit operations are dry processes, which do not require use of water. The first step is to decontaminate WEEE/e-waste and render it non-hazardous. This involves removal of all types of liquids and gases (if any) under negative pressure, and their recovery and storage. Furthermore, all other hazardous WEEE/e-waste residues are dismantled and segregated. These segregated hazardous WEEE/e-waste fractions are then sent for third level treatment/disposal.

Output:

1. Segregated hazardous wastes like CFC, Mercury (Hg) Switches, CRT, batteries and capacitors.
2. Decontaminated WEEE/e-waste consisting of segregated non-hazardous WEEE/e-waste like plastic, circuit board and cables.

Various steps in decontamination (removal of all liquids and gases) e.g. in refrigerators and air conditioners are given below.

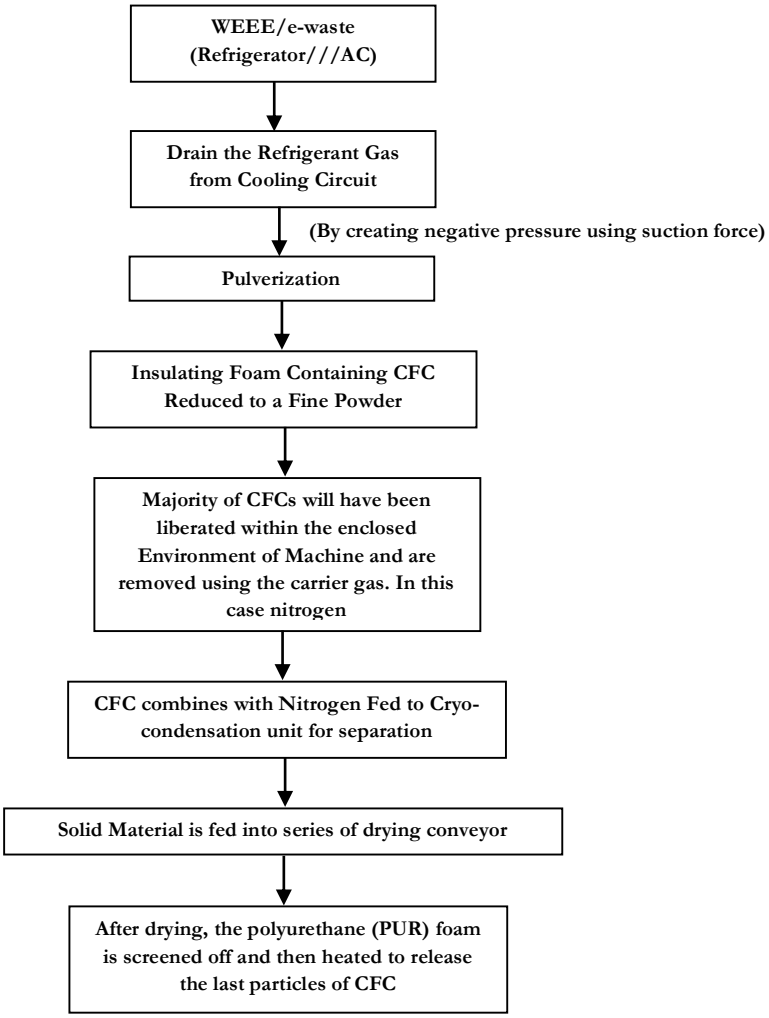


Figure 4.4: Refrigerant Gas from Cooling Circuit

Step 1: The first step of the process is to drain the refrigerant gases from the cooling circuit; the compressor is then removed and can be sold.

Step 2: The fridge carcasses are then pulverized for 6 minutes until the metal and plastic are around 30 mm in size and, more importantly, the insulating foam, potentially containing CFC, is reduced to a fine powder.

Step 3: At this point, the majority of the CFCs will have been liberated within the enclosed environment of the machine and are removed using the carrier gas, in this case nitrogen. The CFCs combined with nitrogen are then fed into a cryo-condensation unit for separation.

Step 4: Once the cycle has finished, the solid material is fed via a sealed discharge into a series of drying conveyors.

Step 5: After drying, the polyurethane (PUR) foam is screened off and then heated to release the last particles of CFC.

Various steps in the manual dismantling process of PC/TV at a WEEE/e-waste dismantling facility are depicted in **Figure 4.5**.

Step 1: Collected WEEE/e-waste enters the disassembly line in the dismantling facility
Step 2: Manual dismantling of monitor/TV (removal of plastic back cover and disposal into a plastic bin)
Step 3: Decontamination by manually removing the WEEE/hazardous items and their collection in bins
Step 4: Complete dismantling and segregation of WEEE/e-waste fractions

Figure 4.5: Manual Decontamination/Dismantling Process

Source: UNEP's/IETC (e-waste Manual II: WEEE/e-waste Management System)

Process flow diagram for decontamination and dismantling of a refrigerator and air conditioner is given in **Figure 4.6.**

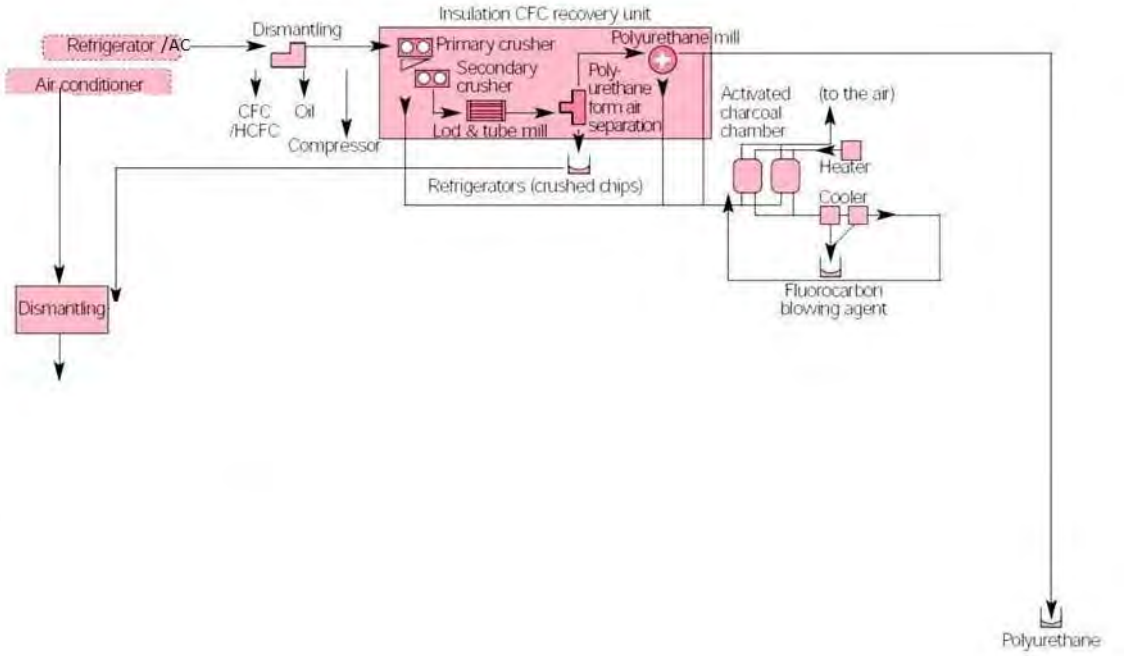


Figure 4.6: Decontamination/Dismantling Process of Refrigerator and Airconditioner

Source: Synthesis report [ENV.G.1/FRA/2004/0081, Study No.16], Gather, process, and summarise information for the review of the waste electric and electronic equipment directive (2002/96/EC), European Commission DG Environment, Bio Intelligence Service

Specifications

1. Input Quantity
2. Output Quantity
3. Area Required
4. Emission Standards

The guiding principles for fixing up the specification for layout of first level WEEE/e-waste treatment facility are given below.

- **Input:** Establish the capacity of WEEE/e-waste treatment facility in terms of WEEE/E-waste numbers (or tonnes) per day.
- Establish the time taken by an operator/worker to dismantle one particular WEEE/e-

waste item.

- Calculate the number of operators/workers required per day and the number of operating shifts.
- Calculate the working area required for each operator/worker based on dismantling area and location of collection bins for segregated WEEE/e-waste components.
- Calculate the total area of the facility based on working area requirement for total number of workers and associated utilities.

4.4.3.2 Second Level WEEE/e-waste Treatment

A simplified conceptual flow diagram for second level WEEE/e-waste treatment is given in **Figure 4.7**. Input, unit operations and outputs are described below.

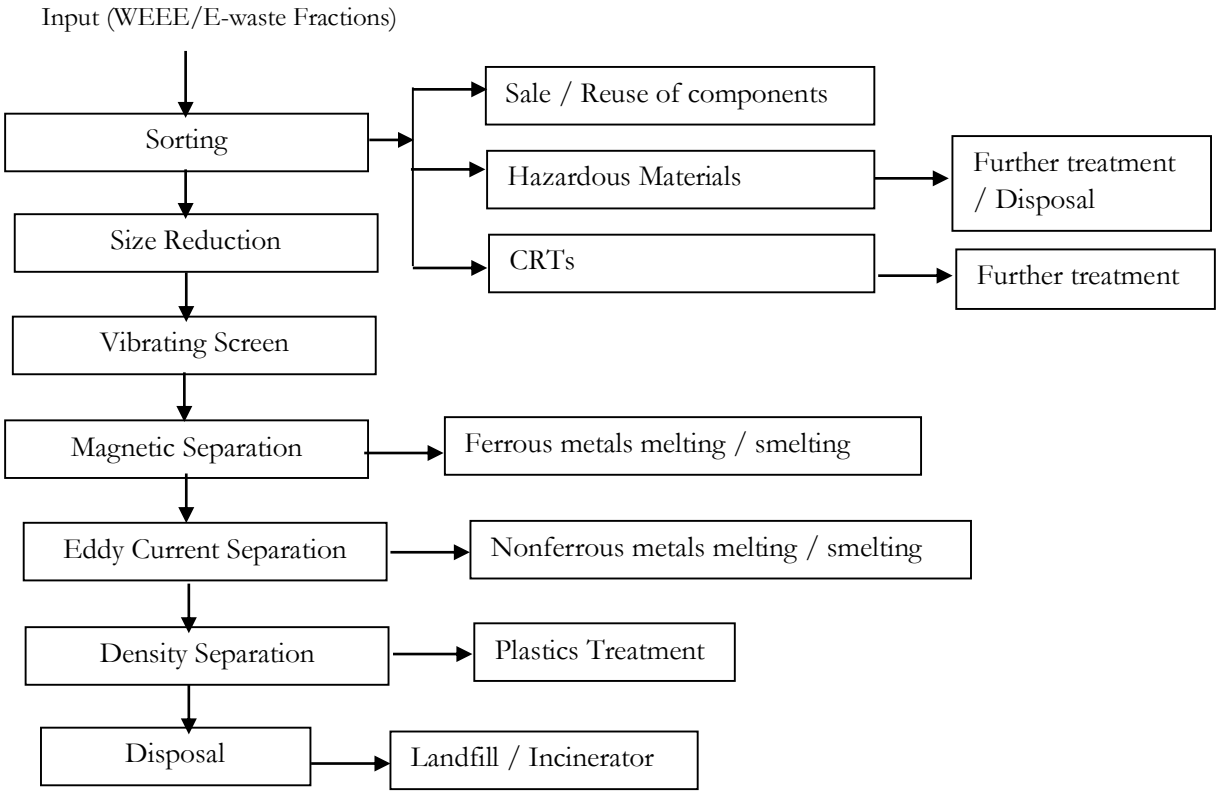


Figure 4.7: Simplified Flow Diagram for second Level WEEE/e-waste treatment

Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation and Recycling 45 (2005) 368-400, Elsevier UNEP's/IETC (e-waste Manual II: WEEE/e-waste Management System)

Input: Decontaminated WEEE/e-waste consisting of segregated non-hazardous WEEE/e-waste like plastic, circuit board and cables.

Unit Operations: There are three unit operations at second level of WEEE/e-waste treatment

1. Hammering
2. Shredding
3. Special treatment processes

Special treatment processes are given below:

1. CRT treatment consisting of separation of funnels and screen glass
2. Electromagnetic separation
3. Eddy current separation

4. Density separation using air or water

The two major unit operations are hammering and shredding. The major objective of these two unit operations is size reduction. The third unit operation consists of special treatment processes. Electromagnetic and eddy current separation utilizes properties of different elements like electrical conductivity, magnetic properties and density to separate ferrous, non ferrous metal and precious metal fractions. Plastic fractions consisting of sorted plastic after first level treatment, plastic mixture and plastic with flame retardants after second level treatment, glass and lead are separated during this treatment. The efficiency of this treatment determines the recovery rate of metal and segregated WEEE/e-waste fractions for third level treatment. An example of unit operations and equipment used are given in **Appendix 4.1**.

Output: Output from the second level treatment technology is given below:

1. Ferrous metal scrap (secondary raw material)
2. Non ferrous metal scrap mainly copper and aluminum
3. Precious metal scrap mainly silver, gold, palladium
4. Plastic consisting of sorted plastic, plastic with flame retardants and plastic mixture

Specifications

1. Input Quantity
2. Output Quantity
3. Area Required
4. Emission Standards

CRT treatment technology

Cathode ray tubes (CRT) are mainly used in either computer monitors or televisions. Handling of CRT can present a danger of implosion. As a consequence, safe systems of work will need to be used to control the risk to operate. This would typically include enclosure of the process to prevent flying glass entering the working area. The objective of the removal of the fluorescent coating is to ensure that it does not cause pollution or harm. The main approach is to separate the lead containing cone glass from the front glass using a wire cutting, followed by removal of the fluorescent coatings. The fluorescent coating that has been removed from the CRT is stored in appropriate labelled containers and then disposed or recovered at an authorized treatment facility. Front panel is crushed and panel dust fines are obtained. Funnel glass and interface glass are transferred to downstream vendors for further processing.

Flow diagram for CRT treatment is given in **Figure 4.8**. Input, unit operations and outputs are described below.

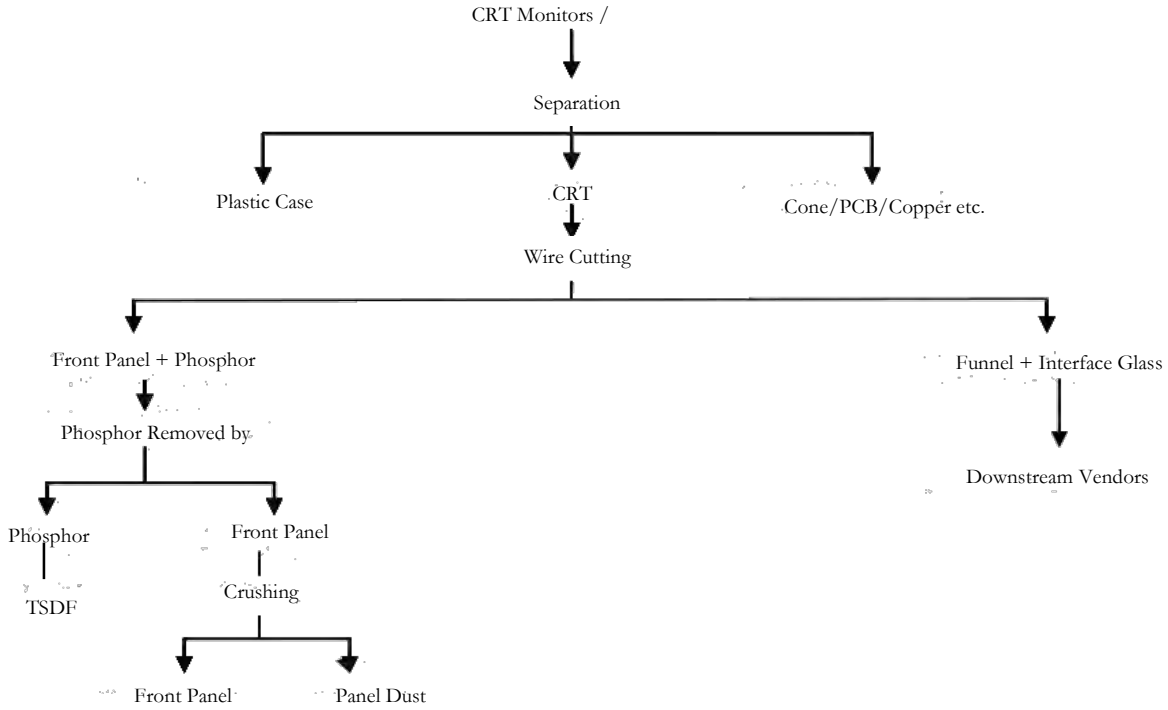


Figure 4.8: CRT Dismantling Operation Procedure

Input: CRT segregated after first level WEEE/e-waste treatment

Unit operations:

1. Dismantling: CRT is manually removed from plastic/wooden casing
2. De-pressurization and Splitting: Picture tube is split and the funnel section is then lifted off the screen section and the internal metal mask can be lifted to facilitate removal of internal phosphor coating. Different types of splitting technology used are given below.

    - NiChrome hot wire cutting: A NiChrome wire or ribbon is wrapped round a CRT and electrically heated for at least 30 seconds to cause a thermal differential across the thickness of the glass. The area is then cooled (e.g. with a water-soaked sponge) to create thermal stress, which results in a crack. When this is lightly tapped, the screen separates from the funnel section.
    - Thermal shock: The CRT tube is subjected to localized heat followed by cold air. This creates stress at the frit line where the leaded funnel glass is joined to the unleaded panel glass and the tube comes apart.
    - Laser cutting: A laser beam is focused inside and this heats up the glass. It is immediately followed by a cold water spray that cools the surface of the glass and causes it to crack along the cut line.
    - Diamond wire method: In this method, a wire with a very small diameter, which is embedded with industrial diamonds is used to cut the glass as the CRT is passed through the cutting plane.
    - Diamond saw separation: Diamond saw separation uses either wet or dry process. Wet saw separation involves rotating the CRT in an enclosure while one or more saw blades cut through the CRT around its entire circumference. Coolant is sprayed onto the surface of the saw blades as they cut. This is to control temperature and prevents warping.

- Water jet separation: This technology uses a high-pressure spray of water containing abrasive, directed at the surface to be cut. The water is focused through a single or double nozzle-spraying configuration set at a specific distance.

3. Cleaning: Internal phosphor coating is removed by using an abrasive wire brush and a strong vacuum system to clean the inside and recover the coating. The extracted air is cleaned through an air filter system to collect the phosphor dust.
4. Shredding

Outputs: Metals, Plastic and Glass Cullet

Specifications

1. Input Quantities
2. Output Quantities
3. Emission Standards
4. Area Requirement

Best practices/treatment examples are given in **Appendix 4.2**. List of Technology Providers in Developed and Developing Countries is given in **Appendix 4.3**. List of companies using different recycling technology is given **Appendix 4.4.**

Guiding principles for fixing up of specifications and selection of second level WEEE/e-waste treatment technology are given below.

1. The proposed technology for sorting, treatment, including recycling and disposal of WEEE/e-waste is fully based on a dry process using mechanical operations.
2. The pre-comminuting stage includes separation of plastic, CRT and remaining non CRT based WEEE/e-waste. Equipment like hammer mill and shear shredder will be used at comminuting stage to cut and pulverize WEEE/e-waste and prepare it as a feedstock to magnetic and eddy current separation.
3. A heavy-duty hammer mill grinds the material to achieve separation of inert materials and metals.
4. After separation of metals from inert material, metal fraction consisting of ferrous and non-ferrous metals are subjected to magnetic current separation. After separation of ferrous containing fraction, non-ferrous fraction is classified into different non-metal fractions, electrostatic separation and pulverization.
5. The ground material is then screened and de-dusted subsequently followed by separation of valuable metal fraction using electrostatic, gravimetric separation and eddy current separation technologies to recover fractions of copper (Cu), aluminum (Al), residual fractions containing gold (Au), silver (Au) and other precious metals. This results in recovery of clean metallic concentrates, which are sold for further refining to smelters. Sometimes air or water may be used for separation at the last stage.
6. Electrical conductivity-based separation separates materials of different electrical conductivity (or resistivity) mainly different fractions of non-ferrous metals from WEEE/e-waste. Eddy current separation technique has been used based on electrical conductivity for non ferrous metal separation from WEEE/e-waste. Its operation is based on the use of rare earth permanent magnets.
7. The efficacy of the recycling system is dependent on the expected yields/output of the recycling system. The expected yields/output from the recycling system are dependent on the optimization of separation parameters. These parameters are given below:

- Particle size
- Particle shape
- Feed rate/RPM.

Size properties are essential for choosing an effective separation technique. Therefore, eddy current separator is best for granular non-ferrous materials that have a size greater than 5mm. Literature cites that magnetic separation leads to recovery of about 90% to 95% of ferrous metal from WEEE/e-waste. Currently, eddy current separators are almost exclusively used for waste reclamation where they are particularly suited to handling the relatively coarse sized feeds of size greater than 5 mm. However, recent developments show that eddy current separation process has been designed to separate small particles. It has been reported that eddy current separation leads to more than 90 % recovery of non-ferrous metals from the WEEE/e-waste.

8. Particle shape is dependent on comminuting and separation. Hammer mills and screens to be used in the technology should be selected to attain the required shape.
9. The feed rate can be optimized based on the speed and width of the conveyor to eddy current separator.

Process flow diagram for second level treatment facility for decontaminated refrigerator, ACs, Washing Machine, TVs, PCs, mobile phones and other ICT/office automation equipment is shown in **Figure 4.9**.

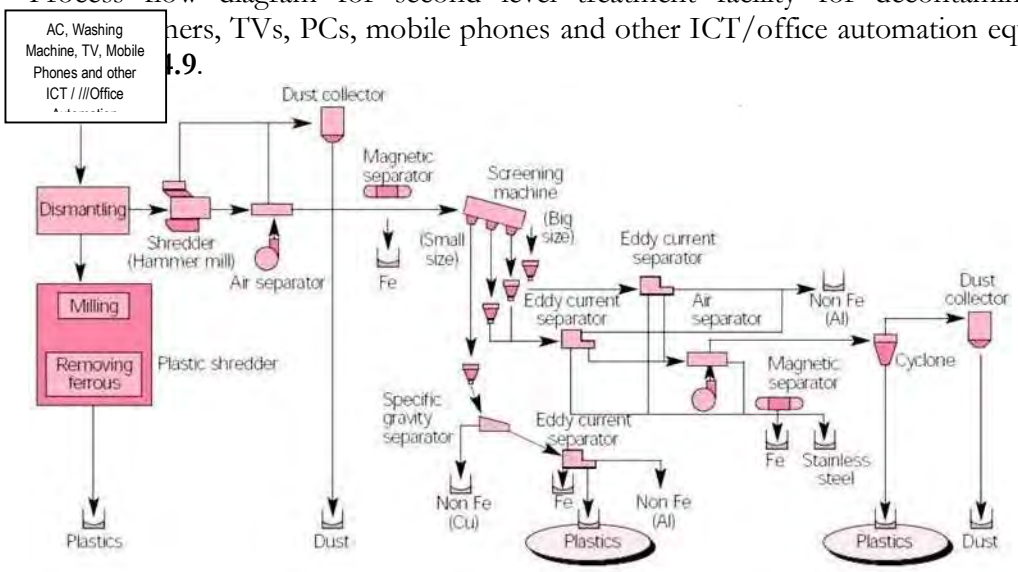


Figure 4.9: Decontaminated Refrigerator, AC, TVs, PCs, Mobile Phones and Other ICT/Office Automation Procedure

Source: Synthesis report [ENV.G.1/FRA/2004/0081, Study No.16], Gather, process, and summarise information for the review of the waste electric and electronic equipment directive (2002/96/EC), European Commission DG Environment, Bio Intelligence Service

4.4.3.3 Third Level WEEE/e-waste Treatment

The input, output and unit operations at third level treatment are described in **Table 4.3**. It may be noted that all the unit operations are geographically distributed.

Table 4.3: Input/Output and unit operations for third level treatment of WEEE/e-waste

Input/WEEE Residues	Unit Operation/ Disposal/ Recycling Technique	Output
Sorted Plastic	Recycling	Plastic Product
Plastic Mixture	Energy Recovery/Incineration	Energy Recovery
Plastic Mixture with Flame Retardants (FR)	Incineration	Energy Recovery
Lead Smelting	Secondary Lead Smelter	Lead

Input/WEEE Residues	Unit Operation/ Disposal/ Recycling Technique	Output
Ferrous metal scrap	Secondary steel/ iron recycling	Iron
Non Ferrous metal Scrap	Secondary copper and aluminum smelting	Copper/Aluminum
Precious Metals	Au/Ag separation (refining)	Gold/Silver/Platinum and Palladium
Batteries (Lead Acid/NiMHand LiION)	Lead recovery and smelting Remelting and separation	Lead
CFC	Recovery/ Reuse and Incineration	CFC/Energy recovery
Oil	Recovery/ Reuse and Incineration	Oil recovery/energy
Capacitors	Incineration	Energy recovery
Mercury	Separation and Distillation	Mercury
Glass	Remelting	Glass

Source: UNEP Manual, E-waste Volume II: E-waste Management Manual, http://www.unep.or.jp/ietc/publications/spc/ewastemanual_vol2.pdf, (Accessed on 14 July, 2016)

The description of some of the third level WEEE/e-waste processes are described below.

Plastic Recycling

There are three different types of plastic recycling options, i.e. chemical recycling, mechanical recycling and thermal recycling. All the three processes are shown in **Figure 4.10**. In chemical recycling process, waste plastics are used as raw materials for petrochemical processes or as reductants in a metal smelter. In mechanical recycling process, shredding and identification process is used to make new plastic products. In thermal recycling process, plastics are used as alternative fuel.

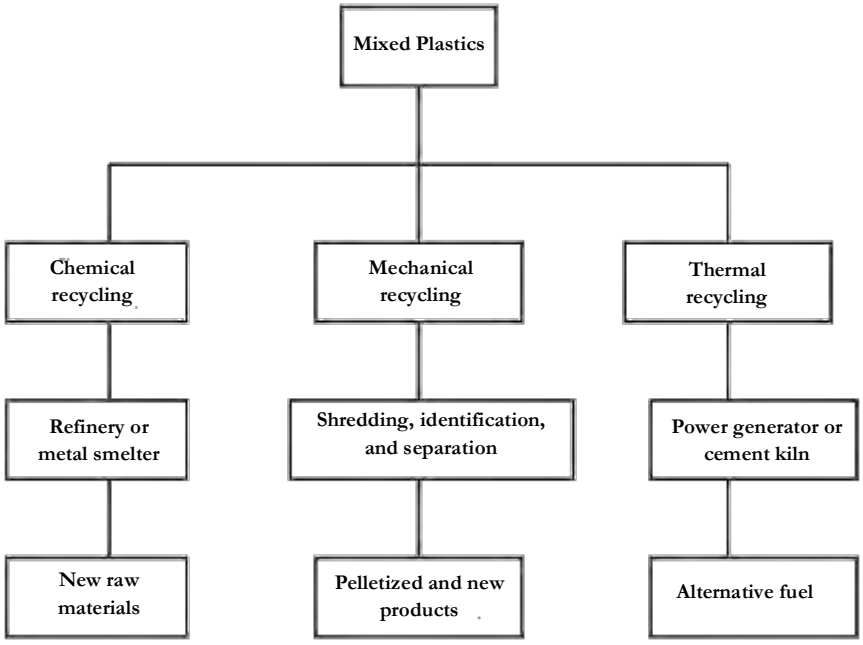


Figure 4.10: Recycling options for managing plastics from end-of-life electronics

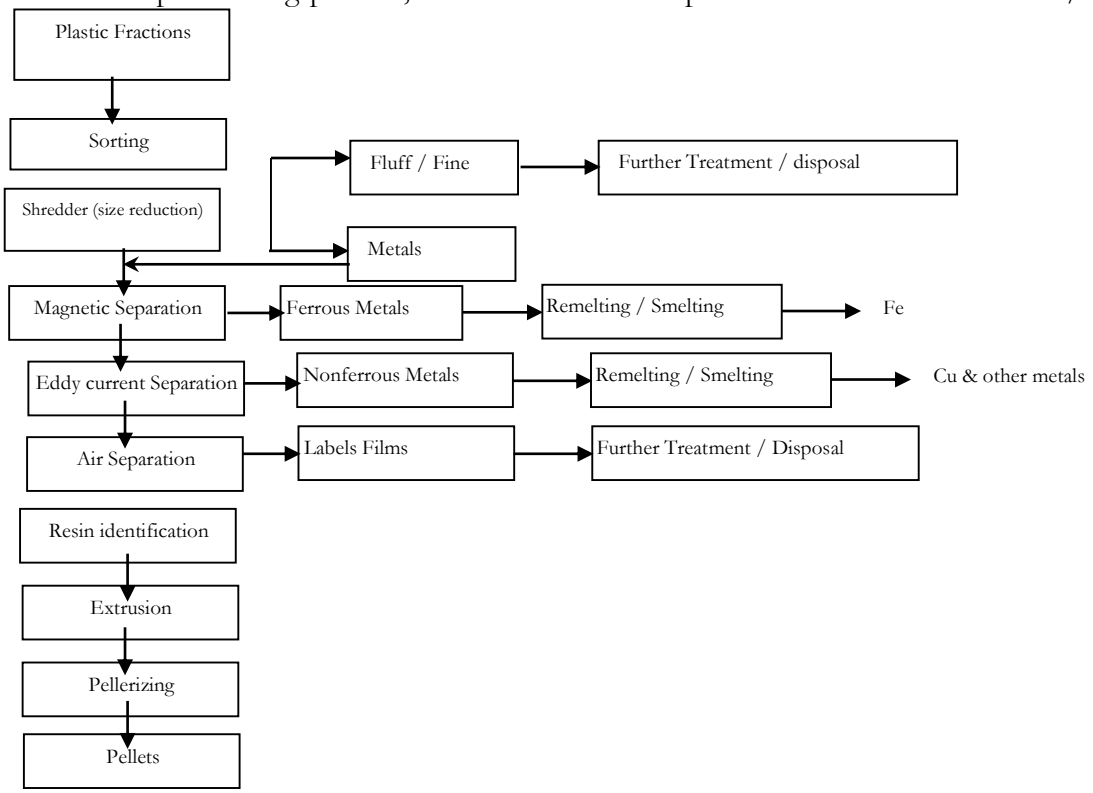
Source: Kang Hai-Yong, Schoenung Julie M. (2005). *Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier.*

(i) Mechanical Recycling Process

Mechanical recycling process is shown in **Figure 4.11**.

Figure 4.11: Representative process flow diagram for the mechanical recycling of post consumer plastics

Source: Kang Hai-Yong, Schoenung Julie M. (2005). *Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier.*



Sorting

The first step is sorting process, where contaminated plastics such as laminated and/or painted plastics are removed. The methods, which may be used for sorting, are grinding, cryogenic method, abrasion/abrasive technique, solvent stripping method and high temperature aqueous based paint removal method. Any of the methods are used for removal of paints and coating from waste plastics.

Size Reduction

Shear-shredder and hammer mills are generally used for size reduction and liberation of metals (coarse fraction) followed by granulation and milling for further size reduction. Granulators use a fixed screen or grate to control particle size, while hammer mills allow particles between hammers and the walls to exit the mills.

Magnetic Separation and Eddy Current Separation

Magnetic separators are used for ferrous metals separation, while eddy current separators are used for non ferrous metals separation.

Air Separation

Resin identification, Air separation system is used to separate light fractions such as paper, labels and films. Resin identification can be carried out by using a number of techniques like hydrocyclones, triboelectric separator, high speed accelerator and X-ray fluorescence spectroscopy. In the hydrocyclones separation technique, plastic fractions are separated using a density separation technique, which is made more effective by enhancing material wettability. In triboelectric separation technique, plastic resins are separated on the basis of surface charge transfer phenomena. Different plastic resins are mixed and contact one another in a rotating drum to allow charging. Negatively charged particles are pulled towards the positive electrode and positively charged particles are pulled towards the negative electrode. This technique has been found to be the most effective for materials with a particle size between 2-4 mm.

In high the accelerator separation technique, a high speed accelerator is used to delaminate shredded plastic waste, which is further separated by air classification, sieve and electrostatics. X-ray fluorescence spectroscopy is effective in identifying heavy metals as well as flame-retardants.

Extrusion and Pelletization

After identification and sorting of different resins, they are extruded and pelletized.

(ii) Chemical Recycling Process

Chemical recycling process is shown in **Figure 4.12**. This process was developed by the Association of Plastic Manufacturers in Europe (APME). The different steps in this process are given below:

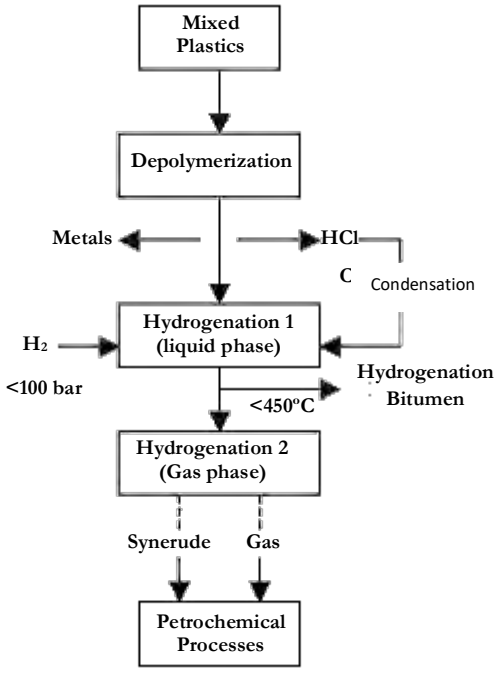


Figure 4.12: De-polymerization of plastics and conversion processes

Source: Kang Hai-Yong, Schoenung Julie M. (2005). *Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier.*

1. Mixed plastic waste is first de-polymerized at about 350°-400°C and dehalogenated (Br. and Cl). This step also includes removal of metals.
2. In hydrogenation unit 1, the remaining polymer chains from depolymerized unit are cracked at temperatures between 350°-400°C and hydrogenated at pressure greater than 100 bar. After hydrogenation, the liquid product is subjected to distillation and left over

inert material is collected in the bottom of distillation column as residue, hydrogenation bitumen.

3. In hydrogenation unit 2, high quality products like off gas and syncrude are obtained by hydrotreatment, which are sent to petrochemical process.

(iii) Thermal Recycling Process

In thermal recycling process, plastics are used as fuel for energy recovery. Since plastics have high calorific value, which is equivalent to or greater than coal, they can be combusted to produce heat energy in cement kilns. APME has found thermal recycling of plastic as the most environmentally sound option for managing WEEE/e-waste plastic fraction.

Metals Recycling

Metals recycling has been described below in terms of **lead recycling, copper recycling and precious metals recycling (Au, Ag and others)**. After sorting of metal fractions at second level WEEE/e-waste treatment, they are sent to metal recovery facilities. These metal recovery facilities use the following processes to recover metals.

Lead Recovery

Reverberatory furnace and blast furnace are used to recover lead from WEEE/e-waste fraction. The process is shown in **Figure 4.13** and involves the following steps:

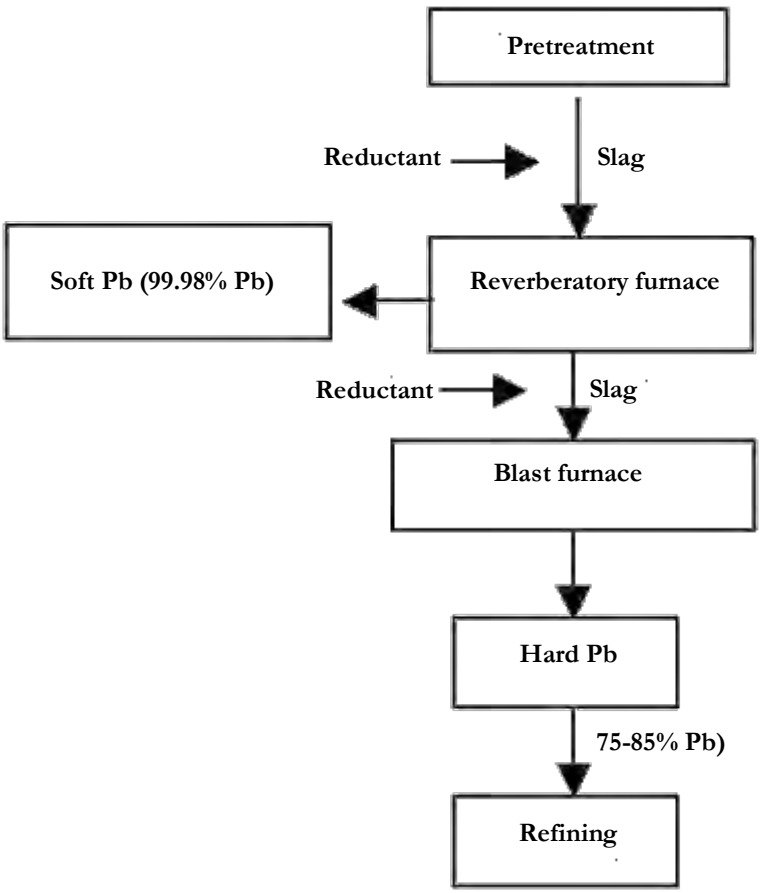


Figure 4.13: Processes flow for secondary lead recovery

Source: Kang Hai-Yong, Schoenung Julie M. (2005). Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier.

1. A reverberatory furnace is charged with lead containing materials and reductants. In this furnace, the reduction of lead compounds is carried out to produce lead bullion and slag. Lead bullion is 99.9% while slag contains 60-70% wt. % lead and a soft (pure) lead product. The following reactions occur in the reverberatory furnace.

$$PbO + C \longrightarrow Pb + CO$$
$$2\,Sb + 3PbO \longrightarrow 3\,Pb + Sb_2O_3$$
$$2\,As + 3PbO \longrightarrow 3\,Pb + As_2O_3$$
$$Sn + 2PbO \longrightarrow 2Pb + SnO_2$$

2. Slag in reverberatory furnace is continuously tapped onto a slag caster. It consists of a thin, fluid layer on top of the heavier lead layer in the furnace.
3. Lead bullion is tapped from the furnace when the metal level builds up to a height that only small amounts of lead appear in the slag.
4. Lead is recovered from the slag by charging it in blast furnace along with other lead containing materials and fluxing agents like iron and limestone.
5. Hard lead is recovered from the blast furnace, which contains 75-85 wt. % Pb and 15-25 wt. % Sb. Slag contains 1-3% lead. Slag contains Cao, SiO_2 and FeO.
6. Flue gas emissions from reverberatory furnace are collected by bag house and feedback into the furnace to recover lead. Slag from blast furnace is disposed of in hazardous waste landfill sites.

Copper and Precious Metal Recycling

The pyrometallurgical and hydrometallurgical processes are the major routes for processing of WEEE/e-waste. Pyrometallurgical routes are used initially for the segregation and upgrading of precious metals (Gold and Silver) into base metals (copper, lead and nickel) followed by hydrometallurgical and electrometallurgical processing (e.g. electro-refining or electro-winning) for selected metal separation and recovery. Basic steps using recovery of copper and precious metals e.g. silver, gold, platinum and palladium are described below.

The copper recycling process is shown in **Figure 4.14**. It involves the following steps:

1. WEEE/e-waste fraction containing Cu is fed into a blast furnace, which is reduced by scrap iron and plastics to produce "black copper". Black copper contains 70-85 wt. % copper. The following reactions occur in the blast furnace. Sn, Pb and Zn are also reduced as gas fumes.

$$Fe + Cu_2O \longrightarrow FeO + 2Cu$$
$$2Zn + C \longrightarrow 2\,Zn\,(g) + CO_2$$

2. The black copper is fed into the converter and oxidized using air or enriched oxygen to produce blister copper having 95 wt. % purity. Sn, Pb and Zn are removed, while Fe is removed as slag.
3. Blister copper and scrap Cu are melted and reduced by coke or wood or waste plastic in the anode furnace. Other less noble metals are oxidized and removed from blister copper. Sulfur is also removed from the anode furnace.

The following reduction reaction occurs in the anode furnace.

$$2CuO + C \longrightarrow 2\,Cu + CO_2$$

4. Recovered anode copper is further purified in electrolytic process where it is dissolved in H2SO4 electrolyte with other elements such as Ni, Zn and Fe. The pure copper 99.99 wt. % purity is deposited on the cathodes.

5. The by-products of copper recovery process and slag are reused for roof shingles, sand blasting and ballasts for railroads. The anode slime from electrolytic process is used for precious metal recovery. The entire secondary recovery of Cu uses only one-sixth of the energy that would be required to produce Cu from ore.
6.

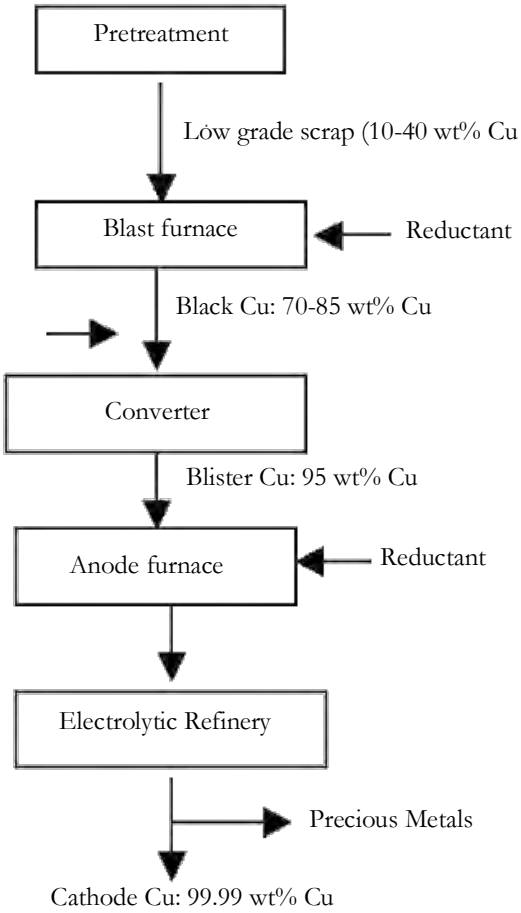


Figure 4.14: Process flow for secondary copper recovery

Source: Source: Kang Hai-Yong, Schoenung Julie M. (2005). *Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier.*

Precious Metals Recovery

The precious metals recovery process is shown in **Figure 4.15**. It involves the steps shown in the flow chart. The anode slime recovered from copper electrolytic process shown in **Figure 4.14** is used for precious metal recovery. The process involves the following steps.

1. Anode slime is leached by pressure.
2. The leached residue is then dried and, after the addition of fluxes, smelted in a precious metals furnace. Selenium is recovered during smelting.
3. The remaining material from smelter is caste into anode and undergoes electrolysis to form high-purity silver cathode and anode gold slime.
4. The anode gold slime is further leached and high purity gold, palladium and platinum sludge are recovered.

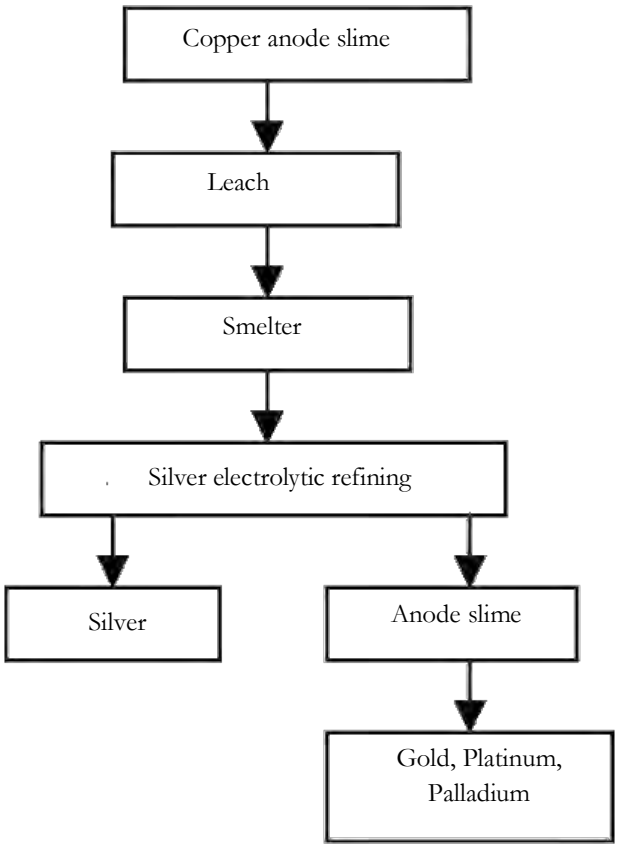


Figure 4.15: Precious metals recovery process

Source: Kang Hai-Yong, Schoenung Julie M. (2005). *Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier.*

A summary of typical pyrometallurgical methods for recovery of metals from electronic waste used by different companies/agencies is given in **Table 4.4**.

Table 4.4: Typical Pyrometallurgical Methods for Recovery of Metals from Electronic Waste

Techniques	Metals Recovered	Main Process Features	Main Results
Noranda process at Quebec, Canada	Cu, Au, Ag, Pt, Pd, Se, Te, Ni	Feeding to copper smelter with copper concentration (14% of the total throughput); Upgrading in converter and anode furnaces; Electrorefining for metal recovery.	High recovery for both copper and precious metals.
Boliden Ronnskar Smelter, Sweden	Cu, Ag, Au, Pd, Ni, Se, Zn, Pb	Feeding to Kaldo reactor with lead concentrates (totally 100,000 tonnes every year); Upgrading in copper converter and refining. Precious metals refining for recovery.	High recovery of copper and precious metals.
Test at Ronnskar Smelter	Copper and precious metals	PC scrap feeding to Zinc Fuming process (1:1 mixture with crushed revert slag); Plastics were tested as reducing agent and fuel. Copper and precious metals following the copper collector to be recovered to the copper smelter.	Almost complete recovery of copper and precious metals in the Zinc Fuming process.

Techniques	Metals Recovered	Main Process Features	Main Results
Umicore's precious metal refining process at Hoboken, Belgium	Base metals, precious metals, Platinum group metals and Selenium, Tellurium, Indium	IsaSmelt, copper leaching and electro-winning and precious metals refinery for Precious Metals Operation (PMO); e-waste cover up to 10% of the feed (250,000 tonnes of different wastes per annual); Plastics partially substitute the coke as reducing agent and fuel in IsaSmelt. Base Metals Operations process by products from the PMO, including Lead blast furnace, lead refinery and special metals plant. Offgas emission control system is installed at the IsaSmelt furnace.	Recovering both base metals, precious metals and special metals such as Sb, Bi, Sn, Se, Te, In.
Full scale trial at Umicore's smelter	Metals in electronic scrap	Plastics rich materials from WEEE were tested to replace coke as a reducing agent and energy source for the IsaSmelt.	The smelter operation and metal recovery are not negatively affected by using 6% WEEE plastics and 1% of coke to replace 4.5% coke.
Dunn's patent for gold refining	Gold	Gold scrap reacted with chlorine at 300ºC to 700ºC; Hydrochloric acid washing to dissolve the impurity metal chlorides; Ammonium hydroxide and nitric acid washing respectively to dissolve the silver chloride; Samples should contain more than 80% of gold.	Gold with 99.9% purity was recovered from gold scraps.
Day's patent for refractory ceramic precious metals scraps	Precious metals such as platinum and palladium	The scrap was charged to a plasma arc furnace at a temperature of at least 1400ºC; A molten metallic phase containing precious metals and collector metal was produced; Ceramic residues went into a slag phase; Silver and copper are suitable collector metals in process.	For an electronic scrap, platinum and palladium were recovered with recovery of 80.3% and 94.2%, respectively.
Aleksandrovich's patent for recovery of PGM and gold from electronic scraps	PGM and gold	Fusing together of scraps based on chalcogenides of base metals with carbon reducer; After the settling and cooling of melted materials, solidification and separation of solidified product are carried out by formed phase boundaries.	PGM and gold were recovered.

Source: Jirang Cui, Lifeng Zhang; Mettalurgical recovery of metals from electronic waste: A review; Department of Materials Science and Engineering, Norwegian University of Science and Technology (NTNU), Alfred Getz vie 2, N-7491 Trondheim, Norway

Hydrometallurgical routes for base metals and precious metal recovery use acid or caustic leaching, solvent extraction, adsorption, electro-refining or chemical reduction process. Solvents especially halides, cyanides, thiourea and thiosulfates are used for the leaching of precious metals (PM) from their primary ores. Process factors including pH, temperature and stirring control the dissolution of metals from their primary ores. The recovery of PMs from the leached solution is carried out by cementation, solvent extraction, and adsorption on activated carbon and ion exchange methods. Similar techniques could be employed for extracting metals from e-waste, however, its complex

nature makes the process complicated compared to natural ores. An example of the process flow of recovery of precious metals from printed circuit board is given in **Figure 4.16**.

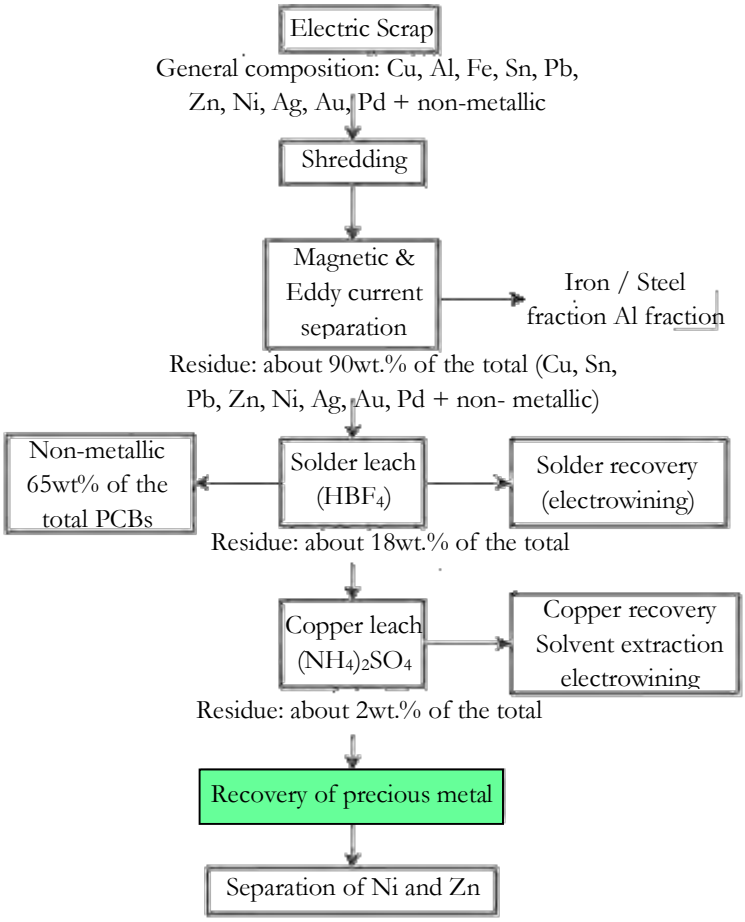


Figure 4.16: Examples of Hydrometallurgical Recycling of PCBs for the Recovery of Precious Metals

*Source: Abdul Khaliq, Muhammad Akbar Rhamdhani *, Geoffrey Brooks and Syed Masood; Metal Extraction Processes for Electronic Waste and Existing Industrial Routes: A Review and Australian Perspective; Resources 2014, 3, 152-179; doi:10.3390/resources3010152; ISSN 2079-9276; www.mdpi.com/journal/resources*

A summary of the process is given in **Table 4.5**.

Table 4.5: Summary of Hydromettalurgical Recovery of Precious Metals

Investigators	Leaching agent	Process conditions	Recovered metals
Park and Fray	Aqua regia	Ratio of metals to leachant = 1:20 g/mL	Au, Ag and Pd
Sheng and Estell	HNO_3 (1st stage), epoxy resin (2nd stage), and aqua regia (3rd stage)	Extraction was carried out in the three stages (self agitation)	Au
Quinet *et al.*	H_2SO_4, chloride, thiourea and cyanide leaching	Leaching and metals recovery by cementation, precipitation, ion exchange and carbon adsorption	Au, Ag, Pd and Cu
Chielewski *et al.*	HNO_3 and aqua regia	Roasting of e-waste in the presence of carbon; leaching with HNO_3 and aqua regia; and solvent extraction with diethyle malonate	Au

Investigators	Leaching agent	Process conditions	Recovered metals
Zhou *et al.*	HCl, H_2SO_4 and $NaClO_3$	Combustion of e-waste at 400–500 °C followed by leaching	Ag, Au and Pd
Kogan	HCl, $MgCl_2$, H_2SO_4 and H_2O_2	Dissolution of e-waste in different solvents and leaching conditions; and recovery of metals in stages	Al, Sn, Pb and Zn (1st stage), Cu and Ni (2nd stage), Au, Ag, Pd and Pt (last stage)
Veit *et al.*	Aqua regia and H_2SO_4	Mechanical processing and then dissolution of e-waste in different solvents	Cu
Mecucci and Scott	HNO_3	Electrochemical deposition of Cu at cathode from solution	Pb and Cu

*Source: Khaliq Abdul, Rhamdhani Muhammad Akbar (2014) *, Geoffrey Brooks and Syed Masood; Metal Extraction Processes for Electronic Waste and Existing Industrial Routes: A Review and Australian Perspective; Resources 2014, 3, 152-179; doi:10.3390/resources3010152; ISSN 2079-9276.*

4.4.4 Technology Options and Proposed CFL/FL Treatment Technology

In CFL/FL treatment technology, the major technology options are primarily focused on the recovery of mercury and Rare Earth Elements (REE) content from phosphor powder. Since CFL/FL is disposed in a regular municipal waste landfill, waste may cause serious damage to the environment by the way of mercury emissions, while REE are lost as a valuable resource.

A conceptual approach to recover mercury from lamp phosphors of end-of-life fluorescent lamps, which is used globally is by heating the phosphor powder in a vacuum at temperatures between 400 and 600ºC to volatilize mercury and distilling it.

Considering the above conceptual approach, the proposed CFL/FL technology has been described based on first, second and third level of treatment described below. The entire treatment scheme and process flow is shown in **Figure 4.17**. Furthermore, each level consisting of input, output and unit operations has also been described below.

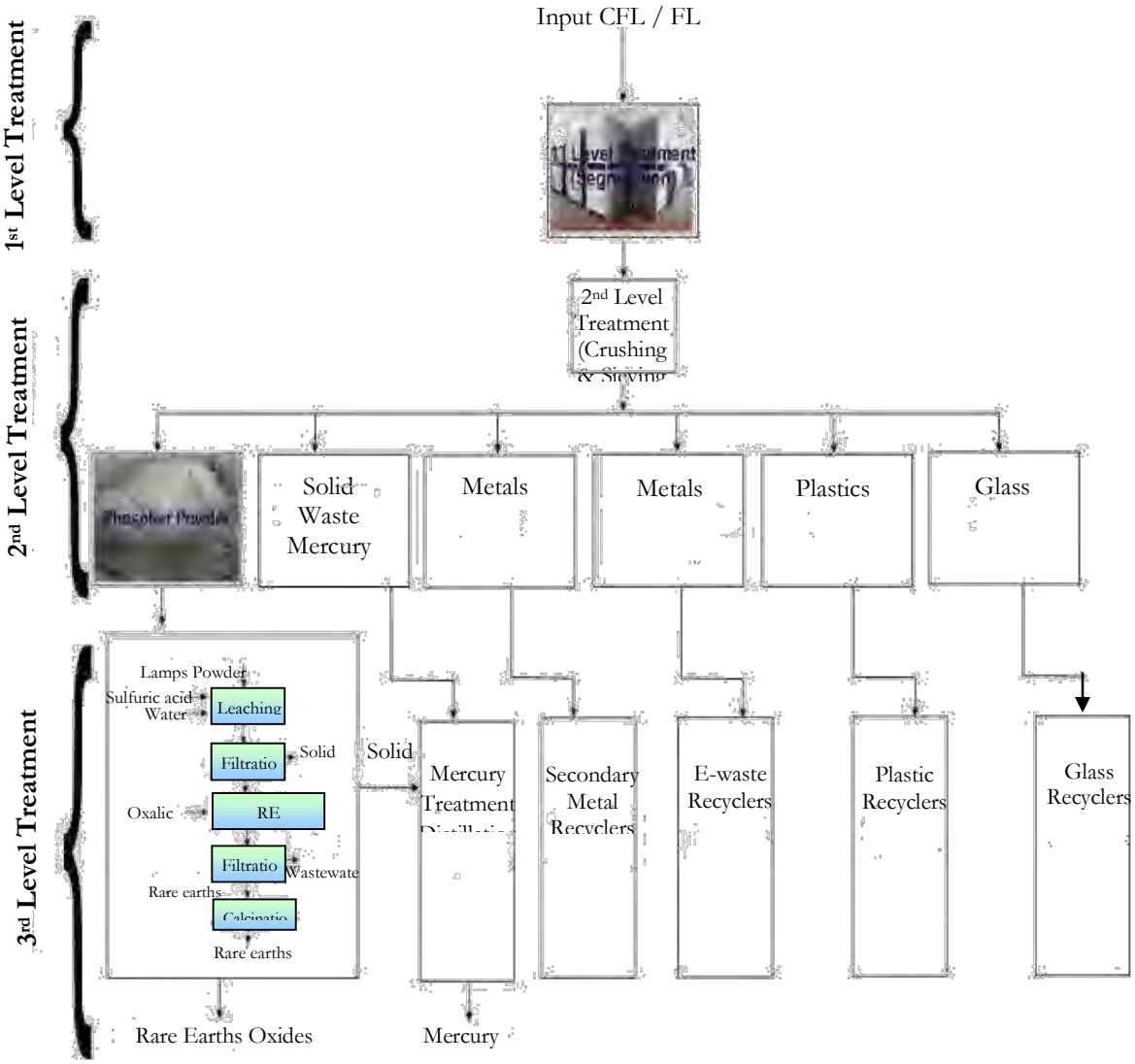


Figure 4.17: Conceptual CFL/FL Waste Treatment Scheme and Process Flow

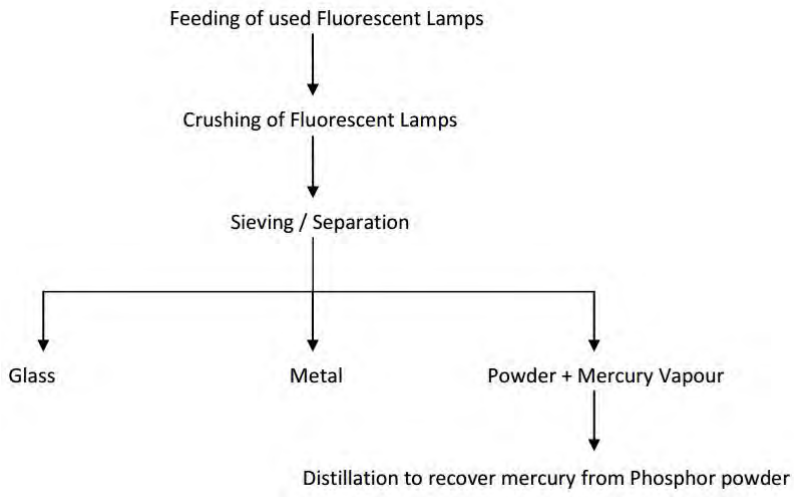


Figure 4.18: Broken Backlights Process Flow *Source:* Jain Amit (2016).

4.4.4.1 First Level WEEE/e-waste Treatment

Input: CFL/FL waste

Unit Operations: The following unit operations occur at first level of treatment

1. Unloading
2. Segregation/Crushing for volume reduction
3. Storage

All the three unit operations are dry processes, which do not require use of water. The first step is unloading followed by segregation as per their size and storage. This step ensures proper handling of CFL/FL waste and formulation of input feed for second level treatment. Various steps in the process at a CFL/FL waste recycling facility are depicted in **Figure 4.19**.

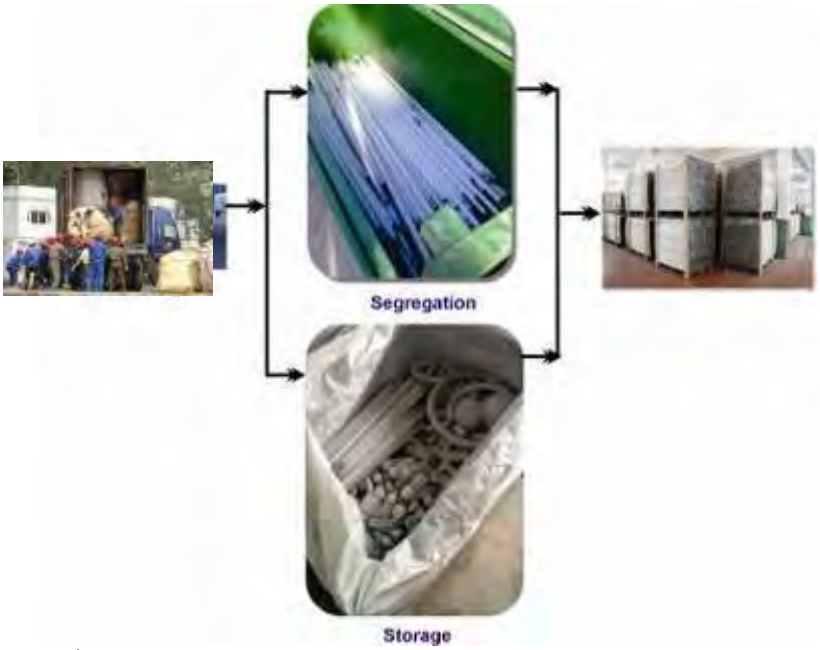


Figure 4.19: CFL/FL Waste first level treatment process. *Source:* Jain Amit (2016).

Output: Segregated CFL and FL Waste and Crushed Material

4.4.4.2 Second Level WEEE/e-waste Treatment

The proposed second level WEEE/e-waste treatment technology has been described in terms of unit operations consisting of process overview and equipment to be used.

Input: Segregated CFL/FL

Unit Operations

In this dry-processing system, lamps are mechanically crushed and sorted into their separate components. The recycling technique is known as "crush and sieve". It can be applied to either waste Tubular Fluorescent Lamps (TFL) or Compact fluorescent Lamps (CFL) of various sizes

and shapes with a very high output fractions purity. The entire system is operated under negative pressure to minimize mercury emissions to the atmosphere. Various steps used in the process are described below.

Step 1: The material is fed to the system through the bin turning device into a vibratory feeder, which feeds the lamps into the crusher. TFLs are fed through the manual feeding table or optionally automatically from the mechanized feeding unit.

Step 2: The spent fluorescent lamps are first broken in a crushing unit. During crushing, a vacuum system placed under crusher grates collects the air powders derived from the crushing, preventing the powders and the mercury from escaping through the feed tube.

Step 3: The process crushes the complete product, after which the various ingredients are separated and processed. The process is focused on the removal of six basic components i.e. Plastic, Glass, Metals, Mercury, Phospher Powder and Printed Circuit Board.

Step 4: Metals and non metals are removed using electromagnetic separator.

Step 5: The lamp phosphor powder constitutes about 3% of the mass of a fluorescent lamp. After the mechanical treatment for separating the fraction, the aspirated air and Fluorescent powders containing Yttrium (Y) and Europium (Eu) and other rare earth elements (REE) powders pass through a further treatment in a cyclone where the bigger parts of glass are separated, and a bag filter.

Step 6: Mercury is controlled via a carbon filter that segregates the element by preventing its dispersion in the air. Part of the mercury is contained in the fluorescent powders. The outcome of the pre-treatment process is fluorescent powder with low content of glass (around 5 to 6 %).

During the entire process, the fluorescent powder follows the air stream and is separated from the ventilation air in three sub steps:

Sub Step 1: First, the air passes through a cyclone where most of the powder is separated into a steel drum or stainless steel distiller barrel.

Sub Step 2: Second, the ventilation air passes through a dust separator where fine particles are captured, and thereafter discharged into a steel drum or distiller barrel. The air is then cleansed from fluorescent powder.

Sub Step 3: Third, the air is lead through the carbon filters to eliminate the risk for any remaining mercury vapour reaching the atmosphere.

Outputs: The recycling process achieves to separate glass, metal (filaments, supply electrodes, caps), plastics (caps, insulators), phosphor powder and mercury. Clean glass can be used for the production of new lamps or in the ceramic industry, and other glass pieces can be used for making new glass products. Metal parts are sent to metal recycling facilities and plastic parts are sent for energy recovery. The broken glass pieces are separated from the phosphor powder by sieving operations. This sieving is done via a dry process. The conceptual layout showing lateral and top view of the process is given in **Figure 4.20**.

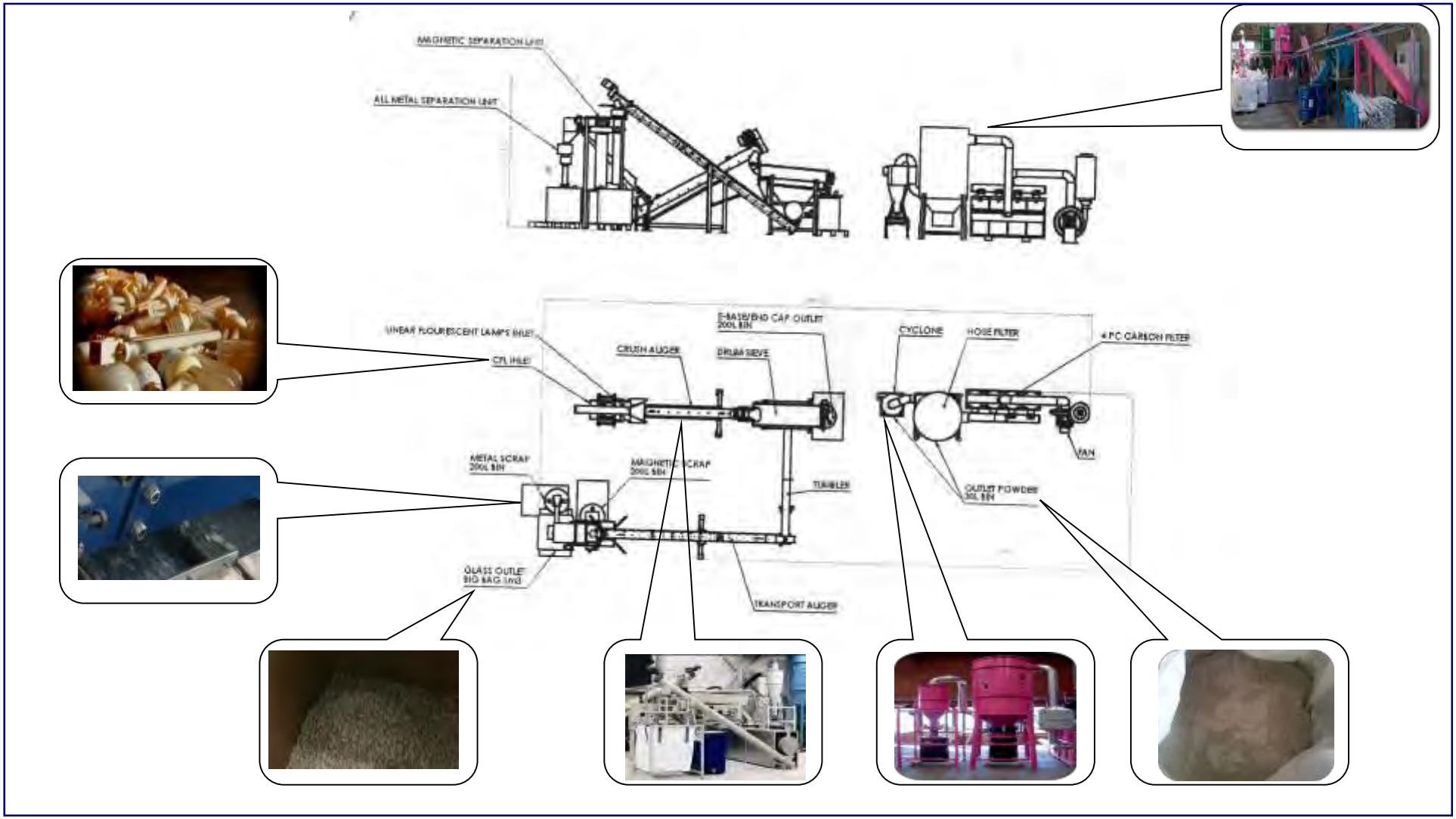


Figure 4.20: Conceptual plant layout (lateral and top view) showing second level treatment process flow diagram

Source: Extracted from M/s MRT system, Sweden

4.4.4.3 Mercury Distillation Process

Input: Phospher Powder and Carbon Filter containing Mercury (Hg).

Unit Operations:
Mercury is distilled under controlled condition in a batch process. The working area has to be ventilated by fresh air. The Hg concentration is mainly dependent on how waste is handled in the working area and how maintenance work on the equipment is executed.

Step 1: Input: feed material in distiller barrels.
Step 2: Heating phase: At first, the vacuum pump will pump towards 10mbar, followed by N_2 pulsed to 500 mbar and heating is activated.
Step 3: Combustion phase: Dome heating is activated at 500 °C, while Dome pressure is adjusted to 700 mbar. Dome temperature is kept at a preset temperature, 500°-675° °C depending on the programme.
Step 4: Ventilation phase: In the ventilation phase, the dome is ventilated by pulsing pressure between 700 - 300 mbar for a preset time period.
Step 5: Cooling phase: In the cooling phase, all heating is turned off. Dome is ventilated by pulsing pressure between 500 - 10 mbar for a preset time period.
Step 6: Dome is cooled externally by a fan down to the preset temperature.

Outputs: Hg content after distillation is about max. 0.1 mg/l. The process is executed in a modular unit.

4.4.4.4 Rare Earth Extraction (REE) Process

Indium, gallium, rare-earth and other metals are leached out or reclaimed by hydrometallurgical principles from electronic waste. Europium and Yttrium metals and some other valuable salts are present in the powder coating on the inner surface of the glass tubes of fluorescent lamps. These elements can be recovered using the process given in **Figure 4.21**.

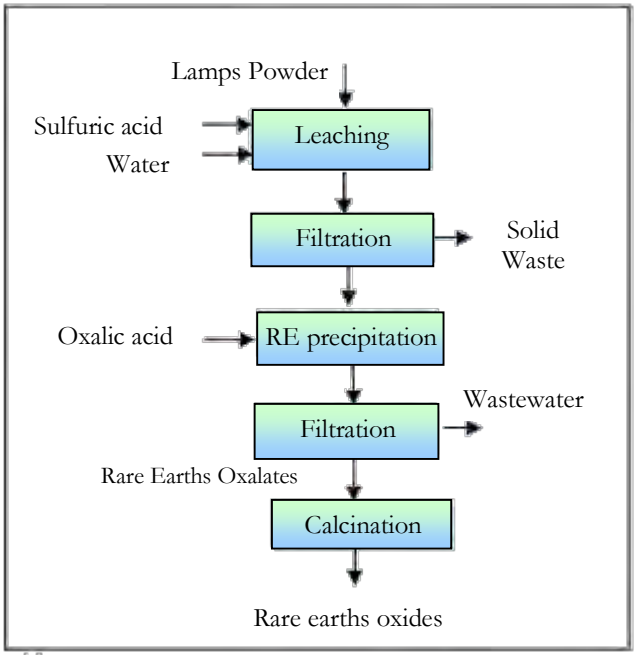


Figure 4.21: Rare Earth Elements Extraction from Phospher Powder[14]

Input: Phospher Powder

Unit Operations:

Phospher powder is subject to leaching with sulfuric acid followed by purification by sodium hydroxide and precipitation by oxalic acid. In this step rare earths oxalates are formed which are calcinated to obtain rare earths oxides.

Chemical reactors are employed to carry on the extraction of high value elements from powder, selective precipitation reactions and treatment of wastewaters. Filter presses allow for the separation of the solid from solid-liquid suspensions. Boiler generates hot water employed for temperature control of jacketed reactors. Rotary screw compressor supply's the compressed air needed for operation of pneumatic devices (valves, pneumatic pumps) and dewatering of cakes formed by filtration of solid liquid suspensions. Centrifugal pumps are employed to drive the circulation of reactants, liquid and solid-liquid suspensions within the plant.

Outputs:: The estimated Y and Eu total recovery is ~93%. **The purity of the final oxide is around 97%**. The main impurities in the product are: sulphates (3.6%), calcium (0.7%), silicon (0.3%) and traces of other metals. Waste water, which is generated, can be treated and reused in the process.

The same process and unit operations are being used to extract rare earths from CRT powder as well as recovery of Cobalt (Co) from powder of lithium Ion batteries (LIBs). The entire process has been designed, pilot tested and upgraded both for industrial scale applications as well as for small scale applications in form of mobile units [15][16]. The results of mobile unit applications are given in Table 4.6.

Table 4.6: Mobile plant processing capacities

Process	Number batches/16h	Processed powder (kg/batch)
Lamps	3	420
CRT	3	420
LIB	2	360

Source: Paper on Design and Construction of Stationary and Mobile Hydrometallurgical Plants for the Recovery of Metals from WEEE

Extraction of Rare Earth Elements at small and medium levels is being carried out in Italy and Romania, in Europe. In Italy it is being carried out at M/s Relight S.R.L. based in Milano. In Romania it is being done at M/s S.C. Greentronics S.R.L, Alexandria, Teleoman.

An example for process specification and Bill of Quantities (BOQ) prepared for a plant in India is given below.

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[14] *Innocenzi Valentina, DeMichelis Ida, Centofanti M., Vegliò Francesco (2013). Paper Hydrometallurgical Processes for the Recovery of Precious and Critical Metals from Spent Lamps And Cathode Ray Tubes. Department of Industrial and Information Engineering and Economics, by University of L'Aquila, Via Giovanni Gronchi 18, 67100 L'Aquila, Italy*

[15] *Ferrari B, Sgarioto S., Romilio D., Giorgetti S., Bacchetta F.; Paper on Urban Mining of Rare Earths from WEEE: A Successful Experience of the EU-FP7 hydroWEEE Project*

[16] Pietro Altimari, Francesca Beolchini, Ida De Michelis, Bibiana Ferrari, Silvia Giorgetti, Valentina Innocenzi, Bernd Kopacek, Emanuela Moscardini, Francesca Pagnanelli, Nebojsa Panjevac, Luigi Toro, Francesco Vegliò (2013). Paper on Design and Construction of Stationary and Mobile Hydrometallurgical Plants for the Recovery of Metals from WEEE. Going Green - Care Innovation. 17-20 November 2013, Vienna, Austria

Process flow specifications for all the three levels treatment are summarized in **Table 4.7,** while bill of quantities has been described in **Table 4.8**.

Table 4.7: Specifications for Process Flow Parameters

Sr. No.	Level of Treatment	Treatment Parameters	Value
1.	1st Level	Unloading	4 to 5 metric tonnes/day
2.	1st Level Crushing (at collection centre)	Crushing	2 to 3 tonnes/day
			Electrical connection 400 V, 50HZ
			Max. Temp +10ºC to +35ºC
			Compressed Air 300 l/min
			Supply 6 bar Pressure dry out free
3.	2nd Level Treatment	**Input :** Capacity	Up to 600 kg/hour input
		Power supply	Electrical connection 400V, 50 Hz
		Compressed air supply	Max consumption 500 l/min 7-8 bar dry oil free (dew point 3ºC) Connection pipe 0.5 inch, thread
		Operational temperature range	+10ºC - + 35ºC
		Hg emission to the atmosphere in: Working area Exhaust: max Exhaust flow	 max 0.020 mg/m^3 0.020 mg/m^3 max 1500 m^3/h
		Yield: Output fractions (collection bag/barrel) Glass/metal fraction Fluorescent powder e-base/socket fraction	**big bag 1m^3** **30L distiller barrels** **200L steel drum**
4.	3rd Level Treatment (Mercury Distillation)	**Input: Capacity**	2 x 100 l/batch
		Process time	approx. 14-16 hours
		Electrical connection	400 V, 50Hz, 5-core cable Max. 35 kW 100 A
		Compressed air Supply pressure	Maximum 500 l/min (300 m^3 per batch) 6 bar dry (dew point +3ºC) oil free Maximum flow 500 l/minute
		Operational temperature range	+10ºC - + 35ºC
		Process temperature range	500ºC to 825ºC
		Hg emission to the atmosphere Working area Exhaust	 max 0.015 mg/m^3 max 0.015/mg/m^3
		Exhaust Exhaust flow	 max. 500 m^3/h
		Yield: Output Hg content after distillation: Hg concentration	 max. 0.1 mg/l
5.	3rd Level Treatment (REE Extraction)	**Input** Phospher Powder	 100 kg/batch
		Process Time	5 to 6 hours/batch
		Process Temperature	60ºC – 90ºC
		Installed Power	90 kW
		Compressed Air Pressure	10 bar
		Yield: Output: Eu and Y oxides	**93% of Eu and Y in Input feed**

Source: Data obtained from M/s MRT system, Sweden, http://www.mrtsystem.com/

Table 4.8: Bill of Quantities

Sr. No.	Level of Treatment	Item	Quantity
1.	1st Level	Storage container CFL (7.5" x 7.5" x 7.5")	15 CFL/Box
		Storage container FL (1200 mm x 1900 mm x 1025 mm)	1000 tubes/Box
		Fork Lift	1
		Weigh bridge	1
2.	1st Level Crushing at Collection Centre	Crusher	1 piece
		Hopper	1 piece

Sr. No.	Level of Treatment	Item	Quantity
		Jet Filter	1 piece
		Carbon Filter	1 piece
		Fan	1 piece
3.	2nd Level Treatment	Manual feeding inlet for CFL lamps	1 piece
		Crush auger	1 piece
		Drum sieve	1 piece
		Tumbler	1 piece
		Transport auger	1 piece
		Complete ventilation system (listed below) • Fan • Dust filter • Carbon filters • Duct work and hoses	 1 piece 1 piece 2 piece 1 piece
		Options: Feeding inlet for linear fluorescent lamps up to 2000 mm Magnetic separator unit, collection (20L steel drum) All metal separator, collection (200L steel drum) Transformer for alternative electrical connection	 1 piece 1 piece 1 piece 1 piece
4.	3rd Level Treatment (Mercury Distillation)	The purchase will include the following components: Dome Condenser Vacuum system Fan Carbon filters Control system Chain hoist Cooling unit Distiller barrels (60L)	 1 piece 1 piece 1 piece 1 piece 2 piece 1 piece 1 piece 1 piece 1 piece
5.	3rd Level Treatment (REE Extraction)	Jacketed agitated reactor	1 piece of 6.5 m^3
		Agitated reactor	1 piece of 6 m^3
		Agitated reactor	1 piece of 9 m^3
		Auxiliary tanks	1 piece of 10 m^3
		Filter-press	1 piece of 288 L (chambers volume); 21.67 m^2 (filtrating surface)
		Filter-press	1 piece of 243 L (chambers volume); 12.55 m^2 (filtrating surface)
		Filter-press	1 piece of 233 L (chambers volume); 13.33 m^2 (filtrating surface)
		Scrubber: Tower for the abatement of acidic gases	1 piece of 3000 Nm^3/h (maximum H_2S concentration 30mg/mc)

Source: Data obtained from M/s MRT system, Sweden, http://www.mrtsystem.com/

Area requirement for CFL/FL recycling facility has been assessed to be 1500 m^2 considering 1st phase recycling. This is based on 75% covered area and 25% open area. Breakup of land requirement is given below.

1. Total Land Requirement – 1500 m^2
2. Covered area – 1125 m^2
3. Processing Area – 600 m^2 for 2nd and 3rd level treatment.
4. Raw material inventory area – 200 m^2
5. Product inventory – 200 m^2
6. Administration area – 125 m^2

The minimum height of the processing, storage and administrative area is limited up to 6 meters.

4.4.5 Hydrometallurgical Processes for the Recovery of Indium from Liquid Crystal Displays [17]

Hydrometallurgical process for Indium recovery from end-of-life LCDs is based on 4 main steps.

Step 1: Crushing of LCD panel

Step 2: LCD washing: Before leaching treatment, an amount of ground LCD panels was washed using deionized water to remove the organic compounds of the LCDs.

Step 3: Metal leaching: Leaching tests were performed, treating the washed wastes with sulfuric acid, at 80°C to promote the dissolution of metals. To perform a cross-leaching process, at the end of each step, filtered leach liquor was used to treat a second amount of LCD fragments, adding a small amount of fresh H_2SO_4 when necessary.

Step 4:Indium recovery by zinc cementation: Indium recovery was performed via a cementation process carried out for 1 h, obtained by a zinc powder addition.

Crushing process is carried out in order to obtain dimensions of about 10 mm.

The flow chart of the process is shown in **Figure 4.22.** A pH adjustment at a value between 2 and 3 is obtained by sodium hydroxide addition. Liquid samples were collected at the end of each leaching step, after sodium hydroxide addition and every 10 minutes during the cementation reaction.

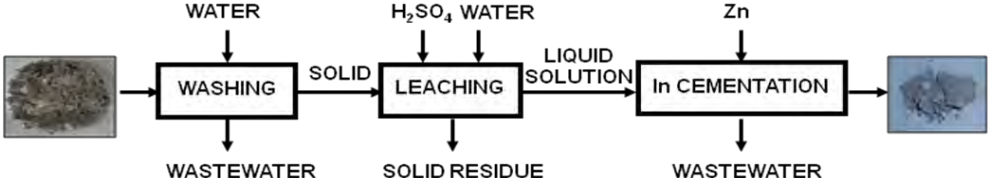

Figure 4.22: Flow chart of the process for indium recovery

Source: Rocchetti Laura, Amato Alessia, Fonti Viviana, Ubaldini Stefano, Michelis Ida De, Kopacek Bernd, Vegliò Francesco, Beolchini Francesca (2013). *Paper on Hydrometallurgical Processes for the Recovery of Precious and Critical Metals from Liquid Crystal Displays* ,Going Green - Care Innovation. 17-20 November 2013, Vienna, Austria

The main conclusions emerging from the experimental data reported in this work are:

- The composition of LCD fragments can be variable, indium concentration is comparable to that in the minerals and therefore indium extraction from LCDs is worthwhile.
- Leaching results showed an indium extraction efficiency in a range of about 90-100%. In addition the cross current design with a multiple steps configuration, is allowed to reduce sulfuric acid consumption without affecting the effectiveness of the process.
- Indium recovery in the solid phase has an efficiency greater than 90%, with a cementation with Zn of 10 min.

A summary of all the technologies and their social, environmental and economic attributes are given in **Table 4.9**.

Table 4.9: Technologies and their Social, Environmental and Economic Attributes

Sr. No.	Technology	Waste streams	Economic attributes	Environmental attributes	Social attributes	Technology Status
1.	**Manual dismantling/sorting of fractions**	All types of e-waste ICT/Consumer Durable	Low capital cost, sorting of valuable fractions/ components	Efficient sorting of fractions	Labour intensive, Job creation	Commercially Available
2.	**De-gassing CFC, HCFC**	Cooling and Freezing (e.g. Air conditioners, Refrigerators)	Mandatory requirement having low cost	Fundamental step to ensure control over hazardous substances that have huge Global warming potential		Commercially Available

[17] *Rocchetti Laura, Amato Alessia, Fonti Viviana, Ubaldini Stefano, Michelis Ida De, Kopacek Bernd, Vegliò Francesco, Beolchini Francesca (2013). Paper on Hydrometallurgical Processes for the Recovery of Precious and Critical Metals from Liquid Crystal Displays , Going Green - Care Innovation. 17-20 November 2013, Vienna, Austria*

Sr. No.	Technology	Waste streams	Economic attributes	Environmental attributes	Social attributes	Technology Status
3.	**Semi-automatic CRT cut and cleaning**	CRT	Low capital and net cost	Low energy consumption	Labour intensive	Commercially Available
4.	**Automatic shredding**	CRT	High capital cost	Higher energy consumption	Low job creation	Commercially Available
5.	**Automatic Shredding and separation**	All (e.g. PCB/Plastic etc.)	High capital costs	Higher energy consumption	Low job creation	Commercially Available
6.	**Degassing, Crushing and Sieving**	Bulbs, tubes, CFL/FL/TFL	Low capital cost	Medium energy consumption	Job creation 'Yes' mix of low to medium skilled jobs	Commercially Available
7.	**Automatic shredding and recovery CFC foam**	Cooling and freezing (e.g. Air conditions, refrigerators)	High capital costs	Higher energy consumption, Sealed container for titration	Low job creation	Commercially Available
8.	**Integrated smelter for non- ferrous (pyrometallurgic al methods)**	Non-ferrous (including printed circuit boards) like Cu, Pb, Zn, Sn or mix	Capital cost high Low net (unit) costs due to economies of scale Local growth potential high	No toxic emissions Low water use Transport: internationally Little waste products Recovery rates >> 90%	Automated process control so less jobs created Highly skilled workforce EHS*	Commercially Available
9.	**Hydro-metallurgical processing**	For simple metallic fractions; dissolving of precious metal coatings from metallic surfaces	Capital cost medium-high	Possibly high water use Management/treatment/disposal of waste fractions and reagents is crucial	EHS: crucial Skilled workforce needed	Commercially Available
10.	**Aluminium remelter/refiner**	Aluminium	Capital cost medium –high Net cost low Economies of scale	No toxic emissions Salt slag has to be treated or disposed Env. sound Transport within region or country Water use: low - medium	Job creation: yes Mix of low skilled and high skilled jobs EHS low risks	Commercially Available
11.	**Mercury Distillation**	CFL/TFL/FL	Capital cost medium	Sealed container for mercury distillation	Job creation 'Yes' Mix of medium skilled jobs	Commercially Available
12.	**Recovery of Rare Earth Elements**	Phosphor Powder/LCD	Capital cost medium	No toxic emission; low water use	Job creation 'Yes' mix of medium to high skilled jobs	Futuristic

Source: Schluep Mathias, Hagelueken Christian, Ruediger Kuehr, Magalini Federico, Maurer Claudia, Meskers Christina, Mueller Esther, Wang Feng (2009). *UNEP / STEP Solving the E-waste Problem. Sustainable Innovation and Technology Transfer Industrial Sector Studies; Recycling – From E-Waste To Resource.*

In Asia, developing countries like Malaysia, Indonesia, India, China, Vietnam and Thailand have technologies identified in serial number 1, 2 and 3 of Table 4.4. Copper smelting (non-ferrous) also exists in India. Aluminum remelting/refining technology also exists in India, China, Malaysia and Indonesia. Hydrometallurgical technology is available in China, India, Indonesia and Malaysia.

4.5 Technologies for Treatment and Disposal

Incineration and secured landfill mechanism is used for final treatment and disposal of WEEE/e-waste fractions which cannot be recycled. A comparison of impacts of WEEE/e-waste treatment and disposal options is described in **Table 4.10**.

Table 4.10: Comparison of impacts of treatment options

Treatment Option	Recycling	Incineration	Landfilling
Possibility to recover valuable materials	✓ Optimal	× Almost nonexistent, except for some metals	× Non-existent, except in the case of an open-air dumpsite with informal waste pickers, which poses health problems.
Contribution to climate change (emissions of GHG)	✓ The GHG impact of recycling is minor compared to the GHG emissions avoided from recovering secondary materials to offset extraction of virgin materials. ✓ Manual dismantling of WEEE/e-waste is ideal.	× Burning WEEE/e-waste, notably the plastic parts that are derived from petroleum, emits GHG emissions.	× In the case of WEEE/e-waste, landfilling has no impact in terms of GHG emissions.
Other environmental impacts	By avoiding the extraction of virgin materials, WEEE/e-waste recycling avoids many forms of contamination due to the extractive industry (e.g., use of acids in mining).	× Not all waste disappears by burning; the ashes that remain after burning generally represents from one third to one-fourth of the initial volume and quantity which then need to be disposed of.	× Almost all landfills leak. The liquid coming out of the wastes, called "leachate", may contain heavy metals and other toxic substances. × Uncontrolled fires often occur in landfills, which can release toxic fumes.
Cost	✓ Can be low in the case of manual dismantling by informal workers. × Quite high when dismantling and pre-processing are done in properly-equipped plants with decent working conditions, and when recycling occurs in specialized plants. But, the net cost depends on the WEEE/e-waste type and value recovery potential.	× Quite high in the case of incineration plants equipped with filters and gas/ashes treatment systems.	× Quite low in appearance as the operation costs of a landfill are not very complicated, but the decontamination of the environment in case of leakages can be very costly in the long run.
Income Generation	✓ Possible, through the selling of recovered materials, in particular metals and precious metals.	✓ Possible, through the selling of energy produced if the incineration plant is equipped with heat recuperation devices.	× No income can be generated from disposing of WEEE in landfill.

Source: McCann Duncan (2015). Solving the E-Waste Problem (Step) Green Paper; E-waste Prevention, Take-back System Design and Policy Approaches (13 February, 2015).

4.6 Guidance Notes

Objective: The major objective of guidance notes is to assist technical personnel/WEEE/e-waste implementation agencies/other stakeholders to identify technology options for WEEE/e-waste treatment. Furthermore, the assessment of technology options will lead to the design and development of technical specifications for WEEE/e-waste management system. The guiding principles for the guidance procedure are given below.

- Initial considerations: investigate the supply of WEEE/e-waste in your area. Are there enough WEEE/e-waste to ensure supply and to offset investment costs?
- Market analysis: What products can be produced from collected WEEE/e-waste and what prices can you achieve?
- Transport: Do you have access to suitable, cost effective transport to get WEEE/e-waste to the processing plant and to deliver your product?
- Land Use planning: Do you have a site suitable for establishing WEEE/e-waste plant?

- Capital investment and ongoing costs: Calculate purchase prices of processing equipment, plus ongoing maintenance costs.

Guidance Procedure: Guidance procedure includes completion of following steps as given below

Step 1: Fix the target of the WEEE/e-waste inventory to be collected and transported within each geographic area.

Step 2: Assess the WEEE/e-waste collection and transport infrastructure required to meet the target to be achieved. Determine the area of collection point/storage facility considering tentative location of the facility. The area of collection point/storage facility is fixed as per the following guiding steps:

1. Calculate the WEEE/e-waste capture rate for the geographical area served in a given time frame (week/month/year).
2. Calculate volume of each of the WEEE/e-waste item based on tonnage captured in a given time frame.
3. Determine the number of collection points/storage facilities and their locations. These are fixed as per the following guiding steps.

    a. Calculate the number of collection/storage points required to achieve the target rate
    b. Calculate the WEEE/e-waste haulage capacity
    c. Calculate the number of trucks/trailers of different capacities required to transport the WEEE/e-waste.
    d. Optimize the route and frequency of collection based on accessibility of the collection site.

Step 3: Assess the price sensitivity of procuring and collecting WEEE/e-waste with respect to the distance to the collection centre and the quantity to be collected under a "business as usual" scenario. This can also be correlated to the capacity of the recycling facility in terms of the numbers of trucks required per day from the catchment area to feed the recycling facility.

Step 4: Design a pilot level WEEE/e-waste collection and transportation system to demonstrate the viability of WEEE/e-waste collection and transportation system.

Step 5: Carry out technology option analysis based on first, second and third level technology options.

Step 6: Determine layout and equipment specifications for Tire Waste treatment facility.
Different guiding steps to fix up layout and specifications for machinery/equipment for second level tyre waste treatment facility are given below:

1. Determine stages of treatment.
2. Determine process based on Waste treatment capacity per day and level of size reduction and other specifications. This will help to fix up the size shredder/other size reduction machines.
3. The output of shredder/other size reduction machines will assist to fix up the magnetic separation machines/equipment.
4. The output from all the equipment will help to assist in defining specifications of conveying system eg. Speed of conveying system (feed rate as per required capacity of equipment).
5. After defining process elements, invite technical quotations from equipment suppliers and identify the area required to establish the process.
6. Determine area for storing waste inventory.
7. Determine storage area for finished products (if applicable).

8. Determine total area of waste treatment facility by adding all the three areas mentioned in items 5,6,7.
9. The facility should have balance, weatherproof covering, impermeable surface, spillage collection facility and equipment for treatment of water (if required).
10. Follow the building laws and environmental laws in fixing up the area of the facility.

Step 8: Identify and determine disposal options. Different guiding steps for this purpose are given below.

1. Identify the hazardous waste landfill sites closest to the Waste treatment facility.
2. Identify the hazardous waste incineration facility closest to Waste treatment facility.
3. Check whether the identified facilities have capacities for disposal of Waste fractions or need up-gradation.

Step 9: General guidelines for WEEE/e-waste treatment facilities.

1. Prepare Environmental Impact Assessment report along with detailed project report of the Waste treatment facility.
2. Regular re-evaluation of environment, health and safety (EHandS) objectives and monitoring of progress toward achievement of these objectives is conducted and documented at all facilities.
3. Facilities take sufficient measures to safeguard occupational and environmental health and safety. Such measures may be indicated by local, state, national and international regulations, agreements, principles and standards, as well as by industry standards and guidelines. Such measures for all facilities include:

    - EHandS training of personnel.
    - An up-to-date, written hazardous materials identification and management plan.
    - Where materials are shredded or heated, appropriate measures to protect workers, the general public and the environment from hazardous dusts and emissions. Such measures include adaptations in equipment design or operational practices, air flow controls, personal protective devices for workers, pollution control equipment or a combination of these measures.
    - An up-to-date, written plan for reporting and responding to exceptional pollutant releases, including emergencies such as accidents, spills, fires, and explosions.
    - Completion of an EHandS audit, preferably by a recognized independent auditor, on an annual basis. However, for small businesses, greater flexibility may be needed, and an audit every three years may be appropriate.

4. Facilities have a regularly-implemented and documented monitoring and recordkeeping programme that tracks key process parameters, compliance with relevant safety procedures, effluents and emissions, and incoming, stored and outgoing materials and wastes.

CHAPTER 5: WEEE/E-WASTE TECHNOLOGY SELECTION

5.0 Introduction

Selection of technology in a country's context is to achieve environmentally sound management of hazardous/toxic substances in WEEE/e-waste, recovery of valuable materials, creation of economically viable and environmentally sustainable businesses inclusive of social considerations under local operations. The following sections provide a perspective of evaluation of pre processing technologies (first and second level) and end level technologies (third level) in terms of "Economic attributes, Environmental attributes, Social attributes and Level of Innovation".

5.1 Economic, Technical, Environmental and Social Implications of Technologies

Literature[12] cites that WEEE/e-waste management, consisting of collection and treatment in a country's context is a complex system, which can be divided into two sub systems: (1) the technical system, which applies treatment technologies and innovations; and (2) the societal system, which adopts and manages the technical system under treatment standards and legal requirements applicable in the country. The performance of the technical system depends on the available technologies, processing equipment and facilities. The societal system provides a conditional framework, which influences performance of technical systems. The major constituents of this system framework include domestic take-back policies/regulations, economic rules, market dynamics and environmental standards. Research into the subject further recommends that selection of technology and development of WEEE/e-waste treatment systems should be combined systematically with the socio-economic context. Therefore, there is a need for identifying systematic treatment solutions with an optimal balance with environmental, economic and social performance. In this context, Chapter 2 and Chapter 3 of this compendium address societal system while Chapter 4 addresses the technical system.

Pilot studies carried out using material flow analysis using mass balance and life cycle analysis as described in chapter 2 and chapter 3 for WEEE/e-waste and impacts assessment, indicate that separation efficiency can improve as a function of dismantling depth and can be higher than mechanical methods. Furthermore, in order to achieve the highest recycling rate of precious metals, the best scenario is to combine full manual dismantling with state-of-the art refining. This approach is costly in industrialized countries because of high labor costs in dismantling, while it may not be feasible in developing countries due to limited access to capital intensive technologies. Complete dismantling generates the highest profit until the labor costs reach a certain threshold in a developing country's context. As labor costs continue to grow, partial dismantling of higher value components becomes more profitable and mechanization is introduced to selectively replace manual work for complex components. After a certain time period, full mechanical separation becomes the most profitable pre-processing method by replacing all manual work. It is expected that based on the strong economic growth and intense industrialization, developing countries will transform labor-intensive work into more mechanized and automated processes (Wang, 2008)[18].

Figure 5.1 and **Figure 5.2** indicate economic and environmental gain for diverse pre-processing and end processing technologies for computers.

[18] *Feng Wang, Jaco Huisman, Christina E.M. Meskers, Mathias Schluep, Ab Stevels and Christian Hageluken; Waste Management Journal 32 (2012) 2134 – 2146; The Best of 2 Wrolds philosophy: Developing local dismantling and global infrastructure network for sustainable e-waste treatment in emerging economies by*

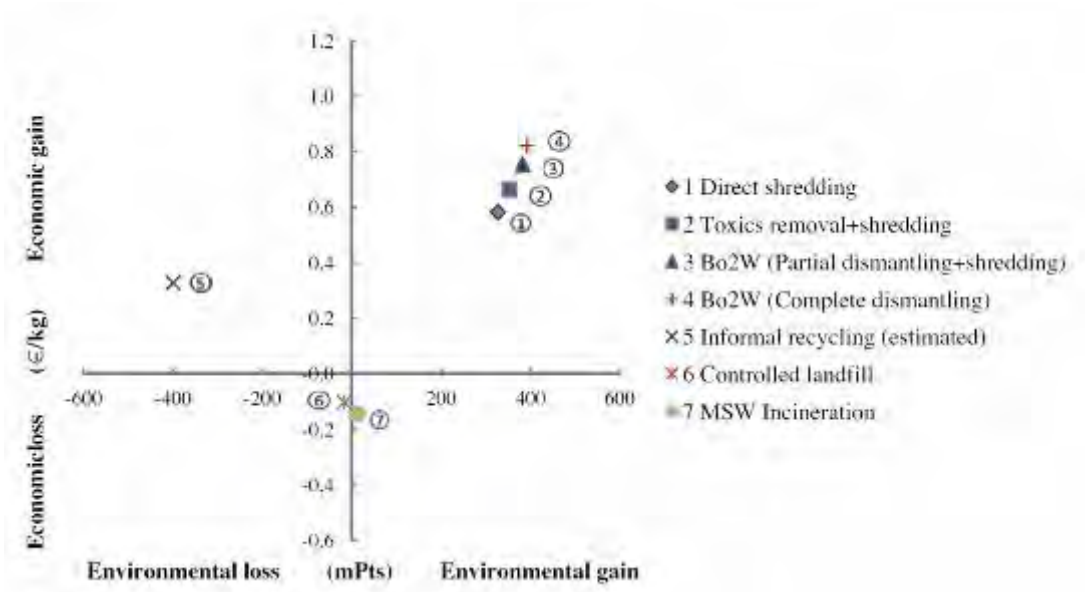

Figure 5.1: Eco-efficiency Scores of Seven Recycling Scenarios for Desktop Computers (based on 2010 price level)

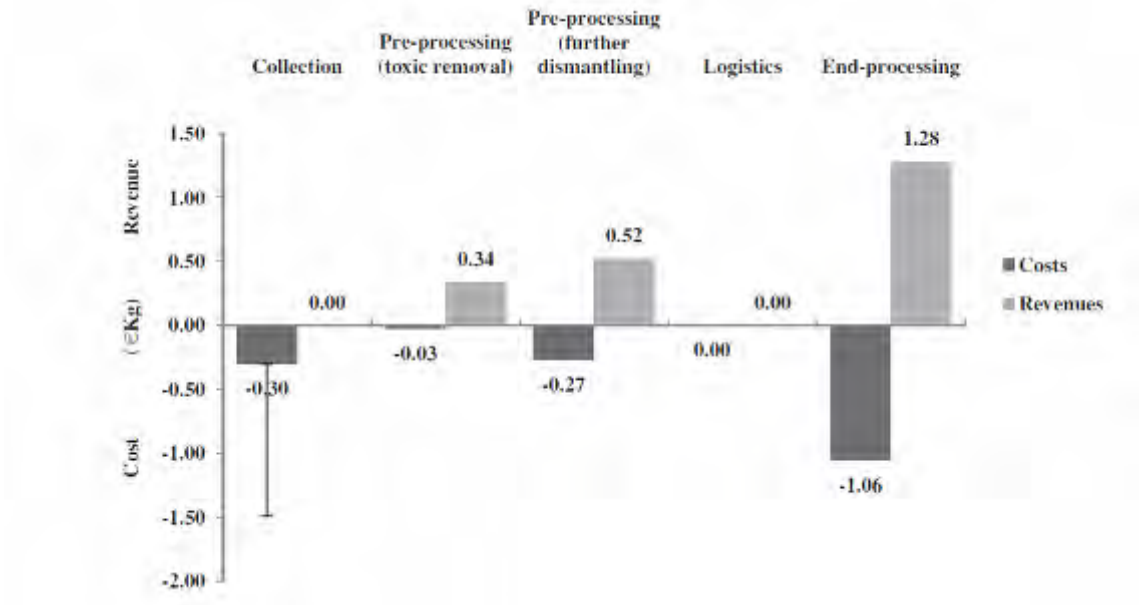

Figure 5.2: Revenues and Costs for Different Treatment Stages of Desktop Computer Applying the Bo2W Philosophy (complete dismantling) [12]

Note[19]: $$\eta(e) = \frac{Environmental\ benefits\ through\ EoL\ operations}{Economic\ benefit\ from\ EoL\ Operations - Cost\ of\ EoL\ operations}$$

Results of eco-efficiency analysis applied as a quantitative tool to measure the balance between economy and ecology of the specific scenarios for different WEEE/e-waste items is shown in **Figure 5.3**. Literature cites that the material composition of products has direct influence on its profitability and environmental impact occurred during the same treatment processes. Products containing substantial amounts of metals (especially precious metals) have higher eco-efficiency scores than products dominant in plastics or other low value materials. It has been reported that complete dismantling of microwave oven, vacuum cleaner and washing machine is more eco-efficient than the combination of partial dismantling and shredding of complex components (such as

[19] *Otmar Deubzer; Step 22 June 2012; Solving the e-waste Problem Green Paper; Recommendations on Standards for Collection, Storage, Transport and Treatment of e-waste*

transformers, motors etc.) under the Chinese setting. Therefore, economic and environmental performance are determined by products' intrinsic characteristics (e.g. type, material composition, way of joints etc.), and optimum recycling configurations shall be adapted to different treatment categories to achieve the best outcome.

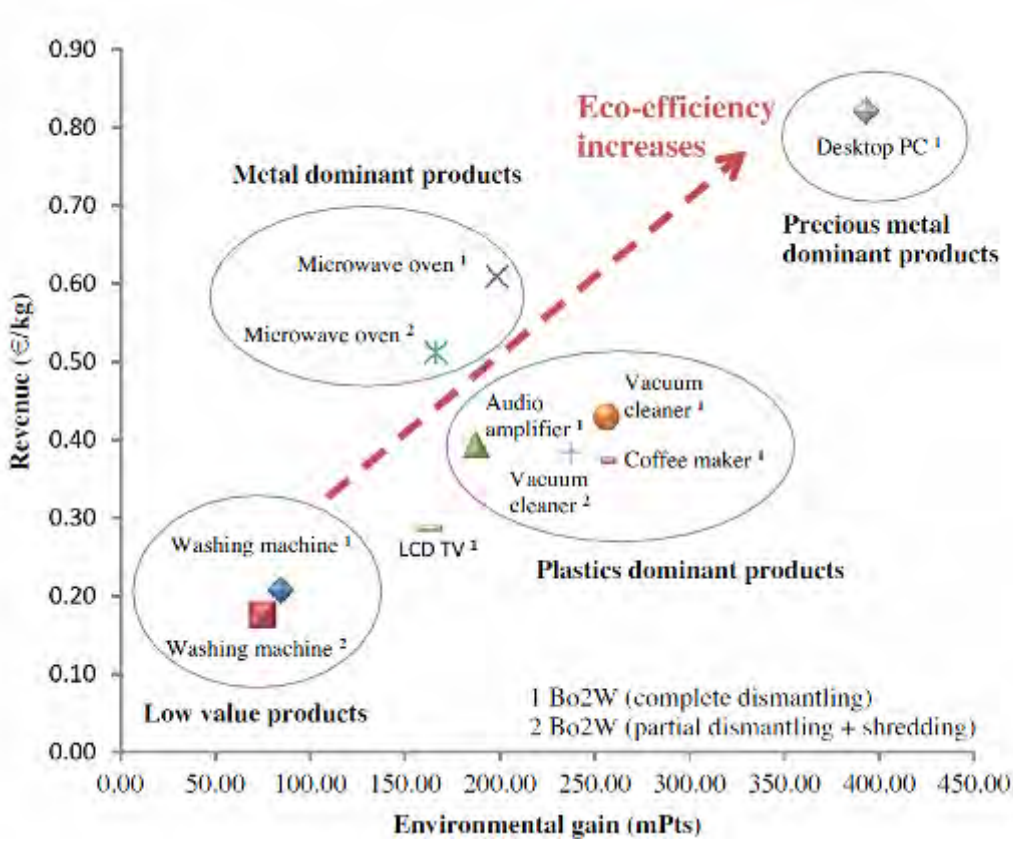

Figure 5.3: Eco-efficiency Scores of Seven Electrical and Electronic Products under the Bo2W Recycling Approach

Source: European Commission DG Environment, Bio Intelligence Service (2004). *Synthesis report [ENV.G.1/FRA/ 2004/0081, Study No.16], Gather, process, and summarise information for the review of the waste electric and electronic equipment directive (2002/96/EC).*

The contextual background, given above, gives ample guidance for selection of e-waste treatment technologies as given below.

Evaluation of First and Second Level WEEE/e-waste Treatment Technologies

Table 5.1 gives a summary of the analysis of the first and second level WEEE/e-waste treatment technologies. Salient features of this analysis in a developing country context are given below.

- Positive benefits exist in manual disassembly and sorting, as well as for the semi-automatic technologies, which aim to fulfill specific and environmentally relevant activities (Decontamination like De-gassing of CFC, HCFC; CRT cut and cleaning).

- Social attributes (e.g. job creations, labor intensity), or economic ones (e.g. like capital intensiveness) play the most crucial role and could hamper the effectiveness of any technology or approach.

- Fully automated technologies are less innovative as well as less suitable for developing countries for pre-processing activities, especially when considering the inter-linkages with end-processing technologies as well as the global recycling chain and material flows.

Table 5.1: Identification of pre-processing technologies for developing countries in the WEEE/e-waste recycling chain

	Waste streams	Economic attributes	Environmental Attributes	Social attributes	Innovative technology
Manual dismantling/sorting of fractions	All	Low capital cost, sorting of valuable fractions/ components	Efficient sorting of fractions	Labour intensive, Job creation	Yes
De-gassing CFC, HCFC	Cooling and freezing	Mandatory requirement having low cost	Fundamental step to ensure control over hazardous substances having huge GWP potential	Job creation	Yes
Semi- automatic CRT cut and cleaning	CRT	Low capital and net cost	Low energy consumption	Labour intensive	Yes
Automatic shredding CRT	CRT	High capital cost	Higher energy consumption	Low job creation	No
Automatic Shredding and separation	All	High capital costs	Higher energy consumption	Low job creation	No, Feasible for specific activities
Automatic shredding and recovery CFC foam	Cooling and freezing	High capital costs	Higher energy consumption, Sealed container for titration	Low job creation	No

Source: Sustainable Innovation And Technology Transfer Industrial Sector Studies; Recycling – From E-Waste To Resources; Solving The E-Waste Problem (Step)

Evaluation of Third Level WEEE/e-waste Treatment Technologies

Table 5.2 and Table 5.3 give a summary of the analysis of the Third Level WEEE/e-waste treatment technologies. Salient features of this analysis in a developing country context are given below.

- Environmentally sound third level WEEE/e-waste treatment technologies require high investment cost compared to first and second level technologies
- Third level WEEE/e-waste treatment technologies require a very high tonnage to operate such processes economically
- Third level WEEE/e-waste treatment technologies require medium to high level of education of the workers.
- It may be most viable to use existing facilities where possible. Locally or regionally available facilities can be used in the case of steel, aluminum and other non-ferrous materials, or globally available facilities when considering treatment of printed circuit boards.
- The division of labor and linking the local recycling chain into an international recycling chain uses the strengths available in each location to create and support environmentally and economical sustainable businesses and recycling chains as well as provides an opportunity for harmonization of regulations and standards.

Table 5.2: Detailed qualitative sustainability analysis for state-of-the-art integrated smelters for printed circuit boards and aluminum smelters

	Integrated smelter for PWBs	Aluminum smelter
Emission to air, soil, Land	Very low	Very low

	Integrated smelter for PWBs	Aluminum smelter
Energy efficiency	High	High
Use of water and land`	Low land use per kg metal produced Low water use because of Reuse	Low land and water use per kg Al Low water use during salt slag recycle because of reuse
Use of additional raw Material	Low, only some reagents	Low, mainly salt flux
Process security	High level of automation	High level of automation
Workers protection	Clothing and off-gas/vent	Clothing and off-gas/vent
Waste amounts	Little	Little
Final fate waste Products	Slag to building industry Hazardous materials to controlled deposit	Salt slag converted to metal, flux and oxides, which go to building industry
Substances recovered	Ag, Au, Pd, Cu, Pb, Sn, Bi, Sb, et al.	Aluminium alloys
Technology used	Combination of pyro- and hydro-metallurgy	Remelter: pyrometallurgy Slag recycler: hydrometallurgy
Feed	Printed Circuit Boards mixed with e-scrap, industrial by-products, other recyclables, manufacturing scrap	Aluminium scrap from WEEE/e-waste, end-of-life vehicles, buildings, beverage cans and manufacturing industry
Feed requirements	Unshredded Printed Circuit Boards, with main Al and Fe parts removed	Aluminium alloys, with low iron Content
Feed availability	Globally sourced from preprocessing	Regionally sourced from preprocessing
Process stability/feed Flexibility	Stability high/flexibility medium-high	Stable/flexibility determined by number and types of furnaces
Product quality and Value	High, meets metal standards	High, meets alloy standards
Impact on recycling Chain	Crucial: final material and value recovery	Crucial: final metal and value Recovery
Metal recovery or Yield	High	High
Skilled labour	High and medium skilled	High and medium skilled
Investment security	Uncertain	At least 5 – 10 years
Critical size	100 000 t/y	Remelter: 50 000 t/y Slag recycle: 60 000 t/y
Greenfield investment cost (in Europe)	>EUR 1 billion for 350 000 t/y mixed smelter feed	Remelter: EUR 25 million for 50 000 t/y Slag recycle: EUR 35 million for 100 000 t/y

Source: Sustainable Innovation And Technology Transfer Industrial Sector Studies; Recycling – From E-Waste To Resources; Solving The E-Waste Problem (Step)

Table 5.3: Identification of innovative third level WEEE/e-waste treatment technologies

	Waste streams	Economic attributes	Environmental attributes	Social attributes	Innovative technology
Integrated smelter for non-ferrous (pyro-metallurgical methods) (details in chapter 3.1.2)	Non-ferrous (including printed circuit boards) like Cu, Pb, Zn, Sn or mix	Capital cost high Low net (unit) costs due to economies of scale Local growth potential high	No toxic emissions, presence of good off-gas treatment is crucial Low water use Transport: internationally Little waste products Recovery rates >> 90%	Automated process control so less jobs created Highly skilled workforce EHS*	Yes
Hydro-metallurgical processing	For simple metallic fractions; dissolving of precious metal coatings from	Capital cost medium-high	Possibly high water use Management/treatment/disposal of waste fractions and reagents is crucial	EHS: crucial Skilled workforce needed	Yes, but not an option at the moment for PWBs, mobile phones or other complex

	Waste streams	Economic attributes	Environmental attributes	Social attributes	Innovative technology
	metallic surfaces				materials as no information in the public domain available for evaluation of the technology
Aluminium remelter/refiner	Aluminium	Capital cost medium – high Net cost low Economies of scale	No toxic emissions Salt slag has to be treated or disposed Env.sound Transport within region or country Water use: low – medium	Job creation: yes Mix of low skilled and high skilled jobs EHS low risks	Yes

Source: Sustainable Innovation And Technology Transfer Industrial Sector Studies; Recycling – From E-Waste To Resources; Solving The E-Waste Problem (Step)

5.2 Development of Criteria for Selection of Technology

Analysis of Table 5.1, Table 5.2 and Table 5.3 as well as examples in a country's context indicates that economic, environmental and social attributes form the basis of the selection of technology. This criterion in terms of "attributes" and "indicators" with respect to each technology is given below in **Table 5.4**.

Table 5.4: Criteria for selection of technology

Attributes	Indicators involved
Economic attributes	
Low net costs	Costs for transport, processing and labour vs. revenues
Low capital costs	Investment costs for additional plants and technologies used in a scenario
Increased potential for local economic growth	Additional industries and services involved by implementing a scenario
Environmental attributes	
Low use of electricity	Savings of electricity but also energy in general by implementing a scenario
Low fuel use for transport	Fuel used by shipping and road transport
Low use of freshwater	Freshwater consumption of a recycling scenario
Little (toxic) emissions	Caused vs. prevented emissions according to the savings of raw materials calculated with eco-indicator '99 (or other appropriate tools)
High metal recovery rates	Range and yields of metals contained in the waste, which can be recovered and used as secondary raw material. In case of technical conflicts prioritization by economic and environmental value ("footprint") of the recovered substances.
Social attributes	
Creation of jobs for the previously unemployed	Working hours for low-skilled and semi-skilled workers generated
Creation of highly skilled jobs	Working hours for highly skilled workers generated
Creation of jobs outside the target country	Working hours generated outside the target country
Low health and safety impacts	Impacts of a scenario on health and safety of the employees engaged in a scenario

Source: Sustainable Innovation And Technology Transfer Industrial Sector Studies; Recycling – From E-Waste To Resources; Solving The E-Waste Problem (Step)

Table 5.5 provides some insights related to selection of technologies in a developing country's context.

Table 5.5: Selection of recycling technologies in a developing country's context

	Waste streams	Economic attributes	Environmental attributes	Social attributes
Manual dismantling/ sorting of fractions	All	Low capital cost, sorting of valuable fractions/ components	Efficient sorting of fractions	Labour intensive, Job creation
De-gassing CFC, HCFC	CandF	Mandatory requirement having low cost	Fundamental step to ensure control over hazardous substances having huge GWP potential	
Semi-automatic CRT cut and cleaning	CRT	Low capital and net cost	Low energy consumption	Labour intensive
Integrated smelter for non- ferrous (pyrometallurgic al methods)	Non-ferrous (including printed circuit boards) like Cu, Pb, Zn, Sn or mix	Capital cost high Low net (unit) costs due to economies of scale Local growth potential high	No toxic emissions Low water use Transport: internationally Little waste products Recovery rates >> 90%	Automated process control so less jobs created Highly skilled workforce EHS*
Aluminium remelter/refiner	Aluminium	Capital cost medium –high Net cost low Economies of scale	No toxic emissions Salt slag has to be treated or disposed Env. sound Transport within region or country Water use: low - medium	Job creation: yes Mix of low skilled and high skilled jobs EHS low risks

Source: Sustainable Innovation And Technology Transfer Industrial Sector Studies; Recycling – From E-Waste To Resources; Solving The E-Waste Problem (Step)

Case study six in Chapter 6 provides a useful example to support the decision making criteria mentioned in Table 5.5.

5.3 Guidance Notes

Objective: The major objective of these guidance notes is to assist the decision maker to make an assessment for the selection of technology in their country's context.

Guidance procedure: The guidance procedure includes completing the following steps:

Step 1: Compile and assess the outputs of the report achieved from guidance notes given in Chapter 2.
Step 2: Compile and assess the outputs of the report achieved from guidance notes given in Chapter 3.

Step 3: Compile and assess the outputs of the report achieved from guidance notes given in Chapter 4.

Step 4: Use template of Table 5.4 by using outputs of Steps 1, 2 and 3 to assess the meeting of requirements in a given country's context.

Step 5: Carry out SWOT analysis with respect to outputs achieved in Step 4 so that "Trade Off's" can be made if required.

Step 6: Compare the results with the results of Table 5.5.

Step 7: Prepare Detailed Project Report giving the specifications and Bill of Quantities (BOQ).

CHAPTER 6: Case Studies

6.0 Introduction

In this section, some WEEE/e-waste case studies, describing management practices in different countries (developed and developing), have been discussed, which could serve as reference for countries planning to develop their own WEEE/e-waste management strategies. Furthermore, these case studies also show outputs expected from chapter 2 to chapter 6. The following case studies provide information on performance of extended producer responsibility (EPR) in developed countries, inventory assessment and selection of recycling technology in developing countries.

6.1 Case Study 1: Mitsubishi Recycling[20]

A case study of recycling carried out by M/s Mitsubishi Corporation has been described to assess the performance of EPR. The bar chart below shows the recycling volume of Mitsubishi's end-of-life electrical home appliances. In 2011, Mitsubishi processed and recycled products weighing around 85,000 tonnes and successfully recycled around 75,000 tonnes of products. Figure 6.1 indicates there was a slight increase in the volume recycled in 2012, as compared to 2010, while there was a significant decline in the amount of product processed and recycled in 2012 compared to 2011.

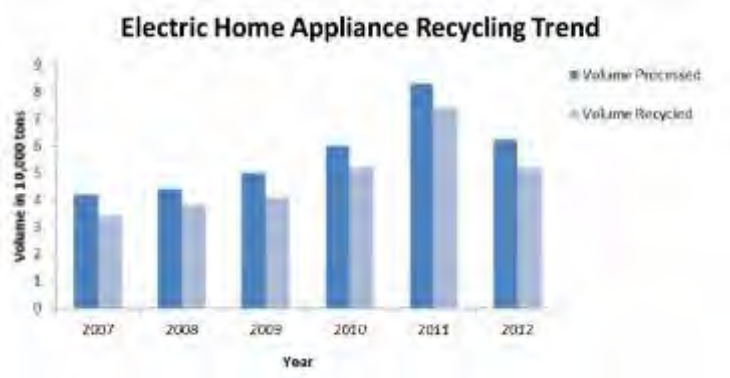

Figure 6.1: Mitsubishi's Electric Home Appliance Recycling trend

Source: http://www.mitsubishielectric.com/company/environment/report/products/recycle/index_print.html

In 2012, Mitsubishi collected a total of 4,891 household and industrial used computers that accounted for a recycling rate of 76%. Table 6.1 below, shows the different types of computers that were recycled by Mitsubishi Electric in 2012.

Table 6.1: Material Recycling from Used Computers (Household and Industrial use) in 2012

	Units	Desktop		Notebooks		CRT Displays		LCD		Total	
Collected Weight		14.8		2.9		11.5		10.4		39.6	
		Office	Home	Office	Home	Office	Home	Office	Home	Office	Home
		12.8	2	2.7	0.1	8.9	2.5	10.1	0.3	34.5	4.9
Collected Units		1579		1052		552		1708		4891	
		Office	Home	Office	Home	Office	Home	Office	Home	Office	Home
		1418	161	1003	49	424	128	1651	57	4496	395
Treated Weight	Tonnes	14.8		2.9		11.5		10.4		39.6	
Recycled Weight	Tonnes	12.1		2		7.8		8.2		30.1	

[20] *Patent Landscape Report on e-waste Recycling Technologies, 2013*

	Units	Desktop	Notebooks	CRT Displays	LCD	Total
Recycling Ratio	%	82	68.3	68.1	78.8	76

Source: http://www.mitsubishielectric.com/company/environment/report/products/recycle/index_print.html

6.2 Case Study 2: Panasonic Recycling[14]

Panasonic Corp., formerly known as Matsushita Electric Industrial Co., Ltd., is a Japanese multinational electronics corporation headquartered in Osaka, Japan[21]. In September 2007, Panasonic Corporation of North America, a subsidiary of Panasonic Corp., Sharp Electronics Corporation, operating as a subsidiary of Japan-based Sharp Corp., and Toshiba America Consumer Products, LLC, a subsidiary of Toshiba America, Inc., created Electronic Manufacturers Recycling Management Company, LLC, (also known as MRM) to foster the efficient management of recycling programs. MRM offers its service to all consumer electronics manufacturers and retailers, and already works with over 35 companies[22]. A list of companies that participate in MRM collection programs[23] are given below.

AOC	Hitachi America Ltd.	Oki Data	Sonitronix
ASUS	Imation Electronics	Orion	Starlogic
Audiovox	JVC America	Panasonic	Sylvania
Barnes and Noble	Kurio	Philips	Symphonic
Brother	Kyocera Mita	Pioneer	Synaps
Canon	Logitgech	PLR IP Holdings	Technics
Eastman Kodak	Magnavox	Quasar	Tachno Source USA
Emerson	Memorex	Radio Shack	Toshiba
Envision	Mitsubishi	Sansui	Touchmark
Four Star Group	MSI America	Sanyo	VIZIO
Funai Corporation	NEC	Sharp Electronics	Vuescape

Source: Patent Landscape Report on e-waste Recycling Technologies, 2013

In line with Japanese electronics recycling laws, MRM established a national recycling infrastructure in 2009. Initially, MRM Recycling network provided recycling opportunities at 280 locations with at least one recycling center located in each state, making it one of the most comprehensive national recycling networks. MRM planned to continue to expand its programme and expected to have established at least 800 drop-off locations by 2011[24]. Table 6.2 below, shows the recycling volume (per year in million lbs) of Panasonic from 1999 till 2011.

Table 6.2: Recycling Trend of Panasonic

	1999-2006	2007	2008	2009	2010	2011
National Programme	724,869	83,435	246,402	2,834,426	4,891,526	4,812,693
Mandated States	242,925	908,888	2,488,323	5,267,713	8,726,146	1,8597,603
Yearly	967,794	992,323	2,734,725	8,102,139	13,617,672	23,410,296
Cumulative	967,94	1,960,117	4,694,842	12,796,961	26,414,653	49,824,949

Source: Patent Landscape Report on e-waste Recycling Technologies, 2013

6.3 Case Study 3: Sony Recycling

Sony, a Japanese multinational conglomerate corporation headquartered in Tokyo, Japan, launched a GreenFill recycling service in 2009. The programme was an extension to their take back programme for the collection of unwanted potable electronics equipment[25]. Sony had also launched similar projects in Australia and Canada.

Sony Recycling Trend

[21] *www.bloomberg.com/quote/6752:JP (Accessed on 14 July, 2016)*
[22] *http://www.panasonic.com/environmental/recycling-electronic.asp (Accessed on 14 July, 2016)*
[23] *www.mrmrecycling.com/ / (Accessed on 14 July, 2016)*
[24] *http://www.mrmrecycling.com/news.htm (Accessed on 14 July, 2016)*
[25] *http://www.gizmag.com/sony-electronics-launches-retail-e-recycling-initiative/11552/ / (Accessed on 14 July, 2016)*

In Japan, Sony recycled approximately 1.412 million CRT televisions and 88,000 flat-screen televisions manufactured by Sony in Japan in 2011. Figure 6.2 below shows the CRT television recycling trend in Japan[26].

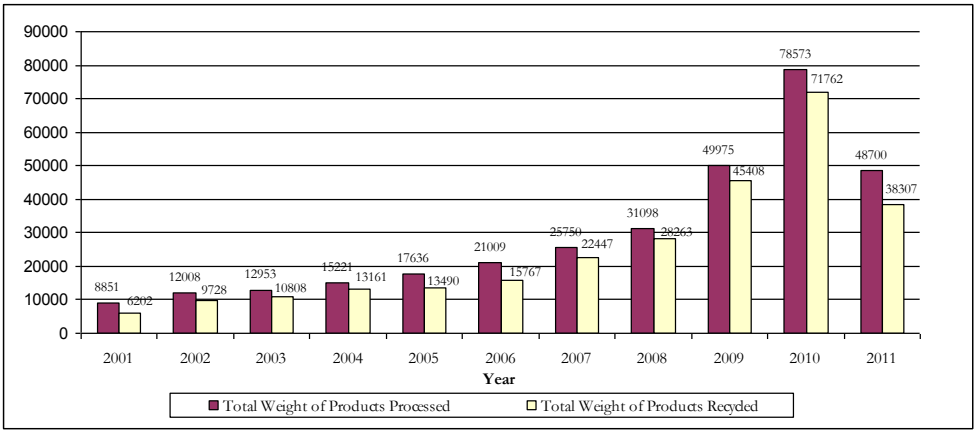

Figure 6.2: CRT Television Recycling Performance in Japan

Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/plastics/gcs/index. html* (Accessed on 14 July, 2016)

Figure 6.3 below, shows the recycling performance of Sony Corp in Japan for Plasma and LCD televisions from 2009-2011.

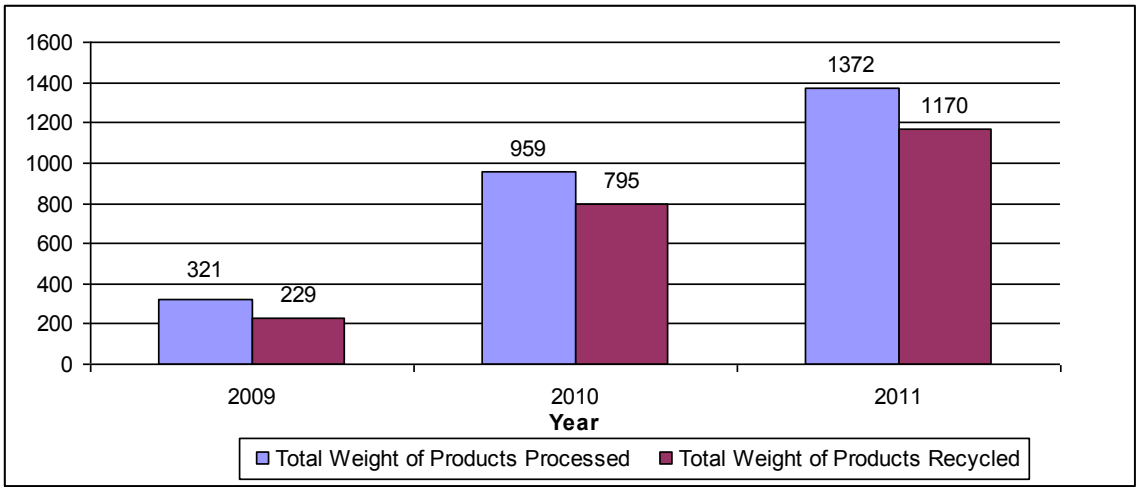

Figure 6.3: LCD and Plasma Television Recycling Performance

Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/plastics/gcs/index. html* (Accessed on 14 July, 2016)

Figure 6.4 below shows the distribution of the resources recycled by Sony Corp from the recycling of CRT Television sets in the year 2011. Around 50% of the total weight recycled was covered by CRT glass, followed by 31% of other valuable resources. 14% Iron and 5% copper were also recycled. About 0.18% percent of nonferrous and ferrous compounds were recycled and 0.03% of aluminum was recycled.

[26] *http://www.sony.net/SonyInfo/csr_report/environment/recycle/japan/index1.html (Accessed on 14 July 2016)*

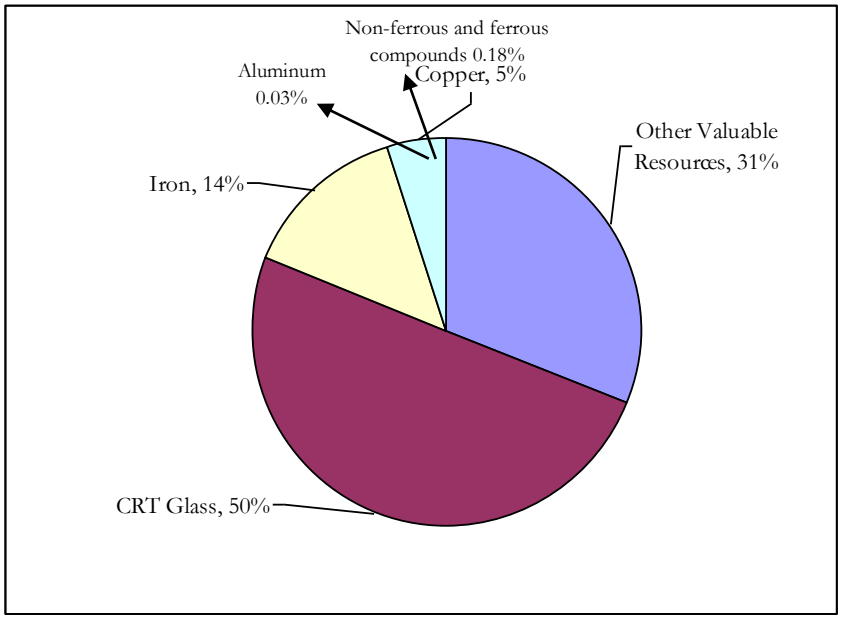

Figure 6.4: Resources Recycled from CRT Television in the year 2011

Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/plastics/gcs/index. html* (Accessed on 14 July, 2016)

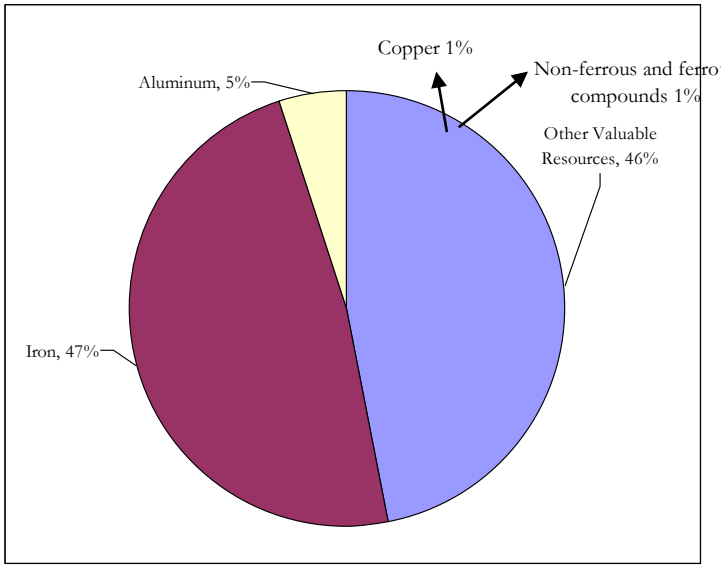

Figure 6.5: Resources Recycled from LCD/Plasma Television in the Year 2011

Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/plastics/gcs/index. html* (Accessed on 14 July, 2016)

Figure 6.5 shows distribution of the resources recycled from LCD/plasma televisions in the year 2011. In 2011, about 546 tonnes of iron was recycled accounting to 47% of the total material recycled. 1% of nonferrous and ferrous compounds and copper were recycled. 46% of mixed valuable materials were recycled and remaining 5% of Aluminum were recycled.

6.4 Case Study 4: Performance of EPR in Europe for WEEE/e-waste

A case study on the performance of EPR in terms of collection performance, recycling and re-use rate performance and normalized average fees paid by producers per piece of WEEE has been presented below in **Figure 6.6, Figure 6.7** and **Figure 6.8.**

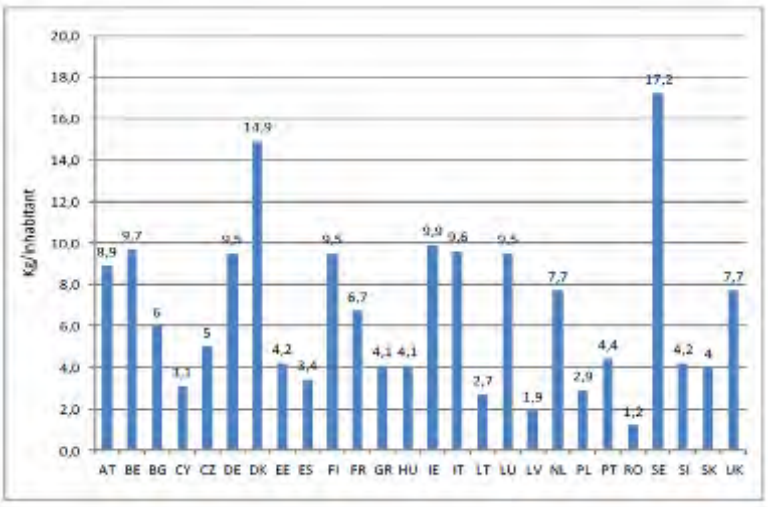

Figure 6.6: Collection Performance for WEEE EPR systems (Eurostat, 2010)
Source: Monier Véronique, Hestin Mathieu, Cavé Jérémie, Laureysens Ilse, Emma Watkins, Reisinger Hubert, Porsch Lucas (2014). European Commission – DG Environment. *Development of Guidance on Extended Producer Responsibility (EPR), Final Report.* (Accessed on 14 July, 2016)

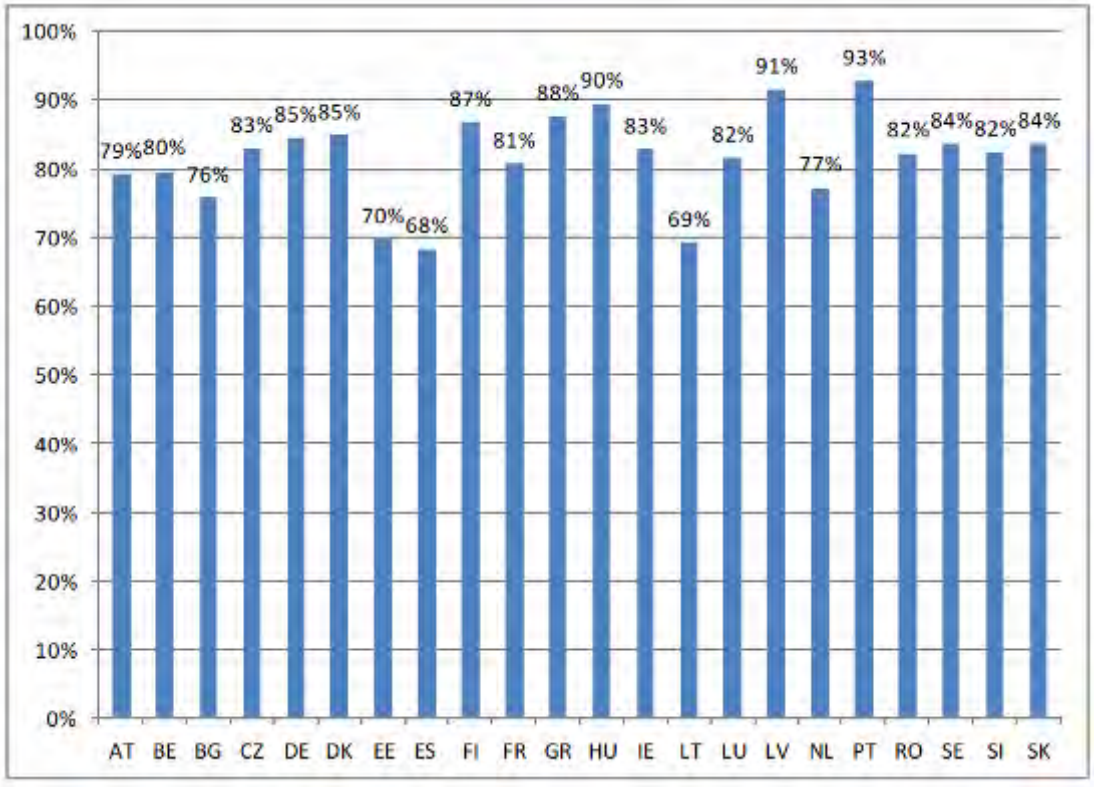

Figure 6.7: Recycling and Re-use Rate for WEEE EPR Systems (Eurostat, 2010)
Source: Monier Véronique, Hestin Mathieu, Cavé Jérémie, Laureysens Ilse, Emma Watkins, Reisinger Hubert, Porsch Lucas (2014). European Commission – DG Environment. *Development of Guidance on Extended Producer Responsibility (EPR), Final Report.* (Accessed on 14 July, 2016)

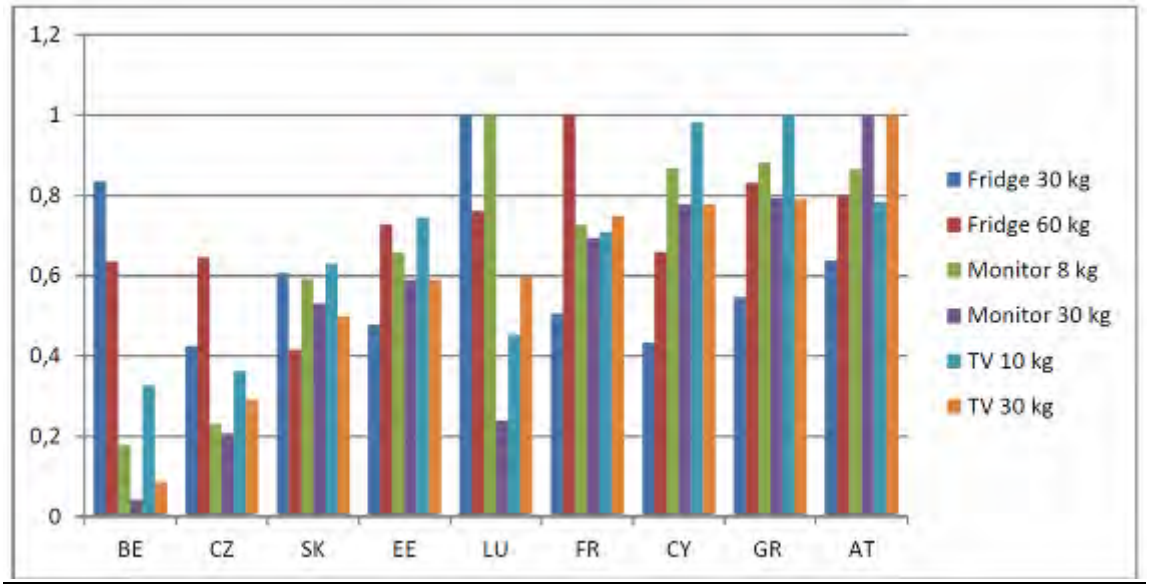

Figure 6.8: Normalised Average Fees Paid by Producers Per Piece of WEEE

Source: Monier Véronique, Hestin Mathieu, Cavé Jérémie, Laureysens Ilse, Emma Watkins, Reisinger Hubert, Porsch Lucas (2014). European Commission – DG Environment. *Development of Guidance on Extended Producer Responsibility (EPR), Final Report.* (Accessed on 14 July, 2016)

Overall EPR System Performance indicates that:

- Collection rates for WEEE/e-waste are extremely variable from one country to another. It ranges from 1.2 kg/capita in Romania to 17.2 kg/capita in Sweden. The collection rates do not reach more than 80%.
- The development of EPR has fostered the achievement of reasonably high recovery targets.
- Economic performance has been assessed based on fees for WEEE. It has been reported that tariffs are not set up in the same way in each country. For example, in France, fees for televisions are divided into eight sub-categories with prices ranging from 0.8 to 8.0 Euro/piece, whereas in Greece, producers pay a contribution of 254 Euro/tonne of televisions put on the market.

6.5 Case Study 5: WEEE/e-waste in China

This case study has been adopted from Example 3 of UNU-IAS WEEE/e-waste statistics guidelines on classification, reporting and indicators 2015, to demonstrate quantification of the WEEE/e-waste market in China for six products. Various steps to prepare it are given below.

Step 1: Figure 6.9 shows the sales data of six EEE products on the Chinese market from 1995 to 2011.

Step 2: Annual sales data were calculated from the total quantity of domestic manufacturing, added to the quantity of import, while subtracting the quantity of import and the quantity of export of specific type of product.

Step 3: The domestic manufacturing data were derived from the China National Statistic Yearbook 1996-2012.

Step 4: The international trade data were obtained from the UN COMTRADE database by tracking the corresponding Harmonized System Codes for international goods shipment. Additional data sources were also applied to validate the data.

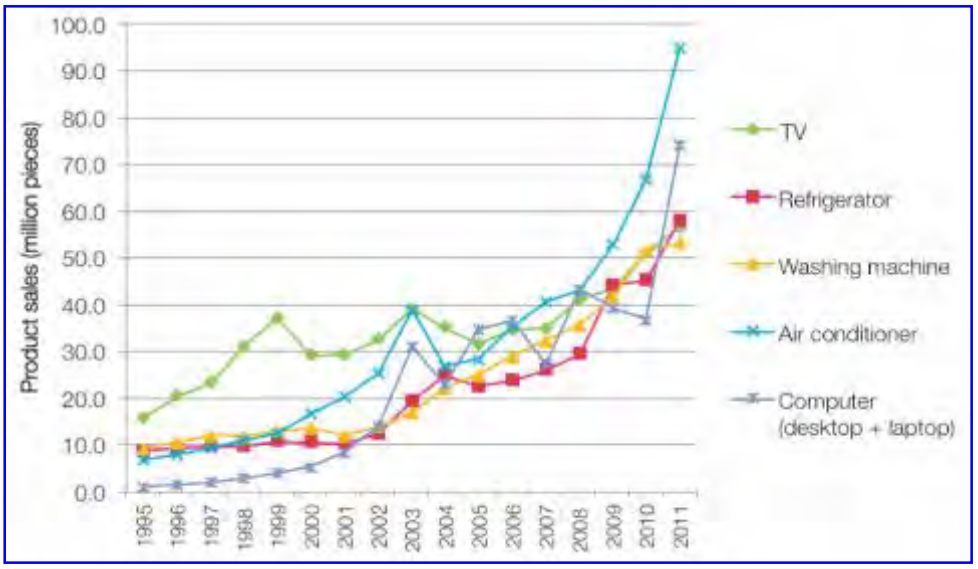

Figure 6.9: Sales of Major Electrical and Electronic Equipment in China (1995-2011)

Source: Balde C.P., Kuehr R., Blumenthal K., Fondeur Gill S., Kern M., Micheli P., E. Magpantay, Huisman J (2015). *E-waste statistics Guidelines on classification, reporting and indicators.*

Step 5: **Figure 6.10** presents the stock of the six types of EEE in Chinese households from 2006-2011. The data was calculated from the statistic survey to ascertain the amount of possessed equipment in both urban and rural Chinese households. These indicators could be proposed as household indicators to be collected through household surveys for other countries.

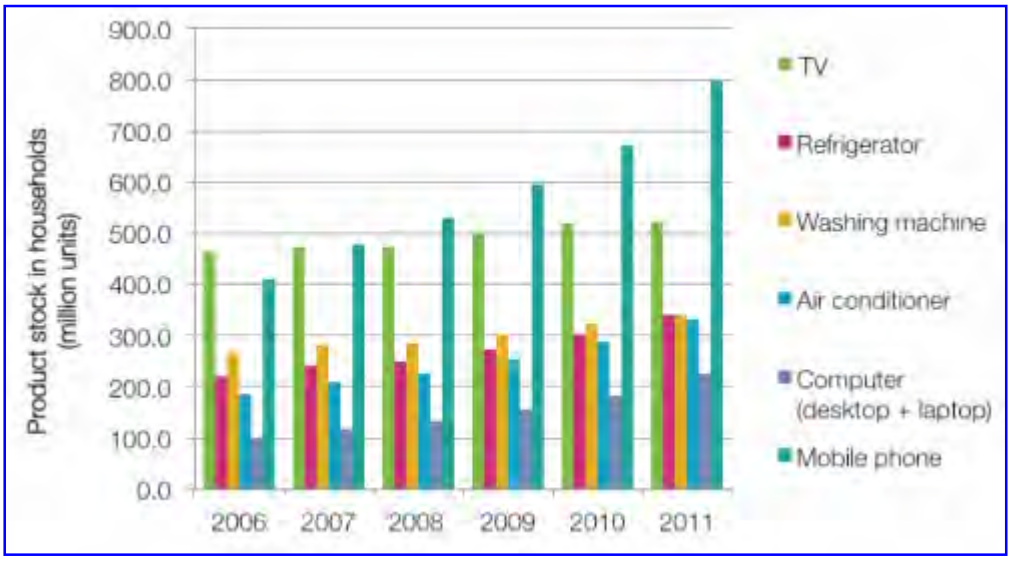

Figure 6.10: Stock of EEE in Chinese Households (2006-2011)

Source: Balde C.P., Kuehr R., Blumenthal K., Fondeur Gill S., Kern M., Micheli P., E. Magpantay, Huisman J (2015). *E-waste statistics Guidelines on classification, reporting and indicators.*

Figure 6.11 describes the WEEE/e-waste generation based on average life of each item. About 3.5 million tonnes of WEEE/e-waste has been generated in the year 2011.

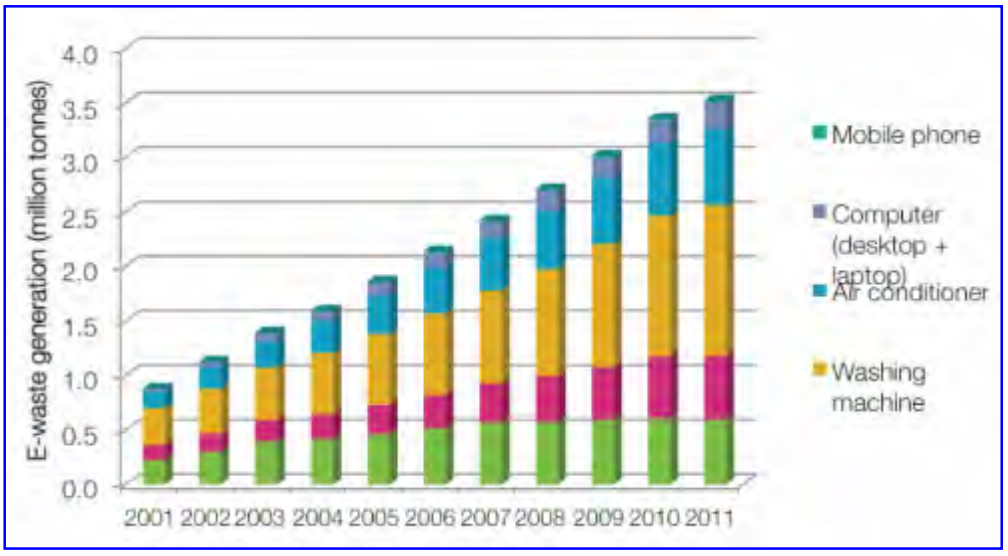

Figure 6.11: Generation of e-waste in China 2001-2011 (in million of tonnes)
Source: Balde C.P., Kuehr R., Blumenthal K., Fondeur Gill S., Kern M., Micheli P., E. Magpantay, Huisman J (2015). *E-waste statistics Guidelines on classification, reporting and indicators.*

6.6 Case Study 6: e-wastes in Republic of Korea[27]

Extended producer responsibility (EPR) system was introduced in Korea in January 2003 by the abolition of the deposit system on waste in 2002. EPR system in Korea has been activated under the Act on the Promotion of Resources Saving and Recycling on packaging materials such as (metal can, glass bottle, carton pack, synthetic resin packaging material) that are used to pack food and beverages, agricultural products, marine products, livestock products, cleansers, medicines and cosmetics etc. and product tire, fluorescent lamp, batteries (Mercury, Silver Oxide, Lithium, Nickel-Cadmium, Manganese, Nickel-hydrogen), lubricant styrofoam float, television, refrigerator, washing machine, air conditioner, computer, audio, mobile phone, copier, fax machine, printer, automatic dispenser, electric water purifier, electric oven, microwave, bidet, air purifier electric stove, electric cooker, water softener, humidifier, iron, fan, blender, vaccum machine and video cassette recorder. Under the Act, the obligation rate of recycling wastes in EPR system has been levied on the association of producers and importers products mentioned in the law. According to the EPR system, the association of producer or the importer decides the obligation rate of recycling wastes in agreement with the government. If the association of producer or the importer does not meet the agreed obligation for rate of recycling wastes, the producer or the importer should pay the recycling charges with fine.

6.6.1 E-waste Generation

E-waste statistics indicate that e-waste generation has increased from 504 kilo tonnes in 2003 to 595 kilo tonnes in 2013. However, it was very difficult to determine the historical e-waste generation amount because the lifetime of electronic and electric equipment was very long and also the unauthorized private sector collected e-wastes without giving any information. The recycling amount and recycling rate of e-waste increased from 58,000 tonnes (12%) in 2003 to 158,000 tonnes (27%) in 2013, respectively. But, the recycling amount of e-wastes from hidden flow was not accounted because there is no data available.

6.6.2 E-waste Collection and Recycling

EPR system imposed obligation target of recycling on the manufacturer and the distributor that should meet the target of recycling. The obligation rate for EPR products has been continuously increased, even

[27] *Seung-Whee Rhee; Beneficial use practice of e-wastes in Republic of Korea; Procedia Environmental Sciences 31 (2016) 707 – 714; The Tenth International Conference on Waste Management and Technology (ICWMT);*

though the actual recycling amount and rate did not meet the obligation rate. For e-waste, the obligation target of recycling was used by recycling the rate of percent until 2013, however, this was changed to recycling amount per capita from 2014. In 2014, the obligation target of e-waste recycling was 3.9 kg per capita, regardless of the type of e-waste.

In Korea, e-waste is mainly collected by 3 ways, such as local government, producers or distributor, and recycling company with self-recovery as shown in **Figure 6.12**. Even though there are approximately 3,300 distribution agencies of electric and electronic producers nation wide, about 10% of e-wastes were collected by producers or distributors with the reverse route system in the case of purchasing new products. More than 60% of e-waste was discharged to 232 local governments by a volume based rate system. Since most local governments only have the collection system of e-waste without the recycling facilities, the cooperation systems was established between producers and local governments to recycle e-waste efficiently. According to this system, collection centers related to recycling centers collect and transfer e-waste by a happy call system. Through this system, customers can call the producers or distributors to pick up the e-waste without any collection fees.

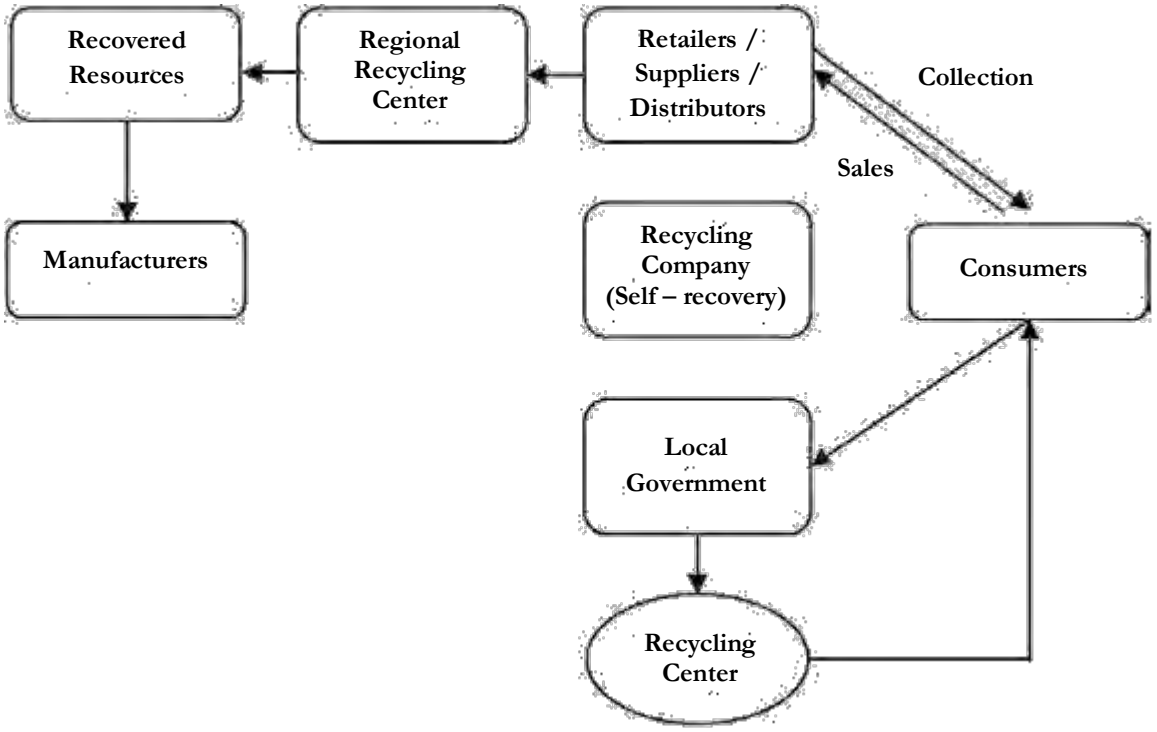

Figure 6.12: Collection system of e-wastes in Korea

Source: Beneficial use practice of e-wastes in Republic of Korea; Procedia Environmental Sciences 31 (2016) 707 – 714; The Tenth International Conference on Waste Management and Technology (ICWMT)

4.0 Recycling

In Korea, 9 regional recycling centers habe unique specific facilities to recycle certain e-wastes such as refrigerators and washing machines. The recycling center in Gyeongbuk region also has recycling facilities for several types of TVs, refrigerators, and washing machines. Recycling centers in north of Gyeonggi and western Metropolitan regions have recycling facilities for TVs, air conditioners, refrigerators, and washing machines. However, the recycling of air conditioners and mobile phones is still at the beginning stage in Korea, because of the high recycling cost of mobile phones and the lack of a constant supply of waste mobile phones. A typical e-waste recycling centre is shown in **Figure 6.13**.

Figure 6.13: E-Waste Recycling Center

Source: Director of the Resource Recycling Division (2006-11). *Ministry of Environment, Republic of Korea. Policy Direction on E-waste Recycling in Korea*

Recycling technologies for air conditioners are still developing, because hazardous substances such as refrigerants should be removed before recycling them. Over the past few years much effort on beneficial use practice has been made to better manage e-wastes such as TVs, refrigerators, washing machines, etc. in Korea.

6.7 Case Study 7: WEEE/e-waste Recycling Technology selection by a Recycler in India

A case study of an Indian WEEE/e-waste Recycler intending to establish WEEE/e-waste dismantling and recycling facility in the state of Gujarat has been presented. The case study described the basic technology proposed for non treatment technology, layout, specifications and cost estimates received from one supplier from Asia and two suppliers from Europe (Germany and Denmark).

6.7.1 Proposed Technology

The proposed technology has been described based on first and second level of treatment given below.

First Level WEEE/e-waste Treatment

Input: WEEE/e-waste items like TV, refrigerator and Personal Computers (PC)

Unit Operations: Following three unit operations occur at first level of treatment

1. Removal of all liquids and Gases
2. Dismantling (manual)
3. Segregation

Output:

1. Segregated hazardous wastes like CFC, Mercury (Hg) Switches, CRT, batteries and capacitors

2. Decontaminated WEEE/e-waste consisting of segregated non-hazardous WEEE/e-waste like plastic, circuit board and cables

Second Level WEEE/e-waste Treatment

The proposed second WEEE/e-waste treatment technology has been described in terms of process overview, unit operations and equipment to be used as shown in **figure 6.14**.

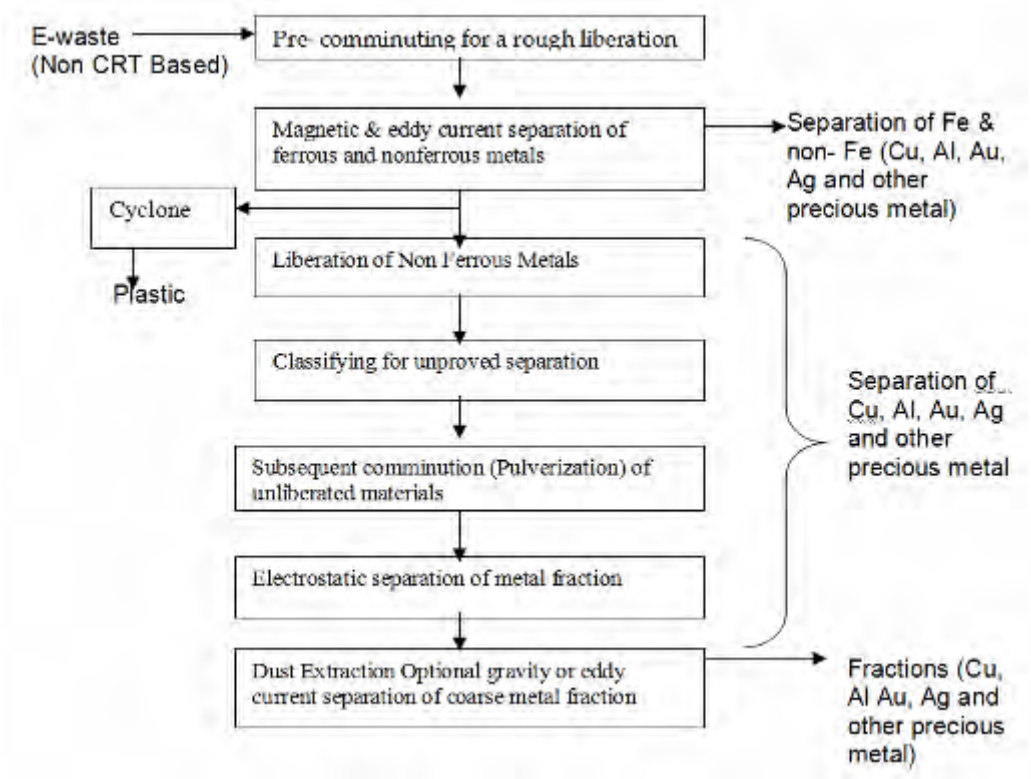

Figure 6.14: Process Flow of Non CRT based WEEE/e-waste Treatment
Source: UNEP Manual, E-waste Volume II: E-waste Management Manual, http://www.unep.or.jp/ietc/publications/spc/ewastemanual_vol2.pdf, (Accessed on 14 July, 2016)

The salient features of Non CRT WEEE/e-waste treatment technology and process are given below.

1. The process will use ICT and brown goods equipment like PCs, cellphones, televisions and other electronic items and will not use white goods like refrigerators, washing machines or air conditioners.

2. The process is focused on removal of three basic components.

    I. Plastic
    II. CRT/Glass
    III. Metals/Non metals

3. There will be different lines for WEEE/e-waste and CRT.

4. The proposed technology for sorting, treatment, including recycling and disposal of WEEE/e-waste is fully based on a dry process using mechanical operations.

5. The process uses a combination of three unit operations for Non-CRT based WEEE/e-waste treatment. These operations include

    I. Pre-comminuting/comminuting
    II. Magnetic/electrostatic separation

III. Eddy current separation

The salient features of CRT based WEEE/e-waste treatment technology and process is given below:

1. CRT is dismantled manually by removing the metal casing around it.

2. The dismantled CRT enters the chamber through a conveyor.

3. CRT is held firmly in the chamber using a vacuum pad.

4. A NiChrome wire or ribbon is wrapped round a CRT and electrically heated for at least 30 seconds to cause a thermal differential across the thickness of the glass. The area is then cooled (e.g. with a water-soaked sponge) to create thermal stress, which results in a crack. When this is lightly tapped, the screen separates from the funnel section.

5. The cut CRT enters the brush cabinet, where the funnel glass is mechanically cleaned by brushes.

6. The coating is sucked through a vacuum and stored separately for disposal.

7. Two types of glass ex. screen glass and funnel glass are separated and sorted out automatically.

8. The CRT can handle a partially broken funnel, ensuring that the operator can process just about anything that comes through the door.

9. The system utilizes the latest technology in recycling and utilises advanced PLC hardware and software to maximise throughput with the minimum of downtime.

6.7.2 Tentative Layout and Specifications

WEEE/e-waste treatment facility will consist of only 1st and 2nd level WEEE/e-waste treatment. as per WEEE/e-waste ESM guidelines of Ministry of Environment and Forests, Government of India. After 1st and 2nd level WEEE/e-waste, WEE/e-waste fractions will be sold to 3rd level recyclers. The installed capacity of the plant has been conceptualized to be about 25 tonnes per day. On a single shift basis and 300 operating days, the installed capacity of the plant will be 7000 tonnes per annum. The tentative layout of the recycling facility is shown in **Figure 6.15**. The total area requirement for a medium size 5000 tonnes – 7000 tonnes per annum WEEE/e-waste recycling facility is about 3000 sq meters as per international best practices. Out of this total area, processing area is about 40%, area for administration, raw material inventory and finished product inventory is 30% and open area is about 30 %. Therefore, the breakup of total area requirement is given below.

1. Total Land Requirement -3000 m^2
2. Processing Area -1200 m^2 on each floor (two floors) with a minimum height of 10 meters
3. Raw material inventory area – 450 m^2
4. Product inventory and administration area – 450 m^2
5. Open area – 900 m^2

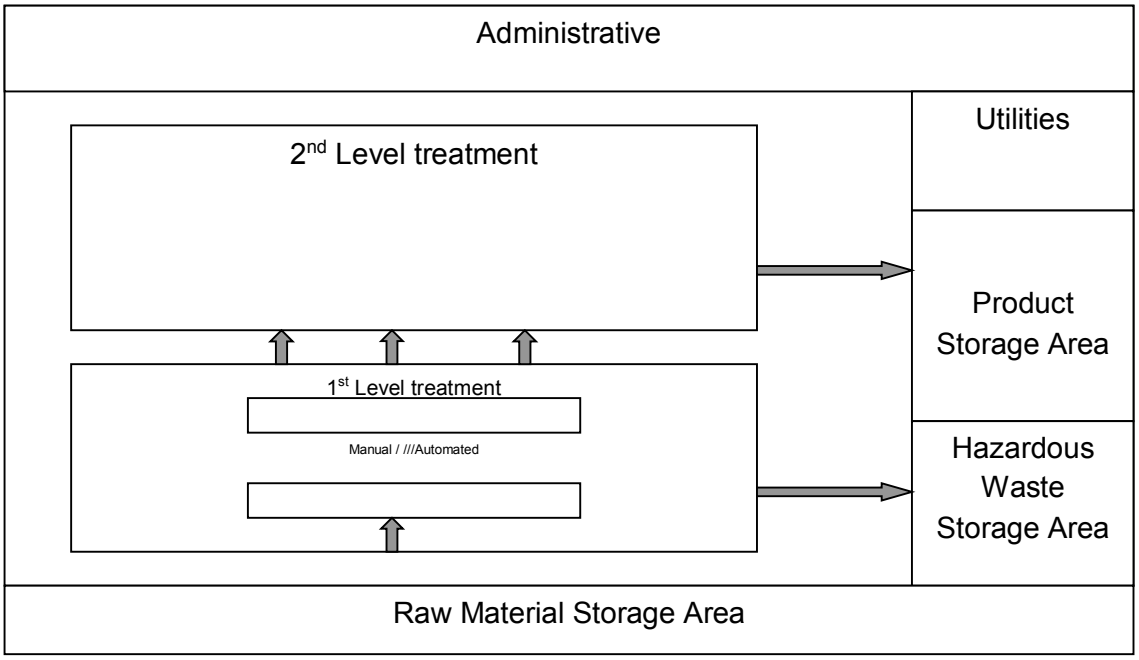

Figure 13: Tentative layout of WEEE/e-waste recycling facility

First level treatment could be either manual or semi-automatic using a conveyor system. The specification of shredder determines the equipment specifications. Tentative shredder specifications are given below.

1. Input – 3 to 4 tonnes per hour
2. Size of output < 4 - 5 mm
3. Driven by motor in the range of 300 to 400 kw
4. Hopper of around 1.5 m by 1 m

The entire system can be automated using a conveyor system of about 0.75 meter width. Depending on the availability of the input raw material, the facility can start with one shredder of half the capacity followed by the second.

Manual WEEE/e-waste dismantling/treatment plant

The specifications and tentative costs in Euro of 1t/hr manual WEEE/e-waste dismantling/treatment plant from Asia is given in table 3.

Table 3: Specification of manual WEEE/e-waste dismantling plant

Name of Equipment	Specifications	Make	Tentative Cost (USD)
Pre-Breaker Crusher	Input: Small House hold appliance Output: 6 x 4 cm.	Asia	90,950
Hammer Mill	Input: 6 x 4 cm. Output: 3-4 mm	Asia	90.950
Post hammer mill WEEE/e-waste complete assembly line (magnetic separator/eddy current separator/cyclones)	Input: 3-4 mm Output: Depending on screen fitted	Asia	385,200

Source: Jain Amit (2016)

Semi-Automatic WEEE/e-waste dismantling/treatment plant

The specifications and costs of the 3-4 tonne/hr semi automatic plant from Germany are given in **Table 6.3**.

Table 6.3: Specifications of semi-automatic WEEE/e-waste dismantling/treatment plant

Name of Equipment	Specifications	Make	Tentative Cost

ERP – Whole plant (compact turnkey solution)	Heavy duty chain mill Magnetic Separator Eddy current separator Cyclones Gravity/Eddy current separator	**Input:** Non disassembled electronic and electrical waste like small household appliances photo copiers, computers (without CRT) **Output:** Highly concentrated metal fractions and non metal fractions. **Metal:** 2mm to 12 cm **Plastic:** 1-2 mm	Germany, Europe	USD 1.39 million

Source: Jain Amit (2016)

Automatic WEEE/e-waste dismantling/treatment plant

The specifications of 3 tonne/hr automatic WEEE/e-waste automatic plant from Denmark are given in **Table 6.4**.

Table 6.4: Specifications of automatic WEEE/e-waste dismantling/treatment plant

Item No.	Quantity (no.)	Designation	Electricity Consumption (kw)
1.	1	Inlet conveyor	4
2.	1	Shredder S1000	252
3.	1	Vibratory Conveyor	3.15
4.	1	Electro Magnet	4
5.	1	Outlet Conveyor	1
6.	1	Inlet Conveyor including drum magnet	2.2
7.	1	Eddy current magnet	7.10
8.	1	Conveyor	2.2
9.	1	Tumble Back Feeder	4.0
10.	1	Rasper MPR 120	132.0
11.	1	Service Platform	
12.	1	Vibrating Discharge Conveyor	1.5
13.	1	Overband Magnet DM 1450	0.55
14.	1	Inlet Conveyor including drum magnet	2.2
15.	1	Eddy current magnet	5.5
16.	1	Conveyor	0.75
17.	1	Inlet Conveyor	2.2
18.	1	Silo SMV	0.40
19.	1	Heavy Granulator HG 169	110
20.	1	Pneumatic Material Transport	23.5
21.	1	Pneumatic Material Transport	23.5
22.	1	Silo SMV	0.40
23.	1	Separation Table C22	12.10
24.	1	Middling Return, Flexible Screw Conveyor	1.10
25.	1	Classifier PC 12 with flexible screw auger	1.85
26.	1	Electric power and control board	
27.	1	Electric power and control board	
28.	1	Filter system for shredder line	21.5
29.	1	Cyclone	
30.	1	Ventilator	
31.	1	Filter system for granulation line	46.5
32.	1	Cyclone	
33.	1	Ventilator	

Source: Jain Amit (2016)

The tentative cost of the plant is about € 2.1 million.

The WEEE/e-waste plant availability scenarios along with manufacturers and tentative costs are summarized in **Table 6.5** and **Table 6.6**.

Table 6.6: WEEE/E-waste plant capacity and manufacturers

WEEE/E-waste plant	Capacity		
	5000 TPA	7500 TPA	15000 TPA
Manual	(one crushers with one assembly line)	Supplier 1 (two crushers with one assembly line), (Asia)	Supplier 1 (three crushers with two assembly line), (Asia)
Semi Automatic	X	Germany	Germany
Automatic	X	Denmark	Denmark

Source: Jain Amit (2016).

Table 6.7: Cost Estimates (ex works)

WEEE/E-waste plant	Cost (USD/$) (Exworks)		
	5000 TPA	7500 TPA	15000 TPA
Manual	567,100	749,000	1,316,100
Semi Automatic	X	1,391,000	1,391,000
Automatic	X	2,247,000	2,247,000

Source: Jain Amit (2016).

Common specifications for utilities

WEEE/e-waste storage areas/hazardous waste storage areas/product storage areas should follow the following basic design principles:

1. Impermeable surface for storage area.
2. Some spare parts (e.g. motors and compressors) will contain oil and/or other fluids. Such parts must be appropriately segregated, and end stored in containers that are secured, such that oil and other fluids cannot escape from them. These containers must be stored in an area with an Impermeable surface and a sealed drainage system.
3. Waste Oil should be either reused or incinerated in common hazardous waste incineration facilities.
4. Capacitors containing PCB's shall be incinerated in common hazardous waste Incineration facilities at CHWTSDF.
5. Based on the volume of WEEE/e-waste items, bin/container/cage/Gaylord container, should be used.
6. Ensures safe transport of the WEEE/e-waste without any spillage.
7. Sites for handling of WEEE/e-waste have balances to measure the weight of the segregated waste.
8. Facility shall maintain a record of destruction of electronic waste collected from generators.

Based on cost estimates and ease of technology used, an Asian supplier was chosen as the technology supplier.

APPENDICES

Appendix – 3.1: WEEE/e-waste Management Regulations EU and India

DIRECTIVE 2012/19/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 4 July 2012
on waste electrical and electronic equipment (WEEE)
(recast)

(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,
Having regard to the Treaty on the Functioning of the European Union, and in particular Article 192(1) thereof,
Having regard to the proposal from the European Commission,
Having regard to the opinion of the European Economic and Social Committee ([1]),
Having regard to the opinion of the Committee of the Regions ([2]),
Acting in accordance with the ordinary legislative procedure ([3]),
Whereas:

1. A number of substantial changes are to be made to Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE) ([4]). In the interests of clarity, that Directive should be recast.
2. The objectives of the Union's environment policy are, in particular, to preserve, protect and improve the quality of the environment, to protect human health and to utilise natural resources prudently and rationally. That policy is based on the precautionary principle and the principles that preventive action should be taken, that environmental damage should, as a priority, be rectified at source and that the polluter should pay.
3. The Community programme of policy and action in relation to the environment and sustainable development (Fifth Environmental Action Programme) ([5]) stated that the achievement of sustainable development calls for significant changes in current patterns of development, production, consumption and behaviour and advocates, inter alia, the reduction of wasteful consumption of natural resources and the prevention of pollution. It mentioned waste electrical and electronic equipment (WEEE) as one of the target areas to be regulated, in view of the application of the principles of prevention, recovery and safe disposal of waste.
4. This Directive supplements the general waste management legislation of the Union, such as Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste ([6]). It refers to the definitions in that Directive, including the definitions of waste and general waste management operations. The definition of collection in Directive 2008/98/EC includes the preliminary sorting and preliminary storage of waste for the purposes of transport to a waste treatment facility. Directive 2009/125/EC of the European Parliament and of the Council ([7]) establishes a framework for setting ecodesign requirements for energy-related products and enables the adoption of specific ecodesign requirements for energy-related products which may also be covered by this Directive. Directive 2009/125/EC and the implementing measures adopted pursuant thereto are without prejudice to the waste management legislation of the Union. Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment ([8]) requires the substitution of banned substances in respect of all electrical and electronic equipment (EEE) within its scope.
5. As the market continues to expand and innovation cycles become even shorter, the replacement of equipment accelerates, making EEE a fast-growing source of waste. While Directive 2002/95/EC has contributed effectively to reducing hazardous substances contained in new EEE, hazardous substances such as mercury, cadmium, lead, hexavalent chromium and polychlorinated biphenyls (PCBs) and ozone-depleting substances will still be present in WEEE for many years. The content of hazardous components in EEE is a major concern during the waste management phase, and recycling of WEEE is not undertaken to a sufficient extent. A lack of recycling results in the loss of valuable resources.
6. The purpose of this Directive is to contribute to sustainable production and consumption by, as a first priority, the prevention of WEEE and, in addition, by the re-use, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste and to contribute to the efficient use of resources and the retrieval of valuable secondary raw materials. It also seeks to improve the environmental

performance of all operators involved in the life cycle of EEE, e.g. producers, distributors and consumers and, in particular, those operators directly involved in the collection and treatment of WEEE. In particular, different national applications of the 'producer responsibility' principle may lead to substantial disparities in the financial burden on economic operators. Having different national policies on the management of WEEE hampers the effectiveness of recycling policies. For that reason, the essential criteria should be laid down at the level of the Union and minimum standards for the treatment of WEEE should be developed.

7. The provisions of this Directive should apply to products and producers irrespective of selling technique, including distance and electronic selling. In this connection, the obligations of producers and distributors using distance and electronic selling channels should, as far as is practicable, take the same form, and should be enforced in the same way, as for other distribution channels, in order to avoid those other distribution channels having to bear the costs resulting from this Directive arising from WEEE for which the equipment was sold by distance or electronic selling.
8. In order to fulfil the obligations pursuant to this Directive in a given Member State, a producer should be established in that Member State. By exception, to reduce existing barriers to the proper functioning of the internal market and administrative burdens, Member States should allow producers that are not established on their territory, but that are established in another Member State, to appoint an authorised representative to be responsible for fulfilling the obligations of that producer under this Directive. In addition, administrative burdens should be reduced by simplifying registration and reporting procedures and by ensuring that duplicate charges are not levied for registrations within individual Member States.
9. This Directive should cover all EEE used by consumers and EEE intended for professional use. This Directive should apply without prejudice to Union legislation on safety and health requirements protecting all actors in contact with WEEE, as well as specific Union waste management legislation, in particular Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators ([9]), and Union product design legislation, in particular Directive 2009/125/EC. The preparing for re-use, recovery and recycling of waste cooling equipment and the substances, mixtures or components thereof should be in accordance with the relevant legislation of the Union, in particular Regulation (EC) No 1005/2009 of the European Parliament and of the Council of 16 September 2009 on substances that deplete the ozone layer ([10]) and Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases ([11]). The objectives of this Directive can be achieved without including large-scale fixed installations such as oil platforms, airport luggage transport systems or elevators within its scope. However, any equipment which is not specifically designed and installed as part of those installations, and which can fulfil its function even if it is not part of those installations, should be included in the scope of this Directive. This refers for instance to equipment such as lighting equipment or photovoltaic panels.
10. A number of definitions should be included in this Directive in order to specify its scope. However, in the framework of a revision of the scope, the definition of EEE should be further clarified in order to bring Member States' relevant national measures and current, applied and established practices closer together.
11. Ecodesign requirements facilitating the re-use, dismantling and recovery of WEEE should be laid down in the framework of measures implementing Directive 2009/125/EC. In order to optimise re-use and recovery through product design, the whole life cycle of the product should be taken into account.
12. The establishment, by this Directive, of producer responsibility is one of the means of encouraging design and production of EEE which take into full account and facilitate its repair, possible upgrading, re-use, disassembly and recycling.
13. In order to guarantee the safety and health of distributors' personnel involved in the take-back and handling of WEEE, Member States should, in accordance with national and Union legislation on safety and health requirements, determine the conditions under which take-back may be refused by distributors.
14. Separate collection is a precondition for ensuring specific treatment and recycling of WEEE and is necessary to achieve the chosen level of protection of human health and the environment in the Union. Consumers have to actively contribute to the success of such collection and should be encouraged to return WEEE. For this purpose, convenient facilities should be set up for the return of WEEE, including public collection points, where private households should be able to return their waste at least free of charge. Distributors have an important role in contributing to the success of WEEE collection. Therefore, collection points set up at retail shops for very small WEEE should not be subject to the registration or permit requirements of Directive 2008/98/EC.

15. In order to attain the chosen level of protection and the harmonised environmental objectives of the Union, Member States should adopt appropriate measures to minimise the disposal of WEEE as unsorted municipal waste and to achieve a high level of separate collection of WEEE. In order to ensure that Member States strive to set up efficient collection schemes, they should be required to achieve a high level of collection of WEEE, particularly for cooling and freezing equipment containing ozone-depleting substances and fluorinated greenhouse gases, given their high environmental impact and in view of the obligations contained in Regulation (EC) No 842/2006 and Regulation (EC) No 1005/2009. Data included in the impact assessment carried out by the Commission in 2008 show that 65 % of the EEE placed on the market was already separately collected then, but more than half of this was potentially the object of improper treatment and illegal exports, and, even when properly treated, this was not reported. This leads to losses of valuable secondary raw materials, environmental degradation, and provision of inconsistent data. To avoid this, it is necessary to set an ambitious collection target and to ensure that WEEE collected is treated in an environmentally sound way and is correctly reported. It is appropriate to lay down minimum requirements for shipments of used EEE suspected to be WEEE, in the application of which Member States may have regard to any relevant Correspondents' Guidelines elaborated in the context of the implementation of Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste ([12]). Such minimum requirements should in any case have the purpose of avoiding unwanted shipments of non-functional EEE to developing countries.
16. The setting of ambitious collection targets should be based on the amount of WEEE generated where due account is taken of the differing life cycles of products in the Member States, of non-saturated markets and of EEE with a long life cycle. Therefore, a methodology for calculating collection rates based on WEEE generated should be developed in the near future. According to current estimates, a collection rate of 85 % of WEEE generated is broadly equivalent to a collection rate of 65 % of the average weight of EEE placed on the market in the three preceding years.
17. Specific treatment for WEEE is indispensable in order to avoid the dispersion of pollutants in recycled material or the waste stream. Such treatment is the most effective means of ensuring compliance with the chosen level of protection of the environment of the Union. Any establishment or undertaking carrying out collection, recycling and treatment operations should comply with minimum standards to prevent negative environmental impacts associated with the treatment of WEEE. The best available treatment, recovery and recycling techniques should be used, provided that they ensure human health and a high level of environmental protection. Best available treatment, recovery and recycling techniques may be further defined in accordance with the procedures of Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control ([13]).
18. The Scientific Committee on Emerging and Newly Identified Health Risks, in its opinion on 'Risk Assessment of Products of Nanotechnology' of 19 January 2009, stated that exposure to nanomaterials that are firmly embedded in large structures, for example in electronic circuits, may occur in the waste phase and during recycling. To control possible risks to human health and the environment from the treatment of WEEE that contains nanomaterials, it is appropriate for the Commission to assess whether specific treatment may be necessary.
19. The collection, storage, transport, treatment and recycling of WEEE as well as its preparation for re-use shall be conducted with an approach geared to protecting the environment and human health and preserving raw materials and shall aim at recycling valuable resources contained in EEE with a view to ensuring a better supply of commodities within the Union.
20. Where appropriate, priority should be given to preparing for re-use of WEEE and its components, sub-assemblies and consumables. Where this is not preferable, all WEEE collected separately should be sent for recovery, in the course of which a high level of recycling and recovery should be achieved. In addition, producers should be encouraged to integrate recycled material in new equipment.
21. The recovery, preparation for re-use and recycling of WEEE should be counted towards the achievement of the targets laid down in this Directive only if that recovery, preparation for re-use or recycling does not conflict with other Union or national legislation applicable to the equipment. Ensuring proper preparation for re-use, recycling and recovery of WEEE is important for sound resource management and will optimise supply of resources.
22. Basic principles with regard to the financing of WEEE management have to be set at the level of the Union, and financing schemes have to contribute to high collection rates, as well as to the implementation of the principle of producer responsibility.

23. Users of EEE from private households should have the possibility of returning WEEE at least free of charge. Producers should finance at least the collection from collection facilities, and the treatment, recovery and disposal of WEEE. Member States should encourage producers to take full responsibility for the WEEE collection, in particular by financing the collection of WEEE throughout the entire waste chain, including from private households, in order to avoid separately collected WEEE becoming the object of suboptimal treatment and illegal exports, to create a level playing field by harmonising producer financing across the Union and to shift payment for the collection of this waste from general tax payers to the consumers of EEE, in line with the 'polluter pays' principle. In order to give maximum effect to the concept of producer responsibility, each producer should be responsible for financing the management of the waste from his own products. The producer should be able to choose to fulfil this obligation either individually or by joining a collective scheme. Each producer should, when placing a product on the market, provide a financial guarantee to prevent costs for the management of WEEE from orphan products from falling on society or the remaining producers. The responsibility for the financing of the management of historical waste should be shared by all existing producers through collective financing schemes to which all producers that exist on the market when the costs occur contribute proportionately. Collective financing schemes should not have the effect of excluding niche and low-volume producers, importers and new entrants. Collective schemes could provide for differentiated fees based on how easily products and the valuable secondary raw materials that they contain could be recycled. In the case of products which have a long life cycle and which are now covered by this Directive, such as photovoltaic panels, the best possible use should be made of existing collection and recovery systems, provided that they meet the requirements laid down in this Directive.
24. Producers could be allowed to show purchasers, on a voluntary basis at the time of sale of new products, the costs of collecting, treating and disposing of WEEE in an environmentally sound way. This is in line with the Commission Communication on Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan, in particular with regard to smarter consumption and green public procurement.
25. Information to users about the requirement not to dispose of WEEE as unsorted municipal waste and to collect WEEE separately and about the collection systems and their role in the management of WEEE is indispensable for the success of WEEE collection. Such information necessitates the proper marking of EEE which could end up in rubbish bins or similar means of municipal waste collection.
26. Information on component and material identification to be provided by producers is important to facilitate the management, and in particular the treatment and recovery or recycling, of WEEE.
27. Member States should ensure that inspection and monitoring infrastructure enables the proper implementation of this Directive to be verified, having regard, inter alia, to Recommendation 2001/331/EC of the European Parliament and of the Council of 4 April 2001 providing for minimum criteria for environmental inspections in the Member States ([14]).
28. Member States should provide for effective, proportionate and dissuasive penalties to be imposed on natural and legal persons responsible for waste management, where they infringe the provisions of this Directive. Member States should also be able to take action to recover the costs of non-compliance and remedial measures, without prejudice to Directive 2004/35/EC of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage ([15]).
29. Information about the weight of EEE placed on the market in the Union and the rates of collection, preparation for re-use, including as far as possible preparation for re-use of whole appliances, recovery or recycling and export of WEEE collected in accordance with this Directive is necessary to monitor the achievement of the objectives of this Directive. For the purposes of calculating collection rates, a common methodology for the calculation of weight of EEE should be developed to ascertain, inter alia, whether this term includes the actual weight of the entire equipment in the form in which it is marketed, including all components, sub-assemblies, accessories and consumables but excluding packaging, batteries, instructions for use and manuals.
30. It is appropriate to allow Member States to choose to implement certain provisions of this Directive by means of agreements between the competent authorities and the economic sectors concerned, provided that particular requirements are met.
31. In order to address difficulties faced by Member States in achieving the collection rates, to take into account technical and scientific progress and to supplement the provisions on fulfilment of recovery targets, the power to adopt acts in accordance with Article 290 of the Treaty on the Functioning of the European Union (TFEU) should be delegated to the Commission in respect of transitional adjustments for certain Member States, adaptation to technical and scientific progress and the adoption of detailed

rules on WEEE exported out of the Union counting towards the fulfilment of recovery targets. It is of particular importance that the Commission carry out appropriate consultations during its preparatory work, including at expert level. The Commission, when preparing and drawing up delegated acts, should ensure a simultaneous, timely and appropriate transmission of relevant documents to the European Parliament and to the Council.

32. In order to ensure uniform conditions for the implementation of this Directive, implementing powers should be conferred on the Commission. Those powers should be exercised in accordance with Regulation (EU) No 182/2011 of the European Parliament and of the Council of 16 February 2011 laying down the rules and general principles concerning mechanisms for control by Member States of the Commission's exercise of implementing powers ([16]).
33. The obligation to transpose this Directive into national law should be confined to those provisions which represent a substantive change as compared with the earlier Directives. The obligation to transpose the provisions which are unchanged arises under the earlier Directives.
34. In accordance with the Joint Political Declaration of 28 September 2011 of Member States and the Commission on explanatory documents ([17]), Member States have undertaken to accompany, in justified cases, the notification of their transposition measures with one or more documents explaining the relationship between the components of a directive and the corresponding parts of national transposition instruments. With regard to this Directive, the legislator considers the transmission of such documents to be justified.
35. This Directive should be without prejudice to the obligations of the Member States relating to the time limits for transposition into national law and application of the Directives set out in Annex XI, Part B.
36. Since the objective of this Directive cannot be sufficiently achieved by the Member States and can therefore, by reason of the scale of the problem, be better achieved at the level of the Union, the Union may adopt measures, in accordance with the principle of subsidiarity as set out in Article 5 of the Treaty on European Union. In accordance with the principle of proportionality, as set out in that Article, this Directive does not go beyond what is necessary in order to achieve that objective,

HAVE ADOPTED THIS DIRECTIVE:

Article 1
Subject matter

This Directive lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste from electrical and electronic equipment (WEEE) and by reducing overall impacts of resource use and improving the efficiency of such use in accordance with Articles 1 and 4 of Directive 2008/98/EC, thereby contributing to sustainable development.

Article 2
Scope

1. This Directive shall apply to electrical and electronic equipment (EEE) as follows:

   a) From 13 August 2012 to 14 August 2018 (transitional period), subject to paragraph 3, to EEE falling within the categories set out in Annex I. Annex II contains an indicative list of EEE which falls within the categories set out in Annex I;
   b) From 15 August 2018, subject to paragraphs 3 and 4, to all EEE. All EEE shall be classified within the categories set out in Annex III. Annex IV contains a non-exhaustive list of EEE which falls within the categories set out in Annex III (open scope).

2. This Directive shall apply without prejudice to the requirements of Union legislation on safety and health, on chemicals, in particular Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency ([18]), as well as of specific Union waste management or product design legislation.

3. This Directive shall not apply to any of the following EEE:

a) equipment which is necessary for the protection of the essential interests of the security of Member States, including arms, munitions and war material intended for specifically military purposes;
b) equipment which is specifically designed and installed as part of another type of equipment that is excluded from or does not fall within the scope of this Directive, which can fulfil its function only if it is part of that equipment;
c) Filament bulbs.

4. In addition to the equipment specified in paragraph 3, from 15 August 2018, this Directive shall not apply to the following EEE:

a) Equipment designed to be sent into space;
b) Large-scale stationary industrial tools;
c) Large-scale fixed installations, except any equipment which is not specifically designed and installed as part of those installations;
d) Means of transport for persons or goods, excluding electric two-wheel vehicles which are not type-approved;
e) Non-road mobile machinery made available exclusively for professional use;
f) Equipment specifically designed solely for the purposes of research and development that is only made available on a business-to-business basis;
g) Medical devices and in vitro diagnostic medical devices, where such devices are expected to be infective prior to end of life, and active implantable medical devices.

5. No later than 14 August 2015, the Commission shall review the scope of this Directive set out in point (b) of paragraph 1, including the parameters to distinguish between large and small equipment in Annex III, and shall present a report thereon to the European Parliament and to the Council. The report shall be accompanied by a legislative proposal, if appropriate.

Article 3
Definitions

1. For the purposes of this Directive, the following definitions shall apply:

a) 'Electrical and electronic equipment' or 'EEE' means equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1 000 volts for alternating current and 1 500 volts for direct current;
b) 'Large-scale stationary industrial tools' means a large size assembly of machines, equipment, and/or components, functioning together for a specific application, permanently installed and de-installed by professionals at a given place, and used and maintained by professionals in an industrial manufacturing facility or research and development facility;
c) 'Large-scale fixed installation' means a large-size combination of several types of apparatus and, where applicable, other devices, which:
   i. are assembled, installed and de-installed by professionals;
   ii. are intended to be used permanently as part of a building or a structure at a pre-defined and dedicated location; and
   iii. can only be replaced by the same specifically designed equipment;
d) 'Non-road mobile machinery' means machinery, with on-board power source, the operation of which requires either mobility or continuous or semi-continuous movement between a succession of fixed working locations while working;
e) 'Waste electrical and electronic equipment' or 'WEEE' means electrical or electronic equipment which is waste within the meaning of Article 3(1) of Directive 2008/98/EC, including all components, sub-assemblies and consumables which are part of the product at the time of discarding;
f) 'Producer' means any natural or legal person who, irrespective of the selling technique used, including distance communication within the meaning of Directive 97/7/EC of the European Parliament and of the Council of 20 May 1997 on the protection of consumers in respect of distance contracts ([19]):
   i. is established in a Member State and manufactures EEE under his own name or trademark, or has EEE designed or manufactured and markets it under his name or trademark within the territory of that Member State;

ii. is established in a Member State and resells within the territory of that Member State, under his own name or trademark, equipment produced by other suppliers, a reseller not being regarded as the 'producer' if the brand of the producer appears on the equipment, as provided for in point (i);

iii. is established in a Member State and places on the market of that Member State, on a professional basis, EEE from a third country or from another Member State; or

iv. Sells EEE by means of distance communication directly to private households or to users other than private households in a Member State, and is established in another Member State or in a third country.

Whoever exclusively provides financing under or pursuant to any finance agreement shall not be deemed to be a 'producer' unless he also acts as a producer within the meaning of points (i) to (iv);

g) 'Distributor' means any natural or legal person in the supply chain, who makes an EEE available on the market. This definition does not prevent a distributor from being, at the same time, a producer within the meaning of point (f);

h) 'WEEE from private households' means WEEE which comes from private households and WEEE which comes from commercial, industrial, institutional and other sources which, because of its nature and quantity, is similar to that from private households. Waste from EEE likely to be used by both private households and users other than private households shall in any event be considered to be WEEE from private households;

i) 'finance agreement' means any loan, lease, hiring or deferred sale agreement or arrangement relating to any equipment whether or not the terms of that agreement or arrangement or any collateral agreement or arrangement provide that a transfer of ownership of that equipment will or may take place;

j) 'making available on the market' means any supply of a product for distribution, consumption or use on the market of a Member State in the course of a commercial activity, whether in return for payment or free of charge;

k) 'placing on the market' means the first making available of a product on the market within the territory of a Member State on a professional basis;

l) 'Removal' means manual, mechanical, chemical or metallurgic handling with the result that hazardous substances, mixtures and components are contained in an identifiable stream or are an identifiable part of a stream within the treatment process. A substance, mixture or component is identifiable if it can be monitored to verify environmentally safe treatment;

m) 'Medical device' means a medical device or accessory within the meaning of, respectively, point (a) or (b) of Article 1(2) of Council Directive 93/42/EEC of 14 June 1993 concerning medical devices ([20]) which is EEE;

n) 'In vitro diagnostic medical device' means an in vitro diagnostic device or accessory within the meaning of, respectively, point (b) or (c) of Article 1(2) of Directive 98/79/EC of the European Parliament and of the Council of 27 October 1998 on in vitro diagnostic medical devices ([21]) which is EEE;

o) 'Active implantable medical device' means an active implantable medical device within the meaning of point (c) of Article 1(2) of Council Directive 90/385/EEC of 20 June 1990 on the approximation of the laws of the Member States relating to active implantable medical devices ([22]) which is EEE.

2. In addition, the definitions of 'hazardous waste', 'collection', 'separate collection', 'prevention', 're-use', 'treatment', 'recovery', 'preparing for re-use', 'recycling' and 'disposal' laid down in Article 3 of Directive 2008/98/EC shall apply.

Article 4

Product design

Member States shall, without prejudice to the requirements of Union legislation on the proper functioning of the internal market and on product design, including Directive 2009/125/EC, encourage cooperation between producers and recyclers and measures to promote the design and production of EEE, notably in view of facilitating re-use, dismantling and recovery of WEEE, its components and materials. In this context, Member States shall take appropriate measures so that the ecodesign requirements facilitating re-use and treatment of WEEE established in the framework of Directive 2009/125/EC are applied and producers do not prevent, through specific design features or manufacturing processes, WEEE from being re-used, unless such specific design features or manufacturing processes present overriding advantages, for example, with regard to the protection of the environment and/or safety requirements.

Article 5

Separate collection

1. Member States shall adopt appropriate measures to minimise the disposal of WEEE in the form of unsorted municipal waste, to ensure the correct treatment of all collected WEEE and to achieve a high level of separate collection of WEEE, notably, and as a matter of priority, for temperature exchange equipment containing ozone-depleting substances and fluorinated greenhouse gases, fluorescent lamps containing mercury, photovoltaic panels and small equipment as referred to in categories 5 and 6 of Annex III.

2. For WEEE from private households, Member States shall ensure that:

   a) Systems are set up allowing final holders and distributors to return such waste at least free of charge. Member States shall ensure the availability and accessibility of the necessary collection facilities, taking into account, in particular, the population density;
   b) When supplying a new product, distributors are responsible for ensuring that such waste can be returned to the distributor at least free of charge on a one-to-one basis as long as the equipment is of equivalent type and has fulfilled the same functions as the supplied equipment. Member States may derogate from this provision provided that they ensure that returning the WEEE is not thereby made more difficult for the final holder and that it remains free of charge for the final holder. Member States making use of this derogation shall inform the Commission thereof;
   c) Distributors provide for the collection, at retail shops with sales areas relating to EEE of at least 400 m^2, or in their immediate proximity, of very small WEEE (no external dimension more than 25 cm) free of charge to end-users and with no obligation to buy EEE of an equivalent type, unless an assessment shows that alternative existing collection schemes are likely to be at least as effective. Such assessments shall be available to the public. WEEE collected shall be properly treated in accordance with Article 8;
   d) Without prejudice to points (a), (b) and (c), producers are allowed to set up and to operate individual and/or collective take-back systems for WEEE from private households provided that these are in line with the objectives of this Directive;
   e) Having regard to national and Union health and safety standards, WEEE that presents a health and safety risk to personnel because of contamination may be refused for return under points (a), (b) and (c). Member States shall make specific arrangements for such WEEE.

   Member States may provide for specific arrangements for the return of WEEE pursuant to points (a), (b) and (c) for cases in which the equipment does not contain its essential components or if the equipment contains waste other than WEEE.

3. Member States may designate the operators that are allowed to collect WEEE from private households as referred to in paragraph 2.

4. Member States may require that the WEEE deposited at collection facilities referred to in paragraphs 2 and 3 is handed over to producers or third parties acting on their behalf or is handed over, for purposes of preparing for re-use, to designated establishments or undertakings.

5. In the case of WEEE other than WEEE from private households, and without prejudice to Article 13, Member States shall ensure that producers or third parties acting on their behalf provide for the collection of such waste.

Article 6

Disposal and transport of collected WEEE

1. Member States shall prohibit the disposal of separately collected WEEE which has not yet undergone the treatment specified in Article 8.

2. Member States shall ensure that the collection and transport of separately collected WEEE is carried out in a way which allows optimal conditions for preparing for re-use, recycling and the confinement of hazardous substances.

In order to maximise preparing for re-use, Member States shall promote that, prior to any further transfer, collection schemes or facilities provide, where appropriate, for the separation at the collection points of WEEE that is to be prepared for re-use from other separately collected WEEE, in particular by granting access for personnel from re-use centres.

Article 7

Collection rate

1. Without prejudice to Article 5(1), each Member State shall ensure the implementation of the 'producer responsibility' principle and, on that basis, that a minimum collection rate is achieved annually. From 2016, the minimum collection rate shall be 45 % calculated on the basis of the total weight of WEEE collected in accordance with Articles 5 and 6 in a given year in the Member State concerned, expressed as a percentage of the average weight of EEE placed on the market in the three preceding years in that Member State. Member States shall ensure that the volume of WEEE collected evolves gradually during the period from 2016 to 2019, unless the collection rate laid down in the second subparagraph has already been achieved.

   From 2019, the minimum collection rate to be achieved annually shall be 65 % of the average weight of EEE placed on the market in the three preceding years in the Member State concerned, or alternatively 85 % of WEEE generated on the territory of that Member State.

   Until 31 December 2015, a rate of separate collection of at least 4 kilograms on average per inhabitant per year of WEEE from private households or the same amount of weight of WEEE as was collected in that Member State on average in the three preceding years, whichever is greater, shall continue to apply.

   Member States may set more ambitious rates for separate collection of WEEE and shall in such a case report this to the Commission.

2. In order to establish whether the minimum collection rate has been achieved, Member States shall ensure that information concerning the WEEE that is separately collected in accordance with Article 5 is transmitted to the Member States free of charge, including at least information on WEEE that has been:

   a) Received by collection and treatment facilities;
   b) Received by distributors;
   c) Separately collected by producers or third parties acting on their behalf.

3. By way of derogation from paragraph 1, Bulgaria, the Czech Republic, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovenia and Slovakia may, because of their lack of the necessary infrastructure and their low level of EEE consumption, decide to:

   a) achieve, from 14 August 2016, a collection rate that is lower than 45 % but higher than 40 % of the average weight of EEE placed on the market in the three preceding years; and
   b) Postpone the achievement of the collection rate referred to in the second subparagraph of paragraph 1 until a date of their own choice which shall not be later than 14 August 2021.

4. The Commission shall be empowered to adopt delegated acts in accordance with Article 20 laying down the necessary transitional adjustments in order to address difficulties faced by Member States in adhering to the requirements laid down in paragraph 1.

5. In order to ensure uniform conditions for the implementation of this Article, the Commission shall, by 14 August 2015, adopt implementing acts establishing a common methodology for the calculation of the weight of EEE placed on the national market and a common methodology for the calculation of the quantity of WEEE generated by weight in each Member State. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 21(2).

6. The Commission shall, by 14 August 2015, present a report to the European Parliament and to the Council on the re-examination of the deadlines relating to the collection rates referred to in paragraph 1 and on

possibly setting individual collection rates for one or more categories set out in Annex III, particularly for temperature exchange equipment, photovoltaic panels, small equipment, small IT and telecommunication equipment and lamps containing mercury. The report shall, if appropriate, be accompanied by a legislative proposal.

7. If the Commission considers, on the basis of an impact study, that the collection rate based on WEEE generated requires revision, it shall submit a legislative proposal to the European Parliament and the Council.

Article 8
Proper treatment

1. Member States shall ensure that all separately collected WEEE undergoes proper treatment.

2. Proper treatment, other than preparing for re-use, and recovery or recycling operations shall, as a minimum, include the removal of all fluids and a selective treatment in accordance with Annex VII.

3. Member States shall ensure that producers or third parties acting on their behalf set up systems to provide for the recovery of WEEE using best available techniques. The systems may be set up by producers individually or collectively. Member States shall ensure that any establishment or undertaking carrying out collection or treatment operations stores and treats WEEE in compliance with the technical requirements set out in Annex VIII.

4. The Commission shall be empowered to adopt delegated acts in accordance with Article 20 concerning the amendment of Annex VII in order to introduce other treatment technologies that ensure at least the same level of protection for human health and the environment.

   The Commission shall evaluate, as a matter of priority, whether the entries regarding printed circuit boards for mobile phones and liquid crystal displays need to be amended. The Commission is invited to evaluate whether amendments to Annex VII are necessary to address nanomaterials contained in EEE.

5. For the purposes of environmental protection, Member States may set up minimum quality standards for the treatment of the WEEE that has been collected.
   Member States which opt for such quality standards shall inform the Commission thereof, which shall publish these standards.

   The Commission shall, not later than 14 February 2013, request the European standardisation organisations to develop European standards for the treatment, including recovery, recycling and preparing for re-use, of WEEE. Those standards shall reflect the state of the art.

   In order to ensure uniform conditions for the implementation of this Article, the Commission may adopt implementing acts laying down minimum quality standards based in particular on the standards developed by the European standardisation organisations. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 21(2).

   A reference to the standards adopted by the Commission shall be published.

6. Member States shall encourage establishments or undertakings which carry out treatment operations to introduce certified environmental management systems in accordance with Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS) ([23]).

Article 9
Permits

1. Member States shall ensure that any establishment or undertaking carrying out treatment operations obtains a permit from the competent authorities in compliance with Article 23 of Directive 2008/98/EC.

2. Exemptions from permit requirements, conditions for exemptions and registration shall be in compliance, respectively, with Articles 24, 25 and 26 of Directive 2008/98/EC.

3. Member States shall ensure that the permit or the registration referred to in paragraphs 1 and 2 includes all the conditions that are necessary for compliance with the requirements of Article 8(2), (3) and (5) and for the achievement of the recovery targets set out in Article 11.

Article 10
Shipments of WEEE

1. The treatment operation may also be undertaken outside the respective Member State or the Union provided that the shipment of WEEE is in compliance with Regulation (EC) No 1013/2006 and Commission Regulation (EC) No 1418/2007 of 29 November 2007 concerning the export for recovery of certain waste listed in Annex III or IIIA to Regulation (EC) No 1013/2006 of the European Parliament and of the Council to certain countries to which the OECD Decision on the control of transboundary movements of wastes does not apply ([24]).

2. WEEE exported out of the Union shall only count towards the fulfilment of obligations and targets set out in Article 11 of this Directive if, in compliance with Regulations (EC) No 1013/2006 and (EC) No 1418/2007, the exporter can prove that the treatment took place in conditions that are equivalent to the requirements of this Directive.

3. The Commission shall, not later than 14 February 2014, adopt delegated acts, in accordance with Article 20, laying down detailed rules supplementing those in paragraph 2 of this Article, in particular the criteria for the assessment of equivalent conditions.

Article 11
Recovery targets

1. Regarding all WEEE separately collected in accordance with Article 5 and sent for treatment in accordance with Articles 8, 9 and 10, Member States shall ensure that producers meet the minimum targets set out in Annex V.

2. The achievement of the targets shall be calculated, for each category, by dividing the weight of the WEEE that enters the recovery or recycling/preparing for re-use facility, after proper treatment in accordance with Article 8(2) with regard to recovery or recycling, by the weight of all separately collected WEEE for each category, expressed as a percentage.

   Preliminary activities including sorting and storage prior to recovery shall not count towards the achievement of these targets.

3. In order to ensure uniform conditions for the implementation of this Article, the Commission may adopt implementing acts establishing additional rules on the calculation methods for the application of the minimum targets. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 21(2).

4. Member States shall ensure that, for the purpose of calculating these targets, producers or third parties acting on their behalf keep records on the weight of WEEE, its components, materials or substances when leaving (output) the collection facility, entering (input) and leaving (output) the treatment facilities and when entering (input) the recovery or recycling/preparing for re-use facility.

   Member States shall also ensure that, for the purposes of paragraph 6, records on the weight of products and materials when leaving (output) the recovery or recycling/preparing for re-use facility are kept.

5. Member States shall encourage the development of new recovery, recycling and treatment technologies.

6. On the basis of a report of the Commission accompanied, if appropriate, by a legislative proposal, the European Parliament and the Council shall, by 14 August 2016, re-examine the recovery targets referred to in Annex V, Part 3, examine the possibility of setting separate targets for WEEE to be prepared for re-use and re-examine the calculation method referred to in paragraph 2 with a view to analysing the feasibility of setting targets on the basis of products and materials resulting (output) from the recovery, recycling and preparation for re-use processes.

Article 12

Financing in respect of WEEE from private households

1. Member States shall ensure that producers provide at least for the financing of the collection, treatment, recovery and environmentally sound disposal of WEEE from private households that has been deposited at collection facilities set up under Article 5(2).

2. Member States may, where appropriate, encourage producers to finance also the costs occurring for collection of WEEE from private households to collection facilities.

3. For products placed on the market later than 13 August 2005, each producer shall be responsible for financing the operations referred to in paragraph 1 relating to the waste from his own products. The producer may choose to fulfil this obligation either individually or by joining a collective scheme.

   Member States shall ensure that each producer provides a guarantee when placing a product on the market showing that the management of all WEEE will be financed and shall ensure that producers clearly mark their products in accordance with Article 15(2). This guarantee shall ensure that the operations referred to in paragraph 1 relating to this product will be financed. The guarantee may take the form of participation by the producer in appropriate schemes for the financing of the management of WEEE, a recycling insurance or a blocked bank account.

4. The responsibility for the financing of the costs of the management of WEEE from products placed on the market on or before 13 August 2005 ('historical waste') shall be borne by one or more systems to which all producers existing on the market when the respective costs occur contribute proportionately, e.g. in proportion to their respective share of the market by type of equipment.

5. Member States shall take the necessary measures to ensure that appropriate mechanisms or refund procedures are developed for the reimbursement of contributions to the producers where EEE is transferred for placing on the market outside the territory of the Member State concerned. Such mechanisms or procedures may be developed by producers or third parties acting on their behalf.

6. The Commission is invited to report, by 14 August 2015, on the possibility of developing criteria to incorporate the real end-of-life costs into the financing of WEEE by producers, and to submit a legislative proposal to the European Parliament and the Council if appropriate.

Article 13

Financing in respect of WEEE from users other than private households

1. Member States shall ensure that the financing of the costs for the collection, treatment, recovery and environmentally sound disposal of WEEE from users other than private households resulting from products placed on the market after 13 August 2005 is to be provided for by producers.

   For historical waste being replaced by new equivalent products or by new products fulfilling the same function, the financing of the costs shall be provided for by producers of those products when supplying them. Member States may, as an alternative, provide that users other than private households also be made, partly or totally, responsible for this financing.

   For other historical waste, the financing of the costs shall be provided for by the users other than private households.

2. Producers and users other than private households may, without prejudice to this Directive, conclude agreements stipulating other financing methods.

Article 14
Information for users

1. Member States may require producers to show purchasers, at the time of sale of new products, the costs of collection, treatment and disposal in an environmentally sound way. The costs mentioned shall not exceed the best estimate of the actual costs incurred.

2. Member States shall ensure that users of EEE in private households are given the necessary information about:

   a) The requirement not to dispose of WEEE as unsorted municipal waste and to collect such WEEE separately;
   b) The return and collection systems available to them, encouraging the coordination of information on the available collection points irrespective of the producers or other operators which have set them up;
   c) Their role in contributing to re-use, recycling and other forms of recovery of WEEE;
   d) The potential effects on the environment and human health as a result of the presence of hazardous substances in EEE;
   e) The meaning of the symbol shown in Annex IX.

3. Member States shall adopt appropriate measures so that consumers participate in the collection of WEEE and to encourage them to facilitate the process of re-use, treatment and recovery.

4. With a view to minimising the disposal of WEEE as unsorted municipal waste and to facilitating its separate collection, Member States shall ensure that producers appropriately mark — preferably in accordance with the European standard EN 50419 ([25]) — EEE placed on the market with the symbol shown in Annex IX. In exceptional cases, where this is necessary because of the size or the function of the product, the symbol shall be printed on the packaging, on the instructions for use and on the warranty of the EEE.

5. Member States may require that some or all of the information referred to in paragraphs 2, 3 and 4 shall be provided by producers and/or distributors, e.g. in the instructions for use, at the point of sale and through public awareness campaigns.

Article 15
Information for treatment facilities

1. In order to facilitate the preparation for re-use and the correct and environmentally sound treatment of WEEE, including maintenance, upgrade, refurbishment and recycling, Member States shall take the necessary measures to ensure that producers provide information free of charge about preparation for re-use and treatment in respect of each type of new EEE placed for the first time on the Union market within one year after the equipment is placed on the market. This information shall identify, as far as it is needed by centres which prepare for re-use and treatment and recycling facilities in order to comply with the provisions of this Directive, the different EEE components and materials, as well as the location of dangerous substances and mixtures in EEE. It shall be made available to centres which prepare for re-use and treatment and recycling facilities by producers of EEE in the form of manuals or by means of electronic media (e.g. CD-ROM, online services).

2. In order to enable the date upon which the EEE was placed on the market to be determined unequivocally, Member States shall ensure that a mark on the EEE specifies that the latter was placed on the market after 13 August 2005. Preferably, the European Standard EN 50419 shall be applied for this purpose.

Article 16
Registration, information and reporting

1. Member States shall, in accordance with paragraph 2, draw up a register of producers, including producers supplying EEE by means of distance communication. That register shall serve to monitor compliance with the requirements of this Directive.

   Producers supplying EEE by means of distance communication as defined in Article 3(1)(f)(iv) shall be registered in the Member State that they sell to. Where such producers are not registered in the Member State that they are selling to, they shall be registered through their authorised representatives as referred to in Article 17(2).
2. Member States shall ensure that:

   a) Each producer, or each authorised representative where appointed under Article 17, is registered as required and has the possibility of entering online in their national register all relevant information reflecting that producer's activities in that Member State;
   b) Upon registering, each producer, or each authorised representative where appointed under Article 17, provides the information set out in Annex X, Part A, undertaking to update it as appropriate;
   c) Each producer, or each authorised representative where appointed under Article 17, provides the information set out in Annex X, Part B;
   d) National registers provide links to other national registers on their website to facilitate, in all Member States, registration of producers or, where appointed under Article 17, authorised representatives.

3. In order to ensure uniform conditions for the implementation of this Article, the Commission shall adopt implementing acts establishing the format for registration and reporting and the frequency of reporting to the register. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 21(2).

4. Member States shall collect information, including substantiated estimates, on an annual basis, on the quantities and categories of EEE placed on their markets, collected through all routes, prepared for re-use, recycled and recovered within the Member State, and on separately collected WEEE exported, by weight.

5. Member States shall, at three-year intervals, send a report to the Commission on the implementation of this Directive and on the information set out in paragraph 4. The implementation report shall be drawn up on the basis of a questionnaire laid down in Commission Decisions 2004/249/EC ([26]) and 2005/369/EC ([27]). The report shall be made available to the Commission within nine months of the end of the three-year period covered by it.

   The first report shall cover the period from 14 February 2014 to 31 December 2015.

   The Commission shall publish a report on the implementation of this Directive within nine months after receiving the reports from the Member States.

Article 17
Authorised representative

1. Each Member State shall ensure that a producer as defined in Article 3(1)(f)(i) to (iii) established in another Member State is allowed, by way of exception to Article 3(1)(f)(i) to (iii), to appoint a legal or natural person established on its territory as the authorised representative that is responsible for fulfilling the obligations of that producer, pursuant to this Directive, on its territory.

2. Each Member State shall ensure that a producer as defined in Article 3(1)(f)(iv) and established on its territory, which sells EEE to another Member State in which it is not established, appoints an authorised representative in that Member State as the person responsible for fulfilling the obligations of that producer, pursuant to this Directive, on the territory of that Member State.

3. Appointment of an authorised representative shall be by written mandate.

Article 18

Administrative cooperation and exchange of information

Member States shall ensure that authorities responsible for implementing this Directive cooperate with each other, in particular to establish an adequate flow of information to ensure that producers comply with the provisions of this Directive and, where appropriate, provide each other and the Commission with information in order to facilitate the proper implementation of this Directive. The administrative cooperation and exchange of information, in particular between national registers, shall include electronic means of communication.

Cooperation shall include, inter alia, granting access to the relevant documents and information including the results of any inspections, subject to the provisions of the data protection law in force in the Member State of the authority which is requested to cooperate.

Article 19

Adaptation to scientific and technical progress

The Commission shall be empowered to adopt delegated acts in accordance with Article 20 concerning the amendments necessary in order to adapt Article 16(5) and Annexes IV, VII, VIII and IX to scientific and technical progress. When amending Annex VII, the exemptions granted under Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment ([28]) shall be taken into consideration.

Before the Annexes are amended, the Commission shall, inter alia, consult producers of EEE, recyclers, treatment operators and environmental organizations and employees' and consumer associations.

Article 20

Exercise of the delegation

1. The power to adopt delegated acts is conferred on the Commission subject to the conditions laid down in this Article.

2. The power to adopt delegated acts referred to in Article 7(4), Article 8(4), Article 10(3) and Article 19 shall be conferred on the Commission for a period of five years from 13 August 2012. The Commission shall draw up a report in respect of the delegation of power not later than nine months before the end of the five-year period. The delegation of power shall be tacitly extended for periods of an identical duration, unless the European Parliament or the Council opposes such extension not later than three months before the end of each period.

3. The delegation of power referred to in Article 7(4), Article 8(4), Article 10(3) and Article 19 may be revoked at any time by the European Parliament or by the Council. A decision to revoke shall put an end to the delegation of the power specified in that decision. It shall take effect the day following the publication of the decision in the *Official Journal of the European Union* or at a later date specified therein. It shall not affect the validity of any delegated acts already in force.

4. As soon as it adopts a delegated act, the Commission shall notify it simultaneously to the European Parliament and to the Council.

5. A delegated act adopted pursuant to Article 7(4), Article 8(4), Article 10(3) and Article 19 shall enter into force only if no objection has been expressed either by the European Parliament or the Council within a period of two months of notification of that act to the European Parliament and to the Council or if, before the expiry of that period, the European Parliament and the Council have both informed the Commission that they will not object. That period shall be extended by two months at the initiative of the European Parliament or of the Council.

Article 21

Committee procedure

1. The Commission shall be assisted by the Committee established by Article 39 of Directive 2008/98/EC. That committee shall be a committee within the meaning of Regulation (EU) No 182/2011.

2. Where reference is made to this paragraph, Article 5 of Regulation (EU) No 182/2011 shall apply.

Where the committee delivers no opinion, the Commission shall not adopt the draft implementing act and the third subparagraph of Article 5(4) of Regulation (EU) No 182/2011 shall apply.

Article 22
Penalties

The Member States shall lay down the rules on penalties applicable to infringements of the national provisions adopted pursuant to this Directive and shall take all measures necessary to ensure that they are implemented. The penalties provided for must be effective, proportionate and dissuasive. The Member States shall notify those provisions to the Commission by 14 February 2014 at the latest and shall notify it without delay of any subsequent amendment affecting them.

Article 23
Inspection and monitoring

1. Member States shall carry out appropriate inspections and monitoring to verify the proper implementation of this Directive. Those inspections shall at least cover:

   a) Information reported in the framework of the register of producers;
   b) Shipments, in particular exports of WEEE outside the Union in compliance with Regulation (EC) No 1013/2006 and Regulation (EC) No 1418/2007; and
   c) The operations at treatment facilities in accordance with Directive 2008/98/EC and Annex VII of this Directive.

2. Member States shall ensure that shipments of used EEE suspected to be WEEE are carried out in accordance with the minimum requirements in Annex VI and shall monitor such shipments accordingly.

3. The costs of appropriate analyses and inspections, including storage costs, of used EEE suspected to be WEEE may be charged to the producers, to third parties acting on their behalf or to other persons arranging the shipment of used EEE suspected to be WEEE.

4. In order to ensure uniform conditions for the implementation of this Article and of Annex VI, the Commission may adopt implementing acts establishing additional rules on inspections and monitoring and in particular uniform conditions for the implementation of Annex VI, point 2. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 21(2).

Article 24
Transposition

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 14 February 2014. They shall immediately communicate to the Commission the text of those provisions.

   When Member States adopt those provisions, they shall contain a reference to this Directive or shall be accompanied by such reference on the occasion of their official publication. They shall also include a statement that references in existing laws, regulations and administrative provisions to the directives repealed by this Directive shall be construed as references to this Directive. Member States shall determine how such reference is to be made and how that statement is to be formulated.

2. Member States shall communicate to the Commission the text of the main provisions of national law which they adopt in the field covered by this Directive.

3. Provided that the objectives set out in this Directive are achieved, Member States may transpose the provisions set out in Article 8(6), Article 14(2) and Article 15 by means of agreements between the competent authorities and the economic sectors concerned. Such agreements shall meet the following requirements:
   a) agreements shall be enforceable;
   b) agreements shall specify objectives with the corresponding deadlines;
   c) agreements shall be published in the national official journal or an official document equally accessible to the public and transmitted to the Commission;
   d) the results achieved shall be monitored regularly, reported to the competent authorities and the Commission and made available to the public under the conditions set out in the agreement;
   e) the competent authorities shall ensure that the progress achieved under the agreement is examined;
   f) in the case of non-compliance with the agreement, Member States must implement the relevant provisions of this Directive by legislative, regulatory or administrative measures.

Article 25
Repeal

Directive 2002/96/EC as amended by the Directives listed in Annex XI, Part A is repealed with effect from 15 February 2014, without prejudice to the obligations of the Member States relating to the time limits for transposition into national law and application of the Directives set out in Annex XI, Part B.

References to the repealed Directives shall be construed as references to this Directive and shall be read in accordance with the correlation table in Annex XII.

Article 26
Entry into force

This Directive shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

Article 27
Addressees

This Directive is addressed to the Member States.
Done at Strasbourg, 4 July 2012.

For the European Parliament
The President
M. SCHULZ
For the Council
The President
A. D. MAVROYIANNIS

(1) OJ C 306, 16.12.2009, p. 39.
(2) OJ C 141, 29.5.2010, p. 55.
(3) Position of the European Parliament of 3 February 2011 (not yet published in the Official Journal) and position of the Council at first reading of 19 July 2011 (not yet published in the Official Journal). Position of the European Parliament of 19 January 2012 (not yet published in the Official Journal) and decision of the Council of 7 June 2012.
(4) OJ L 37, 13.2.2003, p. 24.
(5) OJ C 138, 17.5.1993, p. 5.
(6) OJ L 312, 22.11.2008, p. 3.
(7) OJ L 285, 31.10.2009, p. 10.
(8) OJ L 37, 13.2.2003, p. 19.
(9) OJ L 266, 26.9.2006, p. 1.

(10) OJ L 286, 31.10.2009, p. 1.
(11) OJ L 161, 14.6.2006, p. 1.
(12) OJ L 190, 12.7.2006, p. 1.
(13) OJ L 24, 29.1.2008, p. 8.
(14) OJ L 118, 27.4.2001, p. 41.
(15) OJ L 143, 30.4.2004, p. 56.
(16) OJ L 55, 28.2.2011, p. 13.
(17) OJ C 369, 17.12.2011, p. 14.
(18) OJ L 396, 30.12.2006, p. 1.
(19) OJ L 144, 4.6.1997, p. 19.
(20) OJ L 169, 12.7.1993, p. 1.
(21) OJ L 331, 7.12.1998, p. 1.
(22) OJ L 189, 20.7.1990, p. 17.
(23) OJ L 342, 22.12.2009, p. 1.
(24) OJ L 316, 4.12.2007, p. 6.
(25) Adopted by Cenelec in March 2006.
(26) OJ L 78, 16.3.2004, p. 56.
(27) OJ L 119, 11.5.2005, p. 13.
(28) OJ L 174, 1.7.2011, p. 88.

ANNEX I

Categories of EEE covered by this Directive during the transitional period as provided for in Article 2(1)(a)

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer equipment and photovoltaic panels
5. Lighting equipment
6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)
7. Toys, leisure and sports equipment
8. Medical devices (with the exception of all implanted and infected products)
9. Monitoring and control instruments
10. Automatic dispensers

ANNEX II

Indicative list of EEE which falls within the categories of Annex I

1. LARGE HOUSEHOLD APPLIANCES

- Large cooling appliances
- Refrigerators
- Freezers
- Other large appliances used for refrigeration, conservation and storage of food
- Washing machines
- Clothes dryers
- Dish washing machines
- Cookers Electric stoves
- Electric hot plates
- Microwaves
- Other large appliances used for cooking and other processing of food
- Electric heating appliances
- Electric radiators
- Other large appliances for heating rooms, beds, seating furniture
- Electric fans
- Air conditioner appliances
- Other fanning, exhaust ventilation and conditioning equipment

2. SMALL HOUSEHOLD APPLIANCES

- Vacuum cleaners
- Carpet sweepers
- Other appliances for cleaning
- Appliances used for sewing, knitting, weaving and other processing for textiles
- Irons and other appliances for ironing, mangling and other care of clothing
- Toasters
- Fryers
- Grinders, coffee machines and equipment for opening or sealing containers or packages
- Electric knives
- Appliances for hair cutting, hair drying, tooth brushing, shaving, massage and other body care appliances
- Clocks, watches and equipment for the purpose of measuring, indicating or registering time
- Scales

3. IT AND TELECOMMUNICATIONS EQUIPMENT

- Centralized data processing:
  - Mainframes
  - Minicomputers
  - Printer units
- Personal computing:
  - Personal computers (CPU, mouse, screen and keyboard included)
  - Laptop computers (CPU, mouse, screen and keyboard included)
  - Notebook computers
  - Notepad computers
  - Printers
  - Copying equipment
  - Electrical and electronic typewriters

- Pocket and desk calculators and other products and equipment for the collection, storage, processing, presentation or communication of information by electronic means
- User terminals and systems
- Facsimile machine (fax)
- Telex
- Telephones
- Pay telephones
- Cordless telephones
- Cellular telephones
- Answering systems and other products or equipment of transmitting sound, images or other information by telecommunications

4. CONSUMER EQUIPMENT AND PHOTOVOLTAIC PANELS

- Radio sets
- Television sets
- Video cameras
- Video recorders
- Hi-fi recorders
- Audio amplifiers
- Musical instruments and other products or equipment for the purpose of recording or reproducing sound or images, including signals or other technologies for the distribution of sound and image than by telecommunications
- Photovoltaic panels

5. LIGHTING EQUIPMENT

- Luminaires for fluorescent lamps with the exception of luminaires in households
- Straight fluorescent lamps
- Compact fluorescent lamps
- High intensity discharge lamps, including pressure sodium lamps and metal halide lamps
- Low pressure sodium lamps
- Other lighting or equipment for the purpose of spreading or controlling light with the exception of filament bulbs

6. ELECTRICAL AND ELECTRONIC TOOLS (WITH THE EXCEPTION OF LARGE-SCALE STATIONARY INDUSTRIAL TOOLS)

- Drills
- Saws
- Sewing machines
- Equipment for turning, milling, sanding, grinding, sawing, cutting, shearing, drilling, making holes, punching, folding, bending or similar processing of wood, metal and other materials
- Tools for riveting, nailing or screwing or removing rivets, nails, screws or similar uses
- Tools for welding, soldering or similar use
- Equipment for spraying, spreading, dispersing or other treatment of liquid or gaseous substances by other means
- Tools for mowing or other gardening activities

7. TOYS, LEISURE AND SPORTS EQUIPMENT

- Electric trains or car racing sets
- Hand-held video game consoles
- Video games

- Computers for biking, diving, running, rowing, etc.
- Sports equipment with electric or electronic components
- Coin slot machines

8. MEDICAL DEVICES (WITH THE EXCEPTION OF ALL IMPLANTED AND INFECTED PRODUCTS)

- Radiotherapy equipment
- Cardiology equipment
- Dialysis equipment
- Pulmonary ventilators
- Nuclear medicine equipment
- Laboratory equipment for in vitro diagnosis
- Analysers
- Freezers
- Fertilization tests
- Other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability

9. MONITORING AND CONTROL INSTRUMENTS

- Smoke detector
- Heating regulators
- Thermostats
- Measuring, weighing or adjusting appliances for household or as laboratory equipment
- Other monitoring and control instruments used in industrial installations (e.g. in control panels)

10. AUTOMATIC DISPENSERS

- Automatic dispensers for hot drinks
- Automatic dispensers for hot or cold bottles or cans
- Automatic dispensers for solid products
- Automatic dispensers for money
- All appliances which deliver automatically all kinds of products

ANNEX III

CATEGORIES OF EEE COVERED BY THIS DIRECTIVE

1. Temperature exchange equipment
2. Screens, monitors, and equipment containing screens having a surface greater than 100 cm^2
3. Lamps
4. Large equipment (any external dimension more than 50 cm) including, but not limited to:
   Household appliances; IT and telecommunication equipment; consumer equipment; luminaires; equipment reproducing sound or images, musical equipment; electrical and electronic tools; toys, leisure and sports equipment; medical devices; monitoring and control instruments; automatic dispensers; equipment for the generation of electric currents. This category does not include equipment included in categories 1 to 3.
5. Small equipment (no external dimension more than 50 cm) including, but not limited to:
   Household appliances; consumer equipment; luminaires; equipment reproducing sound or images, musical equipment; electrical and electronic tools; toys, leisure and sports equipment; medical devices; monitoring and control instruments; automatic dispensers; equipment for the generation of electric currents. This category does not include equipment included in categories 1 to 3 and 6.
6. Small IT and telecommunication equipment (no external dimension more than 50 cm)

ANNEX IV

Non-exhaustive list of EEE which falls within the categories listed in Annex III

1. Temperature exchange equipment

Refrigerators, Freezers, Equipment which automatically delivers cold products, Air conditioning equipment, Dehumidifying equipment, Heat pumps, Radiators containing oil and other temperature exchange equipment using fluids other than water for the temperature exchange.

2. Screens, monitors, and equipment containing screens having a surface greater than 100 cm^2

Screens, Televisions, LCD photo frames, Monitors, Laptops, Notebooks.

3. Lamps

Straight fluorescent lamps, Compact fluorescent lamps, Fluorescent lamps, High intensity discharge lamps - including pressure sodium lamps and metal halide lamps, Low pressure sodium lamps, LED.

4. Large equipment

Washing machines, Clothes dryers, Dish washing machines, Cookers, Electric stoves, Electric hot plates, Luminaires, Equipment reproducing sound or images, Musical equipment (excluding pipe organs installed in churches), Appliances for knitting and weaving, Large computer-mainframes, Large printing machines, Copying equipment, Large coin slot machines, Large medical devices, Large monitoring and control instruments, Large appliances which automatically deliver products and money, Photovoltaic panels.

5. Small equipment

Vacuum cleaners, Carpet sweepers, Appliances for sewing, Luminaires, Microwaves, Ventilation equipment, Irons, Toasters, Electric knives, Electric kettles, Clocks and Watches, Electric shavers, Scales, Appliances for hair and body care, Calculators, Radio sets, Video cameras, Video recorders, Hi-fi equipment, Musical instruments, Equipment reproducing sound or images, Electrical and electronic toys, Sports equipment, Computers for biking, diving, running, rowing, etc., Smoke detectors, Heating regulators, Thermostats, Small Electrical and electronic tools, Small medical devices, Small Monitoring and control instruments, Small Appliances which automatically deliver products, Small equipment with integrated photovoltaic panels.

6. Small IT and telecommunication equipment (no external dimension more than 50 cm)

Mobile phones, GPS, Pocket calculators, Routers, Personal computers, Printers, Telephones.

ANNEX V

MINIMUM RECOVERY TARGETS REFERRED TO IN ARTICLE 11

Part 1: Minimum targets applicable by category from 13 August 2012 until 14 August 2015 with reference to the categories listed in Annex I:

a) for WEEE falling within category 1 or 10 of Annex I,
   - 80 % shall be recovered, and
   - 75 % shall be recycled;
b) for WEEE falling within category 3 or 4 of Annex I,
   - 75 % shall be recovered, and
   - 65 % shall be recycled;
c) for WEEE falling within category 2, 5, 6, 7, 8 or 9 of Annex I,
   - 70 % shall be recovered, and
   - 50 % shall be recycled;
d) for gas discharge lamps, 80 % shall be recycled.

Part 2: Minimum targets applicable by category from 15 August 2015 until 14 August 2018 with reference to the categories listed in Annex I:

a) for WEEE falling within category 1 or 10 of Annex I,
   - 85 % shall be recovered, and
   - 80 % shall be prepared for re-use and recycled;
b) for WEEE falling within category 3 or 4 of Annex I,
   - 80 % shall be recovered, and
   - 70 % shall be prepared for re-use and recycled;
c) for WEEE falling within category 2, 5, 6, 7, 8 or 9 of Annex I,
   - 75 % shall be recovered, and
   - 55 % shall be prepared for re-use and recycled;
d) for gas discharge lamps, 80 % shall be recycled.

Part 3: Minimum targets applicable by category from 15 August 2018 with reference to the categories listed in Annex III:

a) for WEEE falling within category 1 or 4 of Annex III,
   - 85 % shall be recovered, and
   - 80 % shall be prepared for re-use and recycled;
b) for WEEE falling within category 2 of Annex III,
   - 80 % shall be recovered, and
   - 70 % shall be prepared for re-use and recycled;
c) for WEEE falling within category 5 or 6 of Annex III,
   - 75 % shall be recovered, and
   - 55 % shall be prepared for re-use and recycled;
d) for WEEE falling within category 3 of Annex III, 80 % shall be recycled.

ANNEX VI

MINIMUM REQUIREMENTS FOR SHIPMENTS

1. In order to distinguish between EEE and WEEE, where the holder of the object claims that he intends to ship or is shipping used EEE and not WEEE, Member States shall require the holder to have available the following to substantiate this claim:
   a) A copy of the invoice and contract relating to the sale and/or transfer of ownership of the EEE which states that the equipment is destined for direct re-use and that it is fully functional;
   b) Evidence of evaluation or testing in the form of a copy of the records (certificate of testing, proof of functionality) on every item within the consignment and a protocol containing all record information according to point 3;
   c) A declaration made by the holder who arranges the transport of the EEE that none of the material or equipment within the consignment is waste as defined by Article 3(1) of Directive 2008/98/EC; and
   d) Appropriate protection against damage during transportation, loading and unloading in particular through sufficient packaging and appropriate stacking of the load.

2. By way of derogation, point 1(a) and (b) and point 3 do not apply where it is documented by conclusive proof that the shipment is taking place in the framework of a business-to-business transfer agreement and that:
   a) The EEE is sent back to the producer or a third party acting on his behalf as defective for repair under warranty with the intention of re-use; or
   b) The used EEE for professional use is sent to the producer or a third party acting on his behalf or a third-party facility in countries to which Decision C(2001)107/Final of the OECD Council concerning the revision of Decision C(92)39/Final on control of transboundary movements of wastes destined for recovery operations applies, for refurbishment or repair under a valid contract with the intention of re-use; or
   c) The defective used EEE for professional use, such as medical devices or their parts, is sent to the producer or a third party acting on his behalf for root cause analysis under a valid contract, in cases where such an analysis can only be conducted by the producer or third parties acting on his behalf.

3. In order to demonstrate that the items being shipped constitute used EEE rather than WEEE, Member States shall require the following steps for testing and record keeping for used EEE to be carried out:

   Step 1: Testing
   a) Functionality shall be tested and the presence of hazardous substances shall be evaluated. The tests to be conducted depend on the kind of EEE. For most of the used EEE a functionality test of the key functions is sufficient.
   b) Results of evaluation and testing shall be recorded.

   Step 2: Record
   a) The record shall be fixed securely but not permanently on either the EEE itself (if not packed) or on the packaging so it can be read without unpacking the equipment.
   b) The record shall contain the following information:
      - Name of item (name of the equipment if listed in Annex II or Annex IV, as appropriate, and category set out in Annex I or Annex III, as appropriate),
      - Identification number of the item (type No) where applicable,
      - Year of production (if available),
      - Name and address of the company responsible for evidence of functionality,
      - Result of tests as described in step 1 (including date of the functionality test),
      - Kind of tests performed.

4. In addition to the documentation requested in points 1, 2 and 3, every load (e.g. shipping container, lorry) of used EEE shall be accompanied by:
   a) A relevant transport document, e.g. CMR or waybill;
   b) A declaration by the liable person on its responsibility.

5. In the absence of proof that an object is used EEE and not WEEE through the appropriate documentation required in points 1, 2, 3 and 4 and of appropriate protection against damage during transportation, loading and unloading in particular through sufficient packaging and appropriate stacking of the load, which are the obligations of the holder who arranges the transport, Member State authorities shall consider that an item is WEEE and presume that the load comprises an illegal shipment. In these circumstances the load will be dealt with in accordance with Articles 24 and 25 of Regulation (EC) No 1013/2006.

ANNEX VII

Selective treatment for materials and components of waste electrical and electronic equipment referred to in Article 8(2)

1. As a minimum the following substances, mixtures and components have to be removed from any separately collected WEEE:
   - Polychlorinated biphenyls (PCB) containing capacitors in accordance with Council Directive 96/59/EC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT) (1),
   - Mercury containing components, such as switches or backlighting lamps,
   - Batteries,
   - Printed circuit boards of mobile phones generally, and of other devices if the surface of the printed circuit board is greater than 10 square centimeters,
   - Toner cartridges, liquid and paste, as well as colour toner,
   - Plastic containing brominated flame retardants,
   - Asbestos waste and components which contain asbestos,
   - Cathode ray tubes,
   - Chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC) or hydrofluorocarbons (HFC), hydrocarbons (HC),
   - Gas discharge lamps,
   - Liquid crystal displays (together with their casing where appropriate) of a surface greater than 100 square centimetres and all those back-lighted with gas discharge lamps,
   - External electric cables,
   - Components containing refractory ceramic fibres as described in Commission Directive 97/69/EC of 5 December 1997 adapting to technical progress for the 23rd time Council Directive 67/548/EEC on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances (2),
   - Components containing radioactive substances with the exception of components that are below the exemption thresholds set in Article 3 of and Annex I to Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation (3),
   - Electrolyte capacitors containing substances of concern (height > 25 mm, diameter > 25 mm or proportionately similar volume).

These substances, mixtures and components shall be disposed of or recovered in compliance with Directive 2008/98/EC.

2. The following components of WEEE that is separately collected have to be treated as indicated:
   - Cathode ray tubes: the fluorescent coating has to be removed,
   - Equipment containing gases that are ozone depleting or have a global warming potential (GWP) above 15, such as those contained in foams and refrigeration circuits: the gases must be properly extracted and properly treated. Ozone-depleting gases must be treated in accordance with Regulation (EC) No 1005/2009,
   - Gas discharge lamps: the mercury shall be removed.

3. Taking into account environmental considerations and the desirability of preparation for re-use and recycling, points 1 and 2 shall be applied in such a way that environmentally-sound preparation for re-use and recycling of components or whole appliances is not hindered.

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(1) OJ L 243, 24.9.1996, p. 31.
(2) OJ L 343, 13.12.1997, p. 19.
(3) OJ L 159, 29.6.1996, p. 1.

ANNEX VIII

TECHNICAL REQUIREMENTS REFERRED TO IN ARTICLE 8(3)

1. Sites for storage (including temporary storage) of WEEE prior to its treatment (without prejudice to the requirements of Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste ([1])):
   - Impermeable surfaces for appropriate areas with the provision of spillage collection facilities and, where appropriate, decanters and cleanser-degreasers,
   - Weatherproof covering for appropriate areas.

2. Sites for treatment of WEEE:
   - Scales to measure the weight of the treated waste,
   - Impermeable surfaces and waterproof covering for appropriate areas with the provision of spillage collection facilities and, where appropriate, decanters and cleanser-degreasers,
   - Appropriate storage for disassembled spare parts,
   - Appropriate containers for storage of batteries, PCBs/PCTs containing capacitors and other hazardous waste such as radioactive waste,
   - Equipment for the treatment of water in compliance with health and environmental regulations.

([1]) OJ L 182, 16.7.1999, p. 1.

ANNEX IX

SYMBOL FOR THE MARKING OF EEE

The symbol indicating separate collection for EEE consists of the crossed-out wheeled bin, as shown below. The symbol must be printed visibly, legibly and indelibly.

ANNEX X

INFORMATION FOR REGISTRATION AND REPORTING REFERRED TO IN ARTICLE 16

A. Information to be submitted upon registration:

1. Name and address of the producer or of the authorized representative where appointed under Article 17 (postal code and location, street name and number, country, telephone and fax number, e-mail, as well as a contact person). In the case of an authorized representative as defined in Article 17, also the contact details of the producer that is represented.
2. National identification code of the producer, including European tax number or national tax number of the producer.
3. Category of EEE set out in Annex I or III, as appropriate.
4. Type of EEE (household or other than household equipment).
5. Brand name of EEE.
6. Information on how the producer meets its responsibilities: individual or collective scheme, including information on financial guarantee.
7. Selling technique used (e.g. distance selling).
8. Declaration stating that the information provided is true.

B. Information to be submitted for reporting:

1. National identification code of the producer.
2. Reporting period.
3. Category of EEE set out in Annex I or III, as appropriate.
4. Quantity of EEE placed on the national market, by weight.
5. Quantity, by weight, of waste of EEE separately collected, recycled (including prepared for re-use), recovered and disposed of within the Member State or shipped within or outside the Union.

Note: information set out in points 4 and 5 must be given by category.

ANNEX XI

PART A

Repealed Directive with its successive amendments
(referred to in Article 25)

Directive 2002/96/EC on waste electrical and electronic equipment (WEEE)	(OJ L 37, 13.2.2003, p. 24)
Directive 2003/108/EC of the European Parliament and of the Council	(OJ L 345, 31.12.2003, p. 106)
Directive 2008/34/EC of the European Parliament and of the Council	(OJ L 81, 20.3.2008, p. 65)

PART B

List of time limits for transposition into national law
(referred to in Article 25)

Directive	Deadline for transposition
2002/96/EC	13 August 2004
2003/108/EC	13 August 2004
2008/34/EC	—

ANNEX XII

CORRELATION TABLE

Directive 2002/96/EC	This Directive
Article 1	—
—	Article 1
Article 2(1)	Article 2(1)
Article 2(2)	Article 2(2)
Article 2(3)	Article 2(3)(a)
Article 2(1) (partly)	Article 2(3)(b)
Annex IB, point 5, last item	Article 2(3)(c)
Annex IB, point 8	Article 2(4)(g)
—	Article 2(4)(a) to (f) and 2(5)
Article 3(a)	Article 3(1)(a)
—	Article 3(1)(b) to (d)
Article 3(b)	Article 3(1)(e)
Article 3(c) to (h)	Article 3(2)
Article 3(i)	Article 3(1)(f)
Article 3(j)	Article 3(1)(g)
Article 3(k)	Article 3(1)(h)
Article 3(l)	—
Article 3(m)	Article 3(1)(i)
—	Article 3(1)(j) to (o)
Article 4	Article 4
Article 5(1) to (2)	Article 5(1) to (2)
—	Article 5(3) to (4)
Article 5(3)	Article 5(5)
—	Article 6(1)
Article 5(4)	Article 6(2)
Article 5(5)	Article 7(1) and (2)
—	Article 8(1)
Article 6(1), first and second subparagraphs, and (3)	Article 8(2), (3) and (4)
Annex II(4)	Article 8(4), second subparagraph, first sentence
Article 6(1), third subparagraph	Article 8(5)
Article 6(6)	Article 8(6)
Article 6(2)	Article 9(1) and (2)
Article 6(4)	Article 9(3)
Article 6(5)	Article 10(1) and (2)
—	Article 10(3)
Article 7(1)	—
Article 7(2)	Article 11(1) and Annex V
—	Article 11(2)
—	Article 11(3)
Article 7(3), first subparagraph	Article 11(4)
Article 7(3), second subparagraph	—
Article 7(4)	—
Article 7(5)	Article 11(5)
—	Article 11(6)

Article 8(1)	Article 12(1)
—	Article 12(2)
Article 8(2), first and second subparagraphs	Article 12(3)
Article 8(2), third subparagraph	Article 14(1) (partly)
Article 8(3), first subparagraph	Article 12(4)
—	Article 12(5)
Article 8(3), second subparagraph	Article 14(1) (partly)
Article 8(4)	—
Article 9(1), first subparagraph	Article 13(1), first subparagraph
Article 9(1), second subparagraph	—
Article 9(1), third subparagraph	Article 13(1), second subparagraph
Article 9(1), fourth subparagraph	Article 13(1), third subparagraph
Article 9(2)	Article 13(2)
Article 10(1)	Article 14(2)
Article 10(2)	Article 14(3)
Article 10(3)	Article 14(4)
Article 10(4)	Article 14(5)
Article 11	Article 15
Article 12(1) (partly)	Article 16(1) to (3)
Article 12(1), first subparagraph (partly)	Article 16(4)
Article 12(1), second subparagraph	Article 16(1) and (2) and Article 17(2) and (3)
Article 12(1), third subparagraph	Article 16(3) and (5)
—	Article 17(1)
Article 12(1), fourth subparagraph	Article 18
Article 12(2)	Article 16(5)
Article 13	Article 19
—	Article 20
Article 14	Article 21
Article 15	Article 22
Article 16	Article 23(1)
—	Article 23(2) to (4)
Article 17(1) to (3)	Article 24(1) to (3)
Article 17(4)	Article 7(3)
Article 17(5)	Article 7(4) to (7), Article 11(6) and Article 12(6)
—	Article 25
Article 18	Article 26
Article 19	Article 27
Annex IA	Annex I
Annex IB	Annex II
—	Annexes III, IV and VI
Annexes II to IV	Annexes VII to IX
—	Annexes X and XI
—	Annex XII

[PUBLISHED IN THE GAZETTE OF INDIA, EXTRAORDINARY PART-II, SECTION-3, SUB-SECTION (i)]

GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

NOTIFICATION

New Delhi, the 23rd March, 2016

G.S.R 338(E). - Whereas the draft rules, namely the e-waste (Management) Rules, 2015, were published by the Government of India in the Ministry of Environment, Forest and Climate Change *vide* number G.S.R. 472(E), dated the 10th June, 2015 in the Gazette of India, Extraordinary Part II, section 3, sub-section (ii) inviting objections and suggestions from all persons likely to be affected thereby, before the expiry of the period of sixty days from the date on which copies of the Gazette containing the said notification were made available to the public;

AND WHEREAS the copies of the Gazette containing the said notification were made available to the public on the 10th day of June, 2015;

AND WHEREAS the objections and suggestions received within the specified period from the public in respect of the said draft rules have been duly considered by the Central Government;

NOW, THEREFORE, in exercise of the powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), and in supersession of the e- waste (Management and Handling) Rules, 2011, published in the Gazette of India, section 3, sub-section (ii), *vide* number S.O. 1035(E), dated the 12th May, 2011, except as respects things done or omitted to be done before such supersession, the Central Government hereby makes the following rules, namely:-

CHAPTER 1: PRELIMINARY

1. Short title and commencement. –

a) These rules may be called the E-Waste (Management) Rules, 2016.

b) They shall come into force from the 1st day of October, 2016.

2. Application. - These rules shall apply to every manufacturer, producer, consumer, bulk consumer, collection centers, dealers, e-retailer, refurbished**,** dismantler and recycler involved in manufacture, sale, transfer, purchase, collection, storage and processing of e-waste or electrical and electronic equipment listed in Schedule I, including their components, consumables, parts and spares which make the product operational but shall not apply to -

a. Used lead acid batteries as covered under the Batteries (Management and Handling) Rules, 2001 made under the Act;
b. Micro enterprises as defined in the Micro, Small and Medium Enterprises Development Act, 2006 (27 of 2006); and
c. Radio-active wastes as covered under the provisions of the Atomic Energy Act, 1962 (33 of 1962) and rules made there under.

3. Definitions. – (1) In these rules, unless the context otherwise requires, -

- 'Act' means the Environment (Protection) Act, 1986 (29 of 1986);
- 'authorisation' means permission for generation, handling, collection, reception, storage, transportation, refurbishing, dismantling, recycling, treatment and disposal of e-waste, granted to manufacturer, dismantler, refurbisher and recycler;
- 'bulk consumer' means bulk users of electrical and electronic equipment such as Central Government or State Government Departments, public sector undertakings, banks, educational institutions, multinational organisations, international agencies, partnership and public or private companies that are registered under the Factories Act, 1948 (63 of 1948) and the Companies Act, 2013 (18 of 2013) and health care facilities which have turnover of more than one crore or have more than twenty employees;
- 'Central Pollution Control Board' means the Central Pollution Control Board constituted under sub-section (1) of section 3 of the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974);
- 'collection centre' means a centre or a collection point or both established by producer individually or as association jointly to collect e-waste for channelizing the e-waste to recycler and play such role as indicated in the authorization for Extended Producer Responsibility granted to the producer and having facilities as per the guidelines of Central Pollution Control Board, including the collection centre established by the dismantler or refurbisher or recycler which should be a part of their authorization issued by the State Pollution Control Board where the facility exists;
- 'component' means one of the parts of a sub-assembly or assembly of which a manufactured product is made up and into which it may be resolved and includes an accessory or attachment to another component;
- 'consumables' means an item, which participates in or is required for a manufacturing process or for functioning of the electrical and electronic equipment and may or may not form part of end-product. Items, which are substantially or totally consumed during a manufacturing process, shall be deemed to be consumables;
- 'consumer' means any person using electrical and electronic equipment excluding the bulk consumers;
- 'Channelization' means to direct the path for movement of e-wastes from collection onwards to authorized dismantler or recycler. In case of fluorescent and other mercury containing lamps, where recyclers are not available, this means path for movement from collection centre to Treatment, Storage and Disposal Facility;
- 'dealer' means any individual or firm that buys or receives electrical and electronic equipment as listed in Schedule I of these rules and their components or consumables or parts or spares

from producers for sale;

- 'deposit refund scheme' means a scheme whereby the producer charges an additional amount as a deposit at the time of sale of the electrical and electronic equipment and returns it to the consumer along with interest when the end-of- life electrical and electronic equipment is returned;
- 'dismantler' means any person or organisation engaged in dismantling of used electrical and electronic equipment into their components and having facilities as per the guidelines of Central Pollution Control Board and having authorisation from concerned State Pollution Control Board;
- 'disposal' means any operation which does not lead to recycling, recovery or reuse and includes physico-chemical or biological treatment, incineration and deposition in secured landfill;
- 'end-of-life' of the product means the time when the product is intended to be discarded by the user;
- 'environmentally sound management of e-waste' means taking all steps required to ensure that e-waste is managed in a manner which shall protect health and environment against any adverse effects, which may result from such e-waste;
- 'electrical and electronic equipment' means equipment which are dependent on electric current or electro-magnetic field in order to become functional;
- 'e-retailer' means an individual or company or business entity that uses an electronic network such as internet, telephone, to sell its goods;
- 'e-waste' means electrical and electronic equipment**,** whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment and repair processes;
- 'e-waste exchange' means an independent market instrument offering assistance or independent electronic systems offering services for sale and purchase of e-waste generated from end-of-life electrical and electronic equipment between agencies or organisations authorised under these rules;
- 'Extended Producer Responsibility' means responsibility of any producer of electrical or electronic equipment, for channelisation of e-waste to ensure environmentally sound management of such waste. Extended Producer Responsibility may comprise of implementing take back system or setting up of collection centres or both and having agreed arrangements with authorised dismantler or recycler either individually or collectively through a Producer Responsibility Organisation recognised by producer or producers in their Extended Producer Responsibility - Authorisation;
- 'Extended Producer Responsibility - Authorisation' means a permission given by Central Pollution Control Board to a producer, for managing Extended Producer Responsibility with implementation plans and targets outlined in such authorisation including detail of Producer Responsibility Organisation and e-waste exchange, if applicable;
- 'Extended Producer Responsibility Plan' means a plan submitted by a producer to Central Pollution Control Board, at the time of applying for Extended Producer Responsibility - Authorisation in which a producer shall provide details of e-waste channelisation system for targeted collection including detail of Producer Responsibility Organisation and e-waste exchange, if applicable;
- 'facility' means any location wherein the process incidental to the collection, reception, storage, segregation, refurbishing, dismantling, recycling, treatment and disposal of e-waste are carried out;
- 'Form' means a form appended to these rules;
- 'historical e-waste' means e-waste generated from electrical and electronic equipment as specified in Schedule I, which was available on the date from which these rules come into force;
- 'manufacturer' means a person or an entity or a company as defined in the Companies Act, 2013 (18 of 2013) or a factory as defined in the Factories Act, 1948 (63 of 1948) or Small and Medium Enterprises as defined in Micro, Small and Medium Enterprises Development Act, 2006 (27 of 2006), which has facilities for manufacture of electrical and electronic equipment;
- 'orphaned products' means non-branded or assembled electrical and electronic equipment as specified in Schedule I or those produced by a company, which has closed its operations;
- 'part' means an element of a sub-assembly or assembly not normally useful by itself, and not amenable to further disassembly for maintenance purposes. A part may be a component, spare or an accessory;
- 'producer' means any person who, irrespective of the selling technique used such as dealer, retailer, e-retailer, etc.;
    a) Manufactures and offers to sell electrical and electronic equipment and their components or consumables or parts or spares under its own brand; or

b) offers to sell under its own brand, assembled electrical and electronic equipment and their components or consumables or parts or spares produced by other manufacturers or suppliers; or
c) offers to sell imported electrical and electronic equipment and their components or consumables or parts or spares;

- 'Producer Responsibility Organisation' means a professional organisation authorised or financed collectively or individually by producers, which can take the responsibility for collection and channelisation of e-waste generated from the 'end-of-life' of their products to ensure environmentally sound management of such e-waste;
- 'recycler' - means any person who is engaged in recycling and reprocessing of waste electrical and electronic equipment or assemblies or their components and having facilities as elaborated in the guidelines of Central Pollution Control Board;
- 'refurbishment' means repairing of used electrical and electronic equipment as listed in Schedule I for extending its working life for its originally intended use and selling the same in the market or returning to owner;
- 'refurbisher' for the purpose of these rules, means any company or undertaking registered under the Factories Act, 1948 or the Companies Act, 1956 or both or district industries centre engaged in refurbishment of used electrical and electronic equipment;
- 'Schedule' means the Schedule appended to these rules;
- "spares" means a part or a sub-assembly or assembly for substitution which is ready to replace an identical or similar part or sub-assembly or assembly including a component or an accessory;
  a) 'State Government in relation to an Union territory means, the Administrator thereof appointed under article 239 of the Constitution;
- 'State Pollution Control Board' means the concerned State Pollution Control Board or the Pollution Control Committee of the Union Territories constituted under sub-section (1) of section 4 of the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974);
- 'target' means the quantity of e-waste to be collected by the producer in fulfilment of Extended Producer Responsibility;
- 'transporter' means a person or company or entity engaged in the off-site transportation of e-waste by air, rail, road or water carrying a manifest system issued by the person or company or entity who has handed over the e-waste to the transporter, giving the origin, destination and quantity of the e-waste being transported;

(2) Words and expressions used in these rules and not defined but defined in the Act shall have the meanings respectively assigned to them in the Act.

CHAPTER 2: RESPONSIBILITIES

4. Responsibilities of the manufacturer. - (1) collect e-waste generated during the manufacture of any electrical and electronic equipment and channelise it for recycling or disposal;

(2) apply for an authorisation in Form 1 (a) in accordance with the procedure prescribed under sub-rule (2) of rule 13 from the concerned State Pollution Control Board, which shall give the authorisation in accordance with Form 1 (bb);

(3) ensure that no damage is caused to the environment during storage and transportation of e-waste;

(4) maintain records of the e-waste generated, handled and disposed in Form-2 and make such records available for scrutiny by the concerned State Pollution Control Board;

(5) file annual returns in Form-3, to the concerned State Pollution Control Board on or before the 30th day of June following the financial year to which that return relates.

5. Responsibilities of the producer. - The producer of electrical and electronic equipment listed in Schedule I shall be responsible for -

(1) implementing the Extended Producers Responsibility with the following frameworks, namely:-

(a) collection and channelisation of e-waste generated from the 'end-of-life' of their products or 'end-of-life' products with same electrical and electronic equipment code and historical waste available on the date from which these rules come into force as per Schedule I in line with the targets prescribed in Schedule III in Extended Producer Responsibility - Authorisation;

(b) the mechanism used for channelisation of e-waste from 'end-of-life' products including those from their service centres to authorised dismantler or recycler shall be in accordance with the Extended Producer Responsibility - Authorisation. In cases of fluorescent and other mercury containing lamps, where recyclers are not available, channelisation may be from collection centre to Treatment, Storage and Disposal Facility;

(c) for disposal in Treatment, Storage and Disposal Facility, a pre-treatment is necessary to immobilise the mercury and reduce the volume of waste to be disposed off;

(d) Extended Producer Responsibility - Authorisation should comprise of general scheme for collection of waste Electrical and Electronic Equipment from the Electrical and Electronic Equipment placed on the market earlier, such as through dealer, collection centres, Producer Responsibility Organisation, through buy-back arrangement, exchange scheme, Deposit Refund System, etc. whether directly or through any authorised agency and channelising the items so collected to authorised recyclers;

(e) providing contact details such as address, e-mail address, toll-free telephone numbers or helpline numbers to consumer(s) or bulk consumer(s) through their website and product user documentation so as to facilitate return of end-of-life
electrical and electronic equipment;

(f) creating awareness through media, publications, advertisements, posters, or by any other means of communication and product user documentation accompanying the equipment, with regard to -

(i) information on address, e-mail address, toll-free telephone numbers or helpline numbers and web site;
(ii) information on hazardous constituents as specified in sub-rule 1 of rule 16 in electrical and electronic equipment;
(iii) information on hazards of improper handling, disposal, accidental breakage, damage or improper recycling of e-waste;
(iv) instructions for handling and disposal of the equipment after its use, along with the Do's and Don'ts;
(v) affixing a visible, legible and indelible symbol given below on the products or product user documentation to prevent e-waste from being dropped in garbage bins containing waste destined for disposal;

(vi) means and mechanism available for their consumers to return e-waste for recycling including the details of Deposit Refund Scheme, if applicable;

(g) the producer shall opt to implement Extended Producer Responsibility individually or collectively. In individual producer responsibility, producer may set up his own collection centre or implement take back system or both to meet Extended Producer Responsibility. In collective system, producers may tie-up as a member with a Producer Responsibility Organisation or with e-waste exchange or both. It shall be mandatory upon on the individual producer in every case to seek Extended Producer Responsibility - Authorisation from Central Pollution Control Board in accordance with the Form-1 and the procedure laid down in sub-rule (1) of rule 13;

(2) to provide information on the implementation of Deposit Refund Scheme to ensure collection of end-of-life products and their channelisation to authorised dismantlers or recyclers, if such scheme is included in the Extended Producer Responsibility Plan.
Provided that the producer shall refund the deposit amount that has been taken from the consumer or bulk consumer at the time of sale, along with interest at the prevalent rate for the period of the deposit at the time of take back of the end-of- life product;

(3) the import of electrical and electronic equipment shall be allowed only to producers having Extended Producer Responsibility authorisation;

(4) maintaining records in Form-2 of the e-waste handled and make such records available for scrutiny by the Central Pollution Control Board or the concerned State Pollution Control Board;

(5) filing annual returns in Form-3, to the Central Pollution Control Board on or before the 30th day of June following the financial year to which that return relates. In case of the Producer with multiple offices in a State, one annual return combining information from all the offices shall be filed;

(6) the Producer shall apply to the Central Pollution Control Board for authorisation in Form 1, which shall thereafter grant the Extended Producer Responsibility - Authorisation in Form 1(aa).

(7) Operation without Extended Producer Responsibility-Authorisation by any producer, as defined in this rule, shall be considered as causing damage to the environment.

6. Responsibilities of collection centres. - (1) collect e-waste on behalf of producer or dismantler or recycler or refurbisher including those arising from orphaned products;
Provided the collection centres established by producer can also collect e-waste on behalf of dismantler, refurbisher and recycler including those arising from orphaned products

(2) ensure that the facilities are in accordance with the standards or guidelines issued by Central Pollution Control Board from time to time;

(3) ensure that the e-waste collected by them is stored in a secured manner till it is sent to authorised dismantler or recycler as the case may be;

(4) ensure that no damage is caused to the environment during storage and transportation of e-waste;

(5) maintain records in Form-2 of the e-waste handled as per the guidelines of Central Pollution Control Board and make such records available for scrutiny by the Central Pollution Control Board or the concerned State Pollution Control Board as and when asked for.

7. Responsibilities of dealers. – (1) in the case the dealer has been given the responsibility of collection on behalf of the producer, the dealer shall collect the e- waste by providing the consumer a box, bin or a demarcated area to deposit e- waste, or through take back system and send the e-waste so collected to collection centre or dismantler or recycler as designated by producer;
(2) the dealer or retailer or e-retailer shall refund the amount as per take back system or Deposit Refund Scheme of the producer to the depositor of e-waste;
(3) every dealer shall ensure that the e-waste thus generated is safely transported to authorised dismantlers or recyclers;
(4) ensure that no damage is caused to the environment during storage and transportation of e-waste.

8. Responsibilities of the refurbisher. – (1) collect e-waste generated during the process of refurbishing and channelise the waste to authorised dismantler or recycler through its collection centre;
(2) make an application in Form 1(a) in accordance with the procedure laid down in sub-rule (4) of rule 13 to the concerned State Pollution Control Board for grant of one time authorisation;
(a) the concerned State Pollution Control Board shall authorise the Refurbisher on one time basis as per Form 1 (bb) and authorisation would be deemed as considered if not objected to within a period of thirty days;
(b) the authorised Refurbisher shall be required to submit details of e-waste generated to the concerned State Pollution Control Board on yearly basis;
(3) ensure that no damage is caused to the environment during storage and transportation of e-waste;
(4) ensure that the refurbishing process do not have any adverse effect on the health and the environment;

(5) ensure that the e-waste thus generated is safely transported to authorised collection centres or dismantlers or recyclers;

(6) file annual returns in Form-3 to the concerned State Pollution Control Board, on or before the 30th day of June following the financial year to which that return relates;
(7) maintain records of the e-waste handled in Form-2 and such records should be available for scrutiny by the appropriate authority.

9. Responsibilities of consumer or bulk consumer. – (1) consumers or bulk consumers of electrical and electronic equipment listed in Schedule I shall ensure that e-waste generated by them is channelised through collection centre or dealer of authorised producer or dismantler or recycler or through the designated take back service provider of the producer to authorised dismantler or recycler;
(2) bulk consumers of electrical and electronic equipment listed in Schedule I shall maintain records of e-waste generated by them in Form-2 and make such records available for scrutiny by the concerned State Pollution Control Board;
(3) consumers or bulk consumers of electrical and electronic equipment listed in Schedule I shall ensure that such end-of-life electrical and electronic equipment are not admixed with e-waste containing radioactive material as covered under the provisions of the Atomic Energy Act, 1962 (33 of 1962) and rules made there under;
(4) bulk consumers of electrical and electronic equipment listed in Schedule I shall file annual returns in Form-3, to the concerned State Pollution Control Board on or before the 30th day of June following the financial year to which that return relates. In case of the bulk consumer with multiple offices in a State, one annual return combining information from all the offices shall be filed to the concerned State Pollution Control Board on or before the 30th day of June following the financial year to which that return relates

10. Responsibilities of the dismantler. - (1)ensure that the facility and dismantling processes are in accordance with the standards or guidelines prescribed by Central Pollution Control Board from time to time;
(2) obtain authorisation from the concerned State Pollution Control Board in accordance with the procedure under sub-rule (3) of rule 13;
(3) ensure that no damage is caused to the environment during storage and transportation of e-waste;
(4) ensure that the dismantling processes do not have any adverse effect on the health and the environment;

(5) ensure that dismantled e-waste are segregated and sent to the authorised recycling facilities for recovery of materials;
(6) ensure that non-recyclable or non-recoverable components are sent to authorised treatment storage and disposal facilities;
(7) maintain record of e-waste collected, dismantled and sent to authorised recycler in Form-2 and make such record available for scrutiny by the Central Pollution Control Board or the concerned State Pollution Control Board;
(8) file a return in Form-3, to the concerned State Pollution Control Board as the case may be, on or before 30th day of June following the financial year to which that return relates;
(9) not process any e-waste for recovery or refining of materials, unless he is authorised with concerned State Pollution Control Board as a recycler for refining and recovery of materials;
(10) operation without Authorisation by any dismantler, as defined in this rule, shall be considered as causing damage to the environment.

11. Responsibilities of the recycler. – (1) shall ensure that the facility and recycling processes are in accordance with the standards or guidelines prescribed by the Central Pollution Control Board from time to time;
(2) obtain authorisation from concerned State Pollution Control Board in accordance with the procedure under the sub-rule (3) of rule 13;
(3) ensure that no damage is caused to the environment during storage and transportation of e-waste;
(4) ensure that the recycling processes do not have any adverse effect on the health and the environment;
(5) make available all records to the Central Pollution Control Board or the concerned State Pollution Control Board for inspection;
(6) ensure that the fractions or material not recycled in its facility is sent to the respective authorised recyclers;
(7) ensure that residue generated during recycling process is disposed of in an authorised treatment storage disposal facility;
(8) maintain record of e-waste collected, dismantled, recycled and sent to authorised recycler in Form-2 and make such record available for scrutiny by the Central Pollution Control Board or the concerned State Pollution Control Board;
(9) file annual returns in Form-3, to the concerned State Pollution Control Board as the case may be, on or before 30th day of June following the financial year to which that return relates;
(10) may accept waste electrical and electronic equipment or components not listed in Schedule I for recycling provided that they do not contain any radioactive material and same shall be indicated while taking the authorisation from concerned State Pollution Control Board;
(11) operation without Authorisation by any recycler, as defined in this rule, shall be considered as causing damage to the environment.

12. Responsibilities of State Government for environmentally sound management of E-waste. – (1) Department of Industry in State or any other government agency authorised in this regard by the State Government, to ensure earmarking or allocation of industrial space or shed for e-waste dismantling and recycling in the existing and upcoming industrial park, estate and industrial clusters;

(2) Department of Labour in the State or any other government agency authorised in this regard by the State Government shall:

a. ensure recognition and registration of workers involved in dismantling and recycling;
b. assist formation of groups of such workers to facilitate setting up dismantling facilities;
c. undertake industrial skill development activities for the workers involved in dismantling and recycling;
d. undertake annual monitoring and to ensure safety & health of workers involved in dismantling and recycling;

(3) State Government to prepare integrated plan for effective implementation of these provisions, and to submit annual report to Ministry of Environment, Forest and Climate Change.

CHAPTER III

PROCEDURE FOR SEEKING AND GRANT OF AUTHORISATION FOR MANAGEMENT OF E-WASTE

13. Procedure for Seeking and Grant of Authorisation. -

(1) **Extended Producer Responsibility - Authorisation of Producers.** – (i) every producer of electrical and electronic equipment listed in Schedule I, shall make an application for Extended Producer Responsibility - Authorisation within a period of ninety days starting from the date of these rules coming into force in Form-1 to Central Pollution Control Board;

(ii) on receipt of the application complete in all respects, the Central Pollution Control Board will carry out evaluation of the Extended Producer Responsibility Plan and on being satisfied that the producer has detailed out an effective system to manage Extended Producer Responsibility in the country, shall grant Extended Producer Responsibility - Authorisation, in Form 1(aa) within a period of one hundred and twenty days. The Extended Producer Responsibility - Authorisation shall be valid for a period of five years;

This authorisation shall include among others the targeted quantity of e-waste, product code wise, to be collected during the year. The actual target for collection of e-waste for dismantling or recycling will be fixed on the basis of quantity of electrical and electronic equipment, product code wise, placed in the market in the previous years and taking into consideration the average life of the equipment. The estimated quantity of e-waste generated during the current year will be indicated by the producer and the quantity expected to be collected with the collection scheme proposed to be implemented by the producer will be indicated in the Extended Producer Responsibility plan. The Central Pollution Control Board shall fix the targets in accordance with Schedule III.

(iii) the Central Pollution Control Board, after giving reasonable opportunity of being heard to the applicant shall refuse to grant Extended Producer Responsibility – Authorisation;

(iv) in the event of refusal of Extended Producer Responsibility - Authorisation by the Central Pollution Control Board, the producer will forfeit his right to put any Electrical and Electronic Equipment in the market till such time the Extended Producer Responsibility - Authorisation is granted;

(v) the Central Pollution Control Board after grant of Extended Producer Responsibility - Authorisation shall forward the Extended Producer Responsibility Plan to respective State Pollution Control Board for monitoring;

(vi) an application for the renewal of Extended Producer Responsibility-Authorisation shall be made in Form-1 before one hundred and twenty days of its expiry to Central Pollution Control Board. The Central Pollution Control Board may renew the authorisation for a period of five years after receipt of compliance report from the concerned State Pollution Control Board which shall submit the compliance report to Central Pollution Control Board within sixty days from the date of the receipt of the application. In case of non receipt of the compliance report from the

State Pollution Control Board within stipulated time period of sixty days, Central Pollution Control Board may renew the Extended Producer Responsibility- Authorisation after examining such case on merit basis, subject to no report of violation of the provisions of the Act or the rules made there under or the conditions specified in the Extended Producer Responsibility - Authorisation;

(vii) every producer of Electrical and Electronic Equipment listed in Schedule I, shall take all steps, wherever required, to comply with the conditions specified in the Extended Producer Responsibility – Authorisation;

(viii) the concerned State Pollution Control Board shall monitor the compliance of Extended Producer Responsibility - Authorisation, take cognizance of any non- compliance and inform Central Pollution Control Board for taking action, as necessary;

(ix) Central Pollution Control Board shall conduct random check and if in its opinion, the holders of the Extended Producer Responsibility - Authorisation has failed to comply with any of the conditions of the authorisation or with any provisions of the Act or these rules and after giving a reasonable opportunity of being heard and after recording reasons thereof in writing cancel or suspend the Extended Producer Responsibility - Authorisation issued under these rules for such period as it considers necessary in the public interest and inform the concerned State Pollution Control Board within ten days of cancellation.

(x) the Central Pollution Control Board shall maintain an online register of Extended Producer Responsibility - Authorisation granted with conditions imposed under these rules for environmentally sound management of e-waste, and which shall be accessible to any citizen of the country.

(xi) The producer authorised under the provision of this rule shall maintain records in Form-2 and shall file annual returns of its activities of previous year in Form-3 to the Central Pollution Control Board on or before 30th day of June of every year;

(2) **Authorisation of Manufacturer. –** (i) the manufacturer generating e-waste shall obtain an authorisation from the concerned State Pollution Control Board;

(ii) the manufacturer shall make an application for authorisation, within a period of ninety days from the date of these rules coming into force in Form 1(a) to the concerned State Pollution Control Board for grant of authorisation;

(iii) on receipt of the application complete in all respects for the authorisation, the concerned State Pollution Control Board may, after such enquiry as it considers necessary and on being satisfied that the applicant possesses appropriate facilities, technical capabilities and equipment to handle e-waste safely, grant within a period of one hundred and twenty days an authorisation in Form 1(bb) to the applicant to carry out safe operations in the authorised place only, which shall be valid for a period of five years;

(iv) the concerned State Pollution Control Board after giving reasonable opportunity of being heard to the applicant may refuse to grant any authorisation;

(v) every person authorised under these rules shall maintain the record of e-waste handled by them in Form-2 and prepare and submit to the concerned State Pollution Control Board, an annual return containing the details specified in Form-3 on or before the 30th day of June following the financial year to which that return relates;

(vi) an application for the renewal of an authorisation shall be made in Form-1(a) before one hundred and twenty days of its expiry and the concerned State Pollution Control Board may renew the authorisation for a period of five years after examining each case on merit and subject to the condition that there is no report of violation of the provisions of the Act or the rules made thereunder or the conditions specified in the authorisation;

(vii) manufacturer shall take all steps to comply with the conditions specified in the authorisation;

(viii) the concerned State Pollution Control Board shall maintain an online register of authorisations granted with conditions imposed under these rules for environmentally sound management of e-waste, and which shall be accessible to any citizen of the country.

(3) **Procedure for grant of authorisation to dismantler or recycler.** - (i) every Dismantler or Recycler of e-waste shall make an application, within a period of one hundred and twenty days starting from the date of coming into force of these rules, in Form-4 in triplicate to the concerned State Pollution Control Board accompanied with a copy of the following documents for the grant or renewal of authorisation, namely:-

(a) consent to establish granted by the concerned State Pollution Control Board under the Water (Prevention and Control of Pollution) Act, 1974, (25 of 1974) and the Air (Prevention and Control of Pollution) Act, 1981(21 of 1981);

(b) certificate of registration issued by the District Industries Centre or any other government agency authorised in this regard;

(c) proof of installed capacity of plant and machinery issued by the District Industries Centre or any other government agency authorised in this behalf;

(d) in case of renewal, a certificate of compliance of effluent and emission standards, treatment and disposal

of hazardous wastes as applicable from the concerned State Pollution Control Board or any other agency designated for this purpose:

Provided that any person authorised or registered under the provisions of the Hazardous Wastes (Management, Handling and Transboundary Movements) Rules, 2008, and the E-waste (Management & Handling) Rules, 2011 prior to the date of coming into force of these rules shall not be required to make an application for authorisation till the period of expiry of such authorisation or registration:

(ii) the concerned State Pollution Control Board, on being satisfied that the application is complete in all respects and that the applicant is utilising environmentally sound technologies and possess adequate technical capabilities, requisite facilities and equipment to dismantle or recycle and process e-waste in compliance to the guidelines specified by Central Pollution Control Board from time to time and through site inspection, may grant authorisation to such applicants stipulating therein necessary conditions as deemed necessary for carrying out safe operations in the authorised place only;

(iii) the concerned State Pollution Control Board shall dispose of the application for authorisation within a period of one hundred and twenty days from the date of the receipt of such application complete in all respects;

(iv) the authorisation granted under these rules shall be valid for a period of five years from the date of its issue and shall be accompanied with a copy of the field inspection report signed by that Board indicating the adequacy of facilities for dismantling or recycling of e-waste and compliance to the guidelines specified by Central Pollution Control Board from time to time;

(v) the concerned State Pollution Control Board may refuse, cancel or suspend an authorisation granted under these rules, if it has reasons to believe that the authorised dismantler or recycler has failed to comply with any of the conditions of authorisation, or with any provisions of the Act or rules made thereunder, after giving an opportunity to the dismantler or recycler to be heard and after recording the reasons thereof;

(vi) an application for the renewal of authorisation shall be made in Form - 4 before one hundred and twenty days of its expiry and the concerned State Pollution Control Board may renew the authorisation for a period of five years after examining each case on merit and subject to the condition that there is no report of violation of the provisions of the Act or the rules made there under or the conditions specified in the authorisation;

(vii) the Dismantler and Recycler shall maintain records of the e-waste purchased, processed in Form-2 and shall file annual returns of its activities of previous year in Form-3 to the concerned State Pollution Control Board on or before 30th day of June of every year;

(viii) the Central Government and the Central Pollution Control Board may issue guidelines for standards of performance for dismantling and recycling processes from time to time.

(4) **Procedure for grant of authorisation to refurbisher.** – (i) every refurbisher of e-waste shall make an application, with in a period of one hundred and twenty days starting from the date of coming into force of these rules, in Form 1 (a) in triplicate to the concerned State Pollution Control Board accompanied with a copy of the following documents for the grant or renewal of authorisation, namely:-

(a) consent to establish granted by the concerned State Pollution Control Board under the Water (Prevention and Control of Pollution) Act, 1974, (25 of 1974) and the Air (Prevention and Control of Pollution) Act, 1981 (21 of 1981);

(b) certificate of registration issued by the District Industries Centre or any other government agency authorised in this regard;

(c) proof of installed capacity of plant and machinery issued by the District Industries Centre or any other government agency authorised in this behalf.

(ii) the concerned State Pollution Control Board, on being satisfied that the application is complete in all respects and complies with the guidelines prescribed by Central Pollution Control Board from time to time, may grant one time authorisation in Form 1 (bb) to such applicants stipulating therein necessary conditions as deemed necessary for carrying out refurbishing activities in the authorised place only;

(iii) the concerned State Pollution Control Board shall dispose of the application for authorisation within a period of one hundred and twenty days from the date of the receipt of such application complete in all respects;

(iv) the concerned State Pollution Control Board may refuse, cancel or suspend a authorisation granted under these rules, if it has reasons to believe that the authorised refurbisher has failed to comply with any of the

conditions of authorisation, or with any provisions of the Act or rules made thereunder, after giving an opportunity to the refurbisher to be heard and after recording the reasons thereof;

(v) the Refurbisher shall maintain records of the e-waste purchased and refurbished in Form-2 and shall file annual returns of its activities of previous year in Form-3 to the concerned State Pollution Control Board on or before 30th day of June of every year.

14. Power to suspend or cancel an authorisation.- (1) The State Pollution Control Board may, if in its opinion, the holder of Manufacturer or Dismantler or Recycler or Refurbisher Authorisation has failed to comply with any of the conditions of the authorisation or with any provisions of the Act or these rules and after giving a reasonable opportunity of being heard and after recording reasons thereof in writing cancel or suspend the authorisation issued under these rules for such period as it considers necessary in the public interest and inform Central Pollution Control Board within ten days of cancellation;

(2) The Central Pollution Control Board, if in its opinion, the holders of the Extended Producer Responsibility- Authorisation has failed to comply with any of the conditions of the authorisation or with any provisions of the Act or these rules and after giving a reasonable opportunity of being heard and after recording reasons thereof in writing cancel or suspend the Extended Producer Responsibility- Authorisation issued under these rules for such period as it considers necessary in the public interest and inform State Pollution Control Boards or Pollution Control Committees within ten days of cancellation;

(3) Upon suspension or cancellation of the authorisation, the Central Pollution Control Board or State Pollution Control Board may give directions to the persons whose authorisation has been suspended or cancelled for the safe storage and management of the e-waste and such persons shall comply with such directions.

CHAPTER IV

15. Procedure for storage of e-waste. - Every manufacturer, producer, bulk consumer, collection centre, dealer, refurbisher, dismantler and recycler may store the e-waste for a period not exceeding one hundred and eighty days and shall maintain a record of collection, sale, transfer and storage of wastes and make these records available for inspection:

Provided that the concerned State Pollution Control Board may extend the said period up to three hundred and sixty five days in case the waste needs to be specifically stored for development of a process for its recycling or reuse.

CHAPTER V

REDUCTION IN THE USE OF HAZARDOUS SUBSTANCES IN THE MANUFACTURE OF ELECTRICAL AND ELECTRONIC EQUIPMENT AND THEIR COMPONENTS OR CONSUMABLES OR PARTS OR SPARES

16. Reduction in the use of hazardous substances in the manufacture of electrical and electronic equipment and their components or consumables or parts or spares. – (1) Every producer of electrical and electronic equipment and their components or consumables or parts or spares listed in Schedule I shall ensure that, new Electrical and Electronic Equipment and their components or consumables or parts or spares do not contain Lead, Mercury, Cadmium, Hexavalent Chromium, polybrominated biphenyls and polybrominated diphenyl ethers beyond a maximum concentration value of 0.1% by weight in homogenous materials for lead, mercury, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ethers and of 0.01% by weight in homogenous materials for cadmium.

(2) Components or consumables or parts or spares required for the electrical and electronic equipment placed in the market prior to 1st May, 2014 may be exempted from the provisions of sub-rule (1) of rule 16 provided Reduction of Hazardous Substances compliant parts and spares are not available.

(3) The applications listed in Schedule II shall be exempted from provisions of sub- rule (1) of rule 16.

(4) Every producer of applications listed in Schedule II shall ensure that the limits of hazardous substances as given in Schedule II are to be complied.
(5) Every producer shall provide the detailed information on the constituents of the equipment and their components or consumables or parts or spares alongwith a declaration of conformance to the Reduction of Hazardous Substances provisions in the product user documentation.
(6) Imports or placement in the market for new electrical and electronic equipment shall be permitted only for those which are compliant to provisions of sub-rule (1) and sub rule (4) of rule 16.
(7) Manufacture and supply of electrical and electronic equipment used for defence and other similar strategic applications shall be excluded from provisions of sub- rule (1) of rule 16.
(8) Every producer while seeking Extended Producer Responsibility - Authorisation will provide information on the compliance of the provisions of sub-rule (1) of rule 16. This information shall be in terms of self-declaration.
(9) Central Pollution Control Board shall conduct random sampling of electrical and electronic equipment placed on the market to monitor and verify the compliance of Reduction of Hazardous Substances provisions and the cost for sample and testing shall be borne by the Producer. The random sampling shall be as per the guidelines of Central Pollution Control Board.
(10) If the product does not comply with Reduction of Hazardous Substances provisions, the Producers shall take corrective measures to bring the product into compliance and withdraw or recall the product from the market, within a reasonable period as per the guidelines of the Central Pollution Control Board.
(11) Central Pollution Control Board shall publish the methods for sampling and analysis of Hazardous Substances as listed in sub-rule(1) of rule 16 with respect to the items listed in Schedule I and II and also enlist the labs for this purpose.

CHAPTER VI MISCELLANEOUS

17. **Duties of authorities. -** Subject to other provisions of these rules, the authorities shall perform duties as specified in Schedule IV.

18. Annual Report. – (1) The concerned State Pollution Control Board shall prepare and submit to the Central Pollution Control Board an annual report with regard to the implementation of these rules by the 30th day of September every year in Form-5.
(2) The Central Pollution Control Board shall prepare the consolidated annual review report on management of e-waste and forward it to the Central Government along with its recommendations before the 30th day of December every year.

19. **Transportation of e-waste.** –The transportation of e-waste shall be carried out as per the manifest system whereby the transporter shall be required to carry a document (three copies) prepared by the sender, giving the details as per Form-6:

Provided that the transportation of waste generated from manufacturing or recycling destined for final disposal to a treatment, storage and disposal facility shall follow the provisions under Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008.

20. Accident reporting.- Where an accident occurs at the facility processing e-waste or during transportation of e-waste, the producer, refurbisher, transporter, dismantler, or recycler, as the case may be, shall report immediately to the concerned State Pollution Control Board about the accident through telephone and e-mail.

21. Liability of manufacturer, producer, importer, transporter, refurbisher, dismantler and recycler.-
(1) The manufacturer, producer, importer, transporter, refurbisher, dismantler and recycler shall be liable for all damages caused to the environment or third party due to improper handling and management of the e-waste;

(2) The manufacturer, producer, importer, transporter, refurbisher, dismantler and recycler shall be liable to pay financial penalties as levied for any violation of the provisions under these rules by the State Pollution Control Board with the prior approval of the Central Pollution Control Board.

22. Appeal.- (1) Any person aggrieved by an order of suspension or cancellation or refusal of authorisation or its renewal passed by the Central Pollution Control Board or State Pollution Control Board may, within a period of thirty days from the date on which the order is communicated to him, prefer a appeal in Form 7 to the Appellate Authority comprising of the Environment Secretary of the State.

(2) The Appellate Authority may entertain the appeal after expiry of the said period of thirty days if it is satisfied that the appellant was prevented by sufficient cause from filing the appeal in time.

(3) Every appeal filed under this rule shall be disposed of within a period of sixty days from the date of its filing.

23. The collection, storage, transportation, segregation, refurbishment, dismantling, recycling and disposal of e-waste shall be in accordance with the procedures prescribed in the guidelines published by the Central Pollution Control Board from time to time. Implementation of e-waste (Management and Handling) Amendment Rules,
2011 shall be in accordance with the guidelines prescribed by the Central Pollution
Control Board from time to time.

24. Urban Local Bodies (Municipal Committee or Council or Corporation) shall ensure that e-waste pertaining to orphan products is collected and channelised to authorised dismantler or recycler.

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SCHEDULE I

[See rules 2, 3(j), 3(y), 3(aa) and 3(ff); 5; 9; 11(10); 13 (1) (i), 13 (1) (vii) and 16(1), 16(11)]

Categories of electrical and electronic equipment including their components, consumables, parts and spares covered under the rules

Sr. No.	Categories of electrical and electronic equipment	Electrical and electronic equipment code
i.	**Information technology and telecommunication equipment :**	
	Centralised data processing: Mainframes, Minicomputers	ITEW1
	Personal Computing: Personal Computers (Central Processing Unit with input and output devices)	ITEW2
	Personal Computing: Laptop Computers(Central Processing Unit with input and output devices)	ITEW3
	Personal Computing: Notebook Computers	ITEW4
	Personal Computing: Notepad Computers	ITEW5
	Printers including cartridges	ITEW6
	Copying equipment	ITEW7
	Electrical and electronic typewriters	ITEW8
	User terminals and systems	ITEW9
	Facsimile	ITEW10
	Telex	ITEW11
	Telephones	ITEW12
	Pay telephones	ITEW13
	Cordless telephones	ITEW14
	Cellular telephones	ITEW15
	Answering systems	ITEW16
ii.	**Consumer electrical and electronics:**	
	Television sets (including sets based on (Liquid Crystal Display and Light Emitting Diode technology)	CEEW1
	Refrigerator	CEEW2
	Washing Machine	CEEW3
	Air-conditioners excluding centralised air conditioning plants	CEEW4
	Fluorescent and other Mercury containing lamps	CEEW5

SCHEDULE II

[See rules 16 (3), 16 (4) and 16 (11)]

Applications, which are exempted from the requirements of sub-rule (1) of rule 16	
	Substance
1	Mercury in single capped (compact) fluorescent lamps not exceeding (per burner):
1(a)	For general lighting purposes <30 W : 2.5 mg
1(b)	For general lighting purposes ≥ 30 W and <50 W : 3.5mg
1(c)	For general lighting purposes ≥ 50 W and <150 W : 5mg
1(d)	For general lighting purposes ≥150 W : 15 mg
1(e)	For general lighting purposes with circular or square structural shape and tube diameter ≤17 mm : 7mg
1(f)	For special purposes:5 mg
2(a)	Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp):
2(a)(1)	Tri-band phosphor with normal life time and a tube diameter < 9mm (e.g. T2): 4mg
2(a)(2)	Tri-band phosphor with normal life time and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5): 3 mg
2(a)(3)	Tri- band phosphor with normal life time and a tube diameter >17 mm and ≤ 28 mm(e.g. T8): 3.5 mg
2(a)(4)	Tri-band phosphor with normal life time and a tube diameter >28 mm (e.g. T 12):3.5 mg
2(a)(5)	Tri-band phosphor with long life time (≥25000 h):5mg
2(b)	Mercury in other fluorescent lamps not exceeding(per lamp):
2(b)(1)	Linear halophosphate lamps with tube >28 mm (e.g. T 10 and T12):10 mg
2(b)(2)	Non-linear halophosphate lamps(all diameters):15mg
2(b)(3)	Non-linear tri-band phosphor lamps with tube diameter >17 mm(e.g.T9): 15 mg
2(b)(4)	Lamps for other general lighting and special purposes (e.g. induction lamps):15mg
3	Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL)for special purposes not exceeding (per lamp):
3(a)	Short length(≤ 500 mm):3.5mg
3(b)	Medium length(>500 mm and≤1500 mm): 5mg
3(c)	Long length(>1500 mm): 13mg
4(a)	Mercury in other low pressure discharge lamps (per lamp): 15mg
4(b)	Mercury in High Pressure Sodium(vapour) lamps for general lighting purposes not exceeding (per burner)in lamps with improved colour rendering index Ra>60:

4(b)-I	P ≤155 W : 30 mg
4(b)-II	155 W < P ≤405 W : 40 mg
4(b)-III	P >405 W: 40 mg
4(c)	Mercury in other High Pressure Sodium(vapour)lamps for general lighting purposes not exceeding (per burner):
4(c)-I	P≤155 W:25mg
4(c)-II	155 W < P ≤ 405 W:30 mg
4(c)-III	P >405 W:40 mg
4(d)	Mercury in High Pressure Mercury (vapour) lamps (HPMV)
4(e)	Mercury in metal halide lamps (MH)
4(f)	Mercury in other discharge lamps for special purposes not specifically mentioned in this Schedule
5(a)	Lead in glass of cathode ray tubes
5(b)	Lead in glass of fluorescent tubes not exceeding 0.2% by weight
6(a)	Lead as an alloying element in steel for machining purposes and in galvanized steel containing up to 0.35% lead by weight
6(b)	Lead as an alloying element in aluminium containing up to 0.4% lead by weight
6(c)	Copper alloy containing up to 4% lead by weight
7(a)	Lead in high melting temperature type solders (i.e. lead-based alloys containing 85% by weight or more lead)
7(b)	Lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signalling, transmission, and network management for telecommunications
7(c)-I	Electrical and electronic components containing lead in a glass or ceramic other than dielectric ceramic in capacitors, e.g. piezoelectronic devices, or in a glass or ceramic matrix compound.
7(c)-II	Lead in dielectric ceramic in capacitors for a rated voltage of 125 V AC or 250 V DC or higher
7(c)-III	Lead in dielectric ceramic in capacitors for a rated voltage of less than 125 V AC or 250 V DC
8(a)	Cadmium and its compounds in one shot pellet type thermal cut-offs
8(b)	Cadmium and its compounds in electrical contracts
9	Hexavalent chromium as an anticorrosion agent of the carbon steel cooling system in absorption refrigerators up to 0.75% by weight in the cooling solution

9(b)	Lead in bearing shells and bushes for refrigerant-containing compressors for heating, ventilation, air conditioning and refrigeration (HVACR) application.

11(a)	Lead used in C-press compliant pin connector systems
11(b)	Lead used in other than C-press compliant pin connector systems
12	Lead as a coating material for the thermal conduction module C- ring
13(a)	Lead in white glasses used for optical applications
13(b)	Cadmium and lead in filter glasses and glasses used for reflectance standards.
14	Lead in solders consisting of more than two elements for the connection between the pins and the package of microprocessors with a lead content of more than 80% and less than 85% by weight
15	Lead in solders to complete a viable electrical connection between semiconductor die and carrier within integrated circuit flip chip packages.
16	Lead in linear incandescent lamps with silicate coated tubes
17	Lead halide as radiant agent in high intensity discharge (HID) lamps used for professional reprography applications.
18(a)	Lead as activator in the fluorescent powder (1% lead by weight or less) of discharge lamps when used as specialty lamps for diazoprinting reprography, lithography, insect traps, photochemical and curing processes containing phosphors such as SMS ((Sr, Ba)2Mg Si2O7:Pb)
18(b)	Lead as activator in the fluorescent powder (1% lead by weight or less) of discharge lamps when used as sun tanning lamps containing phosphors such as BSP (Ba Si2O5:Pb)
19	Lead with PbBiSn-Hg and PblnSn-Hg in specific compositions as main amalgam and with PbSn-Hg as auxiliary amalgam in very compact energy saving lamps (ESL)
20	Lead oxide in glass used for bonding front and rear substrates of flat fluorescent lamps used for Liquid Crystal Displays (LCDs)
21	Lead and cadmium in printing inks for the application of enamels on glasses, such as borosilicate and soda lime glasses
23	Lead in finishes of fine pitch components other than connectors with a pitch of 0.65 mm and less
24	Lead in solders for the soldering to machined through hole discoidal and planar array ceramic multilayer capacitors
25	Lead oxide in surface conduction electron emitter displays (SED) used in structural elements, notably in the seal frit and frit ring.
26	Lead oxide in the glass envelope of black light blue lamps
27	Lead alloys as solder for transducers used in high-powered (designated to operate for several hours at acoustic power levels of 125 dB SPL and above) loudspeakers
29	Lead bound in crystal glass

30	Cadmium alloys as electrical/mechanical solder joints to electrical conductors located directly on the voice coil in transducers used in high-powered loudspeakers with sound pressure levels of 100 dB(A) and more
31	Lead in soldering materials in mercury free flat fluorescent lamps (which e.g. are used for liquid crystal displays, design or industrial lighting)
32	Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes
33	Lead in solders for the soldering of thin copper wires of 100 μm diameter and less in power transformers
34	Lead in cermet-based trimmer potentiometer elements
36	Mercury used as a cathode sputtering inhibitor in DC plasma displays with a content up to 30 mg per display
37	Lead in the plating layer of high voltage diodes on the basis of a zinc borate glass body
38	Cadmium and cadmium oxide in thick film pastes used on aluminium bonded beryllium oxide
39	Cadmium in colour converting II-VI LEDs (<10 μg Cd per mm^2 of light-emitting area) for use in solid state illumination or display systems.

SCHEDULE III

[See rules 5 (1) (a) and 13 (1) (ii)]

Targets for Extended Producer Responsibility - Authorisation

No.	Year	E-Waste Collection Target (Number/Weight)
(i)	During first two year of implementation of rules	30% of the quantity of waste generation as indicated in Extended Producer Responsibility Plan.
(ii)	During third and fourth years of implementation of rules	40% of the quantity of waste generation as indicated in Extended Producer Responsibility Plan.
(iii)	During Fifth and Sixth years of implementation of rules	50% of the quantity of waste generation as indicated in Extended Producer Responsibility Plan.
(iv)	Seventh year onward of implementation of rules	70% of the quantity of waste generation as indicated in Extended Producer Responsibility Plan.

SCHEDULE IV

[See rule (17)]

LIST OF AUTHORITIES AND CORREPONDING DUTIES

Sr. No	AUTHORITY	CORRESPONDING DUTIES
1.	Central Pollution Control Board, Delhi	(i) Grant and Renewal of Extended Producer Responsibility - Authorisation and monitoring of its compliance. (ii) Maintain information on Extended Producer Responsibility - Authorisation on its web site. Set and revise targets for collection of e-waste from time to time. (iv) Coordination with State Pollution Control Boards (v) Preparation of Guidelines for Environmentally Sound Management of e-waste. Conduct random check for ascertaining compliance of the e-waste rules and identification of such importers or producers who have not applied for Extended Producer Responsibility authorisation or are not complying with RoHS provision. Wherever necessary, Central Pollution Control Board will seek the help of customs department or any other agency of the Government of India. Conduct random inspection of dismantler or recycler or refurbisher. Documentation, compilation of data on e-waste and uploading on websites of Central Pollution Control Board (ix) Actions against violation of these rules. (x) Conducting training programmes. (xi) Submit Annual Report to the Ministry. Enforcement of provisions regarding reduction in use of hazardous substances in manufacture of electrical and electronic equipment. Interaction with IT industry for reducing hazardous substances. Set and revise targets for compliance to the reduction in use of hazardous substance in manufacture of electrical and electronic equipment from time to time. Any other function delegated by the Ministry under these rules from time to time.
2.	State Pollution Control Boards or Committees of Union territories	(i) Inventorisation of e-waste. Grant and renewal of authorisation to manufacturers, dismantlers, recyclers and refurbishers. Monitoring and compliance of Extended Producer Responsibility - Authorisation as directed by Central Pollution Control Board and that of dismantlers, recyclers and refurbishers authorisation. Conduct random inspection of dismantler or recycler or refurbisher. Maintain online information regarding authorisation granted to manufacturers, dismantlers, recyclers and refurbishers.

Sr. No	AUTHORITY	CORRESPONDING DUTIES
		(vi) Implementation of programmes to encourage environmentally sound recycling. (vii) Action against violations of these rules. Any other function delegated by the Ministry under these rules.
3.	Urban Local Bodies (Municipal Committee or Council or Corporation)	(i) To ensure that e-waste if found to be mixed with Municipal Solid Waste is properly segregated, collected and is channelised to authorised dismantler or recycler. To ensure that e-waste pertaining to orphan products is collected and channelised to authorised dismantler or recycler.
4.	Port authority under Indian Ports Act, 1908 (15 of 1908) and Customs Authority under the Customs Act, 1962 (52 of 1962)	(i) Verify the Extended Producer Responsibility - Authorisation. Inform Central Pollution Control Board of any illegal traffic for necessary action. (iii) Take action against importer for violations under the Indian Ports Act, 1908/Customs Act, 1962.

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FORM-1

[See Rules 5(1) (g), 13(1) (i), 13(1) (vi)]

Applicable to producers seeking Extended Producer Responsibility - Authorisation

The application form should contain the following information:

1.	Name and full address along with telephone numbers, e-mail and other contact details of Producer (It should be the place from where sale in entire country is being managed)	:	
2.	Name of the Authorised Person and full address with e-mail, telephone and fax number	:	
3.	Name, address and contact details of Producer Responsibility Organisation, if any with full address, e-mail, telephone and fax number, if engaged for implementing the Extended Producer Responsibility	:	
4.	Details of electrical and electronic equipment placed on market year-wise during previous 10 years in the form of Table 1 as given below:	:	

Table 1: Details of Electrical and Electronic Equipment placed on the market in previous years - Code wise

Sr. No.	**Electrical and Electronic Equipment Item**	**Electrical and Electronic Equipment Code**	**Quantity, number and weight placed on market (year-wise)**									
A	**Information technology and telecommunication equipment:**											
1	Centralised data processing: Mainframes, Minicomputers	ITEW1										
2	Personal Computing: Personal Computers (Central Processing Unit with input and output devices)	ITEW2										
3	Personal Computing: Laptop Computers(Central Processing Unit with input and	ITEW3										

	output devices)											
4	Personal Computing: Notebook Computers	ITEW4										
5	Personal Computing: Notepad Computers	ITEW5										
6	Printers including cartridges	ITEW6										
7	Copying equipment	ITEW7										
8	Electrical and electronic typewriters	ITEW8										
9	User terminals and systems	ITEW9										
10	Facsimile	ITEW10										
11	Telex	ITEW11										
12	Telephones	ITEW12										
13	Pay telephones	ITEW13										
14	Cordless telephones	ITEW14										
15	Cellular telephones	ITEW15										
16	Answering systems	ITEW16										
B	**Consumer electrical and electronics:**											
17	Television sets (including sets based on (Liquid Crystal Display and Light Emitting Diode technology)	CEEW1										
18	Refrigerator	CEEW2										
19	Washing Machine	CEEW3										
20	Air-conditioners excluding centralised air conditioning plants	CEEW4										
21	Fluorescent and other Mercury containing lamps	CEEW5										

5. Estimated generation of Electrical and Electronic Equipment waste item-wise and estimated collection target for the forthcoming year in the form of Table 2 including those being generated from their service centres, as given below:

Table 2: Estimated generation of Electrical and Electronic Equipment waste item-wise and estimated collection target for the forthcoming year

Sr. No.	**Item**	**Estimated waste electrical and electronic equipment generation** **Number and weight**	**Targeted collection** **Number and weight**

6. Extended Producer Responsibility Plans:

(a) Please provide details of your overall scheme to fulfil Extended Producer Responsibility obligations including targets. This should comprise of general scheme of collection of used/waste Electrical and Electronic Equipment from the Electrical and Electronic Equipment placed on the market earlier such as through dealers and collection centres, Producer Responsibility Organisation, through buy-back arrangement, exchange scheme, Deposit Refund Scheme, etc. whether directly or through any authorised agency and channelising the items so collected to authorised recyclers.

(b) Provide the list with addresses along with agreement copies with dealers, collection centres, recyclers, Treatment, Storage and Disposal Facility, etc. under your scheme.

7. Estimated budget for Extended Producer Responsibility and allied initiatives to create consumer awareness.

8. Details of proposed awareness programmes.

9. Details for Reduction of Hazardous Substances compliance (to be filled if applicable):

(a) Whether the Electrical and Electronic Equipment placed on market complies with the rule 16 (1) limits with respect to lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominateddiphenyl ethers;

(b)Provide the technical documents (Supplier declarations, Materials declarations/Analytical reports) as evidence that the Reduction of Hazardous Substances (RoHS) provisions are complied by the product based on standard EN
50581 of EU;

(c) Documents required:

i. Extended Producer Responsibility plan;

ii. Copy of the permission from the relevant Ministry/Department for selling their product;

iii. Copies of agreement with dealers, collection centre, recyclers, Treatment, Storage and Disposal Facility, etc.;
iv. Copy of Directorate General of Foreign Trade license/permission as applicable;
v. Self-declaration regarding Reduction of Hazardous Substances provision;
vi. Any other document as required.

(Authorised signature)

Place: _____

Date: _____

FORM 1(a)

[See rules 4(2), 8 (2), 13(2) (ii), 13(2) (vi) and 13(4) (i)]

APPLICATION FOR OBTAINING AUTHORISATION FOR GENERATION OR STORAGE OR TREATMENT OR DISPOSAL OF E-WASTE BY MANUFACTURER OR REFURBISHER*

From: .....
.....
To

The Member Secretary,
..... Pollution Control Board or…… Pollution Control Committee
.....
.....

Sir,

I / We hereby apply for authorisation/renewal of authorisation under rule 13(2) (i) to 13(2) (viii) and/or 13 (4) (i) of the E-Waste (Management) Rules, 2016 for collection/storage/ transportation/ treatment/ refurbishing/disposal of e-wastes.

For Office Use Only

Code No. :
Whether the unit is situated in a critically polluted area as identified by Ministry of Environment and Forests (yes/no);

To be filled in by Applicant

1. Name and full address:
2. Contact Person with designation and contact details such as telephone Nos, Fax. No. and E-mail:
3. Authorisation required for (Please tick mark appropriate activity/ies*) (i) Generation during manufacturing or refurbishing* ☐ (ii) Treatment, if any ☐ (iii) Collection, Transportation, Storage ☐ ☐ (iv) Refurbishing

4. E-waste details:
(a) Total quantity e-waste generated in MT/A
(b) Quantity refurbished (applicable to refurbisher) (c) Quantity sent for recycling
(d) Quantity sent for disposal

5. Details of Facilities for storage/handling/treatment/refurbishing:

6. In case of renewal of authorisation previous authorisation no. and date and details of annual returns:

Place : _____ Signature _____

(Name_____)
Designation: _____

Date : _____

Note:-

(1) * The authorisation for e-waste may be obtained along with authorisation for hazardous waste under the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, if applicable.

(2) Wherever necessary, use additional sheets to give requisite and necessary details.

FORM 1 (aa)

[See rules 5 (6) and 13(1)(ii)]

FORMAT OF EXTENDED PRODUCER RESPONSIBILITY - AUTHORISATION

[Extended Producer Responsibility Authorisation for Producer of the Electrical & Electronic Equipment]

Ref: Your application for Grant of Extended Producer Responsibility - Authorisation for following Electrical & Electronic Equipment under E-Waste (Management) Rules, 2016

1. Number of Authorisation:

Date:

2. **M/s. ----------** is hereby granted Extended Producer Responsibility - Authorisation based on:
   (a) overall Extended Producer Responsibility plan
   (b) proposed target for collection of e-waste

3. The Authorisation shall be valid for a period of _____ years from date of issue with following conditions:

(i) you shall strictly follow the approved Extended Producer Responsibility plan, a copy of which is enclosed herewith;

(ii) you shall ensure that collection mechanism or centre are set up or designated as per the details given in the Extended Producer Responsibility plan. Information on collection mechanism/centre including the state-wise setup should be provided;

(iii) you shall ensure that all the collected e-waste is channelised to authorised dismantler or recycler designated as per the details. Information on authorised dismantler or recycler designated state-wise should be provided;

(iv) you shall maintain records, in Form-2 of these Rules, of e-waste and make such records available for scrutiny by Central Pollution Control Board;

(v) you shall file annual returns in Form-3 to the Central Pollution Control Board on or before 30th day of June following the financial year to which that returns relates;

(vi) General Terms & Conditions of the Authorisation:

a. The authorisation shall comply with provisions of the Environment (Protection) Act, 1986 and the Rules made there under;

b. The authorisation or its renewal shall be produced for inspection at the request of an officer authorised by the Central Pollution Control Board;

c. Any change in the approved Extended Producer Responsibility plan should be informed to Central Pollution Control Board on which decision

shall be communicated by Central Pollution Control Board within sixty days;

d. It is the duty of the authorised person to take prior permission of the concerned State Pollution Control Boards and Central Pollution Control Board to close down the facility;

e. An application for the renewal of authorisation shall be made as laid down in sub-rule (vi) of rule of 13(1) the E-Waste (Management) Rules,
2016;

f. The Board reserves right to cancel/amend/revoke the authorisation at any time as per the Policy of the Board or Government.

Authorized signatory
(with designation)

To,
Concerned Producer
Copy to:
1. Member Secretary, Concerned State.
2. In-charge, concerned Zonal Office, Central Pollution Control Board.

FORM 1(bb)

[See rules 4(2), 8(2)(a), 13(2) (iii) and 13(4)(ii)]

FORMAT FOR GRANTING AUTHORISATION FOR GENERATION OR STORAGE OR TREATMENT OR REFURBISHING OR DISPOSAL OF E-WASTE BY MANUFACTURER OR REFURBISHER

Ref: **Your application for Grant of Authorisation**

1. (a) Authorisation no. ..... and (b) date of issue …….

2. ……..…..……of……is hereby granted an authorisation for generation, storage, treatment, disposal of e-waste on the premises situated at…… for the following:

a. quantity of e-waste;
b. nature of e-waste.

3. The authorisation shall be valid for a period from …… to ……

4. The e-waste mentioned above shall be treated/ disposed off in a manner ..... at .....

5. The authorisation is subject to the conditions stated below and such conditions as may be specified in the rules for the time being in force under the Environment (Protection) Act, 1986.

Signature ----------
Designation ---------- Date: ----------

Terms and conditions of authorisation

1. The authorisation shall comply with the provisions of the Environment (Protection) Act, 1986, and the rules made thereunder.
2. The authorisation or its renewal shall be produced for inspection at the request of an officer authorized by the concerned State Pollution Control Board.
3. Any unauthorised change in personnel, equipment as working conditions as mentioned in the application by the person authorized shall constitute a breach of his authorisation.
4. It is the duty of the authorised person to take prior permission of the concerned State Pollution Control Board to close down the operations.
5. An application for the renewal of an authorisation shall be made as laid down in sub-rule (vi) of rule 13(2).

FORM-2

[See rules 4(4), 5(4), 6(5), 8(7), 9(2), 10(7), 11(8), 13 (1) (xi), 13(2)(v), 13(3)(vii) and 13 (4)(v)]

FORM FOR MAINTAINING RECORDS OF E-WASTE HANDLED OR GENERATED

Generated Quantity in Metric Tonnes (MT) per year

1	Name & Address: Producer or Manufacturer or Refurbisher or Dismantler or Recycler or Bulk Consumer*		
2	Date of Issue of Extended Producer Responsibility Authorisation*/ Authorisation*		
3	Validity of Extended Producer Responsibility Authorisation*/ Authorisation*		
4	Types & Quantity of ewaste handled or generated**	Category	Q u a n t it y
5	Types & Quantity of e-waste stored	Category	Q u a n t it y
		Item Description	
6	Types & Quantity of e-waste sent to collection centre authorised by producer/ dismantler/recycler / refurbisher or authorised dismantler/recycler or refurbisher**	Category	Q u a n t it y
		Item Description	
7	Types & Quantity of e-waste transported*	Category	Q u a n t it y
	Name, address and contact details of the destination		
8	Types & Quantity of e-waste refurbished*	Category	Q u a n t it y
		Item Description	
	Name, address and contact details of the destination of refurbished materials		
9	Types & Quantity of e-waste dismantled*	Category	Q u a n t it y
		Item Description	
	Name, address and contact details of the destination		
10	Types & Quantity of e-waste recycled*	Category	Quantity
	Types & Quantity of	Item Description	

	materials recovered	Quantity	
	Name, address and contact details of the destination		
11	Types & Quantity of ewaste sent to recyclers by dismantlers	Category	Quantity
		Item Description	
	Name, address and contact details of the destination		
12	Types & Quantity of other waste sent to respective recyclers by dismantlers/recyclers of e-waste	Category	Quantity
		Item Description	
	Name, address and contact details of the destination		
13	Types & Quantity of e-waste treated & disposed	Category	Quantity
		Item Description	
	Name, address and contact details of the destination		

Note:-

(1) * Strike off whichever is not applicable

(2) Provide any other information as stipulated in the conditions to the authoriser

(3) ** For producers this information has to be provided state-wise

FORM-3

[See rules 4(5), 5(5), 8(6), 9(4), 10(8), 11(9), 13 (1) (xi), 13(2)(v), 13(3)(vii) and 13(4)(v)]

FORM FOR FILING ANNUAL RETURNS

[To be submitted by producer or manufacturer or refurbisher or dismantler or recycler by 30th day of June following the financial year to which that return relates].

Quantity in Metric Tonnes (MT) and numbers

1	Name and address of the producer or manufacturer or refurbisher or dismantler or recycler			
2	Name of the authorised person and complete address with telephone and fax numbers and e-mail address			
3	Total quantity of e-waste collected or channelised to recyclers or dismantlers for processing during the year for each category of electrical and electronic equipment listed in the Schedule I (Attach list) by PRODUCERS			
	Details of the above	TYPE	QUANTITY	No.
3(A)*	BULK CONSUMERS: Quantity of e-waste			
3(B)*	REFURBISHERS: Quantity of e-waste:			
3(C)*	DISMANTLERS: i Quantity of e-waste processed (Code wise); ii. Details of materials or components recovered and sold; iii. Quantity of e-waste sent to recycler; iv. Residual quantity of e-waste sent to Treatment, Storage and Disposal Facility.			
3(D)*	RECYCLERS: i. Quantity of e-waste processed (Code wise); ii. Details of materials recovered and sold in the market; iii. Details of residue sent to Treatment, Storage and Disposal Facility.			
4	Name and full address of the destination with respect to 3(A)-3(D) above			
5	Type and quantity of materials segregated or recovered from e-waste of different codes as applicable to 3(A)-3(D)	Type	Quantity	

✓Enclose the list of recyclers to whom e-waste have been sent for recycling.

Place_____

Date_____ **Signature of the authorised person**

Note:-

(1) * Strike off whichever is not applicable
(2) Provide any other information as stipulated in the conditions to the authoriser
(3) In case filing on behalf of multiple regional offices, Bulk Consumers and Producers need to add extra rows to 1 & 3(A) with respect to each office.

FORM-4

[See rules 13(3)(i) and 13(3)(vi)]

APPLICATION FORM FOR AUTHORISATION OF FACILITIES POSSESSING ENVIRONMENTALLY SOUND MANAGEMENT PRACTICE FOR DISMANTLING OR RECYCLING OF E-WASTE

(To be submitted in triplicate)

<table>
<tr><td>1.</td><td>Name and Address of the unit</td><td colspan="3"></td></tr>
<tr><td>2.</td><td>Contact person with designation, Tel./Fax</td><td colspan="3"></td></tr>
<tr><td>3.</td><td>Date of Commissioning</td><td colspan="3"></td></tr>
<tr><td>4.</td><td>No.of workers (including contract labour)</td><td colspan="3"></td></tr>
<tr><td>5.</td><td>Consents Validity</td><td colspan="3">a. Water (Prevention and Control of Pollution) Act, 1974;
Valid up to _____ b. Air (Prevention and Control of Pollution) Act, 1981;
Valid up to</td></tr>
<tr><td>6.</td><td>Validity of current authorisation if any</td><td colspan="3">e-waste (Management & Handling) Rules, 2011;
Valid up to _____</td></tr>
<tr><td>7.</td><td>Dismantling or Recycling Process</td><td colspan="3">Please attach complete details</td></tr>
<tr><td rowspan="3">8.</td><td rowspan="3">Installed capacity in MT/year</td><td>Products</td><td colspan="2">Installed capacity (MTA)</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td rowspan="4">9.</td><td rowspan="4">E-waste processed during last three years</td><td>Year</td><td>Product</td><td>Quantity</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td rowspan="4">10.</td><td>Waste Management:</td><td colspan="3"></td></tr>
<tr><td>a. Waste generation in processing e-waste</td><td colspan="3">Please provide details material wise</td></tr>
<tr><td>b. Provide details of disposal of residue.</td><td colspan="3">Please provide details</td></tr>
<tr><td>c. Name of Treatment Storage and Disposal Facility utilized for</td><td colspan="3"></td></tr>
<tr><td>11.</td><td>Details of e-waste proposed to be procured from re-processing</td><td colspan="3">Please provide details</td></tr>
<tr><td>12.</td><td>Occupational safety and health aspects</td><td colspan="3">Please provide details</td></tr>
<tr><td>13.</td><td>Details of Facilities for dismantling both manual as well as mechanised:</td><td colspan="3"></td></tr>
</table>

14.	Copy of agreement with Collection Centre	
15.	Copy agreement with Producer	
16.	Details of storage for dismantled e-waste	
17.	Copy of agreement with Recycler	
18.	Details of Facilities for Recycling	
19.	Copy of agreement with Collection Centre	
20.	Copy agreement with Producer	
21.	Details of storage for raw materials and recovered materials	

II. In case of renewal of **authorisation, previous registration or authorisation no. and date**
I hereby declare that the above statements or information are true and correct to the best of my knowledge and belief.

Signature

Place:_____ Name:_____

Date:_____ Designation:_____

Form-5

[See rule 18 (1)]

FORM FOR ANNUAL REPORT TO BE SUBMITTED BY THE STATE POLLUTION CONTROL BOARD TO THE CENTRAL POLLUTION CONTROL BOARD

To,

The Chairman,
Central Pollution Control Board, (Ministry of Environment And Forests)
Government Of India, 'Parivesh Bhawan', East Arjun Nagar, Delhi- 110 0032

1.	Number of authorised manufacturer, refurbisher, collection centre, dismantler and recycler for management of e-waste in the State or Union territory under these rules	:	
2.	Categories of waste collected along with their quantities on a monthly average basis:	:	Please attach as Appendix-I
3.	A Summary Statement code-wise of e-waste collected	:	Please attach as Appendix-II
4.	Details of material recovered from recycling of e-waste	:	
5.	Quantity of CFL received at Treatment, Storage and Disposal Facility	:	
6.	The above report is for the period from ……to .....……		

Place: _____

Date: _____

Chairman or the Member Secretary
State Pollution Control Board

Form-6

[See rule 19]

E-WASTE MANIFEST

1.	Sender's name and mailing address (including Phone No.) :	
2.	Sender's authorisation No, if applicable. :	
3.	Manifest Document No. :	
4.	Transporter's name and address : (including Phone No.)	
5.	Type of vehicle :	(Truck or Tanker or Special Vehicle)
6.	Transporter/s registration No. :	
7.	Vehicle registration No. :	
8.	Receiver's name & address :	
9.	Receiver's authorisation No, if applicable. :	
10.	Description of E-Waste (Item, Weight/ Numbers) :	
11.	Name and stamp of Sender* (Manufacturer or Producer or Bulk Consumer or Collection Centre or Refurbisher or Dismantler): Signature: Month Day Year	
12.	Transporter acknowledgement of receipt of E-Wastes	
	Name and stamp: Signature: Month Day Year	
13.	Receiver* (Collection Centre or Refurbisher or Dismantler or Recycler) certification of receipt of E-waste	
	Name and stamp: Signature: Month Day Year	

* As applicable

Note:-

Copy number with colour code (1)	**Purpose (2)**
Copy 1 (Yellow)	To be retained by the sender after taking signature on it from the transporter and other three copies will be carried by transporter.
Copy 2 (Pink)	To be retained by the receiver after signature of the transporter.
Copy 3 (Orange)	To be retained by the transporter after taking signature of the receiver.
Copy 4 (Green)	To be returned by the receiver with his/her signature to the sender

FORM 7

[See rule 22]

APPLICATION FOR FILING APPEAL
AGAINST THE ORDER PASSED BY CENTRAL POLLUTION CONTROL BOARD/STATE POLLUTION CONTROL BOARD

1. Name and address of the person making the appeal :
2. Number, date of order and address of the authority to which passed the order, against which appeal is : (certified copy of the order be attached)
3. Ground on which the appeal is being made :
4. Relief sought for :
5. List of enclosures other than the order referred in point 2 against which the appeal is being filed. :

Signature…….

Place:
Date:

Name and address…….

Appendix – 4.1: Unit Operations and Equipments Used in Second Level WEEE/e-waste Treatment

	Equipment	Pictures
1.	**Shredder** For size reduction into a size enabling the majority of the ferrous material to be separated from the non-ferrous/insulation and plastic fraction	
2.	**Eddy Current Separator 1** For separation of the heavy mixed metal fraction.	
3.	**Heavy Pre-Granulator** For size reduction of the material prior to separation in the Eddy Current Separator 2.	

4.	**Eddy Current Separator 2** For separation of the light mixed metal fraction	
5.	**Heavy Granulator** For final size reduction of the material	
6.	**Separation Table** For final separation of the remaining fraction into a plastic (organic) fraction and a mixed metal fraction.	

Source: European Commission DG Environment, Bio Intelligence Service (2004). *Synthesis report [ENV.G.1/FRA/ 2004/0081, Study No.16], Gather, process, and summarise information for the review of the waste electric and electronic equipment directive (2002/96/EC).*

Appendix – 4.2: Best Practices/Treatment Examples

Available Process Technology

Literature cites examples of existing WEEE/e-waste treatment technology in Switzerland (Europe) and Japan[28] as shown in **Figure 1**, **Figure 2** and **Figure 3**. The salient features of these technologies are given below.

1. The process combines manual and machine procedures.
2. WEEE/e-waste is at first cut, crushed and finally sorted into discreet product streams. These streams consist of scrap iron, non-ferrous metal fractions, PC and TV casing components (consisting of wood and plastics), granulates of mixed plastics, cathode ray tubes, printed circuit boards, copper cables, components containing organic pollutants such as batteries and condensers, and fine particulates (dust).
3. The machine processes include breaking of/crushing the equipment in a hammer mill. Further, the crushed material is separated according to density, granulate size and magnetic properties, and multiple pulverizations by milling using magnetic and eddy current separation systems.

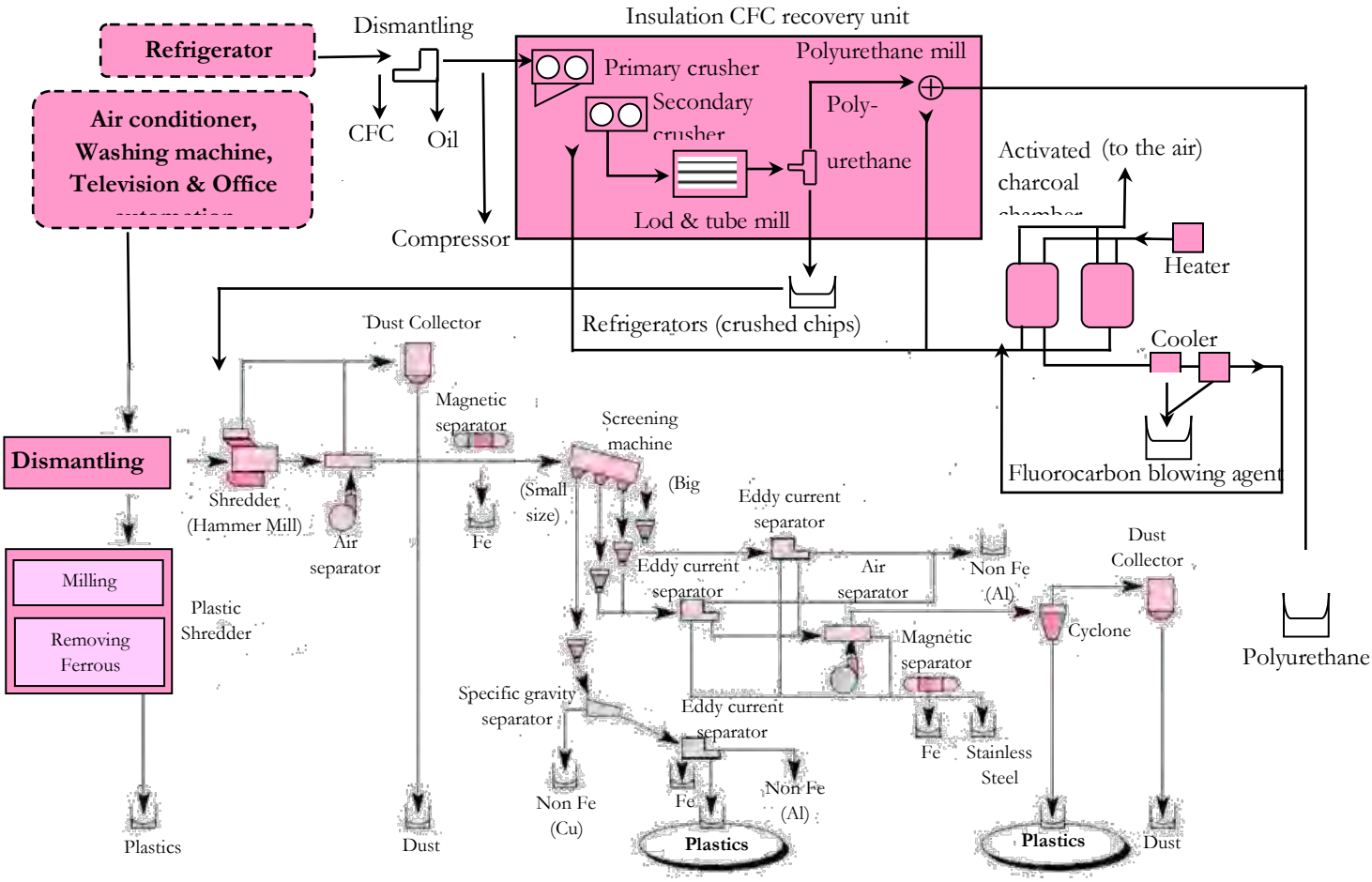

Figure 1: Flow sheet of a WEEE/e-waste recycling plant in Japan
Source: European Commission DG Environment, Bio Intelligence Service (2004). *Synthesis report*

[28] *Synthesis report [ENV.G.1/FRA/2004/0081, Study No.16], Gather, process, and summarize information for the review of the waste electric and electronic equipment directive (2002/96/EC), European Commission DG Environment, Bio Intelligence Service*

[ENV.G.1/FRA/ 2004/0081, Study No.16], Gather, process, and summarise information for the review of the waste electric and electronic equipment directive (2002/96/EC).

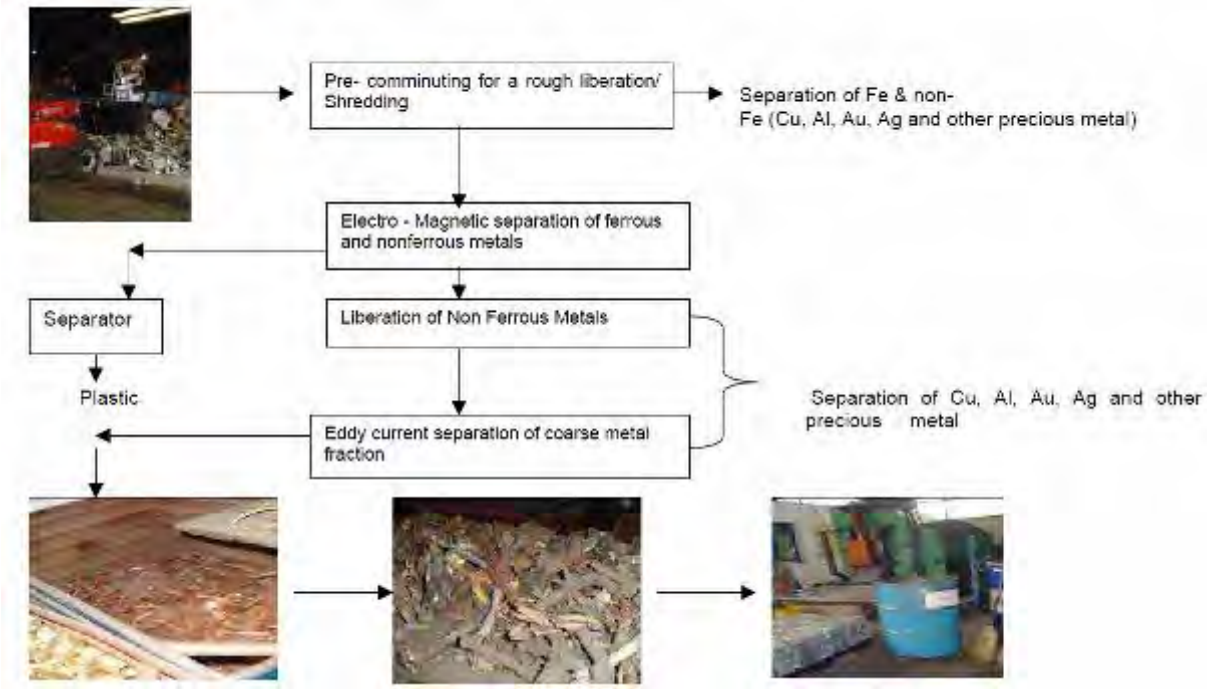

Figure 2: Flow sheet of a non CRT WEEE/e-waste recycling plant in Switzerland
Source: UNEP Manual, E-waste Volume II: E-waste Management Manual, http://www.unep.or.jp/ietc/publications/spc/ewastemanual_vol2.pdf, (Accessed on 14 July, 2016)

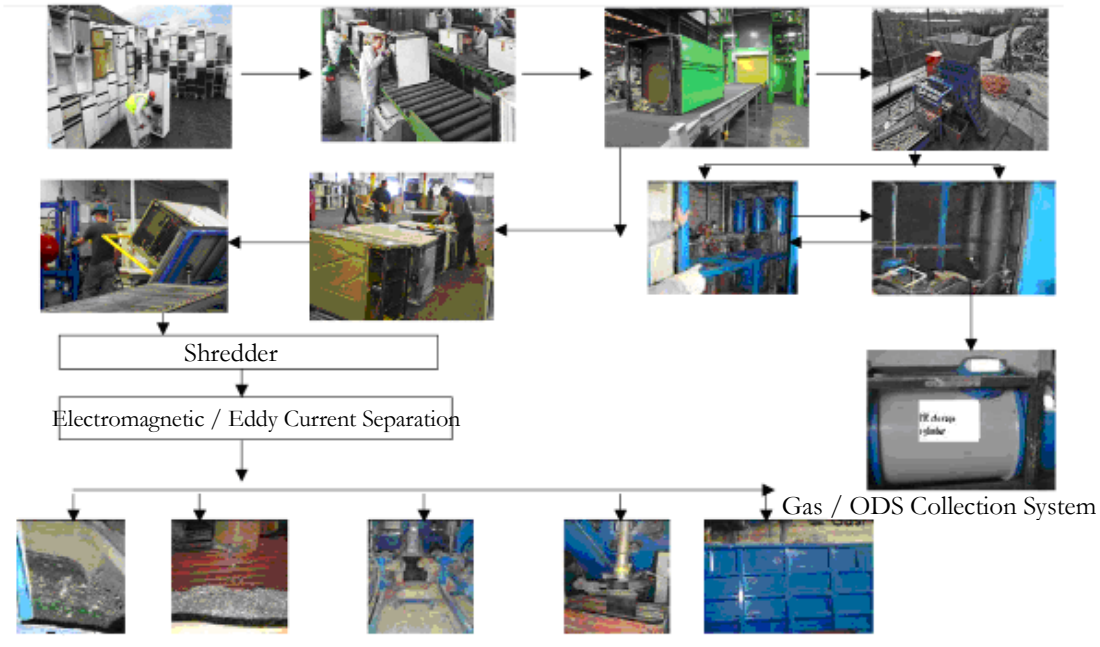

Figure 3: Flow sheet of WEEE/e-waste (refrigerator) recycling plant in Switzerland
Source: UNEP Manual, E-waste Volume II: E-waste Management Manual, http://www.unep.or.jp/ietc/publications/spc/ewastemanual_vol2.pdf, (Accessed on 14 July, 2016)

Appendix 4.3: List of Technology Providers in Developed and Developing Countries

Sr. No.	Company	Contact	Types of Equipments
1.	CP Manufacturing	6795 Calle de Linea San Diego, CA 92154 USA 800-462-5311	Conveyor systems , Shredders, Over-belt magnets, Eddy current separators as well as top-of-the-line optical sorters, like the MSS CIRRUS™ and L-VIS™
2.	GREEN MACHINE	5 Gigante Drive Hampstead, NH 03841 USA, (877) 448-4443 sales@greenmachine.com	Chain Edge Conveyors, Idler Stackers Conveyors, Slider Bed Conveyors, Tumbleback Feeder Conveyor, Ballistic Belt Separator, Metering Bin Feeder Recycling Component, Optical Sorting System The Green Eye® Component, Eddy Current Separators Component
3.	Southeast Machinery	43 Rainey St. Unit 2602 Austin, TX 78701, USA Phone: (724) 960-1146	K Series Single Shaft Shredders, Vision Series Single Shaft Shredders, Behemoth Single Shaft Shredders, Mino Two Shaft Shredder, Xeno Two Shaft Shredder, Gran-Calibur Granulator, Gran-ExCalibur Granulators
4.	MSS Optical Sorters	300 Oceanside Drive Nashville, TN 37204 USA Phone: 615-781-2669 Fax: 615-781-2923	CIRRUS™, L-VIS™, MetalSort™
5.	Sumitomo Corporation	Harumi Island Triton Square Office Tower Y, 8-11, Harumi 1-chome, Chuo-ku, Tokyo 104-8610, Japan Phone: +81-3-5166-5000	Conveyor systems , Shredders, Over-belt magnets, Eddy current separators
6.	STEINERT	Widdersdorfer Straße 329-331 D-50933 Köln Germany Tel.: +49 221 4984-0 Fax: +49 221 4984-102 E-Mail: sales(at)steinert.de	Suspension Magnets,NES,NES 4T, SteelMaster, FinesMaster, ISS,KSS ,XSS, CanMaster
7.	MACHINEX INDUSTRIES INC.	2121, Olivier Street Plessisville, QC, G6L 3G9, CANADA Phone: 819 362-3281 Toll Free: 1 877 362-3281 Fax: 819 362-2280 info@machinex.ca	Optical sorting unit, Trommels, shredder, Bag openers, Glass cleanup systems, Over-belt magnets, Eddy current separators, and Industrial can densifiers
8.	Brentwood Recycling Systems	238 Berkeley Rd, Unanderra NSW 2526, Australia Phone: +61 2 4271 7511	Shredders, Trommels, Belt conveyors, Bounce conveyors, Apron feeders, Aolystyrene recycling, Baling machines, Cable recycling, Scrap metal machinery, New machine stock, Second hand machines, Knowledge base
9.	Eldan Recycling	Værkmestervej 4, 5600 Faaborg, Denmark Phone: +45 63 61 25 45 info@eldan-recycling.com	Pre Choppers/Shredders, Raspers, Granulators, Material Seperation, Additional equipments.
10.	COPARM	Zona Industriale Macchia 75013 Ferrandina (Mt) - Italy Tel. +39.0835.757014 Fax +39.0835.757008 e-mail: coparm@coparm.it commerciale@coparm.it	Balers, Vibrating screens, Shredders, Waste Bale Wrappers, Conveyor Belts, Reel Spliters, Sorting Plants/MRF, Bag Openers
11.	Sesotec	Regener Str. 130, 94513 Schönberg, Germany Phone: +49 8554 3080	Varisorts, Mag, OM, TM, TMG

Sr. No.	Company	Contact	Types of Equipments
12.	MMH Recycling Systems	Broomers Hill Park, Broomers Hill Ln, Pulborough RH20 2RY, United Kingdom Phone: +44 1798 874440	Aligator Shears, Balers, Cable Strippers, Granulators, Pre-Compression Shears, Radiation Detectors, Raspers, Scrap Handling, Seperation Tables, Shredders
13.	Macpresse Europa S.R.L	Loc. S. Giuseppe 20080 Vernate - Milano - Italy – Tel. +39-02.905.24.20 - Fax +39-02.905.28.93 - info@macpresse.com	Balers, Sorting Systems, Wrapping machines, Conveyors, Shredders, Accessories
14.	ERDWICH	Kolpingstraße 8 86916 Kaufering Germany Tel.: 0 81 91 - 96 52 - 0 emaill: infoline@erdwich.de	Single shaft shredder, Two shaft shredder, Three shaft shredder, Cardboard Shredder, Coarse Shredder, Hammer Mills
15.	MG Recycling	Via E. Rossaro, 7, Bondeno FE, Italy Phone: +39 0532 897664	Compact Systems, Pre Shredders, MG, Custom made lines, Accessories
16.	Sims Recycling Solutions Pte. Ltd.	25 Loyang Cres, Singapore 508988 Phone: +65 6214 0627	Shredders, Screnners, Granulators, Conveyor Belts
17.	South African Recycling Equipment 1st Floor, Liberty Builidng, 21 Aurora Drive, Umhlanga, 4307	barry@sarequip.co.za 0871352943	Metal recovery Machine
18.	Mascot Electrotek Private Limited Survey No. 237/4 - A, Behind Vikas Stove Shapar, Rajkot - 360024, Gujarat, India	**08079452894** +91-2827-254160	• Plastic Bottle Recycling Plant • Cable Recycling Plant • Waste Fabric Recycling Plant • Cotton Waste Recycling Plant.
19.	San Lan Technologies Co. LTD 6A, 6th Floor, Nanjingyuan Plaza P.R China	info@san-lan.com +86 13923774083	• Cable recycling plant • Cable granulation plant • Lead acid battery recycling plant • PCB Recycling plants
20.	Shanghai SCM Mining and Construction Machinery Co., Ltd. No.416 Jianye Road, South Jinqiao Area, Pudong, Shanghai, China	alex@crushertrading.com 0086-21-58386256 0086-21-58386258	• Cable recycling plant • Cable granulation plant • Lead acid battery recycling plant • PCB Recycling plants
21.	CP Manufacturing, Inc. 6795 Calle de Linea San Diego, CA 92154	01706756560 800-462-5311	• Recycling sorting equipments • Optical sorting equipments • Aluminium can recycling Machines
22.	Respose Waste Management and Research Pvt Ltd Hira Krishna, Rajaji Road Cross Road no 1, Ramnagar, Dombivli East, Dist Thane Maharashtra - 421201.	info@resposeindia.com 91 -22 - 31921797	• E waste Resposal Plant
23.	Southeast Machinery 43 Rainey St., Unit 2602 Austin TX 78701	724-960-1146	• Shredders • Granulators • Plastic recycling plants • Cable recycling

Sr. No.	Company	Contact	Types of Equipments
24.	SGM Magnetics	4521 19th St Ct E Suite 101, Bradenton, FL 34203, United States Phone: +1 941-342-8800	Drum magnets, Eddy currents Head pulleys and over-belt magnets, Sensor, Color and x-ray Sorters
25.	Global Crushers	11 Montore Road, Minto, NSW 2566 Australia Phone: +61 2 8795 0288 or 1300 450 550	Ball Mill, Belt conveyors, CS Cone Crusher, Hammer Crusher, High frequency Screens, K Series Mobile Crushing Plant, Mobile Cone Crusher, Magnetic Separation Machine, Wharf Belt Conveyor
26.	Emak Refining and Recycling Systems	Sanayi Caddesi No:44 Nish Istanbul D Blok D:117 – Çobançeşme – Bahçelievler İstanbul info@emakmakina.com	Copper Enrichment, Anode casting, Copper electrolysis, Precious metal Recovering systems
27.	Gold International Machinery	136 Newell Avenue (corner of Thurston and Newell Sts.)@Exit 26, Route 95 North Pawtucket, RI USA 02860-0998 Mail@GoldMachinery.com 1-800-619-GOLD**:** 401-724-3200 401-728-5770	Precious Metal Assay Laboratory , Belt Furnaces, Melting Furnaces, Centrifugal Dryers, Ball Mills, Fume Scrubbers, Water Chillers, Plating, Casting, Electric Rotary Baking, E and I-Waste Process and Recovery
28.	BHS SONTHOFEN	BHS-Sonthofen GmbH An der Eisenschmelze 47 87527 Sonthofen GERMANY Phone +49 8321 6099-0 Fax +49 8321 6099-220 E-mail: info[@]bhs-sonthofen[.]de	Impact crusher (PB) and impact mill (PM), Rotor impact mill (RPMV and RPMX), Rotorshredder (RS),Shrredders, Granulators, Bio Grinders, Recycling plant
29.	VARY	No.11, Panpan road, National Economic and Technological Development Zone, Changsha, 410100 Taiwan **Tel:** +86 73182790115 **Fax:** +86 73182796318 **E-Mail:** info@vary.net.cn	Refrigerator Harmless Treatment and Resource Recycling System, Cathode Ray Tube(CRT) Separation and Recycling Equipment, Populated Waste Printed Circuit Board Recycling Line, CRT Crushing and Recycling Equipment TV and PC Disassembly

Sr. No.	Company	Contact	Types of Equipments
			Equipment, Printed Circuit Board (PCB) Recycling Equipment
30.	KSM Mill and Construction	No.416 Jianye Road, South Jinqiao Area,Pudong New Area, Shanghai, China. **Tel.:** +86-21-58386189, 58386176 **Fax:** +86-21-58386211 **E-mail:** sbm@sbmchina.com	PEW Jaw Crusher, VSI5X Series Crusher, CS Cone Crusher, LSX Sand Washing Machine, Hydraulic-Driven Track Mobile Plant, Crusher Mining Machine For Granite
31.	XF MACHINERY	Heluo road and Provincial Road S237 Gongyi, Henan Province, China **Email:** amy@xinfeimachinery.com **Mobile:** 0086-18538721247 **TEL:** 0086-371-64363855 **FAX:** 0086-371-64363855	*Refrigerator Crusher, Computer Case Crusher, Home Appliances Crusher, Radiator Crusher, PCB Recycling Equipment, Wire and Cable Recycling Equipment, Electrostatic Separation Machine, Circuit Board Recycling Equipment*
32.	Europe Recycling Equipment	Wolfveldseweg 1A, 7737 PK Stegeren, Netherlands **Phone:** +31 529 408 170	*Single shaft Shredder, Two shaft shredders, Granulators, Recycling Plants*
33.	Versatile Stoevelaar Machinery	Wolfveldseweg 1a, 7737 PK Stegeren, Netherlands **Phone:** +31 529 461 377	*Self propelled mixer wagon, Drawn Voermeng wagon,* Stationary Mixer
34.	BLUE GROUP	New Cheshire Business Park, Wincham Lane, Wincham, Northwich, CW9 6GG Tel: 01606 261262 Fax: 01606 41068	*Crushers, Screeners, Shredders, Dropstand Trommels, MSD Trommels, Compost Turners, Chippers, Crusher Buckets,*
35.	Global Recycling Solutions Ltd.	Unit 7, Ruston Road, Grantham NG31 9SW, United Kingdom Phone: +44 1476 568384	*Conveyor systems, Shredders, Over-belt magnets, , Granulators*
36.	AWC Engineering	Unit 5, Eagle Iron Works, Tame Street, Stalybridge, Greater Manchester SK15 1ST United Kingdom Mob: 07711 874496 Email: sales@awcengineering.co.uk	*Single Shaft Shredders, Twin Shaft Shredders, Auxiliary Equipments, Granulators, Complete Plants*
37.	Summit Recycling Systems	Tame Park Wilnecote Tamworth Staffordshire B77 5DY Tel: +44 (0)1827 265 800 chris.bailey@summitrecycling.co.uk	*Balers, Conveyors, Granulators, Shredders, Material Storage, Separating and sorting*

Sr. No.	Company	Contact	Types of Equipments
38.	Wright Engineers Ltd.	Masons Rd, Stratford-upon-Avon CV37 9JA, United Kingdom Phone: +44 1789 292939	*Conveyors, Waste and Recycling Equipments, Feeders, Granulators.*
39.	MRT Systems	Lumavägen, SE-371 47 Karlskrona, SWEDEN Phone: +46 455 30 28 70 | Fax: +46 455 30 28 79 | Email: info@mrtsystem.com	*Mercury Distillers, Lamp processors, HID Processors, End Cut Machines, Lamp Crushers, CRT Seperators, Flat Panel Processor*
40.	Sybertech Waste Reduction Ltd.	13698 Coldicutt Avenue White Rock, B.C., Canada V4B 3A9 Toll Free: **1-888-888-7975** Email: **sales@swrl.com**	*Bulb Eater, GTS Systems*
41.	Aircycle Corporation	2200 Ogden Avenue Suite 100 Lisle, IL 60532Tel: 800.909.9709 Email: info@aircycle.com Fax: 866.909.6725	*Bulb Eater, Bulb Eater3, Lamp Crusher, EnviroPure, Smash It In-Drum Compactor, Smash*

Appendix –4.4: Recycling Technologies

Mitsubishi Recycling Technology[29]

Mitsubishi has developed a proprietary method for separating plastics based on their respective characteristics. The technology developed by Mitsubishi separates plastics at high level of purity and high recovery rates.

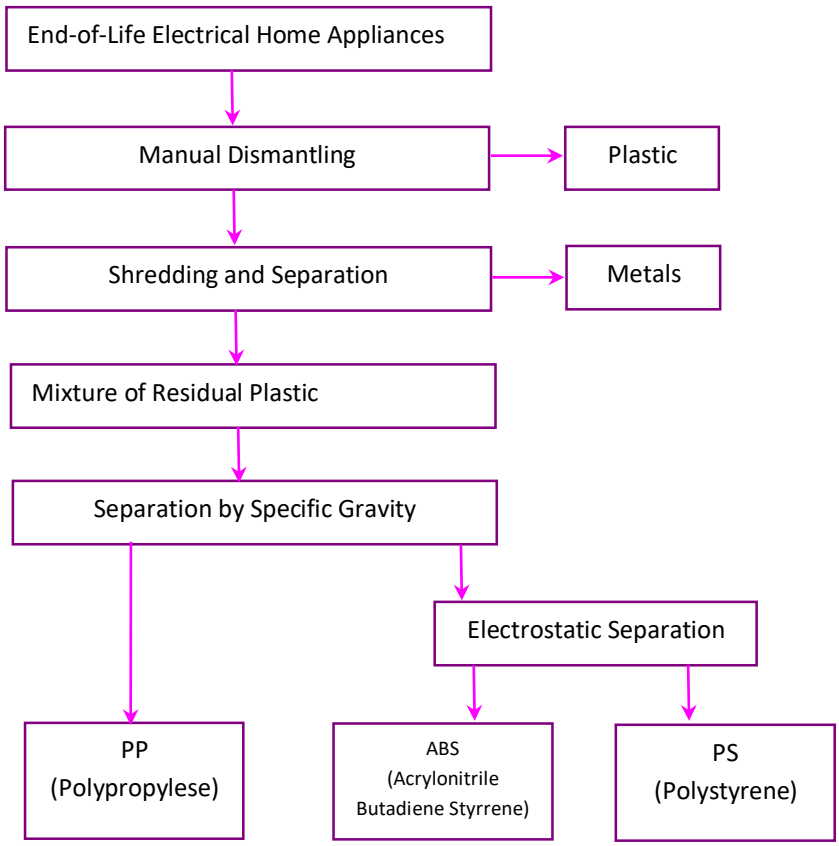

Figure 1: Process for Separating Mixed Plastic at High Levels of Purity

Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/plastics/gcs/index.html* (Accessed on 14 July, 2016)

The flow chart above shows the process of separating mixed plastic with high level of purity.
The end of life electric home appliances are first dismantled manually from which the plastics are separated. Then in shredding and separating phase, the metals are separated from plastic. This residual plastic is then fed for separation by specific gravity. In separation by specific gravity, the substances in plastic mixture are separated according to the weight of different substances. By using specific gravity separation, polypropylene (PP) plastic substances are separated from the mixture. In order to further separate acrylonitrile butadiene styrene and (ABS) polystyrene (PS) the mixture of residual plastic is then treated with electrostatic separation. In electrostatic separation, a frictional static is generated between PS and ABS and then the mixture is passed between the electrode with positive and negative charge. The PS substances are attracted towards positive electrode and the ABS substances are attracted toward negative electrode. The process therefore separates PP, ABS and PS substances from the waste electronic household appliances.

[29] *http://www.mitsubishielectric.com/company/environment/ecotopics/plastics/separation/index.html (visited on April 28, 2013)*

Panasonic Recycling Technology[30]

High-Precision Resin Sorting System (Mass Production Equipment)

Panasonic developed a high-precision resin sorting system that automatically sorts and recovers plastic materials from residues. This system was introduced into the recycling factory of Panasonic Eco Technology Center Co., Ltd. (PETEC) on a trial basis.

The system uses near-infrared rays to instantly identify specific plastic materials contained in the residues carried on a conveyor, and the plastic materials that are identified are shot down for recovery with compressed air. This system enables the sorting and recovery of plastic materials by type at purity of over 99%, and also enables the removal of plastic materials that contain bromine. The mass production equipment is compact in size, does not require the use of water, and has the potential to process 1,000 tonnes annually.

Neodymium Magnet Recovery System

Neodymium (Nd) and dysprosium (Dy) are critical materials for recovery due to their scarcity and high value. In 2012, Panasonic completed the development of a set of equipment that extracts Nd magnets from used products. Panasonic's recycling factory PETEC has developed and introduced compact systems that do not emit heat or gases and therefore have a low environmental impact. With the introduction of this system in fiscal year 2013, Panasonic expects to recover 1.2 tonnes of Nd magnets.

Hitachi Recycling Technology[31]

Separation and Collection of Rare Earth Magnets from End-of-Life Products

Hitachi has developed machinery that separates and collects rare earth magnets from hard disks and compressors.

For HDD's a drum type unit spins to shake and prang the HDD's continuously, which loosens screws and disassembles the HDD's into their structural components. HDD's components like casing, disk, rare earth magnet components, etc. are separated. Since the rare earth magnets emerge from the machine separately the workers can then easily pick out
desired components by screening them visually.

For compressors, cutting machinery is first used to cut the compressor casing. The rotors containing rare earth magnets are then manually exposed. These rotors containing rare earth magnets are disassembled with rotor ejecting machinery. Further, a device that generates a resonant current to weaken the magnetic field of the rare earth magnets having strong magnetic force is used in order to safely collect the rare earth magnets. Finally a rare earth magnet remover causes a vibration to the rotor and only the rare earth magnets inside the rotor are separated and collected.

Extraction of Rare Earths from the Separated and Collected Rare Earth Magnets

Hitachi through partnership with University of Tokyo's Institute of Industrial Science conducted experiments for extraction of rare earth materials from the magnets. These experiments were carried out using dry process instead of conventional method that is by using acids and other chemicals, and

[30] http://panasonic.net/eco/factory/recycle/other.html *(visited on April 22, 2013)*
[31] http://www.hitachi.com/New/cnews/101206.html *(visited on April 22, 2013)*

neodymium and dysprosium to separate the rare earths and extraction of materials from the other non-rare earth materials like iron in the rare magnets.

Hitachi achieved this by using special extraction material with high affinity for neodymium and dysprosium to separate rare earths and extraction material from the other non-rare earth materials like iron in the rare earth magnet. Then the non-rare earth materials are removed and heat is applied to distill the excess extraction material.

Sumitomo Recycling Technology

The flow chart below shows the steps used by Sumitomo for recycling of used electrical wires and cables. The Sumitomo Electric Group collects used electric/wires, fiber optical cables and carbide chips for cutting tools and their plastics cases for recycling as materials for new products.[32]

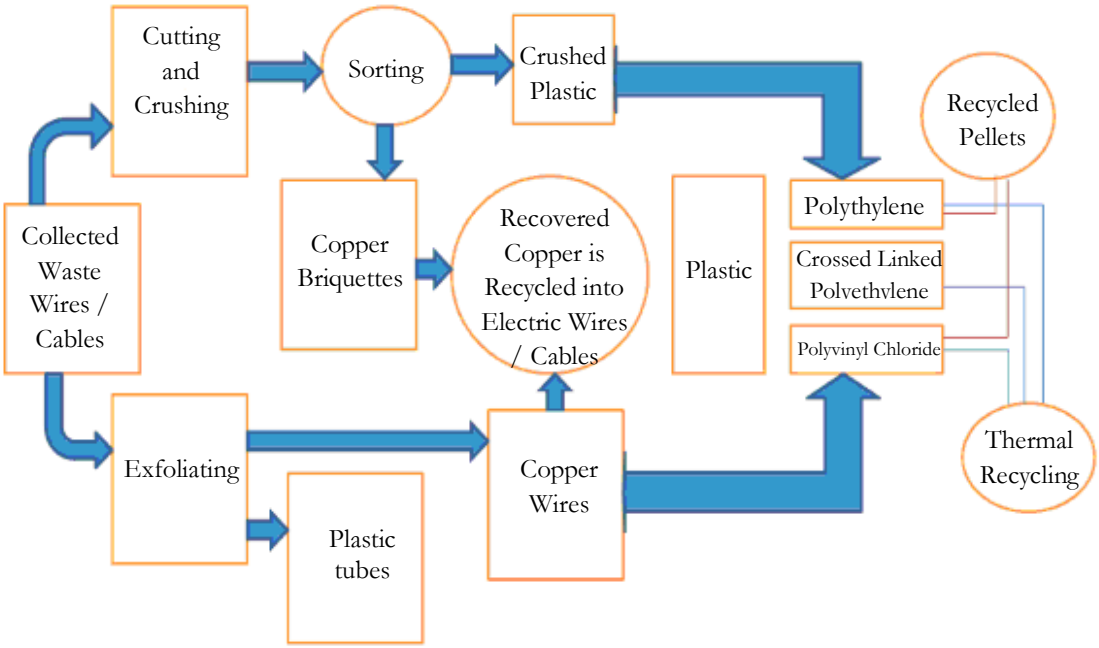

Figure 1: Procedure for Recycling of Electric Wires/Cables[33]
Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013,* http://www.mitsubishielectric.com/company/environment/ecotopics/_plastics/gcs/index. *html* (Accessed on 14 July, 2016)

As shown in the above figure, the collected thin wasted wires/cables are sorted after cutting and crushing using difference in specific gravity and by using static electricity. Different plastic substances like polyethylene (PE), crossed linked polyethylene (PEX) and polyvinyl chloride (PVC) obtained after sorting process. Further, the recycled pellets obtained from PE and PVC is used in electric wires, cables, etc. Whereas, thick wires/cables undergo exfoliating from which recovered copper wires are used for manufacturing of electric wires/cables and the plastic covering of the thick wires/cables are used for recovering plastic substances like PE, PEX and PVC.

Toshiba Recycling Technology[34]

The flow chart below shows the procedure for crushing and sorting the end-of-life electric and electronic equipment. When the end of life electronic equipment is to be recycled, it is put into a

[32] http://global-sei.com/csr/environment/recycling.html *(Accessed on 14 July 2016)*
[33] http://global-sei.com/csr/environment/images/img_recycling_02b.jpg *Accessed on 14 July 2016)*
[34] http://www.toshiba.co.jp/env/en/industry/recycled.htm#anchorLink2011 *Accessed on 14 July 2016)*

large plant for crushing and sorting. First, the equipment is crushed in a crushing machine and then the crushed parts are separated by manual visualizing.

In order to collect different recycled materials like iron, aluminum, stainless steel and plastics a combination of mechanical (magnetic, excess current, high magnetism) and manual sorting is used.

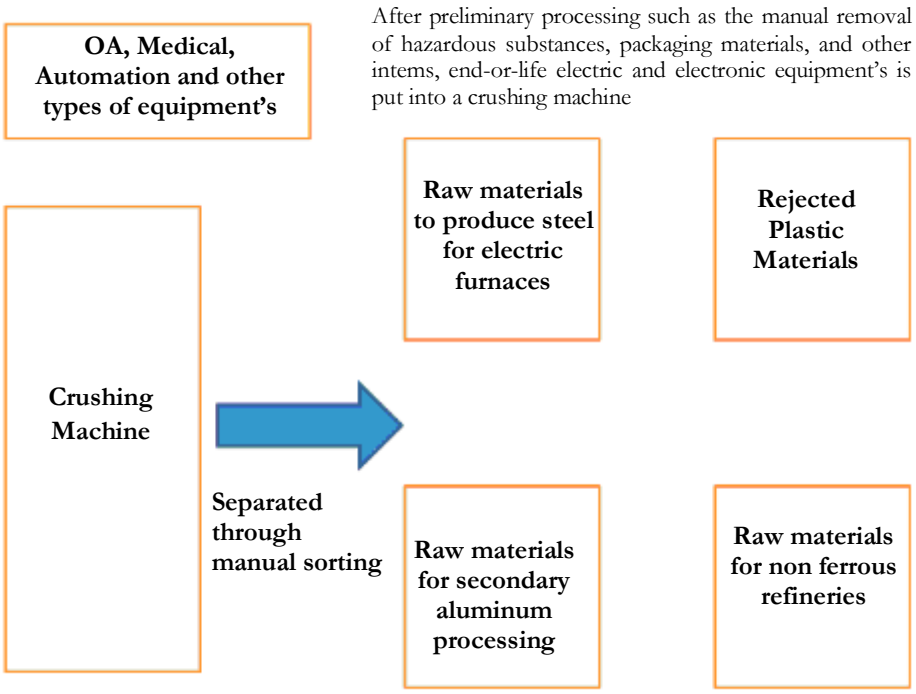

Figure 1: Recycling Steps for End-of-life Electric and Electronic Equipment
Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/plastics/gcs/index.html* (Accessed on 14 July, 2016)

Sharp Recycling Technology

Developing Zeolite from Waste LCD Panel Glass

Sharp has developed this technology in partnership with Osaka Prefecture University. The method uses superheated water to breakdown the organic substances in the LCD panel glass and separate it from other metals.53 The method is basically used for turning the crushed glass from panels into zeolite via reaction in an alkaline solution. Sharp successfully created zeolite by reacting pulverized glass in the alkaline solution. Further, Sharp plans to put the technology into practical use in 2015.54

Technology to Recover Highly Functional Paint from Scrap LCD Panel Glass

In 2009 Sharp developed a highly functional paint made by using scrap glass discarded during the LCD panel production process. The waste LCD panel glass is finely crushed, and the resulting powder is mixed with the paint base or pigment. The paint developed increases the durability of the products installed outdoors that are exposed to sunlight, wind, rain, sand and dust. These paints are used mainly for the LED lighting that utilizes this paint for its external components.

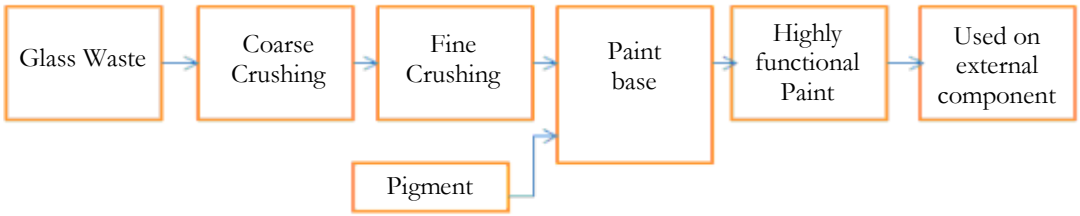

Figure 1: Developing High Functional Paint from Scrap LCD Panel Glass[35]
Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/_plastics/gcs/index. html* (Accessed on 14 July, 2016)

Technology to Recover Indium from Waste LCD Panels

In 2009, Sharp jointly with Osaka Prefecture University, developed a recycling technology for waste LCD panels that uses sub-critical water. This sub-critical water dissolves the organic substances of glass and strips away the organic layer from the glass substrate of the LCD panel, and separates and recovers the indium, a rare metal, from the glass.

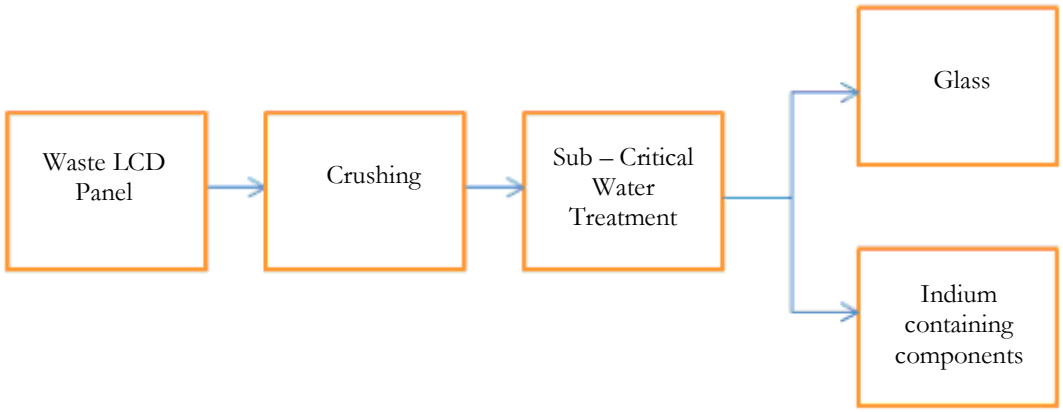

Figure 2: Process to Recover Indium from Waste LCD Panels[36]
Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/_plastics/gcs/index. html* (Accessed on 14 July, 2016)

Process to Disassemble End-of-Life Electronics Products

Sharp developed a new process to disassemble the end-of-life electronic products for recycling easily. In order to disassemble the two combined pieces easily, the washer of the screw is heated at a particular temperature. Due to heating the washer expands and loses its firmness, making it easy to detach the two combined pieces.

JFE Recycling Technology[37]

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[35] *http://sharp-world.com/corporate/img/eco/environment/technology/technology_pdf_002.pdf*

[36] *http://sharp-world.com/corporate/img/eco/environment/technology/technology_pdf_002.pdf* (Accessed on 14 July, 2016)

[37] *http://www.jfe-steel.co.jp (Accessed on 14 July, 2016)(*

The recycling process includes recycling of waste electronic household appliances like refrigerators, air conditioners, washing machines, TV sets. At a first stage, the electrical appliances are manually dismantled, and cathode ray tube (CRT), plastics, etc. are separated from the television sets.

The plastic obtained after dismantling is utilized as a raw material for blast furnace. In crushing and sorting facility, crushing machine, air separator, magnetic separator, urethane comparator, eddy current separator and chlorofluorocarbon collection facility is used. By using the above technique various materials are obtained from waste electrical appliances. Chlorofluorocarbon (subcontracted) is obtained from the chlorofluorocarbon collection facility, urethane which is used as a raw material for blast furnace is obtained from urethane compactor, Steel scrap which is used as a raw material for steel manufacture is recovered from magnetic separator, the left over nonmagnetic material are forwarded to eddy current separator. Shredder dust is recovered from the eddy current separator, which is further processed at thermo bath and kept under examination. Non-ferrous metal and plastics are recovered from the thermal bath.

The used household electrical appliances are first manually dismantled and the major components are removed. The remaining mixed part/substances are then processed in a crusher and then mechanically sorted. The heat insulating urethane in refrigerators is separated by wind sorting, compressed, and are used as blast furnace feed material. Iron and non-ferrous metals are recovered by the magnetic sorting machine and non-ferrous sorting respectively and are used as iron and steel making materials. The plastics, which account for nearly 30% of home appliances, are directly used in blast furnace waste plastic feeding operation. The recycling ratio of this plant currently exceeds 80%.

Dowa Recycling Technology[38]

The figure below shows the recycling process carried by Act-B Recycling Co. Ltd. The recycling process covers equipment's like personal computers, televisions, washing machines, air conditioners, and refrigerators.

[38] *http://www.act-b.co.jp/eng/environment/index2.html* (Accessed on 14 July, 2016)

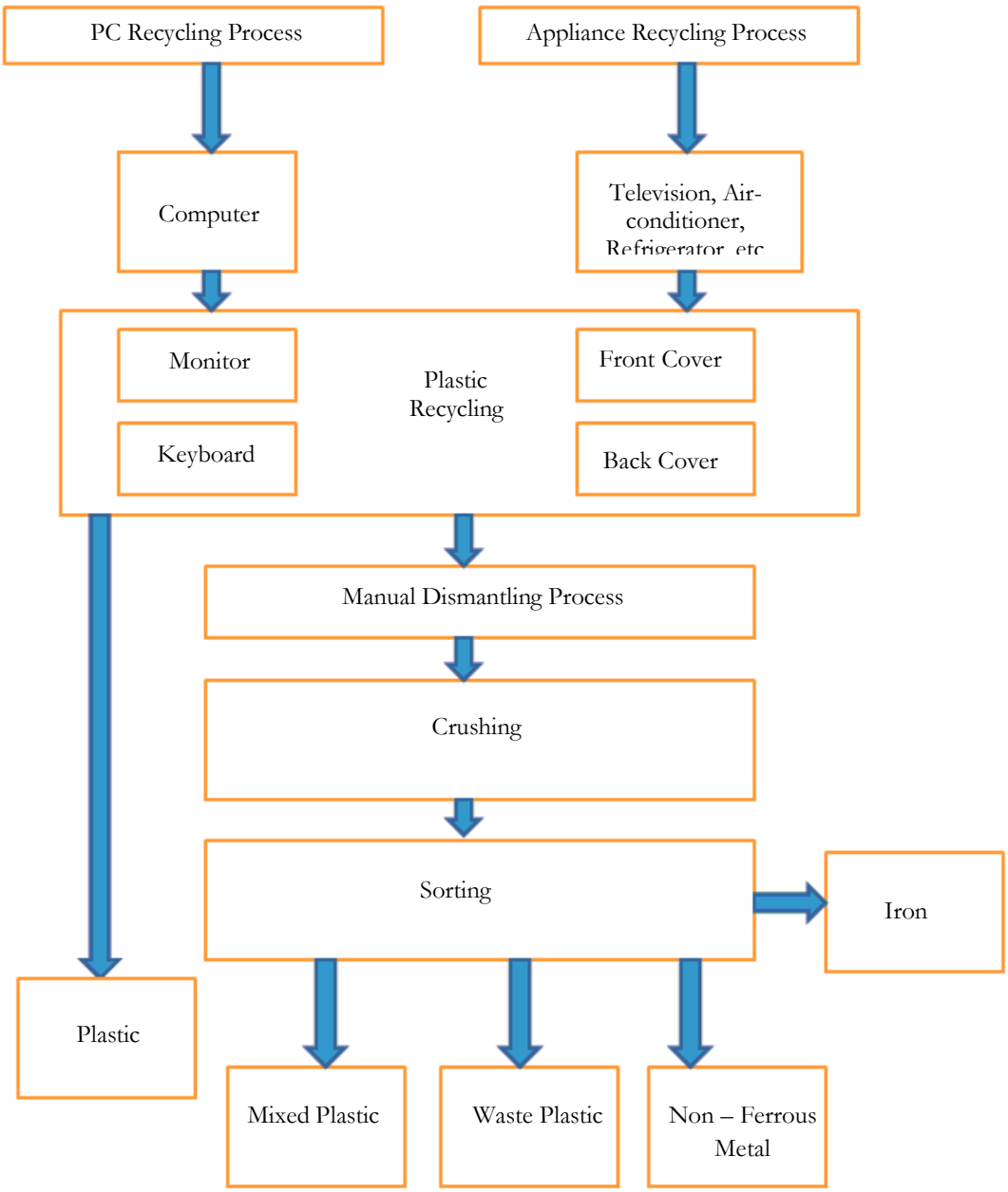


Figure 1: Recycling of WEEE/e-waste
Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013,* http://www.mitsubishielectric.com/company/environment/ecotopics/_plastics/gcs/index. *html* (Accessed on 14 July, 2016)

First, a manual disassembling is carried out and the plastic materials like monitor cover and keyboard from computers, front and back cover of television, washing tub and lid from washing machines, cover of indoor equipment from air conditioners, and tray and vegetable case from the refrigerator is separated for recycling of plastic. Additionally, the main materials collected from the manual dismantling process is circuit boards from televisions and computers, deflection York, funnel glass, and panel glass from televisions, motor and reducer from washing machines, and compressor, copper pipe and heat exchanger from air conditioners and refrigerators. These materials, which are manually dismantled are directly forwarded to traders. Furthermore, the materials that cannot be dismantled manually are then forwarded for crushing. Once these materials are crushed they are then sorted into mixed plastic, waste plastic, non-ferrous magnet and iron. Urethane and chlorofluorocarbon is

recovered from the rest of material obtained after crushing process. These recovered materials are then distributed to traders and waste distributors.

JX Recycling Technology[39]

The flow chart below shows recovery of Cathodes from lithium-ion batteries. A waste lithiumion battery is collected from different sources like from car manufacturers, battery manufacturers, etc. These waste batteries are disassembled then crushed and lastly sorted. Cathode (aluminum sheet) and aluminum package are separated in the sorting process. Leaching process is provided to the sorted cathode from which recycled cathode materials are obtained. The recycled cathode materials further undergo solvent extraction. Electric Co- Ni-Mn lithium carbonate is recovered from the solvent extraction process, and the recovered material is provided to cathode material manufacturer (Isohara Works).

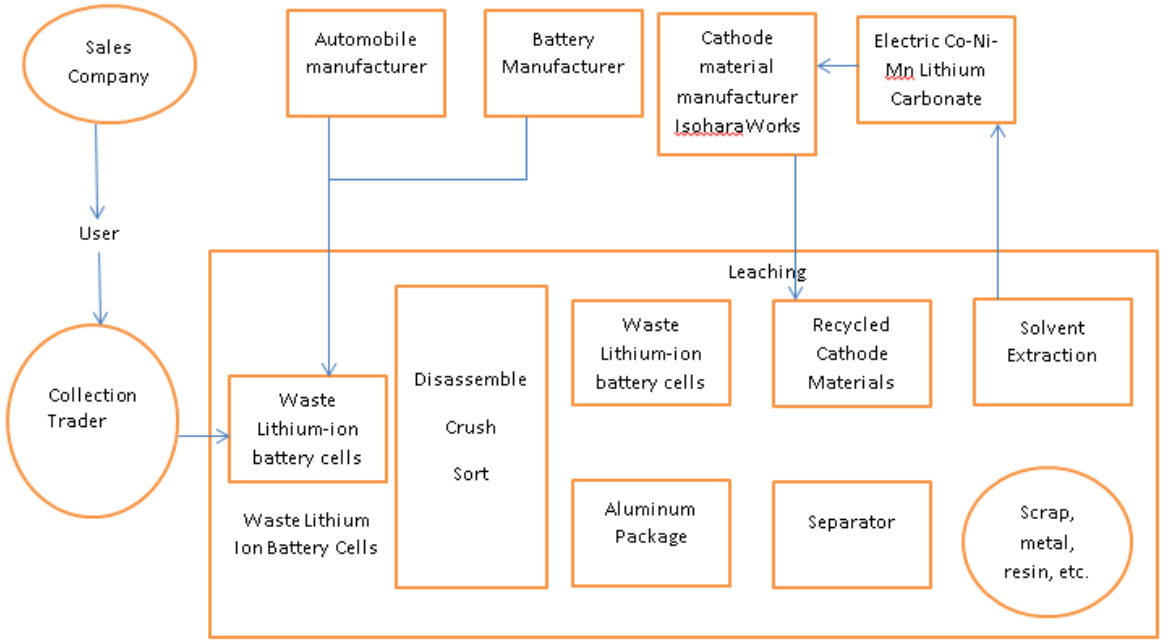


Figure 1: Recovery of Cathodes from Lithium – Ion Batteries

Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/plastics/gcs/index.html* (Accessed on 14 July, 2016)

Toyota Recycling Technology[40]

In 2010, Toyota promoted first battery to battery recycling business, which recovers nickel from the nickel-hydrogen batteries used in hybrid vehicles and reuses it in new batteries.

The figure 1 shows Toyota's first battery to battery recycling process. Firstly, after the hybrid cars receive a battery change or when a hybrid battery reaches the end of its service life, the electric vehicle is dismantled and battery is safely removed. These batteries are then collected and delivered to dealer service centers. In the rebuilding and reusing phase these batteries are again tested and if the batteries are still functional then they are used in hybrid vehicles when they need a battery replacement. The

[39] *http://www.nmm.jx-group.co.jp/english/sustainability/theme/circulation/index.html,* (Accessed on 14 July, 2016)

[40] *http://www.toyota-global.com/sustainability/csr_initiatives/stakeholders/society/environment.html,* (Accessed on 14 July, 2016)

left over nonfunctional batteries are then forwarded for recycling process. In recycling phase the rare metals and all other precious metals in the battery is recovered and further used as resources.

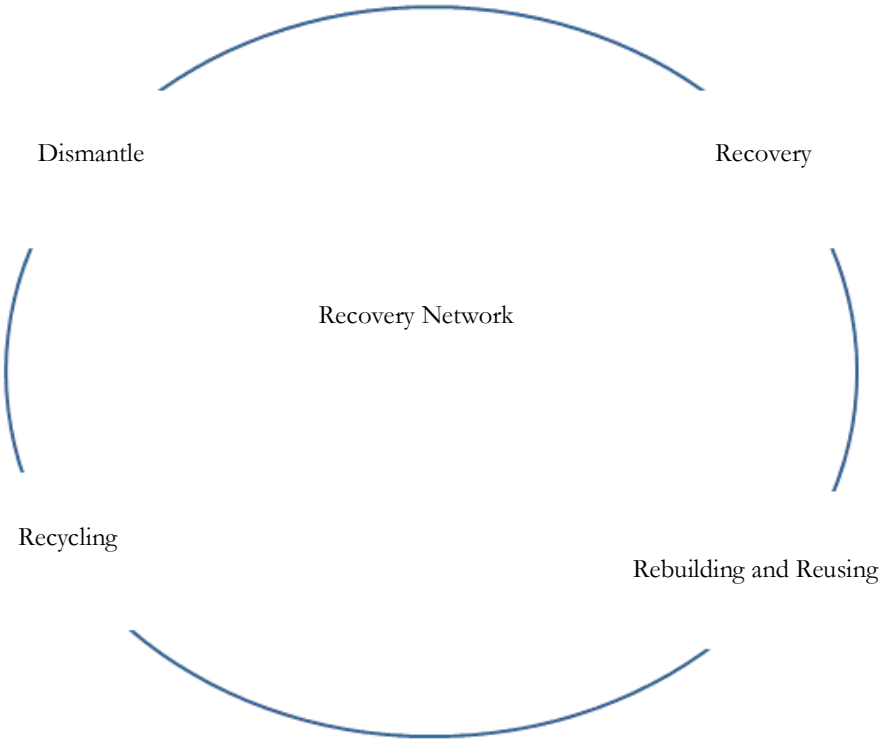


Figure 1: Toyota's Battery to Battery Recycling
Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/_plastics/gcs/index. html* (Accessed on 14 July, 2016)

SHINKO PANTEC Recycling Technology

Shinko Pantec has applied two technologies in order to attain the strict Japanese norms for (PCB) decontamination.

1. The electrical equipments like transformers and capacitors are first cleaned with solvent treatment and then dismantled. These equipments are again cleaned with solvent after dismantling.

2. The oils are first treated in a reactor with a specially made sodium dispersion and a promoter to obtain a high reaction rate. In case of high concentrations of PCBs a moderator is added to avoid the formation of polymerization products containing chlorine, formed from the chlorinated species.

Canon Recycling Technology[41]

Canon is involved in recycling of plastics from used products for application in new Canon products. As shown in the figure below, collected business machines are first disassembled and sorted. After disassembling and sorting the outer casing of business machine that is engineering plastic and the paper supply cassettes that is the commodity plastics is pulverized and washed. All the foreign particles present in the plastic is removed in this phase.

[41] *http://www.canon.com/csr/report/en/06_2.html (visited on April 29, 2013)*

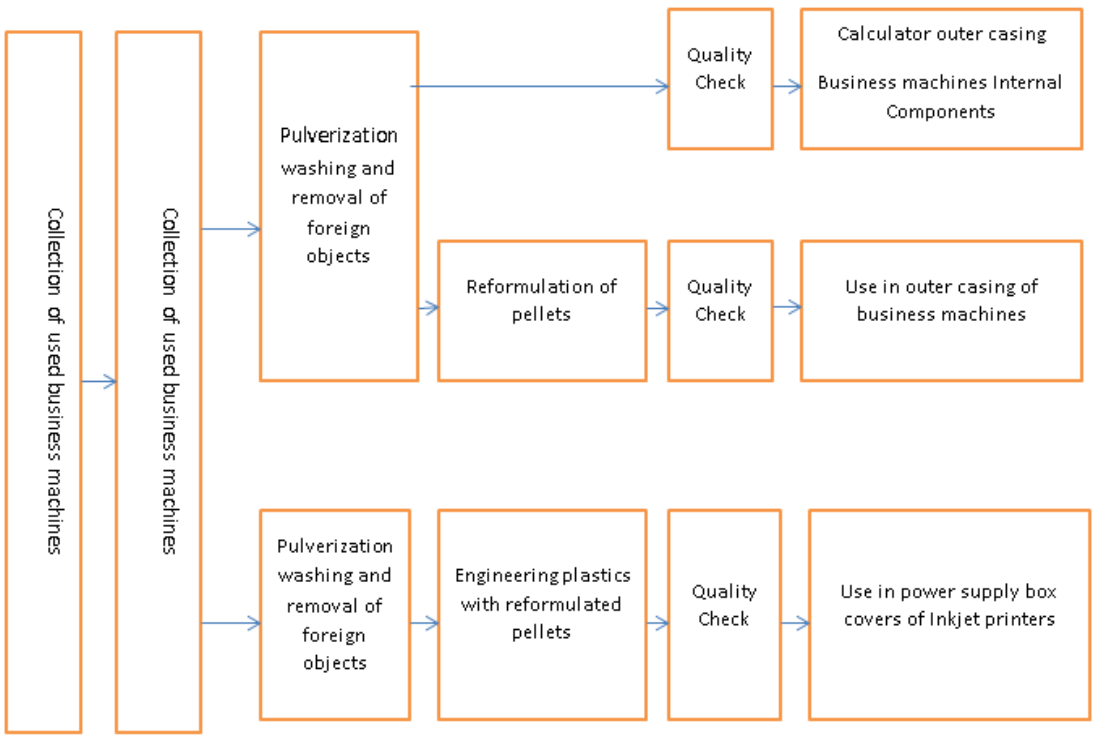
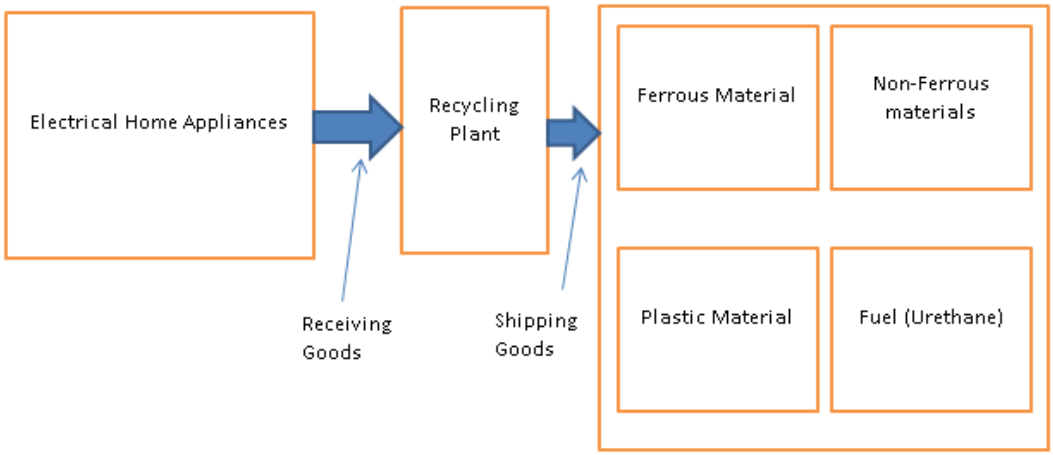


Figure 1: Recycling of Plastic Materials from Business Machines
Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/plastics/gcs/index. html* (Accessed on 14 July, 2016)

Fujitsu Recycling Technology[42]

Fujitsu recycles waste electronic home appliances at their subsidiary recycling plant "Fuji Ecocycle Ltd." As shown above Fujitsu successfully recycles ferrous materials, nonferrous materials, plastic materials and fuel i.e. urethane from the waste electric home appliances.



[42] *http://www.fujitsu-general.com/global/corporate/eco/factories/recycling.html (visited on April 29, 2013)*

Figure 1: Disposition Flow of Used Electric Home Appliances
Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/_plastics/gcs/index. html* (Accessed on 14 July, 2016)

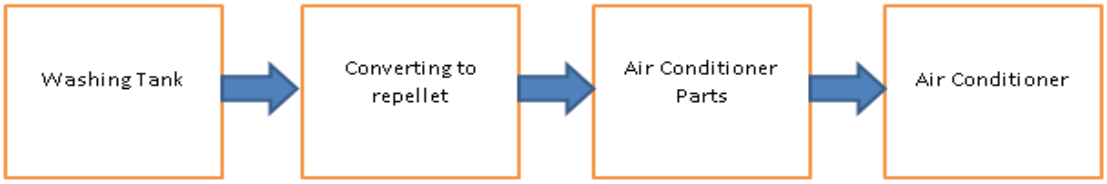


Figure 2: Closed Recycling
Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/_plastics/gcs/index. html* (Accessed on 14 July, 2016)

Fuji Ecocycle Ltd. recovers Polypropylene (PP) materials from the washing tank of used washing machines. These PP materials are recycled to repellet and further used in air conditioners. A large size plastic crushing machine is used for the crushing of large washing tanks (which is outsourced).

Furukawa Electric Recycling Technology[43]

The flow chart below is of the thermo-plasticizing process used by Furukawa for obtaining recycled material using the cross-linked polyethylene (XLPE) waste from the electric wires and cables and processed into nuggets preparatory to be discharged. The XLPE waste is then sorted or separated and is cleaned so that the foreign matter if present can be removed.
The XLPE waste is then broken down into particles of a size suitable for feeding into the processing equipment. Further, the XLPE particles are loaded into the feeder unit and supplied continuously in measured quantity to the thermo-plasticizing equipment. The thermo-plastic material is then discharged from the equipment and then cooled and transformed into pellets.

[43] *http://www.furukawa.co.jp/review/fr023/fr23_17.pdf (visited on April 29, 2013)*

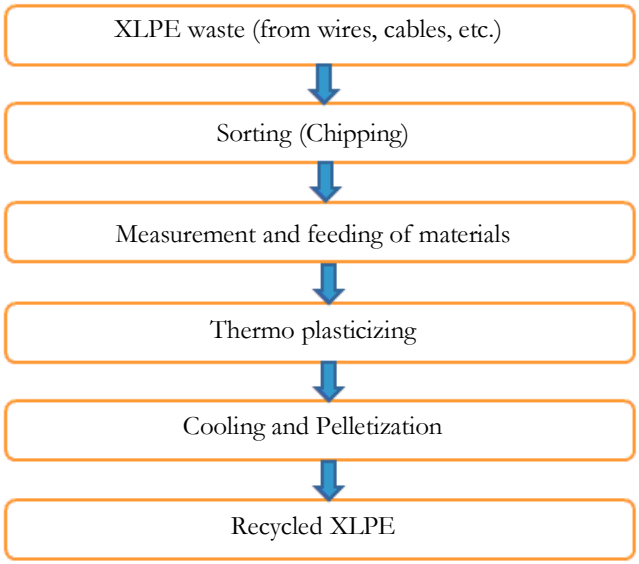


Figure 1: Flow Chart of Thermo-Plasticizing Process for Recycling of XLPE Waste from Electric Wires and Cables

Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/plastics/gcs/index. html* (Accessed on 14 July, 2016)

NEC Recycling Technology

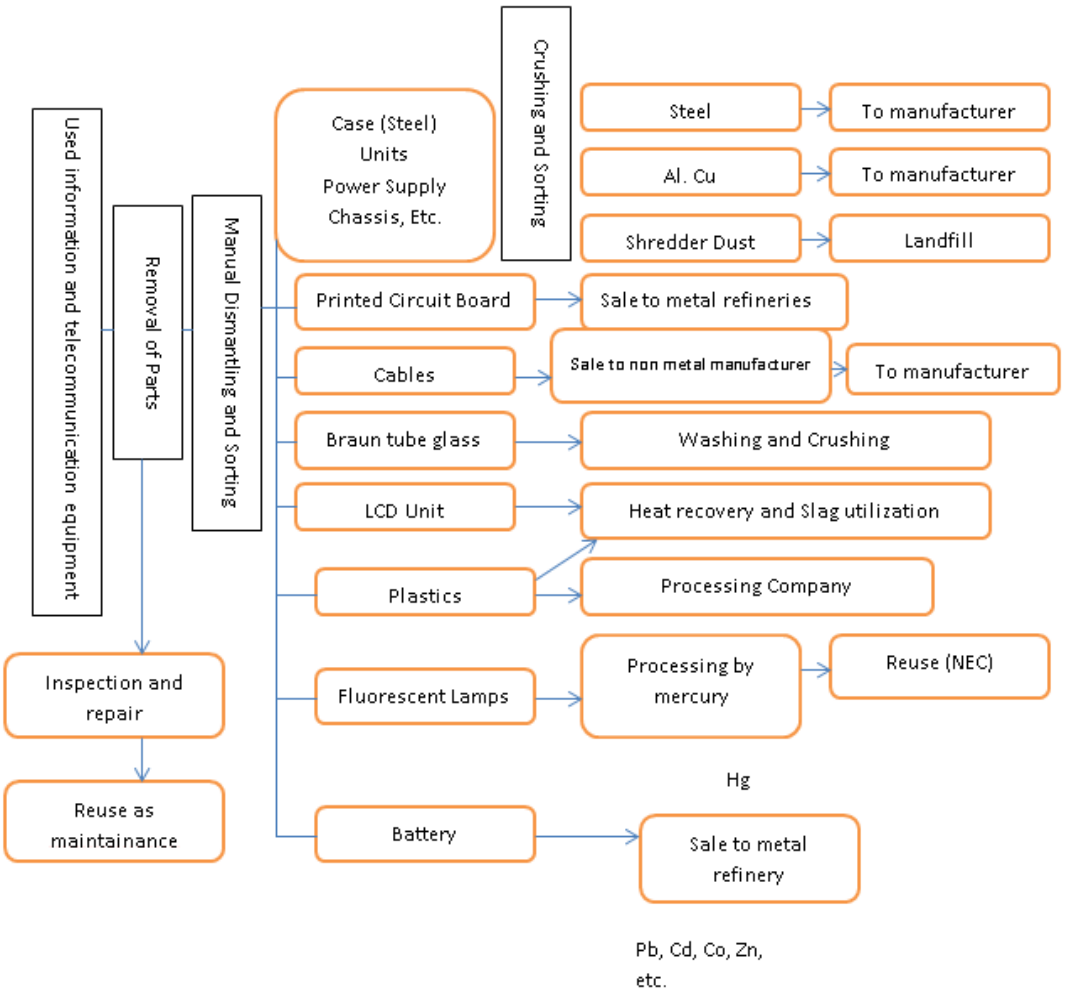


Figure 29: Recycling /Reusing Flow of NEC Corp
Source: Reuters Thomson, White Ed and Singh Gole Rohit (2013), *World Intelectual Property Organization (WIPO) in Cooperation with Basel Convention. Patent Landscape Report on E-Waste Recycling Technologies, 2013, http://www.mitsubishielectric.com/company/environment/ecotopics/_plastics/gcs/index. html* (Accessed on 14 July, 2016)

The figure above shows recycle/reuse flow for an electronic/telecommunication equipment. First the equipment's are inspected for reusability if the product can be reused then it is further repaired. If not then the product is dismantled and sorted manually. The cables are sold to the non metal manufacturers; PCB's are sold to the metal refineries. NEC Corporation uses the fluorescent lamps after processing them with mercury.

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United Nations
Environment Programme

P.O. Box 30552 Nairobi, 00100 Kenya
Tel: (254 20) 762 1234
Fax: (254 20) 762 3927
E-mail: uneppub@unep.org
Website: www.unep.org

For more information, please contact:

Economy Division
International Environmental Technology Centre

2-110, Ryokuchi koen, Tsurumi-ku, Osaka
538-0036, Japan
Tel: +81 6 6915 4581
Fax: +81 6 6915 0304
E-mail: ietc@unep.org
Web: www.unep.org/ietc